sydney METRO | city & southwest

CHATSWOOD TO SYDENHAM

ENVIRONMENTAL IMPACT STATEMENT

MAIN VOLUME

NSW GOVERNMENT | Transport for NSW

NSW MAKING IT HAPPEN

Certification

Submission of Environmental Impact Statement

This Environmental Impact Statement has been prepared under Part 5.1 of the (NSW) *Environmental Planning and Assessment Act 1979* and in accordance with Part 3 of Schedule 2 of the *Environmental Planning and Assessment Regulation 2000*.

Environmental Impact Statement prepared by:

Name	**Jesse Death**	**Todd Brookes**
Qualifications	B.EnvSc	B.EnvMgt
Address	Jacobs Group (Australia) Pty Ltd Level 10, 100 Christie Street St Leonards NSW 2065	Arcadis Australia Pacific Pty Ltd Level 5, 141 Walker Street North Sydney NSW 2060
In respect of	Sydney Metro Chatswood to Sydenham Environmental Impact Statement	
Applicant Name	Transport for NSW Sydney Metro Delivery Office	
Applicant Address	Ground Floor, South Building 22 Giffnock Avenue Macquarie Park NSW 2113	
Proposed development	The project involves the construction and operation of a metro rail line, around 16.5 kilometres in length, between Chatswood and Sydenham. New metro stations would be developed at Crows Nest, Victoria Cross, Barangaroo, Martin Place, Pitt Street and Waterloo, as well as new underground platforms at Central Station. Full details on the project are detailed in Chapter 6 (Project description – operation) and Chapter 7 (Project description – construction).	
Land to be developed	To be carried out on land in the suburbs of Chatswood, Artarmon, Lane Cove North, Naremburn, St Leonards, Crows Nest, North Sydney, McMahons Point, Barangaroo, Millers Point, Sydney, Haymarket, Surry Hills, Chippendale, Redfern, Waterloo, Alexandria, Eveleigh, Erskineville, Newtown, St Peters and Marrickville. The project track alignment would be mainly located underground in twin tunnels extending from Chatswood, crossing under Sydney Harbour, and continue to Sydenham. New metro stations would be developed at Crows Nest, Victoria Cross, Barangaroo, Martin Place, Pitt Street and Waterloo, as well as new underground platforms at Central Station.	
Environmental Impact Statement	An Environmental Impact Statement is attached that assesses all matters specified in the Secretary's Environmental Assessment Requirements dated 22 December 2015, in accordance with Part 5.1 of the (NSW) *Environmental Planning and Assessment Act 1979* and other relevant legislation.	
Declaration	I certify that I have prepared the contents of the Environmental Impact Statement in accordance with Schedule 2 of the Environmental Planning and Assessment Regulation 2000 and the Secretary's Environmental Assessment Requirements dated 22 December 2015, and that, to the best of my knowledge the information contained in the Environmental Impact Statement is not false or misleading.	
Signatures		
Name	Jesse Death	Todd Brookes
Date	3 May 2016	3 May 2016

EXECUTIVE SUMMARY

Executive summary

Introduction

Sydney Metro would transform Sydney, cutting travel times, reducing congestion and delivering economic and social benefits for generations to come.

It would boost economic activity by more than $5 billion a year, supporting major jobs and business growth along its more than 65 kilometre route with better connectivity and land development opportunities and greatly improving business logistics, especially for knowledge-based businesses. Sydney Metro would deliver this major economic boost by:

- Improving access to jobs
- Changing the way people move about the city and reduce congestion
- Allowing people to travel from one key centre to another in minutes
- Enabling housing and employment growth along the Global Economic Corridor and west to Bankstown
- Encouraging greater commercial development – and jobs – in key areas of the city and North Sydney
- Delivering huge flow-on benefits across productivity, wages and the state's overall economic performance.

Employment across Sydney is expected to increase from 2.1 million workers today to about 3 million by 2031. About 60 per cent of people would work in the Global Economic Corridor stretching from Macquarie Park, through Chatswood, North Sydney, the Sydney CBD and on to Sydney Airport. Sydney Metro would connect people across Sydney to these jobs.

Over the next 15 years, NSW will require infrastructure to support 40 per cent more train trips, 30 per cent more car trips and 31 per cent more households. Sydney Metro City & Southwest is identified as a key infrastructure project as part of the NSW government's infrastructure investment program. The NSW Government is committed to the creation of 150,000 new jobs over the next four years. Through investment in infrastructure such Sydney Metro, new jobs and apprenticeships are being created for the construction sector.

Sydney Metro is a key component of *Sydney's Rail Future* (Transport for NSW, 2012a), a plan to transform and modernise Sydney's rail network so that it can grow with the city's population and meet the needs of customers in the future.

The Sydney Metro network consists of Sydney Metro Northwest (previously known as the North West Rail Link) and Sydney Metro City & Southwest. The proposed Sydney Metro City & Southwest comprises two core components:

- Chatswood to Sydenham (the subject of this Environmental Impact Statement). New 15.5 kilometre twin tunnels from Chatswood, under Sydney Harbour through Sydney's CBD to Sydenham.
- Sydenham to Bankstown upgrade. Proposed upgrade and conversion of the existing 13.5 kilometre railway from Sydenham Station to Bankstown to metro standards. This will be subject to a separate environmental assessment process.

Key features of the project

The key components of the project (from north to south) would include:

- Realignment of T1 North Shore Line surface track within the existing rail corridor between Chatswood Station and Brand Street, Artarmon, including a new bridge for a section of the 'down' (northbound) track to pass over the proposed Chatswood dive structure
- About 250 metres of new aboveground metro tracks between Chatswood Station and the Chatswood dive structure
- A northern dive structure (about 400 metres in length) and tunnel portal just north of Mowbray Road, Chatswood
- About 15.5 kilometres of twin rail tunnels (that is, two tunnels located side-by-side) between the northern dive structure and Bedwin Road, Marrickville (the Marrickville dive structure)
- A substation (for traction power supply) at Artarmon
- New metro stations at Crows Nest, Victoria Cross, Barangaroo, Martin Place, Pitt Street and Waterloo, as well as new underground platforms at Central Station
- A southern dive structure (about 400 metres in length) and tunnel portal north of Sydenham Station and south of Bedwin Road, Marrickville
- A services facility (for traction power supply and an operational water treatment plant) adjacent to the southern dive structure.

The project would also include a number of ancillary components, including new and alterations to existing overhead wiring, signalling, access tracks / paths, rail corridor fencing, noise walls, fresh air ventilation equipment, temporary and permanent alterations to the road network, facilities for pedestrians, and other construction related works.

The proposed alignment, stations and key operational ancillary infrastructure are shown in Figure E-1.

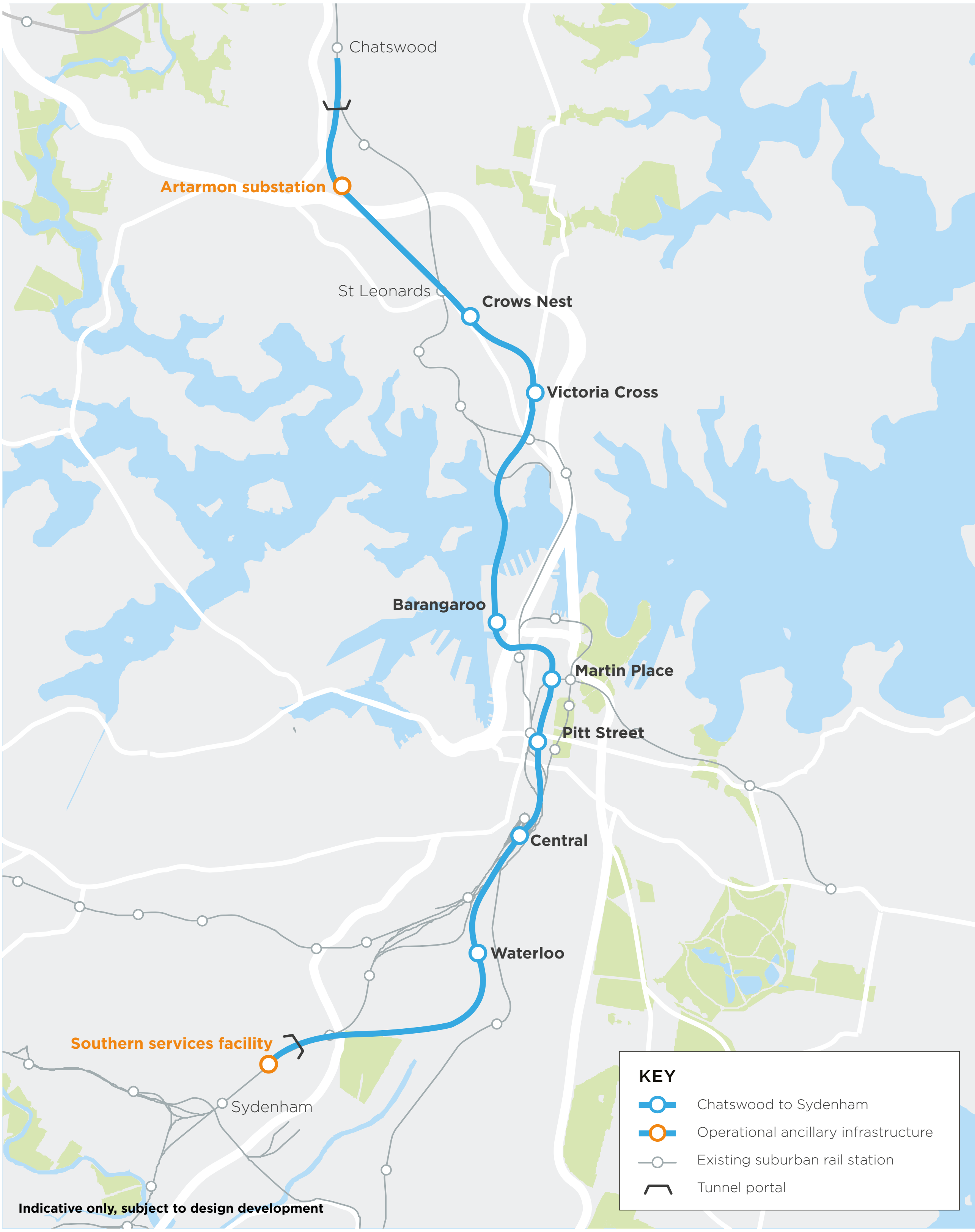


Figure E-1 The project

Project objectives

A set of objectives has been developed for the project having regard to the key challenges and strategic land use and transport policies. The objectives for the project are:

- Improve the quality of the transport experience for customers
- Provide a transport system that is able to satisfy long-term demand
- Grow public transport patronage and mode share
- Support the productivity of the Global Economic Corridor
- Serve and stimulate urban development
- Improve the resilience of the transport network
- Improve the efficiency and cost effectiveness of the public transport system
- Implement a feasible solution recognising impacts, constraints and delivery risk.

The proponent

The proponent for the project is Transport for NSW, which is the lead agency of the NSW transport portfolio, with primary responsibility for:

- Transport coordination
- Transport policy and planning
- Transport services
- Transport infrastructure.

A specialised delivery office has been established as part of Transport for NSW to manage the planning, procurement and delivery of the Sydney Metro network.

Project need and benefits

The project has been developed within the framework of the transport and planning strategies identified in State government policies. In particular this includes the *12 NSW Premier priorities* (established to grow the economy, deliver infrastructure, and improve health, education and other services across NSW), *Sydney's Rail Future: Modernising Sydney's Trains, Draft Metropolitan Strategy for Sydney 2031* and the *NSW Long Term Transport Master Plan*.

These polices indicate a strategic need to:

- Significantly increase transport capacity in key parts of the network, especially to the Sydney CBD and the Global Economic Corridor
- Drive productivity through integrated transport and land use planning to realise the productivity benefits of having businesses close together enabling increased interaction, knowledge sharing and collaboration
- Effectively develop infrastructure to cement Sydney's position among the world's most liveable cities and Australia's only global city.

Sydney Metro would deliver a step-change in the capacity of Sydney's rail network by providing a fully automated rail system across Sydney, supporting high demand with a high capacity, turn-up-and-go service.

Sydney Metro, together with signalling and infrastructure upgrades across the existing network, would increase the capacity of the rail network through the Sydney CBD from about 120 per hour during peak periods today, to up to 200 services per hour beyond 2024, including capacity for up to 60 metro trains per hour during peak periods (or 30 trains per hour in each direction). This would equate to an increase of up to 60 per cent capacity across the network. This means that the railway network across greater Sydney would have room for an extra 100,000 train customers per hour in the peak. The fully automated, Sydney Metro network would have the ultimate capacity to operate 30 trains an hour through the Sydney CBD in each direction – a train every two minutes each way. The proposed new stations would alleviate congestion at Wynyard, Town Hall, Central, Redfern and Green Square stations.

Sydney Metro would deliver a new tier for Sydney's rail network, supporting high demand with a high-capacity, turn-up-and-go service. It is being developed with an emphasis on supporting the needs of customers for 'door to door' journeys from origin to destination as shown in Figure E-2.

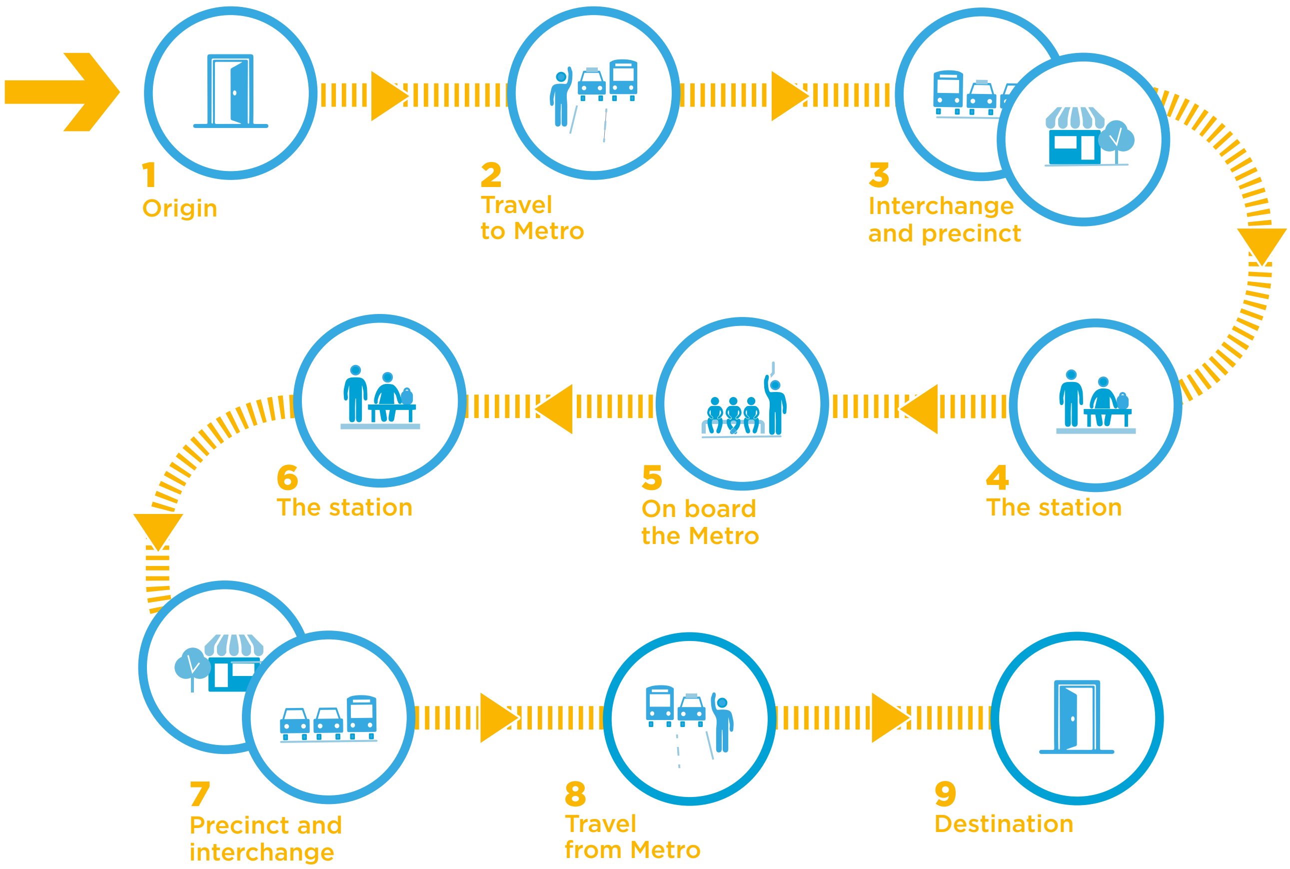


Figure E-2 Customer journey

Other key benefits of the project include:

- Doubling the number of train paths available from the north to Sydney's CBD (by introducing new metro lines beneath Sydney Harbour)
- Strengthening connections and access across Sydney, particularly within the Global Economic Corridor
- Providing new connections to the rail network – including connections to the T4 Eastern Suburbs Line at Martin Place Station, and direct connections between the Sydney CBD with the north west
- Improving the capacity, reliability and efficiency of the existing transport system, by relieving the pressure on existing rail lines, Sydney CBD train stations, Sydney CBD, North Sydney and Sydney South bus routes, and the Sydney CBD road network
- Providing the opportunity for urban development opportunities particularly around the new stations at Crows Nest, Victoria Cross, Barangaroo and Waterloo
- Providing the opportunity for the progressive renewal of the ageing Waterloo social housing estate including a mix of private, affordable and social housing
- Improving network resilience through the Sydney CBD and across Sydney Harbour by providing an additional route during planned and unplanned events affecting other Sydney CBD and harbour links
- Health benefits with the creation of safer and more appealing conditions for pedestrians, cyclists and other transit users in the areas around the stations.

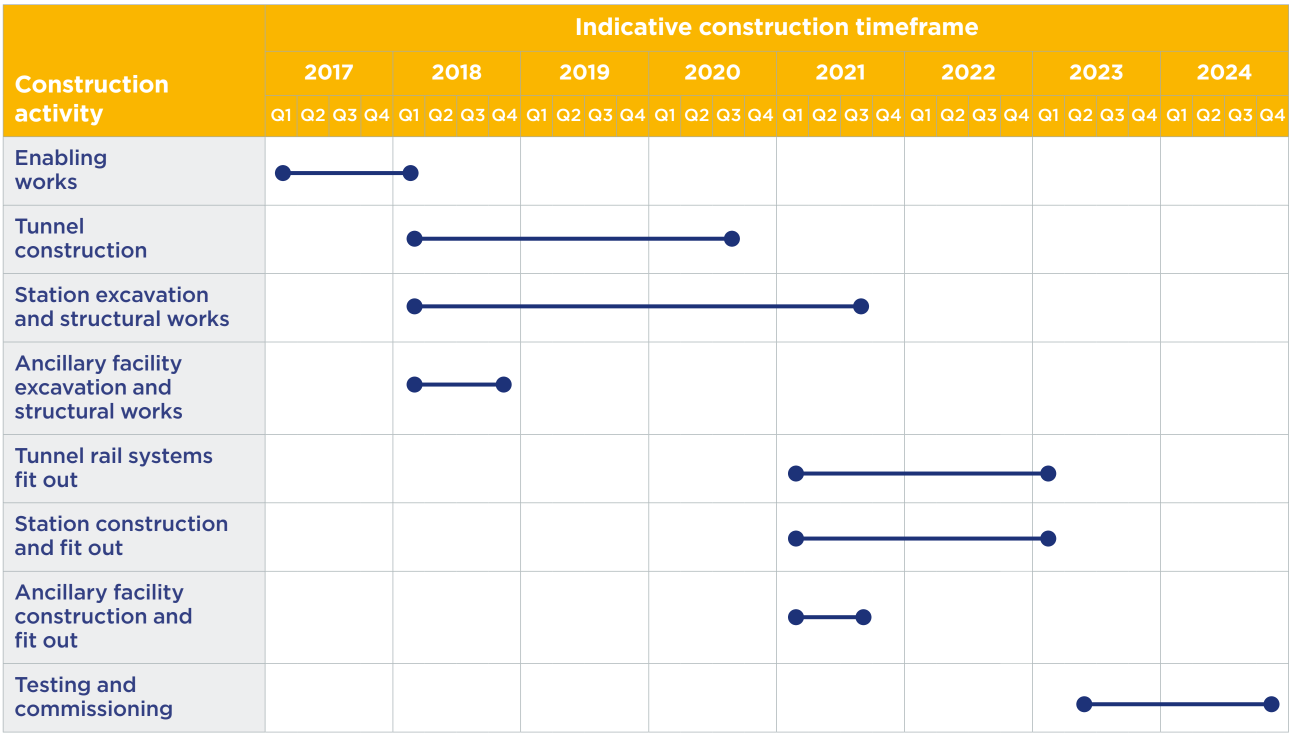
Sydney Metro would also provide important urban renewal and development opportunities through the application of transit oriented development principles that support government objectives to achieve a more sustainable and efficient use of land to meet Sydney's growth.

Construction program and major civil construction works

A number of construction sites would be required for the project. These include locations for tunnel equipment and support, stations, surface track and ancillary facilities.

Subject to planning approval, construction is expected to start in early 2017 and continue over about six years. This would be followed by testing, commissioning and preparation for operation. Services are expected to start in 2024. An indicative construction program is shown in Table E-1.

Table E-1 Indicative construction program



Environmental assessment

This Environmental Impact Statement has been prepared in accordance with the provisions of Part 5.1 of the *Environmental Planning and Assessment Act 1979*. In particular it addresses the requirements of the Secretary of the Department of Planning and Environment. It also includes consideration of the issues raised by the community and stakeholders during the development of the project.

It is inevitable that a project of this scale and location in a heavily urbanised environment would have some adverse impacts, particularly during construction. These impacts need to be considered within the context of the overall objectives of the project and the significant transportation and other benefits it would provide over the medium to longer term and particularly for future generations.

Key environmental issues have been examined throughout the design and development process. Consultation has been carried out with affected stakeholders to identify key potential impacts at an early stage. Where possible, these would be avoided or appropriate mitigation measures developed. This has resulted in a number of design changes and refinements that have mitigated many of the potential significant impacts.

Despite these efforts, a number of adverse impacts would remain. These impacts would be largely temporary and confined to the construction period. The main impacts identified in the environmental assessment are described in the following sections.

Traffic and transport

When operational the project would provide significant improvements to the public transport network capacity and efficiency including new public transport interchange facilities at and around stations. It would improve reliability across the rail network by reducing train crowding, platform and station crowding. It is also expected to provide wider road network benefits by encouraging greater use of public transport. There would be no material change to the performance of road intersections during operation. However there would be temporary adverse impacts during construction which would be minimised as much as possible.

The project would require construction work to be carried out adjacent to areas with high volumes of traffic and pedestrians. This would result in some temporary impacts to traffic performance on the surrounding road network due to construction vehicles, temporary road closures, loss of parking spaces and loading zones, relocation of bus stops, and temporary closure or diversions of pedestrian and cyclist access.

Construction works at the Chatswood dive site (northern) would require the permanent demolition of the Nelson Street bridge over the T1 North Shore Rail Line. To maintain the primary movement facilitated by Nelson Street, it is proposed to construct an all vehicle right-turn movement from the Pacific Highway southbound to Mowbray Road westbound. This would also require the localised widening of the Pacific Highway to the north of the Mowbray Road intersection.

The removal of spoil would generate the highest volumes of heavy vehicle traffic. The main tunnel spoil removal sites at the Chatswood and Marrickville dive sites have direct access to major arterial roads with minimal use of local residential streets.

Key pedestrians impacts during construction would include the temporary closure of some of the paid underground pedestrian connections at Central (a temporary pedestrian bridge would be provided), closure of Devonshire Street pedestrian tunnel for a period of around two weeks and temporary partial closure of Martin Place over a period of about six months. Safe alternative surface pedestrian and cyclist access would be provided. In addition, the existing entry and exit points, including the underground connections, to the existing Martin Place Station located to the west of Castlereagh Street would be permanently closed. Entry and exit to the existing Martin Place Station would remain via the existing point east of Castlereagh Street and via the new metro southern entry.

The short-term temporary (weekend) closures of Frank Channon Walk located near the northern surface track works at Chatswood would also be required during construction. During this period, pedestrians and cyclists would need to use either the Pacific Highway or Orchard Road to access Chatswood Station from areas to the south.

Noise and vibration

Given the nature and duration of works and the close proximity of receivers after the implementation of acoustic sheds and barriers, airborne noise during construction is expected the exceed noise management levels at all sites – and at some sites by possibly more than 20dB(A). During the night-time, airborne noise levels are expected to generally comply with the criteria though there would some moderate exceedances at some locations. Mitigation measures would be implemented including acoustic enclosures, and temporary noise barriers.

Ground-borne noise during construction from rock hammering excavation activities is expected to be very high at a number of the station excavation sites – and potentially higher than 75 dBA during the day and 45 dBA during the night. In order to reduce the duration of these impacts, blasting is proposed to be used as an excavation method at the majority of stations. Preliminary blasting scenarios developed to comply with the blasting criteria show substantial reductions in the duration of rock hammering impacts at most station sites. Further work would be carried out during detailed construction planning including trial blasts with small charge sizes to determine site specific characteristics and to assess the level of predictability. Blasts would be designed to comply with the relevant levels for air-blast overpressure and ground vibration.

For tunnelling, a number of exceedances for ground borne noise levels are also expected to occur – the highest exceedances (up to 10dB(A) above criteria), are predicted at residential receivers between the Chatswood tunnel portal and Artarmon substation, around Pitt Street and Waterloo stations and just north of the Marrickville dive site. These levels are not expected to occur for longer than a few days.

Construction vibration levels are anticipated to remain below the cosmetic damage vibration screening criteria, with some exceptions. For these structures, a more detailed assessment of the structure and attended vibration monitoring would be carried out such that vibration levels remain below appropriate limits for that structure. For heritage items, the more detailed assessment would specifically consider the heritage values of the structure.

A project specific *Sydney Metro Construction Noise and Vibration Strategy* has been developed and would provide a framework for implementation of appropriate mitigation measures. Further measures to minimise and manage construction noise and vibration impacts would be identified during detailed design and construction planning in close consultation with the community.

When operational, through the provision of measures incorporated into the design (such as track form in the tunnels and noise barriers), the project would generally comply with all relevant noise and vibration criteria. One receiver adjacent to the surface track works in Chatswood is predicted to have residual noise levels above the trigger values. Additional measures would be investigated during detailed design including at property treatment if required.

Heritage

The project would have a direct physical impact on three State heritage listed properties – Millers Point & Dawes Point Village Precinct (minor impact), Martin Place Railway (moderate impact) and Sydney Terminal and Central Railway Station Group (moderate to major impact) and seven local heritage items. There would also be indirect and potential indirect impacts to around eight State heritage listed properties and around 28 local heritage listed properties (ie vibration and visual changes).

In addition to archival recording and reporting of directly impacted heritage properties, management and mitigation measures have been identified to minimise direct and indirect impacts to adjacent and / or adjoining heritage items. Where direct impacts are unavoidable, this would include opportunities for the retention, conservation and / or reuse of original and significant heritage fabric. Consultation would be carried out with Sydney Trains and the Heritage Council of NSW during design development and an appropriately qualified and experienced heritage architect would form part of the Sydney Metro Design Review Panel and would provide independent review periodically throughout detailed design.

Construction of the project would not directly or indirectly impact on any previously recorded Aboriginal heritage sites. There is a moderate to high potential for unrecorded items of Aboriginal heritage significance to be present in sub-surface contexts at Barangaroo Station and portions of the construction sites for Martin Place, Pitt Street, Central and Waterloo stations and the Marrickville dive site (southern).

Land use and property

The project would require 98 total property acquisitions and three partial property acquisitions. All property acquisition would be managed in accordance with the *Land Acquisition (Just Terms Compensation) Act 1991*. It would also be necessary to acquire stratum for the tunnel below the surface of properties under the *Transport Administration Act 1988*.

During construction, land use issues would largely relate to indirect impacts associated with reduced amenity such as traffic, noise, air quality, access etc. These issues have been addressed in the specific topic areas. There would be a temporary loss of open space areas associated with the temporary works at Blues Point Reserve. Following activities at this site, the public reserve would be restored to its condition prior to construction. As part of the reinstatement of this open space, Sydney Metro would also explore opportunities for enhancements in consultation with North Sydney Council.

When operational, the project would have no major direct impacts on land use, though would offer substantial future development opportunities. Sydney Metro would address development opportunities and resultant impacts in an integrated manner in direct collaboration with key planning agencies, including the Department of Planning and Environment, UrbanGrowth NSW, the Greater Sydney Commission and the relevant local councils. This may include separate development assessment and approval processes which would include further opportunity for community and stakeholder input.

Soils, contamination and water quality

Given the relatively small areas of surface disturbance anticipated during construction, soil erosion would be adequately managed in accordance with proven standard mitigation measures.

There is a high probability of encountering acid sulphate soils at Barangaroo and between Waterloo Station and the Marrickville dive site. Any acid sulfate soils encountered would be effectively managed in accordance in well-established and proven management and mitigation measures.

The project has a high likelihood of encountering contamination at construction sites in Chatswood and Barangaroo, and the ground improvement work in Sydney Harbour. The risk of impacting on sensitive ecological environments or construction workers, users or visitors would be minimised by well-established mitigation measures.

Due to the expected ground conditions underneath Sydney Harbour, ground improvement to the seabed would be required prior to excavation of the tunnels. Any potential impacts on the water quality of Sydney Harbour during ground improvement work would be managed through measures such as a silt curtain around the grout barges. A water quality monitoring program would also be implemented to ensure the identification and management of any events.

Groundwater and geology

During construction, there would be potential for off-site impacts on groundwater. These changes would generally be within the natural variation of groundwater levels encountered in the past and so are not expected to cause any issues. No change in groundwater is expected at any existing groundwater extraction site.

For the project, a majority of the underground excavation would be within rock that has low permeability, therefore it is expected that settlement associated with groundwater drawdown would be minimal.

The metro tunnels would be tanked (designed to inhibit the inflow of groundwater, typically using concrete lining and waterproofing membrane), so limited to negligible change is expected to groundwater levels along the tunnel alignment. Similarly, the cross passages and most of the station caverns would be tanked, so no change is expected to groundwater levels.

Groundwater collected from any drained station excavations and caverns would be transferred to a permanent water treatment plant at Marrickville prior to discharge to stormwater. The discharge water quality level would be determined in consultation with the NSW Environment Protection Authority during detailed design, taking into consideration the current water quality of the receiving watercourse.

Hydrology and flooding

The majority of construction sites are currently impervious to infiltration and well-established drainage systems are already in place to cater for stormwater flows. At these sites construction activities would not result in any major increase in stormwater volumes or peak flow rates.

At some sites, construction may result in minor changes to existing localised surface water and / or stormwater flow regimes. Erosion and sediment controls, including the redirection and capture of construction site runoff, would be used to manage drainage on construction sites prior to discharge into existing drainage infrastructure.

The Marrickville dive site would be located within a flood-prone area. Potential flood impacts during construction would be managed through detailed construction planning, including the development of appropriate site layouts and staging of construction activities, to avoid or minimise obstruction of overland flow paths and limit the extent of flow diversion required.

When operational, the aboveground station infrastructure would be located within the footprint of existing development and would have a negligible impact on the existing surface hydrology. All surface water from aboveground facilities and tunnel dive structures would also be collected by new drainage infrastructure and connected to existing stormwater systems.

No additional properties would be flood-affected as a result of the project. Flood modelling indicates that the permanent Marrickville dive structure (in addition to elements of the Sydenham to Bankstown project located at and to the north of Sydenham Station) would result in a worst case increase in flood levels within the existing rail corridor of about 470mm in a 100 year annual recurrence interval flood event. The frequency of Sydney Trains rail service disruptions due to flooding would not be increased in the vicinity of the Marrickville dive structure. These increases would only occur in areas that already experience flooding. The flood level increases would also be largely confined to the existing rail corridor and adjacent roads. The project is not likely to require changes to existing community emergency management arrangements for flooding and there would not be an increase in social and / or economic costs to the community as consequence of flooding.

Sustainability

Sustainability principles have been incorporated throughout the design development process. A project specific environment and sustainability policy has also been developed.

Project contractors would be required to clearly identify how they would achieve specific sustainability objectives, initiatives and targets. This approach would encourage industry to develop innovative value-for-money sustainability solutions. Key sustainability themes would include: governance, carbon and energy management, pollution control, climate change resilience, resources (water efficiency and waste and materials), biodiversity conservation, heritage conservation, liveability, community benefit, supply chain, workforce development and economic factors.

Energy consumption and greenhouse emission

When operational, energy consumption is estimated to be around 66,500 megawatt-hours per year (equivalent to around 1,000 households). The estimated greenhouse emissions would be around 66,000 tonnes of carbon dioxide equivalent per year.

An iterative process of greenhouse gas assessments and design refinements would be carried out during detailed design and construction to minimise greenhouse gas emissions. Performance would be measured in terms of a percentage reduction in greenhouse gas emissions from a defined reference footprint. The project would offset 25 per cent of electricity consumption during construction and 100 percent of electricity consumption during operation.

Whilst difficult to quantify and assess, the project would also have the real potential to reduce regional greenhouse gas emissions by providing a low greenhouse gas alternative to private car travel.

Business impacts

Construction of the project would result in broad economic benefits by way of job generation and construction multipliers. Locally, many businesses would receive positive impacts with construction workers requiring food and beverage services and other goods.

Negative impacts would include direct impacts to businesses where properties are to be acquired. Indirect business impacts would include temporary constraints or restrictions on servicing and delivery / access, amenity issues such as increased traffic congestion, noise, vibration and dust, changes to customer access and parking. Measures would be implemented to minimise temporary impacts on businesses.

When operational, impacts at the local and regional scales would be largely positive due to the enhanced capacity and frequency of transport services with improved access to the Sydney CBD including Barangaroo. The new stations at Victoria Cross, Crows Nest, Barangaroo and Waterloo would also enhance the appeal and attraction of visiting, investing, living and working in these precincts.

Cumulative impacts

Given the potential overlap of construction with a considerable number of large infrastructure projects particularly in the Sydney CBD and around the dive structures, the key potential cumulative impact was determined to be construction traffic and transport. Cumulative impacts would be highly dynamic and time / activity specific, so are difficult to define in any detail at this stage of the assessment process. Sydney Metro would work closely with the CBD Co-ordination Office to manage and co-ordinate the interface with other major projects under construction at the same time and would consult a range of state and local government agencies.

Other issues

A number of other issues were assessed including biodiversity, Aboriginal heritage, landscape character and visual amenity, air quality, hazard and risk, and waste management. No issues of major risk or consequence were identified. Notwithstanding, management and mitigation measures have been identified to minimise any potential impacts.

Community consultation

The stakeholder and community consultation process for the project has played an integral role in informing and scoping investigations for this Environmental Impact Statement and will continue to do so through construction.

Engagement with the community and stakeholders began in June 2014 with the announcement of the then Sydney Rapid Transit project as an extension of the then North West Rail Link (now Sydney Metro Northwest).

Key activities have included:

- Stakeholder consultation following the announcement in June 2014
- Project scope consultation and engagement following the announcement of Sydney Metro City & Southwest in June 2015
- Industry consultation in June and December 2015
- Engagement following the project update announcement in November 2015
- Engagement following the announcement of the Waterloo Station location in February 2016
- Engagement regarding the Blues Point temporary site in February 2016.

Key stakeholders for the project have included:

- State agencies (eg Department of Planning and Environment, Roads and Maritime Services, Environment Protection Authority, NSW Office of Water, Port Authority of NSW, Sydney Water and Office of Environment and Heritage)
- Local government (Willoughby, Lane Cove, North Sydney, City of Sydney and Marrickville councils)
- Public utilities, and business and industry groups near the project
- Directly impacted communities
- The broader community.

Transport for NSW has been and continues to be interested in community and stakeholder feedback on the project. The Sydney Metro communication objectives include to:

- Communicate the rationale for the project and the broader network benefits it will deliver, including how it fits into the NSW Government's plans to increase Sydney's rail capacity
- Communicate the Sydney Metro concept and timing
- Build community and key stakeholder relationships and maintain goodwill
- Provide information about the planning approvals process and encourage community participation
- Clearly communicate the corridor protection and property acquisition process.

The project team has developed a community and stakeholder engagement program to continue to proactively engage with local communities, key stakeholders and government agencies.

Project justification and conclusion

The NSW Government is committed to delivering a step-change in the capacity and customer experience of Sydney's rail network. The project would deliver a brand new tier for Sydney's rail network, supporting high demand with a high capacity turn-up-and-go service.

Sydney Metro would provide considerable transport benefits, developed with an emphasis on supporting the needs of customers for 'door to door' journeys. It would significantly increase transport capacity in key parts of the network, especially to the Sydney CBD and the Global Economic Corridor. It would also improve reliability across the rail network by addressing current and emerging constraints such as train crowding, platform and station crowding, and network complexity. This would provide enhanced customer satisfaction in using public transport and improvements in customer safety.

It would also bring a number of city-building benefits. This would include increased economic activity, economic productivity, jobs, savings in infrastructure provision, sustainability benefits, health benefits, more choice of housing and more affordable housing, more access to services, and greater social equity. In particular it would provide a catalyst for urban renewal and development opportunities around the new stations at Crows Nest, Victoria Cross, Barangaroo and Waterloo.

The project has been justified in relation to its strategic transport need and its anticipated benefits, taking into account the objectives of the *Environmental Planning and Assessment Act 1979* and matters of ecologically sustainable development. The project is considered to best meet the objectives when compared to all other alternatives considered.

Key environmental issues have been examined throughout the design development process. Consultation has been carried out with affected stakeholders to identify key potential impacts at an early stage, and where possible, avoided or appropriate mitigation measures developed. This has resulted in a number of design changes that have mitigated many of the potential significant impacts. Provided the measures and commitments specified in the Environmental Impact Statement are applied and effectively implemented during the design, construction and operational phases, the identified environmental impacts are considered to be acceptable and manageable.

Next steps

Transport for NSW is seeking approval from the Minister for Planning for the construction and operation of Sydney Metro Chatswood to Sydenham. Subsequent steps in the process include:

- Exhibition of the Environmental Impact Statement for a minimum of 30 days and invitation for the community and stakeholders to make submissions
- Consideration of submissions. Submissions received by the Secretary of Department of Planning and Environment would be provided to Transport for NSW and any relevant public authorities. Transport for NSW may then be required to prepare and submit:
  - A submissions report, responding to issues raised in the submissions
  - A preferred infrastructure report, outlining any proposed changes to the project to minimise its environmental impacts or to deal with any other issues raised
- Determination of the Environmental Impact Statement. The Minister for Planning, who would then make a decision on the project and, if approved, set Conditions of Approval.

Consultation with the community and stakeholders would continue throughout the detailed design and construction phases as required.

Any person wishing to make a submission should use the online form if possible. To find the online form go to the web-page for the proposal via www.majorprojects.planning.nsw.gov.au/page/on-exhibition.

Your submission must reach the Department of Planning & Environment by close of business on Monday 27 June 2016. Before making your submission, please read the Privacy Statement at www.planning.nsw.gov.au/privacy or for a copy, telephone the number below. The Department of Planning & Environment will publish your submission in accordance with the Privacy Statement.

If you cannot lodge online, you can write to the address below. If you want The Department of Planning & Environment to delete your personal information before publication, please make this clear at the top of your letter. You need to include:

1. Your name and address (at the top of the letter only);
2. The name of the application and the application number (SSI 7400);
3. A statement on whether you support or object to the proposal;
4. The reasons why you support or object to the proposal;
5. A declaration of any reportable political donations made in the previous two years. To find out what is reportable, and for a disclosure form, go to www.planning.nsw.gov.au/donations or phone 1300 305 695 for a copy.

Address:
Department of Planning and Environment
GPO Box 39, SYDNEY, NSW 2001.

Your submission should be marked Attention: Director, Transport Assessments.

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INTRODUCTION

CHAPTER ONE

1 Introduction

This chapter provides an overview of the project, its strategic context and key features, and the structure of the Environmental Impact Statement.

1.1 Secretary's environmental assessment requirements

There are no Secretary's environmental assessment requirements that relate specifically to this chapter.

1.2 Overview

The New South Wales (NSW) Government is implementing *Sydney's Rail Future* (Transport for NSW, 2012a), a plan to transform and modernise Sydney's rail network so that it can grow with the city's population and meet the needs of customers in the future.

Sydney Metro is a new standalone rail network identified in *Sydney's Rail Future*. The Sydney Metro network consists of Sydney Metro Northwest (previously known as the North West Rail Link) and Sydney Metro City & Southwest. The proposed Sydney Metro network is shown in Figure 1-1.

The proposed Sydney Metro City & Southwest comprises two core components:

- The Chatswood to Sydenham project (the project), which is the subject of this Environmental Impact Statement. The project would involve construction and operation of an underground rail line, about 15.5 kilometres long, and new stations between Chatswood and Sydenham
- The second core component would involve upgrading the 13.5 kilometre rail line and existing stations from Sydenham to Bankstown which will be subject to a separate environmental assessment process.

Investigations have started on the possible extension of Sydney Metro from Bankstown to Liverpool. The potential extension would support growth in Sydney's south west by connecting communities, businesses, jobs and services as well as improving access between the south west and Sydney's CBD. It would also reduce growth pressure on road infrastructure and the rail network, including the potential to relieve crowding on the T1 Western Line, T2 South Line and T2 Airport Line.

The project is described in detail in Chapter 6 (Project description – operation) and Chapter 7 (Project description – construction) and is subject to assessment by the Department of Planning and Environment and approval by the Minister for Planning under Part 5.1 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act).

The Sydney Metro Delivery Office has been established as part of Transport for NSW to manage the planning, procurement and delivery of the Sydney Metro network.

1.3 The metro rail network

1.3.1 The three-tier rail network

To cater for the differing and changing needs of customers, *Sydney's Rail Future* proposes a three-tiered rail network:

- Tier 1: Metro (previously known as Rapid Transit) – 'turn-up-and-go' services and single-deck metro trains (see Section 1.3.2)
- Tier 2: Suburban – timetabled services with double-deck trains
- Tier 3: Intercity – timetabled services with on-board amenities for long distance trips.

1.3.2 Sydney Metro

Customer journey

The customer experience underpins how Sydney Metro is being planned and designed. The customer experience incorporates all aspects of travel associated with the transport network, service and project including:

- The decision on how to travel – new metro services would be integrated with other transport modes, including interchanges with the existing Sydney railway network as well as buses, light rail and ferries
- The travel information available – state-of-the-art technology is proposed to keep customers connected at all stages of their journey, from smart phone travel apps on the way to stations to real time journey information at metro stations and onboard trains
- The speed and comfort of the journey
- The range and quantity of services available at stations, interchanges and within station precincts – the project would help customers achieve their daily tasks, whether it's getting to work or getting home, for school or education, sport, a day out or running errands.

A high quality door-to-door transport product is critical to attract and retain customers and also to meet broader transport and land use objectives. This includes providing a system that is inherently safe for customers on trains, at stations and at the interface with the public domain; providing direct, comfortable, legible and safe routes for customers between transport modes; and providing a clean, pleasant and comfortable environment for customers at stations and on trains.

Making it easy for customers at each stage of their journey is integral to the successful delivery of Sydney Metro.

Sydney Metro features

Sydney's new generation of fast, safe and reliable metro trains will first operate on Sydney Metro Northwest, Stage 1 of Sydney Metro. Sydney Metro Northwest will open to customers in the first half of 2019 with 15 trains an hour (one train every four minutes).

The extension of Sydney Metro into the Sydney CBD and beyond by 2024 would provide ultimate capacity for a metro train every two minutes in each direction through the Sydney CBD.

Sydney Metro is being delivered with a door-to-door approach for customers, integrating buses, taxi, parking, cycling and kiss-and-ride infrastructure to make the journey to and from home as seamless as possible.

The active precincts in and around Sydney's new metro railway stations would allow customers easy access to new retail shops and services to make their door-to-door journey as easy as possible. Key features of Sydney Metro include:

- No timetable – customers can just turn up and go
- Opal ticketing – fares set and controlled by the NSW Government the same as the rest of Sydney
- Customer service assistants at every station and moving through the network during the day and night
- Australian-first platform screen doors which keep people and objects away from the edge, improving customer safety and allowing trains to get in and out of stations much faster. These doors run the full length of all metro platforms and only open at the same time as the train doors
- Continuous mobile phone coverage throughout the metro network
- Operational performance requirements that include 98 per cent on time running and clean platforms and trains
- Multi-purpose areas for prams, luggage and bicycles
- Wheelchair spaces, separate priority seating and emergency intercoms inside trains
- Safety benefits including security cameras on trains and the ability for customers to see inside the train from one end to the other
- Video help points at platforms, connecting directly with train controllers – an Australian first
- Level access between the platform and train and three double doors per side per carriage for faster loading and unloading
- Heating and air-conditioning in all metro trains
- On-board real time travel information and live electronic route maps.

As Australia's first fully-automated railway, customer safety is a priority of Sydney Metro. At all times, a team of expert train controllers would monitor the system, making sure everything runs smoothly.

Sydney's current suburban system can reliably carry 24,000 people an hour per line. Sydney's new metro railway has a target capacity of more than 40,000 customers per hour in each direction, similar to other metro systems worldwide.

Components of the Sydney Metro rail network

The development of a metro rail network in Sydney is one of the key initiatives in *Sydney's Rail Future*. Sydney Metro City & Southwest would extend the metro network from Chatswood to Bankstown. This section of Sydney Metro comprises two core components: Chatswood to Sydenham (which is the subject of this Environmental Impact Statement) and the Sydenham to Bankstown upgrade, which would extend the metro network from Sydenham to Bankstown (subject to a separate environmental assessment process).

The Sydney Metro network is shown in Figure 1-1.

The first stage of the metro network is Sydney Metro Northwest (formerly the North West Rail Link), which is currently under construction. This includes a new metro rail line between Rouse Hill and Epping and conversion of the existing rail line between Epping to Chatswood to accommodate metro services. Services will start in the first half of 2019 with a metro train every four minutes in the peak from a new station at Cudgegong Road (beyond Rouse Hill) to the existing station at Chatswood.

The proposed Sydney Metro City & Southwest would extend the metro network from Chatswood to Bankstown.

The Chatswood to Sydenham project would feature:

- Twin tunnels about 15.5 kilometres long between Chatswood and Sydenham, crossing under Sydney Harbour
- New metro stations at Crows Nest, Victoria Cross, Barangaroo, Martin Place, Pitt Street and Waterloo
- New underground metro platforms at Central Station.

Figure 1-1 **The Sydney Metro network**

Capacity of the Sydney Metro rail network

The Chatswood to Sydenham project would have the capacity to run up to 30 trains per hour through the Sydney CBD in each direction, which would provide the foundation for delivering a 60 per cent increase in the number of trains operating in peak periods, and cater for an extra 100,000 customers per hour across the Sydney CBD rail lines.

1.4 Overview of the project

1.4.1 Location

The project track alignment would be mainly located underground in twin tunnels. The project would extend from Chatswood Station on Sydney's north shore, crossing under Sydney Harbour, and continue to just north of Sydenham Station. The proposed alignment, stations and operational ancillary infrastructure are shown in Figure 1-2.

1.4.2 Key features

The project involves the construction and operation of a metro rail line, around 16.5 kilometres in length, between Chatswood Station and just north of Sydenham Station. The key operational components include:

- About 15.5 kilometres of twin rail tunnels (that is, two tunnels located side-by-side) between Mowbray Road, Chatswood and Bedwin Road, Marrickville. The tunnel corridor would extend about 30 metres either side of each tunnel centre line and around all stations
- About 250 metres of aboveground metro tracks between Chatswood Station and the northern dive structure
- A northern dive structure (about 400 metres in length) and tunnel portal south of Chatswood Station and north of Mowbray Road, Chatswood
- A southern dive structure (about 400 metres in length) and tunnel portal north of Sydenham Station and south of Bedwin Road, Marrickville
- New metro stations at Crows Nest, Victoria Cross, Barangaroo, Martin Place, Pitt Street and Waterloo, as well as new underground platforms at Central Station
- Underground pedestrian links and connections to other modes of transport (such as the existing suburban rail network) and surrounding land uses
- Realignment of T1 North Shore Line surface track within the existing rail corridor between Chatswood Station and Brand Street, Artarmon, including a new rail bridge for a section of the 'down' (northbound) track to pass over the proposed northern dive structure
- Permanent closure and demolition of the road bridge on Nelson Street, Chatswood, and provision of an all vehicle right-turn movement from the Pacific Highway (southbound) into Mowbray Road (westbound)
- Signalisation of the Mowbray Road / Hampden Road intersection at Chatswood

- Modification (including protection) of the road bridge on Mowbray Road, Chatswood to accommodate the reconfigured T1 North Shore Line track arrangement
- Services within each of the stations, including mechanical and fresh air ventilation equipment and electrical power substations
- A permanent power supply from Pyrmont or Surry Hills to Pitt Street Station
- Alterations to pedestrian and traffic arrangements and public transport infrastructure around the new stations and surrounding Central Station
- Signalisation of the Edinburgh Road / Edgeware Road / Bedwin Road intersection at Marrickville
- A substation (for traction power supply) at Artarmon
- A services facility (for traction power supply and an operational water treatment plant) adjacent to the southern dive structure
- Installation and modification of existing Sydney Trains rail systems including overhead wiring, signalling, access tracks / paths, rail corridor fencing and noise walls, within surface sections at the northern end of the project at Chatswood
- Removal of the existing Sydney Trains maintenance access point from Hopetoun Avenue, Chatswood and modifications to the existing access point from Drake Street, Artarmon
- Provision of a maintenance access point from Brand Street, Artarmon on the 'down' (western) side of the T1 North Shore Line
- Provision of maintenance access stairs from Albert Avenue, Chatswood
- Temporary ancillary facilities to support the construction of the project.

Full details on the project, including construction and operational elements, are detailed in Chapter 6 (Project description – operation) and Chapter 7 (Project description – construction).

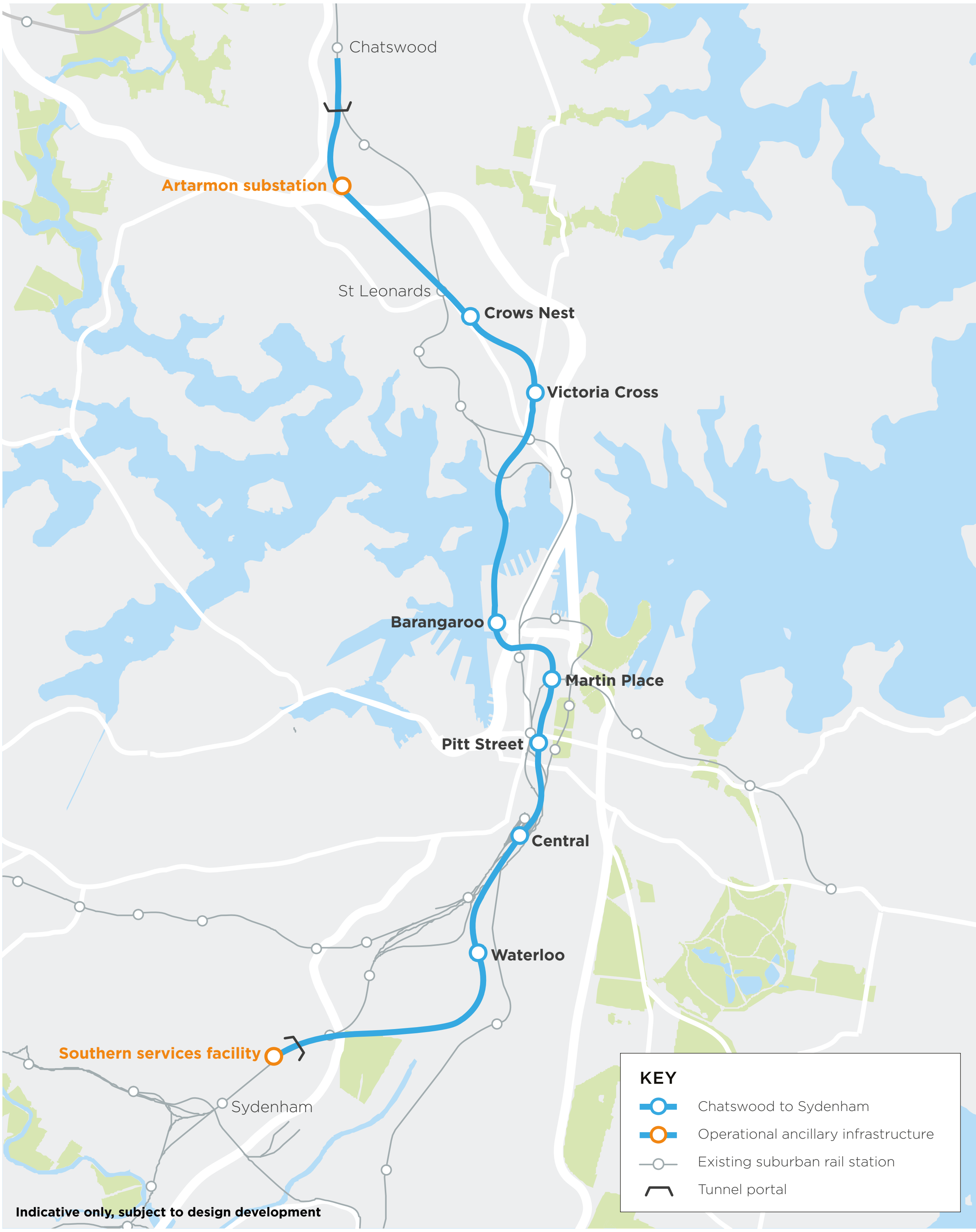

Figure 1-2 The project

1.5 Structure of the Environmental Impact Statement

This Environmental Impact Statement is presented in two volumes. Volume 1 contains the main Environmental Impact Statement (this report) and the appendices. Volume 2 provides the technical papers that form the technical basis of the information in Volume 1. The structure and content of Volume 1 are outlined in Table 1-1.

Table 1-1 Structure and content of Volume 1 of the Environmental Impact Statement

Chapter	Description
Chapter 1	**Introduction (this chapter)** Provides an overview of the project and the proposed metro network for Sydney. Outlines the structure and content of the Environmental Impact Statement.
Chapter 2	**Planning and assessment process** Provides information on the legislation and environmental planning instruments that would apply to the project. Outlines the steps involved in the assessment and approval process.
Chapter 3	**Strategic need and justification** Provides the strategic context, explains the need for the project and identifies the project objectives.
Chapter 4	**Project development and alternatives** Describes how the project was developed and reviews the strategic alternatives and options that were considered.
Chapter 5	**Stakeholder and community engagement** Provides an overview of the community consultation and stakeholder engagement processes that have been carried out for the project to date. Identifies issues raised during consultation and how these have been addressed.
Chapter 6	**Project description – operation** Identifies the physical infrastructure and built form of the project. Describes the functionality of the stations and the operation of the project.
Chapter 7	**Project description – construction** Outlines how the project is likely to be constructed and identifies the location and function of the main construction sites.
Chapter 8	**Construction traffic and transport** Identifies and assesses the potential impacts on the existing road, public transport, pedestrian and cyclist network from construction activities.
Chapter 9	**Operational traffic and transport** Identifies relevant station access, interchange, cyclist and pedestrian needs and the integration of the project with the wider transport network during operation.
Chapter 10	**Construction noise and vibration** Assesses the potential impacts of construction noise and vibration, including surface construction and tunnel excavation.
Chapter 11	**Operational noise and vibration** Assesses the potential impacts of noise and vibration during operation including from operating trains, stations and other fixed facilities.
Chapter 12	**Land use and property** Assesses the potential impacts on existing properties and land use including property acquisition and changes to land use.
Chapter 13	**Business impacts** Assesses the potential impacts on businesses around the project during construction and operation.

Chapter	Description
Chapter 14	**Non-Aboriginal heritage** Assesses the potential impacts on non-Aboriginal archaeological and built heritage during construction and operation.
Chapter 15	**Aboriginal heritage** Assesses the potential impacts on Aboriginal heritage during construction and operation.
Chapter 16	**Landscape character and visual amenity** Assesses the potential changes to landscape character during operation from the introduction of new infrastructure, and the potential visual impacts during construction and operation.
Chapter 17	**Groundwater and geology** Assesses the potential impacts associated with geology and groundwater such as drawdown, ground movement and groundwater treatment.
Chapter 18	**Soils, contamination and water quality** Assesses the potential impacts associated with soils, contamination and water quality during construction and operation.
Chapter 19	**Social impacts and community infrastructure** Assesses the potential direct and indirect impacts on community infrastructure.
Chapter 20	**Biodiversity** Assesses the potential impacts on biodiversity during construction and operation.
Chapter 21	**Flooding and hydrology** Assesses the potential impacts on hydrology and flooding during construction and operation.
Chapter 22	**Air quality** Assesses the potential impacts associated with air quality during construction and operation.
Chapter 23	**Hazard and risk** Assesses the hazard and risks with potential to occur during construction and operation.
Chapter 24	**Waste management** Assesses the potential impacts associated with waste management and resource use during construction and operation, including the management of spoil during construction.
Chapter 25	**Sustainability** Describes the overall approach to sustainability and how specific objectives and initiatives are being incorporated into the design, construction and operation of the project. An assessment of greenhouse gas emissions, climate change adaptation and resource use for the project is also provided.
Chapter 26	**Cumulative impacts** Assesses the potential for cumulative impacts with other construction projects.
Chapter 27	**Consolidated environmental mitigation measures and environmental performance outcomes** Provides a consolidated list of all of the mitigation measures identified in Chapters 8 to 26 and identifies the environmental performance outcomes.
Chapter 28	**Environmental risk analysis** Provides an environmental risk analysis taking into account the potential impacts and mitigation measures identified in Chapters 8 to 26.
Chapter 29	**Justification and conclusions** Confirms the justification for the project, considering the project objectives, consistency with the principles of ecologically sustainable development and the objects of the *Environmental Planning and Assessment Act 1979*.

Chapter	Description
APPENDICES	
Appendix A	Secretary's environmental assessment requirements
Appendix B	Sydney Metro Chatswood to Sydenham design guidelines
Appendix C	Stakeholder and community engagement report
Appendix D	Construction environmental management framework
Appendix E	Construction noise and vibration strategy
Appendix F	Geological long section
Appendix G	Synthesis of the Environmental Impact Statement

PLANNING AND ASSESSMENT PROCESS

CHAPTER TWO

2 Planning and assessment process

This chapter describes the statutory planning process for the project, and identifies other NSW and Commonwealth legislation and approvals which may apply to the project.

2.1 Secretary's environmental assessment requirements

The Secretary's environmental assessment requirements relating to the planning and assessment process, and where these requirements are addressed in this Environmental Impact Statement, are outlined in Table 2-1.

Table 2-1 Secretary's environmental assessment requirements – planning and assessment process

Ref.	Secretary's environmental assessment requirements	Where addressed
1 Environmental Assessment Process		
1.1.	The Environmental Impact Statement must be prepared in accordance with Part 3 of Schedule 2 of the *Environmental Planning and Assessment Regulation 2000* (the Regulation).	This Environmental Impact Statement.
1.2.	It is the Proponent's responsibility to determine whether the project needs to be referred to the Commonwealth Department of the Environment for an approval under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Proponent must contact the Commonwealth Department of the Environment immediately if it is determined that an approval is required under the EPBC Act, as supplementary environmental assessment requirements may need to be issued to ensure a streamlined assessment under the Bilateral agreement can be achieved.	Consideration of the need to refer to the project to the Commonwealth Department of the Environment is provided in Consideration of the need to refer to the project to the Commonwealth Department of the Environment is provided in Section 2.4.1.
1.3.	Where the project requires approval under the EPBC Act and is being assessed under the Bilateral Agreement the EIS should address:	N/A
1.3 (a)	Consideration of any Protected Matters that may be impacted by the development where the Commonwealth Minister has determined that the proposal is a Controlled Action.	As discussed in Section 2.4.1, no significant impacts in relation to Protected Matters have been identified during the course of the assessment. The project has not been referred to the Department of the Environment.
1.3 (b)	Identification and assessment of those Protected Matters that are likely to be significantly impacted.	As discussed in Section 2.4.1, no significant impacts in relation to these matters have been identified during the course of the assessment. Matters of national environmental significance are discussed in detail in Chapter 14 (Non-Aboriginal heritage) and Chapter 20 (Biodiversity).

Ref.	Secretary's environmental assessment requirements	Where addressed
1.3 (c)	Details of how significant impacts to Protected Matters have been avoided, mitigated and, if necessary, offset.	As discussed in Section 2.4.1, no significant impacts in relation to these matters have been identified during the course of the assessment. Matters of national environmental significance are discussed in detail in Chapter 14 (Non Aboriginal heritage) and Chapter 20 (Biodiversity).
1.3 (d)	Consideration of, and reference to, any relevant conservation advices, recovery plans and threat abatement plans.	Biodiversity assessment, including consideration of these requirements, is provided in Chapter 20 (Biodiversity).
1.4	The onus is on the Proponent to ensure legislative requirements relevant to the project are met.	The legislative requirements relevant to the project are outlined in this chapter.

2.2 NSW environmental planning approvals

The *Environmental Planning and Assessment Act 1979* (EP&A Act) and the *Environmental Planning and Assessment Regulation 2000* (EP&A Regulation) are the primary pieces of legislation regulating land use planning and development assessment in NSW. This legislation is supported by a range of environmental planning instruments including State environmental planning policies (SEPPs) and local environmental plans (LEPs).

Section 115V of the EP&A Act provides for the declaration of State significant infrastructure and critical State significant infrastructure (refer to Section 2.2.1), while Part 5.1 of the EP&A Act establishes the assessment and approval regime for State significant infrastructure and critical State significant infrastructure (refer to Section 2.2.2).

2.2.1 Critical State significant infrastructure

Sydney Metro City & Southwest was declared by Ministerial Order on 10 December 2015 to be State significant infrastructure and critical State significant infrastructure under Sections 115U(4) and 115V of the EP&A Act, respectively. The Ministerial Order also amended Schedule 5 of *State Environmental Planning Policy (State and Regional Development) 2011* to include the project as critical State significant infrastructure.

2.2.2 Planning approval process under Part 5.1 of the EP&A Act

The assessment and approval process for a critical State significant infrastructure project is established under Part 5.1 of the EP&A Act and is shown in Figure 2-1.

Transport for NSW submitted a State significant infrastructure application and supporting document to the Secretary of the Department of Planning and Environment on 20 November 2015 (as required by Section 115X of the EP&A Act). The Secretary's environmental assessment requirements for the project were issued on 22 December 2015 (as per Section 115Y of the EP&A Act). The Secretary's environmental assessment requirements are provided in Appendix A.

This Environmental Impact Statement has been prepared in accordance with the Secretary's environmental assessment requirements and the requirements of Schedule 2, Part 3 of the EP&A Regulation (as per Section 115Y(2) of the EP&A Act). A checklist showing where each of the Secretary's environmental assessment requirements has been addressed in this Environmental Impact Statement is also provided in Appendix A.

The Department of Planning and Environment will place this Environmental Impact Statement on public exhibition for a minimum of 30 days (as per Section 115Z of the EP&A Act). During the exhibition period, government agencies, project stakeholders and the community will be able to review the Environmental Impact Statement and will have an opportunity to make a written submission to the Department of Planning and Environment for consideration in its assessment of the project.

At the completion of the public exhibition period, the Department of Planning and Environment will collate and provide Transport for NSW with a copy of all submissions received during the exhibition period. After reviewing the submissions, Transport for NSW will prepare a submissions report that responds to the relevant issues raised. If changes are required to the project as a result of the issues raised or to minimise its environmental impact, a preferred infrastructure report may also be required. If this is required, Transport for NSW would prepare the report to address the changes of the design to minimise impacts and submit this for review to the Department of Planning and Environment. This report would be made available to the public.

Approval from the Minister for Planning is required before Transport for NSW can proceed with the project (as per Section 115ZB of the EP&A Act).

2.2.3 NSW environmental planning instruments

The declaration of the project as critical State significant infrastructure has been made through the provisions of *State Environmental Planning Policy (State and Regional Development) 2011*, as discussed in Section 2.2.1. Section 115ZF of the EP&A Act provides that environmental planning instruments (such as LEPs and SEPPs) do not apply to State significant infrastructure projects. Notwithstanding, the following environmental planning instruments have been considered during the preparation of this Environmental Impact Statement (for the purposes of informing the scope of the environmental assessment):

- *State Environmental Planning Policy (State and Regional Development) 2011*
- *Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005*
- *State Environmental Planning Policy No. 55 – Remediation of Land.*

These environmental planning instruments are discussed further in the following sections.

STAGE 1 EARLY CONSULTATION

Early project consultation undertaken prior to the commencement of the formal assessment process.

↓

Project refined on the basis of the early project consultation.

↓

Initial scoping of EIS investigations undertaken on the basis of early project consultation.

STAGE 2 ENVIRONMENTAL IMPACT STATEMENT

Transport for NSW prepares and submits a State significant infrastructure application to the Secretary of the NSW Department of Planning and Environment (DP&E), which includes a supporting document outlining the project and its likely impacts.

↓

Planning focus meeting with key government stakeholders and community engagement.

↓

DP&E issues Secretary's environmental assessment requirements (SEARs) for EIS with focus on key issues.

↓

EIS prepared addressing the matters outlined in the SEARs.

STAGE 3 EXHIBITION CONSULTATION AND REVIEW

DP&E exhibits the EIS for a minimum of 30 days and invites public submissions.

↓

Secretary may require proponent to respond to submissions and submit a preferred infrastructure report outlining proposed changes to minimise environmental impacts or address any other issues raised during assessment of the application.

STAGE 4 ASSESSMENT AND DETERMINATION

Assessment by DP&E, draft Secretary's environmental assessment report prepared with recommended conditions or refusal. Agencies and councils consulted by DP&E.

↓

Secretary's environmental assessment report finalised with recommendations and submitted to Minister for Planning.

↓

Determination by the Minister, including if approved, any conditions of approval.

Post approval implementation and compliance (if project approved).

Figure 2-1 The assessment and approval process for critical State significant infrastructure

State Environmental Planning Policy (State and Regional Development) 2011

State Environmental Planning Policy (State and Regional Development) 2011 identifies development that is State significant development, State significant infrastructure and critical State significant infrastructure.

As outlined in Section 2.2.1, Schedule 5 of this SEPP was amended (by Ministerial Order on 10 December 2015) to include the project as critical State significant infrastructure.

Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005

Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005 aims to (amongst other things) protect, enhance and maintain the catchment, foreshores, waterways and islands of Sydney Harbour for existing and future generations.

The metro tunnel crossing of Sydney Harbour, Barangaroo Station (including the entry / exit) and various temporary construction sites (including a proposed temporary site at Blues Point) would be located with the defined boundary of *Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005*.

The project also lies within the Sydney Opera House Buffer Zone as gazetted on 19 July 2007. Clause 58B of *Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005* requires specific assessment of projects within the Sydney Opera House Buffer Zone in the context of potential impacts on views and vistas between the Opera House and other public places, the World Heritage value of the Opera House and the visual prominence of the Opera House (refer to Section 2.4.1 for further discussion).

Matters to be considered by public authorities

Of relevance to the project, Clause 20 of *Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005* requires public authorities and others to consider the matters listed in Clause 21 to 27 of the SEPP before they carry out activities to which Part 5 of the EP&A Act applies. The potentially applicable matters are summarised in Table 2-2, along with the sections in the Environmental Impact Statement where the issues have been addressed.

Table 2-2 Relevant Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005 matters

Summary of relevant considerations	Where addressed
Clause 21: Biodiversity, ecology and environment protection	
Development should have a neutral or beneficial effect on the quality of water entering the waterways (clause 21(a))	Chapter 18 (Soils, contamination and water quality)
Development should protect and enhance terrestrial and aquatic species, populations and ecological communities and, in particular, should avoid physical damage and shading of aquatic vegetation (clause 21(b))	Chapter 20 (Biodiversity)
Development should avoid indirect impacts on aquatic vegetation (such as changes to flow, current and wave action and changes to water quality) as a result of increased access (clause 21(d))	
Consideration of the cumulative environmental impact of development, in relation to biodiversity, ecology and environment protection (clause 21(h))	Chapter 26 (Cumulative impacts)
Consideration of whether sediments in the waterway adjacent to the development are contaminated, and what means will minimise their disturbance (clause 21(i))	Chapter 18 (Soils, contamination and water quality)

Summary of relevant considerations	Where addressed
Clause 24: Interrelationship of waterway and foreshore use	
Development on foreshore land should minimise any adverse impact on the use of the waterway, including the use of the waterway for commercial and recreational uses (clause 24(b))	Chapter 8 (Construction traffic and transport)
Development on foreshore land should minimise excessive congestion of traffic in the waterways or along the foreshore (clause 24(c))	
Development should avoid conflict between the various uses in the waterways and along the foreshores (clause 24(e))	
Clause 25: Foreshore and waterways scenic quality	
The scale, form, design and siting of any building should be based on an analysis of: the land on which it is to be erected; the adjoining land; and the likely future character of the locality (clause 25(a))	Chapter 16 (Landscape character and visual amenity)
The development should maintain, protect and enhance the unique visual qualities of Sydney Harbour and its islands, foreshores and tributaries (clause 25(b))	
The cumulative impact of water-based development should not detract from the character of the waterways and adjoining foreshores (clause 25(c))	Chapter 26 (Cumulative impacts)
Clause 26: Maintenance, protection and enhancement of views	
Development should maintain, protect and enhance views (including night views) to and from Sydney Harbour (clause 26(a))	Chapter 16 (Landscape character and visual amenity)
Development should minimise any adverse impacts on views and vistas to and from public places, landmarks and heritage items (clause 26(b))	
The cumulative impact of development on views should be minimised (clause 25(c))	Chapter 26 (Cumulative impacts)

Referral of development proposals not requiring development consent

Clause 31 of *Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005* requires a public authority to notify the Foreshores and Waterways Planning and Development Advisory Committee, or in certain instances other public authority(s) responsible for the provision of services (including water, sewerage or stormwater systems), prior to carrying out certain development.

Whilst the provisions of Clause 31 of the SEPP would not apply to the project as it is State significant infrastructure, Transport for NSW would comply with the intent of the policy and will consult with the Foreshores and Waterways Planning and Development Advisory Committee during the development of the project.

Development on land comprising acid sulfate soils

Clause 36 of *Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005* relates to approval for works that involve the excavation, dredging, filling or contouring of – or the extraction of soil or other extractive material that has the potential to impact on acid sulfate soils.

Whilst these provisions do not apply to State significant infrastructure projects (as discussed above), an acid sulfate soils management plan would be developed and implemented for any excavation works proposed to be carried out in those areas with a high probability of encountering acid sulfate soils. Measures documented in this plan would be consistent with the principles and practices outlined in the *Acid Sulfate Soils Assessment Guidelines* (NSW Acid Sulfate Soil Management Advisory Committee, 1998).

Further details on the management of acid sulfate soils during the construction of the project are provided in Chapter 18 (Soils, contamination and water quality).

Sydney Harbour Foreshores Area Development Control Plan

The *Sydney Harbour Foreshores and Waterways Area Development Control Plan 2005* (Sydney Harbour Foreshores and Waterways Area DCP) supports the Sydney Harbour Catchment SREP by specifying detailed design guidelines for water-based and land-based developments, as well as developments located at the land / water interface.

Part 5 of the Sydney Harbour Foreshores and Waterways Area DCP specifies design guidelines for land-based developments. Whilst the DCP does not apply to State significant infrastructure, as the DCP is part of a deemed State policy, the relevant design guidelines would be considered in the development of Barangaroo Station and the reinstatement of the park at Blues Point.

State Environmental Planning Policy No. 55 – Remediation of Land

State Environmental Planning Policy No. 55 – Remediation of Land (SEPP 55) provides a State-wide approach to the remediation of contaminated land for the purpose of minimising the risk of harm to the health of humans and the environment. In accordance with Clause 7(1) of SEPP 55, a consent authority must not consent to the carrying out of development on any land unless:

- It has considered whether the land is contaminated
- If the land is contaminated, it is satisfied that the land is suitable in its contaminated state (or would be suitable, after remediation) for the purpose for which the development is proposed to be carried out
- If the land requires remediation to be made suitable for the purpose for which the development is proposed to be carried out, it is satisfied that the land would be remediated before the land is used for that purpose.

A Phase 1 contamination investigation has been carried out in accordance with the *Managing Land Contamination Planning Guidelines SEPP 55–Remediation of Land* (Department of Urban Affairs and Planning and Environment Protection Authority, 1998) for the project to inform the design and Environmental Impact Statement. The outcomes of the contamination investigations and recommended environmental mitigation measures are addressed in Chapter 18 (Soils, contamination and water quality).

Local Environmental Plans

The project passes through the local government areas (LGA) of Willoughby, North Sydney, Sydney and Marrickville. Development within these LGAs is regulated by the following Local Environmental Plans (LEP):

- *Willoughby Local Environmental Plan 2012*
- *North Sydney Local Environmental Plan 2013*
- *Sydney Local Environmental Plan 2012 / Sydney Local Environmental Plan 2005*
- *Marrickville Local Environmental Plan 2011.*

As indicated above, the EP&A Act provides that environmental planning instruments (including LEPs) do not apply to State significant infrastructure projects. Notwithstanding, relevant environmental planning instruments have been considered during design development and assessment of the project.

2.3 Other NSW legislation

In accordance with Section 115ZG of the EP&A Act some planning related legislation does not apply to critical State significant infrastructure or must be applied consistently with an approved critical infrastructure project (refer to Section 2.3.1).

2.3.1 Approvals that would otherwise applythat would otherwise apply

Section 115ZG of the EP&A Act specifies approvals that are not required for approved State significant infrastructure under Part 5.1 of the EP&A Act. Those approvals that would otherwise be required for the project if not for it being State significant infrastructure would be:

- Approvals under Part 4, excavation permits under Section 139 and Division 8 of Part 6 of the *Heritage Act 1977*
- Aboriginal heritage impact permits under Section 90 of the *National Parks and Wildlife Act 1974*
- Approval under section 90 of the *Water Management Act 2000*.

Division 8 of Part 6 of the Heritage Act 1977 does not apply to prevent or interfere with the carrying out of the project.

Similarly, Section 115ZG of the EP&A Act specifies directions, orders or notices that cannot be made or given so as to prevent or interfere with the carrying out of approved critical State significant infrastructure. Those that would otherwise apply if not for the project being State significance infrastructure would be:

- An environment protection notice under Chapter 4 of the *Protection of the Environment Operations Act 1997*
- An order under Section 124 of the *Local Government Act 1993*.

Section 115ZH of the EP&A Act identifies approvals or authorisations that cannot be refused if they are necessary for carrying out approved State significant infrastructure and must be substantially consistent with the Part 5.1 approval. Those that would otherwise apply if not for the project being State significance infrastructure would be:

- An Environment Protection Licence (EPL) under Chapter 3 of the *Protection of the Environment Operations Act 1997*
- A consent under Section 138 of the *Roads Act 1993*.

2.3.2 NSW legislation that may still be applicable

Planning related legislation that may still be applicable to an approved critical State significant infrastructure project and may be relevant to this project is identified in Table 2-3.

Table 2-3 Planning related legislation of potential relevance to the project

Legislation	Requirement	Where addressed
Water Management Act 2000	The *NSW Aquifer Interference Policy* (NSW Office of Water, 2012) documents the NSW Government's intention to implement the requirement for approval of 'aquifer interference activities' under the *Water Management Act 2000*. While the project would intercept groundwater aquifers, the requirement for aquifer interference approvals has not yet commenced and as such, this approval is not currently required.	Chapter 17 (Groundwater and geology)
Contaminated Land Management Act 1997	This Act outlines the circumstances in which notification of the Environment Protection Authority (EPA) is required in relation to the contamination of land. This may become relevant during construction and / or operation of the project.	Chapter 18 (Soils, contamination and water quality)
Crowns Land Act 1989	Ministerial approval is required to grant a 'relevant interest' (ie a lease, licence, permit, easement or right of way) over a Crown Reserve if required. The project would pass underneath a number of parcels of Crown land. In addition, there is the potential for construction compounds to be temporarily located on Crown land. Land would be managed in accordance with the objectives of this Act.	Chapter 12 (Land use and property)
Heritage Act 1977 (Section 146)	The Heritage Council must be notified if a relic is uncovered during construction and if it is reasonable to believe that the Heritage Council is unaware of the location of the relic.	Chapter 14 (Non-Aboriginal heritage)
Fisheries Management Act 1994 (Section 199)	A public authority is required to give the Minister written notice of proposed dredging or reclamation work prior to carrying out or authorising the carrying out of such work. Reclamation or dredging work may be required to support construction of the project, for example as part of the proposed Sydney Harbour ground improvement works. The Minister would be provided with written notice of any construction activities requiring dredging or reclamation work, in accordance with Section 199 of this Act.	Construction activities within Sydney Harbour are described in Chapter 7 (Project description – construction) Biodiversity impacts are assessed in Chapter 20 (Biodiversity)
Marine Pollution Act 2012	This Act includes provisions to protect the sea and waters from pollution by oil and other noxious substances discharged from vessels. Any construction activities requiring the use of a vessel (eg a barge) must comply with the requirements of this Act and the *Marine Pollution Regulation 2014*.	Construction activities within Sydney Harbour are described in Chapter 7 (Project description – construction) Water quality impacts are assessed in Chapter 18 (Soils, contamination and water quality)

Legislation	Requirement	Where addressed
Maritime Services Act 1935 and Ports and Maritime Administration Act 1995	A number of authorisations, approvals or permits may be required with respect to the placement of any structures in the water and / or with respect to obstruction to navigation. This would include the proposed Sydney Harbour ground improvement works. Further details are provided in Chapter 7 (Project description – construction).	Construction activities within Sydney Harbour are described in Chapter 7 (Project description – construction) Construction traffic and transport impacts are assessed in Chapter 8 (Construction traffic and transport)
Management of Waters and Waterside Lands Regulations — N.S.W.	The written approval of the Harbour Master is required for any proposed works that would disturb the bed of the Special Port Areas defined under these regulations – which includes Sydney Harbour and any adjoining or adjacent land. Activities that may require approval include the proposed Sydney Harbour ground improvement works.	Chapter 8 (Construction traffic and transport)
Native Title (NSW) Act 1994	This Act provides for native title in relation to land or waters. The project would not affect land subject to native title or to which an Indigenous Land Use Agreement applies.	Property impacts are assessed in Chapter 12 (Land use and property) Aboriginal heritage impacts are assessed in Chapter 15 (Aboriginal heritage)
Aboriginal Land Rights Act 1983	The NSW *Aboriginal Land Rights Act 1983* applies to Crown lands that are not lawfully needed for an essential public purpose; referred to as claimable Crown land. No claimable Crown lands would be affected by the project.	Property impacts are assessed in Chapter 12 (Land use and property) Aboriginal heritage impacts are assessed in Chapter 15 (Aboriginal heritage)
Land Acquisition (Just Terms Compensation) Act 1991	This Act would apply to the acquisition of land required for the project except for underground stratum acquisition where the *Transport Administration Act 1988* indicates that compensation is not payable in most circumstances.	Chapter 12 (Land use and property)
Transport Administration Act 1988	The Act states that compensation for land acquired under the *Land Acquisition (Just Terms Compensation) Act 1991* for the purpose of underground rail facilities is not payable under the Act unless: the surface of the overlying soil is disturbed; the support of that surface is destroyed or injuriously affected by the construction of those facilities; or any mines or underground working in or adjacent to the land are thereby rendered unworkable or are injuriously affected.	Chapter 12 (Land use and property)
Waste Avoidance and Resource Recovery Act 2001	This Act encourages the most efficient use of resources in order to reduce environmental harm.	Chapter 25 (Sustainability)

Legislation	Requirement	Where addressed
Greater Sydney Commission Act 2015	This Act establishes the Greater Sydney Commission which has a principal objective of leading metropolitan planning for the Greater Sydney Region, The core functions of the Greater Sydney Commission are to provide advice to Government and assist local Councils plans or proposals relating to development in the Greater Sydney Region. The Greater Sydney Commission would not have a formal statutory role for this project but would be consulted with respect to its core functions.	Chapter 12 (Land use and property)

2.4 Commonwealth legislation

2.4.1 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) prescribes the Commonwealth's role in environmental assessment, biodiversity conservation and the management of protected areas.

Matters of national environmental significance

Under the EPBC Act, a referral to the Commonwealth Department of the Environment is required for proposed 'actions' that have the potential to significantly impact on any matter of national environmental significance or the environment of Commonwealth land (including leased land). If the project is determined to be a 'controlled action' under the EPBC Act then approval from the Australian Government Minister of Environment would be required.

Current matters of national environmental significance matters are:

- World heritage properties
- National heritage places
- Wetlands of international importance (often called 'Ramsar' wetlands after the international treaty under which such wetlands are listed)
- Nationally threatened species and ecological communities
- Migratory species
- Commonwealth marine areas
- The Great Barrier Reef Marine Park
- Nuclear actions (including uranium mining)
- A water resource, in relation to coal seam gas development and large coal mining development.

There is currently an agreement between the Commonwealth and the NSW State government relating to environmental impact assessment under the EPBC Act (assessment bilateral agreement). For critical State significant infrastructure projects, the assessment bilateral agreement provides for a single environmental assessment process conducted by NSW.

There is also a draft approval bilateral agreement that provides for accreditation of NSW processes for approval of proposed actions that would otherwise require approval by the Commonwealth. Submissions on the draft approval bilateral agreement are currently being considered.

Issues with respect to matters of national environmental significance are discussed in detail in Chapter 14 (Non-Aboriginal heritage) and Chapter 20 (Biodiversity). No significant impacts in relation to these matters have been identified during the course of the assessment. Accordingly, the project has not been referred to the Department of the Environment.

World heritage properties

The *Convention Concerning the Protection of World Cultural and National Heritage* (the World Heritage Convention) aims to promote international cooperation to protect heritage that is of such outstanding universal value that its conservation is important for current and future generations. It sets out the criteria that a site must meet to be included on the World Heritage List and the role of State Parties in the protection and preservation of the item.

To be included on the World Heritage List, a site must be of outstanding universal value, and meet at least one of 10 selection criteria.

The Sydney Opera House is included on the World Heritage List. The Sydney Opera House satisfies Criterion (i) (to represent a masterpiece of human creative genius) of the United Nations Educational, Scientific and Cultural Organisation (UNESCO) World Heritage Centre's (2013) *Operational Guidelines for the Implementation of the World Heritage Convention*.

The Sydney Opera House's World Heritage listing states that it is 'a great architectural work of the 20th century. It represents multiple strands of creativity, both in architectural form and structural design, a great urban sculpture carefully set in a remarkable waterscape and a world famous iconic building'.

Project activities associated with the establishment of a temporary site at Blues Point (as described in Chapter 7 (Project description – construction)) would occur within the buffer zone for the Sydney Opera House. While the project would not directly impact on the fabric of the Sydney Opera House, construction activities within the Sydney Opera House Buffer Zone have the potential to temporarily impact on this Word Heritage property's setting in a 'remarkable waterscape'.

The potential for impacts is considered in Chapter 14 (Non-Aboriginal heritage) and Chapter 16 (Landscape character and visual amenity).

National Heritage List

Established under the EPBC Act, the National Heritage List is a list of places with outstanding heritage value to Australia, including places overseas. A person cannot take an action that has, will have, or is likely to have a significant impact on the national heritage values of a National Heritage Place without the approval of the Commonwealth Minister for the Environment. The project would not have a significant impact on any National Heritage Place.

Commonwealth Heritage List

The Commonwealth Heritage List is established under the EPBC Act. It is a list of properties owned by the Commonwealth that are assessed as having significant heritage value. If a place is included on the Commonwealth Heritage List its Commonwealth owner is required to prepare a heritage management plan in accordance with the *Environment Protection and Biodiversity Conservation Regulations 2000*, to ensure that activities affecting the place avoid or minimise adverse impacts on the heritage values of the place, and provide ongoing protection of the place in event of sale or transfer. The project would not have a significant impact on any Commonwealth Heritage List property. Further details on non-Aboriginal heritage issues are provided in Chapter 14 (Non-Aboriginal heritage).

Actions taken on Commonwealth land

Under Section 26 of the EPBC Act, approval is required for:

- An action taken by any person on Commonwealth land (including Commonwealth leased land) that is likely to have a significant impact on the environment (subsection 26(1))
- An action taken by any person outside of Commonwealth land (including Commonwealth leased land) that is likely to have a significant impact on the environment on Commonwealth land (subsection 26(2)).

For the purposes of the Section 26, the EPBC Act defines the 'environment' as:

a. *Ecosystems and their constituent parts, including people and communities; and*

b. *Natural and physical resources; and*

c. *The qualities and characteristics of locations, places and areas; and*

d. *Heritage values of places; and*

e. *The social, economic and cultural aspects of a thing mentioned in (a), (b) or (c).*

Section 26 of the EPBC Act provides for a broader coverage of environmental and heritage matters relating to activities on Commonwealth land including issues such as noise, pollution, visual amenity or economic impacts.

The project would affect Commonwealth leased land at Crows Nest (the Crows Nest Post Shop) and Pitt Street (the Sydney South Post Shop). The potential land use and property impacts for the project are identified and assessed in Chapter 12 (Land use and property).

2.4.2 Native Title Act 1993

The main objective of the *Commonwealth Native Title Act 1993* is to recognise and protect native title. Section 8 states that the *Native Title Act 1993* is not intended to affect the operation of any law of a State or a Territory that is capable of operating concurrently with the Act. While the project would pass underneath a number of parcels of Crown land (as identified in Chapter 12 (Land use and property)), searches of the register maintained by the National Native Title Tribunal indicate there are no native title claims registered with respect to land within the area of the project. The project would not directly affect any Crown land that is currently the subject of a native title claim.

2.4.3 Disability Discrimination Act 1992

The *Disability Discrimination Act 1992* aims to eliminate as far as possible discrimination against persons on the ground of disability in areas including access to premises and the provision of facilities, services and land. The project would be designed to be independently accessible and in compliance with the objectives and requirements of the *Disability Discrimination Act 1992*. The *Sydney Metro Chatswood to Sydenham Design Guidelines* (Appendix B) are consistent with objectives of this act.

2.4.4 Disability Standards for Accessible Public Transport 2002

Section 33.1 of the *Disability Standards for Accessible Public Transport 2002* requires all new public transport premises, infrastructure and conveyances to be compliant with the requirements of the standard and referenced to the Australian Standards and Design Rules therein, unless unjustifiable hardship is incurred by implementation. The project would be designed, through implementation of the *Sydney Metro Chatswood to Sydenham Design Guidelines* (Appendix B), to be compliant with the requirements of the *Disability Standards for Accessible Public Transport 2002*.

2.5 Planning approvals process for over station development

The project stations would be designed to take into account (and make physical provision for) any design or other requirements associated with possible future over station development.

Typical examples of the infrastructure requirements of over station development includes provision of adequate space for building foyers and entrances, lift wells, and building service requirements. Elements incorporated into the project design for the purposes of making provision for future over station development are identified in Chapter 6 (Project description – operation).

All future over station development will be subject to a separate planning approvals process. Subject to the size, scale and proposed use of the future over station development this could include local development (with the local council as consent authority) or State significant development (with the Minister for Planning or the Planning Assessment Commission as consent authority).

There is a possibility that the assessment and approvals process relating to future over station development may result in changes to elements incorporated in the station design for this project – for example different infrastructure requirements due to refinements to bulk / scale / height, building foyers and entrances, lift wells, building services etc. Any changes required to the design for the project station(s), would be assessed in accordance with statutory requirements.

STRATEGIC NEED AND JUSTIFICATION

CHAPTER THREE

3 Strategic need and justification

This chapter outlines the strategic need and justification for the project taking into account the transport challenges that Sydney faces now and into the future, and NSW strategic planning and transport policy.

3.1 Secretary's environmental assessment requirements

The Secretary's environmental assessment requirements relating to strategic justification and project need, and where these requirements are addressed in this Environmental Impact Statement, are outlined in Table 3-1.

Table 3-1 Secretary's environmental assessment requirements – strategic need and justification

Ref.	Secretary's environmental assessment requirements	Where addressed
2. Environmental Assessment Process		
2.1	The EIS must include, but not necessarily be limited to, the following:	
2.1(c)	a statement of the objective(s) of the project	The objectives of the project are provided in Section 3.9.
2.1(d)	a summary of the strategic need for the project with regard to its critical State significance and relevant State Government policy	The strategic need for the project is discussed in Section 3.3. The key benefits of the Sydney Metro network are discussed in Section 3.4 and the key benefits of the project are discussed in Section 3.5. Consistency of the project with the NSW strategic planning and policy framework and NSW strategic transport infrastructure policy is discussed in Section 3.6 and Section 3.7 respectively. A summary of the strategic need for the project is provided in Section 3.8.

3.2 Sydney's challenges

3.2.1 Population and economic growth

Sydney is Australia's financial and economic capital with half of Australia's globally competitive service sector jobs. Its economy accounts for about 70 per cent of total NSW economic output and 20 per cent of Australia's gross domestic product (SGS Economics, 2014).

The city is home to over four million people and is Australia's economic capital and a 'global city' (NSW Government, 2014) – a status that reflects its importance in terms of its economic and cultural influences, engagement with international trade and finance, and attractiveness to globally-mobile workers and visitors. Businesses and workers are attracted to Sydney for the city's way of life and amenity, which help it score highly in international quality of life surveys.

A sign of Sydney's attractiveness for business is that its economic output and population are growing. Close to 200,000 jobs have been added to the NSW economy over the past five years (NSW Government and Rebuilding NSW, 2014). By 2031 Sydney's economic output will almost double to $565 billion a year and there will be 689,000 new jobs. In the next 20 years Sydney's population will grow by 1.6 million people (Department of Planning and Environment, 2015) (refer to Figure 3-1).

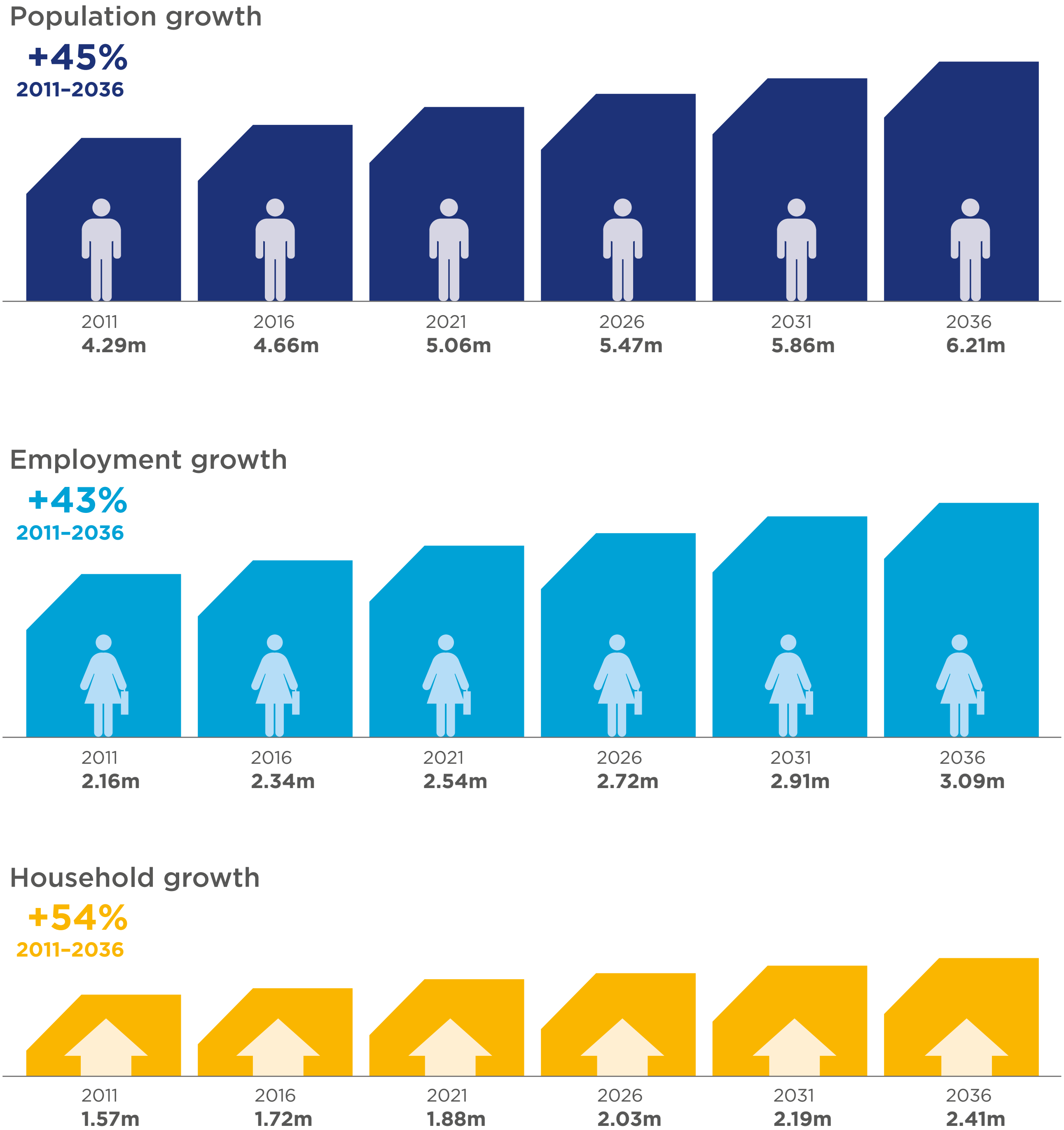

Figure 3-1 Population, employment and dwellings growth (Department of Planning and Environment, 2015)

Sydney's key employment and economic areas are clustered along a corridor that runs from Port Botany and Sydney Airport to Macquarie Park; this is known as the Global Economic Corridor (refer to Figure 3-2). In the last decade, demand for office space has seen overflow activity in Sydney's central business district (CBD) and the Global Economic Corridor extend the corridor towards Parramatta and Norwest Business Park, Sydney Olympic Park and Rhodes. The Global Economic Corridor now accounts for over 41 per cent of the NSW gross State product and provides jobs in a range of knowledge-based sectors including education, financial and other business services, communications, high-tech manufacturing and biotechnology (NSW Government, 2014).

It is important that the Sydney CBD continues to be one of Australia's premier commercial districts. The Sydney CBD has 10 times the number of jobs than any other centre in Sydney, and generates 28 per cent of the city's gross domestic product (Department of Planning and Environment, 2015). Barangaroo is Sydney's newest precinct. It will provide a hub for Sydney's financial and professional services and will further enhance the city's appeal for international investment and skilled workers (Department of Planning and Environment, 2015).

The finance and insurance industry is expected to maintain its position as the largest industry in NSW, with an expected average annual growth rate of 2.9 per cent. Other service based industries, including professional, scientific and technical services, health care, social assistance and education, are also expected to experience growth slightly above the level seen in the economy overall in this period (Deloitte Access Economics, 2014). Many of these jobs are located in the Sydney CBD and the Global Economic Corridor.

Sydney will continue to be NSW's primary employment centre, with employment in the city expected to increase from its current level of 2.1 million workers to 3 million workers by 2031, with about two-thirds working within the Global Economic Corridor (Transport for NSW, 2012a).

To continue to grow and develop, the Global Economic Corridor, including Sydney CBD and Barangaroo, will require high quality transit amenity to remain an attractive place to do business and to work.

Attracted by this economic prosperity, the city's population is growing much faster than during the previous 20 years. To support this growth, the rate of development of new dwellings will also need to increase with up to 664,000 new homes needed by 2036 to house this population. To maintain liveability and support continued growth in productivity, these homes will need to be serviced by transport infrastructure connected to employment areas, thereby enabling residents to actively participate in Sydney's growing economy.

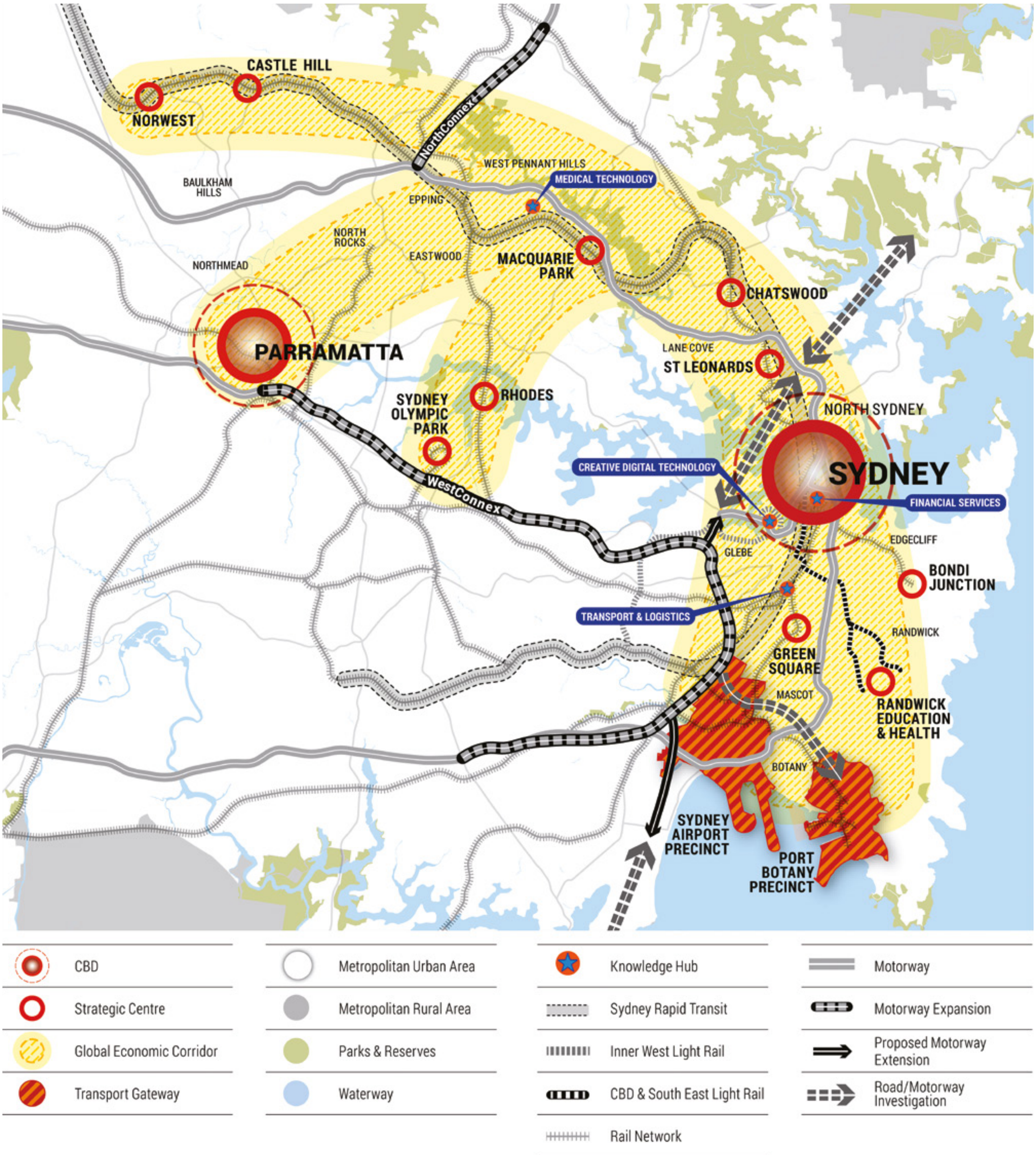

Figure 3-2 Sydney's global economic corridor

Note: Graphic taken from A Plan for Growing Sydney (Department of Environment and Planning and Environment 2015).
References to Sydney Rapid Transit in the above figure are references to Sydney Metro.

3.2.2 Transport capacity and reliability

Importance of the rail network

Sydney's suburban rail network is the backbone of the city's public transport system, which connects the city's skilled workforce with high value employment land located throughout the Global Economic Corridor. On a typical workday, commuters make about one million journeys on the rail network, with one third occurring in the morning peak (between 6 am and 9.30 am) (Transport for NSW, 2012b).

The most critical period for the transport system is the morning peak, when people are travelling to work, dropping children to school, transporting freight and making deliveries to businesses. This is particularly pronounced for key economic centres such as the Sydney CBD. Figure 3-3 provides a daily travel demand profile for the Sydney CBD.

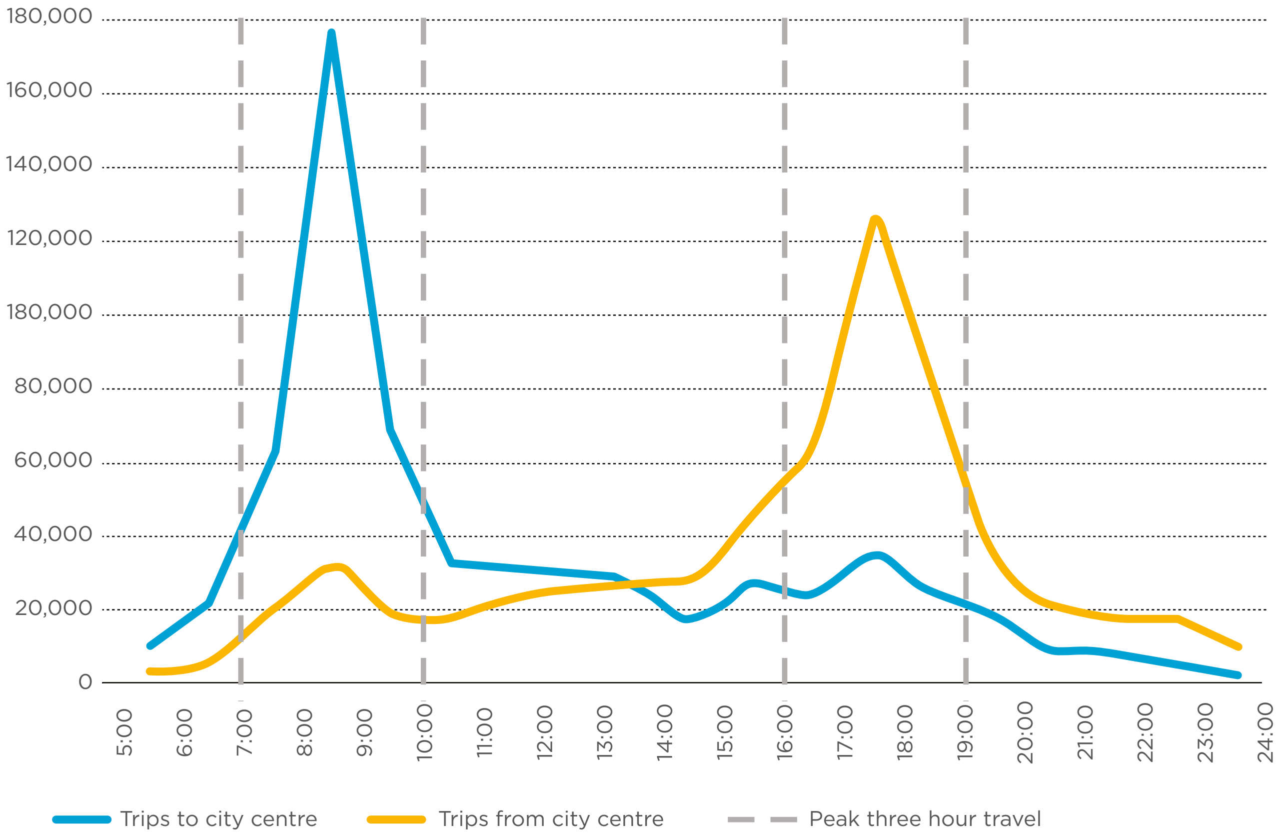

Figure 3-3 Passenger trips (all modes) to and from the Sydney CBD – average weekday by time of day 2010-11 (Transport for NSW, 2013a)

Rail is the dominant mode of public transport for commuters travelling to and from the Sydney CBD and North Sydney, and a significant mode for commuters travelling to and from Chatswood, St Leonards and Macquarie Park.

Figure 3-4 shows the extent of the transport task required to service the Sydney CBD in the one hour AM peak.

Sydney will require increased transportation capability to support employment and population growth. Of the three primary transportation modes, it is projected that travel by rail will experience the highest growth in demand, more than double that of buses and over a third more than that of car trips.

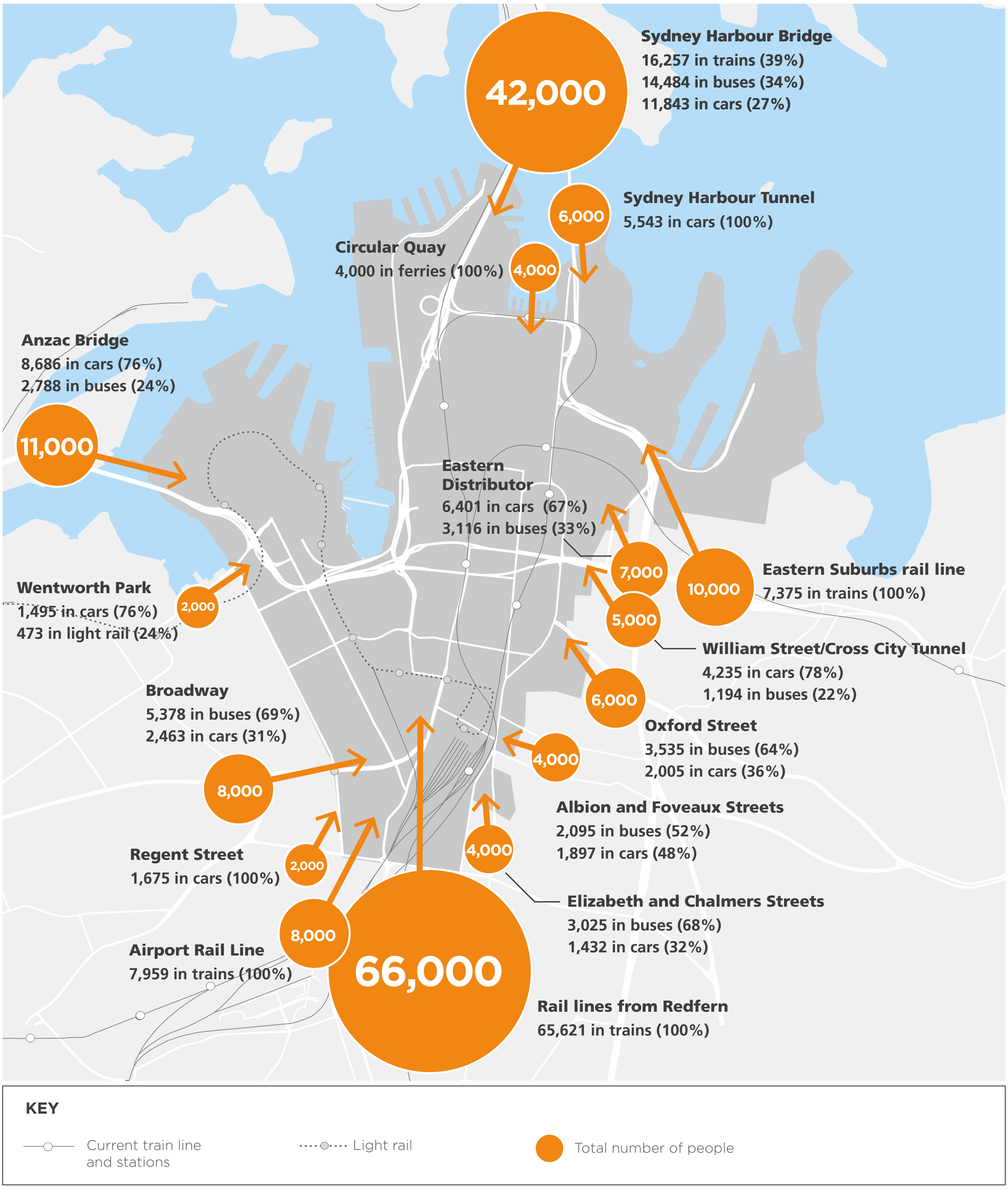

Figure 3-4 2011 Sydney CBD weekday entries in the one-hour AM peak (number of persons) (Transport for NSW, 2013a)

Constraints on the rail network

The rail network is heavily congested, with customers on most train lines often experiencing significant crowding on trains and station platforms during the morning and evening peaks. The reliability and capacity of Sydney's rail network is currently constrained by a number of factors, which include:

- Large numbers of 'junctions' on the rail network (ie points where two train tracks converge, requiring trains to cross paths)
- A large number of tracks that enter Sydney's CBD
- Capacity constraints including limitation in the number of services able to be provided, generally limited to 20 trains per hour per line, with each train having a reliable capacity of 1,200 passengers
- Complex train timetables that demand trains with different service patterns share the same track, which can result in slower trains delaying fast and express trains
- Crowded trains with internal stairs and 3 + 2 seating arrangements, which are slow to load and unload, resulting in long 'dwell times' (the time a train needs to stop in a station for passengers to board and alight)
- Crowded station and narrow platforms in busy Sydney CBD stations, which hinder passenger flow between trains and stairs and make it difficult for customers on the platform to make way for passengers alighting from trains
- Traditional signalling technology, which impedes optimised train running and maximum utilisation of line capacity.

Consequences of forecast passenger growth

As population and employment grow, transport network demand will also grow. By 2031, about 21 million trips will be made in Sydney every day, with all transport modes experiencing growth in demand, as shown in Figure 3-5 (Transport for NSW, 2012b).

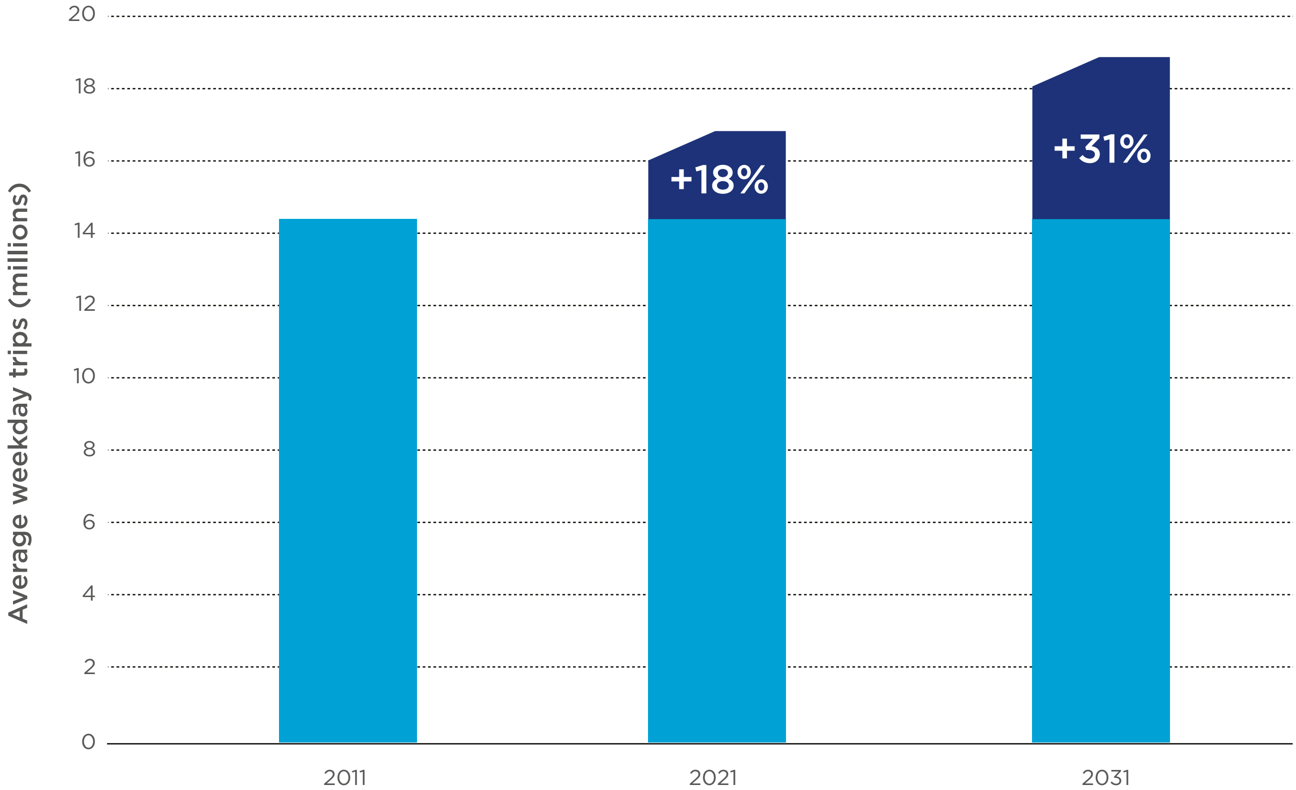

Figure 3-5 Growth in average weekday trips in Sydney (Transport for NSW, 2012b)

Rail is forecast to experience the highest growth in travel demand, with about an additional 100,000 trips expected on Sydney's rail network during the morning peak by 2036 as shown in Table 3-2. This will place additional pressure on the rail network.

Table 3-2 Forecast network rail demand

Year	Demand	Change from 2014	
		Per cent growth	Per cent growth per annum
2014	168,400	N/A	N/A
2026	237,000	41	2.9
2036	271,700	61	2.2

It is forecast that without further investment, Sydney's rail network will reach capacity in the Sydney CBD and on critical suburban rail lines by the mid to late 2020s (Transport for NSW, 2012a). This means most rail lines on the network will be overcrowded in the morning peak. The closer the rail network gets to capacity, the less reliable it will become and the more likely it will fail to meet the needs and expectations of rail customers.

As population and employment continue to grow, key stations in the Sydney CBD will not be able to cater for increased passenger movements. Increased platform crowding at Sydney CBD stations will contribute to increased dwell times, decreased network reliability and reduced network capacity. Without addressing platform crowding at Sydney CBD stations, investment to improve the suburban line capacity will not deliver capacity improvements, and reliability will continue to decline.

Increased platform crowding at Sydney CBD stations will also impact on the level of customer comfort and journey times. Given that timeliness and comfort are key drivers of customer satisfaction, poor customer outcomes have the potential to cause a shift away from rail.

Constraints on alternative transport modes

Alternative transport modes have limited capacity to absorb Sydney's forecast long-term travel demand growth.

Sydney's roads are already some of the most congested in Australia. As transport demand grows there is limited ability to augment the existing road network to increase capacity and reduce congestion, particularly within Sydney's CBD and the Global Economic Corridor. Accessing the Sydney CBD by car is further constrained by a lack of available on-street car parking.

Sydney's bus network is complex, consisting of over 600 bus routes with many different types of bus services that provide more than 220 million bus trips each year (Transport for NSW, 2012a).

With buses competing for road space with cars, the bus network is affected by the growing congestion on Sydney's roads, especially along arterial connections and routes to the Sydney CBD. Road congestion will increasingly slow down bus services, resulting in longer and more uncertain travel times across the network during peak periods. In the morning peak, around 1000 buses converge on the Sydney CBD. Figure 3-6 shows bus volumes entering the Sydney CBD during the two-hour morning peak in 2012, with the highest volume of buses entering the Sydney CBD across the Harbour Bridge.

Previous attempts to meet extra demand have involved adding new services to Sydney's already complex bus network. While extra buses can carry more people, these services are not necessarily faster or more reliable. Without measures to improve journey times, adding more buses simply adds to congestion and each bus becomes less effective in meeting customer needs. Services continue to experience significant delays in peak times, even with bus lanes and traffic light prioritisation.

Recent implementation of changes to bus services in the Sydney CBD as part of the Sydney CBD Bus Plan and the closure of George Street associated with construction of the Sydney CBD and South East Light Rail project has reduced bus numbers in the core of the Sydney CBD by around 45 percent, and altered bus routes around the Sydney CBD to alleviate traffic and bus congestion while maintaining access to important Sydney CBD destinations.

Demand for bus travel across Sydney is forecast to grow by 30 percent by 2031. Whilst the Sydney CBD and South East Light Rail project (when it opens in 2019) will replace bus services in the Sydney CBD from the south, the lack of road and pedestrian space in and around the Sydney CBD means there is limited ability to increase the number of bus services on the Harbour Bridge and the York Street corridor.

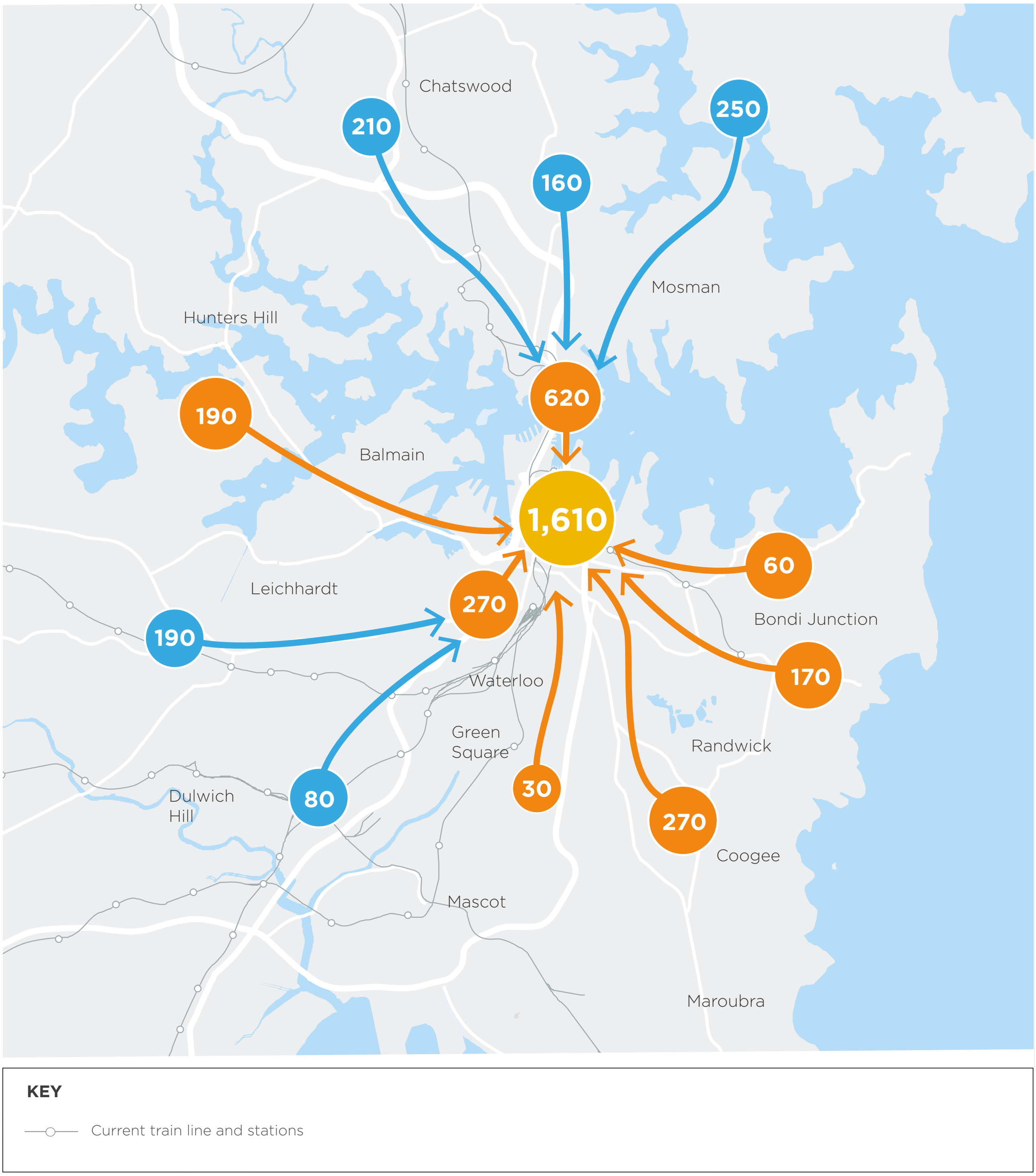

Figure 3-6 Bus volumes entering the Sydney CBD during the two-hour morning peak 2012

3.3 Why Sydney Metro?

Given the current and forecast travel demand for rail services within Sydney, and the limited capacity of other modes of transport to absorb forecast population and employment growth, improvements in rail capacity, through initiatives like the Sydney Metro network, are critical.

The proposed Sydney Metro network, comprising Sydney Metro Northwest and Sydney Metro City & Southwest, would deliver a seamless metro service for more than 65 kilometres between Rouse Hill and Bankstown, with investigations started for an extension of the network to Liverpool. The proposed Sydney Metro network is shown in Figure 1-1 and described in Chapter 1 (Introduction).

At ultimate capacity, the Sydney Metro network would be able to run 30 trains per hour in each direction through Sydney's CBD, providing the foundation for a 60 per cent increase in the number of trains that could operate in the peak periods and catering for an extra 100,000 customers per hour across the Sydney CBD rail lines. At ultimate capacity, the Chatswood to Sydenham component would provide additional capacity for more than 40,000 customers per hour through the Sydney CBD in each direction.

Sydney Metro would improve reliability across the rail network by addressing current and emerging constraints such as train crowding, platform and station crowding, and network complexity. The metro rail network would be capable of carrying more people, more quickly, than any other form of public transport ever seen in Sydney.

Sydney Metro would therefore deliver a new tier for Sydney's rail network, supporting high demand with a high-capacity, turn-up-and-go service. It is also being developed with an emphasis on supporting the needs of customers for 'door-to-door' journeys from origin to destination as shown by Figure 3-7. Sydney Metro would also be Australia's first fully automated rail network. The benefits of the project are expanded in Section 3.4.

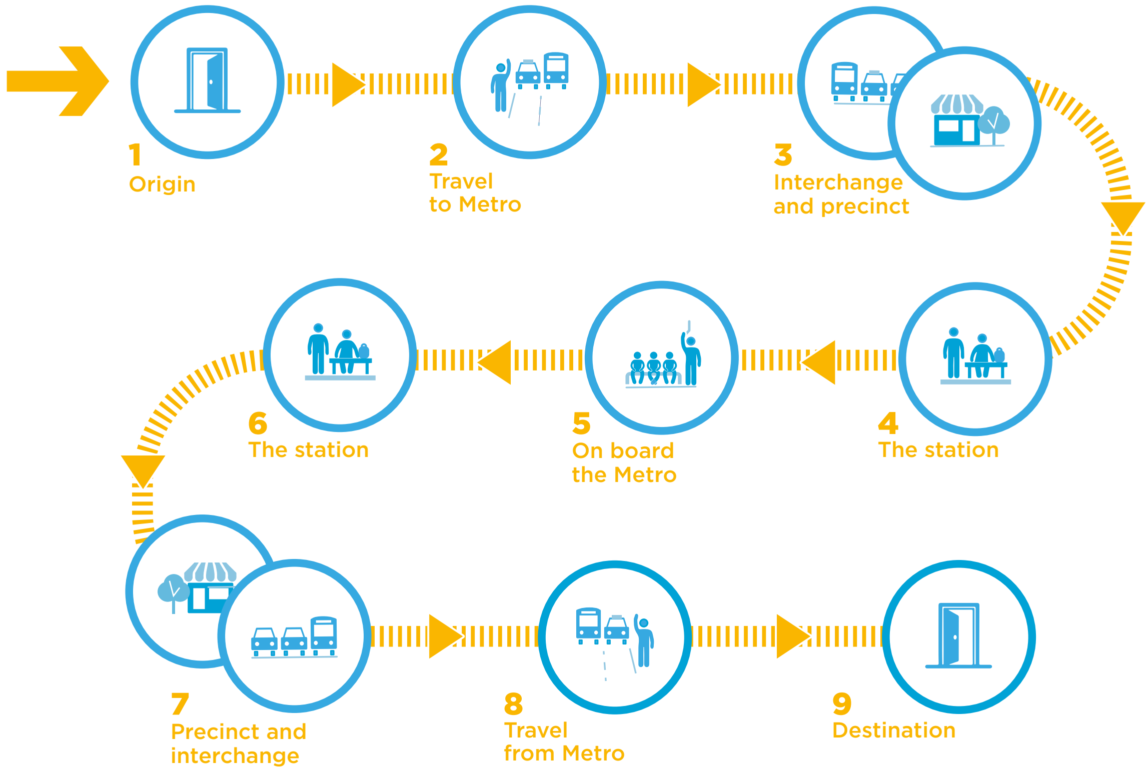

Figure 3-7 Customer journey

3.4 Key benefits of the Sydney Metro network

As indicated in Chapter 1 (Introduction), the Sydney Metro network comprises Sydney Metro Northwest and Sydney Metro City & Southwest. Sydney Metro Northwest is currently under construction and opens in the first half of 2019. Sydney Metro City & Southwest comprises two project components: Chatswood to Sydenham (this project) and the Sydenham to Bankstown upgrade (subject to a separate environmental assessment and approvals process). Sydney Metro City & Southwest would extend the currently approved metro network from Chatswood through the Sydney CBD to Bankstown.

This section outlines the benefits of the proposed extension to the metro network – incorporating both project components of Sydney Metro City & Southwest. It is recognised that this project could operate without the Sydenham to Bankstown upgrade. In this case, the project would still have broader network benefits including its connection to Sydney Metro Northwest, though there would be some changes to benefits without connecting through to Bankstown. Accordingly, benefits of the project in isolation of its connection to the Sydenham to Bankstown upgrade project have been specifically identified and are discussed in Section 3.5. Further discussion on the inter-relationship between the project and the Sydenham to Bankstown upgrade project, including implications for impacts are provided in Chapter 26 (Cumulative impacts).

3.4.1 Key transport benefits of the Sydney Metro Network

Sydney Metro City & Southwest would provide significant additional transit capability to the broader Sydney transport network by:

- Extending Sydney Metro from Chatswood, under Sydney Harbour through the Sydney CBD to Sydenham
- Increasing the number of primary Sydney CBD stations by building new Sydney Metro stations at Barangaroo, Martin Place and Pitt Street
- Providing extra connectivity and interchange capacity at Central Station, Martin Place and Sydenham
- Upgrading the Bankstown Line between Sydenham and Bankstown to be part of the high-capacity, high-frequency Sydney Metro system.

The key transport benefits of the Sydney Metro City & Southwest project are addressed in the following sections.

Catering for growth in demand

As detailed in Section 3.2.2, demand for rail services is projected to grow by about 100,000 trips in the AM peak hour by 2036. Without intervention this growth will be constrained by network capacity limitations. The development of Sydney Metro City & Southwest would support this increase by providing the capacity to accommodate an extra 100,000 customers per hour across the Sydney CBD rail lines.

Increased accessibility and trip diversity

Sydney Metro City & Southwest would increase the network rail catchment through the provision of:

- New stations at Crows Nest, Victoria Cross, Barangaroo, Martin Place, Pitt Street, and Waterloo as well as new underground platforms at Central Station
- More direct connections to high-capacity Sydney CBD stations at Martin Place and Pitt Street
- Additional interchange capability at Central, Martin Place, Sydenham and Bankstown, enabling increased network connectivity and demand for rail services.

By increasing the reach of the rail network, frequency of services, interchange with other modes and connections to key destinations, Sydney Metro City & Southwest is expected to increase accessibility, trip diversity and utilisation of the network during both peak and non-peak periods. This would facilitate a greater mode shift to rail from car, particularly during non-peak periods where travel service consumers have greater choice.

Sydney Metro City & Southwest would facilitate a diverse range of trips, providing not only a fast journey to work but also encouraging trips for other purposes such as access within the Sydney CBD, local or business trips, access to universities and educational institutions, service and recreational uses.

Figure 3-8 provides an overview of destination land uses and facilities along the alignment, interchanges to increase accessibility, and trip choices that are available to metro customers.

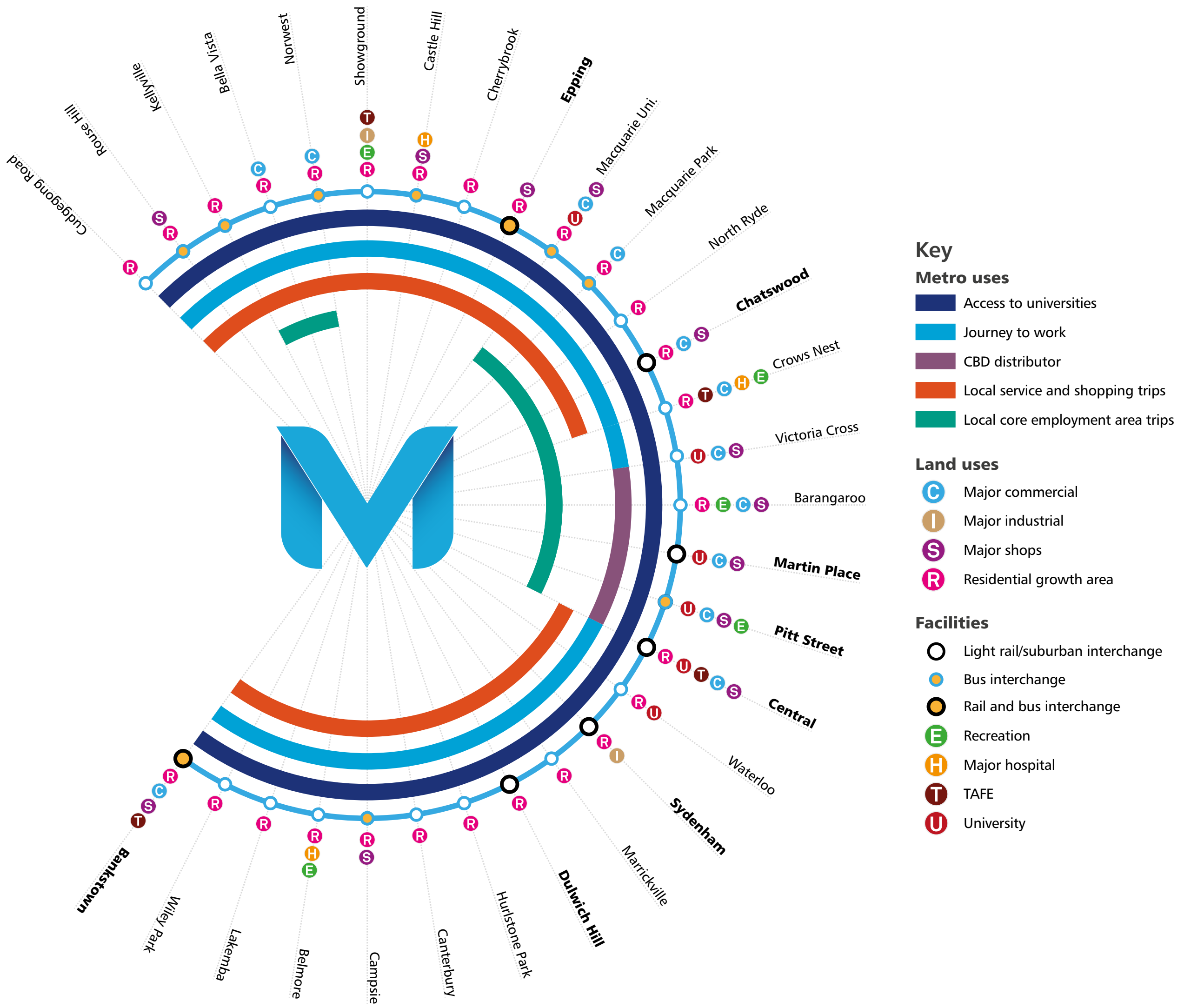

Figure 3-8 Overview of metro uses, land uses and facilities

Increased rail network capacity

The Sydney Metro network would considerably increase rail network capacity by introducing new high-capacity rail connections from the Sydney CBD to other key economic centres in the broader Sydney area. Network capacity is a function of the number of reliable train paths able to be achieved and the carrying capacity of a train.

The reliable capacity of an existing Sydney Trains double deck train is about 1,200 passengers. Upon opening, Sydney Metro would operate with six car trains, with an ultimate capacity to operate eight car trains in the future. These new, high-capacity metro style trains would have a carrying capacity of about 1,500 passengers at the ultimate eight car configuration.

In addition, the Sydney Rail network is generally limited to 20 trains per hour per line. Sydney Metro would provide dedicated track, train control, rolling stock and platform configurations to support up to 30 trains per hour. Figure 3-9 provides an overview of the line capacity between the Sydney Trains and Sydney Metro networks.

Figure 3-9 Line capacity comparison between Sydney Trains and Sydney Metro networks

Sydney Metro City & Southwest would provide a considerable increase in network capacity through the introduction of a new metro line through the Sydney CBD serviced by high-capacity trains. Sydney Metro, together with signalling and infrastructure upgrades across the existing network, would increase the capacity of the rail network through the Sydney CBD from about 120 per hour during peak periods today, to up to 200 services per hour beyond 2024, including capacity for up to 60 metro trains per hour during peak periods (or 30 trains per hour in each direction). This would equate to an increase of up to 60 per cent capacity across the network.

The two additional tracks from Chatswood to the City would more than double the number of train paths available from the north; and the conversion of the Bankstown Line would remove the need for Bankstown services to use the City Circle, providing for additional train paths for other lines using the City Circle. Increasing rail line capacity through Sydney's CBD and removing T3 Bankstown Line services from the City Circle would enable a fundamental change in the suburban network service plan, diverting passengers from the T1 North Shore Line and T1 Western Line; and allowing additional capacity on the T2 Airport, Inner West & South Line.

The extension of Sydney Metro from Chatswood to Bankstown would increase total train paths available to the Sydney CBD, and given that metro trains are of a higher reliable capacity than double deck trains, total passenger carrying capacity would be increased by about 60 per cent.

The increase in network capacity and ability to make a significant change to how the network operates provides other benefits as discussed in the following sections.

The Sydney Metro City & Southwest project would improve travel times by:

- Providing more direct routes to key destinations
- Providing more direct routes on suburban and intercity services, enabling additional capacity
- Reducing crowding on trains and at stations, which would improve the reliability of services.

The largest travel time savings would be experienced in areas where new stations are provided (such as Crows Nest), where more direct routes are provided (such as Martin Place to Chatswood), or where customers are required to transfer between services and new stations added or where there are connections to Sydney Metro Northwest (such as Norwest Business Park to Central).

Travel time savings would be experienced by existing rail customers (who would directly benefit from shorter travel times), new rail customers (who would transfer from road-based transport to rail) and road users (who would experience less congestion).

With the completion of Sydney Metro City & Southwest, customers on the Sydney Metro Northwest, T1 North Shore Line and T3 Bankstown Line, would have access to Sydney Metro services that would provide more direct connection with key destinations in the Global Economic Corridor.

The project would result in travel time savings through:

- More direct access for North Shore and North Sydney customers to key destinations in the Global Economic Corridor such as Martin Place and Norwest Business Park
- More direct access for Eastern Suburbs customers to key destinations in the Global Economic Corridor, interchanging to direct services at Martin Place Station instead of the crowded Town Hall Station.

Table 3-3 also provides examples of the estimated travel time savings to and from certain destinations associated with the introduction of the Sydney Metro City & Southwest to the network. These travel time savings have been forecast based on the time savings a customer would realise on their journey compared with existing rail network travel times, including interchange time and walking time from new metro station locations (such as Crows Nest) to the closest existing train station.

Table 3-3 Examples of estimated trip travel time savings for Sydney Metro City & Southwest

Origin	Destination		Travel time savings (approx.)[1]
Martin Place	Chatswood	**Without project:** 10 minute walk Martin Place to Wynyard Station 20 minute train Wynyard to Chatswood TOTAL: 30 minutes **With project:** 11 minute metro Martin Place to Chatswood	19 minutes
Norwest Business Park	Central	**Without project:** 28 minute metro Norwest to Chatswood 3 minute interchange 26 minute train Chatswood to Central TOTAL: 57 minutes **With project:** 42 minute metro Norwest to Central	15 minutes

Origin	Destination		Travel time savings (approx.)[1]
Martin Place	North Sydney (corner Miller Street and Pacific Highway)	**Without project:** 10 minute walk Martin Place to Wynyard Station 7 minute train Wynyard to North Sydney Station 6 minute walk to Miller Street TOTAL: 23 minutes **With project:** 5 minute metro martin Place to Victoria Cross 3 minute walk to Miller Street TOTAL: 8 minutes	15 minutes
Macquarie Park	North Sydney (corner Miller Street and Pacific Highway)	**Without project:** 9 minute metro Macquarie Park to Chatswood 3 minute interchange 13 minute train Chatswood to North Sydney Station 6 minute walk to Miller Street TOTAL: 31 minutes **With project:** 15 minute metro Macquarie Park to Victoria Cross 3 minute walk to Miller Street TOTAL: 18 minutes	13 minutes
Crows Nest (Hume Street)	Central	**Without project:** 9 minute walk Hume Street to St Leonards Station 23 minute train St Leonards to Central TOTAL: 32 minutes **With project:** 11 minute metro Crows Nest to Central	21 minutes
Bondi Junction	North Sydney (corner Miller Street and Pacific Highway)	**Without project:** 11 minute train Bondi Junction to Town Hall 3 minute interchange 10 minute train Town Hall to North Sydney Station 6 minute walk to Miller Street TOTAL: 30 minutes **With project:** 8 minute train Bondi Junction to Martin Place 3 minute interchange 5 minute metro Martin Place to Victoria Cross 3 minute walk to Miller Street TOTAL: 19 minutes	11 minutes

Origin	Destination		Travel time savings (approx.)[1]
Bankstown	Central	**Without project:** 30 minute to 36 minute train Bankstown to Central **With project:** 26 minute metro Bankstown to Central	Up to 10 minutes

1 *The above estimates are based on analysis carried out in 2015, compared with train journeys at that time*

Reduced train crowding

During periods of heavy train congestion the following impacts can arise:

- Services begin to become unreliable as passengers crowd on to trains and dwell times at stations are more difficult to manage
- Passengers need to board a following train
- Passengers may seek to use another form of transport, travel at a different time or will not travel.

By enabling additional train services on the rest of the suburban rail network and diverting passengers from existing services, Sydney Metro would significantly reduce train crowding on the T1 North Shore Line; T1 Western Line; and the T2 Airport, Inner West and South Line.

Decreased station crowding

Currently there is station crowding at key Sydney CBD stations during peak periods.

With passenger travel demand to the Sydney CBD forecast to increase, additional constraints will be placed on Sydney CBD and other key interchange stations, particularly crowding on platforms and vertical transport. This is likely to result in excessive delays to platform and station clearance times.

A key benefit of Sydney Metro City & Southwest is relief to platform crowding at existing Sydney CBD stations and a reduction in the amount of passenger time spent under heavily crowded platform conditions. Sydney Metro City & Southwest would achieve this by providing an alternative route through the Sydney CBD and increasing the number of high-capacity inner city stations from two to four by:

- Increasing the functionality of Martin Place Station, by providing two new underground platforms with interchange capability
- Providing a new station at Pitt Street.

The project would also provide a new station at Barangaroo and two new underground platforms at Central Station with high interchange capability. This would further reduce congestion at Wynyard Station and support improved dispersal of customers arriving on services that need to interchange at Central Station, such as customers on intercity services which terminate at Central.

The new stations and platforms at Martin Place, Pitt Street, Central and Barangaroo would spread the load of station utilisation and reduce Town Hall and Wynyard expected crowding. The project would also provide relief to the existing North Sydney Station with a new station at nearby Victoria Cross.

Overall passenger movements at the key Sydney CBD stations platforms of Wynyard and Town Hall in 2036 would be reduced by around 30 per cent during the one hour morning peak and by around 40 per cent at North Sydney and St Leonards stations. The anticipated change in passenger demand at key stations is shown in Figure 3-10.

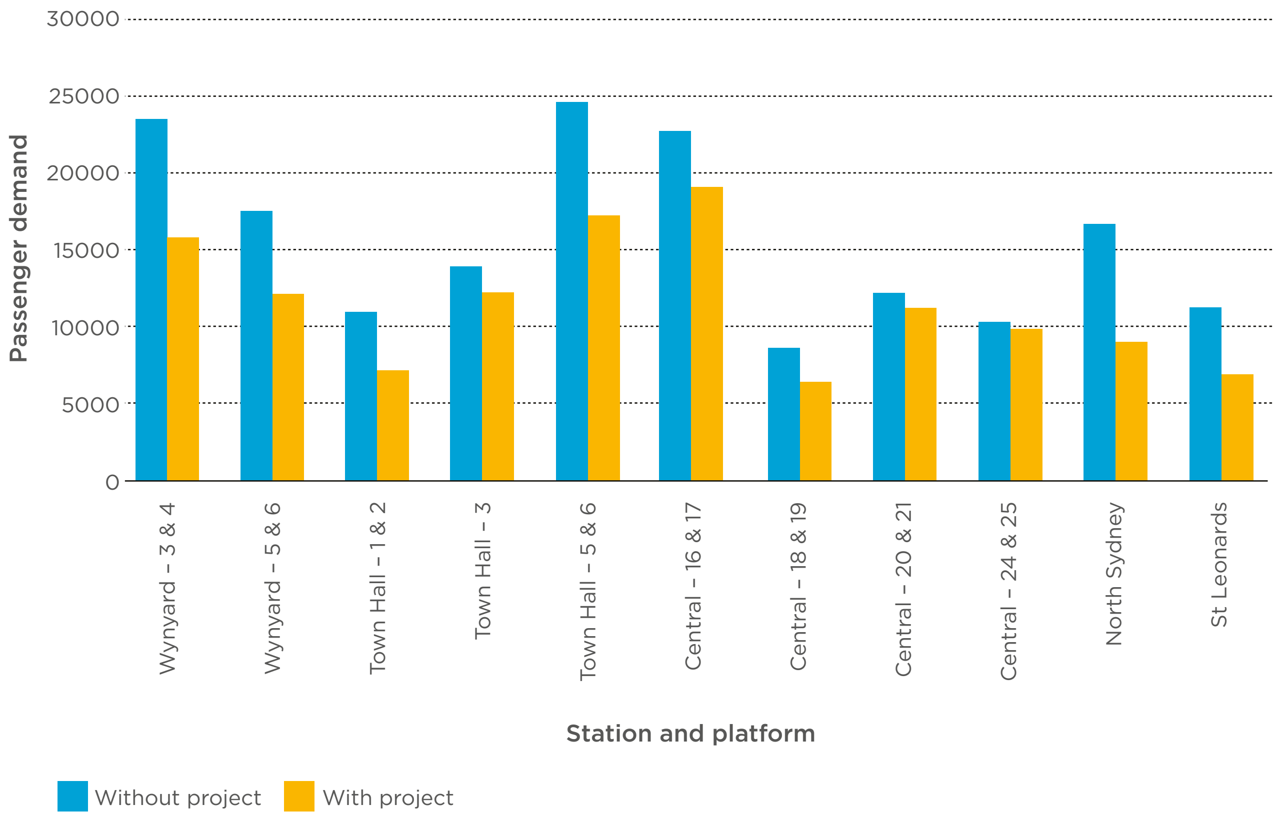

Figure 3-10 Anticipated change in passenger demand at key stations (one hour morning peak)

Improved network resilience

Suburban rail access through the Sydney CBD and across the harbour is limited to the T1 North Shore, Northern and Western Line.

Forced shutdowns during unplanned and planned events impacts on customer service provision. Closures of the Harbour Bridge for example can cease the provision of public transport services linking the Sydney CBD to key destinations on the lower North Shore and Northern Sydney. The T1 North Shore Line is also subject to periodic maintenance which reduces access for passengers to key stations such as North Sydney, St Leonards and Chatswood.

The Sydney Metro City & Southwest project would provide an additional, high-capacity public transport link through the Sydney CBD and across the harbour, enabling rail network redundancy for this critical link. During planned and unplanned events patrons would continue to have access to direct high-capacity transport services.

Improved conditions for bus customers

Sydney Metro City & Southwest would be part of an integrated public transport network with high-quality bus connections to the stations and easy transfers for customers travelling to and from locations beyond walking distance. The existing and future planned bus networks would continue to be reviewed by Transport for NSW to enhance the bus network and its connectivity with Sydney Metro stations.

By connecting with Sydney Metro Northwest at Chatswood, the project would provide a direct connection from Sydney's northwest, potentially allowing for a reduction in the number of bus services from the northwest to the Sydney CBD during the morning peak. The project would contribute to:

- Improving the reliability of journey times for the remaining bus passengers
- Reducing the number of buses in the Sydney CBD
- Reducing the number of buses accessing the Sydney CBD via the Harbour Bridge
- Reducing the number of bus services using the already congested Wynyard Bus Interchange, freeing it for use by other services
- Reducing journey times for existing bus passengers who switch to using Sydney Metro for all or part of their journey.

People around Waterloo have traditionally relied on buses and walking as a transport solution. The introduction of a metro station at Waterloo would therefore benefit existing bus customers by providing a high quality metro / bus connection and by reducing reliance on the bus network.

Improved conditions for road users

By encouraging people to use the metro network, Sydney Metro City & Southwest would reduce the number of trips that would otherwise be made on the road network. This is particularly the case for sections of the road network that are constrained, such as the Harbour Bridge and the Sydney CBD, where the project would provide a high-quality transport alternative. Reduced congestion would mean that those road users who do not shift modes would gain from travel time and reliability benefits.

Public transport already provides for the majority of the AM peak commuter movements in Sydney. As a result of the project in 2026 there could be about 20 million fewer car trips annually. By 2036 the corresponding reductions could be as much 30 million fewer car trips annually.

3.4.2 Key city building benefits

Sydney Metro City & Southwest would provide a significant increase in transit amenity throughout Sydney, which would facilitate increased economic productivity and land use efficiency. Sydney is the most urbanised area within Australia with the density of population and economic activity in its centres being major drivers of national productivity. Sydney Metro City & Southwest would facilitate:

- Higher productivity by enabling businesses to become effectively closer together through reduced travel times between major economic centres, and between economic centres and potential employees
- Opportunities for a higher intensity of land use around new and converted stations, including employment opportunities and potential for higher density residential areas which could offer more affordable housing options with better access to services and employment, and support more liveable, vibrant communities.

Planning being carried out by the Department of Planning and Environment along the Sydney Metro corridor supports the following:

- Global Economic Corridor – about 650,000 jobs within 800 metre station catchments by 2036
- Urban renewal corridor along the full length of the Sydney metro line – about 514,000 people within 800 metre station catchments of the Sydney metro line by 2036
- Future priority precincts emerging from the current investigation between Bankstown and Sydenham
- 460,000 jobs and 67,000 residents at Barangaroo, Martin Place, Pitt Street and Central
- Potential future priority precinct at St Leonards.

3.5 Key benefits specific to the Chatswood to Sydenham project

Section 3.4.1 has detailed the expected benefits of the full Sydney Metro including both Sydney Metro City & Southwest projects. The full realisation of the benefits to the overall Sydney rail network in terms of catering for growth in demand and increasing rail network capacity would ultimately be dependent on delivering both these projects. However, this project would provide specific benefits, particularly given the additional Sydney Harbour rail crossing and the additional stations provided in the Sydney CBD. A summary of the key benefits enabled specifically by the project are provided in Table 3-4.

Table 3-4 Key transport benefits enabled by the project

Benefit category	How the benefits are enabled
Enables longer term development of Sydney rail network	• Facilitates development of the rail network, including continued development of Sydney Metro, and continued development and enhancement of the Sydney Trains network.
Catering for growth in demand	• Increased rail accessibility, number of services, reliability and rail catchment; reduced train and station crowding, particularly at Wynyard, Town Hall and North Sydney stations; travel time savings, would enable rail system to cater for growth in demand.
Increasing the reach of the rail network	• New stations at Barangaroo, Crows Nest, Victoria Cross and Waterloo would directly increase rail catchment areas • More direct connections to high-capacity Sydney CBD stations at Barangaroo, Martin Place and Pitt Street would increase Sydney CBD rail catchment areas • Additional interchange capability at Central, Martin Place and Pitt Street stations.

Benefit category	How the benefits are enabled
Increased accessibility and trip diversity	• Improved frequency of services and interchange with other modes and connections to key destinations would increase accessibility (eg to major commercial, industrial, retail and residential areas) and trip diversity (eg journey to work, education, Sydney CBD distributor, local service trips and work related trips) • **Crows Nest Station** would provide improved connections to the key employment centre of St Leonards, and the restaurants and specialist shops in the Crows Nest village. The station would provide a new transport focus to the south of the St Leonards strategic centre and be an opportunity to respond to North Sydney Council's planning precinct studies for the area • **Victoria Cross Station** would be located in the North Sydney CBD and would provide improved connections to the commercial, retail users, restaurants and cafes of the centre. The station would also improve connections to schools and educational facilities in the locality, including the Australian Catholic University (North Sydney) campus. The station would provide another focal point to North Sydney CBD, relieving pressure on the existing North Sydney Station and extending the rail catchment to the north. The station would improve mid-block connections between Miller Street and the eastern areas of the North Sydney CBD • **Barangaroo Station** would provide customers with easy access to Barangaroo Reserve and the Walsh Bay arts precinct including the Sydney Theatre Company, Sydney Dance Company, and many cafes and restaurants. The station would also provide much needed east-west connectivity across the Sydney CBD. Once Central Barangaroo is constructed and open to the public, customers would be connected to office and retail centres, and a new casino and hotel complex • **Martin Place Station** would serve the high-end commercial and financial precinct within the Sydney CBD. It would provide an opportunity to respond to City of Sydney Council's Martin Place Urban Design Study. It would also provide customers with a new connection to the civic spaces including the State Library, Sydney Hospital, Domain and a short walk to the Royal Botanic Gardens. Customers would be able to easily access events held in or near Martin Place during the off peak period, such as families going to the City of Sydney's Christmas tree lights, Vivid Sydney and the Sydney Festival • **Pitt Street Station** would connect customers to the retail heart of the CBD. It would provide customers with access, by a short walk, to the Queen Victoria Building, Pitt Street Mall and Galleries Victoria. Customers would also have easy access to the entertainment precinct along George Street and to Town Hall and other civic buildings to attend events like Vivid Sydney • **Central Station** would provide customers with connections to a range of attractors including the University of Technology Sydney, University of Notre Dame Australia, the shopping and market districts around Haymarket, and Central Park, Chinatown and Surry Hills for a wide variety of restaurants and bars. Many customers would alight at Central and transfer to another mode to access the Sydney Football Stadium and Sydney Cricket Ground for a variety of concerts and sporting events • **Waterloo Station**, through the provision of new infrastructure and substantial improvements in accessibility for the area, would indirectly contribute to the renewal of the area's social housing, which would in turn contribute to an increase in the supply of new homes close to the Sydney CBD.
Increased rail network capacity	• Additional tracks through the Sydney CBD – two additional tracks enabling up to 30 high-capacity metro services (AM Peak hour) through the Sydney CBD in each direction • Additional tracks from Chatswood to Sydney CBD – two additional tracks providing additional capacity from the north.

Benefit category	How the benefits are enabled
Travel time savings	• Sydney Metro Northwest and T1 North Shore Line customers would have access to more direct Sydney Metro services to key activity areas in the Global Economic Corridor • Central Coast customers travelling to North Shore and Sydney CBD stations would have significant travel time savings, with these services being able to take advantage of the more direct routes made possible by the introduction of Sydney Metro City & Southwest • North Shore and North Sydney customers would have direct rail access to key destinations in the Global Economic Corridor such as Martin Place and Norwest Business Park • Eastern suburbs customers would have more direct access to key destinations in the Global Economic Corridor, interchanging to direct services at Martin Place Station instead of the crowded Town Hall Station.
Decreased train crowding	• Sydney Metro services – at opening of the project 20 new high frequency metro services would reduce crowding on the T1 North Shore Line. For example between Milsons Point and Wynyard, loadings would reduce from around 122 per cent of capacity to around 70 per cent of capacity in the AM peak.
Decreased station crowding	• New Sydney CBD stations and platforms provided at Barangaroo, Martin Place, Pitt Street and Central spreads station loading and decreases crowding at Wynyard and Town Hall stations • New station at Victoria Cross would decrease crowding at North Sydney Station.
Increased reliability	• Reduced train and station crowding would increase reliability of T1 North Shore, Northern and Western Line.
Improved network resilience	• Public transport access through the Sydney CBD and across the harbour is limited to a few key pieces of infrastructure • The project would provide an additional, high-capacity public transport link through the Sydney CBD and across Sydney Harbour. The project provides an alternative option for customers during unplanned and planned events which may force closure of other Sydney CBD and harbour links.
Improved transport integration	• Improved interchange with bus, light rail, pedestrian and cycling networks, and provision of taxi and kiss and ride key stations.
Rail safety benefits	• Improved rail safety through the introduction of new technologies and design, such as communication based train protection system, platform screen doors, modern ventilation systems and emergency arrangements in the tunnelling environment, intrusion detection technologies along the corridor, and extensive CCTV coverage on board and at stations.
Bus network benefits	• Freeing of bus services by bus customers transferring to rail, enabling the opportunity to redeploy bus services from the north and north west • Less demand for Sydney Harbour Bridge bus services, freeing capacity over the Harbour Bridge.
Road network benefits	• Reduced road congestion by road users transferring to rail • Less congestion on key road corridors including Sydney Harbour Bridge, Sydney Harbour Tunnel and Eastern Distributor.

3.6 Consistency with NSW strategic planning and policy framework

The project is consistent with key NSW Government planning strategies, as outlined in this section.

3.6.1 State and Premier priorities

In September 2015 the NSW Premier released 30 'State priorities', including 12 'Premier priorities' to grow the economy, deliver infrastructure, and improve health, education and other services across NSW. Key priorities relevant to the Sydney Metro Chatswood to Sydenham project include 'building infrastructure' and 'creating jobs'.

The project would contribute to economic growth by providing direct benefits to customers in terms of reduced travel time and better reliability. It would also deliver wider economic benefits by facilitating increased connectivity, land development and business logistics improvements, particularly for knowledge based businesses.

There are a number of health benefits associated with the project that relate to increased density and increased active transport (walking and cycling) opportunities around metro stations.

Over the next 15 years, NSW will require infrastructure to support 40 per cent more train trips, 30 per cent more car trips and 31 per cent more households (NSW Government, 2015). Sydney Metro City & Southwest is identified as a key infrastructure project as part of the NSW government's infrastructure investment program.

The NSW Government is committed to the creation of 150,000 new jobs over the next four years. Through investment in infrastructure such as the Chatswood to Sydenham project, new jobs and apprenticeships are being created for the construction sector.

3.6.2 Sydney metropolitan planning strategy

A Plan for Growing Sydney (NSW Government, 2014) sets out the NSW Government's strategy for accommodating Sydney's future population growth over the next 20 years. The plan consists of goals, directions and actions that provide a framework for strengthening the global competitiveness of Sydney and delivering strong investment and jobs growth in Western Sydney. The project's expected contribution to achieving these goals, directions and actions is outlined in Table 3-5.

Table 3-5 Expected contribution to achieving the goals of A Plan for Growing Sydney

Directions of the plan	Corresponding actions of the plan	Project contribution to achieving the plan's directions and actions
Goal 1: A competitive economy with world-class services and transport		
Direction 1.6: Expand the Global Economic Corridor	**Action 1.6.2:** Invest to improve infrastructure and remove bottlenecks to grow economic activity	The project would support the Global Economic Corridor by providing faster and more reliable access and by fostering clusters of activities that support more economic growth.
Direction 1.7: Grow strategic centres – providing more jobs closer to home	**Action 1.7.1:** Invest in strategic centres across Sydney to grow jobs and housing and create vibrant hubs of activity	The project would improve capacity and reliability of links along the Global Economic Corridor to the Sydney CBD. Together with Sydney Metro Northwest, the project would also improve links to the strategic centres of Chatswood, Macquarie Park, Castle Hill, Norwest and Rouse Hill.
Direction 1.11: Deliver infrastructure	**Action 1.11.1:** Preserve future transport and road corridors to support future growth	*A Plan for Growing Sydney* specifically identifies preserving a future corridor for Sydney Metro. The project is consistent with this action.
Goal 2: Sydney's housing choices		
Direction 2.2: Accelerate urban renewal across Sydney – providing homes closer to jobs	**Action 2.2.2:** Undertake urban renewal in transport corridors which are being transformed by investment, and around strategic centres	Together with Sydney Metro Northwest, the project would provide significant opportunities for new housing development, giving new communities shorter and more reliable commutes to major job centres.

3.7 Consistency with NSW strategic transport infrastructure policy

3.7.1 Rebuilding NSW: State Infrastructure Strategy 2014

Rebuilding NSW: State Infrastructure Strategy 2014 (NSW Government and Rebuilding NSW, 2014) outlines the NSW Government's plan to invest $20 billion in new infrastructure to sustain productivity growth in NSW's major centres and regional communities, and to support a forecast population of almost six million people in Sydney and more than nine million in NSW. Projects identified in Rebuilding NSW were based on investment recommendations made by Infrastructure NSW.

Rebuilding NSW states that $7 billion has been reserved to fully fund a second rail crossing of Sydney Harbour as part of Sydney Metro. The project is therefore consistent with this strategy.

3.7.2 NSW Long Term Transport Master Plan

The *NSW Long Term Transport Master Plan* (Transport for NSW, 2012b) is the NSW Government's 20 year plan to improve the NSW transport system by delivering an integrated, modern transport system that puts the customer first. The plan identifies the transport challenges that will need to be addressed to support NSW's economic and social performance over the next 20 years and establishes a number of short, medium and long-term actions to address those challenges. These actions provide the overall framework for how the NSW transport system develops, in terms of services and infrastructure.

A key element of the *NSW Long Term Transport Master Plan* is the need to increase the capacity of Sydney's rail network to meet existing customer needs and accommodate the additional travel demand created by Sydney's forecast population and economic growth over the next few decades. The plan notes that over the next 20 years, the number of trips made by rail is expected to increase by 26 per cent (Transport for NSW, 2012b). This growth cannot be accommodated on Sydney's existing rail network, which is already approaching its capacity and is subject to significant crowding on most lines at the height of the morning and evening peak periods (Transport for NSW, 2012b).

Without the creation of additional rail capacity, crowding levels on the network will continue to increase, with many parts of the rail network forecast to be near capacity in 2031, even with service improvements that are possible within the constraints of the current network configuration (Transport for NSW, 2012b).

The *NSW Long Term Transport Master Plan* identifies a 'three-tiered network' approach to expand the capacity of Sydney's transport system. This approach involves the implementation of high-capacity metro into the current two-tier arrangement of suburban and intercity services to untangle the current system and ensure fast, efficient and reliable services throughout the network. The plan identifies a second Sydney Harbour rail crossing and Sydney CBD rail line, which connects Chatswood to the Sydney CBD, as the centrepiece of Sydney's modernised rail system.

The project is therefore a key long-term action in the *NSW Long Term Transport Master Plan*, which would improve access and connectivity for the T1 North Shore Line and Sydney Metro Northwest, and improve travel times and capacity through the city from the north and south. The project would provide the largest increase in capacity to the Sydney rail network for 80 years, while proposed new stations within the Sydney CBD would relieve pressure on Central, Wynyard and Town Hall stations.

The *NSW Long Term Transport Master Plan* is accompanied by *Sydney's Rail Future* (Transport for NSW, 2012a), which details how the NSW Government will deliver the core elements needed to give Sydney a world-class rail network that can support the city's growth, which is discussed in Section 3.7.3.

3.7.3 Sydney's Rail Future

Sydney's Rail Future: Modernising Sydney's Trains (Transport for NSW, 2012a) is the NSW Government's long-term plan to increase the capacity of Sydney's rail network by investing in new services and upgrading existing infrastructure. It aims to improve the customer's experience, improve reliability and increase services across the rail network. *Sydney's Rail Future* forms an integral part of the *NSW Long Term Transport Master Plan* (discussed in Section 3.7.2) and once implemented will enable Sydney's rail network to carry another 90,000 to 100,000 people per hour in the peak period across the Sydney CBD rail lines.

Sydney's Rail Future recognises key challenges for Sydney's rail system, including increased demand for rail transport driven by employment and population growth, the limited capability of the current network, capacity constraints, Sydney CBD congestion, the need to support the on-going development of the Sydney CBD, and suburban bottlenecks.

Sydney's Rail Future is based on the NSW Government's strategy to meet customer needs, which include:

- Create a more reliable service
- Get 'Sydneysiders' to work on time
- Maintain a safe, clean and comfortable commuting environment
- Run more services
- Reduce travel times.

Sydney's Rail Future describes the plan to transform and modernise Sydney's rail network based on a three-tiered system, comprising:

- Tier 1 – Metro: 'turn-up-and-go' services with single-deck metro trains
- Tier 2 – Suburban: timetabled services with double-deck trains
- Tier 3 – Intercity: timetabled services with double-deck trains and on-board amenities for long-distance commutes.

3.7.4 Sydney City Centre Access Strategy

The *Sydney City Centre Access Strategy* (Transport for NSW, 2013a) is the NSW Government's plan to deliver a fully integrated transport network in Sydney's city centre that puts the customer first and meets the city's growing transport task. The strategy outlines how people will enter, exit and move in and around the Sydney CBD over the next 20 years and demonstrates how light rail, buses, trains, ferries, cars, taxis, pedestrians and cyclists will interact in the heart of Sydney. The strategy also provides a clear direction for how all the different transport modes will work together in the city centre to:

- Reduce congestion
- Provide for future growth
- Improve the customer experience.

Under the *Sydney City Centre Access Strategy*, rail will remain the dominant mode for getting to the city centre. Key features of the integrated network identified in the *Sydney City Centre Access Strategy* are:

- Light rail on George Street between Central and Circular Quay
- Pedestrianisation of George Street between Bathurst Street and Hunter Street
- Improved pedestrian connections throughout the city centre including Wynyard Walk
- Redesigned bus services with priority routes on Elizabeth Street / Castlereagh Street, Park Street / Druitt Street, Clarence Street / York Street and Hickson Road
- New interchange precincts at Town Hall, Wynyard, Central and Circular Quay, and also at Martin Place and Museum stations
- An integrated cycleway network
- A new ferry hub at Barangaroo
- A new railway line and train stations for the city centre (this project)
- New designated traffic routes through and around the city centre.

The project is a key action in the Sydney City Centre Access Strategy, which identifies the following benefits to the Sydney CBD:

- Unlock the Sydney CBD rail bottleneck and enable more rail services from the west, southwest, Illawarra, Bankstown, North Shore and northwest
- Provide up to an extra 60 train services per hour (30 in each direction) across the harbour and through the city centre
- Create new train stations to relieve pressure on existing crowded platforms in the city centre
- Enable better connections to employment opportunities across Sydney
- Help reduce the number of buses travelling into the city centre from north of the Sydney Harbour Bridge.

3.8 Summary of strategic need and justification

The project has been assessed against key relevant State government policies. This includes:

- The NSW Premier's 30 'State priorities', including 12 'Premier priorities' to grow the economy, deliver infrastructure, and improve health, education and other services across NSW
- *Draft Metropolitan Strategy for Sydney 2031*
- *A Plan for Growing Sydney*
- *Rebuilding NSW: State Infrastructure Strategy 2014*
- *NSW Long Term Transport Master Plan*
- *Sydney's Rail Future: Modernising Sydney's Trains (Sydney's Rail Future)*
- *Sydney City Centre Access Strategy.*

To fulfil the objectives of those policies the assessment indicates that there is a need to:

- Significantly increase transport capacity in key parts of the network, especially to the Sydney CBD and the Global Economic Corridor
- Drive productivity through integrated transport and land use planning to realise 'agglomeration benefits' (agglomeration benefits refer to the productivity benefits firms derive from being located in close proximity to each other, enabling increased interaction between firms with resulting improved productivity through knowledge sharing and collaboration)
- Effectively develop infrastructure to cement Sydney's position among the world's most liveable cities.

The project as part of the broader Sydney Metro network would deliver a step-change in the capacity of Sydney's rail network by providing a fully automated rail system, supporting high demand with a high capacity, turn-up-and-go service. It would provide the largest increase in capacity to the Sydney rail network for 80 years. In particular, the proposed new stations within the Sydney CBD would relieve current significant pressure on Central, Wynyard and Town Hall stations. The proposed new station at Victoria Cross would relieve current pressure and crowding at North Sydney Station.

Working together with major upgrades to the T1 Western Line, the Sydney Metro network would deliver the capacity to increase the number of trains entering the Sydney CBD across the entire Sydney railway system from 120 to about 200 in the busiest hour of the day. This means that the rail network across greater Sydney would have room for an extra 100,000 train customers per hour. The fully automated state-of-the-art Sydney Metro network would have the capacity to operate 30 trains an hour through the Sydney CBD in each direction – a train every two minutes each way.

The Sydney Metro network would significantly improve reliability across the rail network by addressing current and emerging constraints such as train crowding, platform and station crowding, and network complexity. It would be capable of carrying more people, more quickly, than any other form of public transport in Sydney. It would improve travel times for customers by providing more direct connections to higher capacity Sydney CBD stations (such as Martin Place and Pitt Street) and improved interchange capability at key locations such as Central Station, including reduced train and station crowding on the existing rail network. It would also result in benefits for customers using the existing bus network as there would be fewer buses accessing the Sydney CBD.

In addition to the broader Sydney transport operational benefits, the customer experience provided by the project would result in health benefits and an improved customer experience with the creation of safer and more appealing conditions for pedestrians, cyclists and other transit users.

The project would also provide important urban renewal and development opportunities through the application of transit oriented development principles that support government objectives to achieve a more sustainable and efficient use of land to meet Sydney's growth. In particular, Waterloo Station would provide the opportunity for renewal of the areas social housing and increase the supply of new homes close to the Sydney CBD. It would help bring new jobs to the area as well as providing a direct public transport link from Waterloo to employment hubs at Barangaroo and Martin Place.

The project also has the potential to reduce network wide greenhouse gas emissions by providing a lower greenhouse gas alternative for transport compared to private car travel.

3.9 Project objectives

A set of objectives has been developed for the project having regard to the key challenges and the strategic land use and transport policies outlined above. The objectives for the project are:

- Improve the quality of the transport experience for customers
- Provide a transport system that is able to satisfy long-term demand
- Grow public transport patronage and mode share
- Support the productivity of the Global Economic Corridor
- Serve and stimulate urban development
- Improve the resilience of the transport network
- Improve the efficiency and cost effectiveness of the public transport system
- Implement a feasible solution recognising impacts, constraints and delivery risk.

These project objectives are referenced in Chapter 4 (Project development and alternatives) and have been used to guide decision-making during design development. They will also be used to guide decision-making on future design development. Chapter 29 (Justification and conclusions) further justifies the project with respect to its delivery against the above project objectives.

PROJECT DEVELOPMENT AND ALTERNATIVES

CHAPTER FOUR

4 Project development and alternatives

This chapter describes the evaluation process undertaken to determine the preferred option. It includes an overview of the strategic alternatives, the alignment options, and station options. This chapter also identifies the consequences of not proceeding with the project.

4.1 Secretary's environmental assessment requirements

The Secretary's environmental assessment requirements relating to project development and alternatives, and where these requirements are addressed in this Environmental Impact Statement, are outlined in Table 4-1.

Table 4-1 Secretary's environmental assessment requirements – project development and alternatives

Ref.	Secretary's environmental assessment requirements	Where addressed
2. Environmental Impact Statement		
2.1 (e)	an analysis of any feasible alternatives to the project	Strategic alternatives to the project are identified and analysed in Section 4.3.
2.1 (f)	a description of feasible options within the project	Options within the project are described in Sections 4.4, 4.5, 4.6 and 4.7.
2.1 (h)	a description of how alternatives to and options within the project were analysed to inform the selection of the preferred alternative / option. The description must contain sufficient detail to enable an understanding of why the preferred alternative to and options(s) within the project were selected	A description of the alternatives and options process is provided in Sections 4.3, 4.4, 4.5, 4.6 and 4.7.

4.2 Overview of the project development process

A large number of studies have identified and assessed potential transport solutions between northern Sydney and the Sydney CBD, including suburban rail and metro alignments. The potential transport solutions have influenced strategic rail planning in documents such as *Sydney's Rail Future – Modernising Sydney's Trains (Sydney's Rail Future)* (Transport for NSW 2012a) and the *NSW Long Term Transport Master Plan* (Transport for NSW 2012b). Therefore, they have also influenced the development process for the Chatswood to Sydenham project.

4.3 Strategic alternatives

A number of strategic alternatives relevant to a metro rail network were considered during the development of the *NSW Long Term Transport Master Plan and Sydney's Rail Future*. These options were:

- Regulatory, governance and better-use reforms
- Investment in road, bus and light rail
- Rail network options.

These options are discussed below, together with an assessment of their overall effectiveness in meeting Sydney's growing transport needs.

4.3.1 Regulatory, governance and better-use reforms

As an alternative to further investment in Sydney Metro, the NSW Government has considered a range of regulatory, governance and better-use reforms. The reforms could include:

- Regulatory reform (including review of passenger transport legislation to allow for more flexible transport services)
- Governance reform (including centralising transport planning and policy functions within Transport for NSW and integrating land use and transport planning, including for major growth corridors)
- Better-use reform (including continued implementation of the integrated electronic ticketing system; a bus priority system; interchange upgrades; and improvements, expansion and modernisation of train and bus fleets).

While these reforms are vital to meeting the government's policy objectives and are already being implemented, additional investment in transport infrastructure will also be required to ensure Sydney's transport network meets future demand.

4.3.2 Investment in road, bus and light rail

The NSW Government is currently delivering or has delivered a number of road, bus and light rail projects across Sydney as part of the *NSW Long Term Transport Master Plan* (Transport for NSW, 2012b) and the *Sydney City Centre Access Strategy* (Transport for NSW, 2013a). These projects include WestConnex, NorthConnex, the CBD and South East Light Rail, Inner West Light Rail and a number of bus priority projects including the Northern Beaches Bus Rapid Transit project.

However, while investments in road, bus and light rail projects will form part of the solution to Sydney's transport needs, these options are, by themselves, insufficient to address forecast growth in travel demand. This is because of the number of people travelling to the Sydney CBD each day is forecast to grow to 775,000 by 2031, which equates to 116,000 more cars or 2,685 more buses each day.

Sydney's mature road network has limited opportunity for additional capacity to connect in to the Sydney CBD. New roads where possible, e.g. a proposed 'Western Harbour Tunnel' to provide additional cross-regional links, cannot provide the mass transit capacity required to support Sydney's growth.

With respect to buses and light rail, these are complementary modes, bringing customers to and dispersing them from the major transport hubs served by suburban and metro rail services. However, buses and light rail cannot wholly support the large hourly commuter movements required in and out of the Sydney CBD. Buses can potentially provide a flexible response to local demand pressures and light rail offers medium capacity solutions for major transport corridors, replacing lower capacity bus services. However, both modes would not provide sufficient mass transit capacity to address Sydney's transport bottlenecks.

4.3.3 Rail network options

Broad rail network options

Based on projected population growth and transport demand, additional investment in rail is seen as a more efficient and effective solution than other strategic alternatives discussed in Sections 4.3.1 and 4.3.2. In developing *Sydney's Rail Future*, 15 alternative capital investment options for an expansion of the transit network were identified. The 15 options were grouped into four broad options (refer to Table 4-2):

- Rail Future A Use of the existing suburban rail network
- Rail Future B Rebuilding parts of the existing network in order to run single-deck metro trains
- Rail Future C A metro rail system that would integrate with the existing rail network
- Rail Future D An independent metro rail system that would not integrate with the existing rail network.

Each option was strategically assessed against a number of evaluation criteria. These criteria included their ability to meet customer requirements; network capacity requirements; ability to improve network resilience; delivery risk; and cost effectiveness. A two-step process was used to select the preferred strategic option.

The first step involved an assessment of whether existing rail operations should be expanded and improved to provide continued operation of a double-deck fleet with a two-tiered system of suburban and intercity services (Rail Future A) or whether a separate, independent 'differentiated' network should be constructed to provide metro 'turn-up-and-go' services (Rail Future B, C and D). An assessment of these two options found that a metro service is required to meet demand in both the short and long term. Rail Future B requires conversion of the T1 North Shore Line services across the Harbour Bridge and rebuilding of other parts of the existing network, resulting in major disruptions and inconvenience for customers would impact on network reliability and resilience. Accordingly, Rail Future A and Rail Future B were discarded and not further evaluated.

The second step involved an analysis of the differentiated service options that would best deliver against the assessment criteria. Criteria applied when assessing differentiated service options included delivery of capacity increases in key sections of Sydney's rail network; high-quality service levels and provision of significant improvements in operational reliability required to service Sydney's growth. The analysis found that Rail Future C would be superior to Rail Future D as it provides interchange potential with the existing network, so Rail Future D was discarded.

Table 4-2 The four rail network options considered in Sydney's Rail Future

Option	Key features
Rail Future A – suburban option	This option would involve the use of the existing double-deck rolling stock on the existing network, including for all future expansions (ie a second harbour crossing). This option would have a capacity of 20 trains per hour per direction (or 24,000 people per hour per direction). However, this option could not meet the long-term capacity and service improvements required by the *NSW The Long Term Transport Master Plan* and would not meet customer expectations for reliability, improved journey times and convenience.
Rail Future B – rebuild option	This option would involve rebuilding parts of the existing network in order to run single-deck metro trains. It would require conversion of the T1 North Shore Line services across the Harbour Bridge and major upgrading of the existing Sydney CBD infrastructure and stations. Although rebuilding the existing network would improve capacity in the medium term, it would not meet demand in the long term because capacity would be restricted to the current single train line across Sydney Harbour. Conversion of the existing line to accommodate a metro rail network would need to occur while maintaining existing services (to the extent possible), and would result in major disruptions and inconvenience for customers for a number of years. Further, the existing stations at Town Hall and Wynyard are already congested and an increase in the number of services using these stations would impact on network reliability and resilience and affect customer safety.
Rail Future C – Sydney's Rail Future (Sydney Metro network)	This option would involve construction of a metro rail network that would operate independently of the existing rail network; however, it would provide integration and interchange points with the existing rail network. New infrastructure would mainly be used; however, a section of Sydney Metro Northwest (historically referred to as the Epping to Chatswood Rail Line) and the existing rail line between Sydenham and Bankstown would be converted to metro and form part of the metro network. This option includes a second crossing of Sydney Harbour and a new underground line within the Sydney CBD. Interchanges would be provided at key stations (eg Chatswood and Central). Rolling stock would be designed to provide faster boarding and alighting, which would reduce dwell and journey times.
Rail Future D – an independent transit system	This option would operate independently and not integrate with the existing rail network. It would require construction of a harbour crossing and a Sydney CBD line. This option would only benefit customers along the new lines and would not adequately address the future requirements of the rail network. It would result in marginal benefits in terms of service enhancement, capacity improvements and improved operating efficiency on the existing rail network. It would also be the most expensive of the four options and would divert funding from service improvements on the rail network.

Why Sydney Metro was selected

Rail Future C (referred to from this point as Sydney Metro, and incorporating the whole proposed Sydney Metro network) was selected as the preferred rail network option because it would:

- Be more flexible and provide frequent services that would benefit customers
- Provide the required capacity and flexibility to respond to growing demand for rail in Sydney
- Create a more modern, resilient and faster service
- Deliver a seamless and less disruptive way of modernising Sydney's rail
- Deliver transport benefits more cost effectively.

Benefits of Sydney Metro

In terms of expanding capacity on the rail network, Sydney Metro would substantially expand capacity on Sydney's most constrained transport corridors and eliminate dependence on the Harbour Bridge as the only mass transit harbour crossing between the North Shore and the Sydney CBD.

The new cross-harbour rail capacity combined with new stations on the North Shore and in the Sydney CBD would also allow for a reduction in buses crossing the Harbour Bridge, offering the potential for substantial reductions in congestion at North Sydney, Wynyard and Town Hall stations and a reduction in road congestion in Sydney's CBD.

The introduction of a metro station at Waterloo would also be consistent with, and would further realise the benefits of Rail Future C.

South of Central Station conversion of the Bankstown line between Sydenham and Bankstown

The full delivery of Sydney Metro, including Sydney Metro Northwest from Cudgegong Road and Sydney Metro City & Southwest extending to Bankstown, was identified as a strategic option in *Sydney's Rail Future*.

Various options were considered for the southern and western component of the Sydney Metro network beyond Central Station.

Converting the T3 Bankstown Line between Sydenham and Bankstown into a dedicated metro line would improve rail network reliability by reducing the number of rail lines sharing the same existing tracks and would facilitate much needed capacity increase from the west and southwest. The Sydenham to Bankstown upgrade would unlock capacity at Central Station platforms and enable the relocation of train paths on the City Circle. It would also significantly reduce platform and train crowding.

The T3 Bankstown Line does not share operations with other lines or rail freight. It would therefore be less complex to convert and segregate from the existing rail network when compared with other lines. The T3 Bankstown line would require less infrastructure work to convert to a metro service when compared with other lines, such as the T2 South Line and T4 Illawarra Line, which would require additional tunnels and tracks, significant enabling works such as alternative freight routes and a new train stabling and maintenance facility for Sydney Trains.

The decision to proceed with a conversion of the T3 Bankstown Line to a metro service led to the alignment of the project from south of Central Station to just north of Sydenham Station.

The Sydenham to Bankstown upgrade, including work at Sydenham Station will be subject to a separate environmental assessment process.

4.4 Station location options

The station options evaluation process used to determine preferred station locations involved a number of stages, each with an increasing level of detailed analysis. The project objectives (refer to Section 3.9) underpinned the evaluation criteria used in the options evaluation process.

The evaluation of station location options has followed a three-phase process:

- Phase 1 – This involved the identification and assessment of a long list of 34 station options to ensure all possible metro station locations were considered. Some potential station options were grouped into station localities to reflect their close proximity to each other. This resulted in 20 station localities being subject to a preliminary station assessment. Of the 20 localities, 13 were shortlisted for further evaluation
- Phase 2 – This involved detailed evaluation of the 13 short-listed station localities and identified a preference for two North Shore station localities and three CBD station localities
- Phase 3 – This involved stakeholder and community consultation on the preferred station localities and the identification of additional station locations seen as having merit to enhance the project and increase project benefits.

The evaluation of station locations is described in more detail in the following sections.

4.4.1 Phase 1 – evaluation of long list station location options

Initially a long list of 34 station options was identified. The selection of preferred station locations on North Shore required a different approach to the selection of station locations in the Sydney CBD that were more heavily influenced by alignment constraints such as building basements. Station locations between Chatswood and Sydney Harbour were identified as 'North Shore' station locations and station locations between Sydney Harbour and Central were defined as Sydney CBD station locations.

Of the 34 options, some were grouped into station localities to reflect their close proximity to each other. This resulted in 20 station localities being subject to a preliminary station assessment. Of the 20 localities, 13 were shortlisted for further evaluation. These locations are shown in Figure 4-1. The evaluation resulted in the removal of seven station locations from further assessment, as discussed in Table 4-3.

Table 4-3 Preliminary station location options that were not shortlisted for further evaluation

Station option	Rationale for not being short-listed for further evaluation
Willoughby and Naremburn	These stations would be located in residential areas with small centres. While these locations would result in a new rail catchment area, they would not serve or stimulate development.
Wollstonecraft and Waverton	The existing suburban rail stations at these locations serve a small residential catchment (comprising detached housing and strata development and a metro station would not serve a new rail catchment.
North Sydney	The existing North Sydney Station is constrained and would not serve a new rail catchment.
Milsons Point	The existing suburban rail station at Milsons Point serves a small residential catchment (characterised by detached housing and strata development). There are a number of heritage constraints at this location (including the Harbour Bridge – an item of outstanding national heritage significance).
Hickson Road (Dawes Point)	Although a station in the north Hickson Road area (at Dawes Point) would introduce public transport to an area currently with limited access, there is only a small catchment (population and employees) that would use the station.

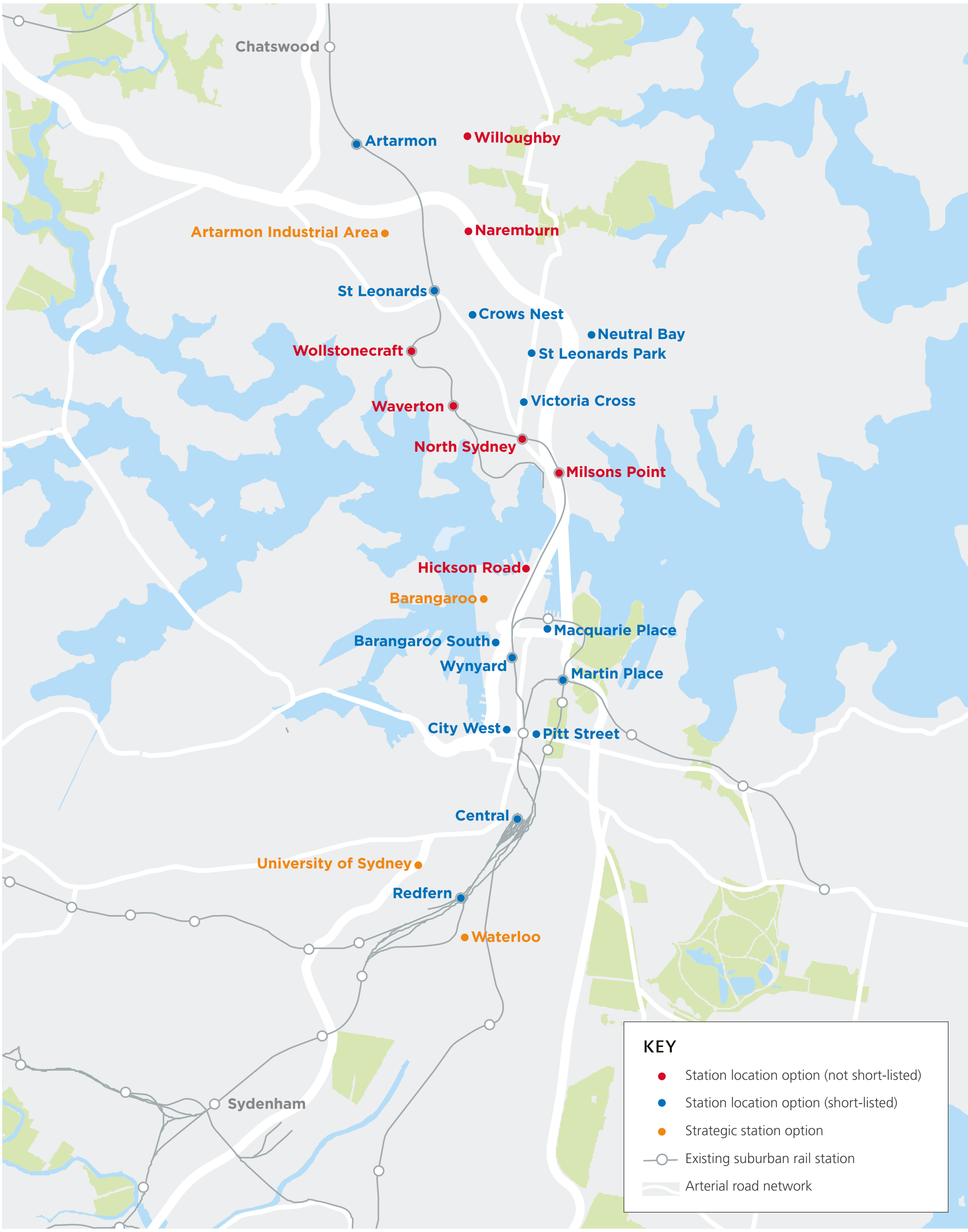

Figure 4-1 Preliminary station location options

4.4.2 Phase 2 – evaluation of short-listed station location options

Evaluation process

Phase two involved detailed analysis of the 13 short-listed station localities. Each of the remaining localities was evaluated against the project objectives using the process shown in Figure 4-2.

The process resulted in the selection of the preferred station location options ('base case' station locations).

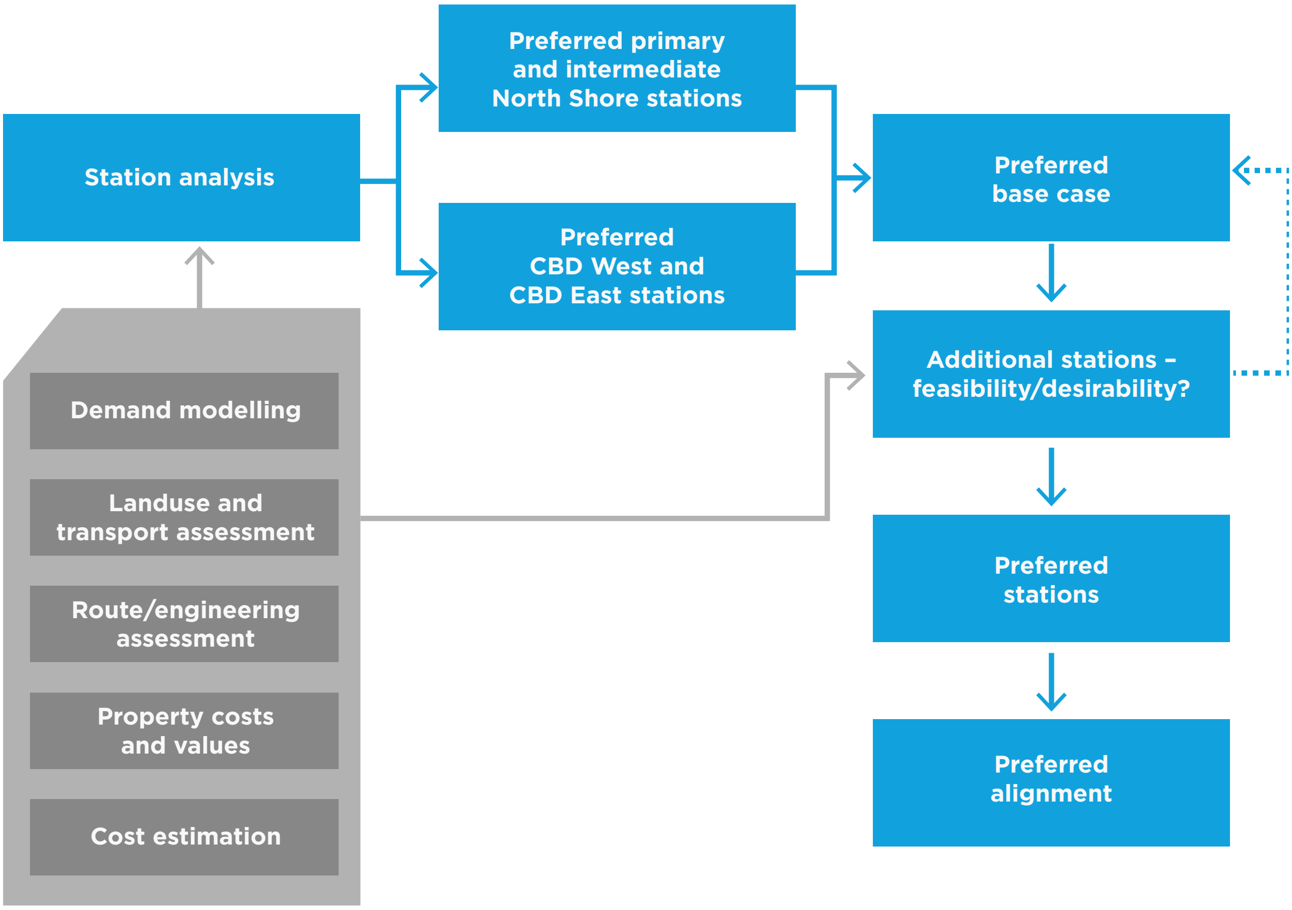

Figure 4-2 Process for evaluating the short-listed station locations

The performance of each of the remaining station locations was assessed against each of the objectives as either 'positive alignment' (green), 'some alignment, or neutral' (orange) or 'no alignment, or negative impacts' (red), as shown in Figure 4-3.

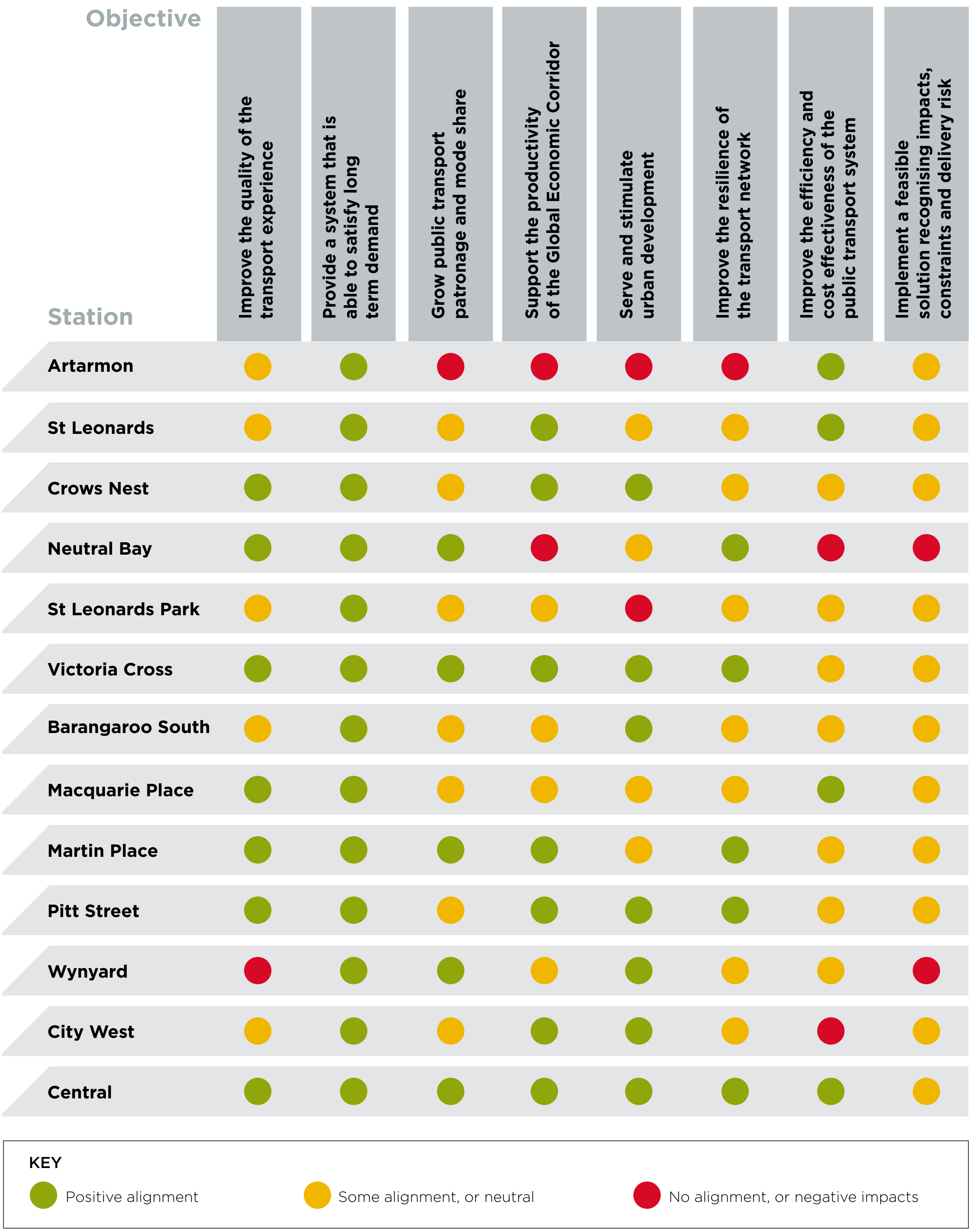

Figure 4-3 Performance of each short-listed station location against the project objectives

Findings of the short list evaluation process

The Artarmon, Neutral Bay and Wynyard station options were discarded as all performed poorly in the evaluation against more than one of the Sydney Metro project objectives. Artarmon is already served by a station on the Sydney Trains network and a metro station at Artarmon would not extend the rail catchment or provide significant travel times savings for customers. A station at Neutral Bay would not support the growth of the Global Economic Corridor and would not substantially improve public transport services for the Northern Beaches and Military Road corridor. Further, the locality was found to have a moderate ability to serve and stimulate development, particularly employment growth and only a moderate ability to serve major attractors.

Providing metro platforms at Wynyard Station would place further pressure on already constrained footpaths and underground connections around Wynyard Station, and would increase customer transfers at an already congested station.

St Leonards Park and City West also performed poorly on at least one of the objectives. St Leonards Park was subsequently compared with the alternative station at Victoria Cross. Victoria Cross was considered superior as it has a greater catchment area and a greater potential for residential, commercial and transit oriented development. St Leonards Park also has a number of heritage and environmental issues and was consequently discarded.

Further review of City West and Barangaroo South stations indicated that they would have a smaller current and potential future catchment than other Sydney CBD locations such as Martin Place. They would also have a number of physical constraints including the Cross City Tunnel alignment that would influence the location and depth of the stations, resulting in a material impact on the overall project cost. Given the relative advantages of alternative Sydney CBD stations (and a Sydney CBD eastern alignment) these stations were subsequently discarded.

A station at St Leonards would meet all the project objectives. However, further consideration indicated that, relative to a station at nearby Crows Nest, it would not extend the rail catchment and all future employment and dwelling growth would be within the existing rail catchment which is already well connected by public transport. In addition, construction of the station would cause disruption to existing customers during construction, and environmental and social issues associated with a tunnel boring machine launch site located close to sensitive receivers including the hospital. Sporting teams that utilise Gore Hill Oval would also need to be relocated. Accordingly St Leonards was not considered further as a preferred location for a metro station.

A station at Macquarie Place would meet all the project objectives. Compared to other Sydney CBD station locations Macquarie Place would have a smaller catchment and would overlap with the existing Circular Quay Station catchment, which already provides direct connections to Wynyard, Town Hall and Central stations and beyond. Accordingly Macquarie Place was not considered further as a preferred location for a metro station.

Crows Nest and St Leonards station options both performed well against the majority of the project objectives. These were carried forward for further investigation as part of Phase 3.

The preferred station locations are described in Chapter 7 (Project description – construction). During the development of preferred station designs a number of alternative station configurations may be considered. The station configurations may be reviewed for a number of reasons, including:

- Orientation of station buildings and associated infrastructure to provide effective and efficient access for customers, accessibility of station entry points, and integration with surrounding land uses
- The need to minimise environmental and property impacts
- Constructability
- The need to not preclude the potential for future over station development.

Preferred station locations

Based on the assessment of the short-listed stations, a decision was made to proceed with a project incorporating new metro stations at Crows Nest / St Leonards, Victoria Cross, Martin Place and Pitt Street, as well as new metro platforms at Central Station.

4.4.3 Phase 3 – additional station options

This phase involved stakeholder and community consultation on the preferred station localities and the identification of additional station location options, which were seen to have the potential to strategically enhance the project. This included further evaluation of a station location at either Crows Nest or St Leonards and the potential introduction of an additional metro station at the following locations:

- At Barangaroo
- In the Artarmon Industrial Area
- Between Central and Sydenham.

These additional station options, described below, were included because they would serve strategic transport needs.

Crows Nest or St Leonards

Based on further evaluation of both options and stakeholder and community feedback, the preferred station location is at Crows Nest. The Crows Nest Station location best meets the needs of this area by ensuring the new metro station is as close as possible to the St Leonards centre while also extending the rail catchment.

Barangaroo

A station at Central Barangaroo (as opposed to Barangaroo South, as discussed in Section 4.4.2) would serve the Barangaroo development and potentially some of the catchment area for Wynyard Station given connectivity improvements in the area associated with projects like Wynyard Walk.

Given the flexibility of the metro tunnel alignment, the provision of a metro station in the central to northern part of Barangaroo is possible while also providing a station at Martin Place.

The station would deliver a unique east west connection between Martin Place and Barangaroo, resulting in improved travel times between Barangaroo and other Global Economic Corridor centres, service special events and reduce future passenger demand on suburban rail platforms at Wynyard Station.

A station at Barangaroo would benefit from the high-quality public domain and amenity to be delivered as part of the broader Barangaroo development. It would connect the Central Barangaroo precinct to the metro network with cultural facilities, Barangaroo Reserve and entertainment within five minutes' walk and the Barangaroo South precinct within 10 minutes' walk. It would also provide a connection to the public domain and entertainment activities at East Darling Harbour. A station at Barangaroo would also service a residential catchment at Millers Point, Walsh Bay and future residents at Barangaroo.

A number of constraints have been considered during the development of sub-options and in the selection of the preferred location for a metro station at Barangaroo. The preferred location and station typology (cut-and-cover vs mined) of Barangaroo Station would have the following benefits:

- It would promote access to the Barangaroo precinct
- It would optimise the balance between station cost and customer outcomes (station depth, travel times, etc)
- It would minimise or avoid impacts on heritage items in the area including Millers Point Conservation Area, the Walsh Bay Wharves Precinct and the Millers Point / Dawes Point Village Precinct, although noting potential archaeological heritage significance as outlined in Chapter 14 (Non-Aboriginal heritage) and Chapter 15 (Aboriginal heritage).

A reference design for Barangaroo Station was assessed against the project objectives listed in Section 4.3.2. Considering that assessment (refer to Figure 4-4) and further consultation with key stakeholders, a station at Barangaroo has been included as part of the Sydney Metro project.

The preferred Barangaroo Station location and configuration has been selected to avoid conflicts with other Barangaroo developments; contain (as far as possible) the station entry and facilities building in the Barangaroo development site and allow for the efficient location of tunnel services and emergency facilities at the ends of the station.

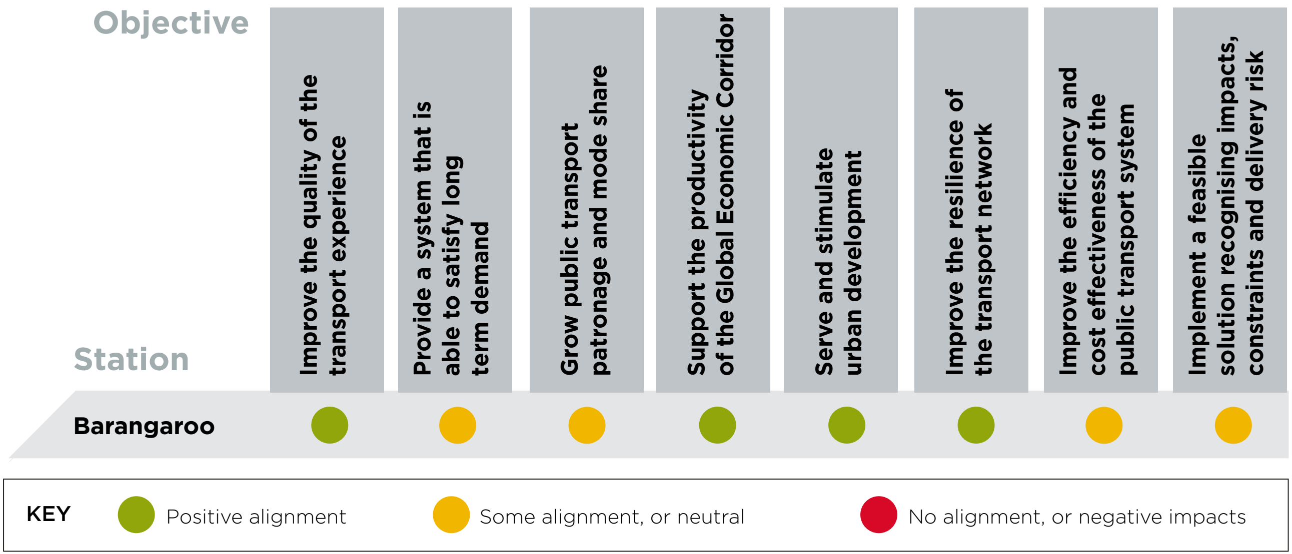

Figure 4-4 Performance of Barangaroo Station location against the project objectives

Artarmon Industrial Area

A station in the Artarmon Industrial Area would facilitate easier access to Artarmon employment areas and result in greater opportunities for commercial, mixed use and higher density residential dwellings.

There is a clustering of traditional light industrial activities, as well as specialist activities such as health and media. The Artarmon Industrial Area is uniquely located with high-quality access for medium and large vehicles, and with a substantial buffer between industry and residential uses. The area supports over 11,000 jobs, has low vacancy and high rents. It has an estimated contribution of $1.6 billion to the NSW economy each year.

The benefits of a station at this location are dependent on the realisation of urban renewal opportunities in the area. However, consultation with major stakeholders indicated that there was limited support for such a major land use change.

The importance of the wide range of industrial uses was recognised. The area would therefore retain its industrial uses, employment and services, resulting in a low demand for transport and a poor return on investment for a station in this area. The performance of an Artarmon Industrial Area Station was assessed against the project objectives (refer to Figure 4-5). Given the high cost of construction of an underground station, and limited ability to serve and stimulate urban development and relieve the existing transport network, an Artarmon Industrial Area Station was not considered further.

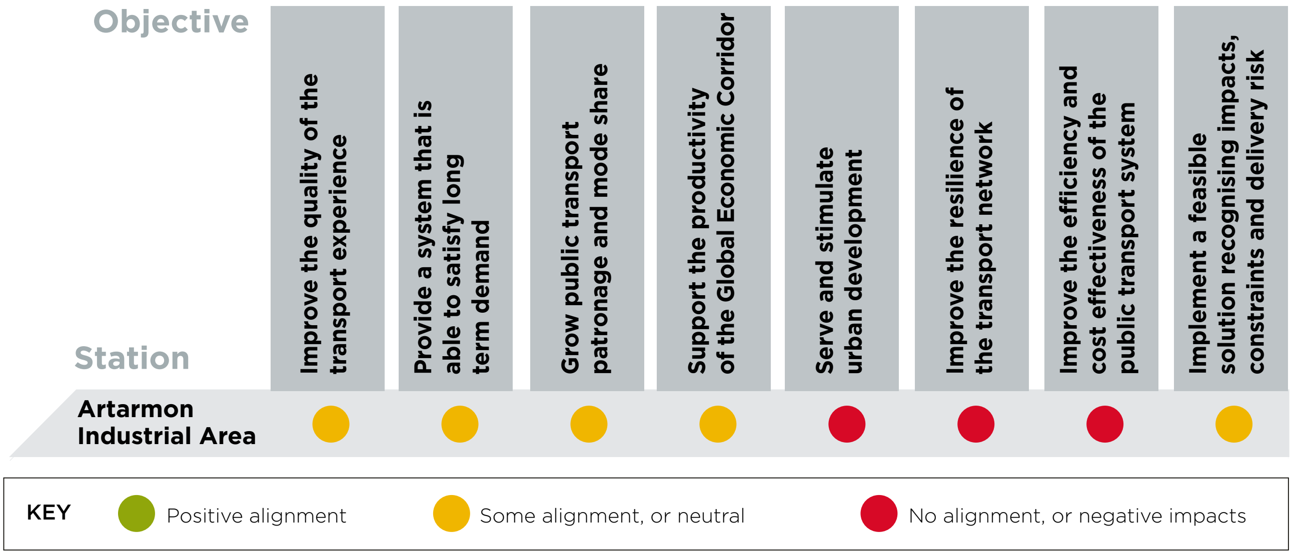

Figure 4-5 Performance of Artarmon Industrial Area Station against the project objectives

A station between Central and Sydenham

A long list of 12 station options was identified for the area between Central and Sydenham. An assessment of these station options against the project objectives was carried out (refer to Figure 4-6).

The assessment identified that new underground metro stations at Erskineville, Green Square, St Peters and Newtown would not serve a new rail catchment and would result in a limited shift to public transport services. Further, these locations would not serve or stimulate new development. As a result these stations were discarded.

Whilst a station at Doody Street would support a new rail catchment and would provide relief to existing bus services, a tunnel alignment associated with this station was considered unreasonable (due to its length and presence of tight curves) and this station was not considered further.

Due to their proximity to existing rail stations, the new rail catchment at Ashmore, Australian Technology Park and Wilson Street (Eveleigh) would be limited, resulting in a limited shift to public transport. Stations at Ashmore and Wilson Street (Eveleigh) would not provide any significant relief to existing public transport services. As such, these station options were also discarded.

Redfern was discarded as a metro station location because suburban rail connections already exist at Central and Redfern stations (that is, Central and Redfern also offers connections to intercity trains and other modes). Redfern also has some construction and technical issues including constraints with the existing station layout and heritage constraints.

McEvoy Street was also discarded as a metro station as is would not provide relief to the existing transport network, and the land use changes in the area would occur regardless of a metro station.

Based on the outcome of the assessment, it was decided to further consider two locations between Central and Sydenham (The University of Sydney and Waterloo).

Station \ Objective	Improve the quality of the transport experience	Provide a system that is able to satisfy long term demand	Grow public transport patronage and mode share	Support the productivity of the Global Economic Corridor	Serve and stimulate urban development	Improve the resilience of the transport network	Improve the efficiency and cost effectiveness of the public transport system	Implement a feasible solution recognising impacts, constraints and delivery risk
Ashmore	Some alignment or neutral	Some alignment or neutral	No alignment, or negative impacts	Some alignment or neutral	No alignment, or negative impacts	No alignment, or negative impacts	Some alignment or neutral	Some alignment or neutral
Australian Technology Park	Some alignment or neutral	Some alignment or neutral	Some alignment or neutral	Some alignment or neutral	Some alignment or neutral	Positive alignment	Some alignment or neutral	Some alignment or neutral
Doody Street	Positive alignment	Some alignment or neutral	Some alignment or neutral	Positive alignment	Positive alignment	Positive alignment	Some alignment or neutral	Positive alignment
Erskineville	No alignment, or negative impacts	Some alignment or neutral	No alignment, or negative impacts	No alignment, or negative impacts	No alignment, or negative impacts	Positive alignment	Some alignment or neutral	No alignment, or negative impacts
Green Square	Positive alignment	Some alignment or neutral	Some alignment or neutral	Positive alignment	Some alignment or neutral	Positive alignment	Some alignment or neutral	Some alignment or neutral
McEvoy Street	Positive alignment	Some alignment or neutral	Positive alignment	Positive alignment	Positive alignment	Positive alignment	Some alignment or neutral	Some alignment or neutral
Newtown	Some alignment or neutral	Some alignment or neutral	No alignment, or negative impacts	No alignment, or negative impacts	Some alignment or neutral	Positive alignment	Some alignment or neutral	No alignment, or negative impacts
Redfern	No alignment, or negative impacts	Some alignment or neutral	Some alignment or neutral	Some alignment or neutral	Some alignment or neutral	No alignment, or negative impacts	Some alignment or neutral	No alignment, or negative impacts
St Peters	No alignment, or negative impacts	Some alignment or neutral	No alignment, or negative impacts	No alignment, or negative impacts	No alignment, or negative impacts	Positive alignment	Some alignment or neutral	No alignment, or negative impacts
The University of Sydney	Positive alignment	Some alignment or neutral	Some alignment or neutral	Positive alignment	Positive alignment	Positive alignment	Some alignment or neutral	Some alignment or neutral
Waterloo	Positive alignment	Some alignment or neutral	Positive alignment	Positive alignment	Positive alignment	Positive alignment	Some alignment or neutral	Some alignment or neutral
Wilson Street (Eveleigh)	No alignment, or negative impacts	Some alignment or neutral	No alignment, or negative impacts	Some alignment or neutral	Some alignment or neutral	No alignment, or negative impacts	Some alignment or neutral	No alignment, or negative impacts

KEY

Positive alignment Some alignment or neutral No alignment, or negative impacts

Figure 4-6 Performance of station options between Central and Sydenham against the project objectives

The University of Sydney or Waterloo

The University of Sydney is located between Parramatta Road and City Road and close to other arterial roads such as Cleveland Street and Glebe Point Road. The university is a key education precinct and is also close to health and retail precincts such as Royal Prince Alfred Hospital and the Broadway shopping area.

Waterloo is a centre for community and cultural activity and is a growing residential area, with business activity increasing in recent years. The NSW Government has earmarked Waterloo for greater residential development and urban renewal.

A station at Waterloo would take pressure off Redfern and Green Square stations and provide local residents with more public transport options, while encouraging the introduction of new homes, jobs, parks and community facilities to meet the needs of a growing Sydney.

A new metro station at Waterloo would help revitalise the Waterloo precinct and would also:

- Provide a high quality connection with bus services along Botany Road
- Provide additional connectivity to Australian Technology Park and Redfern Station
- Contribute to the NSW Government objective to transform Waterloo and Redfern.

The metro station would also allow further development and expansion of the Global Economic Corridor between the Sydney CBD and Green Square.

Outcomes of strategic options assessment

Based on the assessment of the strategic options against the project objectives, Sydney Metro decided to:

- Include a station at Crows Nest
- Include an additional station at Barangaroo
- Not include a station in the Artarmon Industrial Area
- Include a station at Waterloo.

4.5 Alignment options

4.5.1 Influences on the project alignment

The alignment of the Chatswood to Sydenham project has been influenced by:

- Previous investigations (refer to Section 4.2)
- Station locations
- Design criteria such as vertical and horizontal alignment requirements
- A decision on a Sydney CBD east or Sydney CBD west alignment
- Avoidance of underground constraints such as deep basements and major utilities.

More recent alignment options (based on possible station location combinations) are shown in Figure 4-7.

4.5.2 Sydney CBD east or Sydney CBD west alignment

A number of studies have focused on rail / metro alignments through the Sydney CBD. These have been separated into eastern and western options and hybrids of the two. As a result of these previous studies, two protected corridors have been previously created through the Sydney CBD – the CBD Rail Link corridor and the CBD Metro interim rail corridor.

Key issues considered in the selection of the alignment (in the context of metro rail network performance parameters) included the point of connection with the existing rail network in the north and south, and the preferred Sydney CBD station locations. As discussed in Section 4.4.3, given the flexibility of the metro tunnel alignment, the provision of a metro station in the central to northern part of Barangaroo was not an influencing factor in the selection of a Sydney CBD east or a Sydney CBD west metro alignment.

Both the CBD east and CBD west alignment options identified a combination of new and augmented existing stations:

- The eastern alignment included a new station at Martin Place and at Pitt Street (between Park and Bathurst streets) and an augmented Central Station
- The western alignment included an augmented Wynyard Station, a new City West Station (between Town Hall Station and Darling Harbour) and an augmented Central Station.

The evaluation process resulted in the eastern alignment being preferred based on a number of factors:

- The separation of the metro rail network from the existing rail network, especially at Wynyard Station (eastern alignment), means the project could accommodate long-term future demand (of up to 30 trains per hour in the morning peak period across Sydney Harbour)
- The inclusion of a Wynyard metro station (western alignment) would increase pedestrian numbers and congestion within the Wynyard precinct beyond what would otherwise be expected in 2036; and by about 13,000 additional passenger exits in the morning peak period
- Augmentation of existing operational stations (western alignment) would have substantial constructability issues and result in additional construction costs and an extended construction program (Central Station is the only station augmentation required for the Sydney CBD eastern alignment)
- New stations along the eastern alignment would provide better interchange opportunities (Martin Place Station with the T4 Eastern Suburbs Line, and Pitt Street Station with buses, light rail and Town Hall Station). These interchange opportunities would better relieve passenger demand at critical stations including Martin Place and Town Hall.

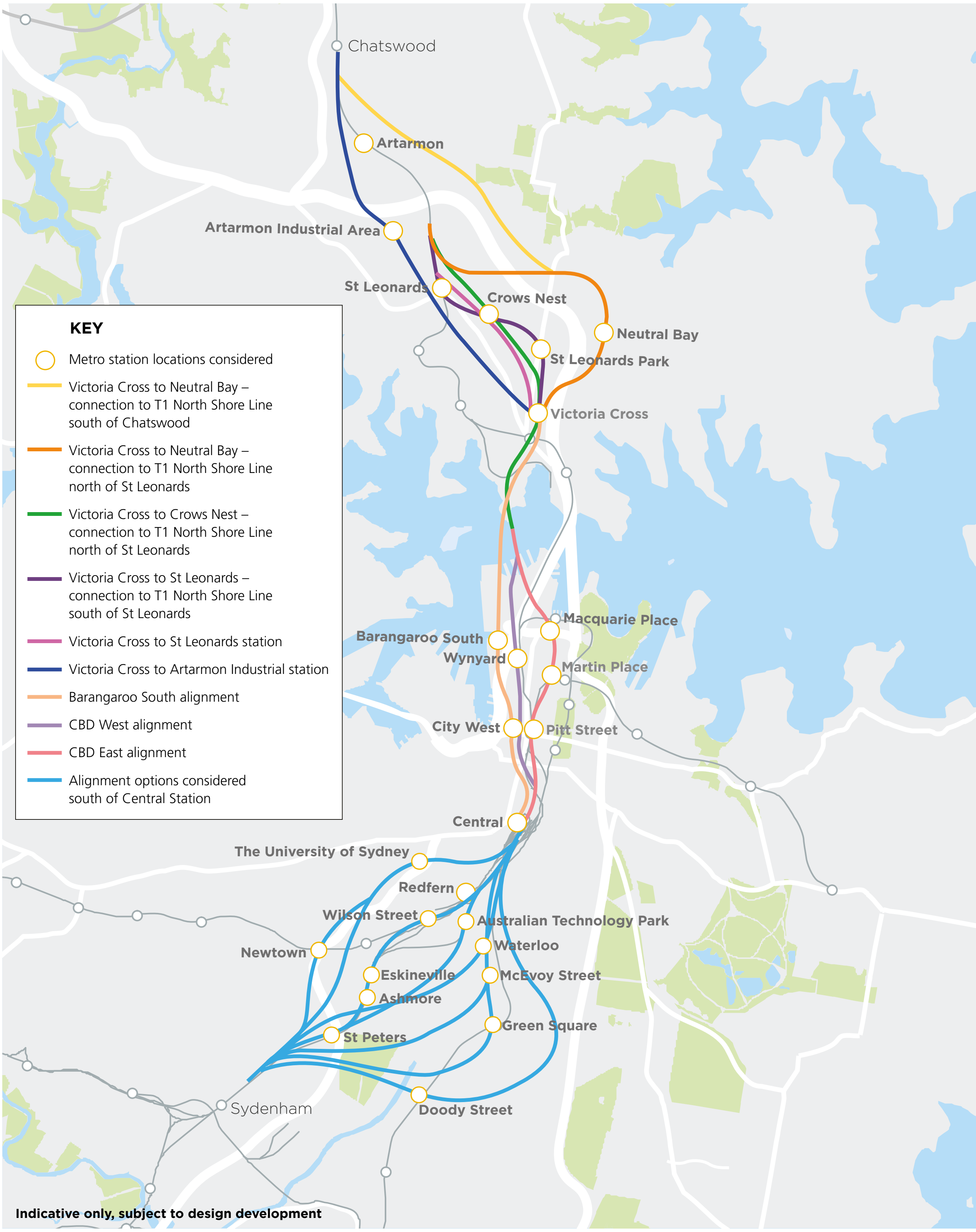

Figure 4-7 More recent alignment options considered based on possible station location combinations

4.6 Crossing of Sydney Harbour

Aboveground and underground options were considered for crossing Sydney Harbour. These included:

- A new carriageway beneath the Sydney Harbour Bridge
- A new rail viaduct above lanes seven and eight of the Sydney Harbour Bridge
- Conversion of lanes seven and eight of the Sydney Harbour Bridge to accommodate metro rail
- An immersed tube tunnel resting on the seabed
- Bored tunnels below the seabed through rock
- Bored tunnel below the seabed through rock and sediments.

4.6.1 Aboveground options

Options to install a new carriageway beneath the Sydney Harbour Bridge or to install a new viaduct above lanes seven and eight were found to have a number of constraints, such as impacts on (reductions to) shipping heights and / or substantial modification to the Sydney Harbour Bridge, which is a major landmark and a listed place on the National Heritage List. These options would also have broader network impacts during construction and operation (particularly in terms of access to the Sydney CBD for other transport modes). Consequently, these options were not progressed further.

The conversion of lanes seven and eight to accommodate the metro network would require connections to metro tunnel alignments to the north and south of the Harbour Bridge. Unlike the tunnel option (see below), use of the Sydney Harbour Bridge would require the use of existing suburban rail stations and platforms at North Sydney and Wynyard. The use of existing infrastructure for the project would largely result in replication of the existing T1 North Shore Line and would not provide additional rail services to new areas. Further, using existing infrastructure would have operational limitations; in particular, this option could not meet long-term capacity requirements (that is, there would be less than 30 trains per hour) and would result in longer journey times than a new tunnel. In addition, using the Sydney Harbour Bridge is estimated to cost substantially more than the preferred bored tunnel option (by over $400 million).

4.6.2 Underground options

Options investigated for underground crossing of Sydney Harbour included an immersed tube tunnel, bored tunnels through the bedrock and bored tunnel through a combination of bedrock and sediments. These options are shown on Figure 4-8.

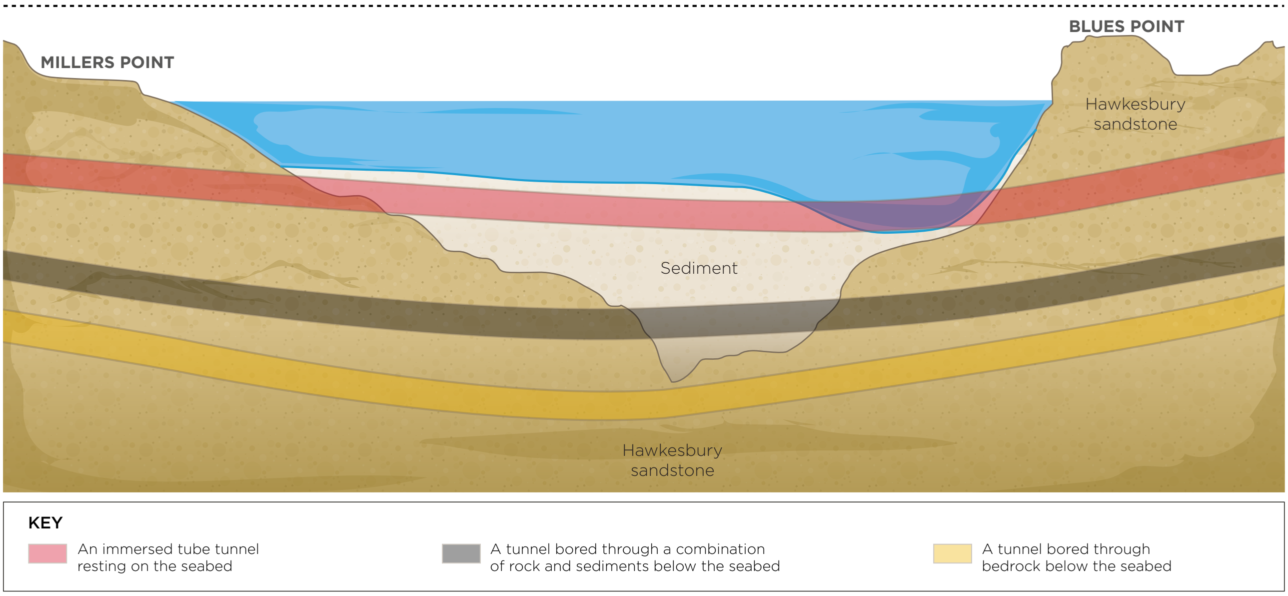

Figure 4-8 Sydney Harbour crossing vertical alignment options considered

A comparative assessment was carried out for these options. It found that:

- An immersed tube option is a favourable option in terms of station depth and tunnel gradient, but the likely environmental impacts associated with dredging and cofferdam construction in the harbour would be considerable, as compared with the tunnel boring machine options. Costs are also likely to be significantly higher than the bored tunnel options
- Given the depth to rock below the harbour, a tunnel bored entirely through rock would result in unacceptable station depths at Barangaroo and at Victoria Cross and / or unacceptable tunnel gradients
- Keeping the tunnel alignment wholly within rock would still likely require a specialised tunnel boring machine for the Harbour Crossing due to the anticipated poor rock quality and high water pressure
- A shallower tunnel involving tunnelling through rock and sediments would result in acceptable station depths. Whilst there would be some construction risks associated with tunnelling through sediments and transition zones from rock to sediment, they are considered to be manageable. The options for managing these transition zones from rock to sediment are discussed in Section 4.6.3.

Given these factors, a bored tunnel through a combination of bedrock and sediments was selected as the preferred option for crossing Sydney Harbour.

4.6.3 Sydney Harbour sediment ground improvement options

The need for ground improvement

Ground improvement (treatment to solidify sediments and other non-rock material), especially at rock-sediment transition zones has been considered for a number of construction-related reasons. Ground improvement would reduce construction risk to workers, prevent damage or excessive wear of cutter tools and allow for inspection of the tunnel boring machine cutter head prior to driving through the rock – sediment transition zones.

Specifically, ground improvement would:

- Reduce safety risks for construction workers by avoiding the need to undertake tunnelling in high pressure (up to 5 bar) environments
- Minimise risks associated with ground instability and / or air-loss issues of rock-sediment transition zones.

The feasibility of a tunnel below the harbour through rock and sediments was subject to detailed investigations including advice from a number of international tunnelling experts. Based on this advice it was concluded that it would be practical to tunnel below Sydney Harbour through rock and sediments using either a traditional slurry tunnel boring machine or a mix-shield tunnel boring machine.

Area targeted for ground improvement

Ground improvement would require the establishment of a grout zone (solid block of cementicious material about 35 metres wide by 20 metres long by 16 metres deep) at the two points where the tunnel alignment passes through a sediment-rock transition zone.

The proposed grout zone would need to extend from about six metres above the tunnel profile to about three metres below the tunnel profile and about six metres either side of both the tunnel profiles. The maximum depth of grouting is estimated at about 40 metres.

The feasibility of different types of ground treatment has been investigated as described below.

Ground treatment options considered

Ground improvement by jet grouting

Jet grouting would involve the injection of a cement grout and would need to be carried out from barges on the harbour. The grout would be delivered to the barges from an on-shore facility and would be injected from the barge via a crane and drilling lead. The use of barges would introduce a number of construction challenges, in addition to logistical issues associated with maintaining open shipping channels.

Jet grouting would result in a smaller physical footprint on the bed of the harbour compared with deep soil mixing (see below) and can better target the necessary treatment zone compared with deep soil mixing techniques.

Ground improvement by deep soil mixing

Deep soil mixing would involve the mechanical mixing of the harbour sediments with a cementitious slurry in order to form columns. Similar to the jet grouting approach, this method would need to be carried out from barges on the harbour, with deliveries of grout via barges.

Deep soil mixing would result in greater disturbance of the bed of the harbour compared to the jet grouting method and, potentially, result in the need to carry out ground improvement over a larger area than jet grouting.

Ground improvement by ground freezing

Ground improvement by ground freezing would involve installing about 24 drill pipes around the circumference of both tunnel alignments and circulating liquid nitrogen through the pipes to freeze all material present at the two rock-sediment transition zones. While this option would have less environmental impact on Sydney Harbour than jet grouting or deep soil mixing, this technique:

- Requires a large construction footprint at Blues Point and / or Barangaroo to support drilling operations and the laying out of drill pipes
- May not be a suitable solution where soft silty material needs to be treated or if the strength of the tunnel bedding material also requires improvement.

This option would also have the greatest construction costs.

Outcome of review of ground treatment options

Following review of the benefits and limitations of each ground improvement technique, jet grouting from barges or deep soil mixing were both considered feasible, however jet grouting would have less overall impact than deep soil mixing.

Based on the current understanding of the project, jet grouting is considered to be the most likely option for ground improvement works should they be required. As such, this approach has been assessed as part of this Environmental Impact Statement. Notwithstanding, ground freezing may be a feasible option depending on the future development of the project and construction techniques.

Further details regarding ground improvement construction methods are provided in Chapter 7 (Project description – construction).

4.7 Dive structures options

A dive structure is required where the surface track transitions to underground tunnel. These would be required near Chatswood (northern dive structure) and just north of Sydenham Station (southern dive structure), as discussed below.

4.7.1 Northern dive structure

Northern dive structure options

Due to a number of factors, including topography, proximity of adjacent infrastructure, engineering requirements, there are limited options for the northern dive structure location. The five options considered were:

- A dive commencing immediately south of St Leonards Station, transitioning into a tunnel north of River Road (St Leonards Option 1)
- A dive north of St Leonards Station, commencing about 100 metres north of the road bridge at Lambs Road, Artarmon (near the Francis Street / Station Street intersection), transitioning into a tunnel about 90 metres south of Lambs Road (near the Francis Street / Park Road intersection) (St Leonards Option 2)
- A dive commencing immediately south of Chatswood Station:
  - transitioning into a running tunnel located within the rail corridor, north of Mowbray Road (Chatswood Option 1)
  - transitioning into a tunnel portal located outside the rail corridor (eastern side), north of Mowbray Road (Chatswood Option 2)
  - transitioning into a tunnel portal located outside the rail corridor (western side), north of Mowbray Road (Chatswood Option 3).

Evaluation of northern dive structure options

The locations of these options are shown in Figure 4-9. Factors influencing the location of the northern dive and tunnel portal include:

- The length of new tunnel versus the extent of work required to accommodate metro tracks within the existing rail line, impacts on existing infrastructure and the extent of 'associated infrastructure' work required
- Interface with existing Sydney Trains and Sydney Metro Northwest operations
- Property impacts including the extent and type of property acquisition required
- Environmental constraints and potential community and business impacts
- Constructability considerations, including customer disruption associated with rail network impacts
- Preferred station locations, particularly in respect of whether a station would be located at Artarmon, St Leonards and / or Crows Nest (this is discussed further in Section 4.4).

Given that Crows Nest has been identified as the secondary North Shore station for Sydney Metro, a dive south of St Leonards Station was discarded based on a number of factors including journey time impacts, adverse environmental and community impacts (particularly during construction), and vertical and horizontal alignment limitations (that is, the tunnel alignment could not meet design requirements and access a Crows Nest station location).

Options to locate a dive structure immediately south of Chatswood Station were preferred over a dive north of St Leonards Station. These options would place a majority of the alignment below ground from Chatswood Station, delivering the following benefits:

- Minimise acquisition of non-government property
- Avoid a complex and prolonged construction interface around Artarmon Station, thereby avoiding substantial customer, community and business impacts in Artarmon
- Avoid direct impacts on the heritage listed Artarmon Station and Artarmon Heritage Conservation area
- Avoid impacts on Sydney Blue Gum – Blackbutt – Smooth-barked Apple moist shrubby open forest on shale ridges (a critically endangered ecological community listed on the NSW *Threatened Species Conservation Act and Commonwealth Environment Protection and Biodiversity Conservation Act*) that is located next to (and east) of the rail line between Artarmon Station and the Gore Hill Freeway
- Reduce construction complexity and risks and operational interfaces by, as much as possible, separating Sydney Metro assets and infrastructure from existing operational Sydney Trains assets
- Reduce the extent of noise walls required along the existing rail corridor by over one kilometre.

Given these benefits, a dive north of St Leonards Station was discarded in favour of a Chatswood dive option.

As shown in Figure 4-9, the three Chatswood dive options share a northern start point, with the primary difference between them relating to the tunnel alignment and portal orientation in the south. A tunnel portal located on the western side of the rail corridor (Chatswood Option 3) was identified to have a number of technical, operational and community benefits over the other two options. It would:

- Avoid acquisition of residential properties
- Avoid impacts on a heritage listed item and Chatswood Heritage Conservation Zone
- Reduce the extent, intensity and duration of construction work next to and impact upon operational Sydney Trains assets
- Avoid impacts to Mowbray Road Bridge during construction
- Provide for the establishment of a tunnel support site away from surrounding residential properties, which would reduce construction noise and other amenity impacts on adjacent receivers
- Substantially reduce construction costs compared to Chatswood Option 1 (Chatswood Option 2 would have a similar construction cost to Chatswood Option 3).

Notwithstanding these benefits, Chatswood Option 3 would have a number of impacts, including:

- The need to permanently close the road bridge at Nelson Street
- Acquisition of an Ausgrid property, containing one heritage listed property (‘Mowbray House’ located at 339 Mowbray Road) and a number of business properties along the eastern side of the Pacific Highway (571 585 Pacific Highway)
- Acquisition of up to five commercial premises
- The need to tunnel beneath a heritage listed water reservoir, a substation and a communications tower
- Impact on a major Telstra utility adjacent to the Ausgrid facility / rail corridor boundary.

On balance, Chatswood Option 3 was preferred over Chatswood Options 1 and 2 as this option represents the best balance between environmental, economic, social and engineering requirements.

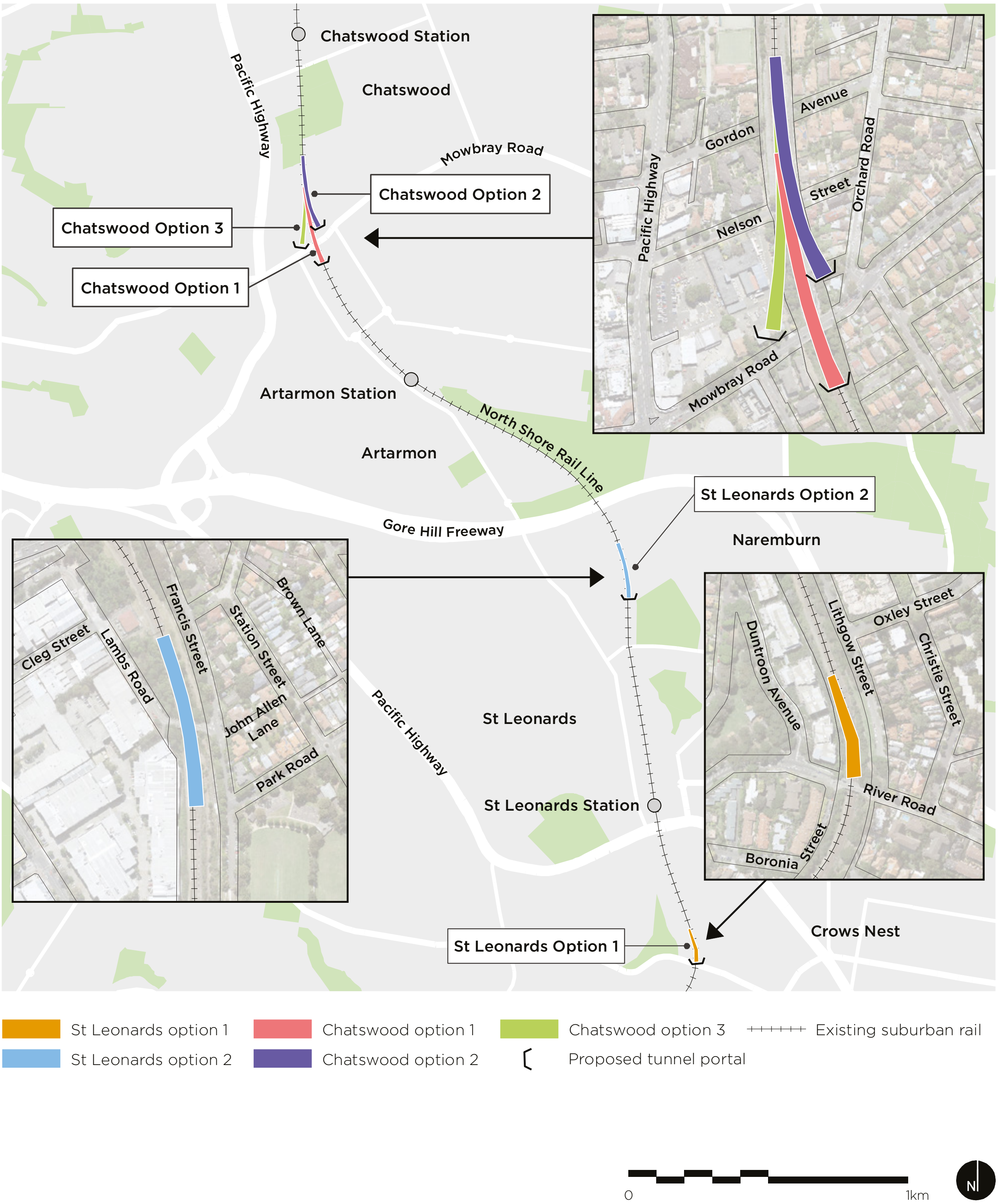

Figure 4-9 Northern dive structure options

4.7.2 Southern dive structure

Southern dive structure options and evaluation

In a broad sense the location of the southern dive structure is determined by the decision to convert the T3 Bankstown Line to Sydney Metro (refer to Section 4.3.4). This decision led the need to transition back to a surface level track in the area between Central Station and Sydenham Station.

Options for the location of a southern dive structure close to Central Station are limited by:

- Suitable available land within and adjacent the suburban rail corridor (between Central and Sydenham stations) to accommodate additional tracks
- Maximum allowable vertical track grades (which influence the length of transition of the tunnel from an underground station at Central to the surface).

Surface track options between Central and Sydenham stations would require widening of the rail corridor and significant property acquisition to accommodate the additional metro tracks and other infrastructure, including noise walls.

A tunnel option is preferred over a surface option as it would considerably reduce direct and indirect impacts on properties adjacent to the existing rail corridor (such as property acquisition, noise and vibration from surface rail operations and visual amenity impacts associated with new overhead wiring and rail infrastructure). The most suitable location for the dive structure between Central and Sydenham stations was identified as the Marrickville industrial area in order to avoid significant residential property acquisition, and avoid the potential noise impacts of a surface metro line within residential areas.

Locally around the Marrickville industrial area options to the west and east of the existing rail corridor were considered. A dive structure to the east of the rail corridor would:

- Be located closer to residential receivers on Unwins Bridge Road
- Require the metro tracks to cross the T4 Eastern Suburbs and Illawarra Line tracks to the south of Sydenham Station. This would result in unnecessary structures and impacts to rail track grades, or operational inefficiencies from tracks crossing at-grade.

Based on these factors, a dive structure to the west of the existing rail corridor was identified as the preferred option as it would:

- Allow for the desired alignment and future conversion of the T3 Bankstown Line to a metro service
- Minimise property acquisition
- Be located as far as practical from residential receivers
- Enable the efficient integration of the Metro network into the existing rail corridor whilst minimising potential impacts to other existing rail lines.

4.8 Consideration of alternatives during station design development

After the selection of metro stations was complete, the design development phase commenced. This involved the identification of the specific location of the stations and the above ground and below ground station footprints. Constructability issues were also considered in this phase. In the case of Martin Place and Central stations, the sensitivity and construction challenges associated with the proposed locations required a more detailed consideration of configuration options. These are discussed below.

4.8.1 Design development of Martin Place Station

The location of Martin Place Station

The station at Martin Place is intended to serve Sydney's financial district and the civic spaces and uses along Martin Place and Macquarie Street. Convenient interchange between the proposed metro station and the existing Martin Place Station is a key locational driver. Designing for Martin Place as a 'one station solution' that provides station-to-station interchange within the paid concourse areas of both stations places a geographical constraint on the station's location.

The specific location of the proposed Martin Place Station has also been influenced by a number of other key constraints. These include:

- Underground constraints such as basements and other services and infrastructure that influence the tunnel alignment and depth and therefore the location and orientation of the station itself
- Minimising impacts to heritage buildings and places, including direct and indirect impacts to the Commonwealth Bank building and the existing Martin Place Station, which are heritage items listed on the State Heritage Register
- Minimising impacts to, and optimising integration of the station with the public domain of Martin Place, a major civic spine that is a focus of the City of Sydney's *Martin Place Urban Design Study*.

The above constraints have resulted in the separation of the northbound and southbound tunnel alignments generally beneath Castlereagh and Pitt streets respectively; two station footprints (rather than one) that increase the offset distance from the Commonwealth Bank Building; and the provision of station entrances that avoid the direct use of Martin Place.

Design and layout of Martin Place Station

Secondary constraints and challenges that have influenced the design and layout of Martin Place Station include:

- Accommodating large pedestrian volumes and the need for convenient and safe connections into the broader precinct
- The provision of adequate pedestrian circulation spaces to accommodate increased pedestrian volumes
- The provision of adequate space for construction of the project
- Not precluding over station development at station sites.

Over 10 options were been developed for the design and layout of Martin Place Station that are located in the area bound by Bligh, King, Castlereagh and Pitt streets. These options differed in the following general ways:

- Single or multiple station entrances with corresponding street level footprints
- Station layouts to optimise station entry locations and street level footprint size, including within the public domain of Martin Place, at various locations along Castlereagh Street and Elizabeth Street, Hunter Street and Bligh Street
- The number of station entrances and their specific location and orientation within the various station footprint configurations.

The preferred option includes platforms south of Hunter Street between Castlereagh and Elizabeth streets with two street level footprint areas incorporating station entries: at the Hunter Street corners of Elizabeth and Castlereagh streets; and the Martin Place corners of Elizabeth and Castlereagh streets. Refer to Chapter 6 (Project description – operation) for more detail.

Discounted options did not perform as well as the preferred option for the following reasons or combination of reasons:

- Options that proposed one station footprint resulted in unacceptable customer outcomes and / or pedestrian level of service. Limited footpath widths on Castlereagh Street exacerbated this situation for many options. Some of these options also precluded provision for future over station development and resulted in poor urban design outcomes
- Some of the options that minimised the size of the street level footprint did not provide adequate station functionality and also resulted in unacceptable construction constraints, including poor construction efficiency based on limited space and challenges for construction site access
- Options that proposed direct access via Martin Place were not preferred because they did not meet pedestrian level of service requirements and would not be consistent with the objectives for Martin Place outlined City of Sydney's *Martin Place Urban Design Study*
- Some options did not provide suitable offset from the Commonwealth Bank building resulting in poor urban design outcomes and increased risk of impacts to this building
- Some options with predominantly northern street level footprints did not meet the 'one station solution' objective with regard to interchange functionality with the existing Martin Place Station.

The preferred option best optimises the number, size and location of street level footprints and station entries to:

- Respond to the major customer movement and desire lines to and from the station
- Relieve pedestrian congestion within Martin Place and complement objectives outlined in the Martin Place Master Plan
- Provide suitable space for potential future over station development while minimising the number of private properties required to ensure an adequate footprint for construction and operation of the station
- Provide a superior underground interchange with the existing Martin Place Station and although technically challenging, minimise direct impacts to the fabric of the existing State Heritage listed station.

4.8.2 Design development of Central Station

The development of Central Station over time has led to a configuration that makes day-to-day use of the station difficult, resulting in a number of sub-standard features such as difficult way-finding, and access and capacity constraints. These include changes in levels between different areas of the station and long customer routes. Consultation with Sydney Trains and other stakeholders has been undertaken in the development of the design for Central Station. This has influenced options developed for the design of the station; supporting infrastructure requirements and construction methodology.

Why metro platforms at Central?

Central Station is the busiest station in the Sydney transport network, providing key interchange for suburban and intercity rail services, light rail, bus, taxi and intercity coach services. Central Station has a large catchment comprising education, commercial and residential land uses. Having Sydney Metro services at Central Station reinforces the role of Central Station as the primary transport interchange for Sydney and also recognises the potential for the area around Central to be the civic, economic and community focus of the southern Sydney CBD.

Sydney Metro would build on the significant transport investments being made at Central, including the CBD and South East Light Rail project. The new metro platforms would support and enhance Central Station's historical role as the major interchange in the Sydney transport network and further build on the interchange functionality of the station.

As shown in Figure 4-3, compared with all other short-listed station locations, metro platforms at Central perform best against the identified project objectives. Metro platforms at Central Station would provide a number of benefits, including:

- Direct servicing of a large employment catchment with considerable growth forecast
- Efficient and direct connection to metropolitan-wide suburban rail services, inter-city services, light rail services and bus and coach services.

Based on the assessment of the short-listed stations, a decision was made to proceed with a project incorporating new metro platforms at Central Station.

Location of the metro platforms at Central Station

A number of locations were investigated for the provision of Sydney Metro platforms at Central Station. These included:

- Utilising existing disused platforms on the eastern side of the existing station
- Constructing the metro platforms on the eastern side of the existing station below Elizabeth Street
- Constructing the metro platforms on the western side of the existing station below the western forecourt
- Constructing new metro platforms in the centre of the station below existing platforms 13 to 15.

The introduction of underground metro platforms at Central Station would have material impacts to the station irrespective of the option chosen. Decision-making on the placement of the underground metro platforms seeks to balance the substantial benefits with the recognised constraints and challenges associated with its introduction.

Recognised constraints and challenges that required detailed consideration and management include:

- Maintaining acceptable customer accessibility and amenity during construction
- Ensuring acceptable customer outcomes during operations
- Ensuring the reliability of existing network operations while construction is occurring within an operational transport interchange
- The need for reliable ongoing access across operational rail for pedestrians and vehicles during construction and operation
- Minimising impacts to the State heritage significant Central station, including the curtilage which extends beyond existing building footprints.

Options to locate the metro platforms on the eastern side of Central Station below Elizabeth Street did not maximise the efficiency of interchange for customers between metro and suburban and intercity rail and other transport modes. Other concerns related to potential property impacts, heritage impacts and the required depth of the new platforms, which would affect the quality of the transport experience for customers.

Options that would utilise the existing disused platforms were discounted because of the inability to achieve a tunnel alignment that would not impact the T4 Eastern Suburbs and Illawarra rail line, and an Ausgrid cable tunnel. Although the platforms themselves could accommodate the metro trains, there would be sub-optimal customer outcomes with respect to the customer environment (light and space, comfort) and connectivity (distance to interchange). There would also be technical challenges for the provision of platform screen doors and other fire and life safety infrastructure (including provision of suitable ventilation systems and emergency egress).

Options to locate the new metro platforms below the western forecourt of Central Station were discounted because this location did not maximise the efficiency of interchange for customers between metro and suburban and intercity rail and other transport modes. Metro platforms at this location would also have potential impacts on known items of heritage and archaeological significance.

The proposed location for the new underground platforms below platforms 13 to 15 at Central Station has been selected for the following key reasons:

- It provides the most efficient interchange for customers between suburban and intercity platforms (and associated travel time benefits)
- The interchange and travel time benefits result in customer preference for interchange at Central Station rather than at Wynyard or Town Hall stations, providing congestion relief at these stations
- It best encourages the use of Sydney Metro as a service, resulting in a reduction in the use of crowded Central Station suburban platforms such as platforms 16 and 17.
- It allows for an efficient construction method (shallow cut-and-cover arrangement) that minimises construction duration and disruption to customers using Central Station.

Design development of the station services building

All metro stations include services infrastructure to support metro operations. A key design driver at Central Station has been to place the services infrastructure only at the southern end of the metro platforms to:

- Avoid conflicts between customers entering the metro and the services infrastructure (and its maintenance), which improves functionality and pedestrian circulation
- Minimise heritage and visual impacts of services infrastructure near the grand concourse and supports the integration of the station with the existing station (provides a better transport product through the provision of a clear and uncluttered access / exit point to the metro stations for customers)
- Allow for maintenance of the services building directly via the Sydney Yard Access Bridge from the south of Sydney Yard, minimising disruption to operation at Central Station.

Design for the provision of all station services at the southern end of the metro platforms is influenced by the length of the station. A shorter station requires a higher above-ground services building to accommodate all services infrastructure, whereas a longer station allows for a less visually intrusive above-ground services building (about a 50 per cent reduction in height).

The design of the station services building results in the removal of the heritage listed garden, the Rolling Stock Officers building and the Cleaners Amenities building in Sydney Yard. Options to avoid impacts to the Cleaners Amenities building were considered, however all options would result in:

- Sub-optimal operational outcomes for maintenance activities (a key restriction given the metro station at Central would be one of the busiest interchange stations on the metro network) and restricting space for emergency services access to the metro station
- Poor design outcomes that would result from a reduced services building footprint and retention of the Cleaners Amenities building immediately adjacent to the proposed infrastructure
- An unworkable construction arrangement for Central Station platforms that would overly restrict station excavation activities near the building, preclude over-size deliveries that would be required at the site (including ventilation fans and other large pre-cast station elements) and limit the functionality of the main construction access for the station.

Considering operational efficiency and the balance of impacts generated and those minimised or avoided, the design option for a longer station and reduced height services building is preferred.

Design considerations for the northern emergency egress and draught relief infrastructure

Design standards require emergency egress at the north and south of every station and require access be to a relatively open area. The proposed design includes provision for northern emergency egress in the location of the existing maintenance access ramp from Eddy Avenue. This is preferred because it best meets the design requirements while minimising direct infrastructure impacts within Central Station. It also minimises conflict with existing station operations (in both construction and operation phases).

Draught relief is required at the both ends of the station to support operational performance and efficiency, including to manage air pressure and temperatures within the station and tunnels and to minimise energy use in operation. Northern draught relief is proposed in the same location as the northern emergency egress. Provision of a single point for draught relief at the southern end of the station was considered, however was discounted because it would have greater impacts associated with a larger construction footprint, require substantial additional operational energy, and result in sub-standard performance.

Design considerations for access to Sydney Yard

Sydney Yard is the rail infrastructure staging area bounded by inter-city rail lines to the west, suburban rail lines to the east and Central Station and Sydney Terminal to the north. Access to Sydney Yard is currently limited to a primary access / exit via Eddy Avenue and the tracks adjacent to platform 15 (limited to medium-sized vehicles) and a secondary (infrequent) at-grade access over the inter-city rail lines for heavy vehicles during track possessions via the bus layover facility on the western side of Central Station. Access to Sydney Yard via Eddy Avenue would be removed as a result of the project.

Alternative permanent heavy vehicle access to Sydney Yard would be required to allow for ongoing operations and maintenance of the Sydney Trains and NSW Trains network and metro infrastructure.

A 'do nothing' option would not result in an acceptable outcome and a new access from Eddy Avenue would not be possible based on the constraints introduced by the location of the metro platforms and restrictions to access that will be created by the CBD and South East Light Rail that uses Eddy Avenue.

Other options considered for the provision of an alternative access to Sydney Yard included:

- Formalising the at-grade access via the bus layover facility. This option was not preferred as access would not be 'all hours' as is the case with the Eddy Avenue access (ie still be restricted to possession periods) and would result in conflict with buses using the layover facility
- Underground access via the bus layover facility on the western side of Central Station. This option was not preferred because:
  - the required horizontal geometry and vertical grades could not be achieved
  - it would likely require cut-and-cover construction with additional track possessions and disruption to the rail network
  - it has the potential to introduce additional constraints to the provision of future infrastructure at Central Station
  - it would result in conflict with buses using the layover facility.

- Underground access via Prince Alfred Park. This option was not preferred because:
  - the required horizontal geometry and vertical grades could not be achieved
  - it would likely require cut-and-cover construction with additional track possessions and disruption to the rail network
  - it has the potential to introduce additional constraints to the provision of future infrastructure at Central Station
  - it would be constrained by the alignment of the existing T4 Eastern Suburbs Line tunnel
  - it would require the use of a large area of Prince Alfred Park, permanently reducing the area of available public open space
- An access bridge from Regent Street to Sydney Yard. This option was preferred because:
  - it best accommodates the operational access requirements of Sydney Trains, NSW Trains and Sydney Metro
  - it minimises construction risk and disruption to the operational rail network during construction and does not affect the bus layover facility
  - can be introduced to support construction of the underground platforms at Central Station, thereby minimising the extent of long term track possessions and overall disruption at Central Station
  - improves customer safety by removing construction and operational access away from the main station entrance thereby separating activity from the heavily congested operational station environment.

Station excavation methodology

The metro platforms at Central Station are proposed to be excavated using a cut and cover technique (see Chapter 7 (Project description – construction) for more information). Some other metro stations would be constructed using a mined technique. While a station cavern could be constructed using a mined technique with a shaft located remotely, cut and cover construction would always be required at the station site to facilitate construction of the necessary vertical transport and services infrastructure.

Temporary pedestrian footbridge

Construction of the underground platforms at Central Station using a mined or cut-and-cover technique requires excavation through the existing underground pedestrian connections. A temporary pedestrian footbridge is therefore required to maintain pedestrian connections between above ground platforms (see Chapter 7 (Project description – construction) for more information). A temporary above-ground pedestrian footbridge is preferred because:

- A 'do nothing' option results in unacceptable outcomes for rail customers due to substantially increased interchange times and significant and unsafe levels of congestion at key circulation points around the existing station based on reduced options for transfer and access and exit from each platform
- Retention of the existing underground pedestrian connections 'in situ' would require staged construction of the metro platforms which would increase construction risks, substantially extend the duration of construction within Central Station and also be substantially more expensive to construct.

The above-ground temporary pedestrian footbridge extends between, and connects to each of platforms four to 23 because other connection options (such as above-ground connection only between platforms 12 and 16) would result in:

- Customers having to transfer over three vertical levels rather than two (resulting in associated increases to interchange times)
- Unacceptable safety outcomes for customers on heavily congested platforms and at key circulation points within the station.

As with other elements affecting Central Station, an above-ground temporary footbridge would be subject to further design development in order to minimise impacts to heritage fabric.

Minimising impacts at Central Station

As identified above, a new access for Sydney Yard would be required due to the removal of the existing access via Eddy Avenue. The Sydney Yard Access Bridge is the preferred solution for this new access. On balance, metro platforms below existing platforms 13 to 15 would have reduced heritage impacts compared with other metro station locations considered. The metro platforms at Central Station have been subject to ongoing design development to optimise the performance of the station while minimising impacts, including heritage impacts, to the existing station and adjacent heritage items.

The design has minimised the extent of metro station services and other infrastructure in the northern part of the station to reduce the footprint within the existing Central Station northern concourse and below the Bradfield Building (former Lost Property Office). The design of the station services building has also been refined to minimise the bulk and scale of above ground infrastructure that in turn, reduces visual impacts and changes within the setting of heritage items. The design of metro infrastructure at Central Station, including the Sydney Yard Access Bridge, is ongoing and would minimise direct impacts as well as impacts to the setting of adjoining and nearby heritage items. It would be developed in consultation with Sydney Trains and the Heritage Council of NSW and would be subject to review by the Sydney Metro Design Review Panel, including periodic independent review by an appropriately qualified and experienced heritage architect.

4.9 Consequences of not proceeding with the project (do nothing)

Demand on much of Sydney's rail network is nearing capacity during the morning and evening peak periods. In particular, demand on the T1 North Shore, Northern and Western Line experiences heavy train loads at peak times and is forecast to grow at 2.9 per cent a year over the next 10 years. Patronage will continue to grow as land is released or rezoned along the Sydney Metro Northwest corridor.

Changes in patronage growth will exacerbate crowding at Central, Town Hall, Wynyard and Chatswood stations and on the T1 North Shore, Northern and Western Line. When Sydney Metro Northwest opens in 2019, the T1 North Shore, Northern and Western Line will be operating almost at capacity during the morning peak period, with many customers on individual services experiencing crowded conditions.

By 2026, demand for rail transport will grow to a total of 237,000 trips in the morning peak (representing a 41 per cent increase in travel demand). The existing transport system cannot provide the capacity to accommodate this forecast growth as:

- The road and bus networks are already heavily constrained and cannot be effectively augmented to accommodate the additional capacity required
- Sydney's rail network is complex and becoming more crowded and less reliable (the growth in the demand for rail travel to the Sydney CBD alone is expected to increase by 31 per cent by 2026).

Even with the additional services provided by Rail Future A and Rail Future B of *Sydney's Rail Future* (refer to Section 4.3.3), the rail network will run out of capacity at some point during the mid to late 2020s.

To ensure continued growth in productivity, cater for forecast employment and population growth, and sustain the city's liveability, Sydney's transport capacity will need to substantially increase. This is particularly important given the leading role Sydney plays in the Australian economy.

The consequences of delaying the delivery of the project are as follows:

- Insufficient transport capacity will prevent Sydney from reaching its economic potential, leading to worse economic outcomes for the State and nation
- Sydney's transport network will not provide the minimum standard of service expected by rail customers and there will be major impacts on the operational efficiency, reliability and capacity of the suburban rail network in the medium to long term.

These consequences are outlined in Table 4-4.

Table 4-4 Consequences of not proceeding with the project

Problem	Impact per year
Broader challenges for Sydney	
• Constrained economic productivity and growth • Constrained employment and population growth • Reduced access to major employment and activity centres • Reduced connectivity between activity centres	• Lost economic benefits: $2.0 billion per year on average over 30 years • Lost economic value-add in the corridor by 2036: including $5.2 billion in the Sydney CBD • Jobs lost: 44,000 in the Global Economic Corridor by 2036 (3500 per year) • Reduced population growth in key areas. By 2036: 1950 less people in the Sydney CBD • Reduced competitiveness between Sydney and other Australian cities such as Melbourne and Brisbane.
Sydney's transport network problems	
• Increasing transport demand • Road network congestion • Bus network at capacity	• Additional public transport travel time: 12.7 million passenger hours per year (weighted) • Additional road users: 20,000 driver and passenger trips (2036 AM peak) • Cost of road congestion: 5.9 million vehicle hours per year (weighted).
Sydney's rail network problems	
• Network complexity • Capacity constraints • Increased train crowding • Increased platform crowding • Longer dwell times • Reduced reliability	• Increased rail demand to the Sydney CBD impacting existing Central, Town Hall, Martin Place and Wynyard stations: 6733 per year (2026 AM peak) • Increased train services required: six per year • Increased train crowding: 3.3 million passenger hours (weighted) in 2026, increasing in severity each year thereafter • Increased station crowding: 8.4 million hours by 2026 (weighted) • Reduced reliability: 5.1 million hours per year by 2026 (weighted).

Further details on the need and justification of the project taking into account all issues considered in this Environmental Impact Statement are provided in Chapter 29 (Justification and conclusion).

STAKEHOLDER AND COMMUNITY ENGAGEMENT

CHAPTER FIVE

5 Stakeholder and community engagement

This chapter provides an outline of the consultation carried out on the project, and how this has influenced the project and the scope of the Environmental Impact Statement. It identifies who has been consulted, how the consultation was carried out, the issues raised and how those issues have been addressed.

5.1 Secretary's environmental assessment requirements

The Secretary's environmental assessment requirements relating to stakeholder and community engagement, and where these requirements are addressed in this Environmental Impact Statement, are outlined in Table 5-1.

Table 5-1 Secretary's environment assessment requirements – stakeholder and community engagement

Ref.	Secretary's environmental assessment requirements	Where addressed
4. Consultation		
4.1	The project must be informed by consultation, including with relevant government agencies, infrastructure and service providers, special interest groups, affected landowners, businesses and the community. The consultation process must be undertaken in accordance with the current guidelines (NSW Sustainable Design Guidelines Version 3.0 (TfNSW, 2013b)).	Details of consultation carried out to inform the project development are provided in Sections 5.4 and 5.6. Further details are provided in Appendix C.
4.2	The Proponent must document the consultation process, and demonstrate how the project has responded to the inputs received.	Details of consultation carried out to inform the project development are provided in Sections 5.4 and 5.6. Further details are provided in Appendix C.
4.3	The Proponent must describe the timing and type of community consultation proposed during the design and delivery of the project, the mechanisms for community feedback, the mechanisms for keeping the community informed, and procedures for complaints handling and resolution.	Consultation which has occurred during the development of design to date is described in Section 5.4. Consultation proposed during ongoing design and delivery is described in Section 5.7.

5.2 Overview

The stakeholder and community consultation process for Sydney Metro City & Southwest has played an integral role in informing and scoping investigations for this Environmental Impact Statement.

In June 2014, the NSW Government announced that Sydney Metro City & Southwest (formally Sydney Rapid Transit) would extend Sydney Metro Northwest (formally North West Rail Link) under Sydney Harbour, through the Sydney CBD and on to Bankstown.

Engagement with the community and stakeholders began in June 2014 and has continued through the preparation of the Environmental Impact Statement. This was not a statutory consultation process, but was carried out by Sydney Metro to proactively engage with the community during the Environmental Impact Statement process.

Key stakeholders for the project include (but are not limited to):

- State agencies (eg Department of Planning and Environment, Roads and Maritime Services, CBD Coordination Office, Environment Protection Authority, NSW Office of Water, Port Authority of NSW, Sydney Water and Office of Environment and Heritage)
- Local government (Willoughby City, Lane Cove, North Sydney, City of Sydney and Marrickville councils)
- Public utilities, and business and industry groups near the project
- Directly impacted communities
- The broader community.

This chapter provides an overview of the consultation activities to date and identifies future consultation activities. Further details can be found in Appendix C (Stakeholder and community engagement report).

5.3 Communication objectives

Transport for NSW has been and continues to be interested in community and stakeholder feedback on the project. The Sydney Metro communication objectives include to:

- Communicate the rationale for the project and the broader network benefits it would deliver, including how it fits into the NSW Government's plans to increase Sydney's rail capacity
- Communicate the Sydney Metro concept and timing
- Build community and key stakeholder relationships and maintain goodwill
- Provide information about the planning approvals process and encourage community participation
- Clearly communicate the corridor protection and property acquisition process.

The project team has developed a comprehensive community and stakeholder engagement program to proactively engage with local communities, key stakeholders and government agencies.

5.4 Consultation and engagement activities to date

Transport for NSW began consulting and engaging with key stakeholders prior to the preparation of the Environmental Impact Statement. This included:

- Stakeholder consultation following the announcement of Sydney Rapid Transit in June 2014
- Project scope consultation and engagement following the announcement of Sydney Metro City & Southwest in June 2015
- Industry consultation in June and December 2015
- Engagement following the project update announcement in November 2015
- Engagement following the announcement of the Waterloo Station location in February 2016
- Engagement regarding the Blues Point temporary site in February 2016
- Engagement regarding the Marrickville dive site pre-cast facility in April 2016.

5.4.1 Stakeholder consultation June 2014

On 11 June 2014, the Premier of NSW announced that the proposed Sydney Rapid Transit (now Sydney Metro) project would extend the North West Rail Link under Sydney Harbour, through the Sydney CBD and on to Bankstown. Consultation was carried out with key stakeholders and information was provided to the community.

A summary of the issues raised during this period is provided in Table 5-5 along with a cross-reference to where the issues are addressed in the Environmental Impact Statement. Full details of this stage of engagement can be found in Appendix C (Stakeholder and community engagement report).

Stakeholder meetings

Key stakeholders (including local government, NSW and Australian Government departments, peak bodies and industry associations) were briefed via meetings, presentations and phone calls. The briefings were designed to ensure stakeholders were adequately informed of the project (including the concept design alignment and station locations); to ensure issues and concerns were understood, captured and addressed in the planning process; and to receive feedback.

Public information and engagement

The stakeholder meetings were accompanied by information distributed to the wider community through:

- Media releases
- Printed information:
  - Fact sheet – *'More trains, faster services right across Sydney'* (June 2014)
  - Fact sheet – *'Transforming Sydney'* (November 2014)
- Websites:
  - Sydney Metro Northwest (formerly North West Rail Link)
  - Transport for NSW
- Community Information Centres:
  - George Street, Sydney
  - Castle Hill (formerly North West Rail Link).

5.4.2 Project scope consultation and engagement June 2015

On 4 June 2015, the Premier of NSW announced a change to the name of the Sydney Rapid Transit project and that funding had been secured to progress planning on Sydney Metro City & Southwest. The announcement also initiated a round of consultation and engagement to collect stakeholder and community feedback on the project with a focus on preferred station locations, options for extra stations and information about the proposed rail line route, to help inform the development of the Environmental Impact Statement. Consultation during this period was completed along the Sydney Metro City & Southwest project alignment between Chatswood and Bankstown. Engagement activities have also continued throughout the preparation of the Environmental Impact Statement.

A summary of the issues raised during this period is provided in Table 5-5 along with a cross-reference to where the issues are addressed in the Environmental Impact Statement. Further details of this stage of engagement can be found in Appendix C (Stakeholder and community engagement report).

Stakeholder meetings

Key stakeholders (including local government, NSW and Australian Government departments, peak bodies and industry associations) were briefed via meetings, presentations and phone calls. The briefings were designed to ensure stakeholders were adequately informed of the project (including the concept design alignment and station locations); to ensure issues and concerns were understood, captured and addressed in the planning process; and to receive feedback. A full list of stakeholders can be found in Appendix C (Stakeholder and community engagement report).

The project team also presented at the *Australian Financial Review* National Infrastructure Summit in June 2015.

Public information and engagement

Table 5-2 identifies the activities used to provide up-to-date information to the community and stakeholders.

Table 5-2 Community contact and information points

Activity	Date established	Detail
Community information line (toll free)	4 June 2015	1800 171 386
Community email address	4 June 2015	sydneymetro@transport.nsw.gov.au
Website	4 June 2015	www.sydneymetro.info
		This website includes an online forum function to collect feedback on various aspects of the project including station locations.
Postal address	4 June 2015	Sydney Metro City & Southwest PO Box K659, Haymarket, NSW 1240
Transport for NSW community information centre	4 June 2015	388 George Street, Sydney
Sydney Metro Northwest community information centre[1]	4 June 2015	Shop 490, Castle Towers Shopping Centre Old Castle Hill Road, Castle Hill

1 *The Transport for NSW community information centre has been operating in Castle Hill for a number of years, providing information on the North West Rail Link, now known as Sydney Metro Northwest. From 4 June 2015, the centre began providing information on Sydney Metro City & Southwest.*

These activities were accompanied by:

- Place Managers, employed on the project since April 2015 to cover the following areas:
  - Chatswood to Sydney Harbour
  - Sydney CBD to Marrickville
  - Sydenham to Bankstown
- Community Information Sessions:
  - 13 June 2015 – Dougherty Community Centre (Auditorium)
  - 17 June 2015 – North Sydney Harbour View Hotel
  - 18 June 2015 – Marrickville Metro
  - 18 June 2015 – Transport for NSW Information Centre
  - 20 June 2015 – Crows Nest Markets
  - 20 June 2015 – Redfern Oval Community Room
  - 23 June 2015 – Canterbury-Hurlstone Park RSL
  - 27 June 2015 – Bankstown Sports Club
- Media releases
- Advertisements in local and ethnic newspapers:
  - Email alert – sent to 6,000 community members registered in the Sydney Metro City & Southwest and Northwest databases
- Printed materials
  - Booklet – *'Project Overview'* (June 2015)
  - Booklet – *'Delivering Sydney Metro, Industry Briefing'* (June 2015)
  - Newsletter – *'Have your say, more choice, more opportunity with metro rail'* (June 2015):
    - 220,000 newsletters delivered to properties within about one kilometre of the proposed alignment and station locations
    - 3,500 newsletters handed out at Sydney Trains stations (Martin Place, St Leonards, Town Hall, Chatswood, North Sydney)
- Display of Project Overview and strategic options documents at Transport for NSW Information Centres and local councils affected by the project corridor.

Online forum

During the project scope engagement period and development of the Environmental Impact Statement, the Sydney Metro City & Southwest website included an online forum for public feedback about the proposal.

One of the objectives of the forum was to collect feedback from the local community on the planning process and how they would like to see the project delivered and impacts managed. The forums covered proposed station locations, station options, and management of construction impacts such as noise and vibration, and traffic. The responses to questions received have been considered in the preparation of the Environmental Impact Statement and will continue to be considered in ongoing project development.

During the project scope engagement period, from 4 June to 17 July 2015, the forum sought feedback on Sydney Metro and particularly the proposed station options around Barangaroo, Waterloo or The University of Sydney, St Leonards or Crows Nest and the Artarmon Industrial Area. There were 8,699 visitors to the forum.

In August 2015, the forum sought feedback on the planning process and how the project should be delivered and impacts managed. There were 2,140 visitors to the forum. A summary of the issues raised during this period, including from the online forums, is provided in Table 5-5 along with a cross-reference to where the issues are addressed in the Environmental Impact Statement. Further details of this stage of engagement can be found in Appendix C (Stakeholder and community engagement report).

5.4.3 Industry consultation June 2015

An industry briefing was held on 16 June 2015 at the Roslyn Packer Theatre, Walsh Bay. Invitations to attend the briefing were included in:

- The Sydney Metro City & Southwest website
- Advertisements in Australian and international newspapers
- Direct invitations.

The briefing detailed plans for Sydney Metro City & Southwest, the project scope and the process for industry to contribute to the project and take part in its delivery. The session was attended by just under 500 industry representatives from Australian and international firms. Attendees received a copy of the booklet – *Delivering Sydney Metro, Industry Briefing*.

5.4.4 Project update announcement November 2015

On 16 November 2015, the Premier of NSW and Minister for Transport and Infrastructure announced the project's State Significant Infrastructure Application Report had been lodged with the Department of Planning and Environment, confirmed station locations at Crows Nest and Barangaroo and advised of ongoing investigations into a proposed metro station at either Waterloo or The University of Sydney.

Stakeholders directly affected by property acquisition were individually notified by the project team.

Engagement during this period was completed along the project alignment between Chatswood and Sydenham.

A summary of the issues raised during this period is provided in Table 5-5 along with a cross-reference to where the issues are addressed in the Environmental Impact Statement. Further details of this stage of engagement can be found in Appendix C (Stakeholder and community engagement report).

Public information and engagement

The public contact and information points outlined in Table 5-2 above continued to provide up-to-date information to the community and stakeholders as part of this announcement.

These activities were again accompanied by:

- Place Managers, covering the following areas:
  - Chatswood to Sydney Harbour
  - Sydney CBD to Marrickville
- Media releases.

Communication tools were also introduced including:

- An animation including an artist impression of the trains and stations
- A *'Project Information'* flyer and fridge magnet delivered to 37,000 properties within 60 metres of the project alignment
- An updated *'Project Update'* (November 2015) booklet
- Early Community Consultation Submissions Report (November 2015)
- Newspaper advertising (State significant infrastructure application report notice)
- Fact sheets for owners and tenants explaining the acquisition process
- Email update (to registered stakeholders)
- Translation service available.

Stakeholder meetings

Key stakeholders (including local government, NSW and Australian Government departments, peak bodies and industry associations) were again briefed via meetings, presentations and phone calls. A full list of stakeholders can be found in Appendix C (Stakeholder and community engagement report).

5.4.5 Industry consultation December 2015

An industry briefing was held on 4 December 2015 at the Civic Pavilion in The Concourse, Chatswood. Invitations to attend the briefing were included in:

- The Sydney Metro City & Southwest website
- Advertisements in Australian and international newspapers
- Direct invitations.

The briefing detailed plans for Sydney Metro City & Southwest, the project scope and the process for industry to contribute to the project and take part in its delivery. The session was attended by just over 460 industry representatives from Australian and international firms. Attendees received a copy of the booklet – *Sydney Metro, City & Southwest Industry Briefing*.

5.4.6 Waterloo Station announcement February 2016

On 11 February 2016, the Minister for Transport and Infrastructure announced the location of Waterloo Station.

Stakeholders directly affected by property acquisition were individually notified by the project team.

Engagement during this period was completed around the Waterloo Station site.

A summary of the issues raised during this period is provided in Table 5-5 along with a cross-reference to where the issues are addressed in the Environmental Impact Statement. Further details of this stage of engagement can be found in Appendix C (Stakeholder and community engagement report).

Public information and engagement

The public contact and information points outlined in Table 5-2 continued to provide up-to-date information to the community and stakeholders as part of this announcement.

These activities were again accompanied by:

- The Place Manager, covering Sydney CBD to Marrickville area
- Media release

Communication tools were also introduced including:

- An updated *'Project Update'* (February 2016) booklet
- Email update (to registered stakeholders)
- Translation service available.

Stakeholder meetings

Key stakeholders were again briefed via meetings, presentations and phone calls. A full list of stakeholders can be found in Appendix C (Stakeholder and community engagement report).

5.4.7 Blues Point temporary site

On 22 and 23 February 2016, the project team Place Managers visited residential and business properties adjacent to the Blues Point temporary site. In addition, a factsheet was delivered to properties along Blues Point Road and all businesses (up to Union Street), visited by the Place Managers.

A summary of the issues raised during this period is provided in Table 5-5 along with a cross-reference to where the issues are addressed in the Environmental Impact Statement. Further details of this stage of engagement can be found in Appendix C (Stakeholder and community engagement report).

Public information and engagement

The public contact and information points outlined in Table 5-2 continued to provide up-to-date information to the community and stakeholders on this component of the project.

Communication tools were also introduced including:

- Fact sheet 'Blues Point Temporary Retrieval Site' (February 2016)
- Construction site info graphic (used when talking to stakeholders)
- Translation service available.

Stakeholder meetings

Key stakeholders were again briefed via meetings, presentations and phone calls. A full list of stakeholders can be found in Appendix C (Stakeholder and community engagement report).

5.4.8 Marrickville dive site pre-cast facility April 2016

On 21 April 2016, the project team Place Managers visited commercial properties adjacent to the Marrickville dive site pre-cast facility.

Stake holder meetings

Key stakeholders were again briefed via meetings, presentations and phone calls. A full list of stakeholders can be found in Appendix C (Stakeholder and community engagement report).

5.5 Contact statistics

Table 5-3 outlines the contacts received by the project team between 11 June 2014 and the finalisation of the Environmental Impact Statement.

Table 5-3 Contact statistics between 11 June 2014 and 30 April 2016

Activity	Number of contacts
Calls to 1800 171 386	247
Emails to sydneymetro@transport.nsw.gov.au	870
Project update subscriptions	5375
Doorknocks	911
Meetings	528
Website visitors – total hits	1,948,542
Online forum visitors – Project scope engagement, 4 June to 17 July 2015	8,699
Online forum visitors – Planning process engagement, August 2015	2,140
Community information sessions (June and July 2015)	About 800 attendees
Submissions	More than 1, 500
Industry engagement	About 1,000 attendees

5.6 Stakeholder and community feedback

As outlined in Section 5.4.2, a round of consultation and engagement to collect stakeholder and community feedback on the project was carried out in June 2015 with a focus on preferred station locations, options for extra stations and information about the proposed rail line route. More than 1,500 submissions were received as part of this early consultation process. The project team reviewed each submission and prepared a report that captured key themes raised and how the Sydney Metro City & Southwest concept has been modified as a direct result of community input. This report was made publicly available on the project website in November 2015. A summary of the issues raised and an outline of the project response is provided in Table 5-4.

Table 5-4 Project response to feedback received

Feedback received	Project response
Artarmon Industrial Area Station	
The majority of the submissions supported an Artarmon Industrial Area station. The main reasons for this support were: • Meeting a public transport need for the workers in the area • Reducing the number of cars in the area • Providing a more convenient location than the current Artarmon Station • Supplementing the current council bus service. A small number of submissions were made against the proposed station. Reasons included: • The absence of a town centre or central area • A lack of demand • That Artarmon already has a train station • That visitors to the area are mostly purchasing larger items that cannot be carried on public transport • That the station should be located at Lane Cove instead. Willoughby City Council expressed support for a station in the area, provided the industrial uses, employment and services in the area are maintained for future employment use.	The benefits of a station at this location are dependent on the realisation of urban renewal opportunities in the area. However, consultation with major stakeholders indicated that there was limited support for such a major land use change. This important industrial area is uniquely located with high-quality access for medium and large vehicles, and with a substantial buffer between industry and residential uses. The area is likely to retain its industrial uses, employment and services, resulting in a low demand for rail transport. Therefore the project would not include an Artarmon Industrial Area Station. A metro station at this location would not offer any significant opportunity to relieve the existing transport network, including buses.

Feedback received	Project response
Artarmon Reserve and the tunnel from the Chatswood area	
At the time of consultation, the project was in the process of identifying where the new twin railway tunnels would start their dive underground. Options included in the project overview document were St Leonards and just south of Chatswood. Most submissions received on this issue supported the project being in tunnel (or underground) from the Chatswood area. This support was largely due to concerns about the impacts of aboveground rail on localities such as Artarmon, and in particular on the flora and fauna in Artarmon Reserve. Willoughby City Council also stated the need to avoid and protect Artarmon Reserve. No submissions were made against the project being underground from the Chatswood area.	It is now proposed that the project would be underground from an area south of Chatswood. • An underground line would: • Avoid any harm to the flora and fauna in Artarmon Reserve, particularly the Blue Gum population • Protect the heritage value of the current Artarmon Station • Minimise impact on the community associated with a surface option, including noise, traffic, potential property acquisitions and impacts on existing stations.
St Leonards or Crows Nest Station options	
The majority of feedback on this issue supported a station in the Crows Nest area, in order to provide necessary public transport, increase accessibility to small businesses and restaurants, and support the growing population. No submissions state a direct opposition to a station being built at Crows Nest. A small number of submissions support a metro station at the current St Leonards Station to provide access to public services and facilities, such as hospitals, schools and TAFE. A larger number of submissions were opposed to St Leonards, mainly due to the fact that it is already well serviced by public transport. A small number of submissions support both St Leonards and Crows Nest, as building both stations is seen as the only way that the entire area could be sufficiently serviced by public transport.	Based on investigations to date, and stakeholder and community feedback, the project now includes a station at Crows Nest. Crows Nest is an active and vibrant village centre, with its cafes, restaurants and shops attracting many visitors. A station at Crows Nest would be located at the western fringe of the village to protect and maintain the character of Willoughby Road. The addition of Crows Nest Station to the area would almost double the number of people within a 30-minute walk to a station. Both the St Leonards and Crows Nest areas are experiencing rapid growth in high-rise residential accommodation and mixed-use developments, increasing the need for quality, reliable transport. The location for the proposed Crows Nest Station carefully balances the aim of facilitating access to St Leonards and its surrounding commercial and residential zones while also extending the rail catchment towards the village along Willoughby Road and adjoining residential areas.

Feedback received	Project response
Barangaroo	
The majority of submissions received in response to this option, including from the City of Sydney, support a station at Barangaroo. The location was seen to have many advantages, including providing access to the new development and the surrounding entertainment precincts (including Walsh Bay). A small number of submissions were opposed to Barangaroo Station, stating that it was not needed, costs too much, and would not be used by residents at Barangaroo.	The NSW Government has committed to the inclusion of this station in the proposed project scope, which would improve accessibility to this area. The location, north of Wynyard, would increase the number of people within walking distance of a station. The station would ease congestion at Wynyard and Martin Place Stations, and provide a new east-west connection across the Sydney CBD, connecting the new financial hub at Barangaroo with the existing financial centre at Martin Place. It would also provide access to ferry services from the new Barangaroo ferry hub, the Walsh Bay arts precinct, King Street Wharf, and Barangaroo Reserve.
The University of Sydney or Waterloo	
The majority of feedback received for this issue favoured a station being built at The University of Sydney. Reasons were mainly centred on greater accessibility to the University, Royal Prince Alfred Hospital, Broadway shopping centre, businesses located in Glebe and nearby entertainment facilities. Submissions against a station at The University of Sydney stated that the University was well serviced by Redfern Station and numerous bus routes, and that many students live locally. Submissions received in support of a station at Waterloo expressed that both Green Square Station and Redfern Station were not close enough to Waterloo for the residents to efficiently use these services. These services, as well as bus routes running through Waterloo, are seen to be not coping with demand, and road congestion is an issue in the area. Residents are concerned that current public transport will not be able to cater for Waterloo's rapidly increasing population. Submissions against a station at Waterloo argued that Green Square and Redfern stations, and bike paths, already serviced the area, and that a more cost effective alternative would be to add a station onto the current airport line. A small number of submissions supported stations at both The University of Sydney and Waterloo. These submissions stated that having both stations would encourage people to catch public transport and would ease road congestion overall.	A station at Waterloo would take pressure off Redfern and Green Square stations and provide local residents with more public transport options, while encouraging the introduction of new homes, jobs, parks and community facilities to meet the needs of a growing Sydney. A new metro station at Waterloo would help revitalise the Waterloo precinct and would also: • Provide a high quality connection with bus services along Botany Road • Provide additional connectivity to Australian Technology Park and Redfern Station • Contribute to the NSW Government objective to transform Waterloo and Redfern. The metro station would also allow further development and expansion of the Global Economic Corridor between the Sydney CBD and Green Square.

A summary of the issues raised in the submissions relevant to the Environmental Impact Statement along with feedback received since the project announcement (11 June 2014) is provided in Table 5-5 along with a cross-reference to where the issues are addressed in the Environmental Impact Statement.

Table 5-5 Community and stakeholder issues raised

Issues raised	Individuals and businesses	Government	Peak bodies / community groups	Environmental Impact Statement reference
Sydney Metro – project wide				
Connectivity with other modes of public transport; bicycle and pedestrian networks		●	●	Chapter 6 (Project description – operation) Chapter 9 (Operational traffic and transport)
Connectivity to social infrastructure		●		Chapter 19 (Social impacts and community infrastructure)
Commuter parking		●	●	Chapter 9 (Operational traffic and transport)
Traffic congestion around stations		●	●	Chapter 8 (Construction traffic and transport) Chapter 9 (Operational traffic and transport)
Impacts to parking, delivery bays and local road network	●			Chapter 8 (Construction traffic and transport) Chapter 9 (Operational traffic and transport)
Protection of parks and reserves and endangered ecological communities	●	●	●	Chapter 20 (Biodiversity)
Protection of heritage items and conservation areas	●	●	●	Chapter 14 (Non-Aboriginal heritage) Chapter 15 (Aboriginal heritage)
Additional / alternative stations	●	●	●	Chapter 4 (Project development and alternatives)
Urban density / development over and around new metro stations	●	●	●	Chapter 6 (Project description – operation) Chapter 12 (Land use and property)
Tunnel and construction methodology / preference for alternatives (like the Harbour Bridge)	●			Chapter 4 (Project development and alternatives) Chapter 7 (Project description – construction)
Noise pollution (during construction and operation)	●		●	Chapter 10 (Construction noise and vibration) Chapter 11 (Operational noise and vibration)
Overcrowding at existing stations	●	●	●	Chapter 3 (Strategic need and justification) Chapter 9 (Operational traffic and transport)
Accessibility (more / larger lifts and train / platform gaps)	●		●	Chapter 6 (Project description – operation)
Property acquisitions	●	●		Chapter 12 (Land use and property)
Power use and sustainability	●	●		Chapter 25 (Sustainability)
Station facilities (platform screen doors, seating, bicycle facilities, weather protection, taxi ranks, kiss-and-ride and lockers)	●	●	●	Chapter 6 (Project description – operation) Chapter 9 (Operational traffic and transport)
Replacement services / station closures during construction	●	●	●	Chapter 8 (Construction traffic and transport)

Issues raised	Individuals and businesses	Government	Peak bodies / community groups	Environmental Impact Statement reference
Tunnelling around St Peters and Newtown	●			Chapter 10 (Construction noise and vibration)
Spoil management		●		Chapter 24 (Waste management)
Request for steering committees and community consultation groups		●	●	This chapter
Underground pedestrian links to stations	●			Chapter 6 (Project description – operation)
Management of construction traffic / traffic control around construction sites	●			Chapter 8 (Construction traffic and transport)
Chatswood surface works / tunnel				
Impacts to Artarmon	●			Chapter 4 (Project development and alternatives)
Impacts to Artarmon Reserve and Artarmon Oval	●	●	●	Chapter 4 (Project development and alternatives)
Preference for tunnelling to reduce construction and operational noise and construction access along local roads	●		●	Chapter 4 (Project development and alternatives)
Artarmon Industrial Area Station				
Support for a station to support local employment, relieve pressure at the existing Artarmon Station and provide access to the hospitals, schools and TAFE	●	●		Chapter 4 (Project development and alternatives)
Opposition due to lack of density and existing station at St Leonards	●			Chapter 4 (Project development and alternatives)
St Leonards / Crows Nest Station				
Support for St Leonards to utilise existing spare platforms, encourage transit-orientated development, expand the commercial centre and provide access to the hospitals, schools and TAFE	●	●		Chapter 4 (Project development and alternatives)
Support for Crows Nest as parking is limited, buses through the area are crowded and St Leonards has an existing station	●	●	●	Chapter 4 (Project development and alternatives)
Support for both stations to reduce crowding at the existing station, relieve pressure on the North Shore Line and support increased housing density in the area	●			Chapter 4 (Project development and alternatives)
Traffic impacts on the Pacific Highway / loss of right turn at Hume Street	●			Chapter 8 (Construction traffic and transport)

Issues raised	Individuals and businesses	Government	Peak bodies / community groups	Environmental Impact Statement reference
Loss of kerbside parking for customers of local businesses	●			Chapter 8 (Construction traffic and transport) Chapter 9 (Operational traffic and transport)
Loss of the post office	●			Chapter 19 (Social impacts and community infrastructure)
How will the station fit into Council's Master Plan for Crows Nest	●			Chapter 12 (Land use and property)
Victoria Cross Station				
Loss of local small business / restaurants through property acquisition	●			Chapter 13 (Business impacts)
Pedestrian routes during construction / loss of foot traffic to businesses	●			Chapter 8 (Construction traffic and transport) Chapter 13 (Business impacts)
Blues Point temporary site				
Local traffic impacts	●		●	Chapter 8 (Construction traffic and transport)
Loss of parking	●		●	Chapter 8 (Construction traffic and transport)
Noise and vibration from construction	●		●	Chapter 10 (Construction noise and vibration)
Construction timeframe and working hours			●	Chapter 7 (Project description – construction)
Local air quality impacts from construction			●	Chapter 22 (Air quality)
Heritage impacts			●	Chapter 14 (Non-Aboriginal heritage) Chapter 15 (Aboriginal heritage)
Cumulative impacts with other nearby developments			●	Chapter 26 (Cumulative impacts)
Barangaroo Station				
Support for a station as long as it does not justify further development of the site		●		Chapter 4 (Project development and alternatives)
Support for the station to reduce crowding at Wynyard, support the redevelopment of the site and access to the new headland reserve, Walsh Bay and Millers Point	●			Chapter 4 (Project development and alternatives)
Preference for Barangaroo Central station location		●		Chapter 4 (Project development and alternatives)

Issues raised	Individuals and businesses	Government	Peak bodies / community groups	Environmental Impact Statement reference
Martin Place Station				
Integrate Sydney Metro station with an upgrade to the existing Martin Place Station		●		Chapter 4 (Project development and alternatives) Chapter 6 (Project description – operation)
Integrated station access points		●		Chapter 6 (Project description – operation) Chapter 9 (Operational traffic and transport)
Pitt Street Station				
Integrated station access points		●		Chapter 4 (Project development and alternatives) Chapter 6 (Project description – operation) Chapter 9 (Operational traffic and transport)
Waterloo / The University of Sydney Station				
Support for The University of Sydney Station over Waterloo to increase access to education and health precinct, Broadway and Glebe, and reduce traffic and bus congestion on King Street and Parramatta Road	●	●	●	Chapter 4 (Project development and alternatives)
Opposition to The University of Sydney Station due to existing public transport servicing the area (buses and Central Station)	●			Chapter 4 (Project development and alternatives)
Opposition to Waterloo Station due to existing public transport servicing the area (Green Square and Redfern Stations)	●			Chapter 4 (Project development and alternatives)
Support for Waterloo Station due to future redevelopment plans and increasing population, lack of existing transport services; services not coping with demand; road congestion impacting bus services.	●			Chapter 4 (Project development and alternatives)
Support for having both stations to be included	●			Chapter 4 (Project development and alternatives)

In addition to the above, regular consultation has been carried out with government agencies throughout the development of the design and the Environmental Impact Statement.

A summary of the key issues raised during this consultation and the project response is provided in Table 5-6.

Table 5-6 Project response to agency consultation

Nature of consultation and application to the project
Roads Integration Working Group (CBD Coordination Office, Roads and Maritime Services, Department of Planning and Environment)
Regular meetings were held with the Roads Integration Working Group between June and December 2015.
Traffic impact assessment methodology The proposed traffic impact assessment methodology was presented and discussed with the Roads Integration Working Group.
Haul routes Consultation identified that haul routes should minimise traffic impacts in the Sydney CBD and avoid the use of the key bus routes along Elizabeth and Castlereagh streets as much as possible. Haul routes in the Sydney CBD have been designed to exit the Sydney CBD as efficiently as possible. The haul routes to and from the Pitt Street construction sites were specifically altered to reduce the use of Elizabeth and Castlereagh streets.
Impacts to road space in the Sydney CBD Consultation identified that the end-state design should not encroach into existing road space in the Sydney CBD. Design of the stations has avoided the used of pedestrian blisters into existing road space. Where additional pedestrian space was required, this was achieved by creating pedestrian plazas and storage space within the metro station site.
Mowbray Road / Pacific Highway intersection Consultation has occurred with Roads and Maritime Services to ensure that the Sydney Metro scope of works at this intersection safeguards any future upgrade of the intersection by Roads and Maritime.
Construction traffic impacts in the Sydney CBD Consultation identified that the use of heavy vehicles in the Sydney CBD should be minimised. Options to barge spoil and other materials should be investigated. The feasibility of barging of spoil and other material would continue to be investigated during detailed design and construction planning.
Sydney Trains
Maintenance access at Central Station Sydney Train identified a need for permanent maintenance access into Sydney Yard. The project includes the provision of a permanent access bridge from Regent Street to Sydney Yard to provide dedicated maintenance access.
Operations at Central Station during construction Sydney Metro has and will continue to consult with Sydney Trains to ensure Central Station can continue to provide necessary services during construction with the removal of platforms 13 to 15.
Works in the T1 North Shore Line Through consultation, Sydney Trains expressed a desire for works within the T1 North Shore Line to be minimised. The location of the northern dive structure minimises the extent of work within the T1 North Shore Line, the potential number of possessions and the potential impacts to the T1 North Shore Line compared to the other options.

Nature of consultation and application to the project
Heritage Advisory Panel (Sydney Trains, Department of Planning and Environment)
Three meetings were held with the Heritage Advisory Panel between June and October 2015.
Impacts at Central Station Sydney Trains provided information regarding key heritage items and the importance of individual items. The potential key heritage impacts at Central Station were presented to the Panel. Sydney Trains highlighted the importance of the Lost Property Office at Central Station. Key heritage items have been an ongoing consideration in the options assessment and design of the stations. The design of Central Station metro concourse has aimed to limit direct impacts to the Lost Property Office
Impacts at Martin Place Station Consultation with Sydney Trains has informed the design of the platform to platform connection at Martin Place. Ongoing consultation would help inform the future material and finishes for the interface.
Maritime Group (Port Authority of NSW and Roads and Maritime Services)
Shipping channels Consultation identified the potential for impacts to shipping channels, mainly associated with Viva Energy ships, associated with the Sydney Harbour ground improvement work. This consultation led to the development of the construction method for the ground improvement work to carry out one grout zone at a time in order to maintain shipping channels.
Barangaroo Delivery Authority
Prior to and following the announcement of a metro station at Barangaroo, a working part was formed involving Sydney Metro, Barangaroo Delivery Authority, Department of Premier and Cabinet and Treasury. Between June and December 2015, 11 meetings were held. In addition, regular interface has occurred directly with Barangaroo Delivery Authority.
Impacts to construction of Central Barangaroo Consultation has been carried out to plan the metro construction site to limit the use of space within Central Barangaroo. Ongoing consultation would be carried out to manage the potential conflicts between the two construction projects. The station was also progressed as a cut-and-cover rather than a mined station which results in a reduction to the construction timeframe.
Integration with the Central Barangaroo master plan The station and transport interchange arrangement have been developed in consultation with Barangaroo Delivery Authority to responds to the Barangaroo master plan and the preferred design for Hickson Road, including safeguarding for a future light rail.
Station entries to serve Barangaroo South and events in Barangaroo Reserve Two station entries have been planned with one towards the southern extent to help serve the Barangaoro South precinct and one to the north to serve Barangaroo Reserve and events.
Hickson Road Consultation with Barangaroo Delivery Authority has been carried out in relation to the use of Hickson Road during construction. Construction works at Barangaroo have been planned to keep Hickson Road open to traffic through staging of the excavation works, although there may be discreet periods when a full closure is required (most likely at night). Consultation would continue with Barangaroo Delivery Authority in relation to the coordination of works and traffic management arrangements within Hickson Road.

Nature of consultation and application to the project
UrbanGrowth NSW
Meetings with Urban Growth NSW commenced in June 2014 to discuss the opportunity for an additional station within the Central to Eveleigh precinct. Following the announcement of Waterloo Station, weekly project meeting have been carried out with UrbanGrowth NSW, Family and Community Services and Housing NSW.
Central to Eveleigh Urban Transformation and Transport Program Consultation in relation to the Central to Eveleigh Urban Transformation and Transport Program led to the opportunity for an additional station between Central and Sydenham, later determined to be located at Waterloo.
Waterloo Station design Since the announcement of Waterloo Station, consultation with UrbanGrowth NSW, Family and Community Services and Housing NSW has informed the station design, end-state transport interchange arrangements and the station location (planned to minimise impacts on social housing tenants).
Willoughby City Council
Willoughby City Council has been kept informed of scope of the project and the broader Sydney Metro program. This includes: - The closure and demolition of Nelson Street bridge - Ongoing conversations regarding the use of residual land.
North Sydney Council
Integration with urban domain and strategic plans – Crows Nest Consultation has been carried out with North Sydney Council in order for the station to support their urban domain and strategic plans at Crows Nest. This includes: - The Hume Street entry integrates with the proposed upgrade of Hume Street Park - The northern station entry serves the commercial core of St Leonards - The station avoids impacts to Crows Nest Village - Provision of active transport connections between station entries and existing links.
Integration with urban domain and strategic plans – Victoria Cross
Consultation has been carried out with North Sydney Council in order for the station to support their urban domain and strategic plans at North Sydney. This includes: - Supporting the desire for strong commercial and specialised centres at North Sydney - Fitting in with the future desire for Miller Street as a premier civic space - East-west permeability with a connection from Miller Street to Dennison Street - Preference for aboveground pedestrian movements - Provision of active transport connections between station entries and existing links.

Nature of consultation and application to the project
City of Sydney Council
Integration with urban domain and strategic plans Consultation has been carried out with City of Sydney Council in order to support their urban domain and strategic plans in the Sydney CBD. This includes: • Removal of access points to underground concourse within Martin Place • ensuring consistency with Martin Place masterplan, built form desires and urban design strategies • Not precluding the provision of a future retail space beneath Martin Place • Providing quality connections between the two Martin Place stations • Supporting the vision of three squares: • Allowing the City of Sydney to proceed with Town Hall Square • Supporting the longer term Central square vision through transport connectivity • Providing the opportunity for an underground connection from Pitt Street Station to the future Town Hall Square • Understanding the role of Pitt Street Station as an interchange place between Town Hall and Museum stations, buses and Light Rail • Provision of active transport connections between station entries and existing links.
Marrickville Council
Marrickville Council has been kept informed of scope of the project and the broader Sydney Metro program. This includes: • Signalisation of the Edinburgh Road / Edgeware Road / Bedwin Road intersection • Provision of flooding advice from Marrickville Council to Sydney Metro • Ongoing conversations regarding the use of residual land.
Sydney Motorways Corporation
Consultation with Sydney Motorways Corporation was carried out in relation to coordination of Sydney Metro and WestConnex Stage 3 tunnel alignments.
Utility providers
Consultation has been carried out with various utility providers between November 2015 and March 2016. This has included meetings with Ausgrid, Sydney Water, Transgrid, Telstra and Optus among others in order to identify the location of existing assets to inform design. For example, the location of the Marrickville dive was adjusted to reduce the interface with the 330 kV Transgrid cable and the tunnel alignment was lowered to avoid the curtilage of the Sydney Water Tank Stream.
Commonwealth Department of the Environment
Consultation with the Commonwealth Department of the Environment confirmed that Matters of National Environmental Significance would not be affected by the project.
State Emergency Service
A meeting was held with the State Emergency Service (SES) to discuss potential construction and operational phase flooding impacts in the vicinity of the Marrickville dive site, including the flood evacuation routes in the area. The SES requested ongoing consultation during construction planning and the development of the flood management plan for the Marrickville dive site.

5.7 Future consultation and engagement

5.7.1 Public exhibition of Environmental Impact Statement

The Department of Planning and Environment will place this Environmental Impact Statement on public exhibition for a minimum of 30 days (as per Section 115Z of the EP&A Act). During the exhibition period, government agencies, project stakeholders and the community will be able to review the Environmental Impact Statement and will have an opportunity to make a written submission to the Department of Planning and Environment for consideration in its assessment of the project.

Advertisements will be placed in newspapers and newsletters delivered along the project corridor to advise of the public exhibition and where the Environmental Impact Statement can be viewed, and details on community consultation activities and information sessions. A full list of the activities to be implemented are included in Table 5-7.

Submissions report

At the completion of the public exhibition period for the Environmental Impact Statement, the Department of Planning and Environment will collate and provide Transport for NSW with a copy of all submissions received. After reviewing the submissions, Transport for NSW will prepare a submissions report that responds to the relevant issues raised. The submissions report will be made publicly available on the Department of Planning and Environment website. Anyone making a public submission will receive a letter notifying them of the publication of the submissions report on the Department of Planning and Environment website.

If changes are required to the project as a result of the issues raised in submissions or to minimise environmental impact, a preferred infrastructure report may also be required. If this is required, Transport for NSW would prepare the report to address the changes to the design and submit this for review to the Department of Planning and Environment. This report may be made available for public review.

5.7.2 Ongoing consultation and engagement activities

Transport for NSW will continue to work with stakeholders and the community to ensure they are informed about the project and have opportunities to provide feedback to the project team. A list of activities and their timing is provided in Table 5-7.

Table 5-7 Ongoing consultation and engagement activities

Activity	Timing	Design	EIS exhibition	Delivery	Operation
Awareness and marketing campaign to engage future customers	Ongoing	●	●	●	●
Community event stalls	Ongoing		●	●	
Community information centres	Ongoing	●	●	●	
Community information sessions	Mid-2016		●		
Construction communications plan	Prior to construction			●	
Construction complaints management system	Prior to construction			●	
Construction notifications	Seven days prior to construction starting			●	
Displays at council offices	Mid-2016		●		
Doorknocks	As required	●	●	●	●
Email updates	Relevant milestones	●	●	●	●
Enquiries and complaints hotline	Ongoing	●	●	●	●
Environmental Impact Statement summary document	Mid-2016		●		
Fact sheets	As required	●	●	●	●
Government stakeholder engagement	As required; relevant milestones	●	●	●	●
Local business engagement	As required; relevant milestones	●	●	●	●
Media releases	Relevant milestones	●	●	●	
Newsletter	Relevant milestones	●	●	●	●
Newspaper advertising	Relevant milestones	●	●	●	●
Operation communications plan	Prior to operation				●
Place Managers	Ongoing	●	●	●	
Project briefings and presentations	Relevant milestones	●	●	●	
Project overview document	Relevant milestones	●	●	●	
Site signage	Prior to construction			●	
Social media updates	As required; relevant milestones	●	●	●	●
Stakeholder Engagement and Communications Plan	Ongoing	●	●	●	
Stakeholder meetings	As required; relevant milestones	●	●	●	●
Website, animations and online forums	Ongoing	●	●	●	

Transport for NSW would also specifically consult with stakeholders to fulfil mitigation measures outlined in this Environmental Impact Statement. These consultation activities are identified in the relevant mitigation measures in Chapter 27 (Consolidated environmental mitigation measures and environmental performance outcomes).

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PROJECT DESCRIPTION – OPERATION

CHAPTER SIX

6 Project description – operation

This chapter provides a description of the project once it is operational, including the proposed layout of the stations, the location of the track alignment and how customers would use Sydney Metro. A description of how the project is likely to be constructed is provided in Chapter 7 (Project description – construction).

6.1 Secretary's environmental assessment requirements

The Secretary's environmental assessment requirements relating to project description – operation, and where these requirements are addressed in this Environmental Impact Statement, are outlined in Table 6-1.

Table 6-1 Secretary's environmental assessment requirements – project description – operation

Ref.	Secretary's environmental assessment requirements	Where addressed
2. Environmental Impact Statement		
2 (b)	The EIS must include, but not necessarily be limited to, the following: a description of the project, including all components and activities (including ancillary components and activities) required to construct and operate it	This chapter provides a description of the project once operational. Chapter 7 (Project description – construction) provides a description of how the project would be constructed.
2 (i)	a demonstration of how the project design has been developed to avoid or minimise likely adverse impacts	Details of adverse impacts which have been avoided through design are described in Section 6.2.4. Additional details of adverse impacts which have been avoided through construction methodologies are described in Chapter 7 (Project description – construction).

6.2 Project overview

6.2.1 Key features of the project

The Sydney Metro Chatswood to Sydenham project (the project) involves the construction and operation of a metro rail line and associated stations between Chatswood Station and just north of Sydenham Station. The proposed alignment and key operational features of the project are shown in Figure 6-1 and would include:

- Realignment of T1 North Shore Line surface track within the existing rail corridor between Chatswood Station and Brand Street, Artarmon, including a new bridge for a section of the Sydney Trains 'down' (northbound) track to pass over the proposed northern dive structure
- About 250 metres of aboveground metro tracks between Chatswood Station and the Chatswood dive structure
- A dive structure (about 400 metres long) and tunnel portal south of Chatswood Station and north of Mowbray Road, Chatswood (the Chatswood dive structure)

- About 15.5 kilometres of twin rail tunnels (that is, two tunnels located side-by-side) between Mowbray Road, Chatswood and Bedwin Road, Marrickville. The tunnel corridor would extend about 30 metres either side of each tunnel centre line and around all stations
- A substation (for traction power supply) in Artarmon, next to the Gore Hill Freeway, between the proposed Crows Nest Station and the Chatswood tunnel portal
- Metro stations at Crows Nest, Victoria Cross, Barangaroo, Martin Place, Pitt Street and Waterloo; and new underground platforms at Central Station
- A dive structure (about 400 metres long) and tunnel portal between Sydenham Station and Bedwin Road, Marrickville (the Marrickville dive structure)
- A services facility beside the Marrickville dive structure and tunnel portal, including a tunnel water treatment plant and a substation (for traction power supply).

The project would also include:

- Permanent closure of the road bridge at Nelson Street, Chatswood, and provision of an all vehicle right-turn movement from the Pacific Highway (southbound) into Mowbray Road (westbound)
- Signalisation of the Mowbray Road / Hampden Road intersection at Chatswood
- Permanent support work to the western abutment of Mowbray Road bridge. The western pier would also require a deflection wall around the existing pier columns
- Installation and modification of existing Sydney Trains rail systems including overhead wiring, signalling, access tracks / paths, rail corridor fencing and noise barriers, within the surface section between Chatswood Station and the dive structure at the northern end of the project
- Retaining walls for the realigned T1 North Shore Line 'down' track (between around Ellis Street, Chatswood and around Drake Street, Artarmon)
- Removal of the Sydney Trains maintenance access point at Hopetoun Avenue, Chatswood
- Maintenance access stairs from Albert Avenue, Chatswood to the eastern side of the rail corridor immediately south of Chatswood Station
- A maintenance access point from Brand Street, Artarmon on the 'down' (northbound) side of the T1 North Shore Line and modifications to the existing access point from Drake Street, Artarmon
- Services within each of the stations, including mechanical, electrical and ventilation equipment
- A permanent power supply from Pyrmont or Surry Hills to Pitt Street Station
- Underground pedestrian links at some stations and connections to other modes of transport (such as the existing suburban rail network) and surrounding land uses
- Alterations to pedestrian and traffic arrangements and public transport infrastructure (where required) around the new stations and surrounding Central Station
- Permanent signalisation of the Edinburgh Road / Edgeware Road / Bedwin Road intersection at Marrickville
- Noise barriers (where required) and other environmental protection measures.

The project is described in more detail in the following sections.

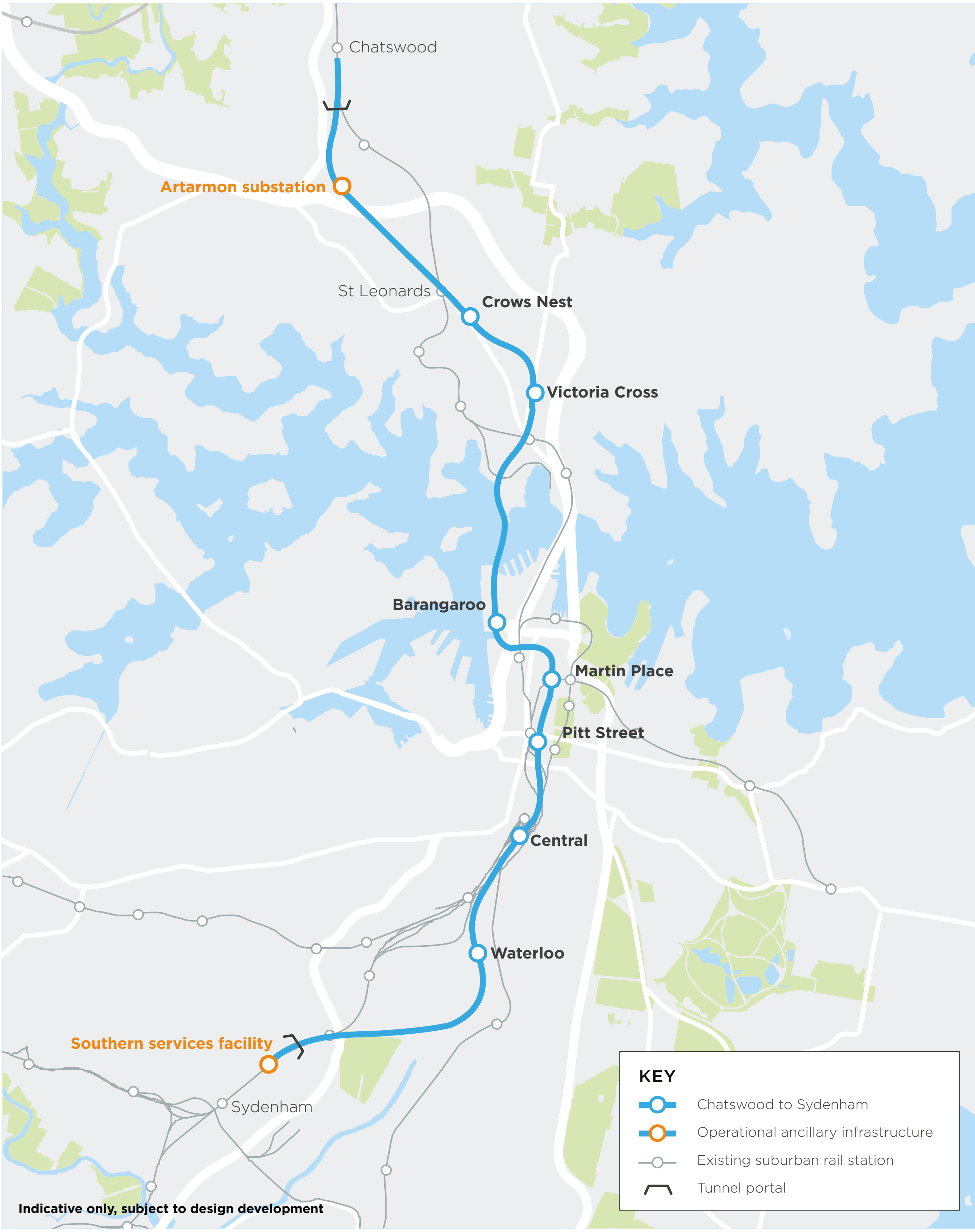


Figure 6-1 Key features of the project

6.2.2 Key metro characteristics

The customer experience underpins how Sydney Metro is being planned and designed. The customer experience incorporates all aspects of travel associated with the transport network, service and project including:

- The decision on how to travel – new metro services would be integrated with other transport modes, including interchanges with the existing Sydney railway network as well as buses, light rail and ferries
- The travel information available – state-of-the-art technology is proposed to keep customers connected at all stages of their journey, from smart phone travel apps on the way to stations to real time journey information at metro stations and onboard trains
- The speed and comfort of the journey
- The range and quantity of services available at stations, interchanges and within station precincts – the project would help customers achieve their daily tasks, whether it's getting to work or getting home, for school or education, sport, a day out or running errands.

A high quality door-to-door transport product is critical to attract and retain customers and also to meet broader transport and land use objectives. This includes providing a system that is inherently safe for customers on trains, at stations and at the interface with the public domain; providing direct, comfortable, legible and safe routes for customers between transport modes; and provide a clean, pleasant and comfortable environment for customers at stations and on trains.

Making it easy for customers at each stage of their journey is integral to the successful delivery of Sydney Metro. Key characteristics of Sydney Metro that would be delivered by the project are outlined in Table 6-2.

Table 6-2 Key metro characteristics

Product characteristic	Description
Fast and reliable service	• Delivering fast journeys between stations with new generation single deck trains • Ensuring easy boarding and alighting to reduce dwell times at stations • Creating a highly reliable service (expected target of 98 per cent on time running).
Ability to move more people	• Designing infrastructure, trains and systems to be able to run 30 trains per hour through the Sydney CBD • Ability to move more than 40,000 customers per hour in each direction at ultimate capacity (23,000 customers per hour at opening) • Catering for short to medium length journeys between multiple centres means metro is able to make better use of train capacity.
Modern trains and technology	• Trains operate safely closer together with communications-based train control that allows automated train operations and driverless operation • Improving safety and comfort with platform screen doors that run the full length of all metro platforms and only open at the same time as the train doors • On-board real time travel information and live electronic route maps.
Accessible system	• Fully accessible stations and single deck trains • Three double doors per side per carriage for faster loading and unloading • Level access between the platform and train and reduced gaps between the platform and the train – providing access for all • Designing for bicycles on trains • Delivering modern customer information systems.
Highly legible	• ‘Turn up and go’ frequencies means there is no need for a timetable • Consistent stopping patterns that mean metro would stop at all stations.
Safe and secure	• Improving customer experiences, with customer service assistants at every station and moving through the network during the day and night • Stations and precincts that are designed to be highly visible, active spaces with good lighting and amenity • Ensuring customers can see all the way along the train and move easily between carriages, including wide, open walkways between carriages • Providing platform screen doors at stations which keep people and objects away from the edge, improving customer safety and allowing trains to get in and out of stations much faster • Station and train design allows for good line of sight to enable passive and active surveillance.
Comfortable service	• Air-conditioned trains with large windows, warm lighting and open walkways • Seating and standing room designed to maximise personal space • Easy boarding and alighting at stations.

6.2.3 Design guidelines

Sydney Metro has developed design guidelines in order to guide the design development process, and establish the aesthetic standards for the project. The development of the design guidelines has considered the urban design strategies and initiatives of the relevant local councils. These guide the design of:

- The interface between stations and their surrounding locality including:
  - Station entries
  - Transport interchange facilities (bicycle facilities, bus stops, kiss-and-ride, taxi ranks and connections to existing rail, ferry and light rail transport)
  - Landscaping and other public domain elements.
- Rail corridor works including the tunnel dive structures, rail cuttings and embankments.
- Station and service buildings, including underground stations.

Five design objectives for the project have been developed to guide decision making and the design process for the project. These are:

1. Ensuring an easy customer experience
2. Being part of a fully integrated transport system
3. Being a catalyst for positive change
4. Being responsive to distinct contexts and communities
5. Delivering an enduring and sustainable legacy for Sydney.

The Chatswood to Sydenham Design Guidelines are provided in Appendix B.

6.2.4 Environmental considerations in design

The design of the project has been influenced by a number of environmental factors. In general, the project has been designed to:

- Avoid known structures including buildings, basements, utilities and infrastructure (including other rail and road infrastructure)
- Minimise the potential for direct and indirect impacts to heritage items
- Minimise direct impact on property.

Specific design responses to avoid and minimise adverse impacts are identified in Table 6-3.

Table 6-3 Adverse operational impacts avoided or minimised through design

Environmental aspect	Design response
Noise	• Provision of track form to meet ground-borne noise and vibration goals • Provision of new noise barriers and increases to the height of existing noise barriers at the northern end of the project to mitigate airborne noise from train operations • Location of the northern dive structure minimises the extent of surface track and potential airborne noise impacts.
Property and land use	• Provision of mined stations at Victoria Cross, Martin Place and Pitt Street to avoid more extensive property acquisition • Location of the Artarmon substation to avoid the need to acquire residential, commercial or industrial property • Location of the Marrickville dive structure to avoid potential impacts on Sydney Water assets and a Transgrid 330 kilovolt (kV) underground cable.

Heritage	• The design has avoided the following listed heritage items:
	  – Mowbray House adjacent to the Chatswood dive structure
	  – The brutalist building adjacent to Crows Nest Station
	  – The Edinburgh Castle Hotel adjacent to Pitt Street Station
	  – The Congregational Church adjacent to Waterloo Station
	  – The Sydney Water Pit and Drainage Pumping Station near the Marrickville dive structure.
	• The design has minimised impacts to the Lost Property Office at Central Station.

Groundwater	• Provision of tanked tunnels, mined stations and cut-and-cover stations at Barangaroo and Waterloo to minimise the inflow of groundwater • Provision of a tanked station at Barangaroo to minimise the potential for contaminated groundwater inflow.
Biodiversity	• Location of the northern dive structure has avoided impacts to Blue Gum High Forest at Artarmon Reserve.

6.3 Metro rail tunnels

6.3.1 Tunnel alignment

The twin underground metro rail tunnels would extend about 15.5 kilometres between the Chatswood tunnel portal (north of Mowbray Road, Chatswood) and the Marrickville tunnel portal (south of Bedwin Road, Marrickville). The tunnel alignment (as shown on Figure 6-2 (a-i)) is indicative at this stage, and has been used for the purposes of the environmental impact assessment including all specialist investigations. During detailed design the alignment may change (horizontally and / or vertically). Any changes to the alignment would be reviewed for consistency with the assessment contained in this Environmental Impact Statement including relevant mitigation measures, performance outcomes and any future conditions of approval. The key features of the tunnels are described in the following sections.

The location of the proposed alignment was primarily driven by the general location of metro stations and then refined by the functional requirements of a metro system. In particular there is a need to:

- Match up with the location, depth and platform configurations of the metro stations
- Provide a track with a maximum vertical grade of 4.5 per cent
- Locate station platforms along a straight and level section of track (ie zero per cent grade)
- Construct tunnels that are deep enough, where possible, to provide suitable rock cover above the tunnel crown (the top surface of the tunnel structure) to minimise the requirement for ground support
- Provide track curvature, where possible, that can accommodate a train operating speed of 100 kilometres per hour (tighter radius curves have been adopted at some locations for a number of reasons, including to avoid subsurface constraints such as building basements and foundations)
- Respond to a number of physical constraints across Sydney Harbour, including major submarine utilities, services and structures and shipping channel requirements; and to ensure acceptable depths at Barangaroo and Victoria Cross stations
- Accommodate stub tunnels to the north of Victoria Cross Station and between Waterloo Station and the Marrickville dive structure. The stub tunnels are required to minimise disruption to the operating Metro network during construction of any potential future extensions to the network.

There would be a future statutory corridor for the project established through the *State Environmental Planning Policy (Infrastructure) 2007*. Any future development within this corridor would be referred to Transport for NSW for concurrence. A preliminary project corridor, which extends 30 metres either side of the tunnel alignment, is shown on Figure 6-2 (a-i). This corridor would be confirmed consistent with any changes to the alignment described above.

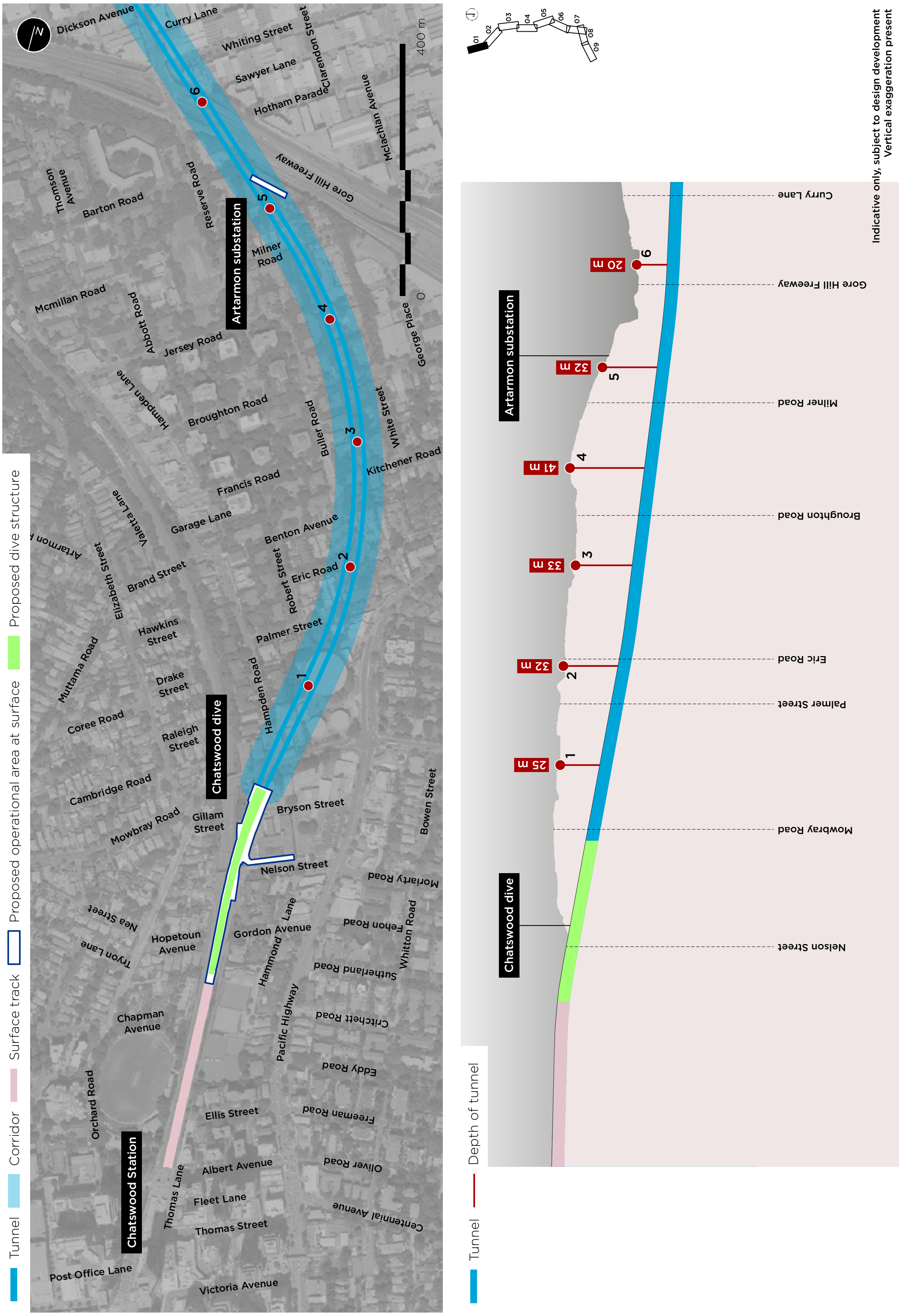


Figure 6-2a Indicative Chatswood to Sydenham alignment plan and long section

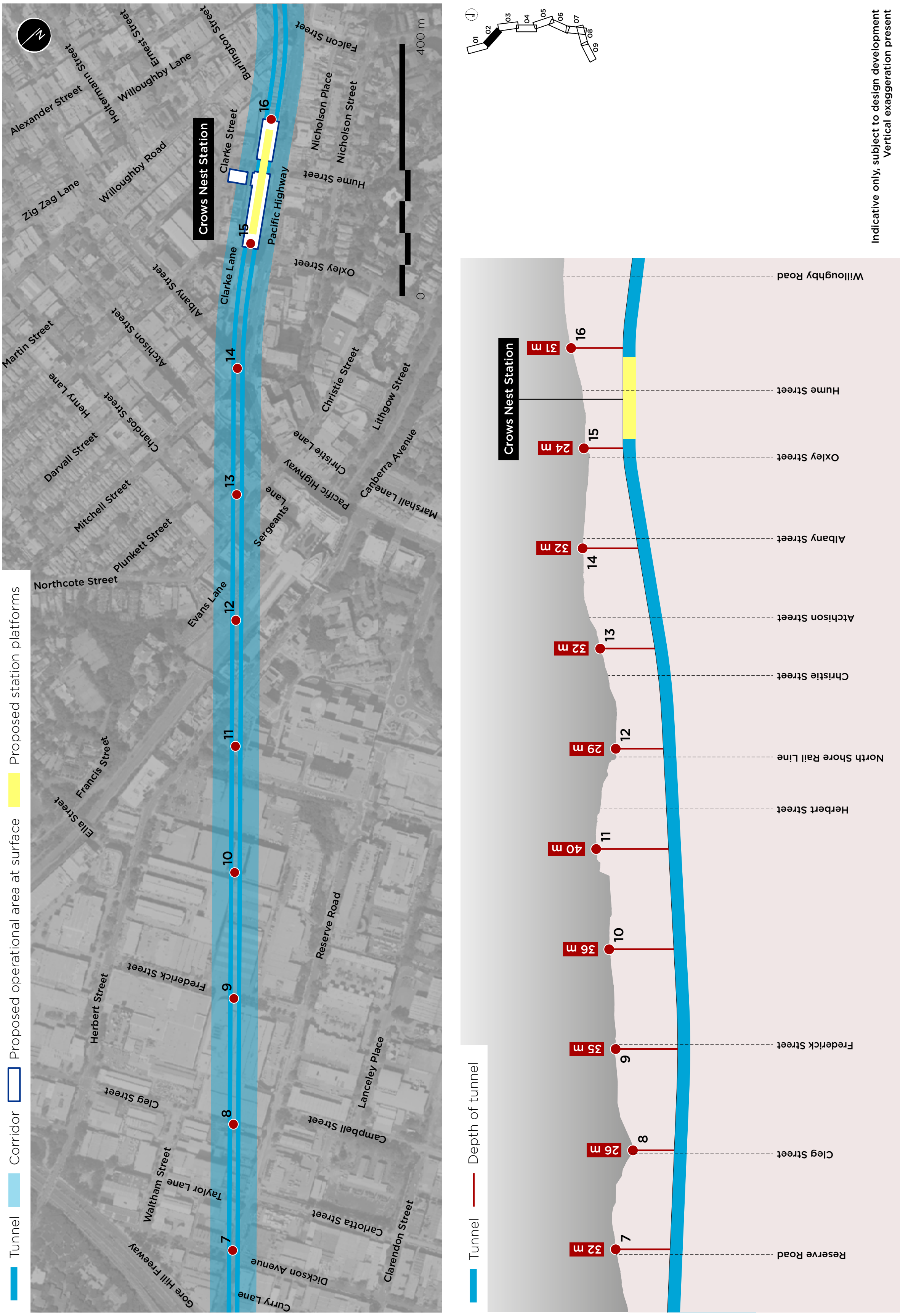


Figure 6-2b Indicative Chatswood to Sydenham alignment plan and long section

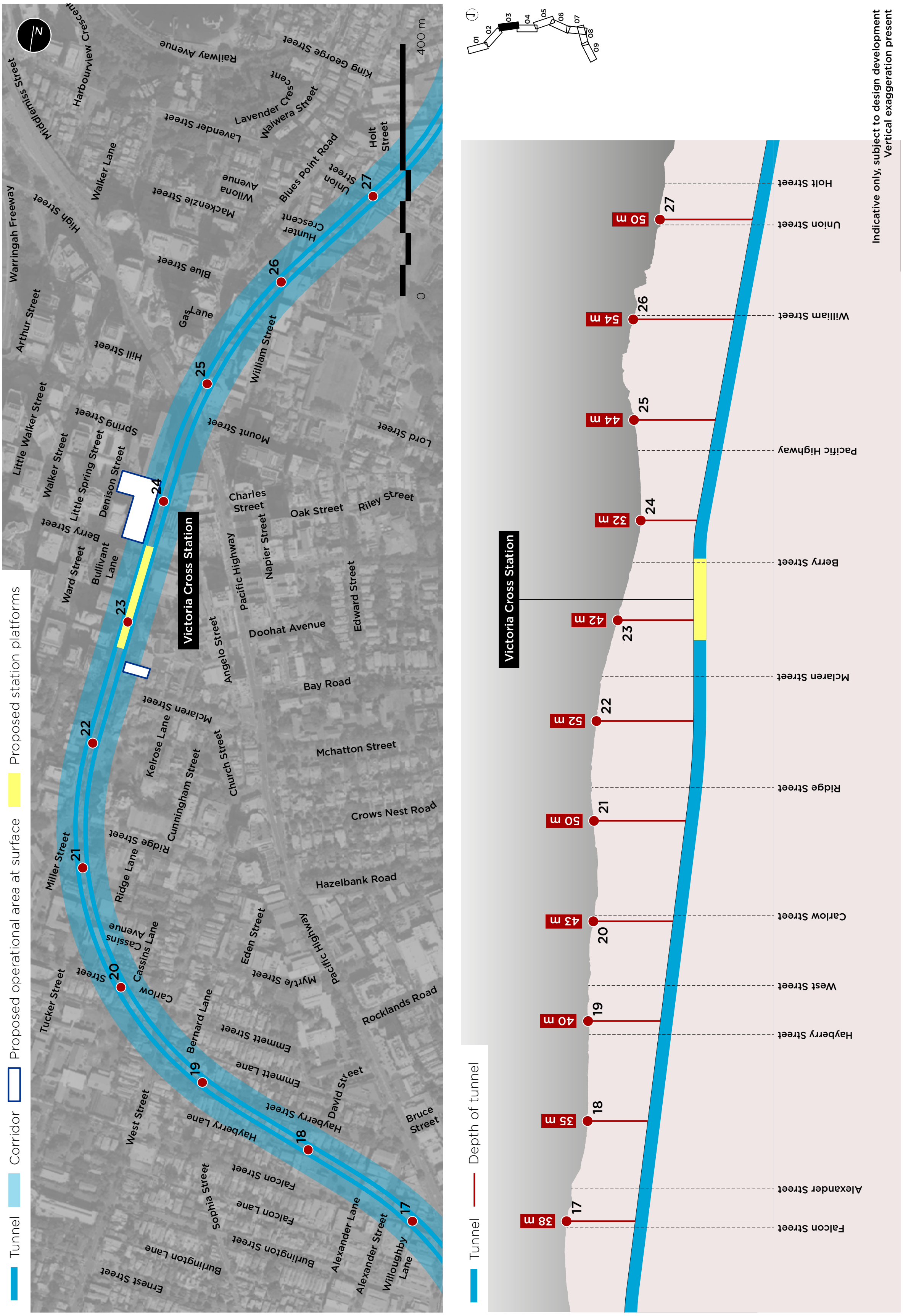


Figure 6-2c Indicative Chatswood to Sydenham alignment plan and long section

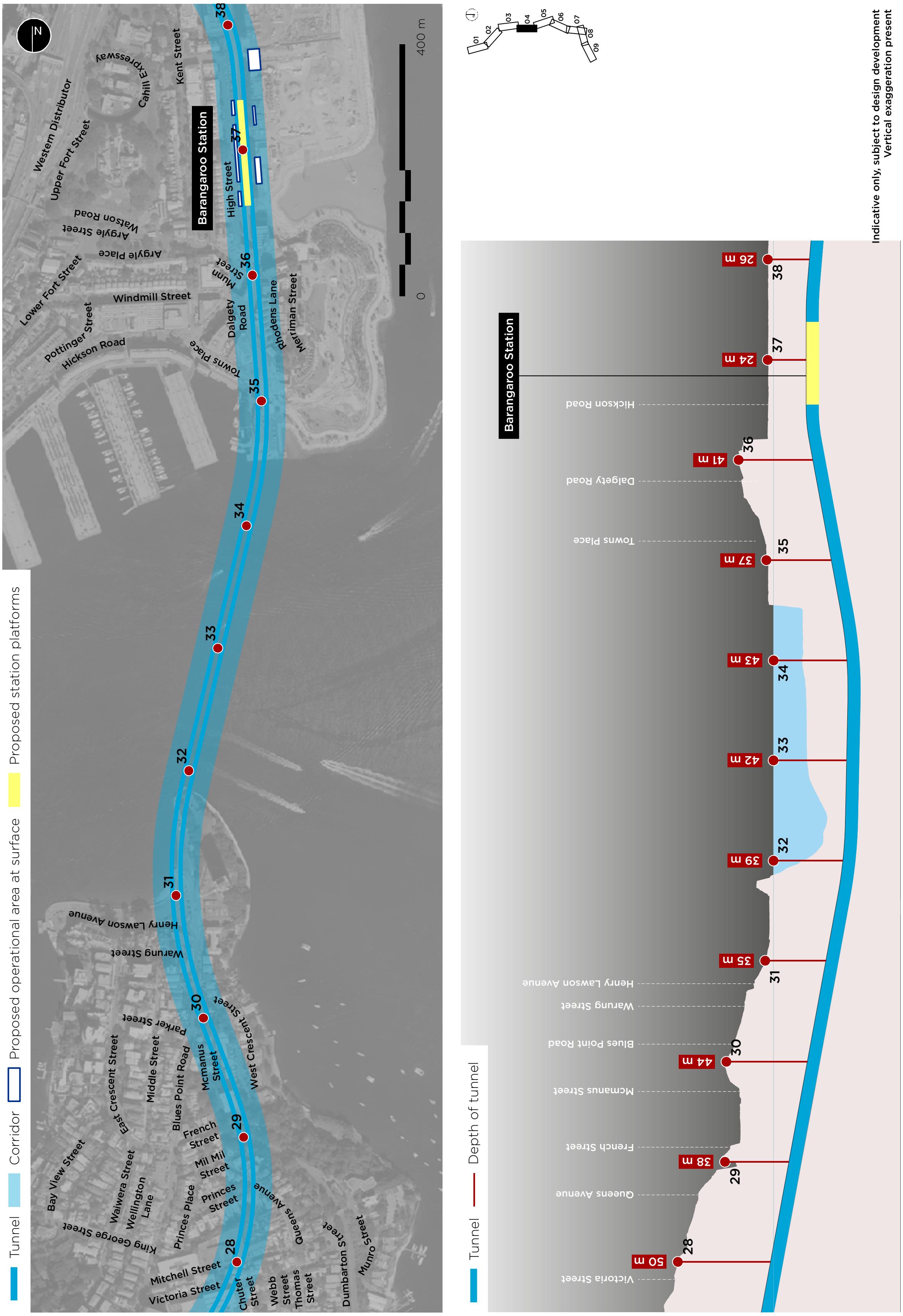


Figure 6-2d Indicative Chatswood to Sydenham alignment plan and long section

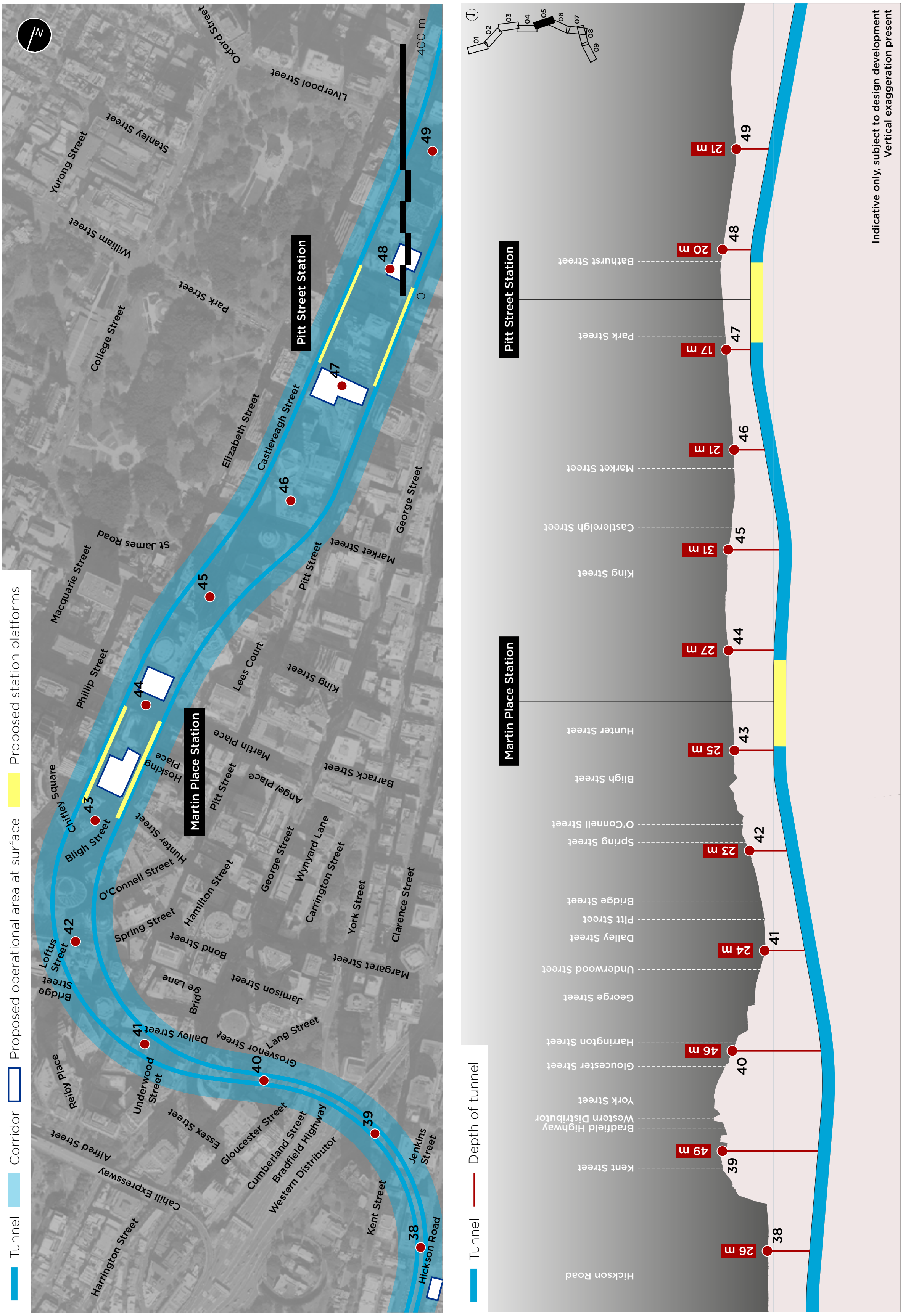


Figure 6-2e Indicative Chatswood to Sydenham alignment plan and long section

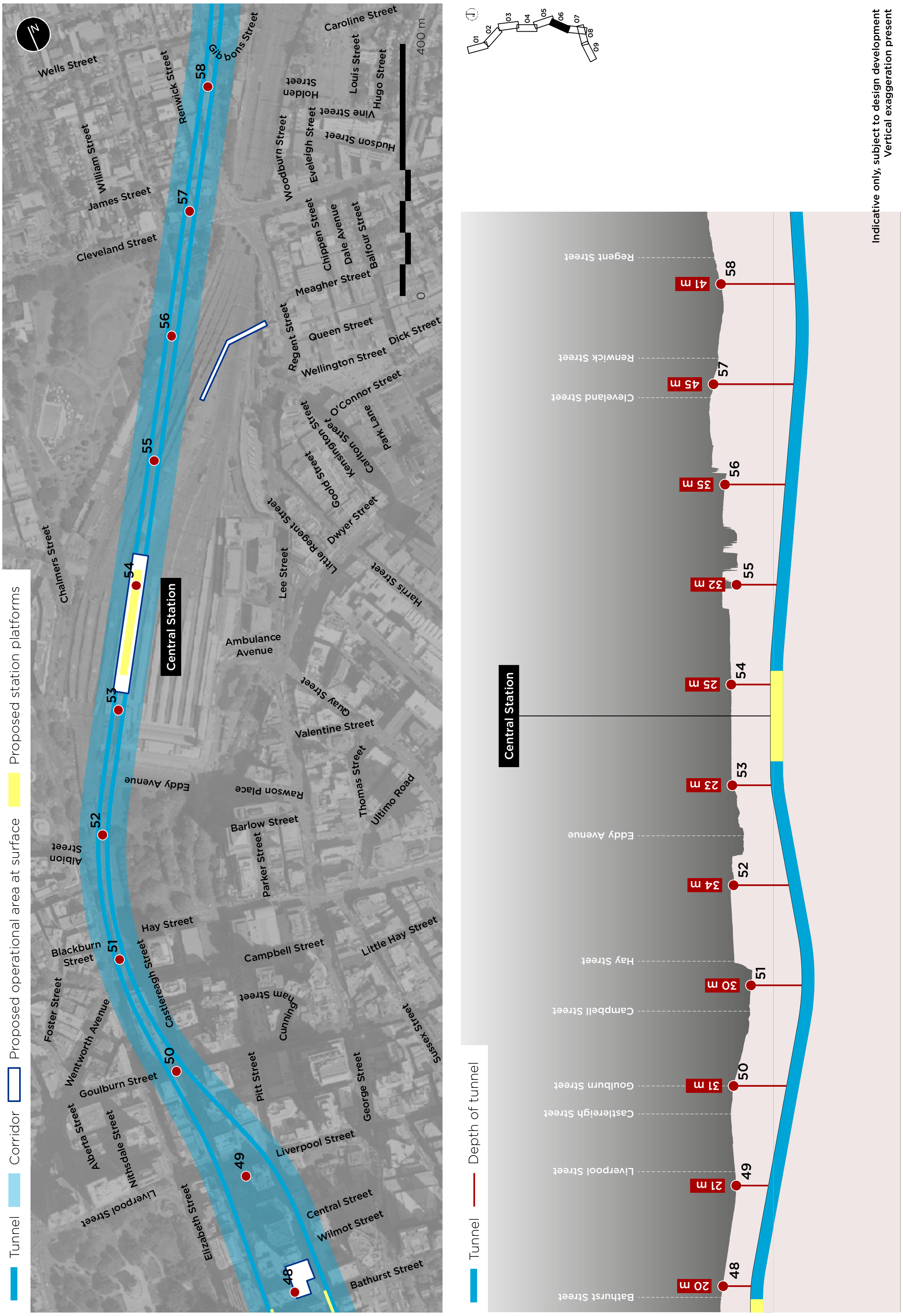


Figure 6-2f Indicative Chatswood to Sydenham alignment plan and long section

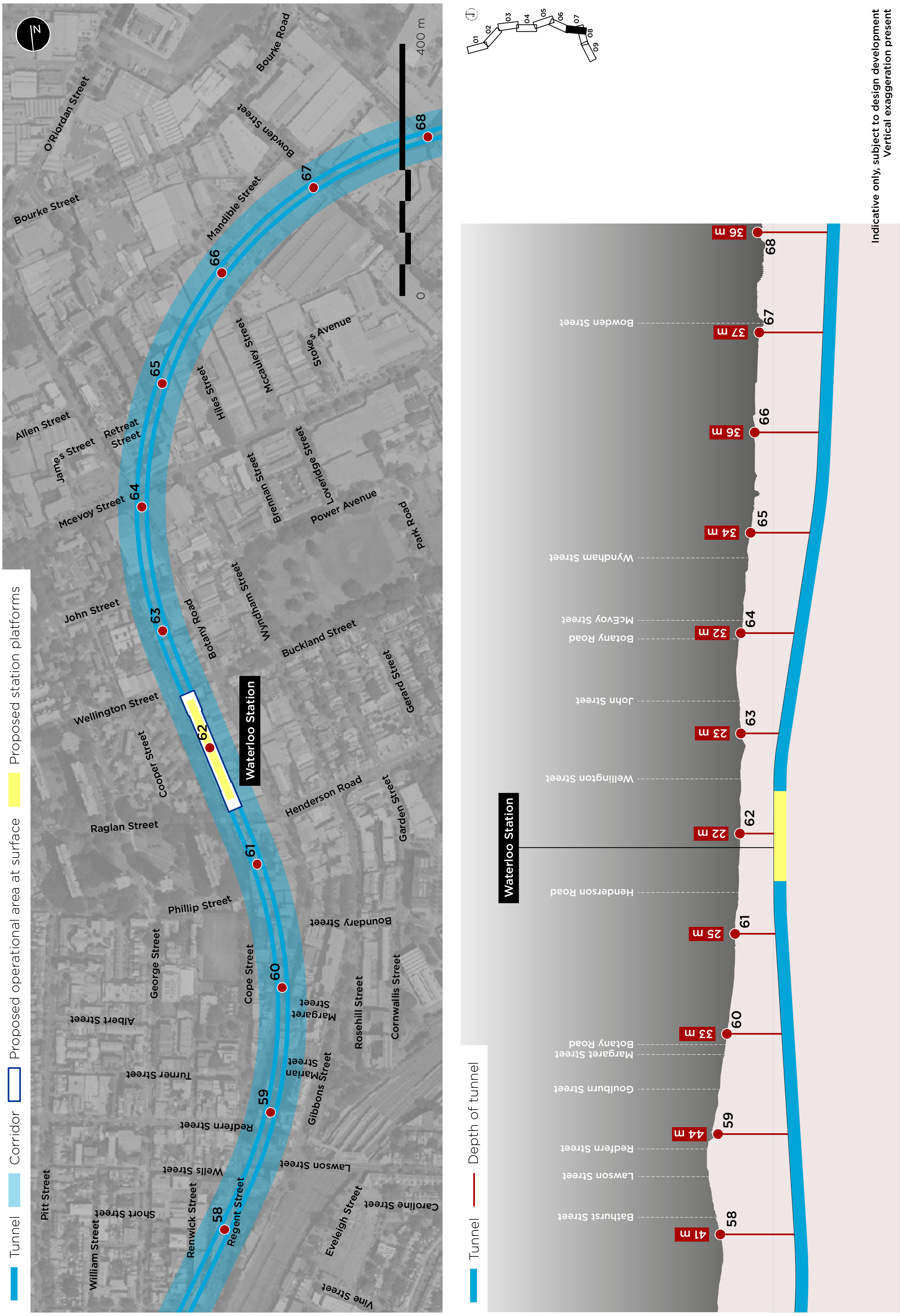


Figure 6-2g Indicative Chatswood to Sydenham alignment plan and long section

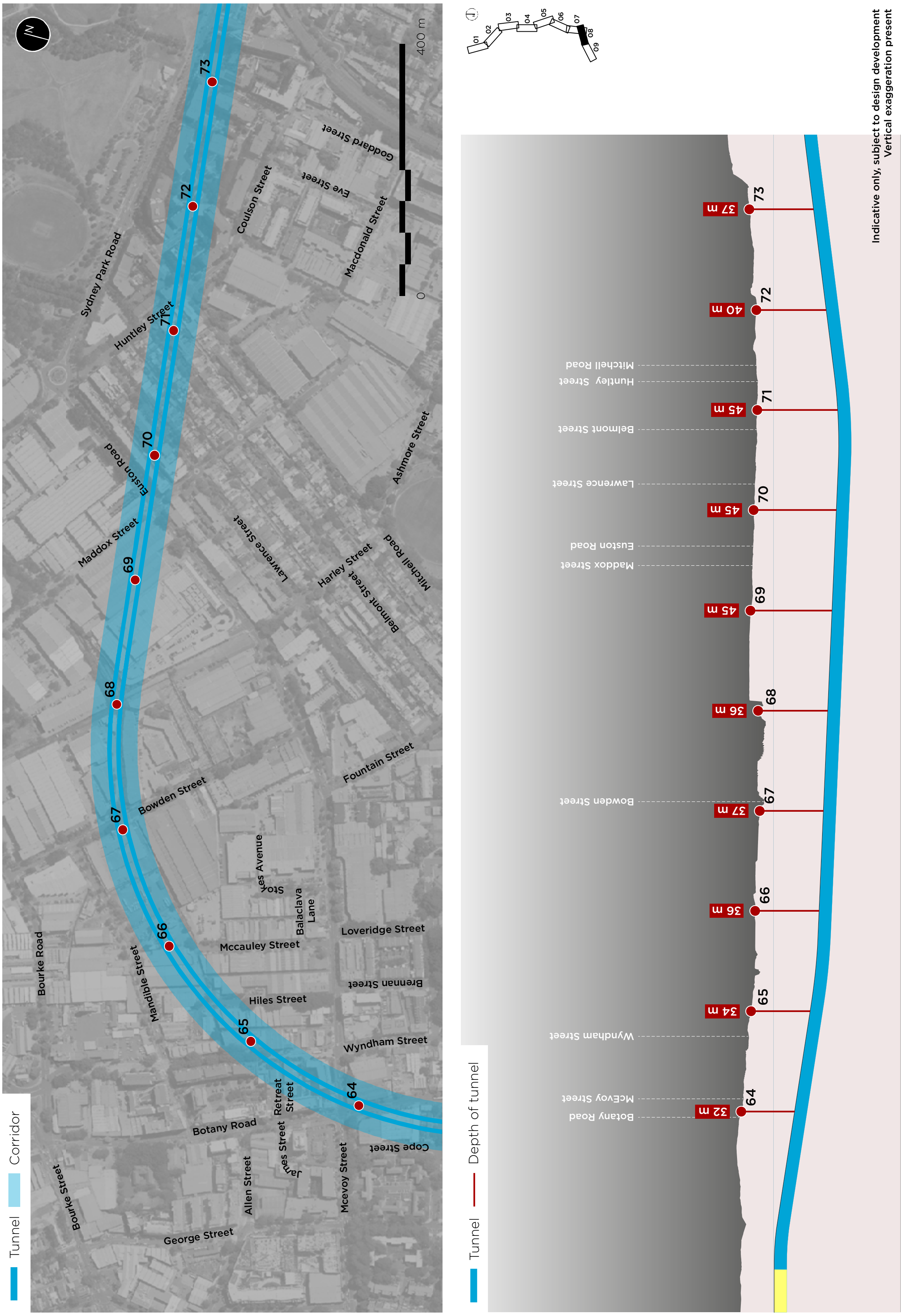


Figure 6-2h Indicative Chatswood to Sydenham alignment plan and long section

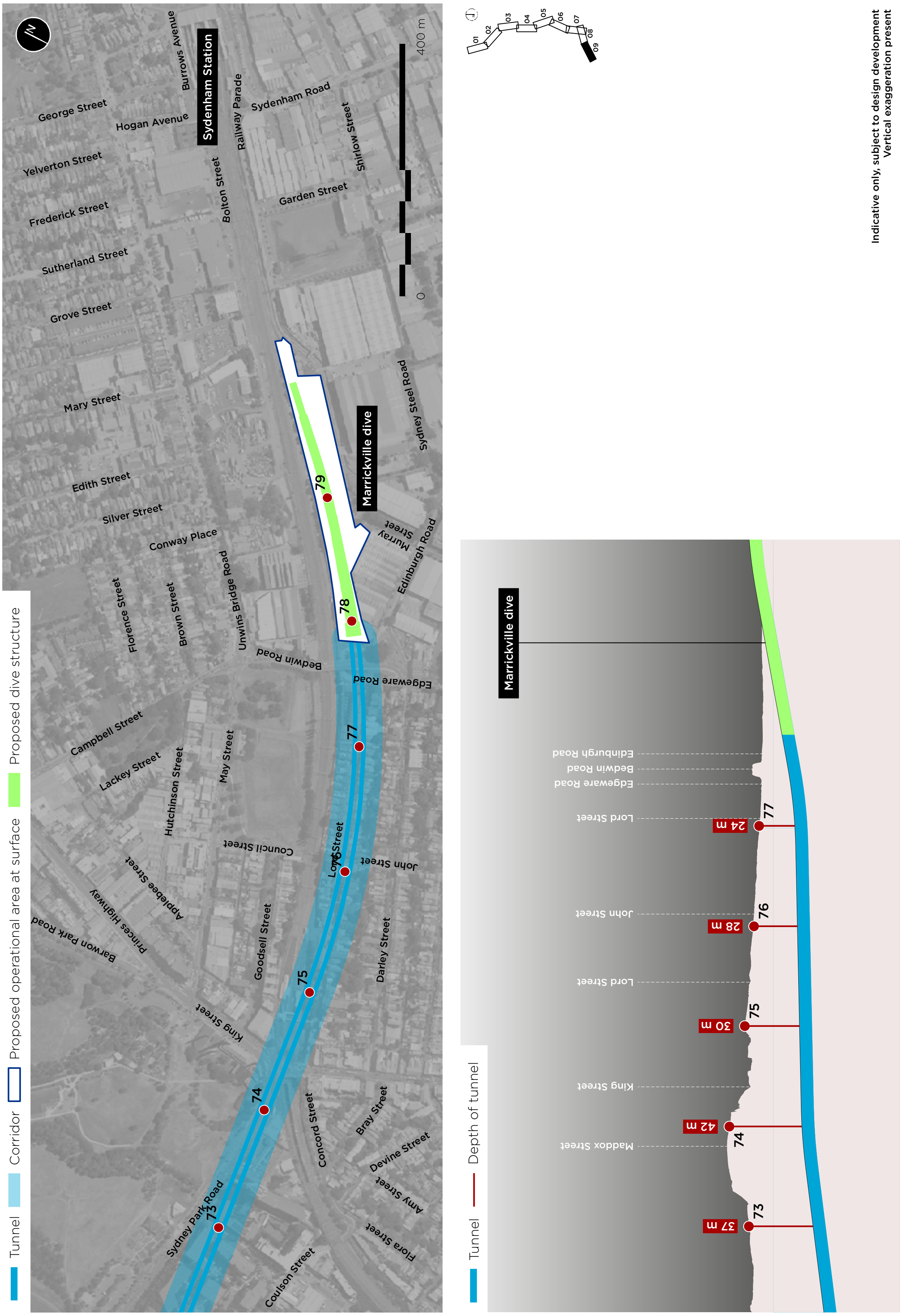


Figure 6-2i Indicative Chatswood to Sydenham alignment plan and long section

6.3.2 Tunnel and underground track features

Tunnel size

The metro rail tunnels would have a circular cross-section with an internal diameter of about six metres (radius of about three metres) and would be sized to accommodate the type of metro trains planned for Sydney Metro Northwest. The tunnels would be lined with pre-cast concrete segments to maximise the tunnel lifespan and minimise groundwater inflow. In addition to accommodating the trains and tracks, the tunnels would provide space for other equipment and services including rail signalling, controls and communication, overhead traction power, ventilation, fire and life safety systems, lighting and drainage.

An indicative cross-section of the underground tunnel is shown in Figure 6-3.

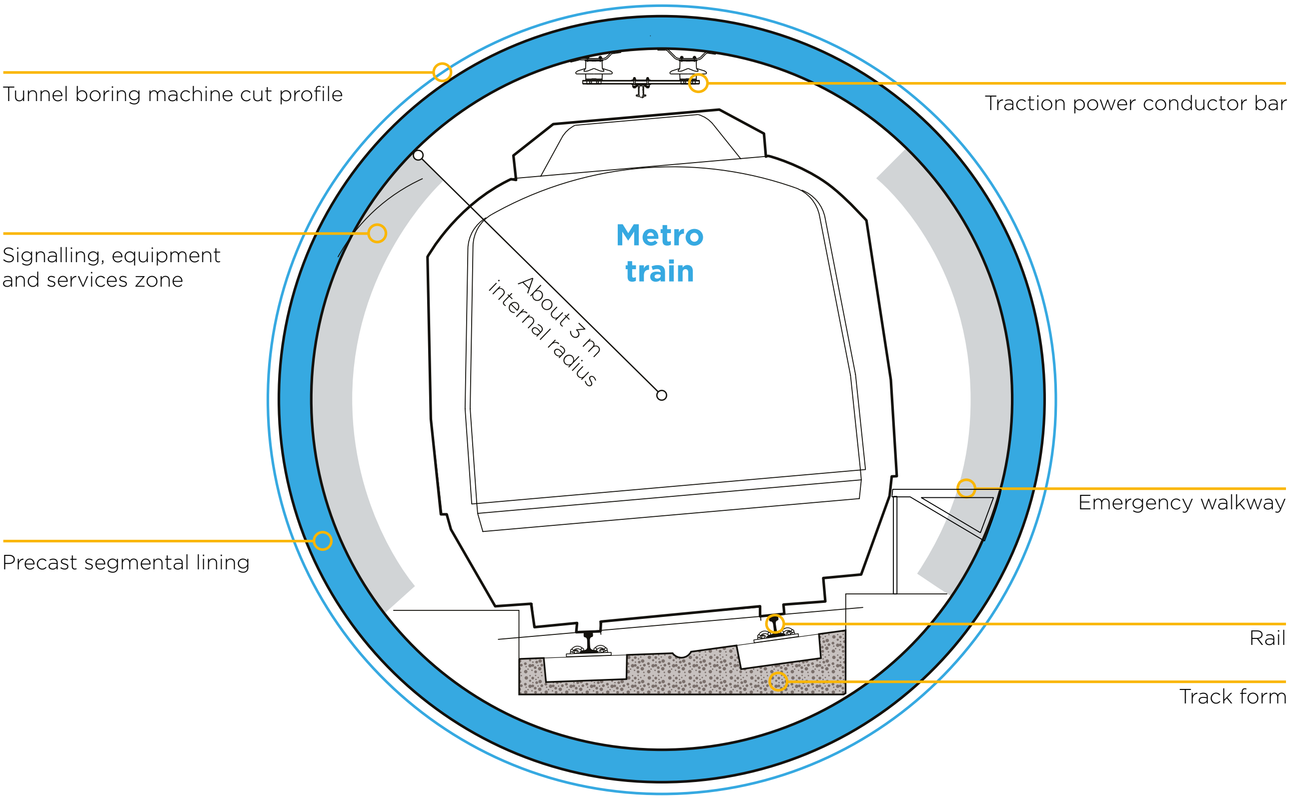


Figure 6-3 Indicative cross-section of a metro tunnel

Track type and configuration

The track in tunnel would consist of a fixed concrete slab combined with a continuously welded rail.

Track with higher noise and vibration attenuation may be used, where feasible and reasonable, to further mitigate ground-borne noise in certain locations (for example, where the tunnels are close to particularly sensitive receptors, such as residential buildings, schools, medical facilities or places of worship). Based on the current design this is likely to include a combination of hard, medium and soft resilient baseplates. Operational noise and vibration issues are addressed in Chapter 11 (Operational noise and vibration).

The tunnel track centrelines would typically be about 14 metres apart; however, variations to this tunnel spacing would occur at a number of locations to overcome geotechnical and other subsurface constraints (such as foundations and basements of existing overlying buildings).

The proposed configuration of the metro tracks between Chatswood and Sydenham is shown in Figure 6-4.

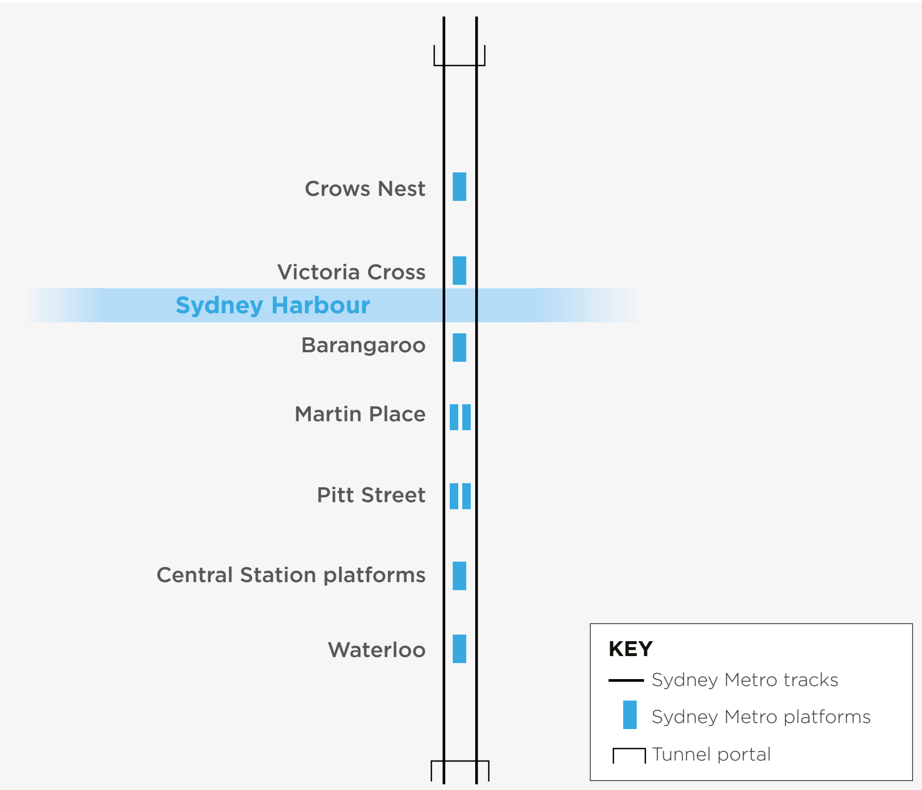


Figure 6-4 Track configuration for the project

Tunnel depth

Tunnels would typically be about 25 to 40 metres below surface level (the indicative depth of the tunnels is shown on Figure 6-2). At its shallowest point (approaching the tunnel portals), the tunnel crown (top of the tunnel) would be about 20 metres below the ground surface, while its deepest point (between Barangaroo and Martin Place stations) would be about 60 metres below the ground surface. For the section below Sydney Harbour, the tunnels would be about 40 metres below surface water level.

Emergency tunnel access and exit

A raised walkway would be provided throughout the tunnels to provide for emergency access and exit. These walkways would be the same height as the train floor so customers could evacuate in an emergency. To facilitate emergency access and exit between the two tunnels, cross passages would be provided at maximum intervals of about 240 metres. Figure 6-5 shows an indicative cross-section of a cross passage.

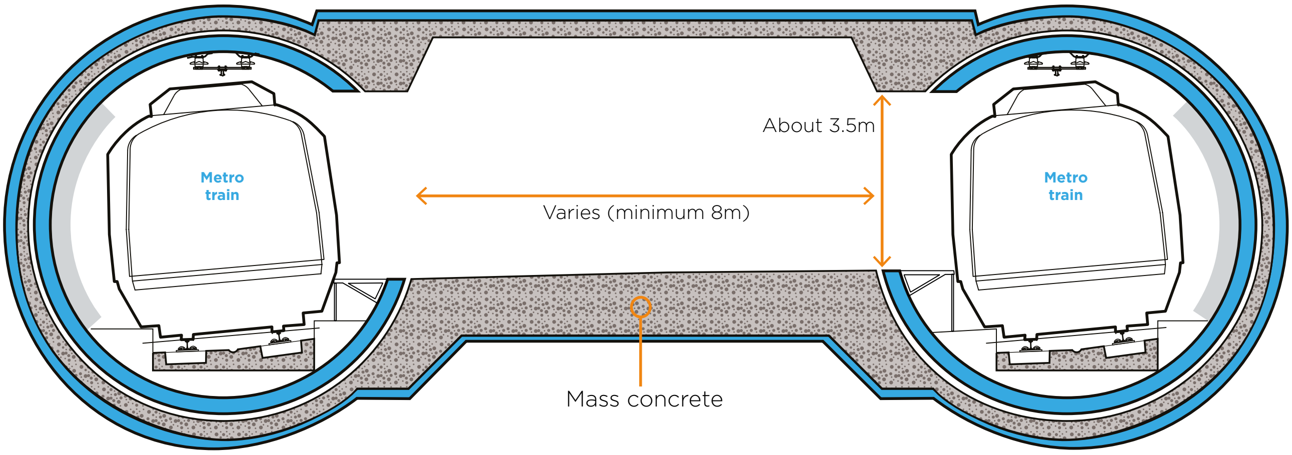


Figure 6-5 Indicative section of a tunnel cross passage

Ventilation system

During normal operations, tunnel ventilation would be provided by train movements and the operation of fans at the stations to exhaust air from the tunnels. Heat removal would typically occur via the tunnel exhaust; however, ventilation fans could also be operated to provide additional heat removal particularly in peak summer conditions. Typically, the direction of ventilation would be the direction of train travel; however, the system would be designed to allow for ventilation in both directions.

In the event of a tunnel fire, the ventilation system would generate longitudinal flow in the incident tunnel to prevent smoke building up in the area of the fire.

Separate mechanical ventilation systems would be provided at each underground station for heat removal and to provide fresh air. Full height platform screen doors at stations would assist in controlling underground station temperatures by physically separating the tunnel and station environments.

Drainage and stormwater

Within the tunnels, drainage depressions would be incorporated into the concrete slabs that form the base for the rail track. Drainage at the dive structures would be designed for the 100 year average recurrence interval event and drainage of at-grade sections would be through a combination of pit and pipe, open and subsurface drains.

Stormwater drainage at the dive structures would be designed to ensure no net increase in discharge rates to downstream stormwater systems for all storm events up to and including the 100 year average recurrence interval event. Further details regarding flooding are provided in Chapter 21 (Flooding and hydrology).

A tunnel water treatment plant would be located adjacent to the Marrickville dive structure. The water treatment plant would treat wastewater pumped from the tunnels, stations and other underground facilities. The water treatment plant building would contain holding tanks, chemical treatment tanks and filters. Further information regarding the likely treatment methods, wastewater volumes and discharge points is provided in Chapter 18 (Soils, contamination and water quality).

In order to mitigate the potential flood impacts around the Marrickville dive structure, the project would include the introduction of 10 grated inlets (around 3m x 1.2m) at around ten metre spacing on the eastern side of the proposed metro rail tracks, each connected to Eastern Channel via two underground reinforced concrete box culverts (around 1.2m x 0.9m).

6.4 Surface tracks

6.4.1 Metro tracks

The project would include about 250 metres of surface metro tracks between the Chatswood dive structure and Chatswood Station, connecting to the Sydney Metro Northwest tracks. The surface metro tracks would be located between the T1 North Shore Line tracks. The spacing (track centres) between the Sydney Trains tracks and the metro tracks would be about 4.7 metres. The arrangement of these tracks is shown on Figure 6-6 and an indicative cross-section on Figure 6-7.

The surface metro tracks would generally be placed on ballast with concrete sleepers. Alternative track types may be used in some locations where additional noise mitigation is required.

The connection of the metro tracks from the Marrickville dive structure to Sydenham Station would be subject to a separate assessment as part of the Sydenham to Bankstown upgrade project.

6.4.2 Sydney Trains tracks

The T1 North Shore Line tracks and rail systems would be adjusted between the southern end of Chatswood Station and Brand Street, Artarmon to accommodate the metro surface tracks and Chatswood dive structure.

Between Chatswood Station and the Chatswood dive structure the T1 North Shore Line tracks would be re-located to the outside of the metro tracks. To accommodate the metro tracks, including the dive structure and tunnel portal, the T1 North Shore Line 'down' (northbound) track would be relocated to the west and would pass over the metro dive structure on a bridge.

The T1 North Shore Line would continue to be managed by Sydney Trains. The arrangement of the T1 North Shore Line tracks and the metro tracks is shown on Figure 6-6.

There would be no changes to the Sydney Trains tracks at the southern end of the project. Any adjustments to these Sydney Trains tracks that may be required would be subject to a separate assessment as part of the Sydenham to Bankstown upgrade project.

Figure 6-6 Arrangement of metro tracks and T1 North Shore Line tracks

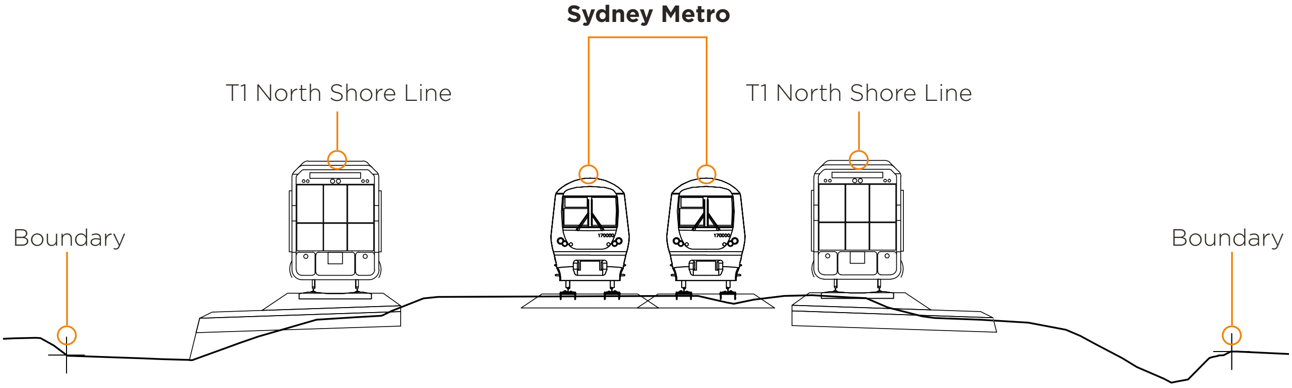


Figure 6-7 **Indicative cross-section of metro tracks and T1 North Shore Line tracks**

6.5 Overview of metro stations

New metro stations would be located at Crows Nest, Victoria Cross, Barangaroo, Martin Place, Pitt Street and Waterloo, and new metro platforms would be located at Central Station.

This section discusses the common station elements and identifies the station configurations.

6.5.1 Common station elements

Metro stations would be designed to provide safe and efficient interchange between transport modes, including minimising conflicts between pedestrians, cyclists, buses and vehicles.

Each metro station would have a number of common elements or design features. These would include:

- Station concourses (paid and unpaid) and platforms
- Vertical transport including escalators and lifts
- Station service buildings – located to minimise the street frontage within important urban areas
- Signage and wayfinding within the station and the surrounding public domain
- Awnings for shade and shelter at street level station entries
- Retail space within the station building
- Enhancements to the footpath in the vicinity of the station entries
- Landscaping and street furniture to maintain high quality urban design outcomes.

6.5.2 Station configurations

The metro stations would be configured as either a large ‘single-span’ cavern that accommodates tracks for both directions of travel and a central island platform or a ‘binocular cavern’ where each platform and track is housed in a single smaller cavern (refer Figure 6-8).

The decision on whether a single-span or binocular station cavern would be used at a particular station has been based primarily on constraints to the tunnel alignment (building basements or other subsurface infrastructure). Where the tunnel alignment is unrestricted by underground constraints, a single-span cavern is the preferred configuration as it is more cost effective to construct and minimises customer travel time to and from the platforms. Single-span caverns can be constructed using either a cut-and-cover or a mined technique (as described in Chapter 7 (Project description – construction).

A single-span mined cavern is proposed for Victoria Cross Station. Single-span cut-and-cover stations are proposed for Crows Nest, Barangaroo, Central and Waterloo stations. Binocular mined cavern stations are proposed for Martin Place and Pitt Street stations.

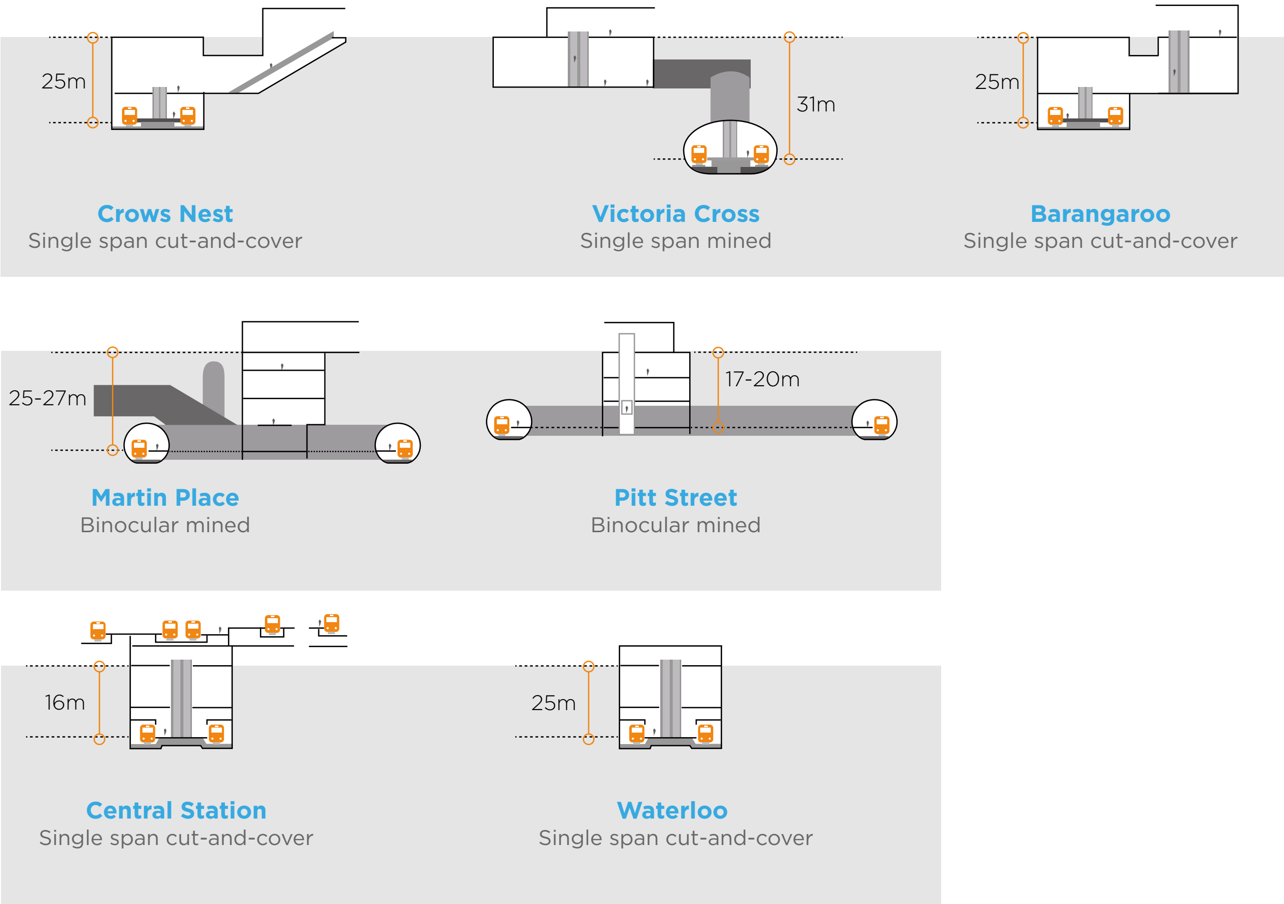


Figure 6-8 Station configurations

6.5.3 Provision for over station development

As discussed in Chapter 2 (Planning and assessment process), all aspects of the over station development above the transfer slab would be subject to a separate planning approval process.

Over station development uses the air-space over rail assets including stations. Sydney Metro has identified the following sites with potential for property development over or associated with the proposed metro stations:

- Crows Nest Station
- Victoria Cross Station (southern site only)
- Martin Place Station (northern and southern sites)
- Pitt Street Station (northern and southern sites)
- Waterloo Station.

Barangaroo Station is located within the Central Barangaroo precinct. Over station development at this site would form part of the Barangaroo development and be the subject of separate applications for approval.

There are no over station development opportunities at Central Station as part of the proposed Sydney Metro works.

The metro stations would be designed to take into account, and make physical provision for, any design or other requirements associated with possible future over station development. In general the metro stations would include:

- Structural elements (steel and / or concrete), building grids, column loadings and building infrastructure to enable to construction of the future over station development
- Space for future lift cores, access, parking and building services for the future over station development.

This design integration would ensure the future developments can be built efficiently and effectively.

Figure 6-9 provides a typical interface of a metro station with an over station development. Typically, the metro station would progress up to a 'transfer slab' level above the ground plane.

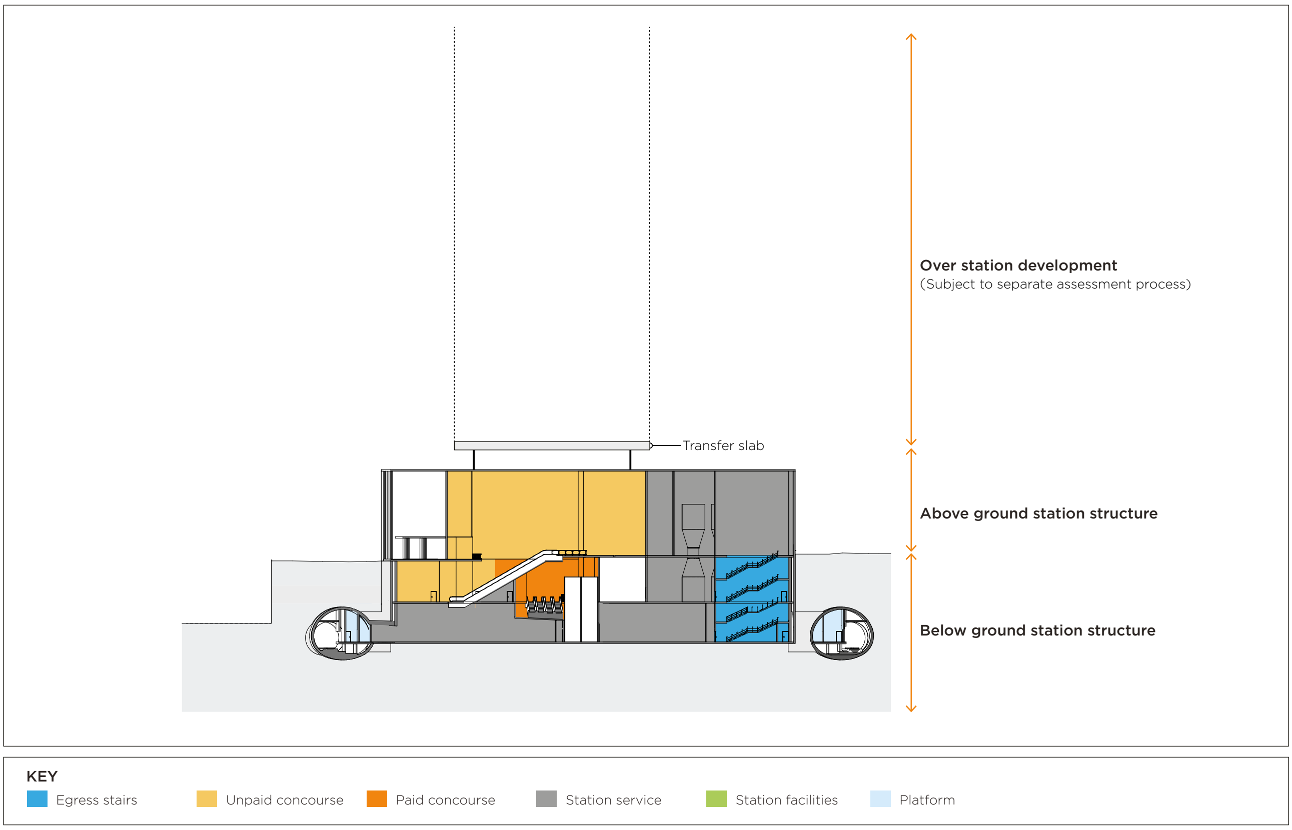


Figure 6-9 Typical over station development interface

6.6 Metro stations

The following sections discuss specific design elements relating to each metro station.

6.6.1 Crows Nest Station

Crows Nest Station would be located between the Pacific Highway and Clarke Lane (eastern side of the Pacific Highway) and between Oxley Street and south of Hume Street (refer to Figure 6-10). It would be strategically located to the south of the existing station at St Leonards and close to the leisure and retail strip along Willoughby Road.

Station strategy

Crows Nest Station would support the St Leonards specialised centre as a southern gateway to commercial and mixed use activities. The station would also improve access to the restaurants and specialist shops in the Crows Nest village. The station strategy for Crows Nest would:

- Create a new transport focus on the southern side of the St Leonards specialised centre
- Maximise legibility and connectivity with the local urban structure
- Integrate the station with local improvement plans and make a positive contribution to the sense of place.

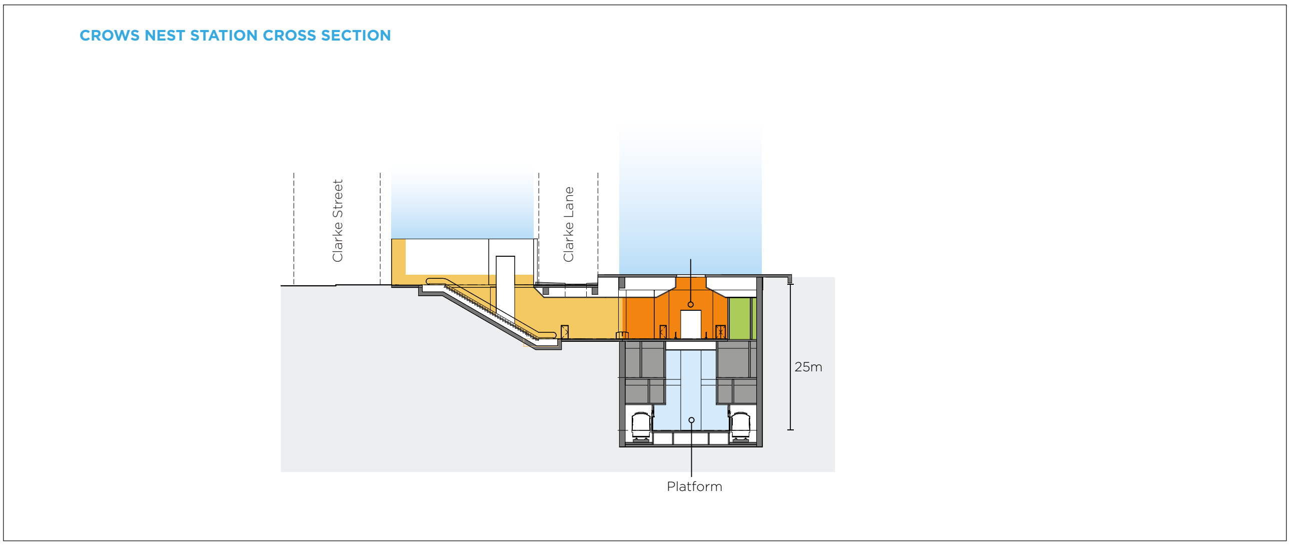
The location and key features of Crows Nest Station are shown in Figure 6-10 to Figure 6-12 and summarised in Table 6-4.

Figure 6-10 Crows Nest Station – location and indicative layout

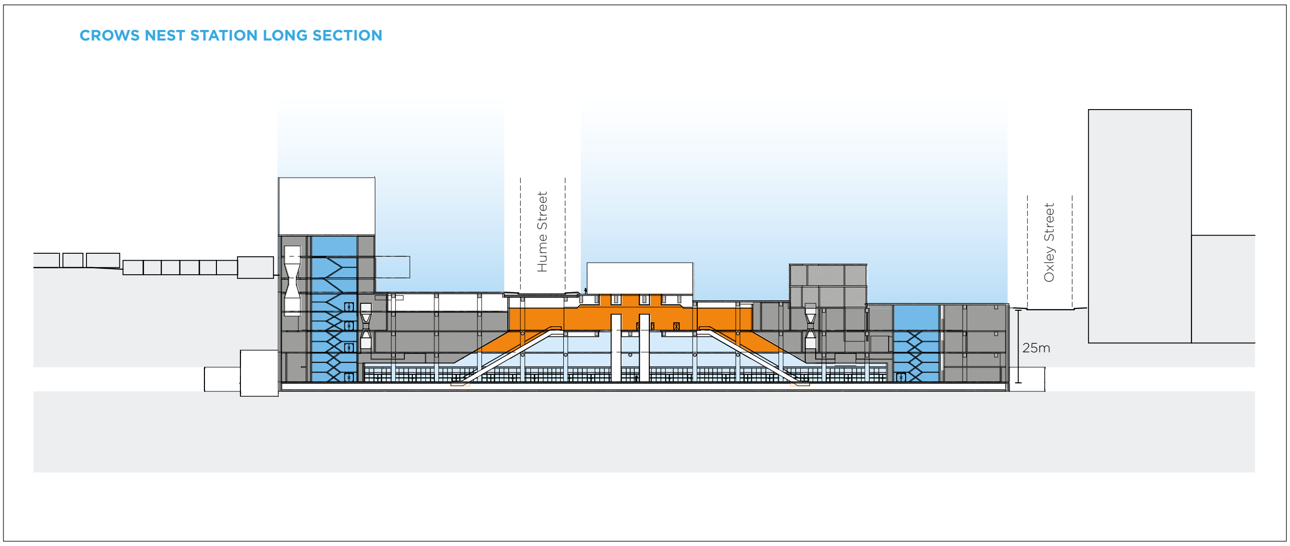
Figure 6-11 Crows Nest Station – artist's impression

Table 6-4 Crows Nest Station design elements

Feature	Description
Centre type	Specialised centre
Station type	Single-span (cut-and-cover) cavern with island platform
Transport interchange	Walking, cycling, bus, taxi and kiss-and-ride
Station entry / exit	• On the corner of Hume and Clarke Streets • On the corner of Pacific Highway and Oxley Street
Customers	• Existing residents within walking and cycling distance • Visitors and patrons accessing the leisure and retail strip along Willoughby Road • Existing employment area along Willoughby Road, Christie Street and the Pacific Highway
Platform depth	About 25 metres
Platform length	About 170 metres
Platform width	About 10 metres
Overall station length	About 210 metres
Transport and access	• New signalised pedestrian crossing on northern side of Pacific Highway / Oxley Street intersection • New pedestrian crossings on Clarke, Hume and Oxley streets • New bike parking on Hume and Oxley streets • New on-road marked cycle link on Hume Street • Existing bus stops close to the station retained on the Pacific Highway • New kiss-and-ride and taxi bays on Clarke Street



KEY
Emergency egress stairs | Unpaid concourse | Paid concourse | Station service | Station facilities | Platform | Over station development



KEY
Emergency egress stairs | Unpaid concourse | Paid concourse | Station service | Station facilities | Platform | Over station development

Figure 6-12 Crows Nest Station – indicative cross-section and long section

6.6.2 Victoria Cross Station

Victoria Cross Station would be located beneath Miller Street (to the north of the Pacific Highway) between McLaren Street and south of Berry Street (refer to Figure 6-13). It would be strategically located within the North Sydney CBD and close to a number of educational institutions (including the Australian Catholic University) and mixed employment areas along Miller Street, Walker Street and the Pacific Highway.

Station strategy

A metro station at Victoria Cross would support the continued growth of the North Sydney CBD as an integral part of Global Sydney. The new station would improve customer experience at the existing North Sydney Station by relieving demand in peak times.

The station strategy for Victoria Cross would:

- Create a new transport focus in the North Sydney CBD
- Contribute to the attractiveness of the North Sydney CBD by adding to and integrating with the public domain
- Improve the permeability of the immediate station context.

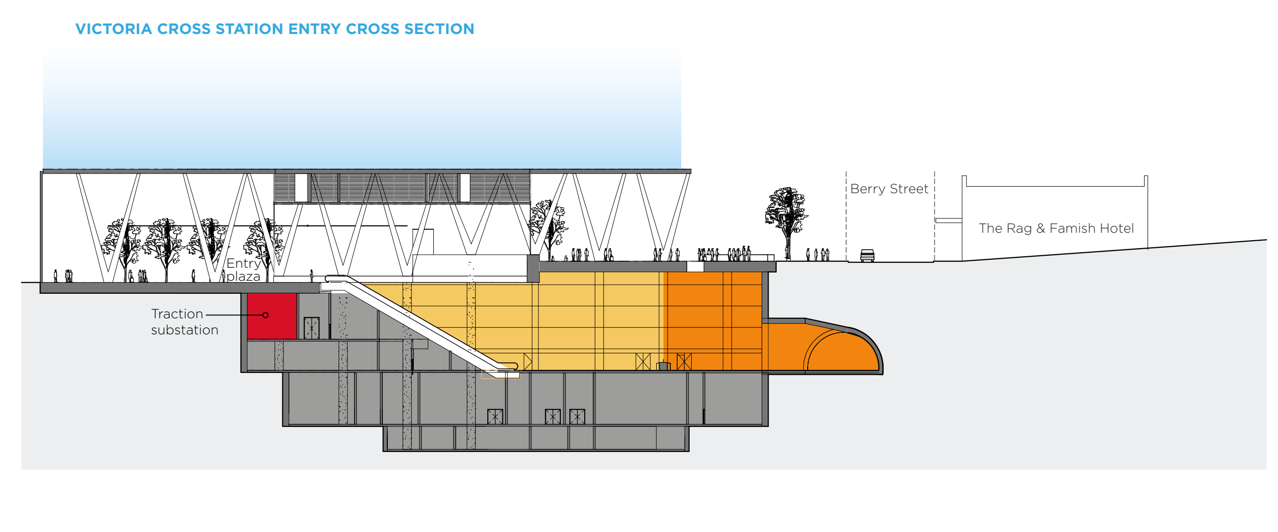
The location and key features of Victoria Cross Station are shown in Figure 6-13 to Figure 6-15 and summarised in Table 6-5.

Figure 6-13 Victoria Cross Station – location and indicative layout

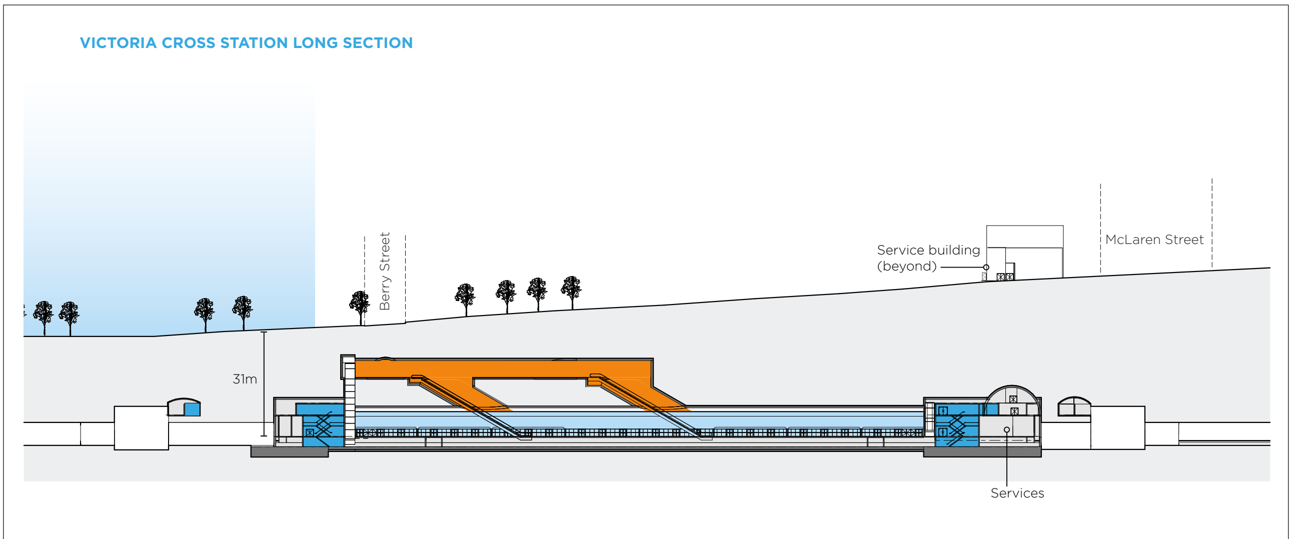
Figure 6-14 Victoria Cross Station – artist's impression

Table 6-5 Victoria Cross Station design elements

Feature	Description
Centre type	Global Sydney (North Sydney CBD)
Station type	Single-span (mined) cavern with island platform
Transport interchange	Walking, cycling, bus, taxi and kiss-and-ride
Station entry / exit	Via a pedestrian plaza opening to Miller, Denison and Berry streets
Customers	Customers travelling to nearby employment, education and residential precincts
Platform depth	About 31 metres
Platform length	About 170 metres
Platform width	About 10 metres
Overall station length	About 220 metres
Transport and access	• New signalised mid-block pedestrian crossing on Miller Street • New bike parking near the corner of Miller and Berry streets • Existing bus stops close to the station retained on Miller Street • New kiss-and-ride bays on Berry Street
Services	Dedicated services building on Miller Street to the north of the station providing station and tunnel services



KEY
Emergency egress stairs | Unpaid concourse | Paid concourse | Station service | Station facilities | Platform | Traction substation | Over station development



KEY
Emergency egress stairs | Unpaid concourse | Paid concourse | Station service | Station facilities | Platform | Over station development

Figure 6-15 Victoria Cross Station – indicative cross-section and long section

6.6.3 Barangaroo Station

Barangaroo Station would be located beneath Hickson Road towards its northern end (refer to Figure 6-16). It would be strategically located to provide immediate access to commercial, mixed use (residential and commercial) and entertainment precincts within the overall Barangaroo development. A station at Barangaroo would also service a residential catchment at Millers Point, Walsh Bay and future residents at Barangaroo. A station at Barangaroo would also provide relief to Wynyard Station.

Station strategy

The Barangaroo Station would improve accessibility to Barangaroo and the Walsh Bay Arts and Culture precinct.

The station strategy for Barangaroo would:

- Maximise connectivity and legibility to the primary uses within and nearby the Barangaroo precinct
- Ensure legible and direct access to Barangaroo Reserve and Barangaroo Ferry Hub
- Integrate with development plans for Barangaroo.

The location and key features of Barangaroo Station are shown in Figure 6-16 to Figure 6-18 and summarised in Table 6-6.

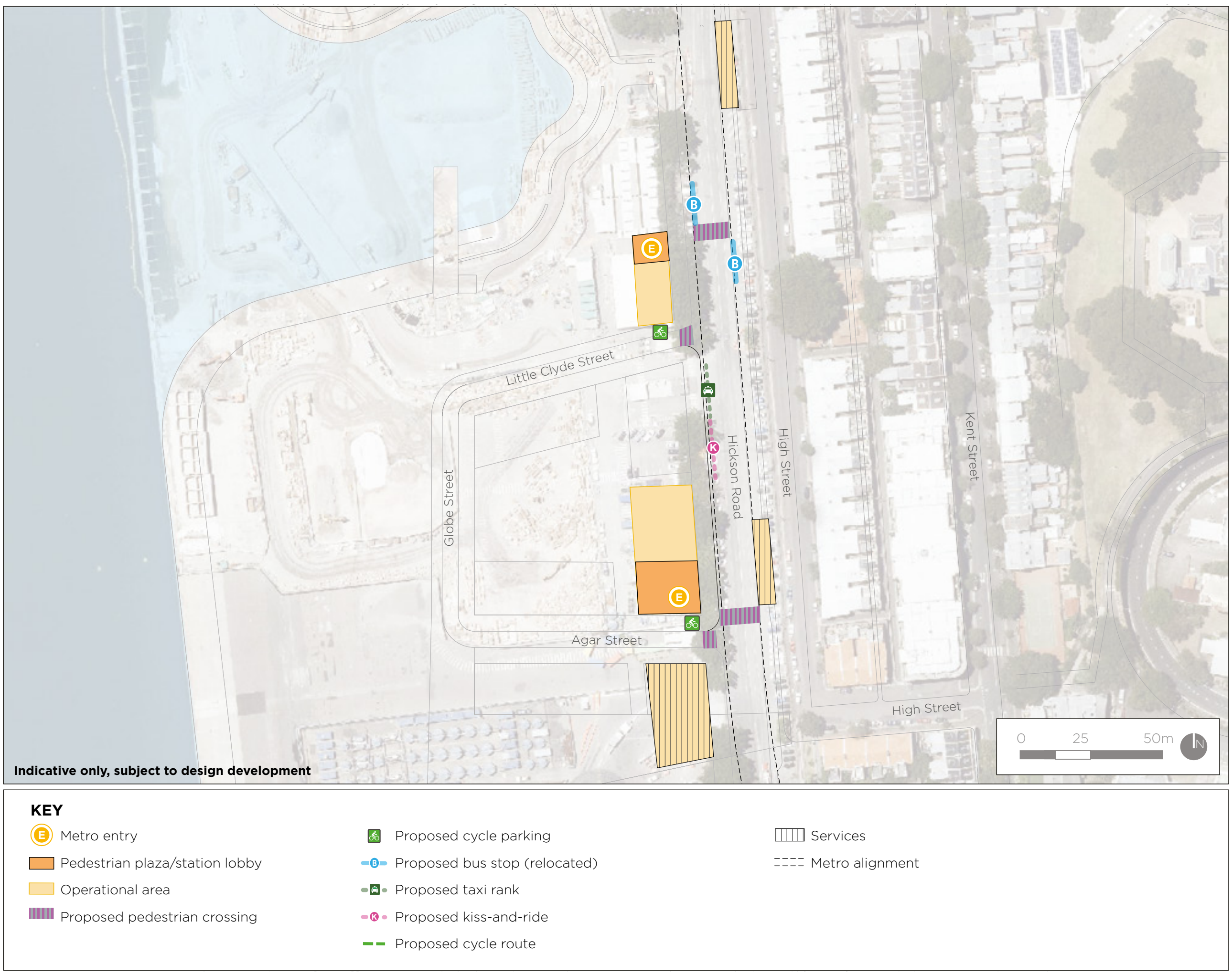


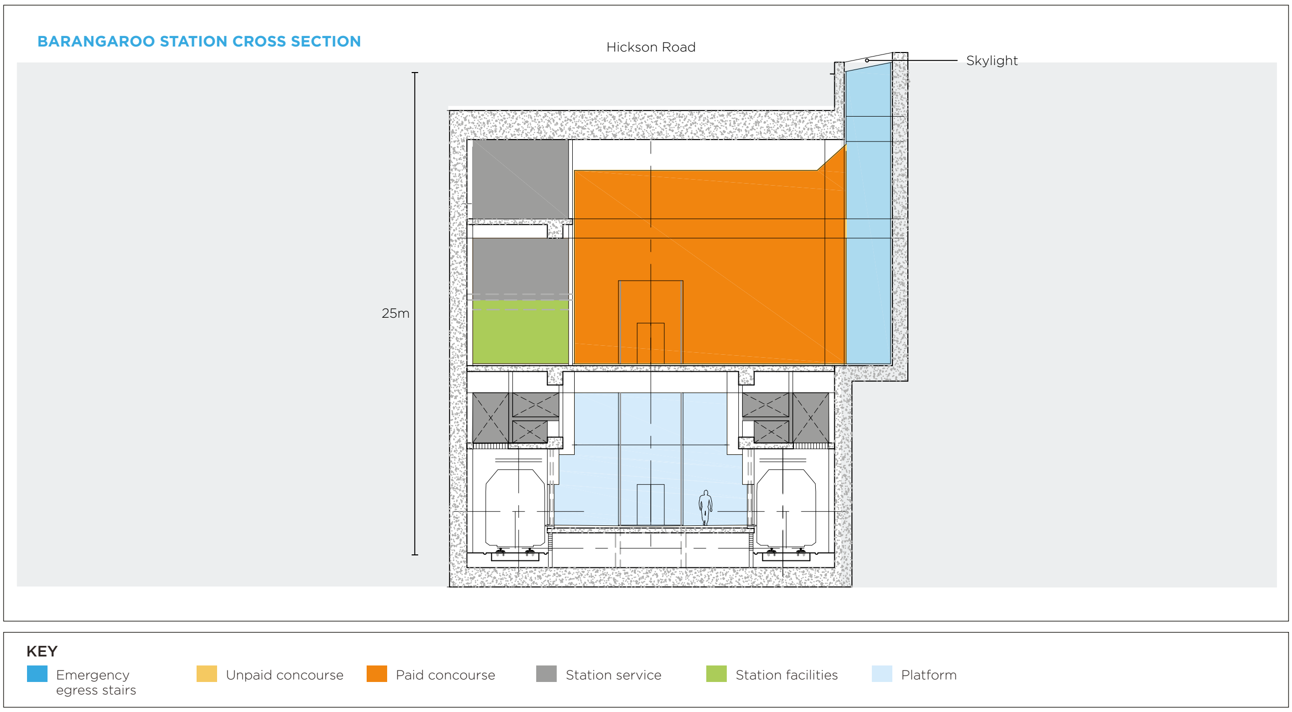
Figure 6-16 Barangaroo Station – location and indicative layout

Figure 6-17 Barangaroo Station – artist's impression

Table 6-6 Barangaroo Station design elements

Feature	Description
Centre type	Global Sydney (Sydney CBD)
Station type	Single-span (cut-and-cover) cavern with island platform
Transport interchange	Walking, cycling, bus, taxi and ferry
Station entry / exit	Within Central Barangaroo and Barangaroo Reserve
Customers	• Customers travelling to nearby employment, recreation and tourist precincts • Customers travelling to and from nearby existing and future residential areas
Platform depth	About 25 metres
Platform length	About 170 metres
Platform width	About 10 metres
Overall station length	About 210 metres

Feature	Description
Transport and access	Transport for NSW would develop transport and access arrangements in consultation with Banangaroo Delivery Authority. At this stage, they are expected to include: • New pedestrian crossings on Hickson Road, Little Clyde Street and Agar Street • New bike parking on Little Clyde and Agar streets • Relocation of the bus stops on Hickson Road closer to the station entry • New kiss-and-ride and taxi bays on Hickson Road.



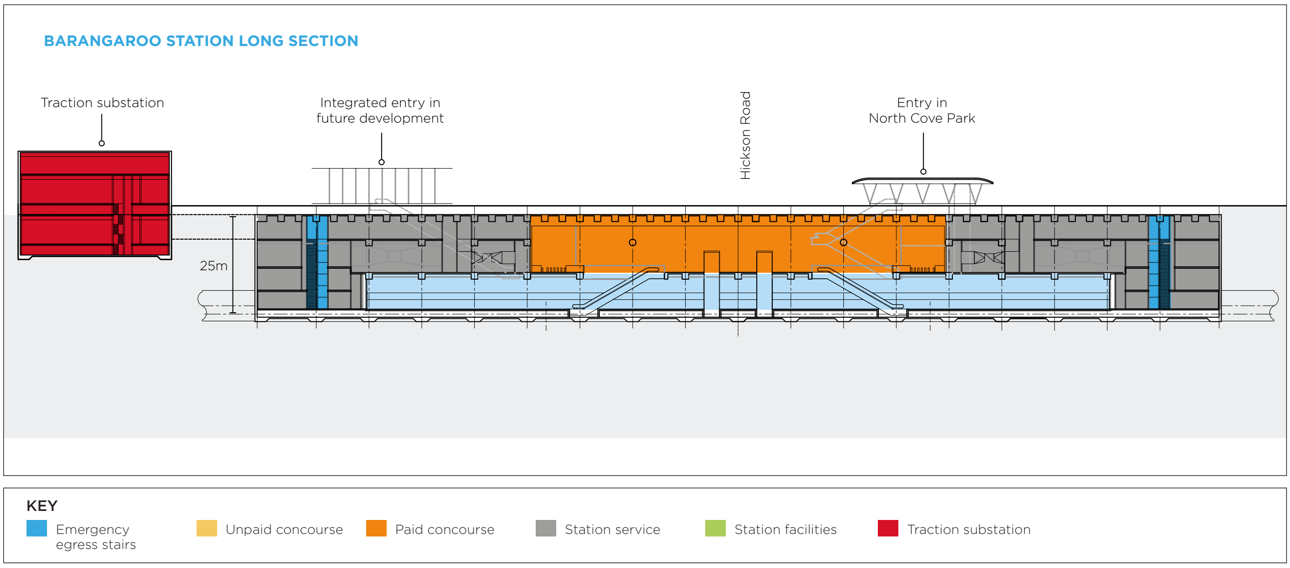


Figure 6-18 Barangaroo Station – indicative cross-section and long section

6.6.4 Martin Place Station

Martin Place Station would be located to the south of Hunter Street between Castlereagh and Elizabeth streets (refer to Figure 6-19). The metro station would be integrated with the existing Martin Place suburban and intercity rail station and would be strategically located close to Sydney's financial district, the Macquarie Street civic precinct, the Pitt Street retail zone and Martin Place (Sydney CBD's primary east-west pedestrian corridor).

Martin Place Station would also involve the closure of existing access and egress points, inclduing the underground connections, to the west of Elizabeth Street from Martin Place to the underground concourse connection to the existing Martin Place Station.

Further investigations are currently being carried out in relation to an underground pedestrian connection at the northern end of the Martin Place Station platform concourse to 33 Bligh Street. The connection would be at platform level leading to an exit via escalators to street level at O'Connell Street and / or Bligh Street. Provision of this connection would aid in the distribution of Metro and Sydney Trains customers into the northern Sydney CBD precinct, from Martin Place Station. A connection from the station to the 33 Bligh Street could also help separate metro customers from vehicular traffic movements at the Castlereagh Street / Hunter Street intersection.

Further investigations are being carried out to refine the optimal station entrance location for the pedestrian connection to 33 Bligh Street.

Station strategy

A metro station at Martin Place would serve Sydney's high-end commercial and financial district, the Macquarie Street precinct and the Pitt Street retail zone.

The station strategy for Martin Place would:

- Reflect the significance of Martin Place and flagship status of the station by designing clear, legible, iconic, integrated entries
- Provide generous space for customers in a busy pedestrian environment by extending the public domain into station entries
- Provide an efficient interchange in the centre of the Sydney CBD through convenient, direct connections to the T4 Eastern Suburbs and Illawarra line platforms
- Integrate with the public domain and transport access improvements currently planned.

The location and key features of Martin Place Station are shown in Figure 6-19 to Figure 6-22 and summarised in Table 6-7.

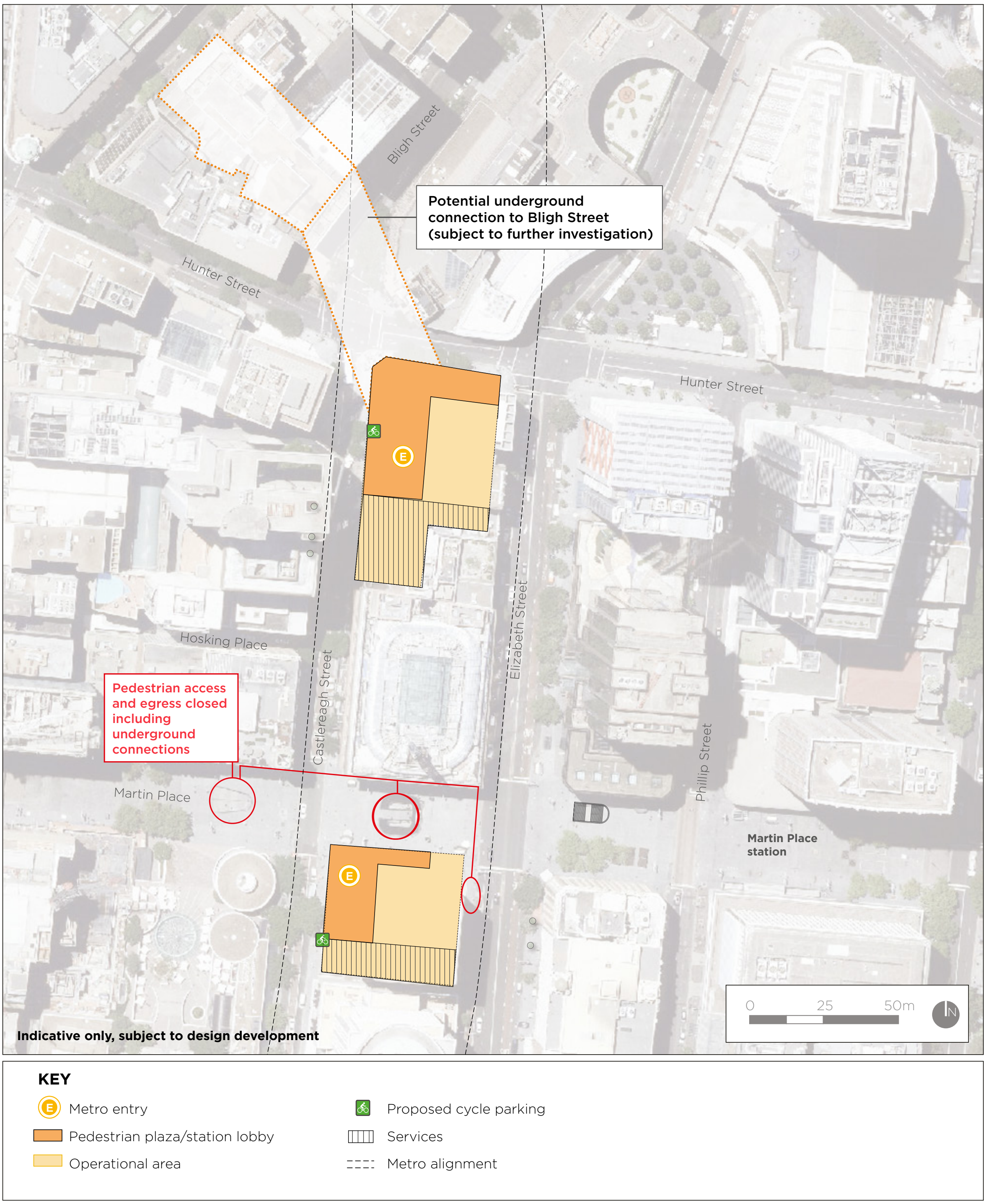


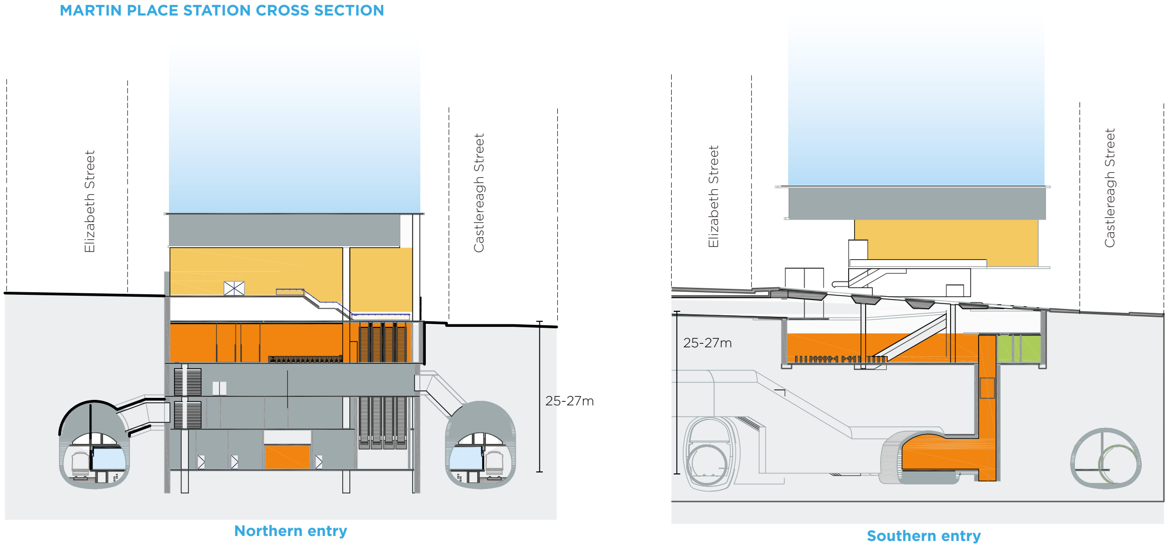
Figure 6-19 Martin Place Station – location and indicative layout

Figure 6-20 Martin Place Station – artist's impression

Table 6-7 Martin Place Station design elements

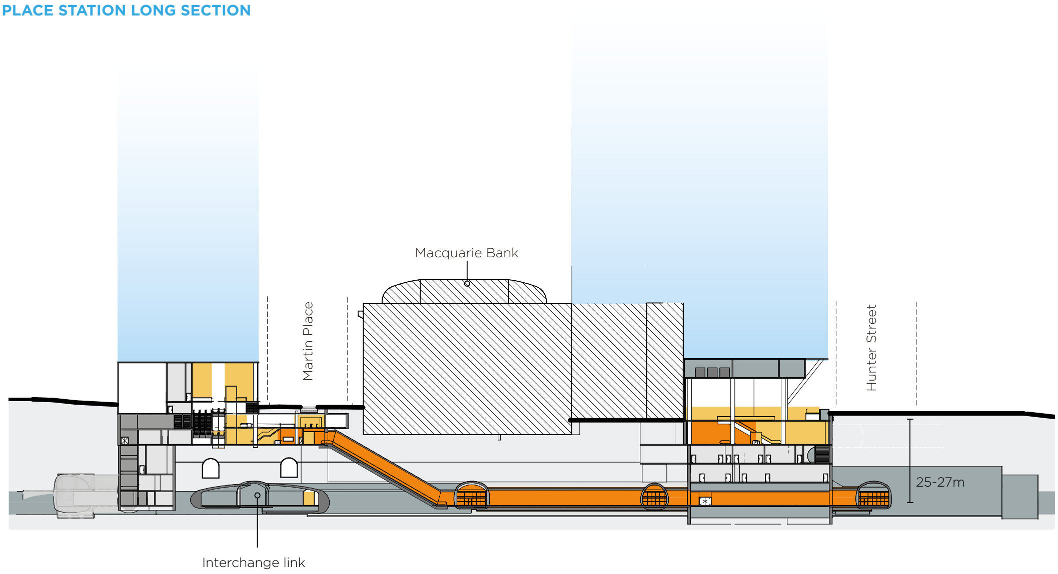
Feature	Description
Centre type	Global Sydney (Sydney CBD)
Station type	Binocular cavern (mined) with two single side platforms
Transport interchange	Walking, cycling, taxi, bus, light rail and suburban and intercity rail
Station entry / exit	• A northern entry via a pedestrian plaza opening to Castlereagh, Hunter and Elizabeth streets • A northern entry via an underground pedestrian connection below Hunter Street to O'Connell Street and / or Bligh Street (subject to further investigation) • A southern entry via a pedestrian plaza opening to Martin Place and Castlereagh Street
Customers	• Customers travelling to and from nearby employment, civic, commercial, retail, entertainment and recreational precincts • Customers interchanging to and from metro services and other modes of transport
Platform depth	About 25 metres (at the northern end) and about 27 metres (at the southern end)
Platform length	About 170 metres
Platform width	About six metres (each platform)
Overall station length	About 200 metres
Transport and access	• New underground pedestrian link between the existing suburban and intercity Martin Place Station platforms and the metro station platforms (shown on Figure 6-22) • New underground pedestrian connection between the station platform at O'Connell Street and / or Bligh Street (subject to further investigation) • New bike parking on Castlereagh Street at both station entries • Existing bus stops close to the station retained on Elizabeth and Castlereagh streets • Existing taxi ranks close to the station retained on Elizabeth and Castlereagh streets.

MARTIN PLACE STATION CROSS SECTION



KEY
Emergency egress stairs | Unpaid concourse | Paid concourse | Station service | Station facilities | Platform | Over station development

MARTIN PLACE STATION LONG SECTION



KEY
Emergency egress stairs | Unpaid concourse | Paid concourse | Station service | Station facilities | Platform | Over station development

Figure 6-21 Martin Place Station – indicative cross-section and long section

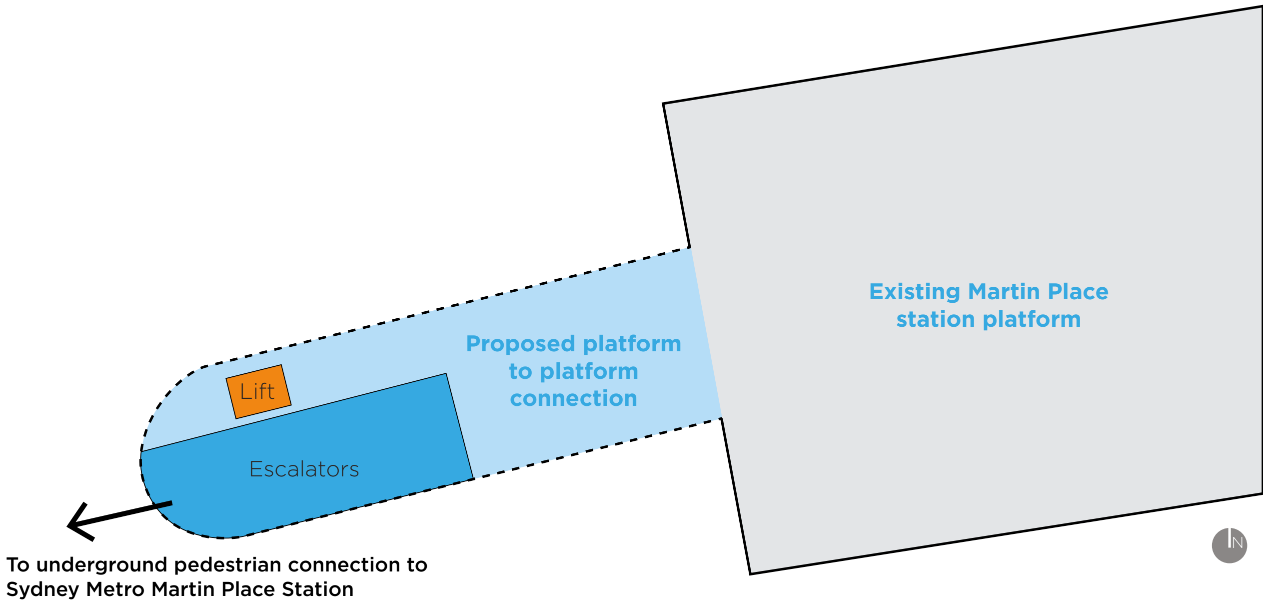


Figure 6-22 Martin Place Station – metro platform to Sydney Trains platform connection

6.6.5 Pitt Street Station

Pitt Street Station would be located between Pitt and Castlereagh streets, north of the Park Street intersection and south of the Bathurst Street intersection (refer to Figure 6-23). It would be strategically located at the junction of Sydney's southern CBD and the midtown retail precinct and close to the mixed employment, residential, entertainment, cultural and events based activities in the southern Sydney CBD and Chinatown. A station at Pitt Street would also service the residential catchment within the southern Sydney CBD.

Station strategy

A metro station at Pitt Street would serve the retail centre of the Sydney CBD on George and Pitt streets, the civic and entertainment uses on George Street and the emerging southern Sydney CBD residential developments between Park Street and Belmore Park.

The station strategy for Pitt Street would:

- Provide space for customers in a busy pedestrian environment by extending the public domain into the station entries
- Integrate with the Sydney City Centre Access Strategy and other Sydney CBD planning
- Anticipate connections to a future Town Hall Square and other nearby developments
- Extend the transport focus along Park Street, near Pitt Street.

The location and key features of Pitt Street Station are shown in Figure 6-23 to Figure 6-25 and summarised in Table 6-8.

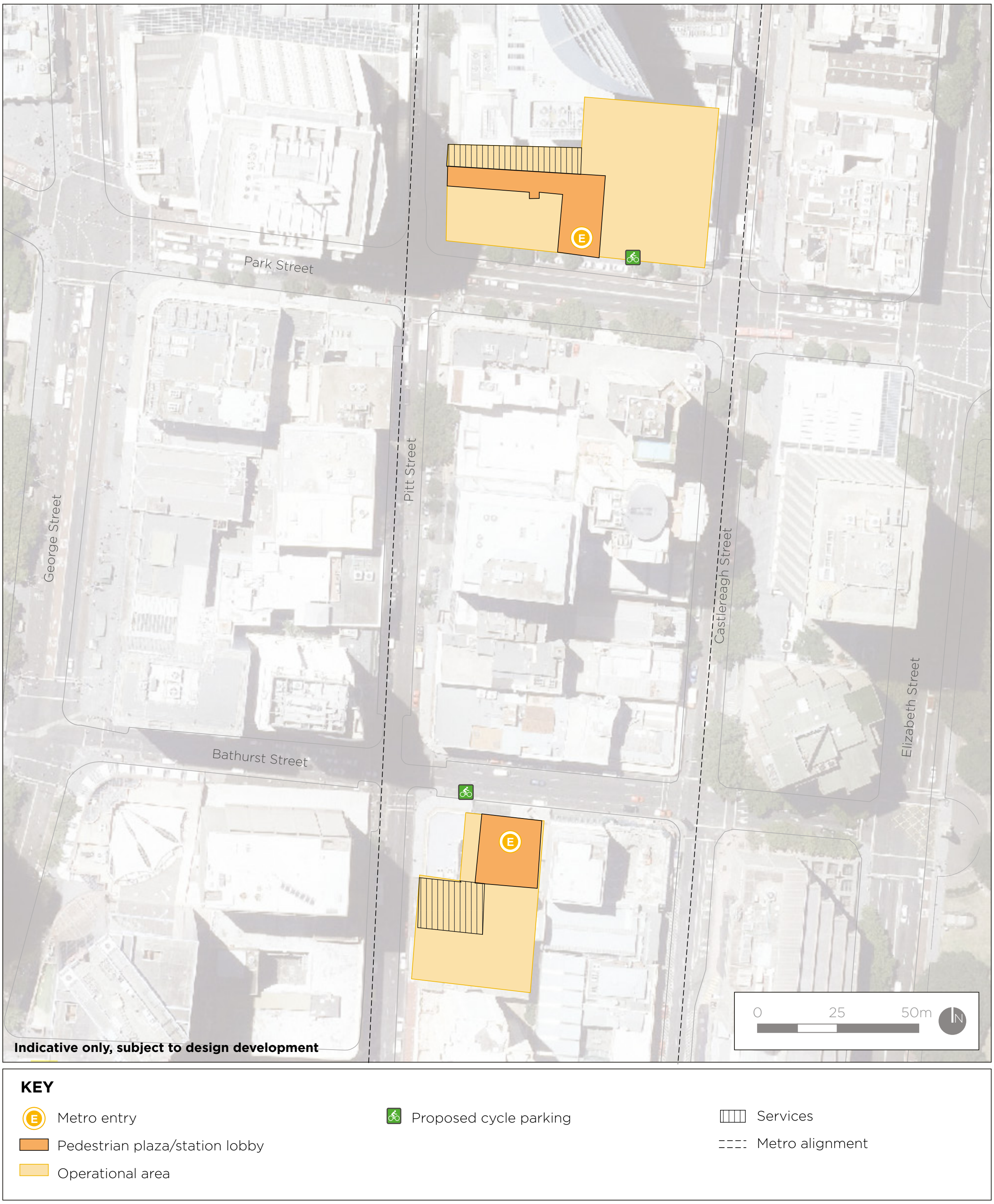
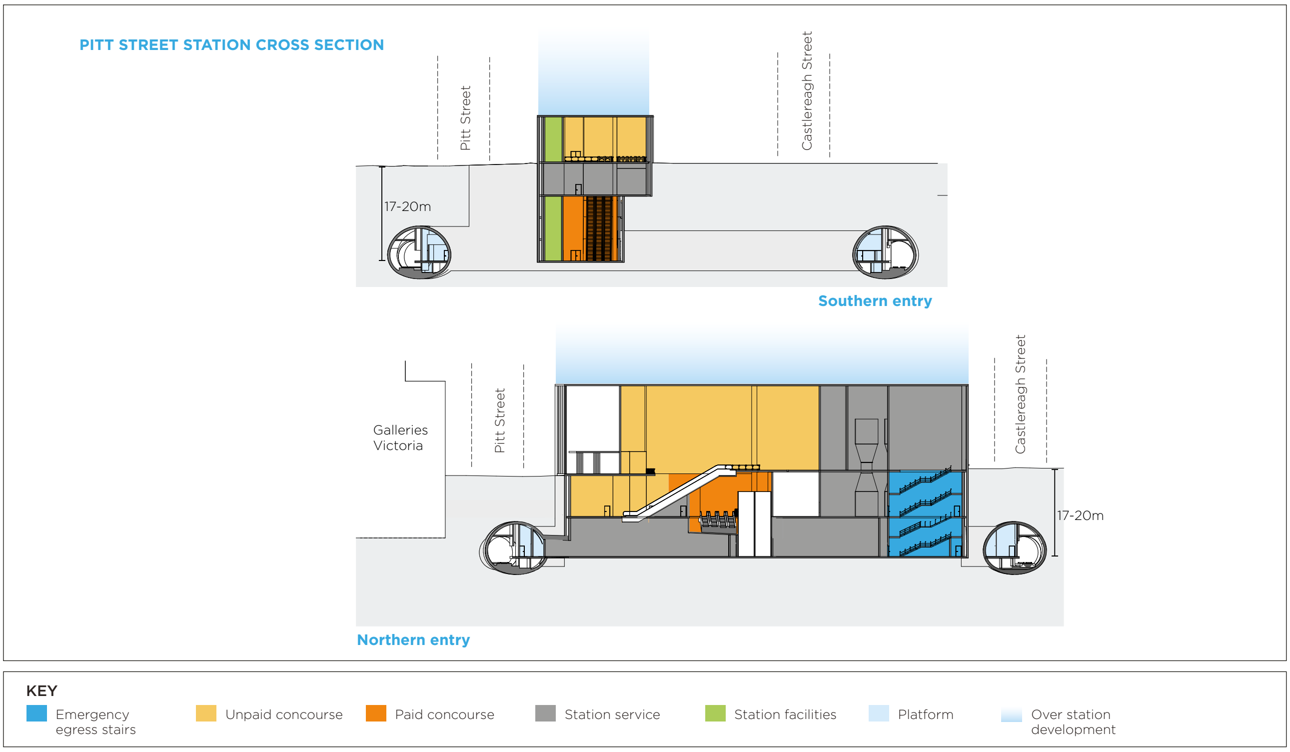


Figure 6-23 Pitt Street Station – location and indicative layout

Figure 6-24 Pitt Street Station – artist's impression

Table 6-8 Pitt Street Station design elements

Feature	Description
Centre type	Global Sydney (Sydney CBD)
Station type	Binocular cavern (mined) with two single side platforms
Transport interchange	Walking, cycling, taxi, bus and light rail
Station entry / exit	• A northern entry via a pedestrian plaza opening to Pitt and Park streets • A southern entry via a pedestrian plaza opening to Bathurst Street
Customers	Mid-town retail, employment, entertainment and residential precinct
Platform depth	About 17 metres (at northern end) and about 20 metres (at southern end)
Platform length	About 170 metres
Platform width	About five metres (each platform)
Overall station length	About 200 metres
Transport and access	• New bike parking on Park and Bathurst streets • Existing bus stops close to the station retained on Park and Castlereagh streets • Existing taxi ranks retained near to the station.



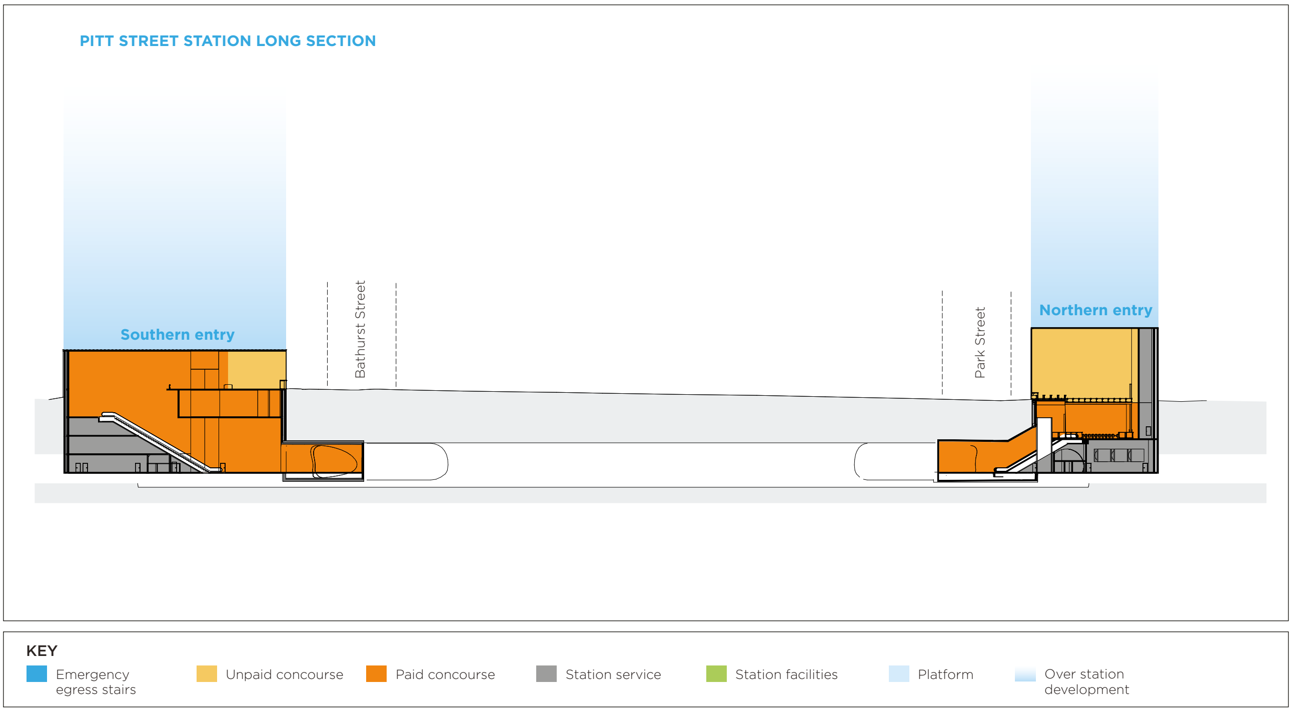


Figure 6-25 Pitt Street Station – indicative cross-section and long section

6.6.6 Central Station metro platforms

The metro platforms at Central Station would be located within the existing Central Station precinct, below the existing suburban rail service platforms 13, 14 and 15 (refer to Figure 6-26). The location of the two new underground metro platforms would facilitate an essential interchange with intercity and suburban rail services, light rail and bus services. To provide access for Sydney Metro and Sydney Trains once the project is operational, an access bridge for maintenance vehicles would be provided from Regent Street to 'Sydney Yard', located between the suburban and intercity rail lines (referred to as the Sydney Yard Access Bridge). Further details regarding the Sydney Yard Access Bridge are provided in section 6.9.2.

Platforms 13 and 14 would be reinstated as intercity platforms, and platform 15 could potentially be converted to a suburban platform following construction of the new Sydney Metro platforms.

Station strategy

The metro platforms at Central Station would have a major interchange role with suburban and intercity trains, light rail, buses and coaches.

Metro platforms at Central would provide access to retail and mixed use precincts in the locality such as Haymarket, Chinatown, Central Park, Surry Hills and to educational facilities including the University of Technology Sydney and the University of Notre Dame, Australia.

The strategy for the Sydney metro underground platforms at Central Station would:

- Provide an efficient and a high quality interchange for customers to connect to other public transport services
- Respect the heritage significance of the Central Station precinct
- Integrate with the Sydney City Centre Access Strategy and the Central Station Precinct Plan
- Support connectivity with major land uses and development in the locality.

The location and key features of Central Station are shown in Figure 6-26 and Figure 6-27 and summarised in Table 6-9.

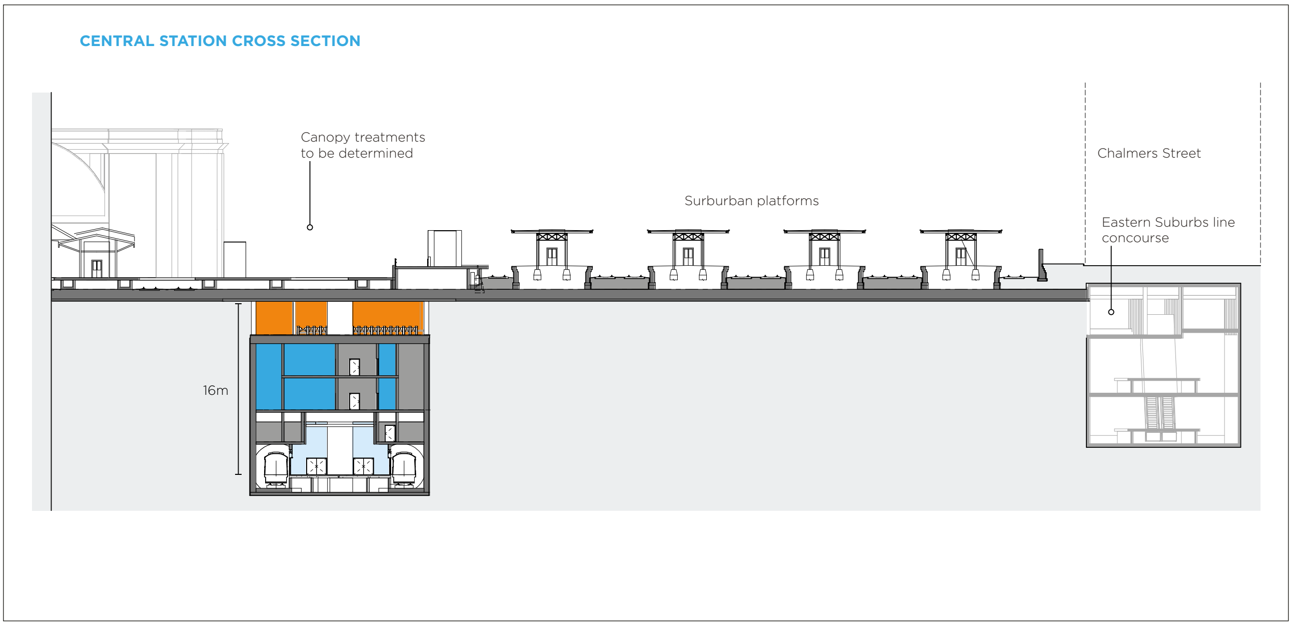
KEY

Metro entry | Metro concourse | Metro platforms | Services | Metro alignment

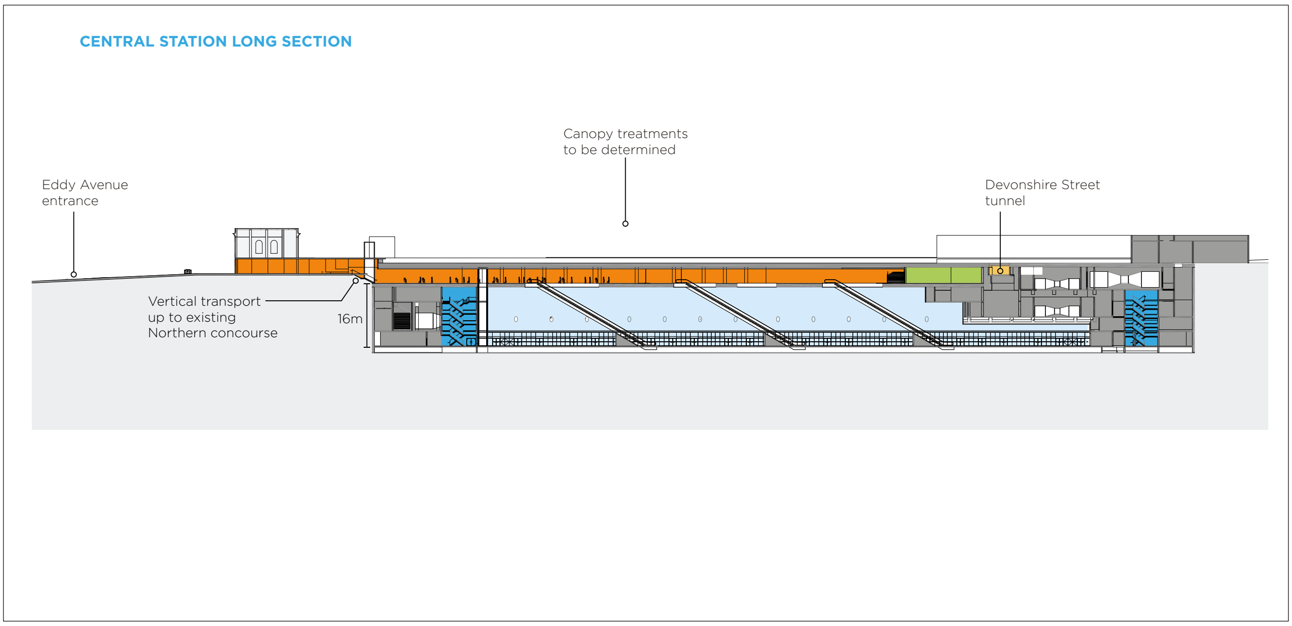
Figure 6-26 Central Station – location and indicative layout

Table 6-9 Central Station metro platforms design elements

Feature	Description
Centre type	Global Sydney (Sydney CBD)
Station type	Single-span (cut-and-cover) cavern with island platform
Transport interchange	Walking, cycling, intercity rail, suburban rail, light rail, bus, coach, taxi and kiss-and-ride
Station entry / exit	• Via the existing northern station entry from Eddy Avenue and the main northern concourse • Via the existing paid underground pedestrian connections within Central Station
Customers	• Customers travelling to nearby employment, education and entertainment precincts • Customers interchanging to and from metro services and other modes of transport
Platform depth	About 16 metres
Platform length	About 170 metres
Platform width	About 12 metres
Overall station length	About 220 metres
Transport and access	• Connect to the northern concourse and existing underground pedestrians links with Central Station for interchange • Existing bike parking retained • Existing bus stops retained • Existing kiss-and-ride and taxi ranks retained



KEY
Emergency egress stairs
Unpaid concourse
Paid concourse
Station service
Station facilities
Platform



KEY
Emergency egress stairs
Unpaid concourse
Paid concourse
Station service
Station facilities
Platform

Figure 6-27 Central Station – indicative cross-section and long section

6.6.7 Waterloo Station

Waterloo Station would be located on Cope Street between Raglan and Wellington streets (refer to Figure 6-28).

Station strategy

A metro station at Waterloo would be a catalyst for a Waterloo transformation program to regenerate social housing stock, support greater residential development and urban renewal. In addition a metro station at Waterloo would connect the Australian Technology Park and the residents in the Waterloo and Redfern areas with Sydney Metro.

The station strategy for Waterloo would:

- Contribute to the sense of place and public domain
- Create a new transport focus in Waterloo
- Integrate the station with local improvement plans.

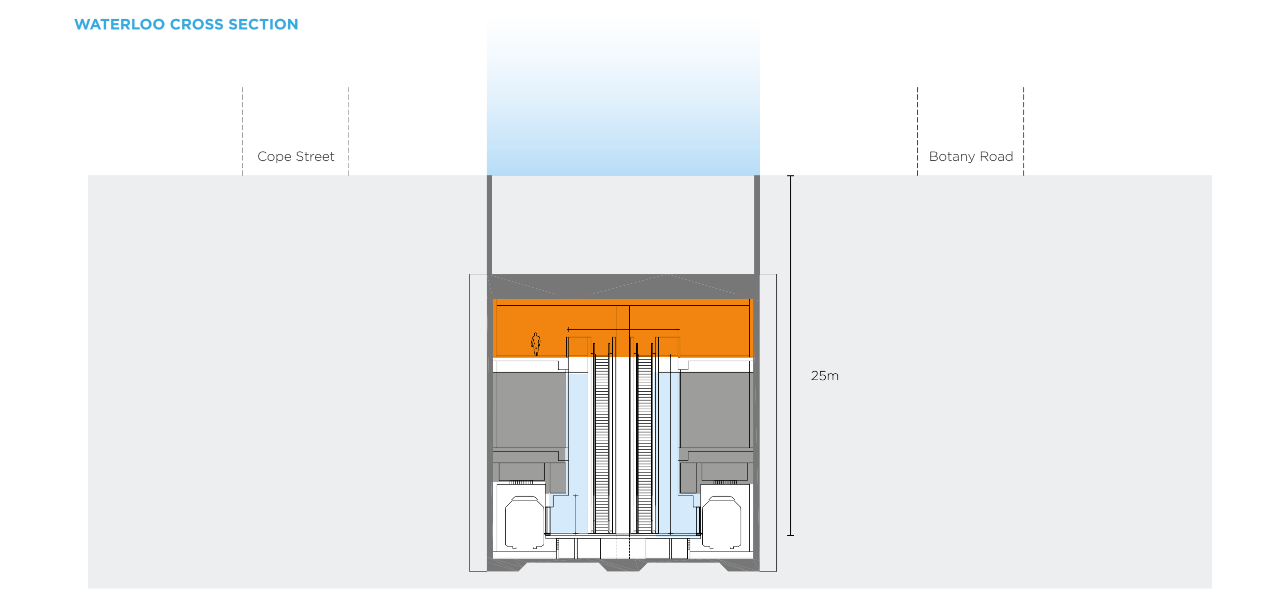
The location and key features of Waterloo Station are shown in Figure 6-28 to Figure 6-30 and summarised in Table 6-10.

Figure 6-28 Waterloo Station – location and indicative layout

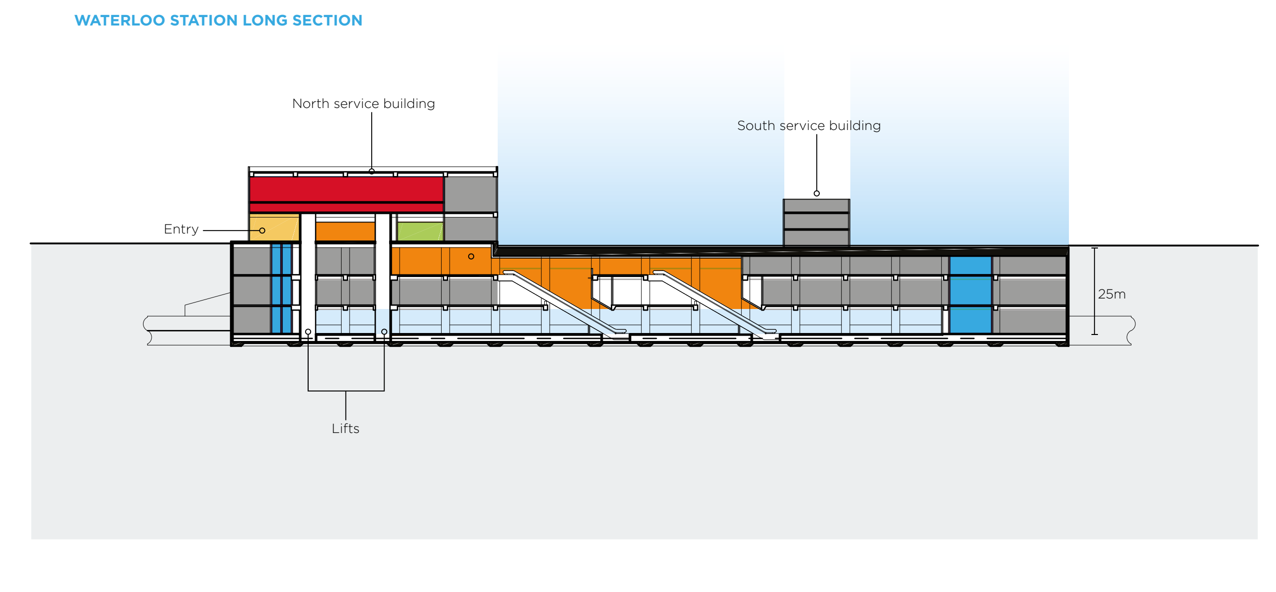
Figure 6-29 Waterloo Station – artist's impression

Table 6-10 Waterloo Station design elements

Feature	Description
Centre type	Global Sydney (Sydney CBD)
Station type	Single-span (cut-and-cover) cavern with island platform
Transport interchange	Walking, cycling, bus, taxi, and kiss-and-ride
Station entry / exit	At the northern end of the station on the corner of Raglan and Cope streets
Customers	• Customers travelling to and from the nearby residential developments (existing and future) • Customers travelling to and from commercial precincts
Platform depth	About 25 metres
Platform length	About 170 metres
Platform width	About 10 metres
Overall station length	About 210 metres
Transport and access	• New pedestrian crossings on Raglan and Cope streets • New bike parking on Cope Street • New on-road marked cycle link on Raglan Street • Existing bus stops retained northbound along Botany Road • Relocation of the bus stops southbound on Botany Road closer to Raglan Street • Relocation of the bus stops on Cope Street to Botany Road • New taxi and kiss-and-ride bays on Cope Street



KEY
Emergency egress stairs
Unpaid concourse
Paid concourse
Station service
Station facilities
Platform
Over station development



KEY
Emergency egress stairs
Unpaid concourse
Paid concourse
Station service
Station facilities
Platform
Traction substation
Over station development

Figure 6-30 Waterloo Station – indicative cross-section and long section

6.7 Dive structures and tunnel portals

6.7.1 Chatswood dive structure and tunnel portal

As shown in Figure 6-31 and Figure 6-32, the Chatswood dive structure would commence about 250 metres south of Chatswood Station, while the Chatswood tunnel portal would be located to the north of Mowbray Road.

The dive structure would comprise an initial length of open trough, which would then transition to a cut-and-cover structure (the tunnel portal). A fire protection wall would be installed along the entire length of the dive structure to provide separation between the two metro tracks. The Chatswood dive structure would also incorporate rail dampers and deck absorption to provide mitigation for operational train noise.

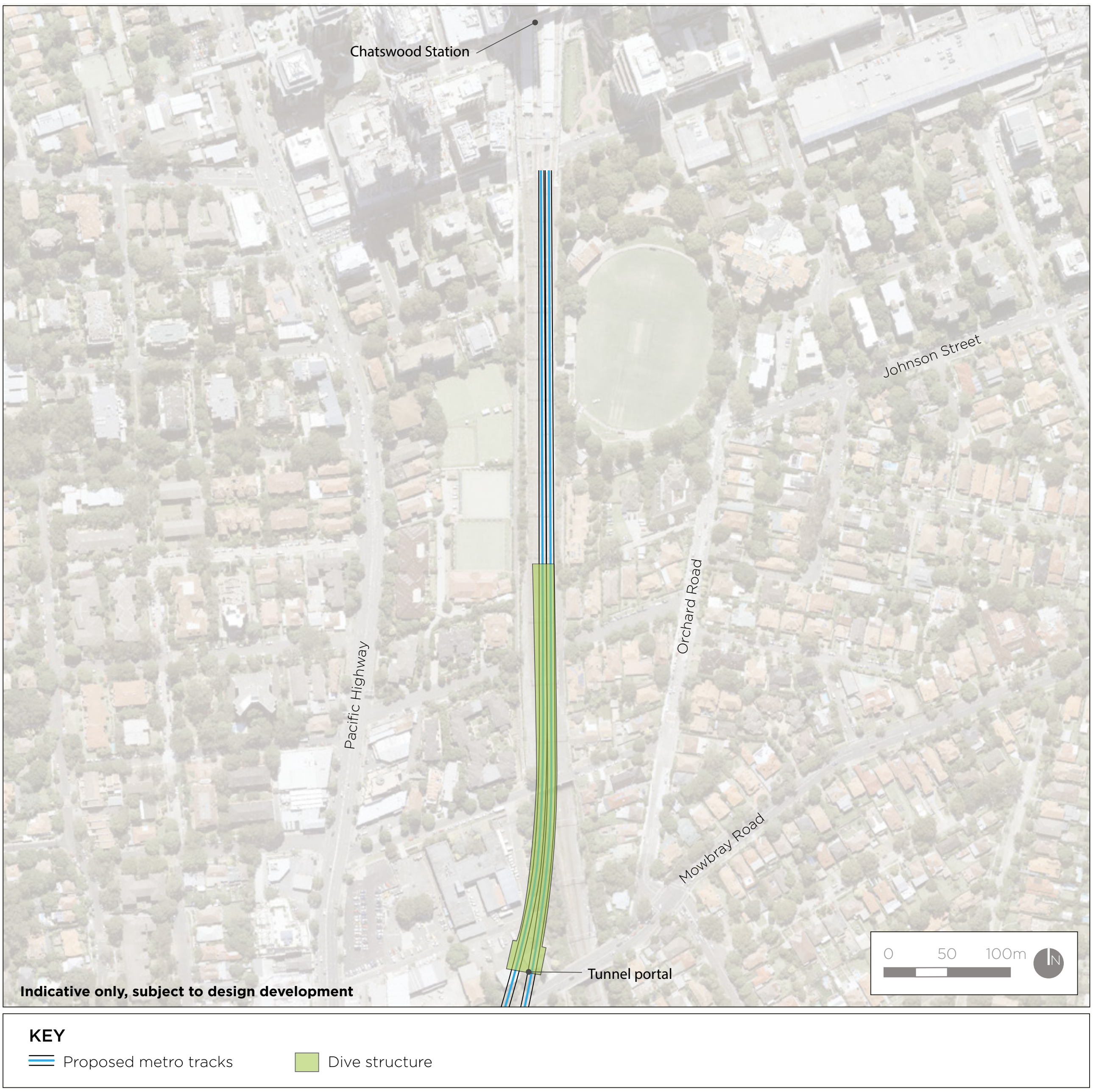


Figure 6-31 Chatswood dive structure and tunnel portal – indicative plan view

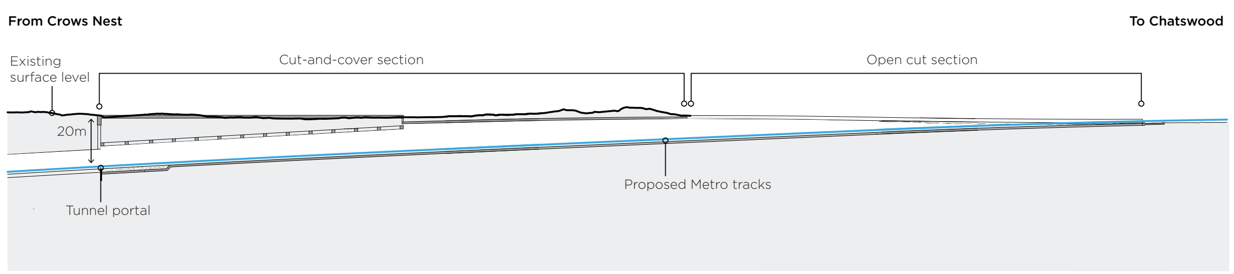


Figure 6-32 Chatswood dive structure and tunnel portal – indicative long section

6.7.2 Marrickville dive structure and tunnel portal

The Marrickville dive structure, shown in Figure 6-33 and Figure 6-34, would commence about 400 metres north of Sydenham Station and the Marrickville tunnel portal would be located in the suburb of Marrickville about 840 metres north of Sydenham Station (to the south of Bedwin Road).

The dive structure would comprise an initial length of open trough, which would then transition to a cut-and-cover structure (the tunnel portal). The dive structure has been designed to be protected from the probable maximum flood level to avoid floodwater flowing into the tunnel. A fire protection wall would be installed along the entire length of the dive structure to provide separation between the two metro tracks.

Figure 6-33 Marrickville dive structure and tunnel portal – indicative plan view

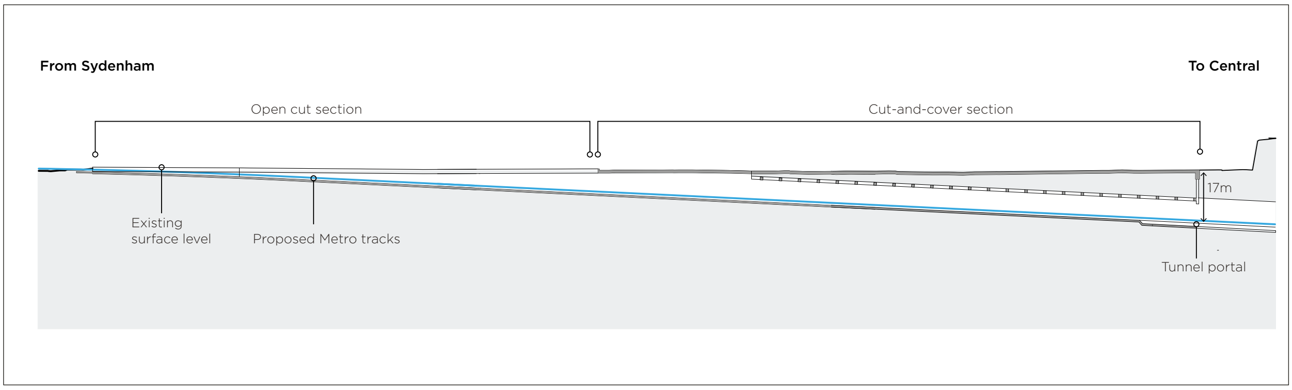


Figure 6-34 Marrickville dive structure and tunnel portal – indicative long section

6.8 Ancillary infrastructure

6.8.1 Artarmon substation

A substation would be required at Artarmon (between the northern tunnel portal and Crows Nest Station) to provide traction power to the tunnels. The substation would be part of the electrical power supply network for the project.

The substation would be located above the tunnels near the edge of the Gore Hill Freeway as shown in Figure 6-35. The traction substation and ancillary equipment would be housed in an aboveground building (around five metres above ground level) with a shaft (with a diameter of around three metres) to reticulate cables to the tunnels below.

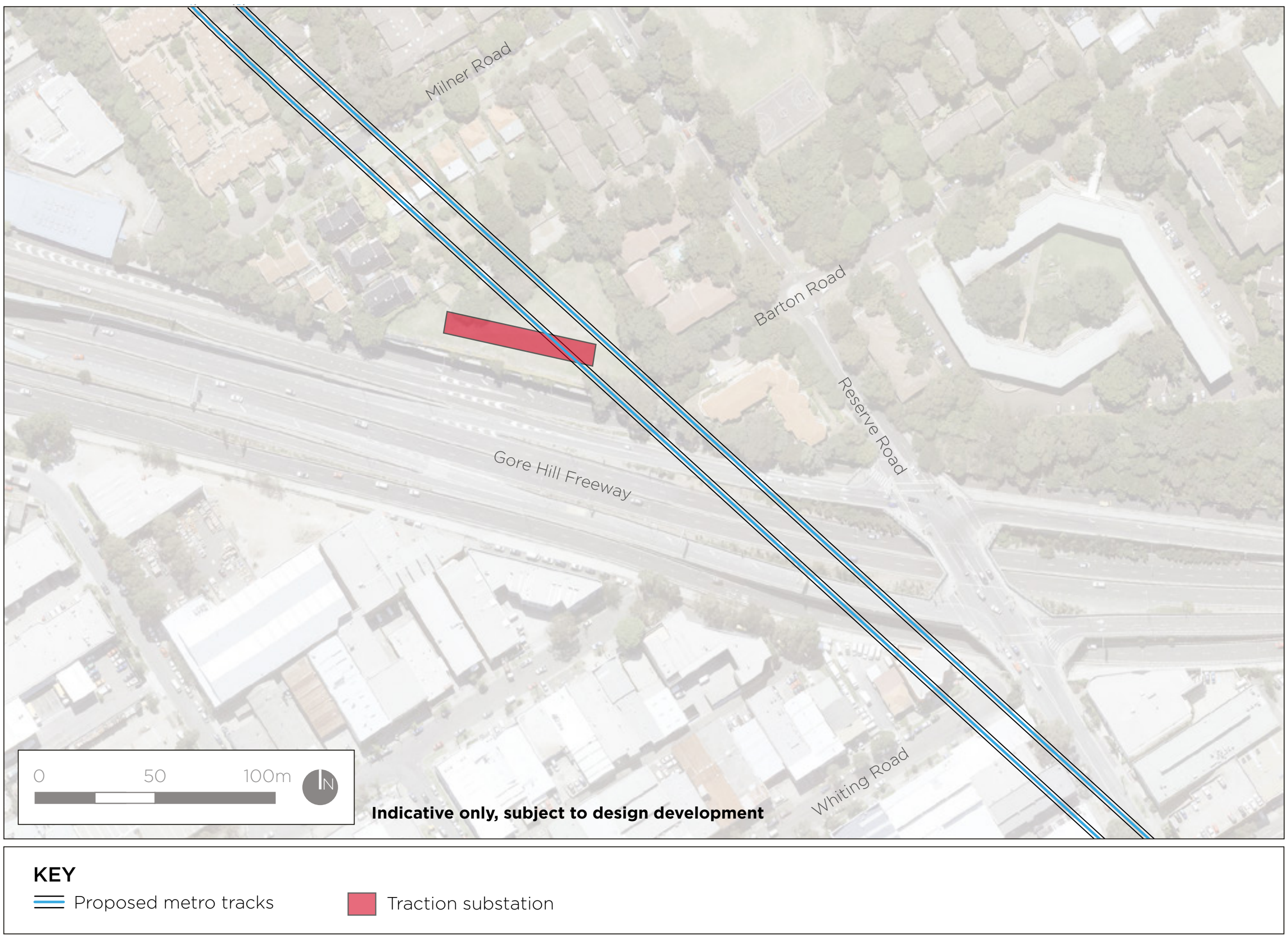


Figure 6-35 Artarmon substation – indicative plan view

6.8.2 Southern services facility

The southern services facility would be located adjacent to the Marrickville tunnel portal. It would include a tunnel water treatment plant and a traction substation. The indicative location of the water treatment plant and traction substation is shown in Figure 6-36.

The tunnel water treatment plant would treat wastewater pumped from the tunnels, stations and other underground facilities. The water treatment plant would be housed within a building about eight metres high and covering an area of about 500 square metres. The water treatment plant building would contain holding tanks, chemical treatment tanks and filters. Further information regarding the likely treatment methods, wastewater volumes and discharge points is provided in Chapter 18 (Soils, contamination and water quality).

An aboveground building (around five metres above ground level) for a traction substation and ancillary equipment would be provided, with cables reticulated into the tunnels.

Figure 6-36 Southern services facility – indicative plan view

6.9 Other key project features

6.9.1 Permanent closure of Nelson Street bridge

The Chatswood dive structure and tunnel portal would result in the demolition and permanent closure of the Nelson Street bridge. The primary role of the Nelson Street bridge is to enable motorists travelling south on the Pacific Highway to access Mowbray Road westbound via Orchard Road. Nelson Street also provides local vehicle access to residents of Nelson Street. To maintain this primary movement, it is proposed to construct an all vehicle right-turn movement from the Pacific Highway southbound to Mowbray Road westbound. This would require the widening of the Pacific Highway to the north of the Mowbray Road intersection.

Roads and Maritime Services are currently investigating further upgrades to the Pacific Highway / Mowbray Road intersection. Sydney Metro would continue to consult with Roads and Maritime in relation to coordination of these works and any opportunities to carry out these works concurrently.

Nelson Street also provides local access for properties located to the east of the T1 North Shore Rail Line. Following closure of the Nelson Street bridge, these residents would need to use alternative route to cross the rail line such as Mowbray Road or Albert Avenue.

As part of the project, Frank Channon Walk (a shared path currently connection Chatswood Station to Nelson Street) would be extended from Nelson Street to Mowbray Road on the western side of the rail line to provide an enhanced facility for pedestrians and cyclists and provide continued access between Chatswood Station and residential areas to the south. Those travelling from residential areas to the south-east of the rail line would need to use the underpass adjacent to Chatswood Oval to cross the rail line and access Frank Channon Walk. Orchard Road, running parallel to Frank Channon Walk on the eastern side of the rail line, could also be used as an alternative north-south route for journeys between the Chatswood retail areas and residential areas to the south.

6.9.2 Other bridges

T1 North Shore Line bridge over the metro dive structure

The realigned T1 North Shore Line 'down' (northbound) track would pass over the top of the metro Chatswood dive structure on a bridge. The track level across the bridge would be around two metres higher than the existing track level. The bridge is anticipated to be a single-span concrete structure around 60 metres long.

Sydney Yard Access Bridge

To provide access for Sydney Metro and Sydney Trains once the project is operational, an access bridge for maintenance vehicles at Central Station would be provided from Regent Street to 'Sydney Yard', located between the suburban and intercity rail lines. A plan view of the bridge is provided as Figure 6-37 and a long section as Figure 6-38.

The bridge would be about 170 metres long with a central span of about 50 metres, crossing the Intercity rail lines. The bridge deck would be about nine metres above the ground.

Because of the prominence of the bridge and the heritage sensitivity associated with its setting, the following principles would guide its detailed design:

- The bridge would be of high quality design and integrate with the industrial rail context
- The bridge architecture would draw reference from the existing forms, materials and colours of Sydney Yard
- The bridge structure and abutments would be of masonry construction
- Where throw screens are required they would be of largely transparent material and construction
- Lighting of the bridge would be inconspicuous and not cause nuisance in the public domain or spill towards Mortuary Station.

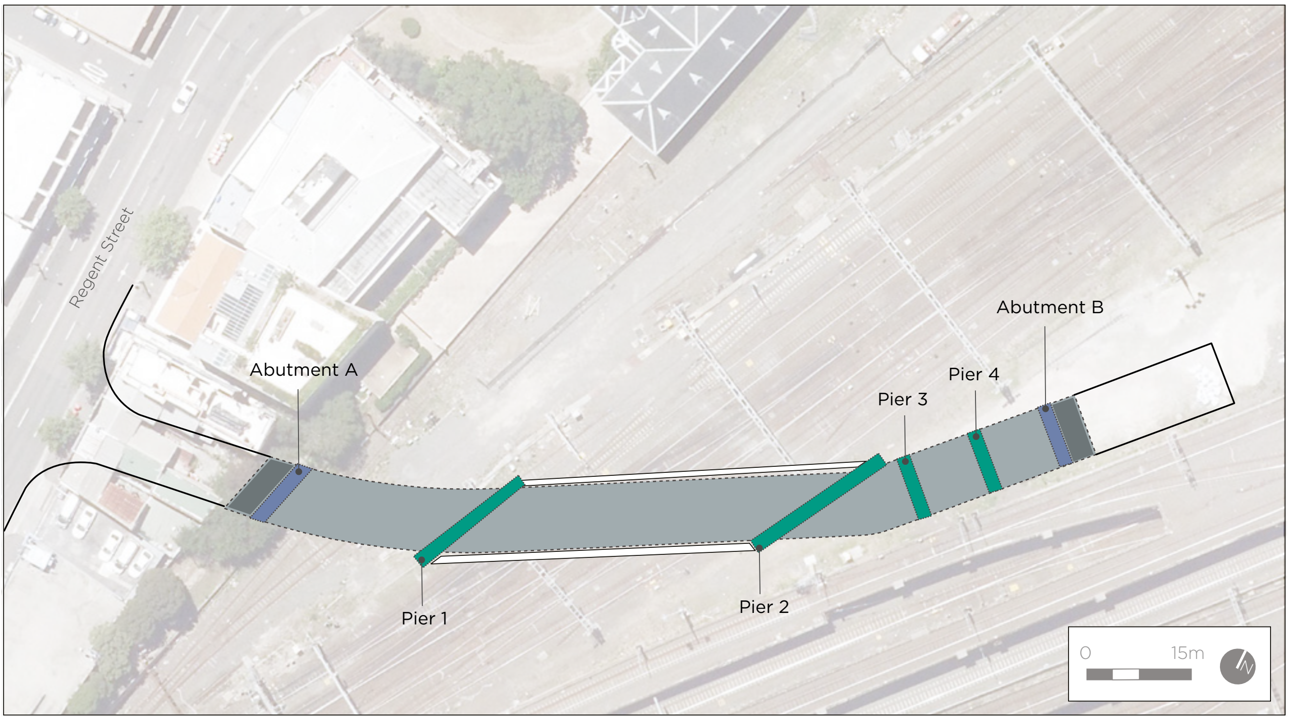


Figure 6-37 Sydney Yard Access Bridge – indicative plan view

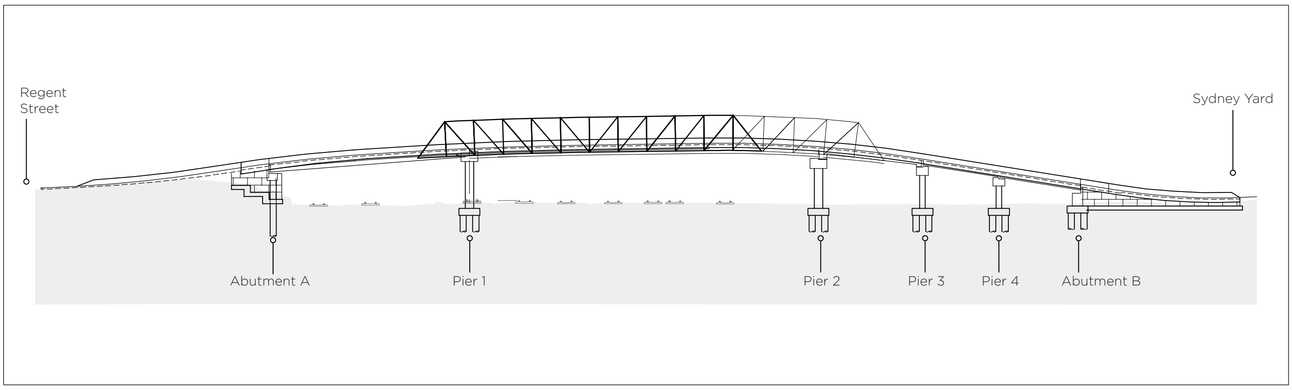


Figure 6-38 Sydney Yard Access Bridge – indicative long section

6.9.3 Noise barriers

Noise barriers at the northern end of the project would be relocated and increased in height in order to mitigate potential airborne noise impacts from operating trains. Specifically, the design at this stage has incorporated the following measures:

- An increase in the height (to four metres) of the noise barrier between Chapman Avenue and Nelson Street on the eastern side of the rail line
- An increase in the height (to four metres) of the noise barrier between the Frank Channon Walk pedestrian underpass and Albert Avenue on the western side the rail line
- An increase in the height (to four metres) of the noise barrier between Nelson Street and Gordon Avenue on the western side the rail line
- A two metre high noise barrier to the south of Mowbray Road on the western side of the rail line.

The heights noted above are indicative only with the exact height and extent of the noise barriers in these locations to be further refined during detailed design.

6.9.4 Retaining walls

The realignment of the T1 North Shore Line 'down' (northbound) track would require new retaining walls between around Ellis Street, Chatswood and around Drake Street, Artarmon. Retaining walls would generally be provided on either side of the 'down' track. Noise barriers (where required) would be located on top of this retaining wall.

6.9.5 Maintenance access

The realignment of the T1 North Shore Line 'up' (southbound) track would require the closure (in around 2019) of the existing Sydney Trains maintenance access from Hopetoun Avenue, Chatswood. There is alternative access for Sydney Trains from Drake Street, Artarmon. This access point would be upgraded to provide a new entrance and a Hi-Rail access pad adjacent to the rail track within the corridor.

Provisions would be made for new maintenance access near the Chatswood dive structure for Sydney Trains and Sydney Metro.

New maintenance access stairs for Sydney Trains would be provided from Albert Avenue on the eastern side of the rail line. New maintenance access may also be provided from Brand Street, Artarmon on the western side of the rail line.

6.10 Metro rail systems

6.10.1 Signalling and train control

All sections of the Sydney Metro network would use advanced signalling technology to support safe operations. The signalling system would include:

- Automatic Train Protection, which provides train spacing and speed monitoring and control functionality
- Automatic Train Regulation, which monitors and adjusts train speeds and station dwell times to maintain timetable and / or spacing between trains
- Automatic Train Operation, which provides automated train driving functionality.

The signalling system would control the stopping of trains at stations, ensure trains stop at the correct location on the platform (in line with platform screen doors), control train speed between stations, and initiate the opening and closing of doors on the correct side of the train.

The signalling system would allow for bi-directional operation (ie trains would run in either direction on either track) in special circumstances. This would provide functionality to respond to a range of incidents to support continuity of service. All control systems would be integrated with rail systems to provide consistent performance and high levels of safety.

The signalling system for the project would be linked via dedicated fibre optic cable and network switches to the Sydney Metro Trains Facility at Tallawong Road, Rouse Hill.

6.10.2 Communications

The project would include an integrated information system to communicate with customers or metro staff via audio and visual links at each station and on all trains. The communications equipment would be within the designated services area at each station and within the tunnel. The communications system would comprise:

- Radio communications systems for operator and emergency services
- Customer mobile telephone and other modern telecommunication methods
- Customer information display and public address
- Closed-circuit television system and video broadcasting system
- Digital voice video recording system
- Telephone system and personnel wireless terminal
- Trackside intruder detection system
- Emergency warning information system.

6.10.3 Traction power supply, substations and overhead wiring

The Sydney Metro network electrical power system would be designed to operate as an independent standalone system, which would be segregated from the Sydney Trains network, and would be designed with suitable redundancy to enable continued rail operations under 'fault conditions'. All Sydney Metro traction supply infrastructure would be controlled and monitored from the Sydney Metro Trains Facility at Tallawong Road, Rouse Hill.

The electrical power supply network for the project would comprise:

- Traction substations at Artarmon and adjacent to the Marrickville tunnel portal
- Traction substations at Victoria Cross, Barangaroo, Pitt Street and Waterloo stations. These substations would be integrated into the station buildings and located partly underground
- A high voltage (1500 volt) direct current traction power system (consisting of an in-tunnel conductor bar) that would be used to power the trains. The high voltage power system would be supplied by a 33 kilovolt high voltage network feeder connected to the Pitt Street Station traction substation. It would connect to the other project traction substations through the tunnels and to the Sydney Metro Northwest electrical supply network at the Chatswood North traction substation. The power supply route to the Pitt Street Station traction substation is shown in Chapter 7 (Project description – construction)
- A low voltage (415 volt) power system for electrical services at stations for tunnel services and ventilation and signalling and communications systems. The low voltage power system would be supplied by a number of services substations, which would generally be located in the services area of each station. Each services substation would transform the high voltage power supply to low voltage (415 volts).

6.11 Metro operations

This section provides a description of the operation of the project in the context of the broader Sydney Metro network. The Chatswood to Sydenham project would operate in conjunction with Sydney Metro Northwest and the Sydenham to Bankstown upgrade project. All Sydney Metro operations would be controlled and monitored from the Sydney Metro Trains Facility at Tallawong Road, Rouse Hill.

The Sydenham to Bankstown upgrade project is subject to a separate environmental assessment process and, subject to planning approvals, is expected to be completed and opened concurrently with the opening of this project in 2024. Should the construction timeframes of this project be advanced, there may be an opportunity to operate this project before completion of the Sydenham to Bankstown upgrade project. Should this occur, an additional track-turnback would be constructed between the Marrickville dive structure and Sydenham Station. A supplementary environmental assessment and appropriate community and stakeholder consultation would be carried out and the appropriate approvals obtained prior to this component being constructed.

To improve operational efficiency and flexibility in the event of an incident, a track crossover may be provided within the tunnel section of the project. Further investigation on the need and optimal location for the track crossover is currently being carried out.

6.11.1 Service frequency and reliability

The project is being designed as a 'turn up and go' service. The proposed service frequency at the time of opening would be:

- Weekday morning and evening peaks – a six car train at least every four minutes (20 trains per hour)
- Weekday daytime off-peak – a six car train every five minutes through the Sydney CBD (12 trains per hour)
- Weekday early mornings, late at night and on weekends – a six car train every ten minutes with options to increase based on level of demand (six trains per hour).

The indicative service frequency of the project through the Sydney CBD for a typical weekday is shown in Figure 6-39. The metro trains would operate independently of the existing rail network, with an expected target of 98 per cent on-time reliability.

At ultimate capacity the service frequency would be an eight car train every two minutes through the Sydney CBD. The assessment within this Environmental Impact Statement is based on this ultimate capacity.

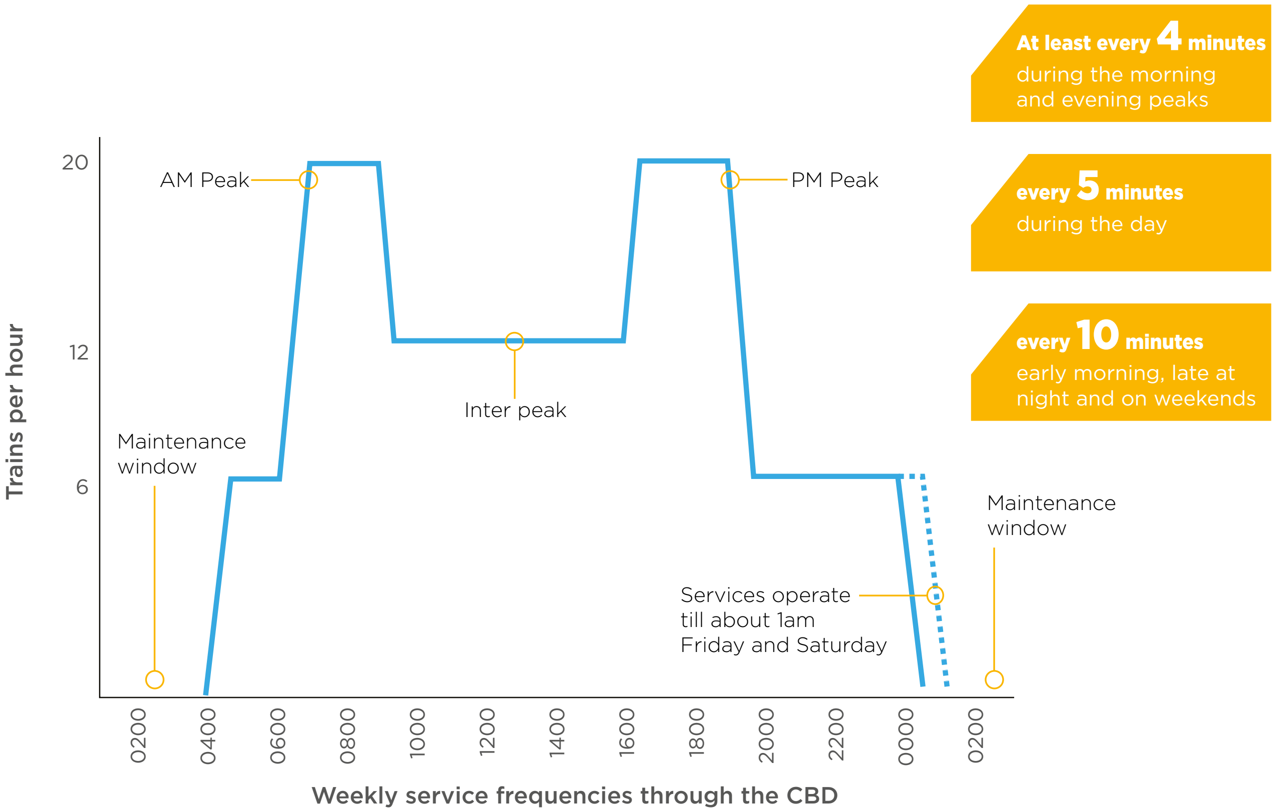


Figure 6-39 Indicative service frequency at opening of metro trains through the Sydney CBD on a typical weekday

6.11.2 Capacity and customer transfers

Initially, each train would have six carriages and would be capable of transporting up to 1,150 people. Based on the service frequency, the project would initially have the capacity to move around 23,000 people per hour in each direction in peak periods.

The project would be designed to cater for long term growth in travel demand. When required to meet increased demand, capacity would be increased to cater for more than 40,000 people per hour in each direction. This would be achieved by increasing from six car to eight car trains and increasing the service frequency from 20 trains per hour to up to 30 trains per hour through the Sydney CBD in peak periods. The assessment within this Environmental Impact Statement is based on this ultimate capacity.

The stations at Martin Place and Central would provide the key interchange points with the existing Sydney Trains network. By 2036 about 13,700 customers are expected to transfer between Sydney Metro and the Sydney Trains network at these stations during the morning peak hour, with the largest number of transfers at Central Station.

6.11.3 Indicative travel time savings

The project would substantially improve travel times for customers. The largest travel time savings would be experienced by customers travelling from new stations (such as Crows Nest) or where the project provides a more direct route of travel (such as Victoria Cross to Martin Place). Some key forecast travel time savings associated with the project are:

- Martin Place to Chatswood – 19 minute savings
- Norwest Business Park to Central – 15 minute savings
- Martin Place to North Sydney (corner Miller Street and Pacific Highway) – 15 minute saving
- Macquarie Park to North Sydney (corner Miller Street and Pacific Highway) – 13 minute savings
- Crows Nest to Central – 21 minute saving
- Bondi Junction to North Sydney (corner Miller Street and Pacific Highway) – 11 minute saving.

Information on how indicative travel time savings have been calculated is provided in Chapter 3 (Strategic need and justification).

6.11.4 Hours of operation

The first metro service to depart Cudgegong Road Station (Sydney Metro Northwest) and Bankstown Station (as part of the Sydenham to Bankstown upgrade) would arrive at Central Station in the early morning and the last metro service to Cudgegong Road and Bankstown stations would depart Central Station late at night (around midnight and potentially later on weekends). The operating hours could be extended to accommodate for planned special events.

The operating hours would be determined as part of the development of the services schedules for the project taking into account customer and maintenance access requirements.

6.11.5 Train types

All trains would be single-deck metro trains (similar to those to be introduced on Sydney Metro Northwest). The trains would deliver a fast, safe and reliable journey for customers. An artist's impression of the type of train proposed is provided as Figure 6-40.

The single-deck metro trains would be able to carry more customers per hour than would be the case with double-deck trains. This is because single-deck trains allow customers to get on and off at stations more efficiently than double-deck trains which reduces dwell times (the time a train is stopped at a station) and increases frequency. The modern signalling technology is also more efficient for running the trains, which increases the capacity of the metro network.

Metro trains would feature high performance standards and good customer amenities. These would include:

- Heating and air-conditioning in all metro trains
- Three doors per side per carriage for faster boarding and alighting
- Provision for customers in wheelchairs
- Accessible priority seating for mobility impaired, the elderly, people with prams or luggage
- Efficient seating and standing arrangements for access and alighting the metro
- On-board real time travel information and live electronic route maps
- Emergency intercoms inside trains
- Level access between the platform and train.

Figure 6-40 Indicative metro train and carriage

6.11.6 Ticketing

The Opal electronic ticketing system would be used on the Sydney Metro network. This system would be installed at all new stations.

6.11.7 Stabling and maintenance

Infrastructure maintenance

Maintenance planning for the project would generally allow routine and major periodic maintenance of infrastructure with a view to maximising service availability and minimising impacts on customers. Scheduled maintenance would generally occur between the last and first train services, or during planned weekend maintenance periods, when train services would not be in operation on parts of the line.

Rail maintenance vehicles would be able to use the network, and the project has been designed to allow access for maintenance crews. The following types of maintenance activities would be required:

- Scheduled maintenance – involving routine inspections and repairs to enable the project to operate at prescribed levels of safety, reliability and service frequency; this type of maintenance would be performed on a regular and recurring basis at specified intervals
- Non-scheduled maintenance – involving emergency repairs to address those unexpected defects (such as signal failure), vandalism and breakage that would impact on the project's prescribed levels of safety, reliability and / or service frequency; this type of maintenance would be performed as needed
- Overhaul and repairs – involving the repair, replacement and testing of project infrastructure that has been removed from its working location.

Stabling and metro train maintenance

Trains operating on the Sydney Metro network would be maintained and stabled at the Sydney Metro Trains Facility in Rouse Hill. This approved facility forms part of the Sydney Metro Northwest project and is therefore not required to be addressed in this Environmental Impact Statement.

Stabling may also occur at a dedicated facility near the southern end of the project. Any additional facility required to support operations would be delivered and assessed as part of the Sydenham to Bankstown upgrade project.

6.11.8 Operational staff

It is anticipated that around 150 full-time equivalent staff would be required to operate and maintain the project, including the operation and maintenance of rolling stock, stations and tracks. Staffing would be subject to future operator requirements.

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PROJECT DESCRIPTION – CONSTRUCTION

CHAPTER SEVEN

7 Project description – construction

This chapter describes the likely key construction activities for the project and identifies the construction sites required. A description of the project once it is operational is provided in Chapter 6 (Project description – operation).

7.1 Secretary's environmental assessment requirements

The Secretary's environmental assessment requirements relating to project description – construction, and where these requirements are addressed in this Environmental Impact Statement, and where they are addressed are outlined in Table 7-1.

Table 7-1 Secretary's environmental assessment requirements – project description – construction

Ref.	Secretary's environmental assessment requirements	Where addressed
2. Environmental Impact Statement		
2.1 (b)	The EIS must include, but not necessarily be limited to, the following: a description of the project, including all components and activities (including ancillary components and activities) required to construct and operate it	This chapter provides a description of how the project would be constructed. Chapter 6 (Project description – operation) provides a description of the project once operational.
2.1 (i)	a demonstration of how the project design has been developed to avoid or minimise likely adverse impacts	Details of adverse impacts which have been avoided through construction methods are described in Section 7.2.1. Additional details of adverse impacts which have been avoided through design are described in Chapter 6 (Project description – operation).
19. Utilities		
19.1	The proponent must consider: **a.** the impact of the project on the integrity of truck assets and the need to augment or relocate **b.** opportunities to support initiatives adopted by Councils and utilities providers **c.** how access to assets will be maintained during construction.	The potential need to adjust, relocate or protect utilities is described in Section 7.11.6.

7.2 Overview

The proposed construction activities to be carried out for the Sydney Metro Chatswood to Sydenham project (the project) broadly include:

- Demolishing buildings and structures at the station sites and other construction sites
- Constructing dive structures and tunnel portals
- Constructing tunnels, adits and cross passages
- Excavating a shaft for a temporary tunnel boring machine retrieval site at Blues Point
- Excavating, constructing and fitting out metro stations
- Carrying out surface works between Chatswood Station and Brand Street, Artarmon
- Excavating a shaft, carrying out structural work and fitting out ancillary infrastructure at Artarmon
- Carrying out structural work and fitting out ancillary infrastructure at Marrickville
- Fitting out the tunnel with rail operating systems
- Testing and commissioning of stations, tunnels, ancillary infrastructure, rail systems and trains.

A number of activities would also be carried out before the start of substantial construction works. These 'enabling works' are described in Section 7.4.

A number of construction sites would be required to construct the project. These include locations for tunnel equipment and support, stations, surface track and ancillary facilities. These construction sites are shown on Figure 7-1.

7.2.1 Environmental considerations in construction

The construction methodology for the project has been influenced by a number of environmental factors. Specific construction methods developed to avoid and minimise adverse impacts are identified in Table 7-2.

Table 7-2 Adverse construction impact avoid or minimised through design

Environmental aspect	Design response
Traffic and transport	• Two main tunnel support sites (at Chatswood and Marrickville) were selected because they are located at either end of the tunnel, allowing the majority of tunnelling spoil to be managed away from the critical Sydney CBD section • All three tunnel support sites (at Chatswood, Barangaroo and Marrickville) are located close to major arterial roads, which would minimise the use of local roads for spoil haulage • The location of the northern dive structure minimises the extent of construction works within the T1 North Shore Line corridor and disruption to customers at Artarmon Station • The location of Marrickville dive structure minimises the potential need for rail possessions within the T3 Bankstown Line corridor and the T4 Eastern Suburbs and Illawarra Line corridor • Development of haul routes to minimise impacts on the road network.
Noise	• Location of the two main tunnel boring machine support sites (at Chatswood and Marrickville) on light industrial land to minimise noise to residential areas • Arrangement of haul routes to minimise the use of local roads • Adoption of blasting as an excavation method at station sites to minimise the duration of impacts associated with rock hammering.
Property and land use	• Location of the two main tunnel boring machine support sites (at Chatswood and Marrickville) in light industrial areas to minimise acquisition of residential properties and changes in land use • Construction footprints consistent with operational footprint as much as feasible to minimise property acquisition • Barangaroo Station construction site arranged to minimise the potential to delay the adjacent Barangaroo development.
Groundwater	• A hybrid tunnel boring machine was in part selected for the section of tunnel beneath Sydney Harbour as it includes a slurry operation that pressurises the cut materials between the cutter head and the tunnel face, preventing uncontrolled sudden groundwater inflow and collapse of the tunnel face.
Social and community facilities	• Selection of tunnel boring machines to excavate the twin tunnels because they operate faster than other excavation machinery, resulting in a reduced construction timeframe and less disruption for the local community.
Waste	• Selection of tunnel boring machines to excavate the twin tunnels because they cut the ideal circular profile for a rail tunnel, thereby minimising spoil generation.

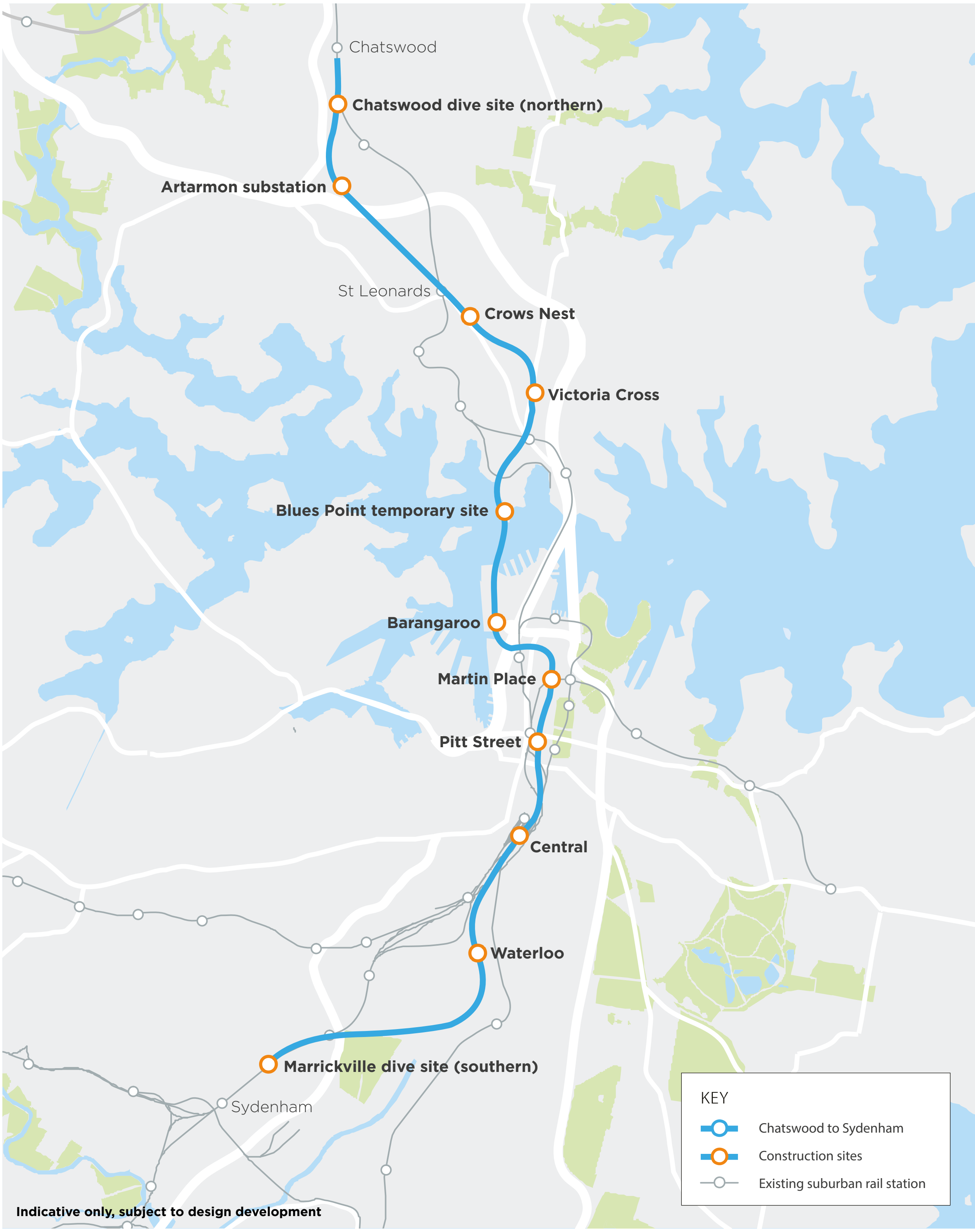
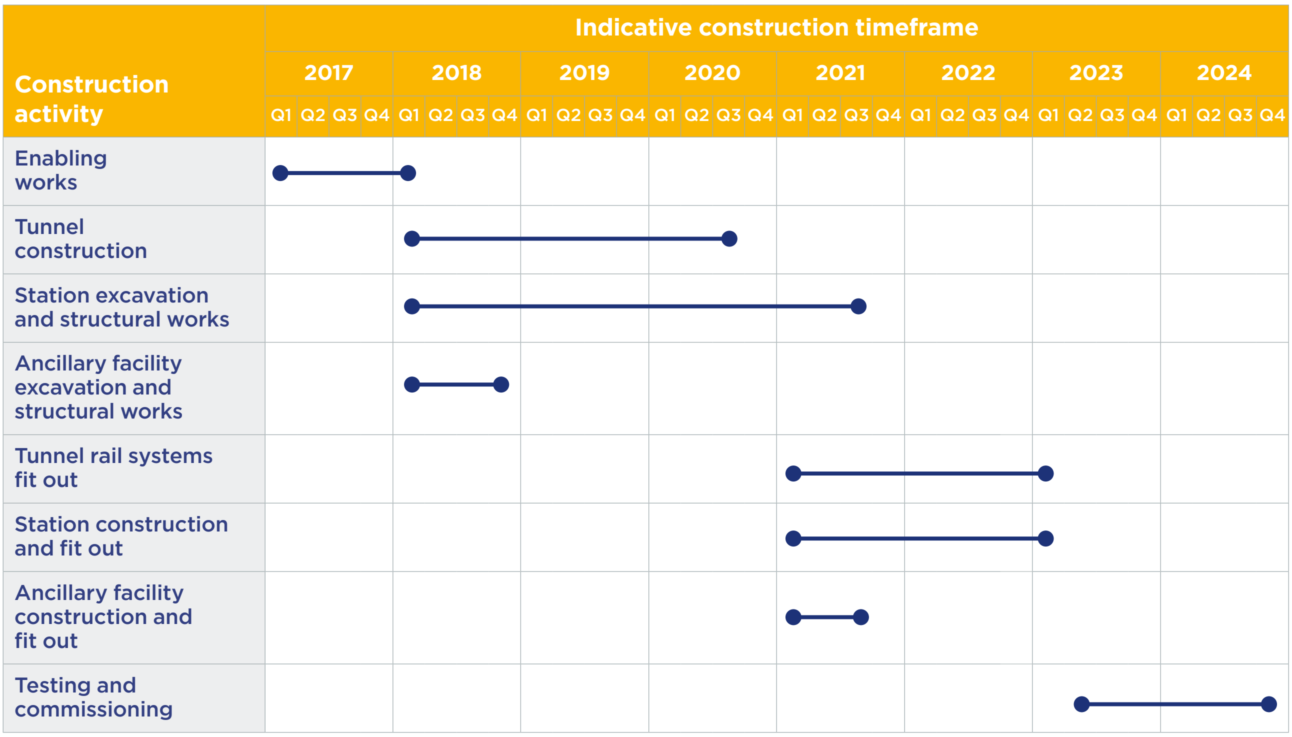


Figure 7-1 Construction sites

7.3 Indicative construction program

Enabling works (preliminary construction activities required to facilitate substantial construction) would likely commence in early 2017, with substantial construction of the project planned to commence in early 2018. The total period for construction would be about seven years, with the project expected to be opened to the public in 2024. An indicative construction program is shown in Table 7-3.

Table 7-3 Indicative construction program



7.4 Enabling works

Enabling works for major infrastructure are typically carried out before the start of substantial construction in order to make ready the key construction sites and provide protection to the public. Enabling works are expected to include:

- Demolishing buildings and other structures
- Supplying power, water and other utilities
- Adjusting, modifying and protecting utilities and services
- Establishing ancillary construction facilities and construction sites
- Carrying out heritage investigations, protection and archival recordings
- Alterations to the intersections and approaches of Pacific Highway, Mowbray Road, Hampden Road and Nelson Street near the Chatswood dive site
- Adjusting Sydney Trains rail infrastructure within the T1 North Shore rail corridor
- Adjusting and protecting major utilities at Barangaroo Station
- Relocating utilities, adjusting overhead wiring, removing platform canopies and carrying out piling works at Central Station
- Alterations to the intersections and approaches of Edinburgh Road, Edgeware Road and Bedwin Road near the Marrickville dive site.

These works are described further in the respective sections of this chapter.

7.5 Dive structures and tunnel portals

Construction of the dive structures and tunnel portals would generally involve:

- Cast in-situ concrete piling along the edge of the dive structure to form the walls
- Excavating below track level
- Placing of pre-cast and cast in-situ concrete for the cut-and-cover section and to form the tunnel portal.

7.6 Tunnels

Tunnel boring machines would be used to excavate twin tunnels about 15.5 kilometres long. As identified in Chapter 6, the tunnel alignment is indicative at this stage, and has been used for the purposes of the environmental impact assessment including all specialist investigations. During detailed design the alignment may change (horizontally and / or vertically). Any changes to the alignment would be reviewed for consistency with the assessment contained in this Environmental Impact Statement including relevant mitigation measures, performance outcomes and any future conditions of approval.

The two bored tunnels would have a circular cross-section with an internal lined diameter of about six metres and an excavated diameter of about seven metres.

The following underground features would also be excavated:

- Cross passages between the two tunnels at intervals of about 240 metres to allow for emergency access
- Stub tunnels from the twin tunnels near Victoria Cross Station and Sydenham to allow for potential future extensions to the metro network.

The centre lines of the two tracks would typically be about 14 metres apart, however this would depend on specific geological constraints and the need to avoid building basements. The tunnels would be lined with pre-cast concrete segments to ensure the long term life of the asset and minimise groundwater inflow.

The depth of the tunnels would vary from about 20 metres to 60 metres deep, due to changes in the topography and the need to cross Sydney Harbour. The shallower tunnel sections would generally be near each tunnel portal and near the cut-and-cover stations.

7.6.1 Tunnelling methods

Tunnel boring machines

Tunnel boring machines are likely to be used to excavate the majority of the twin tunnels as they are faster and safer than roadheaders and excavate the desired tunnel profile, thereby reducing spoil volumes.

Each tunnel boring machine would typically consist of a shielded cutting head and trailing backup support services and mechanisms. At the front of the shield is a rotating cutter head, and behind the cutter head is a chamber where the excavated rock and sediments (spoil) are removed. The spoil is transferred to a conveyor or slurry pipe to transport the spoil to the tunnel boring machine launch site for removal. The tunnel boring machine is propelled forward by hydraulic jacks pushing off the previously erected segments or pushing off the tunnel wall with rock grippers. Gaps between the excavated tunnel wall and the tunnel lining are filled with cement based grout from grout batching plants located at each of the tunnel boring machine launch sites.

Photo of a tunnel boring machine cutter head

Aerial photo of the Cherrybrook tunnel boring machine support site as part of Sydney Metro Northwest.
Note Cherrybrook site is around 75,000 m^2

Roadheaders

Roadheaders would be used to excavate irregular shaped tunnels such as stub tunnels, niches and cross-passages. Roadheaders would also be used to excavate mined station caverns, underground pedestrian connections and adits (described in Section 7.7).

A roadheader is an excavation machine consisting of a boom mounted rotating cutter head mounted on bulldozer style tracks, a loading device, and a crawler track to move the machine forward into the rock face. Tunnel support for roadheader sections would consist of a primary lining (likely to be pattern rock bolting and shotcreting) and a final cast in-situ or sprayed concrete lining.

Photo of a roadheader

Rock hammers

Excavators with rock hammer attachments would also be used to excavate cross passages and niches within the tunnels.

Photo of a rock hammer

Pre-cast concrete segments

The tunnels would be lined with pre-cast concrete segments as the tunnel boring machines moves forward. The pre-cast concrete segments would be manufactured at a dedicated batch plant and pre-cast facility at the Marrickville dive site with storage at each of the tunnelling boring launch sites.

At peak production, the pre-cast facility would produce about 75 tunnel lining rings per day (or about 2,300 tunnel lining rings per month). In order to meet this production rate, the facility would require the delivery of about 1,200 tonnes per day of a combination of sand, aggregate, cement, polypropylene and steel reinforcement.

Pre-cast concrete segments would be transported by road from the pre-cast facility at the Marrickville dive site to the other tunnel boring machine launch sites at Chatswood dive site and Barangaroo.

Photo of the pre-cast facility at Bella Vista as part of Sydney Metro Northwest. Note the Bella Vista site is around 150,000 m²

Sydney Harbour sediment ground improvement

Due the expected ground conditions underneath Sydney Harbour, ground improvement work is likely to be required prior to excavation of the tunnels. Ground improvement work is likely to be carried out at the rock-sediment transition zones to reduce construction risks and allow for maintenance of the tunnel boring machine cutters prior to driving through the rock-sediment transition zones. Ground improvement would:

- Reduce safety risks for construction workers and provide an option to avoid the need to carry out tunnelling in high pressure (up to 5 bar) environments
- Minimise risks associated with ground instability and / or air-loss issues at rock-sediment transition zones.

Ground improvement would require the establishment of solid blocks (each about 35 metres wide by 20 metres long by 16 metres deep) at the two points where the tunnel alignment passes through a rock-sediment transition zone. The indicative locations of the ground improvement works are shown on Figure 7-2.

The proposed ground improvement zones would need to extend from about six metres above the tunnel profile to about three metres below the tunnel profile and about six metres either side of both the tunnel profiles, essentially forming a grout block within the softer sediments located at around 30 metres below the sea bed. The maximum depth of grouting is estimated at about 40 metres.

Based on the current design, the preferred method of ground improvement is through jet grouting, although alternative approaches such as ground freezing may be considered during detailed design. Jet grouting would involve the injection of a cement grout from barges via a crane and drilling lead. This would be achieved through the use of three barges on the harbour. One barge would be used to carry out the grout works which would generally remain in the harbour for the duration of the works. The other two barges would be used to transport grout to and spoil from the works area to an on-shore facility. In addition, tug boats would be required to move the barges and small boats would transport construction workers.

In order to reduce the potential impact on shipping channels, construction of the two grout blocks would be carried out separately. At this stage it is expected that the southern grout block would be carried out first, followed by the northern grout block, although this would be dependent on the timing of the activity and scheduling with shipping requirements.

Consultation would be carried out with the Port Authority of NSW, Roads and Maritime Services and Sydney Ferries to maintain open shipping channels during ground improvement work. The jet grouting process is shown in Figure 7-3.

An on-shore facility would be required to support the ground improvement work. This facility would be used as a staging area for the delivery of grout and the removal of spoil, provide facilities to transport workers to and from the barges on the harbour and provide amenities for construction workers. The location of this facility is currently under investigation, however it would be sited to meet the following criteria:

- Provide direct access to the harbour
- Have ready access to the road network
- Be located to minimise the need for heavy vehicles to travel on local streets and / or through residential areas
- Be located on relatively level land
- Be separated from the nearest residences by at least 200 metres, unless feasible and reasonable noise and light spill mitigation measures are implemented
- Not require native vegetation clearing beyond that already required for the project
- Not have any more than a minor impact on heritage items beyond those already required for the project
- Not unreasonably affect the land use of adjacent properties
- Be above the 20 year average recurrence interval flood level, unless a contingency plan to manage flooding is prepared and implemented
- Provide sufficient space for the storage of materials to minimise, to the greatest extent practical, the number of deliveries required outside standard daytime construction hours.

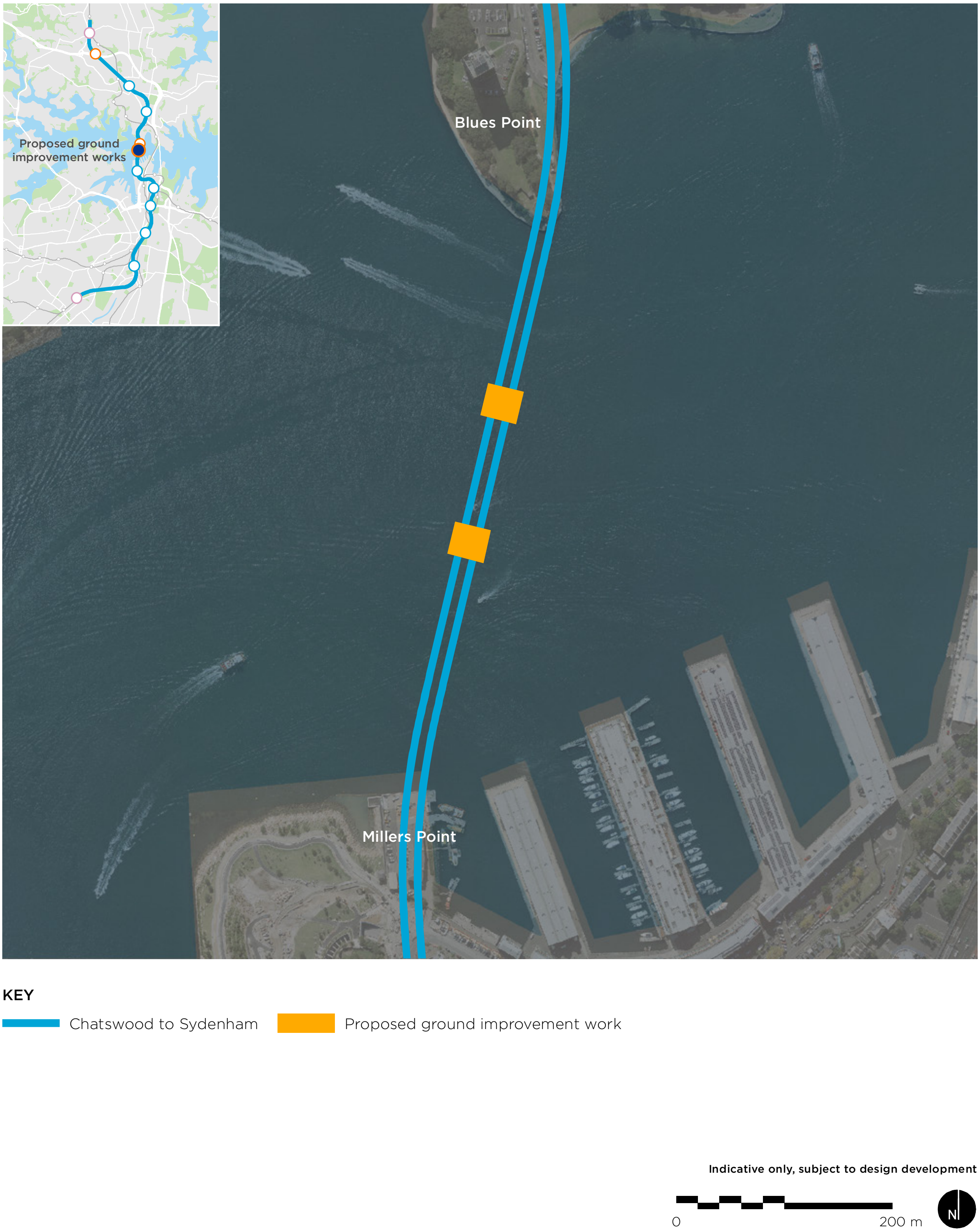


Figure 7-2 Indicative locations of ground improvement work

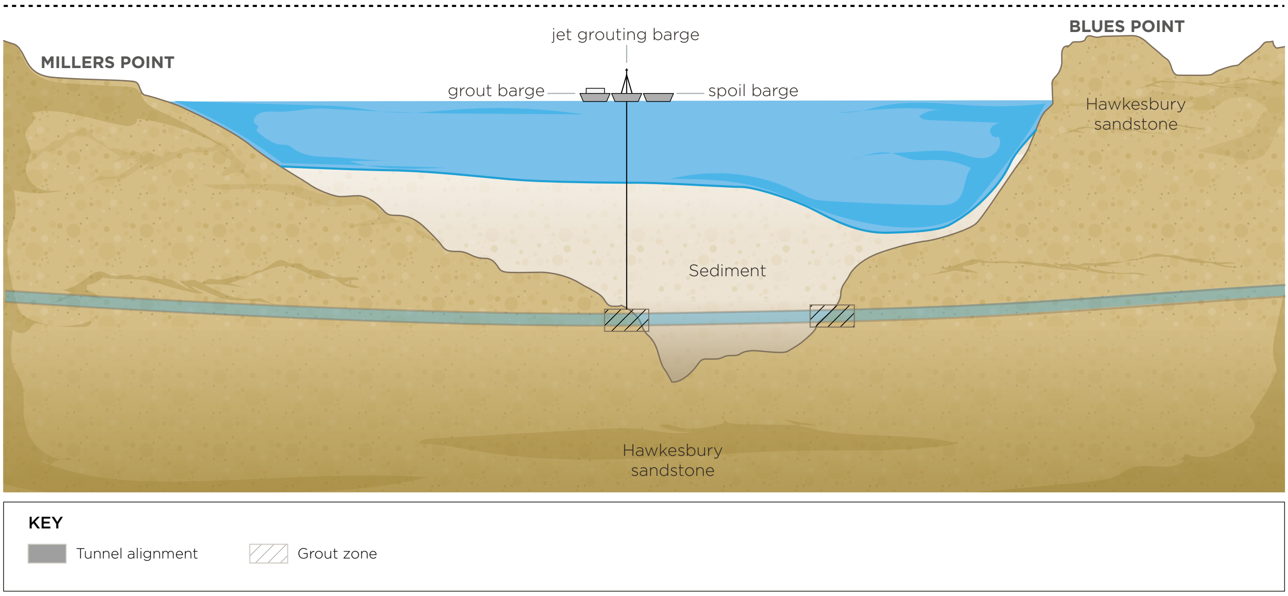


Figure 7-3 Ground improvement work process

7.6.2 Tunnelling launch and support sites

Launch sites and sequence

It is anticipated that tunnelling would occur from three tunnel boring machine launch and support sites:

- A site in Chatswood (south of Chatswood Station and north of Mowbray Road), referred to as the Chatswood dive site (northern)
- A site in Marrickville (north of Sydenham Station and south of Bedwin Road), referred to as the Marrickville dive site (southern)
- A site at the proposed Barangaroo Station for the crossing of Sydney Harbour (Barangaroo Station construction site).

A temporary site would also be established at Blues Point for the retrieval of the cutter head and shields of the tunnel boring machine driven from the Chatswood dive site and the Barangaroo Station construction site.

Tunnelling from the tunnel boring machine launch sites would occur concurrently, with the use of five tunnel boring machines. The tunnelling sequence is shown on Figure 7-4.

Tunnelling from the Chatswood dive site (northern)

Two tunnel boring machines (one for each tunnel) would be driven from the Chatswood dive site about six kilometres to the Blues Point temporary site. There, the cutter heads and shields from these tunnel boring machines would be dismantled and retrieved, with the remaining components of each tunnel boring machine (including support services) pulled back and retrieved from the Chatswood dive site.

Tunnelling from the Marrickville dive site (southern)

Two tunnel boring machines (one for each tunnel) would be driven from the Marrickville dive site about eight kilometres to Barangaroo Station. The cutter heads and shields from these tunnel boring machines would be dismantled and retrieved from the Barangaroo Station excavation with the remaining components (including support services) pulled back and retrieved from the Marrickville dive site.

Tunnelling from Barangaroo Station (harbour crossing)

Due to the different ground conditions expected, a separate tunnel boring machine drive would occur for the Sydney Harbour crossing component. This is likely to involve one hybrid tunnel boring machine although the preferred machine and method may change based on further design development. This machine would operate as a standard earth-pressure balance machine for the sections of the drive within rock and would be converted to a slurry type machine (to pressurise the cutting face) for the section of the drive within sediments.

This machine would be driven from Barangaroo Station about one kilometre to the Blues Point temporary site where the cutter heads and shields would be retrieved and transported back to Barangaroo Station. The remaining components (including support services) would be pulled back to Barangaroo Station. The tunnel boring machine would be re-assembled to carry out the excavation of the other tunnel under Sydney Harbour. The cutter heads and shields would then be retrieved through the Blues Point temporary site and the remaining components (including support services) pulled back and retrieved from Barangaroo Station.

Support services

The three launch sites would require support services for the tunnel boring machines, incorporating power supply, fresh air ventilation, work trains, grout batching plant, storage space for pre-cast concrete ring segments, water supply, drainage and water treatment, workforce facilities, and spoil handling and removal facilities. Given the length of tunnelling between Sydenham and Barangaroo an additional tunnel boring machine power supply point may be required at Pitt Street Station. Section 7.10 provides further details regarding these construction sites.

The Barangaroo Station construction site would also provide a separation treatment plant to remove excavated spoil from the slurry material and allow the recirculation of the slurry to the tunnel boring machine cutting face.

The tunnel boring machine support sites and the other construction sites would be required to provide fresh air ventilation (both the extraction of air and the provision of fresh air) to the tunnels during construction to ensure the safety of workers. Fresh air ventilation fans would operate 24 hours per day, seven days per week during tunnelling and subsequently during tunnel fit-out and station construction.

Work trains would be required within the tunnels to transport materials, pre-cast concrete lining segments and the workforce to the cutting face. Temporary tracks for the work trains would be progressively laid in sections as the tunnel boring machines advance. At the completion of tunnelling, the temporary rail tracks would be removed. Alternatively, transport of materials into the tunnels may be carried out with conveyor systems and special purpose rubber tyred vehicles.

Figure 7-4 Indicative tunnelling sequence

7.6.3 Tunnel fit-out

The main access points for the tunnel fit-out would be via the Chatswood dive site and the Marrickville dive site. Secondary access via the underground stations would be possible, however this access would diminish as the station fit-out progresses. Tunnel fit-out work is described in Table 7-4.

Table 7-4 Tunnel rail systems fit-out

Item	Works
Fresh air ventilation	The majority of tunnel fresh air ventilation equipment would be located at the stations and service facilities. The fit-out of these elements is described as part of the mechanical and electrical fit-out components in Sections 7.7.3 and 7.9.
Track slab and rail fastening	The track slab would be formed by mass concrete pours. Rail fasteners would be attached to the concrete. Rail fasteners may incorporate resilient base plates as required to mitigate operational noise and vibration (refer to Chapter 11 (Operational noise and vibration)).
Rail installation, fixing and welding	Rail would be delivered to the Chatswood dive site and the Marrickville dive site where they would be welded into around 110 metre lengths. In-tunnel welding would also be required once rail is in place. Placement, fixing and fastening of rail within the tunnels would likely be an automated process.
Cable and equipment installation	Dedicated cable routes would be provided within the tunnel for signalling, communications and power supply. Rooms for signalling and communications equipment would be provided at every second cross passage, alternating with power equipment rooms within the other cross passages.
Overhead traction power	Overhead traction power is likely to be provided through a conductor bar with a main support located centrally over the track.
Other equipment	Other equipment to be installed in the tunnels would include lighting (including emergency lighting), drainage, and fire and life safety systems (including walkways connecting to emergency egress and fire hydrant systems).

7.7 Stations

Seven stations are proposed along the tunnel alignment. This section provides an overview of the station excavation and structural work, aboveground building and fit-out.

7.7.1 Station excavation and structural work

Excavation method

Traditionally, excavation of the stations would be carried out through the use of excavators and rock hammers. Due to the anticipated magnitude and duration of impacts associated with this excavation method, a number of contemporary alternatives were explored. This includes blasting, track sawing, wire cutting, rock bursting / splitting and penetrative cone fracture; or a combination of methods.

Based on the preliminary construction planning carried out for the project, it is unlikely that track sawing, wire cutting, rock bursting / splitting or penetrative cone fracture would not be able to achieve the necessary excavation rates in isolation. However, there is potential they could be used to supplement other excavation methods in order to reduce overall construction timeframes.

Blasting is likely to result in an overall reduced duration of excavation, and associated impacts, of rock hammering. In order to achieve compliance with the relevant criteria for blasting, the use of rock hammers would still be necessary until appropriate offset depths are reached.

Based on the above analysis, the preferred excavation method for the stations is a combination of rock hammers, use of excavators and blasting. Due to the location of the metro platforms at Central Station, there are limited residential and commercial receivers which could be impacted by rock hammering works. Additionally, the site is located within a busy transport interchange and heritage precinct. As a result, the preferred excavation method is the traditional use of rock hammers and excavators for this station site.

Preferred excavation method

Initial excavation at each station site would involve the use of rock hammers and excavators until appropriate offset depths are reached in order to achieve compliance with the relevant blasting criteria. Based on the anticipated ground conditions, the depth at which blasting could commence at each site is provided in Table 7-5.

The initial charge size at these depths would be a maximum instantaneous charge on one kilogram or smaller. As the excavation progresses (and the offset distances to receivers increases), charge sizes would be increased while still meeting the relevant criteria. Further details regarding blasting are provided in Chapter 10 (Construction noise and vibration).

Table 7-5 Indicative initial depth of blasting

Station site	Indicative initial depth of blasting (metres)
Crows Nest	25
Victoria Cross – north	15
Victoria Cross – south	15
Barangaroo	15
Martin Place – north	4
Martin Place – south	15
Pitt Street – north	15
Pitt Street – south	15
Waterloo	15

Cut-and-cover stations

Cut-and-cover construction is proposed for Crows Nest, Barangaroo, Central and Waterloo stations.

A typical construction method for cut-and-cover station excavation is shown in Figure 7-5. Generally, the construction method would involve:

- Securing the site perimeter, demolishing buildings and diverting utilities
- Establishing site access roads, signalised intersections and hardstand areas
- Excavating the station from the surface with either:
  - temporary steel piles, anchors and timber shoring
  - permanent retaining structures of concrete piles and shotcrete in-fills and anchors
  - a continuous piled wall.

With the exception of Central Station, acoustic sheds are proposed at the cut-and-cover stations, although alternative means of achieving the same noise outcome, such as acoustic panels over the station excavations, may be adopted. The specific noise mitigation measures would be determined during detailed construction planning taking into account construction program, construction working hours and construction traffic management in accordance with the *Construction Noise and Vibration Strategy* (Appendix E).

The construction of the station would progress down to the level of the base slab with intermediate temporary horizontal braces, anchors and shoring installed as required. The base slab and permanent structural elements would then be built up from the bottom of the excavation, removing temporary structural supports as the work progresses upwards. The last element of the structure would be the roof slab – leaving only discrete entry and exit points – and any required backfilling to the new ground level over the slab.

Typically, station excavation would occur prior to arrival of the tunnel boring machines. At Central Station it is feasible that tunnelling may occur prior to the completion of the excavation to base level, due to the significant activities required to occur within the operational station area before the station excavation. If this occurs, the station excavation would progress to base level in the space between the tunnels and then break into the excavated tunnel space once the tunnel excavation is completed.

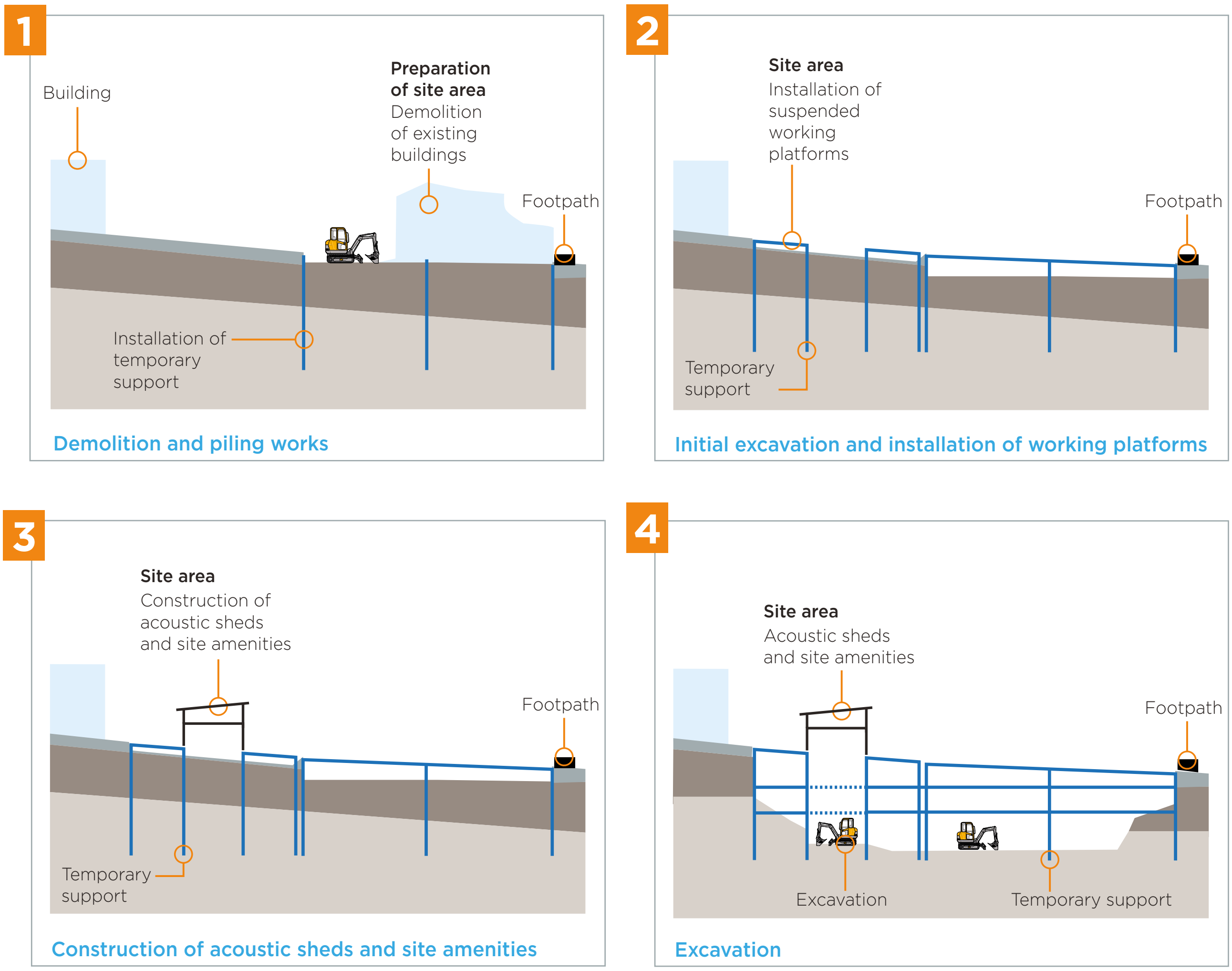


Figure 7-5 Typical cut-and-cover station construction

Mined stations

The stations at Victoria Cross, Martin Place and Pitt Street would be mined. A typical construction method for mined station excavation is shown in Figure 7 6. Acoustic sheds are proposed at the mined stations, although alternative means of achieving the same noise outcome, such as acoustic panels over the shaft excavations, may be adopted. The specific noise mitigation measures would be determined during detailed construction planning taking into account construction program, construction working hours and construction traffic management in accordance with the *Construction Noise and Vibration Strategy* (Appendix E).

For mined stations, the station entry and vertical transport would be typically offset from the station platforms. Shafts would be progressively excavated from the surface within the footprint of the future vertical transport to an intermediate floor level. Roadheaders and other excavation equipment would then be lowered through the shaft to excavate the underground station and pedestrian connections. Spoil would be moved to the shafts, transferred to the surface and then removed from site.

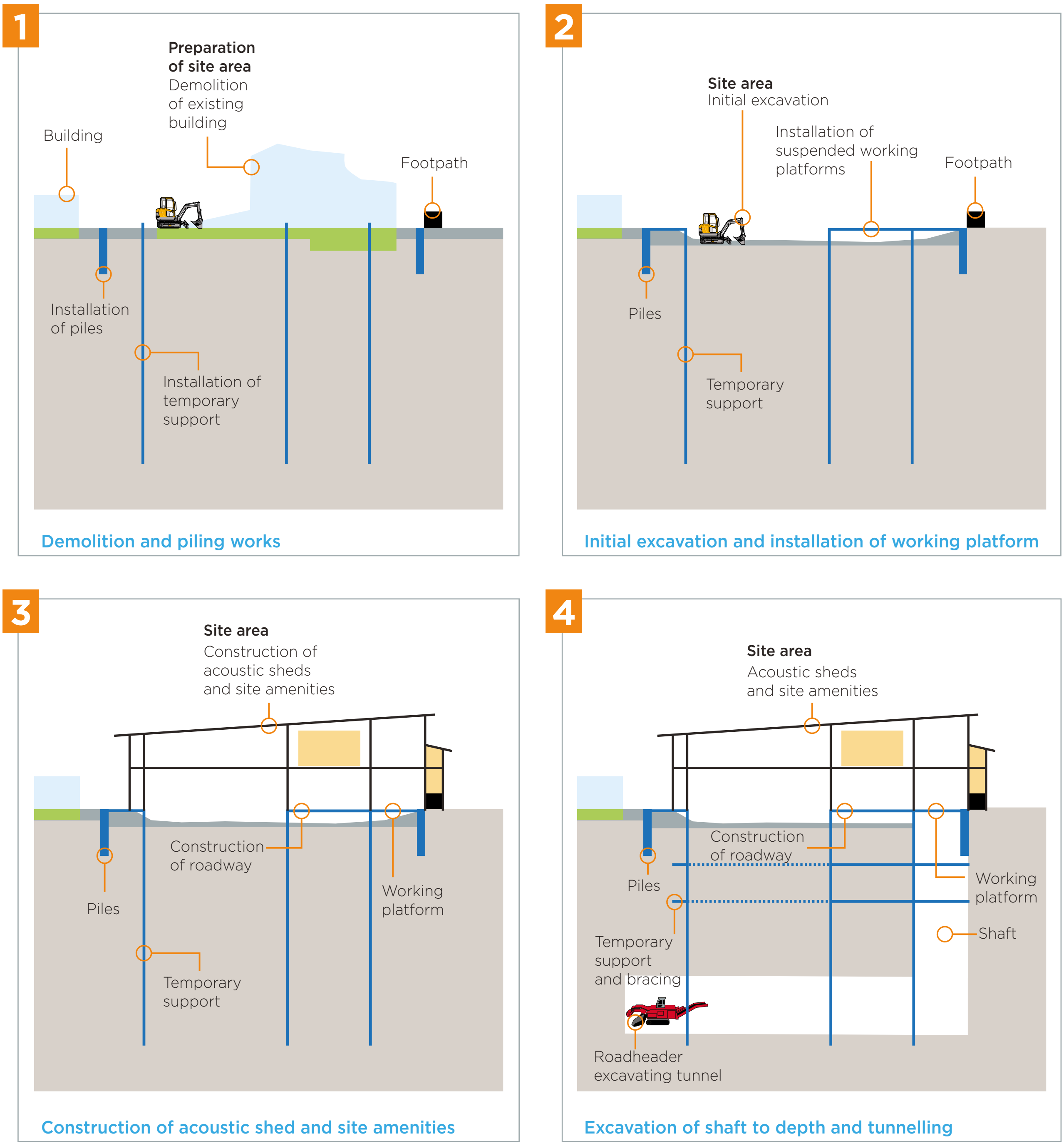


Figure 7-6 Typical mined station construction

Structural work

Following excavation, the station works would involve the construction of structural elements, including:

- Platforms – platform slabs would be constructed by placing formwork panels, followed by pouring of concrete into the panels using concrete pumps located aboveground. During this work, allowance would be made for the location of the vertical transportation elements (escalators and lifts)
- Vertical supports – these would be generally constructed by installing either pre-fabricated or cast in-situ concrete columns at the base slab level followed by a cast in-situ concrete edge beam connecting the column heads
- Intermediate floors – these would likely be constructed by installing structural beams to span the full width of the station excavation or vertical transport shaft, followed by secondary beams between the main beams. A concrete slab would then be poured in sections supported by the beams. Where large voids are required through the intermediate floors (for lifts and escalators), longitudinal beams would be provided at the edge of the voids to support the slabs. This process would be repeated for each of the intermediate floors
- Roof slabs (for cut-and-cover stations) – roof slabs would likely consist of a cast in-situ concrete slab spanning the full width of the station excavation, placed on the piled wall capping beam (installed as part of the excavation). A concrete topping slab would be poured on the girders, followed by a waterproof membrane and a concrete protection layer. The area would then be backfilled (as required) to the surface level.

The stations would also include structural elements to enable the construction of the future over station development and reduce the impact on the operational station during the construction of the over station development. These elements are incorporated, as relevant, into the design of the stations and assessed as part of this Environmental Impact Statement.

7.7.2 Aboveground building

Aboveground buildings associated with station entry and exit points, services and emergency egress would generally be constructed following the station structural works. Buildings would be constructed using conventional steel frame or reinforced concrete methods.

7.7.3 Station fit-out

The station fit-out would involve:

Mechanical and electrical fit-out would consist of two major elements: the tunnel rail systems located at the stations and the services required for the function of the stations. The initial fit-out of mechanical and electrical services would likely occur concurrently with the structural work via openings left in the floors and roof structure (for cut-and-cover stations) or through the vertical transport shaft (for mined stations). This would include the installation of large equipment such as fresh air ventilation fans. The final fit-out of services would occur after the completion of structural work.

Architectural fit-out would occur after completion of the station structural works. It would include elements such as glazing, wall and ceiling cladding, and floor finishes.

7.8 Northern surface track works

Surface track works would involve the provision of metro tracks and associated rail systems between the southern end of Chatswood Station and the Chatswood dive structure. Adjustments would also be carried out to the T1 North Shore Line between the southern end of Chatswood Station and Brand Street, Artarmon. The extent of work is shown on Figure 7-7.

7.8.1 Surface metro tracks

Surface metro tracks would be provided at the northern end of the project between Chatswood Station and the Chatswood dive structure. The main access point for this surface metro rail fit-out would be the Chatswood dive site. Fit-out would involve:

- Placement of ballast and rail
- Installing, fixing and welding the rails
- Constructing noise barriers (where required)
- Installing cable and equipment including signalling, communications and electrical systems
- Installing overhead wiring for rolling stock
- Installing drainage, and fire and life safety systems (including walkways connecting to emergency egress and fire hydrant systems).

7.8.2 T1 North Shore Line

The T1 North Shore Line would need to be adjusted between Chatswood Station and Brand Street, Artarmon (as shown on Figure 7-7) to accommodate the surface metro tracks. The works would involve:

- Vegetation clearing and excavation within the existing rail corridor to construct new metro and T1 North Shore Line rail track formations
- Carrying out structural work for the proposed T1 North Shore Line 'down' (northbound) bridge over the Chatswood dive structure. This would involve piling and cast in-situ concrete for the sub-structure and placing pre-cast concrete units for the super structure. The bridge would be around 60 metres long
- Constructing retaining walls for the T1 North Shore Line 'down' (northbound) track between around Ellis Street, Chatswood and around Drake Street, Artarmon
- Constructing, relocating or increasing the height of noise barriers
- Slewing the T1 North Shore Line tracks (to temporary and permanent alignments)
- Adjusting overhead wiring, signalling and other rail services
- Modifications and / or augmentation of stormwater infrastructure
- Constructing maintenance access stairs from Albert Avenue, Chatswood
- Constructing a new vehicle access point from Brand Street, Artarmon and upgrading the existing access from Drake Street, Artarmon.

Access to carry out this work would be primarily through the Chatswood dive site although access may also be gained from other points along the rail corridor including the existing access points at Hopetoun Avenue, Chatswood and Drake Street, Artarmon; and from a new access point at Brand Street, Artarmon.

Figure 7-7 Northern surface track works

7.9 Ancillary infrastructure

7.9.1 Artarmon substation

Construction of the Artarmon substation would involve:

- Excavating a vertical shaft to the tunnels below. This is likely to be carried out using a large diameter piling rig or a raised bore; however, drill and blast or penetrating cone fracture techniques may also be used
- Lining and reinforcing the shaft
- Building aboveground components
- Installing electrical equipment.

7.9.2 Southern services facility

The southern services facility would be constructed within the Marrickville dive site and would incorporate a tunnel water treatment plant and a traction substation for use during the operation of the project.

The tunnel water treatment plant would typically be a modular unit constructed on a concrete base slab. Drainage pipes would connect the water treatment plant with the tunnels.

The traction substation would consist of an aboveground building and installation of electrical equipment. Trenching and / or aboveground conduits would be provided to reticulate electrical cables into the tunnels.

7.10 Construction sites

A number of construction sites would be required for tunnel boring machine (TBM) launch, support and retrieval; roadheader support; station construction; and operational ancillary facility construction. Wherever possible, construction sites would be co-located with the operational footprint to minimise property acquisition and temporary disruption. Table 7-6 shows the proposed construction sites and their uses. All construction sites would provide staff facilities such as offices, lunch rooms and amenities.

Table 7-6 Construction site activities

Site	Area (m²)	TBM launch and support	TBM retrieval	Roadheader support	Spoil removal	Station construction	Ancillary infrastructure construction	Rail systems fit-out	Surface track works	Pre-cast concrete facility
Chatswood dive site (northern)	24,000			✓	✓	✓				
Artarmon substation	3,500		✓		✓					
Crows Nest	North – 4,500 South – 1,500	✓	✓	✓	✓	✓				
Victoria Cross	North – 700 South – 4,700			✓	✓	✓				
Blues Point	2,100		✓		✓					
Barangaroo	13,800	✓	✓	✓	✓	✓				
Martin Place	North – 2,800 South – 2,000			✓	✓	✓				
Pitt Street	North – 3,100 South – 1,700			✓	✓	✓				
Central	16,500			✓	✓	✓				
Waterloo	12,000				✓	✓				
Marrickville dive site (southern)	81,500	✓		✓	✓		✓	✓		✓

Site establishment activities would initially be carried out at each construction site. This would involve:

- Demolishing buildings and clearing landscaped vegetation, where required
- Protecting and / or relocating utilities
- Providing services required for construction, such as power, water, sewer and communications
- Establishing site compound and ancillary facilities, such as offices, amenities and workshops
- Establishing vehicle access and egress points
- Establishing truck wheel wash or rumble grid
- Establishing internal roads
- Establishing hardstand areas for storage and car parking
- Establishing site hoardings, noise barriers and / or fencing around the perimeter of the site.

Some of these site establishment activities may be carried out as enabling works (refer to Section 7.4).

7.10.1 Chatswood dive site (northern)

The Chatswood dive site would cover about 24,000 square metres adjacent to the T1 North Shore Line. The site is currently occupied by an Ausgrid depot and commercial and retail buildings. The heritage listed Mowbray House would be retained and protected within the site.

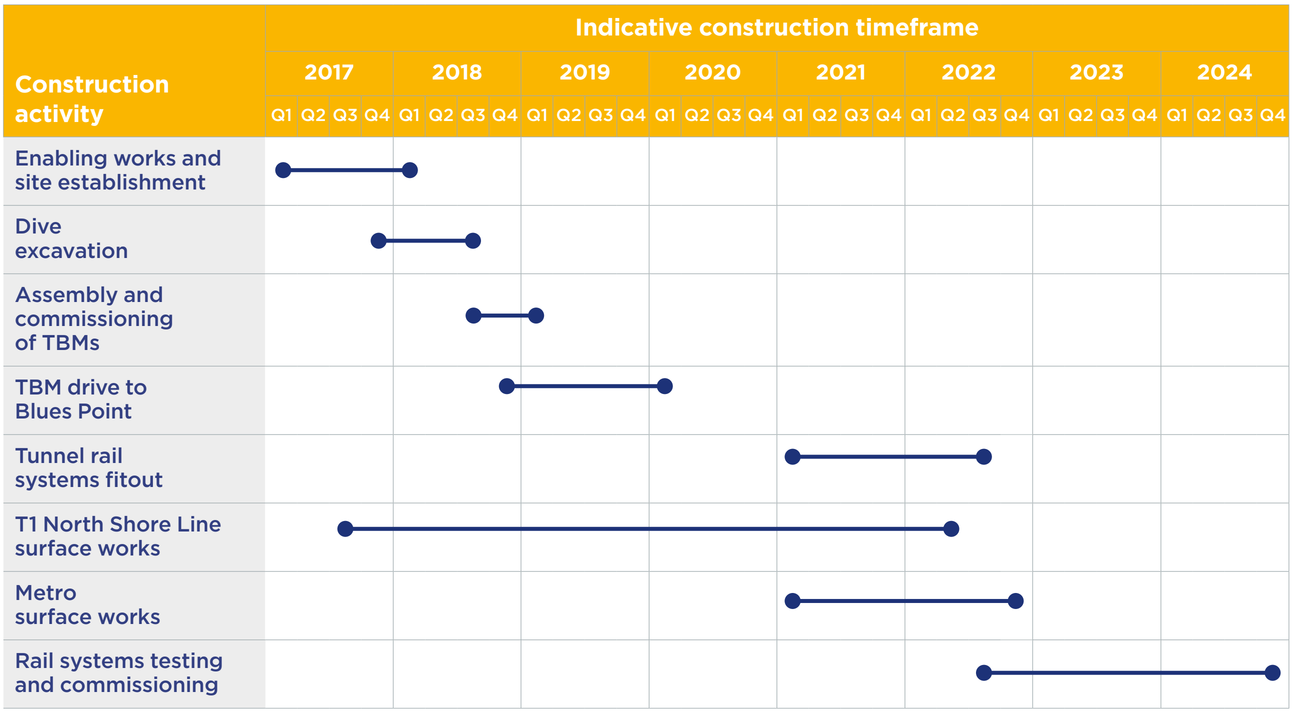
The site would be used to:

- Support surface metro track work and adjustment to the T1 North Shore Line between Chatswood Station and Brand Street, Artarmon, including track slewing and construction of the T1 North Shore Line 'down' (northbound) track bridge (described in Section 7.8)
- Excavate and construct the Chatswood dive structure and tunnel portal (described in Section 7.5)
- Launch and support two tunnel boring machines for the drive to the Blues Point temporary site
- Support the fit-out of the tunnel rail systems.

Access to and egress from the site would be right-in from Nelson Street; and left-in, right-out via Mowbray Road at a new set of traffic signals at the Mowbray Road / Hampden Road intersection.

The location and indicative layout of the Chatswood dive site, including vehicle access and egress, are illustrated in Figure 7-8. The indicative construction program is outlined in Table 7-7.

Table 7-7 Chatswood dive site (northern) indicative construction program



Tunnel boring machine launch and support

Two tunnel boring machines would be assembled and launched within the dive structure for the drive to Blues Point. To allow unrestricted access from the support site to the tunnel boring machine launch area the existing T1 North Shore Line tracks would be temporarily relocated further to the east.

Tunnel boring machine support services would include high voltage power supply, water supply, fresh air ventilation, work train, grout batching plant, drainage and water treatment, workforce facilities, spoil storage and removal, and storage and introduction of pre-cast concrete lining elements.

The Chatswood dive site would be a substantial spoil removal site. About 520,000 cubic metres would be removed through the site (460,000 cubic metres from tunnelling and 60,000 cubic metres from the dive structure).

Adjustments to Mowbray Road bridge

The arrangement of the Chatswood dive structure would avoid direct impacts on the Mowbray Road bridge. It is likely that support to the western abutment would be required with soil nails and shotcrete. The western pier would also require a deflection wall to be constructed around the existing pier columns due to the increased height of the realigned T1 North Shore Line 'down' track.

Road upgrades

Track and associated rail corridor works would require the permanent removal of the Nelson Street bridge. The primary role of the Nelson Street bridge is to enable motorists travelling south on the Pacific Highway to access Mowbray Road westbound via Orchard Road.

Prior to the planned closure and subsequent removal of the bridge, it is proposed to construct an all vehicle right turn movement from the Pacific Highway (southbound) to Mowbray Road westbound to maintain this movement.

In addition, the Mowbray Road / Hampden Road intersection would be signalised to provide safe access and egress to and from the construction site.

Rail systems fit-out

Following tunnelling, the Chatswood dive site would be used as a major staging and delivery site to fit out the tunnel and rail systems. Activities at the site would include:

- Delivery of mechanical and electrical equipment and materials for installation at the dive and within the tunnels
- Storage, handling and delivery into the tunnels of equipment such as fresh air ventilation fans, and cabling for signalling, communication and electrical systems
- Delivery of concrete
- Welding of track and delivery into the tunnels.

Figure 7-8 Chatswood dive site (northern) indicative layout

7.10.2 Artarmon substation construction site

The Artarmon substation construction site would cover about 3,500 square metres beside the Gore Hill Freeway in Artarmon.

The site would be used to construct the Artarmon traction substation (described in Section 7.9.1). This would involve the excavation of a shaft (about three metres in diameter) to reticulate electrical cables to the tunnel below (resulting in the removal of about 2,000 cubic metres of spoil) and construction of an aboveground building that would be fitted out with electrical equipment.

Access to and egress from the site would be via Barton Road.

The location and indicative layout of the Artarmon substation construction site, including vehicle access and egress, are illustrated in Figure 7-9. The indicative construction program is outlined in Table 7-8.

Table 7-8 Artarmon substation indicative construction program

Construction activity	Indicative construction timeframe																															
	2017				2018				2019				2020				2021				2022				2023				2024			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Enabling works and site establishment														●																		
Shaft excavation and structural works														●	—	●																
Aboveground building works																●	—	●														
Traction substation fitout																			●	●												
Traction substation testing and commissioning																					●											

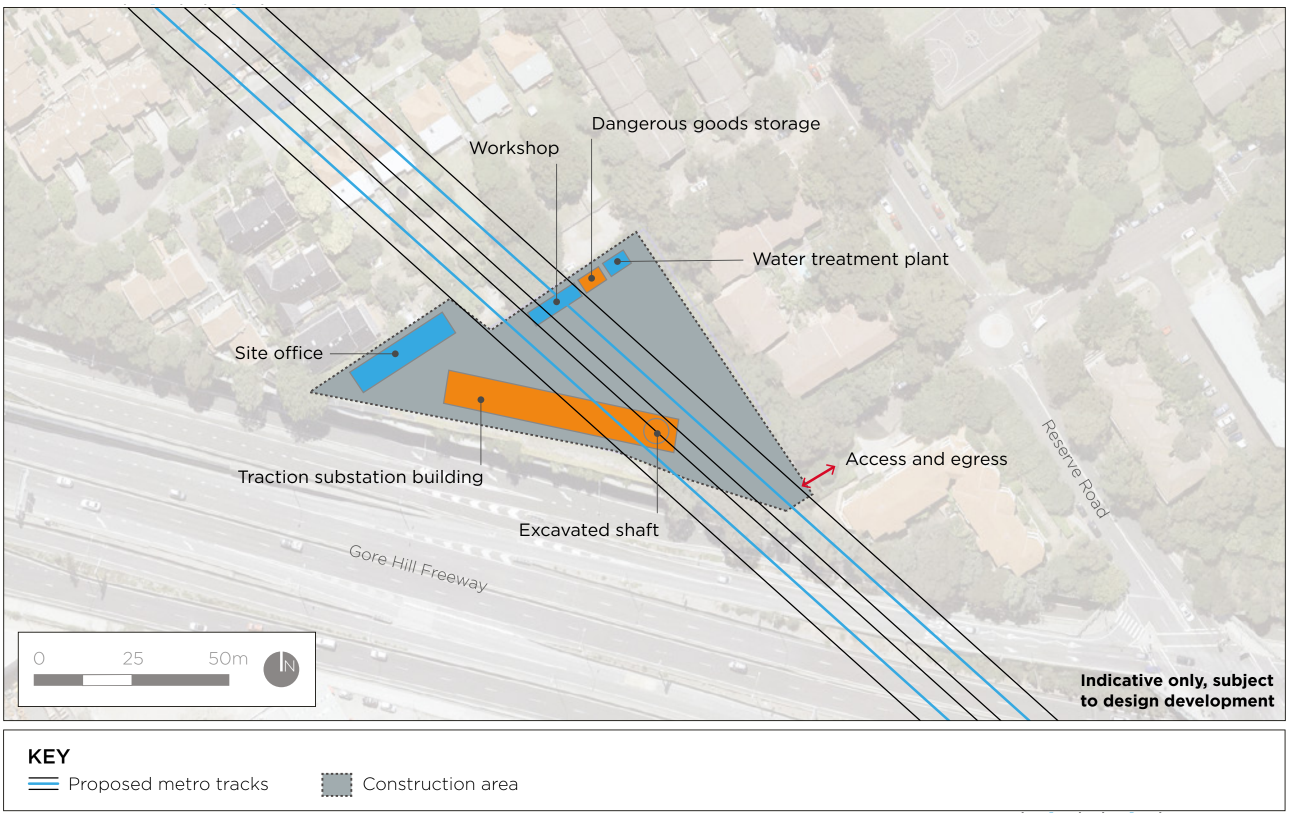


Figure 7-9 Artarmon substation construction site indicative layout

7.10.3 Crows Nest Station construction site

The Crows Nest Station construction site would cover about 6,000 square metres beside the Pacific Highway, to the south of Oxley Street. The site currently contains commercial and residential buildings.

This station would be constructed using a cut-and-cover method, resulting in the removal of about 150,000 cubic metres of spoil. The site would function as two separate construction zones split by Hume Street. There would be a short-term closure of Hume Street whilst cut-and-cover works is carried out through this section. During these works, pedestrian and cyclist access would be maintained to the south of Hume Street.

Access to and egress from the site would be via Hume Street, Clarke Street and Clarke Lane.

The station excavation would cover the majority of the site, requiring the installation of temporary street level working platforms. Support services would be provided on the working platforms, including offices, amenities, spoil handling and storage, and workshops.

The location and indicative layout of the Crows Nest Station construction site, including vehicle access and egress, are illustrated in Figure 7-10. The indicative construction program is outlined in Table 7-9.

Table 7-9 Crows Nest Station indicative construction program

Construction activity	Indicative construction timeframe																															
	2017				2018				2019				2020				2021				2022				2023				2024			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Enabling works and site establishment		●	—	—	●																											
Station excavation					●	—	—	—	—	●																						
TBM pass through station										●	●																					
Station structural works										●	—	—	—	—	—	●																
Station fit out																	●	—	—	—	—	●										
Station testing and commissioning																							●	●								

Figure 7-10 Crows Nest Station construction site indicative layout

7.10.4 Victoria Cross Station construction sites

Construction of Victoria Cross Station would require two sites:

- The Victoria Cross north site would cover about 700 square metres on the western side of Miller Street, towards the northern extent of the station. This site currently contains one commercial building
- The Victoria Cross south site would cover about 4,700 square metres on the south east corner of Berry and Miller streets. The site currently contains commercial buildings.

The station would be constructed using a mined technique. A shaft would be excavated within the Victoria Cross south site adjacent to the proposed station cavern. This shaft would be used to provide the future station entry and vertical transport. The station cavern, located under Miller Street, would then be excavated from the shaft.

Shafts would also be excavated from the Victoria Cross north site to the underground station cavern. The Victoria Cross north site would become a future service facility. This shaft may also be used throughout the construction period for the delivery of materials.

About 175,000 cubic metres of spoil would be removed to construct the station.

It is also likely that roadheaders would be established from this site to excavate stub tunnels located to the north of Victoria Cross Station. These stub tunnels would enable a future expansion of the metro network.

Access to and egress from the Victoria Cross south site would be left-in via Miller Street and left-out to Denison Street. Access and egress to and from the Victoria Cross north site would be left-in and left-out via Miller Street.

Street level working platforms would be required over the shaft excavations at both sites. The platforms would house support services including office, amenities, spoil handling and storage, and workshops.

The location and indicative layout of the Victoria Cross Station construction site, including vehicle access and egress, are illustrated in Figure 7-11. The indicative construction program is outlined in Table 7-10.

Table 7-10 Victoria Cross Station indicative construction program

Construction activity	Indicative construction timeframe																															
	2017				2018				2019				2020				2021				2022				2023				2024			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Enabling works and site establishment	●	—	—	—	●																											
Station excavation					●	—	—	—	—	—	●																					
TBM pass through station											●	●																				
Station structural works											●	—	—	—	—	●																
Station fit out																	●	—	—	—	—	—	●									
Station testing and commissioning																							●	●								

Figure 7-11 Victoria Cross Station construction site indicative layout

7.10.5 Blues Point temporary site

The Blues Point temporary site would be established to enable the retrieval of the cutter heads and shields of the tunnel boring machines from the Chatswood dive site and from Barangaroo Station.

The site would cover about 2,100 square metres within Blues Point Reserve, at the end of Blues Point Road. The site contains public open space and a public road. Public access to the foreshore would be maintained during works at this site.

Works at this site would involve the excavation of a shaft to the tunnels below resulting in about 8,000 cubic metres of spoil being removed through the site. The cutter heads and shield of the tunnel boring machines from the Chatswood dive site and from Barangaroo would be retrieved through this shaft. During retrieval of these components, this site would expand to encompass the current car parking on Blues Point Road adjacent to the reserve and the end of Blues Point Road. Further details regarding the loss of parking are provided in Chapter 8 (Construction traffic and transport).

Access to and egress from the site would be left-in from Blues Point Road and left-out to Henry Lawson Avenue. The removal of the tunnel boring machine components via Blues Point Road would occur on four occasions and require oversized truck movements. This would involve the temporary short-term closure of the road (most likely overnight) and the temporary removal of street furniture, such as signage, pedestrian islands and bollards. It may also be feasible to remove the tunnel boring machines via barge using the wharf at the end of Blues Point Road. This opportunity would be further investigated during detailed design.

The location and indicative layout of the Blues Point temporary site, including vehicle access and egress, are illustrated in Figure 7-12. The indicative construction program is outlined in Table 7-11.

Table 7-11 Blues Point temporary site indicative construction program

Construction activity	Indicative construction timeframe																															
	16.724 pt				2018				2019				2020				2021				2022				2023				2024			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Enabling works and site establishment									●																							
Shaft excavation									●	—	—	●																				
TBM retreival (Barangaroo drive 1)												●																				
TBM Retreival (northern drives)													●	●																		
TBM retreival (Barangaroo drive 2)															●																	
Rehabilitation																●	●															

Figure 7-12 Blues Point temporary site indicative layout

7.10.6 Barangaroo Station construction site

The Barangaroo Station construction site would cover about 13,800 square metres within the road reserve of Hickson Road and the adjacent Barangaroo development area.

The site would be used to:

- Launch and support the tunnel boring machine for the Sydney Harbour crossing drive to Blues Point
- Retrieve the cutter heads and shields of the two tunnel boring machines driven from the Marrickville dive site (described in Section 7.6)
- Carry out the excavation and construction of Barangaroo Station.

Access to and egress from the Barangaroo site would be via Hickson Road. It may also be feasible to remove some of the spoil generated through this site by barge using wharf facilities around Barangaroo. This opportunity would be further investigated during detailed design in consultation with Barangaroo Delivery Authority.

The location and indicative layout of the Barangaroo Station construction site, including vehicle access and egress, are illustrated in Figure 7-13. The indicative constriction program is outlined in Table 7-12.

Table 7-12 Barangaroo Station indicative construction program

Construction activity	Indicative construction timeframe																															
	2017				2018				2019				2020				2021				2022				2023				2024			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Enabling works and site establishment		●	—	—	●																											
Station excavation					●	—	—	—	●																							
Assembly and commissioning of TBM									●																							
TBM drive 1 to Blues Point									●	—	●																					
Assembly and commissioning of TBM												●																				
TBM drive 2 to Blues Point													●	●																		
TBM retreival (southern drives)													●	●																		
Station structural works									●	—	—	—	—	—	—	●																
Station fit out																	●	—	—	—	—	—	●									
Station testing and commissioning																							●									

Tunnel boring machine launch and support

The northern section of the station would be excavated to enable assembly and launch of the tunnel boring machine for the harbour crossing drive to Blues Point.

This site would require tunnel boring machine support services including high voltage power supply, water supply, fresh air ventilation, work train, grout batching plant, drainage and water treatment, workforce facilities, spoil storage and removal, and storage and introduction of pre-cast concrete lining elements. The site would also require a separation treatment plant to remove excavated spoil from the slurry mixture and re-circulate the slurry material to the cutting face. The separation plant would only be required when the tunnel boring machine is operating in a 'slurry mode' through the non-rock section of the drive.

About 90,000 cubic metres of spoil would be removed through the site from the tunnelling works.

Station excavation and construction

The station would be constructed using a cut-and-cover technique, resulting in about 145,000 cubic metres of spoil.

Cut-and-cover work underneath Hickson Road would be managed to generally maintain one traffic lane in each direction, with the exception of some full road closures at night.

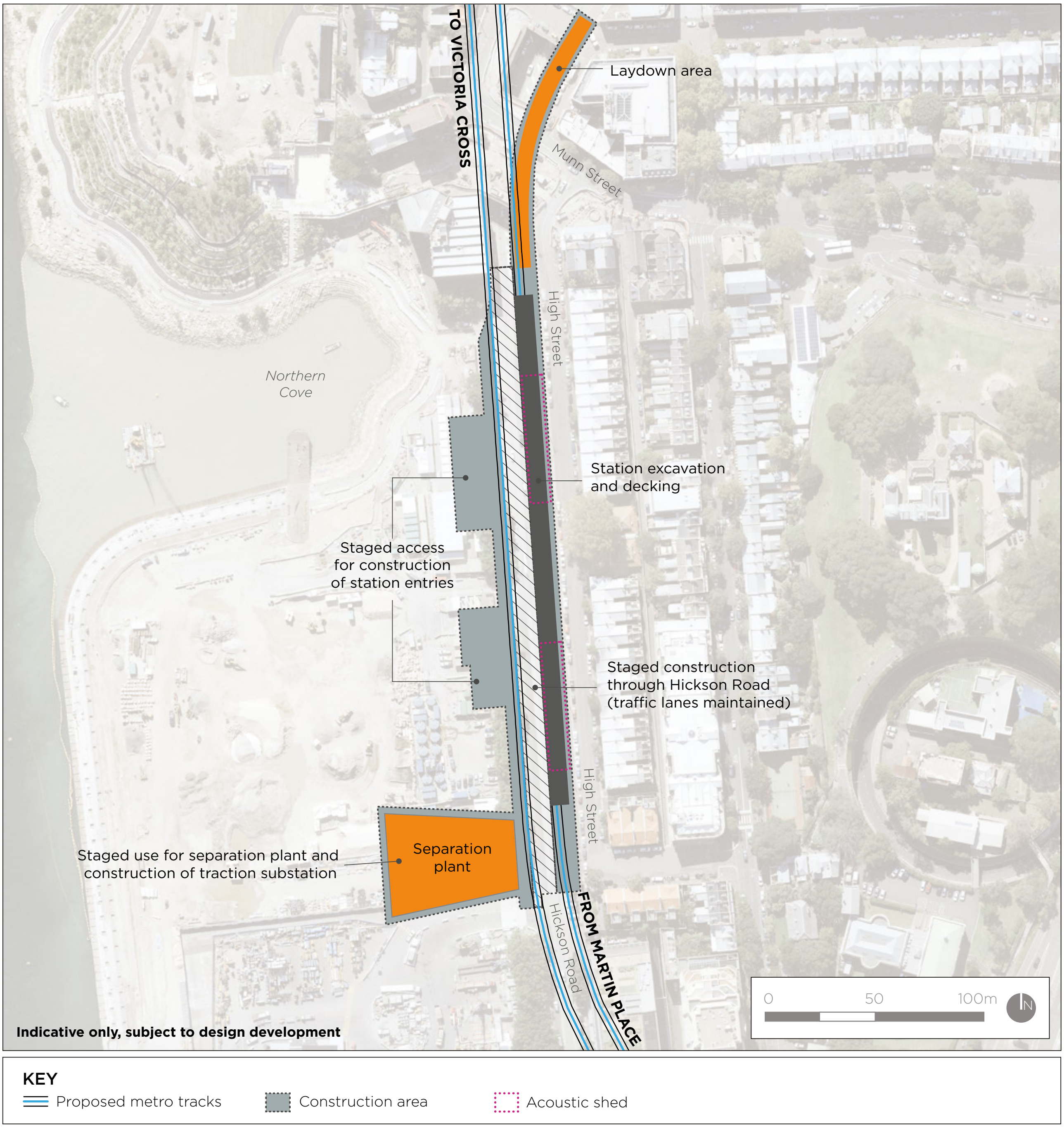


Figure 7-13 Barangaroo Station construction site indicative layout

7.10.7 Martin Place Station construction sites

Construction of Martin Place Station would require two sites:

- The Martin Place north site would cover about 2,800 square metres and occupy part of the block bounded by Elizabeth, Hunter and Castlereagh streets
- The Martin Place south site would cover about 2,000 square metres and would front Martin Place between Elizabeth and Castlereagh streets.

The two sites currently contain commercial and residential buildings.

The station would be constructed using a mined technique. At the Martin Place north site, a shaft would be excavated to provide the future station entry and vertical transport. The station cavern would then be excavated from the shaft.

Staged construction would be necessary at the Martin Place south site in order to maintain pedestrian access and construct the underground concourse connection between the metro station and the existing Martin Place Station. Once the building on the Martin Place south site has been demolished, pedestrians would be diverted to the site previously occupied by this building. This would allow cut-and-cover construction within the footprint of Martin Place between Elizabeth and Castlereagh streets. The existing underground concourse would be demolished and re-constructed as part of this work. Following the cut-and-cover construction, pedestrians would be relocated back to Martin Place. A shaft would then be excavated for the future station entry and vertical transport within the footprint of the Martin Place south site.

The underground platform to platform connection between the existing Martin Place Station and the metro station would mainly be carried out by excavating new pedestrian tunnels from the Sydney metro construction site. During the final connection to the existing Martin Place Station, occupation of some space at the western end of the Sydney Trains platforms would be required. Hoarding would be established to provide a separated work zone for the breakthrough works. These works are likely to be carried out without the need for rail possessions and without impacting on any Sydney Trains suburban rail services. Sufficient space for pedestrian circulation would be maintained on the existing Martin Place platforms during this work.

Initial investigations have been carried out to determine the construction activities required for the underground pedestrian connection to 33 Bligh Street. These investigations have identified:

- Demolition of the site has recently been carried out under a separate approval by Ausgrid
- Excavation of the underground pedestrian connection would be via a mined technique to avoid cut-and-cover works across Hunter Street
- Construction of the pedestrian access for the station would be carried out from 33 Bligh Street towards the main station shaft, with spoil removal from 33 Bligh Street and 12 O'Connell Street
- Spoil removal, and associated truck movements would load and unload from both Bligh Street and O'Connell Street, via Hunter Street to the Eastern Distributor.

Further investigations are currently being carried out to refine the construction methodology, and potential impacts.

About 175,000 cubic metres of spoil would be removed for the construction of Martin Place Station.

Access to and egress from the sites would be left-in from Castlereagh Street and left-out to Elizabeth Street.

For both sites, the shaft excavations would comprise the majority of the site, requiring the installation of temporary street level working platforms. The platforms would house support services including offices, amenities, spoil handling and storage, and workshops.

The location and indicative layout of the Martin Place Station construction sites, including vehicle access and egress, are illustrated in Figure 7-14. The indicative construction program is outlined in Table 7-13.

Table 7-13 Martin Place Station indicative construction program

Construction activity	Indicative construction timeframe																															
	2017				2018				2019				2020				2021				2022				2023				2024			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Enabling works and site establishment		●	—	—	●																											
Station excavation					●	—	—	—	—	—	●																					
TBM pass through station											●	●																				
Station structural works											●	—	—	—	—	●																
Station fit out																	●	—	—	—	—	—	●									
Station testing and commissioning																							●	●								

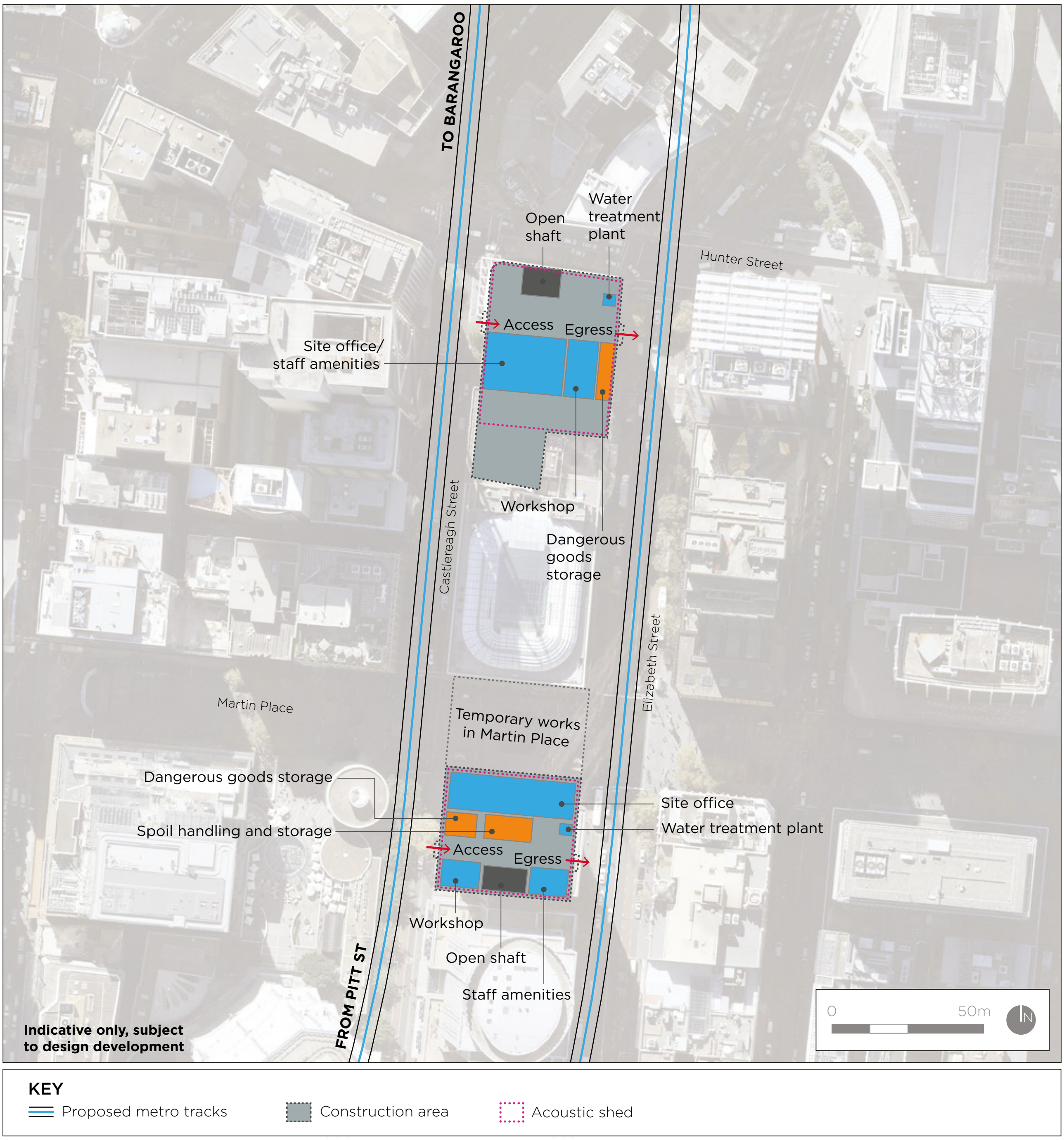


Figure 7-14 Martin Place Station construction sites indicative layout

7.10.8 Pitt Street Station construction sites

Construction of Pitt Street Station would require two sites:

- The Pitt Street north site would cover about 3,100 square metres on the corner of Pitt, Park and Castlereagh streets
- The Pitt Street south site would cover about 1,700 square metres and would front Bathurst and Pitt streets.

The two sites currently contain commercial buildings. The Pitt Street south site was located to avoid direct impacts on the heritage listed hotel on the corner of Bathurst and Pitt streets.

The station would be constructed using the mined technique. Shafts would be excavated within the two sites to provide the future station entry and vertical transport. The station excavation and other underground pedestrian connections would then be excavated from the shafts. About 160,000 cubic metres of spoil would be removed for the construction of Pitt Street Station.

Access to and egress from the Pitt Street north site would be right-in and right-out via Castlereagh Street, and right-in from Pitt Street. Access to and egress from the Pitt Street south site would be right-in from Bathurst Street and right-out to Pitt Street.

For both sites, the shaft excavations would comprise the majority of the site, requiring the installation of temporary street level working platforms. The working platforms would house support services including offices, amenities, spoil handling and storage, and workshops.

The location and indicative layout of the Pitt Street Station construction sites, including vehicle access and egress, are illustrated in Figure 7-15. The indicative construction program is outlined in Table 7-14.

Table 7-14 Pitt Street Station indicative construction program

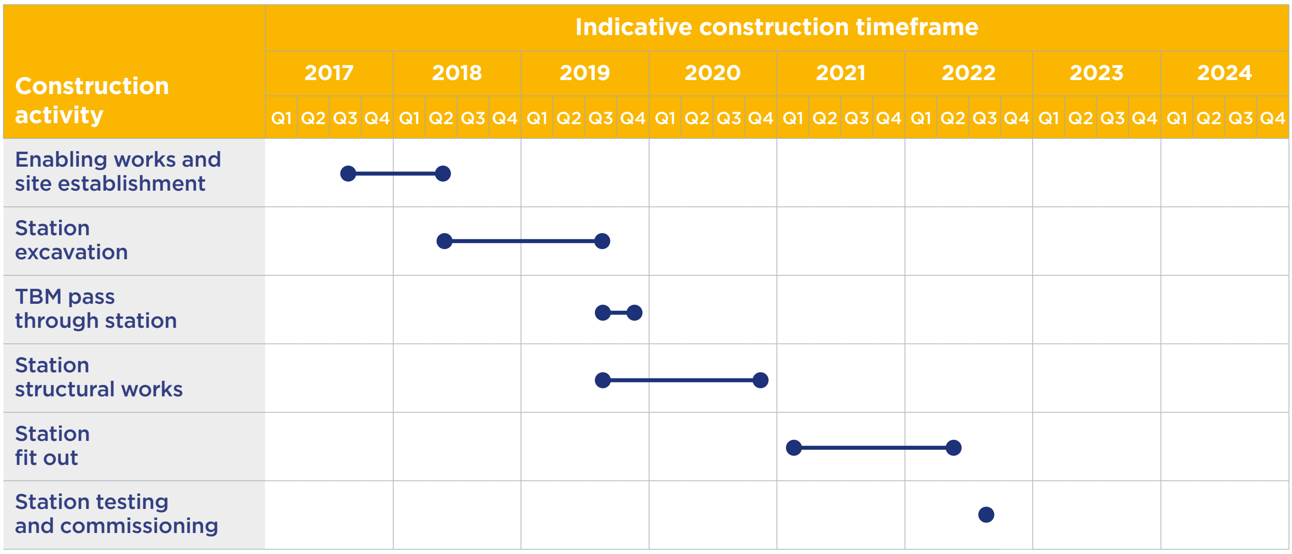


Figure 7-15 Pitt Street Station construction sites indicative layout

7.10.9 Central Station construction sites

The Central Station construction site would cover about 16,500 square metres in the area of existing platforms 13, 14 and 15 and an area known as Sydney Yard between the suburban and country lines to the south. This would require the closure of platforms 13, 14 and 15 during construction. This site would incorporate the footprint of the future underground metro platforms. This site is currently part of the Central Station operational area.

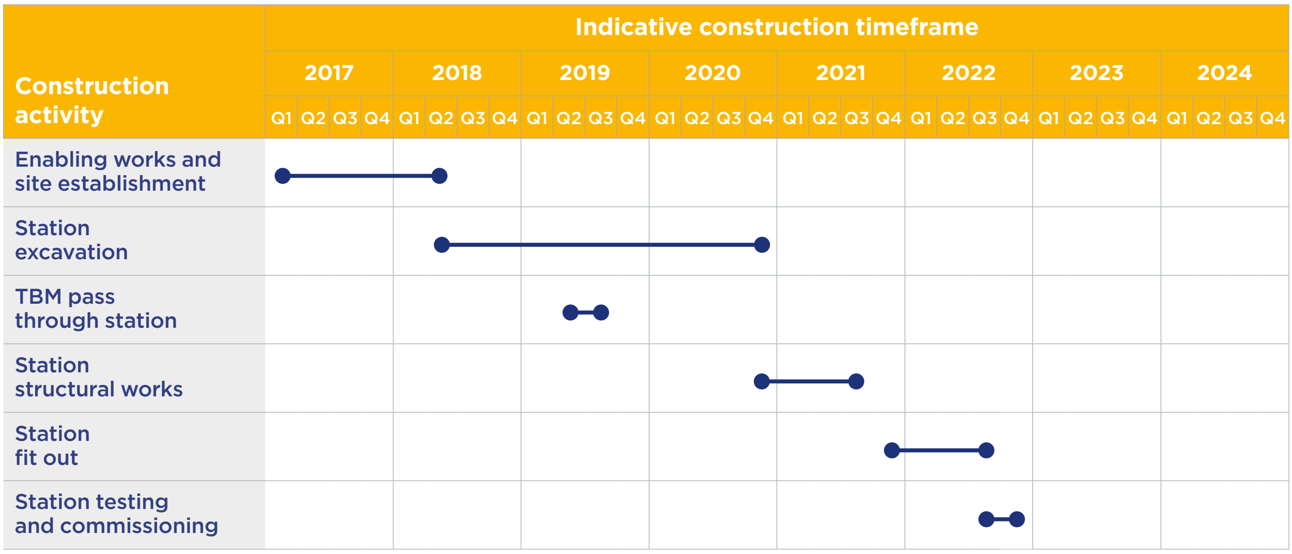
Access to and egress from the sites would be:

- Left-in, left-out via Eddy Avenue to access the Central Station Sydney Yard site (this would be the main access until the Sydney Yard Access Bridge is constructed; it would subsequently be used for access by light vehicles and construction workers)
- Left-in, left-out from Regent Street, via a permanent bridge over the country rail lines to the Central Station Sydney Yard site.

In order to facilitate construction of the metro platforms, ancillary works would be required at Central Station including services relocations, the construction of a permanent vehicle access bridge from Regent Street (the Sydney Yard Access Bridge) and the construction a temporary pedestrian overbridge to provide for transport interchange.

The location and indicative layout of the Central Station construction sites, including vehicle access / egress, are illustrated in Figure 7-16. The indicative construction program is outlined in Table 7-15.

Table 7-15 Central Station indicative construction program



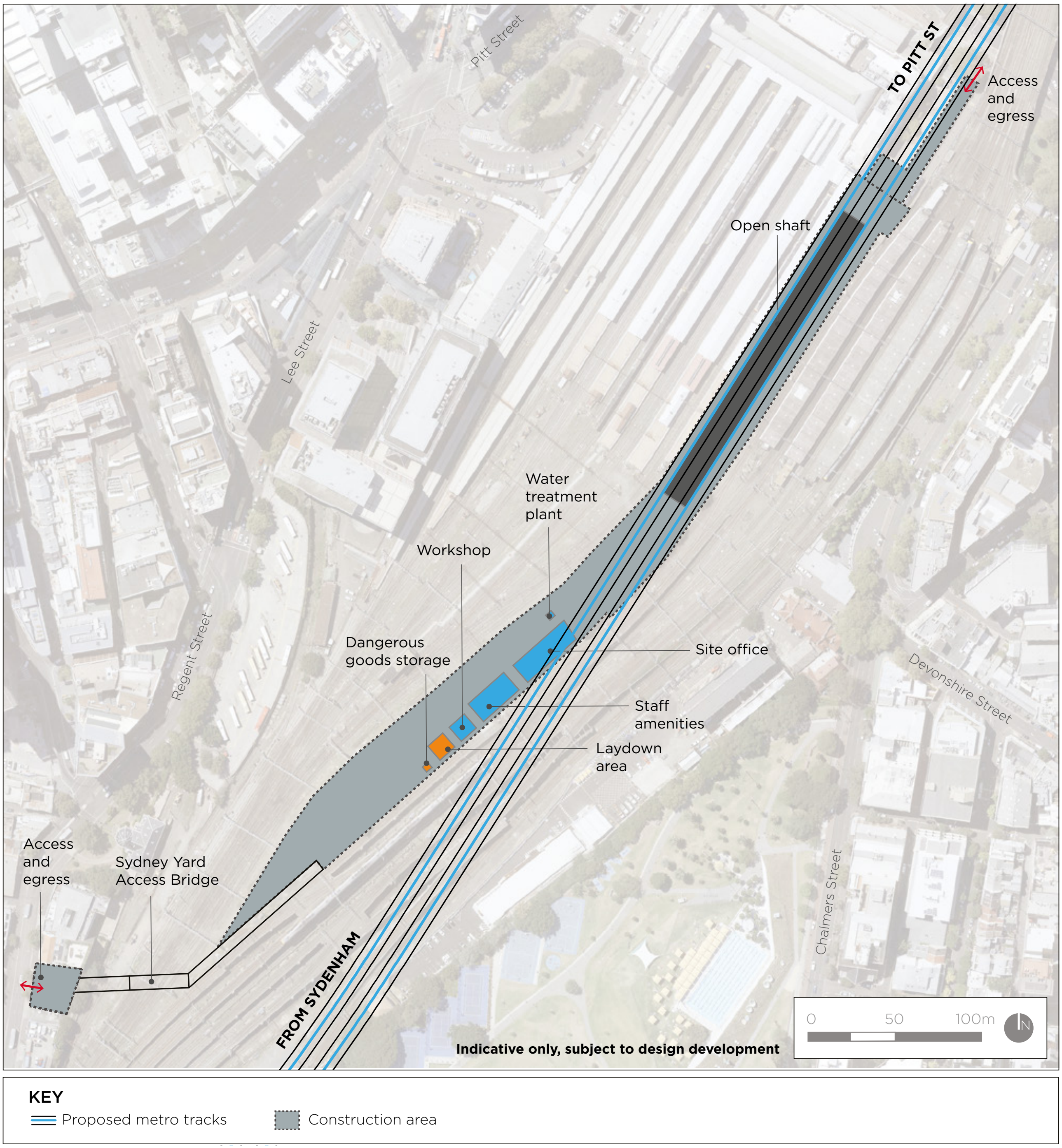


Figure 7-16 Central Station construction sites indicative layout

Services relocation

The existing services routes at Central Station are contained within the underground services and pedestrian tunnels beneath the existing platforms. In order to provide uninterrupted access for the construction of the metro platforms, it is proposed to relocate these services into a combined service ring located around the perimeter of the station. The services ring is likely to include power cables, communications cables, signalling cables and fire services.

The location of the combined services ring is shown on Figure 7-17. Where possible, the services ring would use existing tunnels and underutilised space in buildings. The new sections of the services ring are likely to involve the construction of small diameter tunnels.

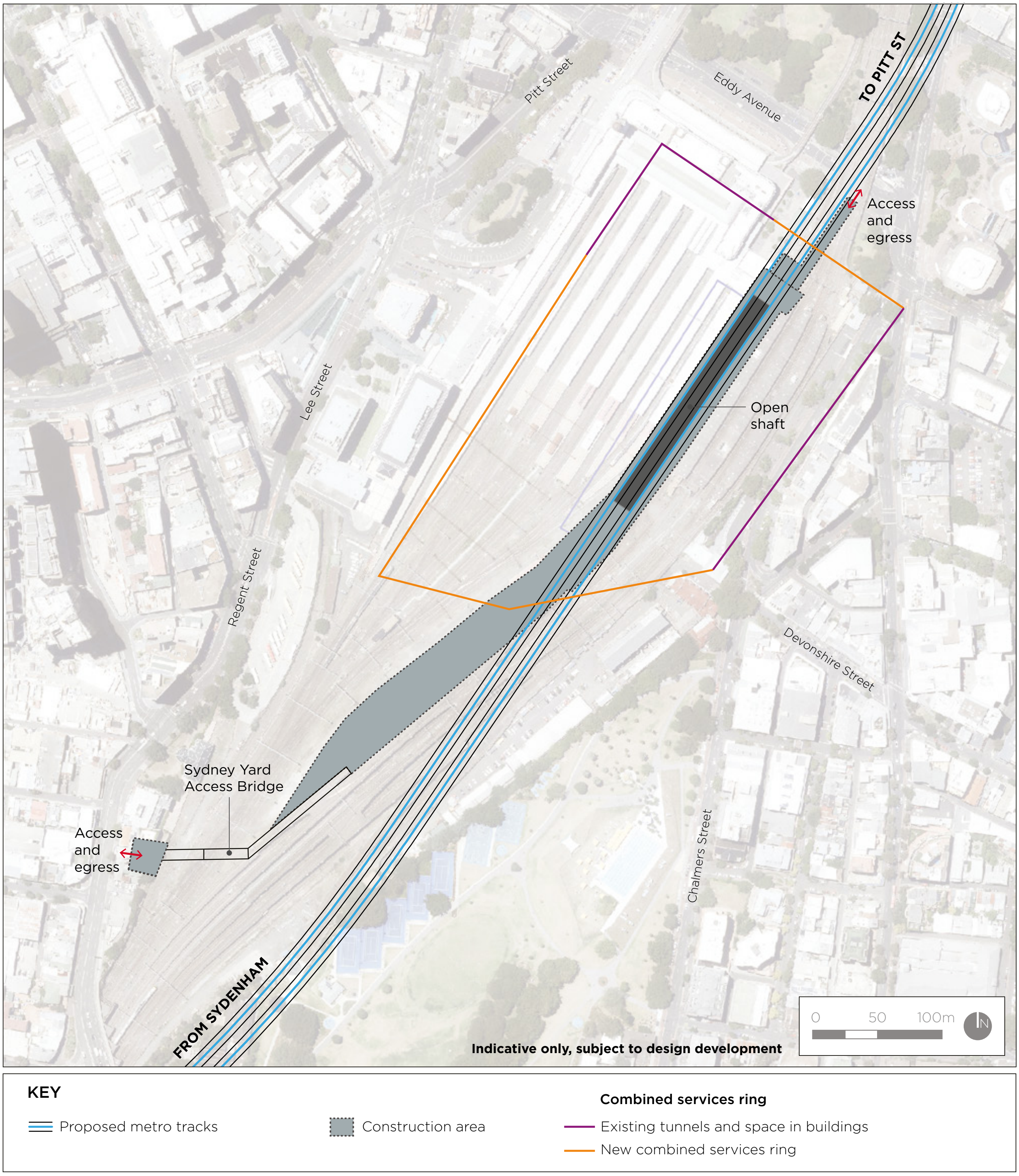


Figure 7-17 Central Station indicative combined services ring

Sydney Yard Access Bridge

A new permanent bridge would be constructed from Regent Street over the intercity rail lines to Sydney Yard to provide access for construction of the metro platforms. Following construction, this bridge would provide maintenance access for Sydney Metro and Sydney Trains.

The construction of the Sydney Yard Access Bridge would involve:

- Demolition of properties on Regent Street
- Installation of new overhead wiring gantries for the intercity tracks and removal of old overhead wiring gantries
- Cast in-situ concrete piling for bridge abutments and piers
- Construction of bridge abutments and piers
- Placement of pre-cast concrete elements for the bridge superstructure (girders between the piers)
- Cast in-situ concrete bridge deck.

The construction of the Sydney Yard Access Bridge is likely to require number of rail possessions to enable it to be completed.

The location of the Sydney Yard Access Bridge is shown on Figure 7-17.

Metro platform construction

The station would be constructed using the cut-and-cover technique beneath platforms 13, 14 and 15, requiring the removal of about 230,000 cubic metres of spoil.

Construction of the station would impact on the existing underground pedestrian connections between station platforms. Opportunities would be investigated to retain some underground connectivity by staging the construction works. Construction of the station would also require the demolition and re-construction of a section of Devonshire Street tunnel. This would involve a short-term (around two week) closure of the Devonshire Street tunnel.

Temporary pedestrian bridge

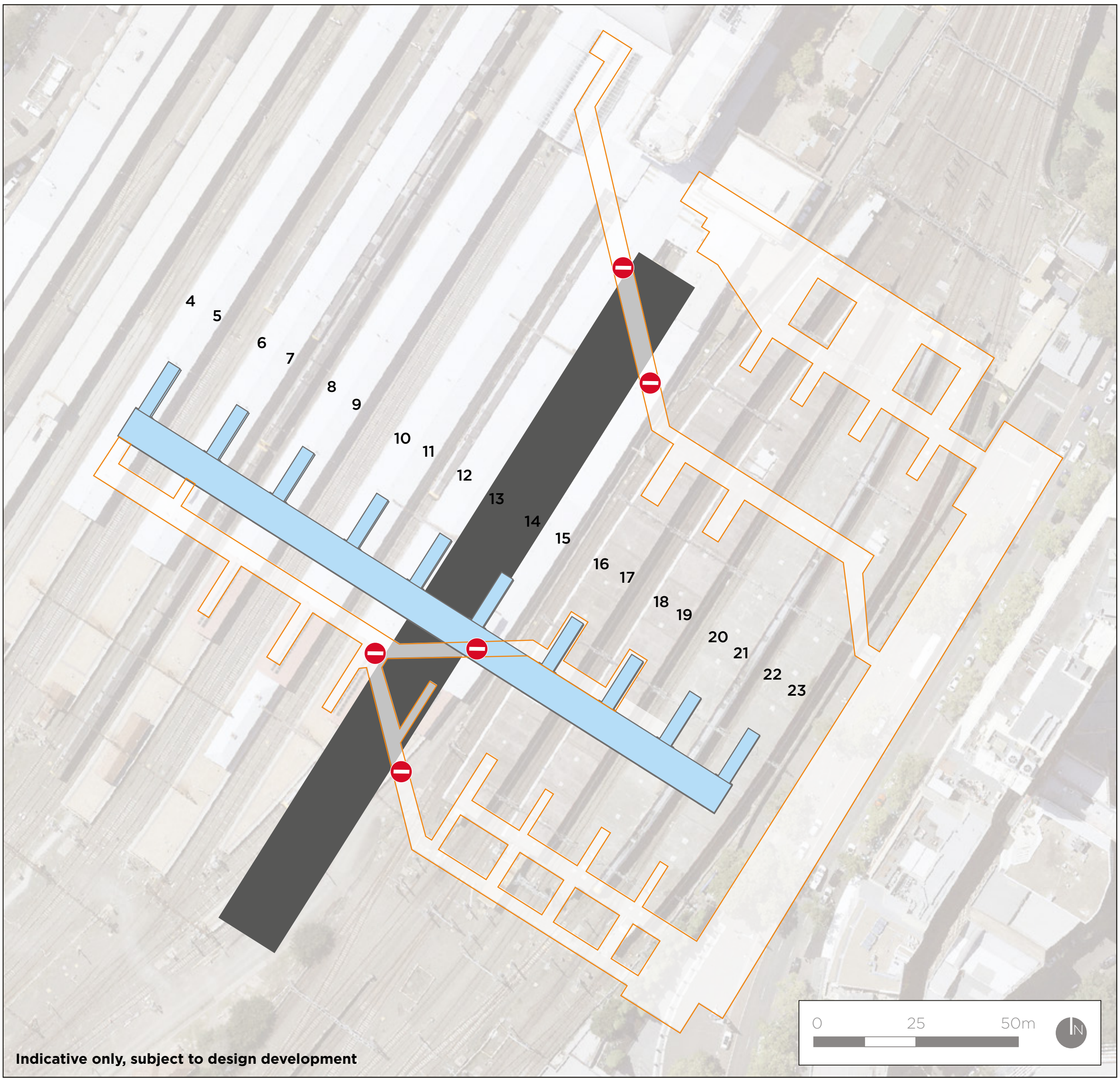
A temporary pedestrian bridge would be provided at Central Station from Platform 4 to Platform 23 to maintain interchange connectivity between the station platforms (refer to Figure 7-18). The bridge would provide stair connections to each platform which provides a like-for-like replacement. The existing lift access at the northern concourse at Central Station would be maintained. Construction of the temporary pedestrian bridge would involve:

- Removal and modification of platform canopy sections from platforms 4 to 23
- Piling through existing platforms 4 to 23
- Construction of piers and trusses
- Construction of stairs from the bridge to each platform
- Fit-out, including floor panels and installation of services.

Construction of the temporary pedestrian bridge would require a number of rail possessions to enable it to be completed.

Following construction of the metro platforms, the temporary bridge would be dismantled and removed, and platform canopy sections re-instated.

An artists' impression of the temporary pedestrian bridge is provided in Figure 7-19.



KEY

- Station excavation
- Pedestrian bridge
- Existing underground pedestrian access
- Pedestrian access closed during construction

Figure 7-18 Central Station temporary pedestrian bridge

Figure 7-19 Temporary pedestrian bridge artists' impression

7.10.10 Waterloo Station construction site

The Waterloo Station construction site would cover about 12,000 square metres within the block bounded by Raglan Street, Cope Street, Wellington Street and Botany Road. The site contains commercial and residential buildings.

This station would be constructed using a cut-and-cover technique, requiring the removal of about 115,000 cubic metres of spoil.

Access to and egress from the site would be left-in and left-out via Botany Road; and left-in, right-in and left-out via Raglan Street.

The location and indicative layout of the Waterloo Station construction site, including vehicle access and egress, are illustrated in Figure 7-20. The indicative construction program is outlined in Table 7-16.

Table 7-16 Waterloo Station indicative construction program

Construction activity	Indicative construction timeframe																															
	2017				2018				2019				2020				2021				2022				2023				2024			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Enabling works and site establishment		●	─	─	●																											
Station excavation					●	─	─	─	─	●																						
TBM pass through station										●	●																					
Station structural works											●	─	─	─	─	●																
Station fit out																	●	─	─	─	─	─	●									
Station testing and commissioning																							●	●								

Figure 7-20 Waterloo Station construction site indicative layout

7.10.11 Marrickville dive site (southern)

The Marrickville dive site would cover about 81,500 square metres and be located to the west of the T3 Bankstown Line in Marrickville (to the north of Sydenham Station). The site is occupied by commercial and industrial buildings.

The site would be used to:

- Excavate and construct the Marrickville dive structure and tunnel portal (described in Section 7.5)
- Launch and support two tunnel boring machines for the drive to Barangaroo
- Manufacture and storage of the pre-cast concrete tunnel lining segments (described in Section 7.6.1)
- Support the fit-out of the tunnel rail systems
- Support the construction of the southern services facility (described in Section 7.9.2).

Access and egress to and from the site would be via Murray Street and Sydney Steel Road. In order to provide safe access and egress to and from the construction site, the Edinburgh Road / Edgeware Road / Bedwin Road intersection would be signalised.

The location and indicative layout of the Marrickville dive site, including vehicle access / egress, are illustrated in Figure 7-21. The indicative construction program is outlined in Table 7-17.

Table 7-17 Marrickville dive site (southern) indicative construction program

Construction activity	Indicative construction timeframe																															
	2017				2018				2019				2020				2021				2022				2023				2024			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Enabling works and site establishment		●	—	—	●																											
Dive excavation						●	●																									
Assembly and commissioning of TBMs							●	●																								
TBM drive to Barangaroo								●	—	—	—	—	—	●																		
Tunnel rail systems fitout																	●	—	—	—	—	—	●									
Rail systems testing and commissioning																							●	—	—	—	—	—	—	—	—	●
Pre-cast facility establishment				●	—	—	●																									
Pre-cast segment manufacturing							●	—	—	—	—	●																				
Southern services facility construction					●	—	—	●																								
Southern services facility fit out								●	—	●																						
Services testing and commissioning										●																						

Tunnel boring machine launch and support

The two tunnel boring machines would be assembled and launched within the dive structure for the drive to Barangaroo.

This site would require tunnel boring machine support services including high voltage power supply, water supply, fresh air ventilation, work train, grout batching plant, drainage and water treatment, workforce facilities, spoil storage and removal, and storage and introduction of pre-cast concrete lining elements.

The Marrickville dive site would be a substantial spoil removal site. About 630,000 cubic metres of spoil would be removed (560,000 cubic metres from tunnelling and 70,000 cubic metres from the dive structure).

Rail systems fit out

Following tunnelling, the Marrickville dive site would be used as a major staging and delivery site to fit out the tunnel and rail systems. Activities would include:

- Delivery of mechanical and electrical equipment and materials for installation at the dive and within the tunnels
- Storage, handling and delivery into the tunnels of equipment such as fresh air ventilation fans, and cabling for signalling, communication and electrical systems
- Delivery of concrete
- Welding of track and delivery into the tunnels.

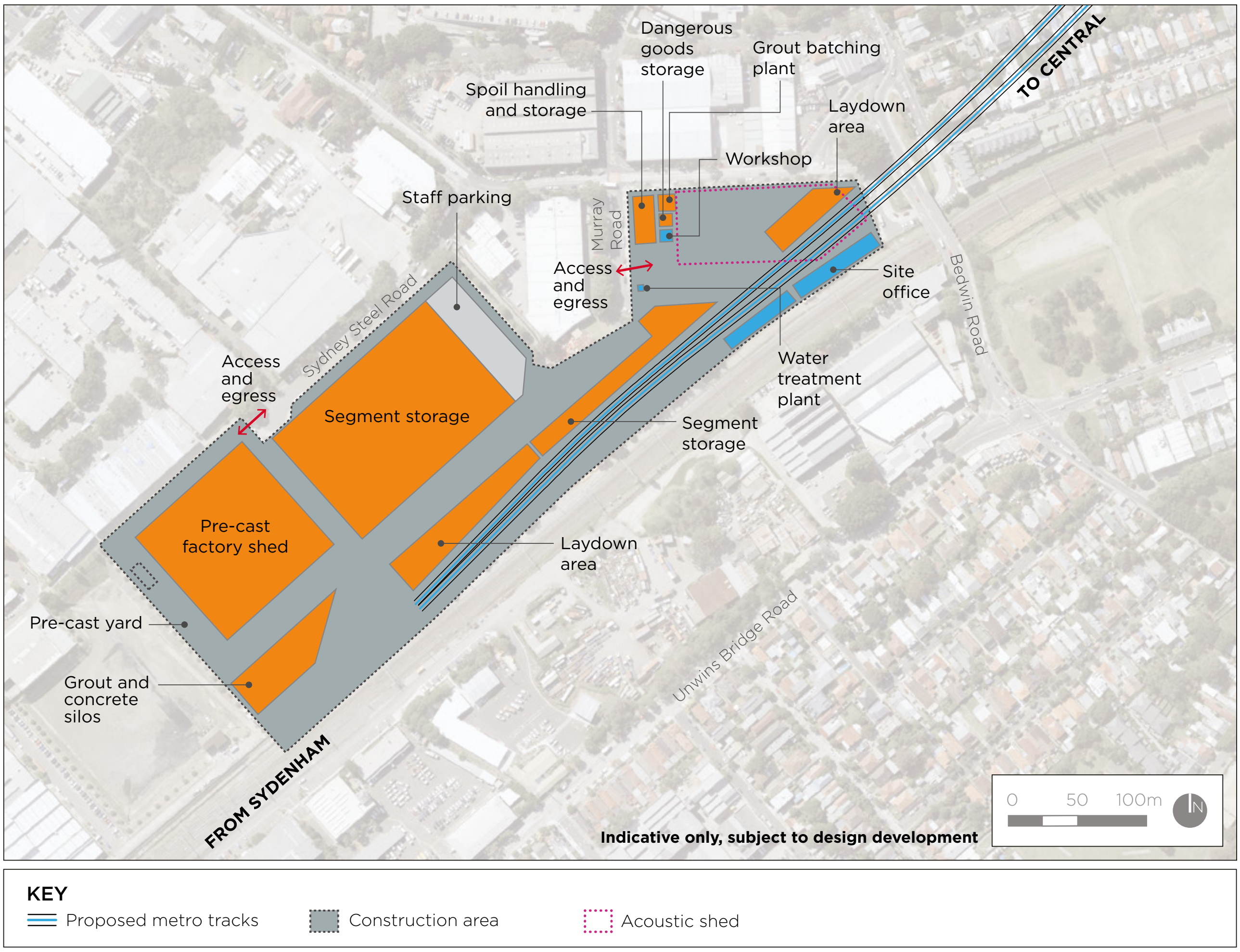


Figure 7-21 Marrickville dive site (southern) indicative layout

7.10.12 Approach for selecting additional construction sites

Although every endeavour has been made to identify all lands required for construction, the construction contractor(s) may require additional construction sites and / or compounds to those detailed above. For example, construction methodologies may require mid tunnel access shafts for materials delivery such as grout or concrete and for safety reasons during construction such as fresh air ventilation and emergency egress. Alternative or additional sites (apart from the Sydney Harbour ground improvement work on-shore facility) would be assessed against the following environmental criteria, and the impacts assessed in accordance with relevant legislation:

- Be located more than 50 metres from a waterway, unless an erosion and sediment control plan is developed and implemented
- Be located within or adjacent to the project
- Have ready access to the road network
- Be located to minimise the need for heavy vehicles to travel on local streets and / or through residential areas
- Be located on relatively level land

- Be separated from the nearest residences by at least 200 metres, unless feasible and reasonable noise and light spill mitigation measures are implemented
- Not require native vegetation clearing beyond that already required for the project
- Not have any more than a minor impact on heritage items beyond those already required for the project
- Not unreasonably affect the land use of adjacent properties
- Be above the 20 year average recurrence interval flood level, unless a contingency plan to manage flooding is prepared and implemented
- Provide sufficient space for the storage of raw materials to minimise, to the greatest extent practical, the number of deliveries required outside standard daytime construction hours.

7.11 Other construction elements

This section provides an overview of other construction elements that may occur at one or more of the construction sites.

7.11.1 Spoil generation

Based on the concept design, it is envisaged that excavation would generate about 2.4 million cubic metres of spoil. The expected volumes for each construction site are shown on Figure 7-22 and in Table 7-18. Table 7-18 also identifies the truck type that is likely to be used at each construction site.

Further details on the impacts associated with spoil generation and their management are provided in the related chapters of this environmental impact statement including Chapter 8 (Construction traffic and transport), Chapter 22 (Air quality) and Chapter 24 (Waste management).

Table 7-18 Anticipated spoil generation by construction site and likely truck type

Site	Volume of spoil (m^3)	Truck type [1]
Chatswood dive site – dive excavation	60,000	Truck and dog
Chatswood dive site – tunnelling	460,000	Truck and dog
Artarmon substation	2,000	Tipper truck
Crows Nest Station	150,000	Tipper truck
Victoria Cross Station	175,000	Tipper truck
Blues Point temporary site	8,000	Tipper truck
Barangaroo Station	145,000	Tipper truck
Barangaroo Station – tunnelling	90,000	Tipper truck
Martin Place Station	175,000	Tipper truck
Pitt Street Station	160,000	Tipper truck
Central Station	230,000	Tipper truck
Waterloo Station	115,000	Tipper truck
Marrickville dive site – dive excavation	70,000	Truck and dog
Marrickville dive site – tunnelling	560,000	Truck and dog
TOTAL	2,400,000	

1 *A truck and dog is the common term for a tipper truck and trailer.*

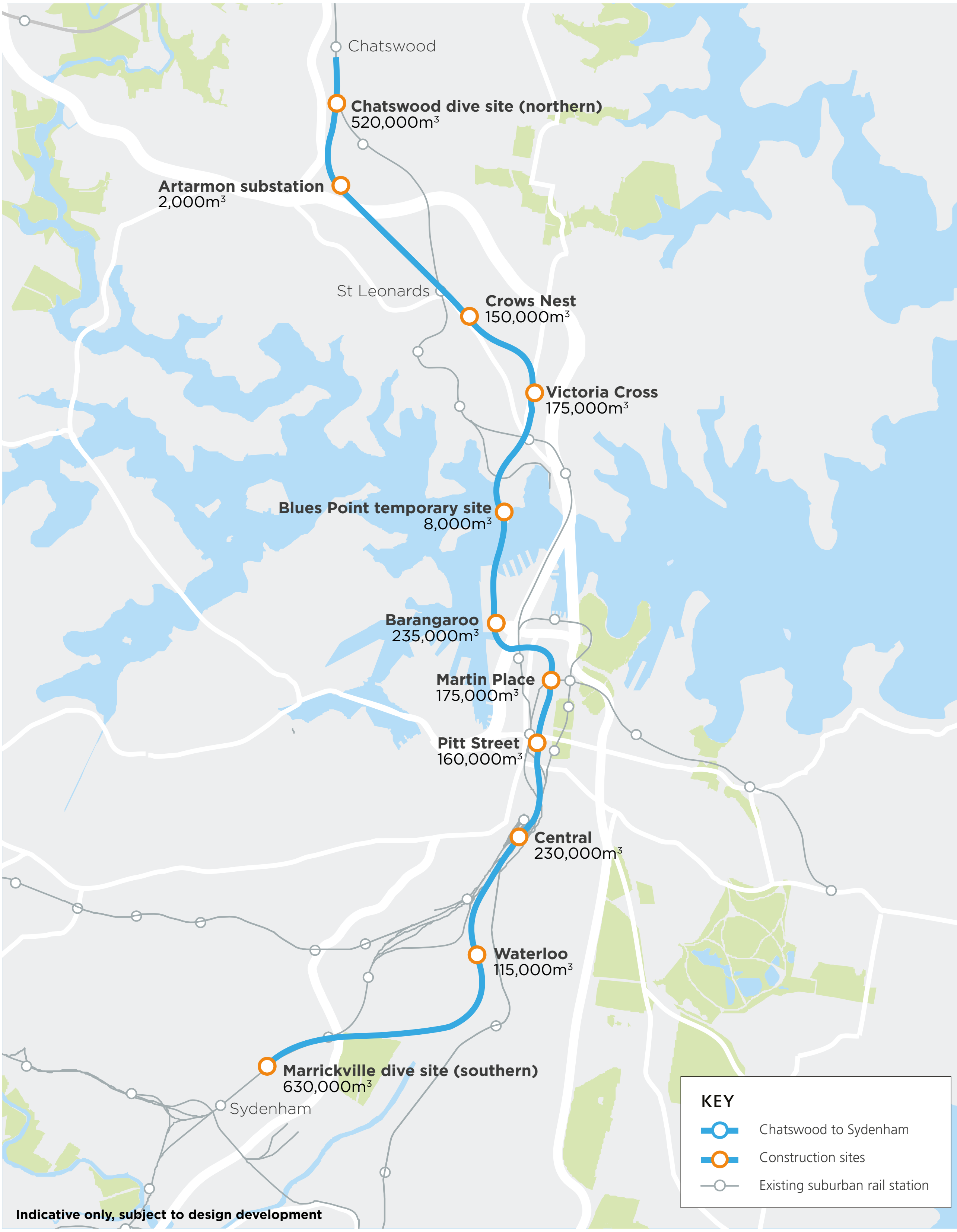


Figure 7-22 Indicative spoil generation volumes

7.11.2 Construction traffic

The proposed access to the construction sites is summarised in Table 7-19. Wherever possible, access is proposed to be gained from major arterial roads.

The CBD Coordination Office has been established to oversee all traffic and transport in the Sydney CBD including decisions, directions and approvals affecting all road and traffic arrangements in the Sydney CBD. Sydney Metro would liaise closely with the CBD Coordination Office during detailed construction planning and throughout construction phase to minimise potential construction traffic impacts within the Sydney CBD, including potential cumulative impacts with other projects or special events.

Construction traffic management plans for each site would be submitted to the relevant roads authority for review before work starts. Further information relating to haulage routes, construction traffic impacts and mitigation is provided in Chapter 8 (Construction traffic and transport).

Table 7-19 Access to the construction sites

Site	Proposed primary construction access
Chatswood dive site (northern)	Nelson Street (right-in); Mowbray Road (left-in, right-out)
Artarmon substation	Barton Road
Crows Nest Station	**North site** Hume Street ; Clarke Street (left-out); Clarke Lane (left-out)
	South site Hume Street
Victoria Cross Station	**North site** Miller Street (left-in, left-out)
	South site Miller Street (left-in); Denison Street (left-out)
Blues Point temporary site	Blues Point Road (left-in); Henry Lawson Drive (left-out)
Barangaroo Station	Hickson Road
Martin Place Station	**North site** Castlereagh Street (left-in); Elizabeth Street (left-out)
	South site Castlereagh Street (left-in); Elizabeth Street (left-out)
Pitt Street Station	**North site** Pitt Street (right-in); Castlereagh Street (left-in, right-out)
	South site Bathurst Street (right-in); Pitt Street (right-out)
Central Station	Eddy Avenue (left-in, left-out); Regent Street (left-in, left-out)
Waterloo Station	Raglan Street (left-in, right-in, left-out); Botany Road (left-in, left-out)
Marrickville dive site (southern)	Murray Street (left-in, right-out); Sydney Steel Road (left-in, right-out)

7.11.3 Construction hours

Proposed construction hours are shown in Table 7-20. These hours have been developed based on a balanced consideration of the construction program and the need to minimise noise and traffic related impacts. As the tunnel boring machines would operate continuously, the tunnelling and associated support activities would need to be carried out up to 24 hours per day and seven days per week.

The majority of the station fit-out and other aboveground construction activities would be carried out during the following hours:

- 7 am to 6 pm Monday to Friday
- 8 am to 1 pm Saturdays
- No works on Sundays or Public Holidays.

However, other substantial activities (as identified in Table 7-20) would need to be carried out outside these hours.

Table 7-20 Proposed construction hours

Activity	Construction hours	Comments or exceptions
Underground construction activities		
Tunnelling	24 hours per day, seven days per week	Activities that support tunnelling may need to occur 24 hours per day, up to seven days per week. Rock hammering in the tunnel between 10 pm and 7 am would be precluded except where there would be no impact on sensitive receivers. Drill and blast, if required, would be carried out during periods anticipated to have the least impact on receivers.
Underground excavation at station and ancillary sites	24 hours per day, seven days per week	May need to occur outside standard daytime construction hours provided appropriate noise mitigation is in place. Drill and blast, would be carried out during periods anticipated to have the least impact on receivers.
Tunnel and station fit-out (underground)	24 hours per day, seven days per week	Activities that support tunnel and station fit-out may need to occur 24 hours per day, up to seven days per week.
Aboveground construction activities		
Demolition **Station and ancillary facility fit-out and construction (aboveground)**	• 7 am to 6 pm Monday to Friday • 8 am to 1 pm Saturdays • No works on Sundays and Public Holidays	Aboveground work supporting underground construction activities (eg concrete pumping, truck loading) are expected to be required 24 hours per day, up to seven days per-week where noise mitigation is in place. Non-disruptive preparatory work, repairs or maintenance may be carried out on Saturday afternoons between 1 pm and 5 pm or Sundays between 8 am and 5 pm. Activities requiring the temporary possession of roads or to accommodate road network requirements may need to be carried out outside the standard daytime construction hours during periods of low demand to minimise safety impacts and inconvenience to commuters. Activities requiring rail possessions may need to be carried out outside the standard construction hours up to 24 hours per day, seven days per week.

Activity	Construction hours	Comments or exceptions
Construction traffic for material supply to, and spoil removal from, tunnelling and underground excavation (station and ancillary facility sites)	24 hours per day, seven days per week	Restrictions would be in place during peak hours and special events. At locations where night-time sensitive noise receivers are close to construction sites, significant construction vehicle movements are likely to be restricted during evening and night-time periods.

Other activities that would be carried out outside of the standard daytime construction hours would include:

- Work determined to comply with the relevant noise management level (NML) at the nearest sensitive receiver
- Work required to be carried out during rail possessions
- The delivery of materials outside approved hours as required by the NSW Police or other authorities (including Roads and Maritime) for safety reasons
- Emergency situations where it is required to avoid the loss of lives and property and / or to prevent environmental harm
- Situations where agreement is reached with affected receivers.

With the exception of emergencies, activities would not take place outside standard daytime construction hours without prior notification of local residents, businesses and the Environment Protection Authority.

7.11.4 Demolition

It is anticipated that construction would require the demolition of about 79 buildings. Some demolition would occur in the enabling works phase before substantial construction begins. This would result in less chance of vandalism and assist in managing potential conflicts between the scheduling of the metro station construction and the construction of the CBD and South East Light Rail.

Table 7-21 provides an indicative list of the number of buildings and their current primary use proposed to be demolished at each site.

Table 7-21 Indicative number and types of buildings proposed for demolition

Site	Commercial	Residential	Industrial	Subtotal
Chatswood dive site (northern)	7	0	0	7
Crows Nest Station	10	0	0	10
Victoria Cross Station	4	0	0	4
Martin Place Station	4	1	0	5
Pitt Street Station	12	0	0	12
Central Station	3	5	0	8
Waterloo Station	17	1	0	18
Marrickville dive site (southern)	0	0	15	15
TOTALS	58	6	15	79

Typically, access and egress to and from the site during the demolition would use existing driveways; however, alternative site access may be required. Indicative heavy vehicle movements associated with the demolition phase are provided in Chapter 8 (Construction traffic and transport).

Demolition would be carried out by licensed demolition contractors and in stages where possible. Typically, building demolition would involve:

- Establishment of hoarding, scaffolding and protection barriers around the perimeter of the site
- All services into the buildings would be decommissioned, made safe and redundant
- Soft stripping internal building materials
- Demolition of the building using an excavator, bobcat cranes or other conventional methods following a top-down approach. Temporary propping and / or waterproofing would be provided for structural integrity of adjacent structures as required during the demolition works.

A hazardous materials analysis would be carried out prior to stripping and demolition of the main structure. Any hazardous materials would be removed and disposed of in accordance with the relevant legislation, codes of practice and Australian Standards.

Materials such as bricks, tiles, timber, plastics and metals would be sorted where practicable and sent to a waste facility with recycling capabilities.

Structures other than buildings to be demolished, include:

- Nelson Street road bridge at the Chatswood dive site
- The pedestrian bridge across Denison Street connecting Berry Square and Tower Square adjacent to the Victoria Cross Station site
- The pedestrian connection beneath Martin Place between Castlereagh and Elizabeth streets
- Existing platforms, canopies, overhead supports and underground pedestrian connections at Central Station.

Construction contractors would be required to meet the requirements of the Construction Environmental Management Framework (refer to Section 7.13).

7.11.5 Utility and power supply

Utilities such as water, sewer and telecommunications would need to be supplied to each of the major construction sites. Generally, these utilities are located close to the sites (such as the adjacent footpath) and the supply is considered 'business as usual' for supply companies.

Power supply

High voltage (11 kV) power supply would be required for the operation of tunnel boring machines at the Chatswood dive site, the Marrickville dive site, Barangaroo Station and potentially at Pitt Street Station; and for roadheaders at the station sites. The power supply for each site would need to be brought in from a substation outside the project corridor. Table 7-22 describes the power supply required at each construction site. Indicative supply routes are provided on Figure 7-23 to Figure 7-31. The supply route for the Pitt Street site would also be used to supply the permanent power supply to the Pitt Street traction substation. This would involve replacing the 11 kV cables with 33 kV cables within the same conduits.

Power supply routes would generally be located within existing road reserves. Construction of these power supply routes would generally be carried out by open trench. Underbores would be used when crossing major infrastructure or to avoid other major constraints.

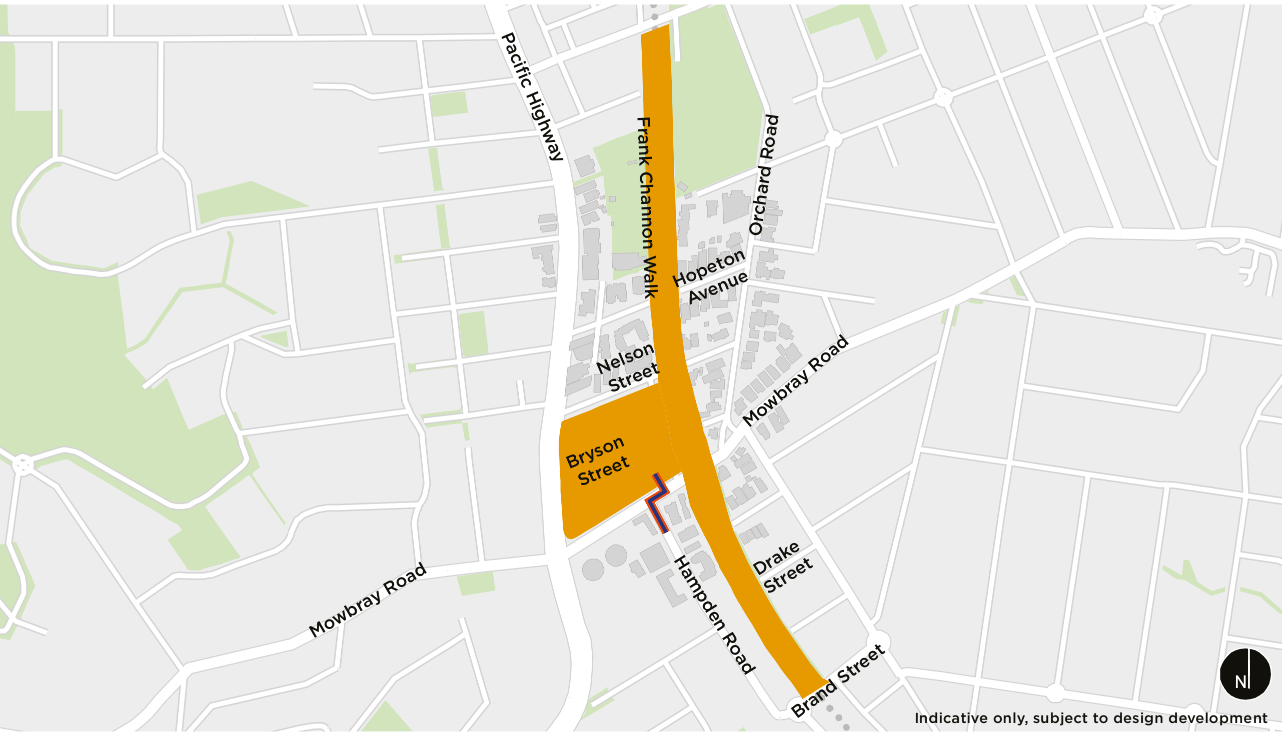
Any construction power supply for Artarmon substation and Blues Point temporary site would be provided directly from the local grid.

Preliminary consultation has been carried out with energy suppliers. A program of ongoing consultation is underway to further assess the requirements for the project.

Construction contractors would be required to meet the requirements of the Environmental Management Framework (refer to Section 7.13).

Table 7-22 Construction power for tunnel boring machines

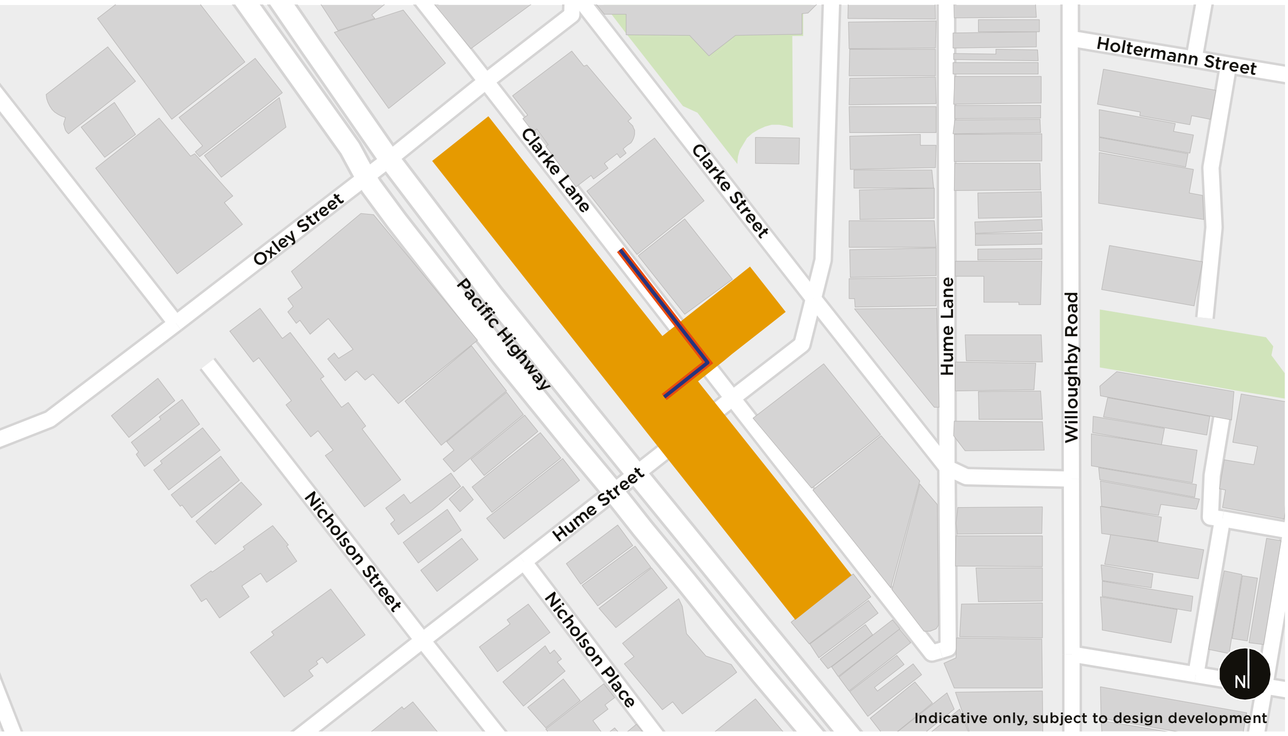
Site	Supply source	Distance to site	Power (mega volt ampere)
Chatswood dive site (northern)	Chatswood substation	100 m	15
Crows Nest Station	Existing cables in Clarke Lane	30 m	3
Victoria Cross Station	Existing cables in Berry Street	50 m	6
Barangaroo Station	City North substation	950 m	12
Martin Place Station	City North substation	1.3 km	7
Pitt Street Station	Surry Hills substation or Pyrmont substation	1.5 km 1.7 km	15
Central Station	Belmore Park substation	600 m	3
Waterloo Station	Zetland substation	850 m	3
Marrickville dive site (southern)	Existing cables in Princes Highway	850 m	14



KEY

Proposed construction site area | Power supply route | Existing suburban rail

Figure 7-23 Chatswood dive site (northern) – power supply route



KEY

Proposed construction site area | Power supply route

Figure 7-24 Crows Nest Station – power supply route

KEY

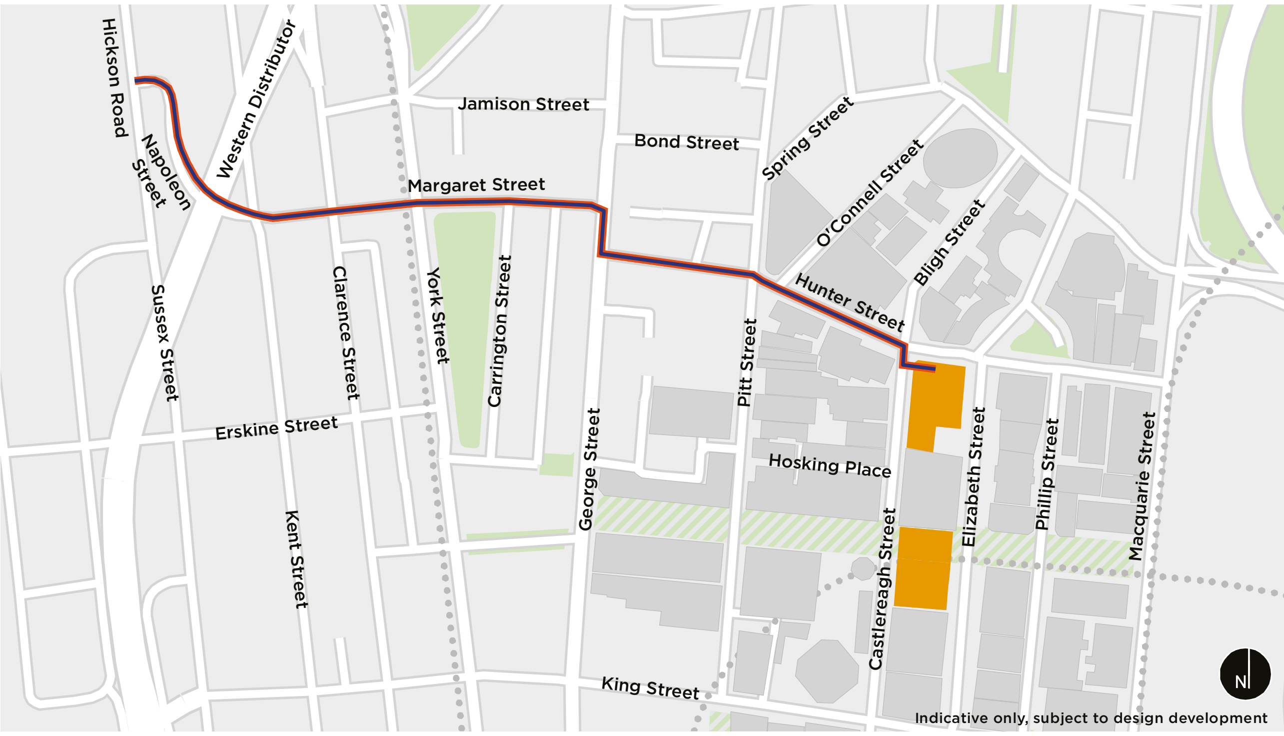
Proposed construction site area — Power supply route

Figure 7-25 Victoria Cross Station – power supply route

KEY

Proposed construction site area — Power supply route — Existing suburban rail

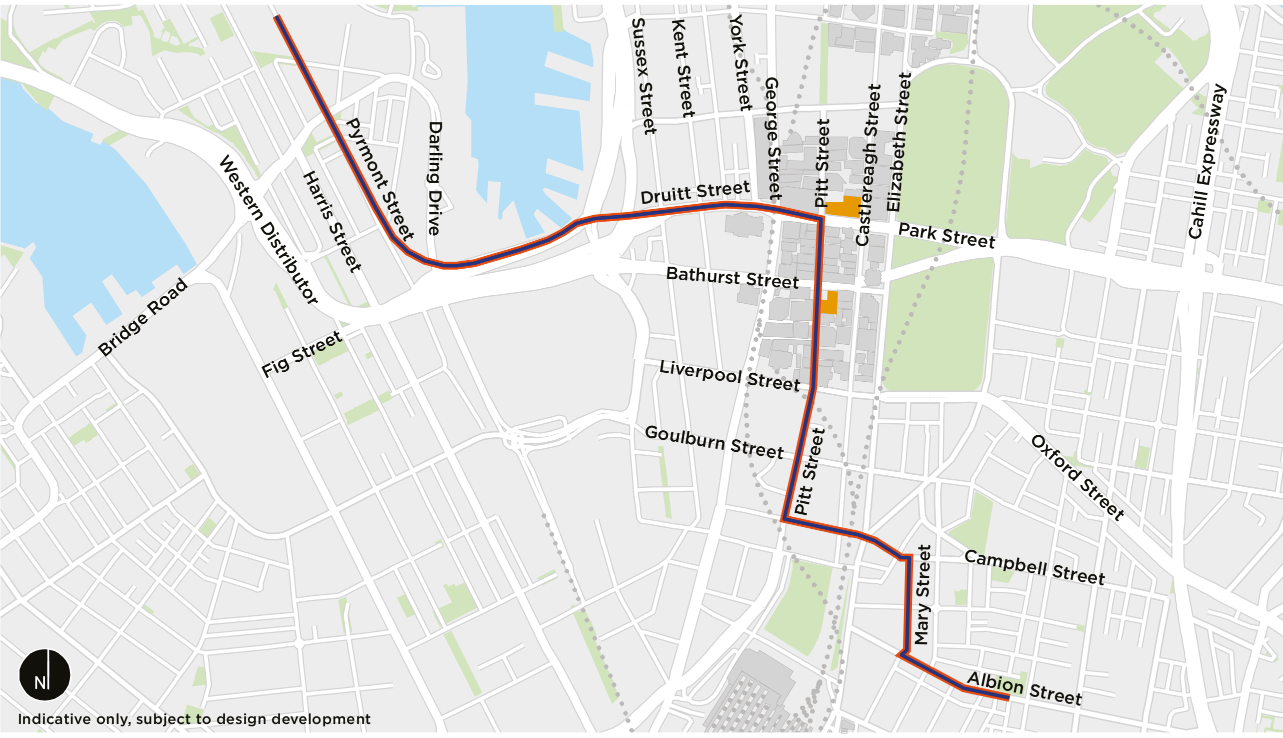
Figure 7-26 Barangaroo Station – power supply route



KEY

Proposed construction site area — Power supply route — Existing suburban rail

Figure 7-27 Martin Place Station – power supply route



KEY

Proposed construction site area — Power supply route — Existing suburban rail

Figure 7-28 Pitt Street Station – power supply route

KEY

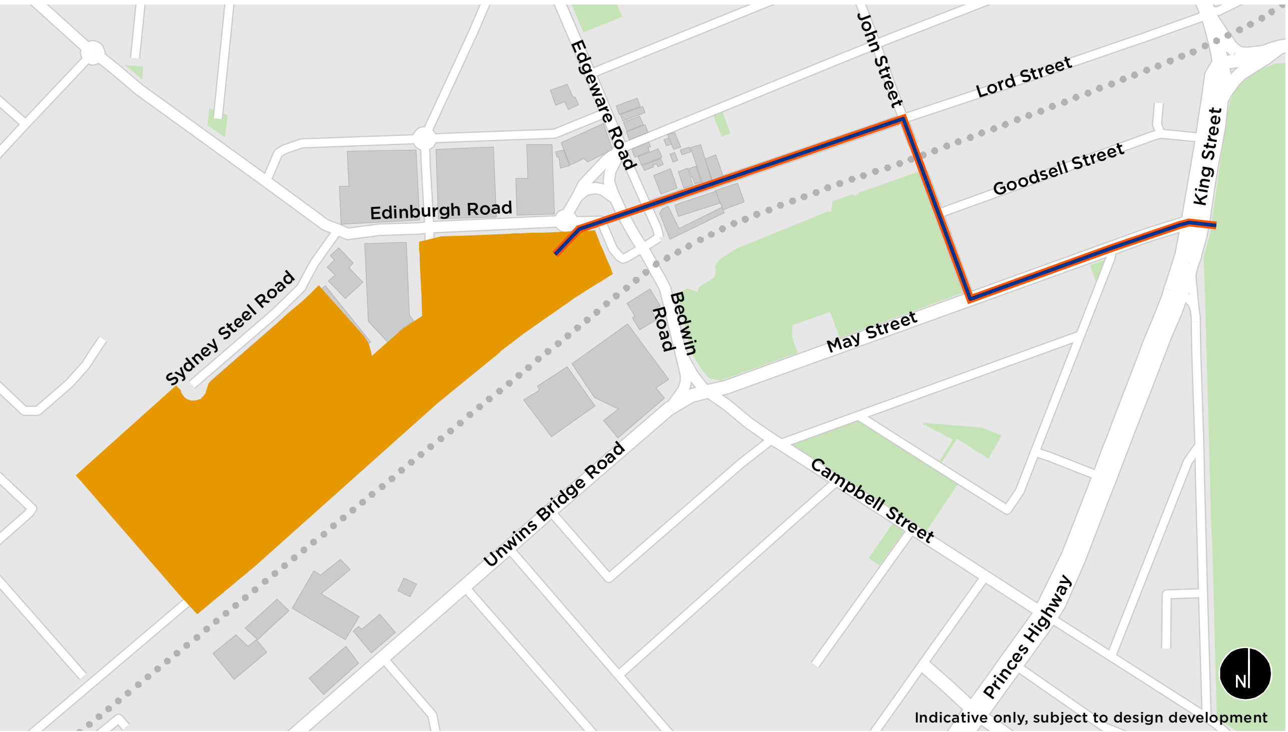
Proposed construction site area | Power supply route | Existing suburban rail

Figure 7-29 Central Station – power supply route

KEY

Proposed construction site area | Power supply route | Existing suburban rail

Figure 7-30 Waterloo Station – power supply route



KEY

Proposed construction site area | Power supply route | Existing suburban rail

Figure 7-31 Marrickville dive site (southern) – power supply route

Use of generators

At a number of the station construction sites, generators may be used instead of providing a mains power connection, or for a period of time prior to the mains power supply becoming available. Each generator is likely to be around 1,000 kVA in order to supply the necessary power for the project. The likely sites and number of generators required is as follows:

- Crows Nest Station – one generator
- Victoria Cross Station – three generators
- Martin Place Station – three generators
- Pitt Street Station – three generators
- Central Station – one generator
- Waterloo Station – one generator.

7.11.6 Utility adjustments and protection

Utilities would need to be adjusted, relocated and / or protected where there is a possibility they would otherwise be impacted by construction. The location of utilities has been determined from Dial Before You Dig plans, utility data, and local authority and council records. Further investigation and consultation with service asset owners would be carried out as the design develops to confirm exact locations, heights and depths of the utilities.

Where an existing utility conflicts with the proposed design, it may be necessary to:

- Provide physical protection for the utility where the utility is not directly affected but may be indirectly affected by vibration or accidental impact. Protection could include constructing a piled wall between the excavation and the utility, plating over the utility to minimise the impact of construction traffic, or marking out or fencing off the location of a utility to avoid it being accidentally damaged
- Modify construction methods to avoid impacting a nearby utility. For example, this could involve using only hand excavation and compaction tools such as hand digging tools, a vibration plate or pedestrian rollers where compacting within a specified distance of utilities
- Wrap and support the utility service to provide mechanical protection
- Divert the utility around the construction site.

The following utility providers have assets which may require protection and / or relocation:

- Sydney Water – water, sewer and stormwater
- Ausgrid – power and communications
- AGL – power and gas
- Transgrid – power and communications
- Endeavour Energy – power and communications
- Local councils – stormwater and power
- Roads and Maritime Services – power, traffic signals, communications
- Sydney Trains – power, signalling, communications
- Jemena – gas
- Telstra – communications
- Optus – communications
- NBN – communications.

Table 7-23 provides a preliminary list of major utilities that could be potentially affected by construction and may require protection and / or relocation. The list is indicative only and subject to further design refinement, investigations and detailed assessment in consultation with asset owners and any affected stakeholders. Access would be maintained to utility assets within or adjacent to the construction footprint when required during construction.

Preliminary consultation has been held with Ausgrid, Endeavour Energy, TransGrid, Sydney Water, Jemena, NBN, Roads and Maritime Services, Optus and Telstra. A program of ongoing consultation has been established and implemented to further assess requirements for utilities. In addition, Sydney Metro would consult with local councils and utility providers to identify any opportunities to support future initiatives or utility augmentations.

Construction contractors would be required to meet the requirements of the Construction Environmental Management Framework (refer to Section 7.13).

Table 7-23 Known major utility relocation and / or protection

Site	Major utility impacts
Northern surface works and Chatswood dive site (northern)	- Protection of Telstra cables along the 'down' (northbound) side of the T1 North Shore Line rail corridor - Adjustments to T1 North Shore Line rail systems
Martin Place Station	- Protection and / or relocation of services within the underground pedestrian connection beneath Martin Place
Barangaroo Station	- Protection and / or relocation of underground services in Hickson Road
Central Station	- Protection and / or relocation of Sydney Trains rail, station and building services
Marrickville dive site (southern)	- Widening and strengthening of existing bridge structures to provide access over the existing stormwater channel - Protection and / or relocation of a Transgrid 330kv cable

7.11.7 Transport network modifications

This section provides an overview of the modifications anticipated to be required to the road network, the public transport network and the pedestrian and cyclist network in the vicinity of each construction site. Further details and the potential impacts of these modifications are provided in Chapter 8 (Construction traffic and transport).

Road network

It is anticipated that road network modifications would be required to facilitate construction of the project. These modifications are outlined in Table 7-24. The modifications would be reviewed by the construction contractor during the preparation of Construction Traffic Management Plans, with the objective of minimising disruptions to the road network.

Table 7-24 Indicative road network modifications

Location	Indicative road network modifications
Chatswood dive site (northern)	- Nelson Street – permanent closure and demolition of the road overbridge - Pacific Highway / Mowbray Road – an all vehicle right turn movement would be constructed from the Pacific Highway southbound to Mowbray Road westbound. This would also require the local widening of the Pacific Highway to the east - Mowbray Road / Hampden Road – provision of new traffic signals at the Mowbray Road / Hampden Road intersection, with potential modifications to the traffic signals at the Mowbray Road / Orchard Road intersection.
Artarmon substation	- No modifications
Crows Nest Station	- Clarke Lane – temporary closure near Hume Street. Clarke Lane to be made two-way to the north - Hume Street – temporary closure during construction of the station - Hume Street – removal of 2-4 on street parking spaces - Clarke Lane – removal of off street parking spaces. however these are likely currently used by businesses that would be acquired.
Victoria Cross Station	- Miller Street – removal of 2-4 parking spaces.

Location	Indicative road network modifications
Blues Point temporary site	• Blues Point Road – removal of 4 on street parking spaces at the end of Blues Point Road during shaft excavation • Blues Point Road – occupation of the end of Blues Point Road during tunnel boring machine removal • Blues Point Road – removal of on street parking spaces at the end of Blues Point Road during tunnel boring machine removal • Blues Point Road – potential short term closure during tunnel boring machine transport.
Barangaroo Station	• Hickson Road – temporary lane restrictions during staged construction. Two traffic lanes would generally be maintained with some short-term full closures outside of peak periods subject to road occupancy licences • Hickson Road – removal of 125 on street parking spaces.
Martin Place Station	• Full or partial temporary closures (night time only).
Pitt Street Station	• Full or partial temporary closures (night time only).
Central Station	• No modifications.
Waterloo Station	• Raglan Street – removal of 2-4 on street parking spaces • Cope and Wellington streets – removal of car parking during demolition.
Marrickville dive site (southern)	• Bedwin Road / Edinburgh Road / Edgeware Road intersection – provision of new traffic signals • Unwins Bridge Road / Bedwin Road / May Street – traffic signal modifications to allow signalised right turn from May Street into Bedwin Road • Edinburgh Road – removal of 2-4 on street parking spaces.

Public transport

It is anticipated that some modifications would be needed to the public transport network to facilitate construction of the project. These modifications are outlined in Table 7-25. The modifications would be reviewed during detailed design with the objective of minimising disruptions to public transport services.

Table 7-25 **Indicative modifications to public transport during construction**

Location	Indicative public transport network modifications
Northern surface works	• Likely rail track possessions for: ◦ demolition of the Nelson Street road bridge ◦ adjustments to the T1 North Shore Line including track slewing, signalling, overhead wiring, and other rail services ◦ Metro track and rail systems works within the T1 North Shore Line corridor.
Chatswood dive site (northern)	• Likely rail track possessions for track slewing and other surface track works • Relocation of the bus stop at 575 Pacific Highway, Chatswood.
Artarmon substation	No modifications.
Crows Nest Station	• Relocation of the bus stop at 497 Pacific Highway, Crows Nest.
Victoria Cross Station	• Relocation of the bus stop at 194 Miller Street, North Sydney.
Blues Point temporary site	• Relocation of the bus stop on Henry Lawson Avenue.
Barangaroo Station	No modifications.

Location	Indicative public transport network modifications
Martin Place Station	○ Likely rail track possessions for: ◆ possible service relocations and strengthening works to existing rail tunnels ◆ modifications to existing underground pedestrian facilities.
Pitt Street Station	No modifications.
Central Station	○ Alterations to the Sydney Trains and NSW TrainLink timetable due to closure of platforms 13, 14 and 15 during construction ○ Likely rail track possessions, including extended rail possessions of selected rail lines, for: ◆ construction of access bridge from Regent Street to Sydney Yard and associated adjustments to existing rail systems ◆ construction of the temporary pedestrian bridge ◆ adjustments to rail systems around platforms 13, 14 and 15 to facilitate cut-and-cover construction of the station ◆ adjustments to rail systems around platforms, the paid underground pedestrian connections and Devonshire Street tunnel to facilitate cut-and-cover construction of the station.
Waterloo Station	○ Relocation of the bus stop near 103 Botany Road.
Marrickville dive site (southern)	No modifications.

Pedestrian and cyclist facilities

It is anticipated that some modifications would be needed to pedestrian and cyclist facilities to facilitate construction of the project. These modifications are outlined in Table 7-26. The modifications would be reviewed by the construction contractor during detailed design and / or during the preparation of construction traffic management plans, with the objective of minimising disruptions to pedestrians and cyclists.

Table 7-26 Indicative modifications to pedestrian and cyclist facilities during construction

Location	Indicative modifications to pedestrian and cyclist facilities
Chatswood dive site (northern) and northern surface works	○ Frank Channon Walk – temporary closure of the shared path linking Chatswood Station and Nelson Street ○ Nelson Street – permanent removal of pedestrian and cyclist connectivity at Nelson Street over the T1 North Shore Line.
Artarmon substation	No modifications.
Crows Nest Station	○ Hume Street and Pacific Highway – footpaths adjacent to the site narrowed by about 600 millimetres over a distance of about 300 metres ○ Hume Street – re-routing of pedestrians and cyclists over the demolished building area during cut-and-cover works through Hume Street.
Victoria Cross Station	○ Miller Street – footpaths adjacent to the site narrowed by about 600 millimetres over a distance of about 150 metres.
Blues Point temporary site	○ Blues Point Road – closure of the footpath adjacent to Blues Point Reserve during tunnel boring machine removal ○ Blues Point Road – temporary removal of street furniture and infrastructure along Blues Point Road for tunnel boring machine transport.

Location	Indicative modifications to pedestrian and cyclist facilities
Barangaroo Station	- Hickson Road – footpath narrowed by about 600 millimetres over a distance of about 600 metres - Hickson Road – periodic closures of the footpath adjacent to the site during construction.
Martin Place Station	- Elizabeth and Castlereagh streets – footpaths adjacent to the site narrowed by about 600 millimetres over a distance of about 200 metres - Martin Place (between Castlereagh and Elizabeth streets) – closed during cut-and-cover work with pedestrians and cyclists re-routed - Underground connections to Martin Place Station – closed west of Elizabeth Street during cut-and-cover work in Martin Place.
Pitt Street Station	- Pitt, Bathurst and Castlereagh streets – footpaths adjacent to the site narrowed by about 600 millimetres over a distance of about 150 metres.
Central Station	- Devonshire Street Tunnel – short term closure (about 2 weeks) - Central Station – closure during the construction period of underground paid pedestrian connections within Central Station providing for transport interchange between platforms. Alternative temporary pedestrian bridge to be constructed.
Waterloo Station	- Botany Road, Cope Street, Raglan Street and Wellington Street – footpaths adjacent to the site narrowed by about 600 millimetres over a distance of about 500 metres.
Marrickville dive site (southern)	No modifications.

7.11.8 Heritage investigations, protection and archival recordings

Additional heritage investigations, protection work and archival recordings (as required) may be carried out prior to substantial construction to minimise delays and provide unrestricted access to the sites from the start of substantial construction. Locations where this work would be required are provided in Chapter 14 (Non-Aboriginal heritage) and Chapter 15 (Aboriginal heritage).

7.11.9 Construction water management

The excavation of the tunnels, stations and shafts is likely to intercept groundwater resulting in the need to capture, treat and discharge water. This water would be treated and re-used as much as possible.

Based on the current scope of the project, construction water treatment plants would be required at the three tunnelling support sites, each station site and the ancillary shaft excavation sites. Treated water would be re-circulated to the tunnel cutting face and used for surface dust suppression.

Despite this re-use, there would be a surplus of treated water which would need to be discharged from the sites. It is anticipated that water would be discharged to the local stormwater system or directly to a local surface watercourse; although other options, such as Sydney Water trade waste agreements, would be investigated during detailed design. The potential water treatment regime, likely discharge quantity and quality are provided in Chapter 18 (Soils, contamination and water quality).

Surface water management at the construction sites would be managed through the implementation of standard erosion and sediment control measures in accordance with Managing Urban Stormwater: Soils and Construction Volume 1 (Landcom, 2004) and Managing Urban Stormwater: Soils and Construction Volume 2 (Department of Environment and Climate Change, 2008a). Further details regarding surface water quality management are provided in Chapter 18 (Soils, contamination and water quality).

7.11.10 Construction plant and equipment

The plant and equipment likely to be used during construction are listed in Table 7-27. This list is indicative only. The actual plant and equipment used on site and the numbers required would be further refined during the detailed design phase of the project.

Table 7-27 Indicative construction plant and equipment

Plant and equipment	Northern surface works	Chatswood dive site (northern)	Artarmon substation	Crows Nest Station	Victoria Cross Station	Blues Point temporary site	Barangaroo Station	Martin Place Station	Pitt Street Station	Central Station	Waterloo Station	Marrickville dive site (southern)
Tunnel boring machine		2					1					2
Roadheader				1	2		2	2	2	1	1	
Piling rig	2	6	1	4	4	1	4	4	4	4	4	6
Drilling jumbo	2	4	1	4	4	1	4	4	4	4	4	4
Excavator	4	10	2	8	8	8	8	8	8	8	8	10
Front end loader	2	2	1	2	2	2	2	2	2	2	2	2
Bobcat		3	2	3	4			4	4	4	3	5
Mobile crane	2	6	1	6	3	3	6	2	2	6	6	6
Truck mounted crane	1	1	1	2	1		1	2	2	2	2	2
Generator	6	6	6	6	6	6	6	6	6	6	6	6
1,000 kVA generator				1	3			3	3	1	1	
Compressor	6	6	6	6	6	6	6	6	6	6	6	6
Concrete pump	2	2	2	2	2	2	2	2	2	2	2	2
Water treatment plant		1	1	1	1	1	1	1	1	1	1	1
Separation plant							1					
Water cart	1	1	1	1	1	1	1	1	1	1	1	1

7.11.11 Materials and water usage

A variety of materials would be needed to construct the project. The major items and indicative quantities would be:

- Electricity – 45,500 megawatt hours
- Fuel use – 46 mega litres
- Concrete – 407,000 cubic metres
- Pre-cast concrete lining segments – 370,000 tonnes
- Steel – 64,000 tonnes
- Water – 550,000 cubic metres.

7.11.12 Construction workforce

About 2,820 jobs are expected to be directly created during the peak construction period. Further jobs would also be indirectly created by the project. Figure 7-32 provides a breakdown of the peak construction workforce numbers across the alignment. Sydney Metro has developed a Workforce Development and Industry Participation strategy which includes objectives to support local employment and business opportunities, provide skills development and increase workplace diversity. Further details of the workforce strategy are provided in Chapter 25 (Sustainability).

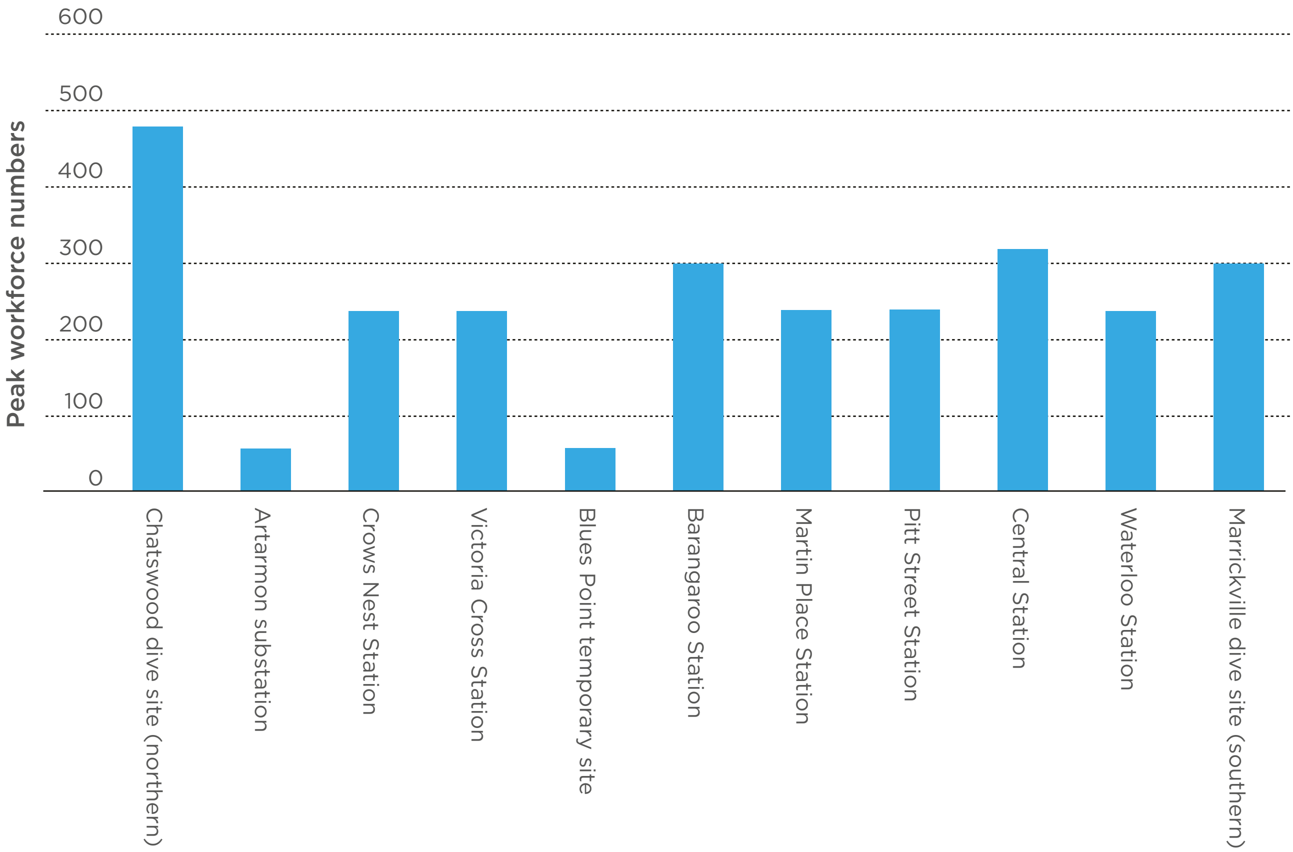


Figure 7-32 Construction workforce

7.11.13 Demobilisation, rehabilitation and landscaping

At the end of the construction phase, the contractor(s) would demobilise all construction equipment from the construction sites. Where relevant, sites that were occupied temporarily and do not form part of the operational footprint, such as Blues Point temporary site, would be rehabilitated and revegetated. Other temporary sites, such as the residual land at Chatswood dive site and Marrickville dive site is likely to be stabilised prior to future development.

As part of the operational readiness phase, the contractor would progressively deliver the station precinct and services facility elements as described in Chapter 6 (Project description – operation). Typically, this would involve the progressive removal of construction equipment, site sheds and other temporary construction site elements.

Landscaping and finishing works would be carried out at permanent operational sites as described in Chapter 6 (Project description – operation) and Chapter 16 (Landscape character and visual amenity).

7.12 Testing and commissioning

The rail systems at each site (stations and services facilities) would initially be commissioned progressively as standalone entities. Once all services are installed, testing and commissioning of the whole system would occur in three stages:

- Collection of safety and quality assurance documentation and commissioning of readiness checks
- Installation and operation tests and checks
- Final inspection, site acceptance tests, commissioning and validation of individual systems.

During the final stages of commissioning, test trains would be run on the line to test the signal system and the traction power.

7.13 Construction environmental management framework

A construction environmental management framework (CEMF) was developed and successfully implemented as part of the Sydney Metro Northwest project. This document has been reviewed and amended to be applicable to this project and is provided in Appendix D. The CEMF provides a linking document between the planning approval documentation and the construction environmental management documentation, which would be developed by the construction contractors.

The CEMF details the environmental, stakeholder and community management systems and processes for the construction of the project. Specifically, it details the requirements in relation to the Construction Environmental Management Plan, sub-plans and other supporting documentation for each specific environmental aspect.

CONSTRUCTION TRAFFIC AND TRANSPORT

CHAPTER EIGHT

8 Construction traffic and transport

This chapter assesses the potential impact on traffic and transport during the construction stage of the project. It describes the existing traffic and transport environment and identifies the potential nature and extent of impacts to traffic and transport services. Measures to address the potential impacts are also identified. Technical paper 1 – Traffic and transport provides further details.

8.1 Secretary environmental assessment requirements

The Secretary's environmental assessment requirements relating to construction traffic and transport, and where these requirements are addressed in this Environmental Impact Statement, are outlined in Table 8-1.

Table 8-1 Secretary's environmental assessment requirements – construction traffic and transport

Ref.	Secretary's environmental assessment requirements	Where addressed
13 Traffic and transport		
13.1	The Proponent must assess construction transport and traffic (vehicle, pedestrian and cyclists) impacts, including, but not necessarily limited to:	
13.1(a)	a considered approach to route identification and scheduling of transport movements;	Factors considered in determining haul routes are identified in Section 8.2.5. Haul routes for each sites are identified in Section 8.4.
13.1(b)	the number, frequency and size of construction related vehicles (passenger, commercial and heavy vehicles, including spoil management movements);	Construction vehicles are addressed in Section 8.4.
13.1(c)	the capacity of or need to upgrade roads proposed as construction vehicle routes including Bedwin Road;	Construction vehicle routes are addressed in Section 8.4.
13.1(d)	changes to existing local and regional road networks including access to and around the proposed Chatswood tunnelling site;	Road network changes are addressed in Section 8.4.
13.1(e)	construction worker parking;	Construction worker parking is addressed in Section 8.4.4.
13.1(f)	the nature of existing traffic (type and number of movements) on construction access routes (including consideration of peak traffic times and sensitive road users and parking arrangements), including access to the Overseas Passenger Terminal for deliveries and passenger coaches;	Existing traffic and transport environment is described in Section 8.3. Potential access impacts to the Overseas Passenger Terminal are identified in Section 8.4.13.
13.1(g)	details of how construction and scheduling of works are to be coordinated in regard to public events; cumulative traffic impacts resulting from concurrent work on WestConnex, Barangaroo, Sydney Light Rail and other key construction projects in the Sydney CBD;	Coordination with public events is addressed in Section 8.4.3. Cumulative traffic impacts area addressed in Chapter 26 (Cumulative impacts).

Ref.	Secretary's environmental assessment requirements	Where addressed
13.1(h)	alternatives to road transport of construction spoil;	Construction spoil is addressed in Section 8.2.3.
13.1(i)	access constraints and impacts to public transport, pedestrian access and cyclists;	Public and active transport is addressed in Section 8.4.
13.1(j)	the need to close, divert or otherwise reconfigure elements of the road and cycle network associated with construction of the project;	Road network impacts are addressed in Section 8.4.
13.1(k)	assess the likely risks of the project to public safety, paying particular attention of pedestrian safety and users of Sydney Harbour;	Safety is addressed in Section 8.4.1.
13.1(l)	impacts to water based traffic and shipping channels on users of Sydney Harbour with particular reference to the channel between Blues Point and Millers Point for passage to and from White Bay, Glebe Island and Gore Cove.	Maritime traffic is addressed in Section 8.4.11.
10. Socio-economic, Land Use and Property		
10.2	The Proponent must assess impacts from construction and operation on potentially affected properties, approved development applications, businesses, public open space, recreational users and land and water users (for example, recreational and commercial fishers, oyster farmers), including property acquisitions/adjustments, access, amenity and relevant statutory rights.	Access is addressed in Section 8.4.
10.3	Assess the likely risks of the project to public safety, paying particular attention to subsidence risks, bushfire risks and the handling and use of dangerous goods.	Public safety relating to construction traffic and transport is addressed in Section 8.4.1.

8.2 Assessment methodology and assumptions

8.2.1 Traffic assessment

The construction traffic impact assessment is based on the analysis of existing traffic movements on the road network near each construction site to determine the current operational performance. Construction traffic from the project is then added to the existing network and analysed to identify potential impacts. The approach to traffic modelling carried out for this assessment aligns with the Traffic Modelling Guidelines (Roads and Maritime, 2013).

For the purposes of this assessment, it has been assumed that all spoil would be transported from the construction site by truck. The use of other methods of transport, such as train or barge, may be possible subject to further investigation. This would reduce the potential road traffic impacts as described in this chapter. As such, this assessment provides a potential worst-case assessment of road based traffic.

Consistent with the standard approach for traffic assessments on major infrastructure projects, the traffic modelling carried out is of the AM and PM peak periods only. These peak traffic periods represent a 'worst case scenario' as during these periods the road network experiences the maximum background traffic demand and the available spare capacity of the road network is at its most limited. In order to minimise impacts to the road network, construction vehicle volumes have been planned to be higher outside the AM and PM weekday peak periods; however, the number movements would remain relatively low and would be within the range of daily variations in traffic volumes on the road network when compared to background traffic.

To assess the impact of the construction activities on the road network performance, intersections along the proposed construction routes between construction sites and the arterial road network have been assessed using Linsig 3.2 modelling software. Linsig 3.2 is used for the analysis of a corridor or a small transport network. The main performance indicators for Linsig 3.2 include:

- Degree of Saturation (DoS) – the ratio between traffic volumes and capacity (v/c) of the intersection, used to measure how close to capacity an intersection is operating. The Degree of Saturation is a direct measure of the congestion level at the intersection. As Degree of Saturation approaches 1.0, both queue length and delays increase rapidly. Satisfactory operations usually occur with a Degree of Saturation range between 0.8-0.9 or below
- Average Delay – duration, in seconds, of the average vehicle waiting time at an intersection
- Level of Service (LoS) – a measure of the overall performance of the intersection. For this purpose, average delay from Roads and Maritime Services LoS calculations has been used. Criteria for these performance indicators are provided in Table 8-2.

Table 8-2 Level of Service criteria

Level of service	Average delay (seconds per vehicle)	Traffic signals and roundabout operations
A	Less than 14	Good operation
B	15 to 28	Good with acceptable delays and spare capacity
C	29 to 42	Satisfactory
D	43 to 56	Operating near capacity
E	57 to 70	At capacity; at signals incidents will cause excessive delays
F	Greater than 70	Exceeds capacity; roundabouts require other control mode

The Sydney CBD is undergoing major changes in travel patterns and traffic behavior due to the construction of the CBD and South East Light Rail and the associated closure of George Street to vehicular traffic. The traffic survey data used to develop the traffic models for this assessment was collected at a point in time when George Street was open to all traffic. Therefore, in order to replicate the road network arrangements that would be in place during construction, the traffic data collected has been redistributed within the Sydney CBD in line with the preferred Sydney CBD driving routes (Transport for NSW, 2015a), and in consultation with the CBD Coordination Office. it is anticipated that the closure of George Street would be completed and the preferred driving routes fully in operation at the time the project commences construction.

The CBD Coordination Office has been established as a central point of leadership and authority on all traffic and transport in the Sydney CBD including:

- Ensuring urgent and coordinated responses by the Transport Management Centre and Roads and Maritime Services to traffic incidents
- Oversight of approvals for traffic management plans, and the allocation of areas and times for parking, loading zones and taxi ranks
- Coordination of permits to hold major events
- Sydney CBD related customer information and communications.

The CBD Coordination Office and Roads and Maritime Services have been consulted during the development of the traffic and transport assessment.

8.2.2 Transport assessment

A qualitative assessment has been carried out on the potential impacts to transport services during construction. This includes consideration of the active transport network (pedestrian and cyclist facilities) and public transport services (suburban rail, buses and ferries).

8.2.3 Spoil transport options

There are a number of transport options available for removing spoil from the station excavation and dive sites. Spoil haulage options that have been considered for the project are outlined in Table 8-3.

Table 8-3 Spoil transport options

Transport option	Discussion
Road	Considered feasible for all sites due to their location directly adjacent to the existing road network, in particular the proximity to the motorway and arterial road network.
Rail	Rail transport options were investigated for the Chatswood dive site, Central Station and the Marrickville dive site due to their proximity to the rail network. **Chatswood dive site** The T1 North Shore Line is not currently rated for freight transport and includes steep grades and tight curves. The addition of spoil transport on this line would more than likely impact passenger rail operations. As such, rail transport is not considered feasible at this site. **Central Station construction site** Some rail siding space is available on the former Darling Harbour freight line, located on the western side of Central Station. The length of the siding is currently insufficient to accommodate a spoil train and additional infrastructure would be required to transport the spoil from the main construction site to the siding location. Train paths for spoil trains would also need to be secured which may impact passenger rail operations at Central Station. As such, rail transport is not considered feasible at this site. **Marrickville dive site** Track that could be used for a siding is potentially available on the southern side of the rail corridor. This track also provides ready access to the Metropolitan Freight Network. The use of this track would require the transport of spoil material across the suburban rail lines which may result in safety risks and impacts to passenger rail operations. Rail transport of spoil may be feasible at this site subject to further investigations regarding rail safety risks and the identification of a suitable destination for unloading spoil in proximity to a reuse or disposal site.

Transport option	Discussion
Barge	Barge transport options were investigated for the Blues Point temporary site and the Barangaroo Station construction site due to their proximity to Sydney Harbour. **Blues Point temporary site** The site has ready access to potential barge loading facilities via the existing wharf at the end of Blues Point Road. The use of a barge from this location may require strengthening works to the wharf and potentially dredging of the harbour bed to ensure sufficient depth. Additionally, the volume of spoil proposed to be transport from this site is relatively minor and the establishment of barging facilities at this site may not be a feasible solution. Barge transport of spoil may be feasible at this site subject to further investigations. **Barangaroo Station construction site** Barging of spoil at this site could potentially be achieved by using existing wharf areas at Barangaroo (to the south of the newly created 'Northern Cove') or to the north at Moore's Wharf (a Port Authority of NSW facility to the east of Barangaroo Reserve). The use of wharf space at Barangaroo could result in disruption to the construction of the adjacent Barangaroo development. However, barge transport of spoil from this location may be feasible subject to further investigation and agreement with Barangaroo Delivery Authority. The use of Moore's Wharf would require the transport of spoil from the Barangaroo Station construction site to the wharf through the use of a conveyor system or by road. Moore's Wharf is currently used by the Port Authority of NSW for various functions including emergency response. Barge transport of spoil may be feasible at this site subject to further investigations, agreement of the Port Authority of NSW and the development of a solution which ensured the existing functions supported by Moore's Wharf are not impacted.

The investigation found that, subject to further feasibility analysis, rail transport may be possible from the Marrickville dive site and barge transport may be possible from the Barangaroo Station construction site and from the Blues Point temporary site. However, as there are substantial constraints to these options that would need to be overcome, this traffic and transport assessment has assumed that all spoil would be transported by road.

Further consideration of rail and barge options would be carried out during the detailed design phase of the project. In the event that either or both of these options are adopted this is likely to result in a reduction to the road based construction traffic impacts described in this chapter.

8.2.4 Hours of truck operation

As identified in Chapter 7 (Project description – construction), tunnelling and station excavation activities would be carried out up to 24 hours per day and seven days per week. These activities would require support construction vehicles for material supply and spoil removal, to also occur up to 24 hours per day and seven days per week.

The proposed timing of vehicle movements throughout the day for each site is identified in Section 8.4. The development of these truck movements has aimed to minimise movements during the AM and PM peak traffic periods and during the night-time period. Section 8.2.1 provides further discussion regarding the hours of heavy vehicle operations that have been assessed in the traffic model.

8.2.5 Haul routes

Haul routes to and from the construction site have been developed in consultation with Roads and Maritime Services and the CBD Coordination Office, and with the following aims:

- Minimise the use of local or residential streets and maximise the use of arterial roads
- Minimise potential safety implications for pedestrians, cyclists and other road users
- Avoid the need to pass through or under the Sydney CBD for the construction sites external to the Sydney CBD
- Exit the Sydney CBD as efficiently as possible for the Sydney CBD construction sites
- Minimise the cumulative use of roads by trucks accessing different Sydney CBD construction sites.

The proposed haul routes for all construction sites are provided in the respective sections of this chapter.

8.2.6 Spoil generation

Based on the concept design, it is envisaged that excavation would generate about 2.4 million cubic metres of spoil. Table 8-4 identifies the expected spoil volumes and truck type that is likely to be used at each construction site.

Table 8-4 Anticipated spoil generation by construction site and likely truck type

Site	Volume of spoil (m^3)	Truck type [1]
Chatswood dive site – dive excavation	60,000	Truck and dog
Chatswood dive site – tunnelling	460,000	Truck and dog
Artarmon substation	2,000	Tipper truck
Crows Nest Station	150,000	Tipper truck
Victoria Cross Station	175,000	Tipper truck
Blues Point temporary site	8,000	Tipper truck
Barangaroo Station – station excavation	145,000	Tipper truck
Barangaroo Station – tunnelling	90,000	Tipper truck
Martin Place Station	175,000	Tipper truck
Pitt Street Station	160,000	Tipper truck
Central Station	230,000	Tipper truck
Waterloo Station	115,000	Tipper truck
Marrickville dive site – dive excavation	70,000	Truck and dog
Marrickville dive site – tunnelling	560,000	Truck and dog
TOTAL	2,400,000	

1 *A truck and dog is the common term for a tipper truck and trailer.*

8.3 Existing environment

8.3.1 Regional traffic environment

The regional transport environment is described in Chapter 9 (Operational traffic and transport). This section describes the regional road network.

Regional road network

North of Sydney Harbour, the road network is dominated by the key motorways – the Warringah Freeway / Gore Hill Freeway, the Lane Cove Tunnel and the Hills M2 Motorway. The Warringah Freeway / Gore Hill Freeway, connects to the Sydney Harbour Bridge and the Sydney Harbour Tunnel. As the main route to and from the Sydney CBD from the north, it carries large volumes of traffic that progressively increase to the south and on the approaches to the crossing of Sydney Harbour.

The main arterials roads relevant to the project north of Sydney Harbour are:

- The Pacific Highway, which is the key arterial road to the north. It passes through North Sydney, Crows Nest, St Leonards and Chatswood. Traffic volumes on the Pacific Highway generally increase to the north, especially between North Sydney and the connection to the Warringah Freeway around Artarmon
- Mowbray Road, which provides an important east–west connection between Lane Cove, Chatswood and Willoughby. It intersects with Epping Road, the Pacific Highway, Penshurst Street and Willoughby Road.

Numerous arterial and sub-arterial roads provide connections from the surrounding areas to the Pacific Highway and Military Road. North–south arterial roads such as Eastern Valley Way and Willoughby Road are also used as alternative routes to the Pacific Highway. The majority of the arterial and sub-arterial road network experiences significant traffic volumes and congestion, especially during the peak traffic periods.

South of Sydney Harbour, the motorway network provides regional through routes primarily located on the periphery of the Sydney CBD or within tunnels beneath the Sydney CBD providing access for motorists whose origin or destination is not within the Sydney CBD. These roads include the Western Distributor, Eastern Distributor, Cahill Expressway and Cross City Tunnel.

The arterial road network within the Sydney CBD generally forms a grid pattern. Key north–south roads include Elizabeth, York and Clarence streets. Key east–west roads include Park, Market, King, Bathurst, Liverpool and Goulburn streets. Many roads within the Sydney CBD are one-way and experience high traffic volumes and congestion, especially during the peak periods. Pressure on key north–south roads is expected to increase following the closure and subsequent pedestrianisation of George Street between Hunter and Bathurst streets as part of the CBD and South East Light Rail project.

South of the Sydney CBD, the road network is dominated by the Eastern Distributor (providing a connection to the M5 Motorway) and the key arterial roads of King Street, the Princes Highway and Regent Street.

Changing CBD traffic and transport environment

The Sydney CBD traffic and transport environment is complex and characterised by generally high volumes of traffic, high levels of congestion, numerous one-way streets and significant pedestrian volumes especially at peak travel times. This environment is currently undergoing changes through the implementation of the Sydney City Centre Access Strategy (Transport for NSW, 2013a) including major transport projects such as the CBD and South East Light Rail, the pedestrianisation of George Street between Hunter Street and Bathurst Street, the new CBD Bus Strategy and the cycleway program. Construction of these projects, and other changes to the traffic and transport environment within the Sydney CBD would be occurring concurrently with the construction of Sydney Metro. The Sydney City Centre Access Strategy will be progressively updated to reflect the changing Sydney CBD.

The CBD and South East Light Rail will run along George Street from Circular Quay to Central Station. *Sydney's Light Rail Future* (Transport for NSW, December 2012a) states that it expects that once the CBD and South East Light Rail is operational in 2020, it would remove 180 buses from the Sydney CBD while additional bus network changes would bring this to a total of about 220 fewer buses entering the city centre in the morning peak.

The CBD Coordination Office has been established to oversee all traffic and transport in the Sydney CBD including decisions, directions and approvals affecting all road and traffic arrangements in the Sydney CBD. Sydney Metro would liaise closely with the CBD Coordination Office during detailed construction planning and throughout construction phase to minimise the potential construction traffic impacts within the Sydney CBD, including potential cumulative impacts with other projects or special events.

8.3.2 Chatswood dive site (northern) and northern surface works

The Chatswood dive site would be bounded by Nelson Street to the north, the Pacific Highway to the west, Mowbray Road to the south and the T1 North Shore Rail Line to the east. The northern surface works would extend along the existing rail corridor from south of Chatswood Station to around Brand Street, Artarmon. The location of the construction site and the surrounding road network are shown on Figure 8-1.

Figure 8-1 Chatswood dive site (northern) and northern surface works road network

Active transport network

Footpaths are located on all sides of the Pacific Highway, Nelson Street and Mowbray Road. Signalised crossing facilities are located on all arms of the intersection of the Pacific Highway and Mowbray Road. There are few crossing opportunities along the Pacific Highway with the nearest signalised crossings being located 600 metres north at the Pacific Highway / Albert Avenue intersection and 680 metres south at the Pacific Highway / Gore Hill Freeway intersection.

Nelson Street is part of a key active transport route that provides a link between the Pacific Highway and Frank Channon Walk, a shared path running along the western side of the rail corridor from Nelson Street to Chatswood Station and the Chatswood commercial centre. Nelson Street also provides east-west connectivity across the T1 North Shore Rail Line, along with Mowbray Road to the south and Albert Avenue to the north. Surveys carried out in December 2015 identified in the AM peak hour a total of 16 pedestrians and five cyclists crossing Nelson Street bridge in both directions and in the PM peak hour 22 pedestrians and five cyclists were observed.

Public transport services

Frequent bus services currently operate along the Pacific Highway with a bus stop located between Bryson Street, Chatswood and Mowbray Road, Chatswood in the southbound direction serving five routes to destinations such as Manly, the Sydney CBD, Ryde and Castle Hill. These services generally operate every five minutes during peak periods and every 10 minutes at other times. Additional routes also operate past the proposed construction site.

The Epping to Chatswood Rail Conversion Temporary Transport Project will be providing rail replacement bus services for six to seven months from the end of 2018. An additional 30 bus services will arrive and depart Chatswood in the AM and PM peak hours. Buses would travel from North Ryde, via Fullers Road and use Victoria Avenue, Help Street, Brown Street and Railway Street in Chatswood. The replacement bus services would operate to the north of the Chatswood dive site and be temporary in nature.

Traffic volumes and patterns

The existing traffic volumes on the surrounding road network are provided in Table 8-5. This table shows a typical Sydney commuter peak pattern with the Pacific Highway experiencing heavier flows in the southbound direction (towards the city) in the AM peak and in the northbound direction (away from the city) in the PM peak. Traffic volumes on the Pacific Highway are higher to the south of Mowbray Road. On Mowbray Road, traffic volumes are marginally higher in the eastbound direction in the AM peak and in the westbound direction in the PM peak. Current traffic volumes on Nelson Street are very low.

Intersections on the Pacific Highway and Mowbray Road currently experience long delays due to high through volumes and conflicting right-turn movements. The following intersections currently perform at level of service E or F:

- Pacific Highway / Fullers Road / Help Street (AM peak)
- Pacific Highway / Victoria Avenue (AM and PM peaks)
- Pacific Highway / Mowbray Road (AM and PM peaks)
- Pacific Highway / Gore Hill Freeway ramps (AM peak).

Currently, the southbound right turn movement from the Pacific Highway into Mowbray Road westbound is prohibited for all vehicles with the exception of buses. Motorists wishing to undertake this movement are required to turn left into Nelson Street, right into Orchard Road and then right into Mowbray Road (a ‘G’ turn) before proceeding straight across the Pacific Highway.

Table 8-5 Chatswood dive site (northern) existing traffic volumes

Road	Direction	AM peak hour (vehicles per hour)	PM peak hour (vehicles per hour)
Pacific Highway Between Fullers Road and Victoria Avenue	Southbound	2,320	1,710
	Northbound	1,550	2,470
Pacific Highway Between Albert Avenue and Nelson Street	Southbound	2,020	1,760
	Northbound	1,880	2,430
Pacific Highway Between Mowbray Road and Howarth Road	Southbound	2,180	2,020
	Northbound	1,920	2,570
Mowbray Road Between Pacific Highway and Orchard Road	Eastbound	1,340	1,130
	Westbound	1,050	1,420

8.3.3 Artarmon substation

The Artarmon substation would be located adjacent to the Gore Hill Freeway and bounded by Butchers Lane and Barton Road. The location of the construction site and the surrounding road network are shown on Figure 8-2.

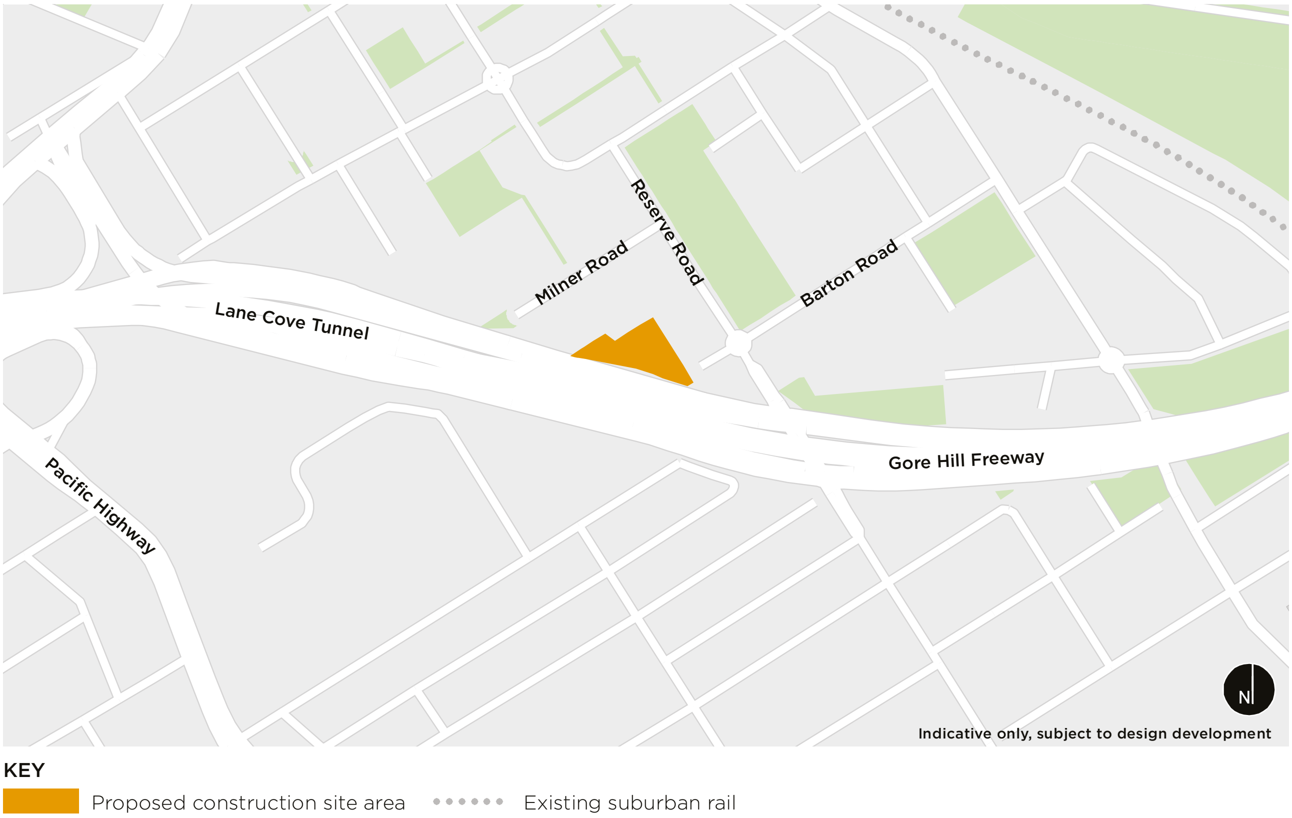


Figure 8-2 Artarmon substation road network

Active transport network

Footpaths are located along Reserve Road, Barton Road and Milner Road. Pedestrian facilities are not provided on Butchers Lane which is primarily used for residential parking and access to driveways of properties fronting Milner Road. A combination of marked and signalised pedestrian crossings exist at the Gore Hill Freeway / Reserve Road interchange.

A shared path runs along the southern side of the Gore Hill Freeway and provides facilities for cyclists. There are no dedicated cycle facilities in the vicinity of the proposed site.

Public transport services

Public transport services do not operate near the proposed site. The nearest rail service is the T1 North Shore Rail Line accessible from Artarmon Station, around 700 metres from the site. The nearest bus services are at least 800 metres from the site and operate along the Pacific Highway and Campbell Street towards destinations such as Chatswood, Manly and the Sydney CBD.

The Artarmon Loop (a free shuttle service operated by Willoughby Council) runs along Reserve Road in the vicinity of the site providing a link between St Leonards and Artarmon. Services run every 30 minutes between 10 am and 2:30 pm.

Traffic volumes and patterns

The existing traffic volumes on the surrounding road network are provided in Table 8-6. The table shows that traffic volumes are relatively low to the north of the Gore Hill Freeway. Reserve Road south of the Gore Hill Freeway has higher traffic volumes, particularly southbound in the AM peak. Butcher's Lane and Barton Road west of Reserve Road are 'no through' roads and record low traffic volumes.

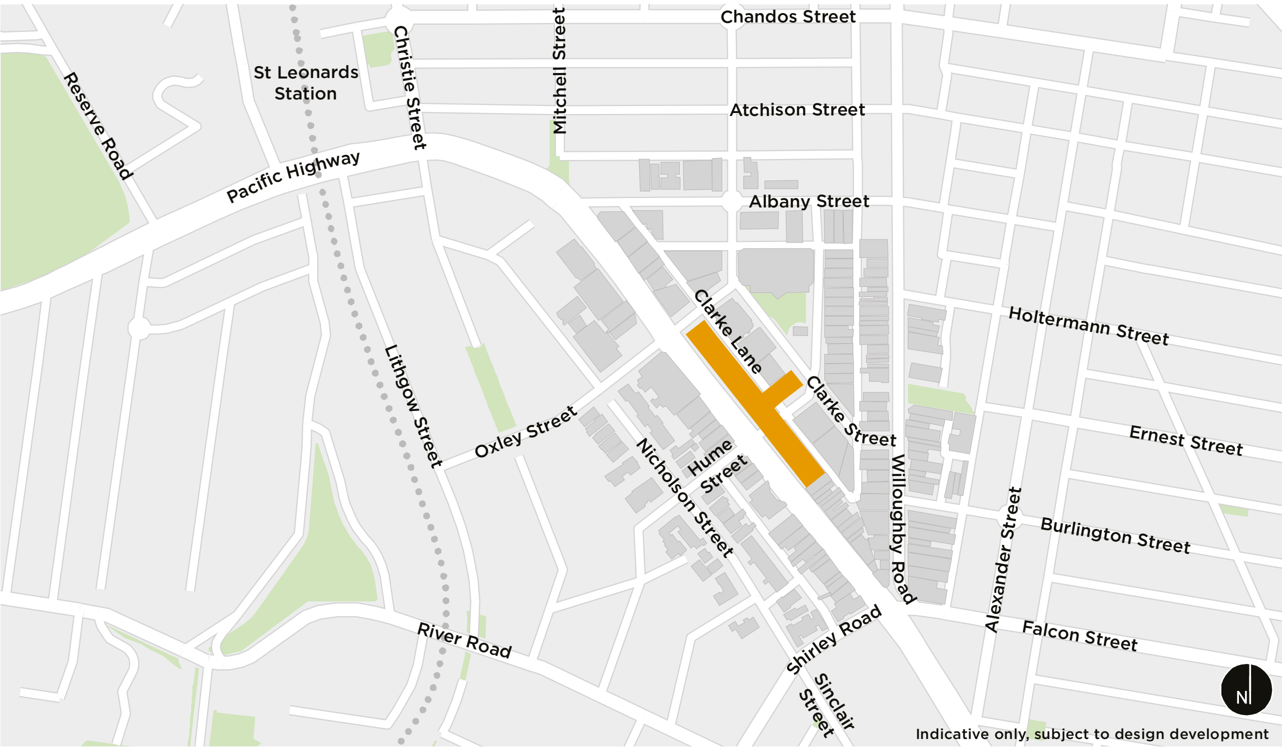
Currently, all intersections in the vicinity of Artarmon substation operate at level of service B or better in both the AM and PM peak periods.

Table 8-6 Artarmon substation existing traffic volumes

Road	Direction	AM peak hour (vehicles per hour)	PM peak hour (vehicles per hour)
Reserve Road Between Butchers Road and Barton Road	Southbound	430	280
	Northbound	300	520
Reserve Road Between Barton Road and Gore Hill Freeway	Southbound	530	320
	Northbound	450	610
Reserve Road South of Gore Hill Freeway	Southbound	1,270	520
	Northbound	530	1,170

8.3.4 Crows Nest Station

Crows Nest Station would be located on the Pacific Highway in the vicinity of Oxley Street and Hume Street. The location of the construction site and the surrounding road network are shown on Figure 8-3.



KEY

Proposed construction site area

Existing suburban rail

Figure 8-3 Crows Nest Station road network

Active transport network

The pedestrian network immediately surrounding the proposed site is well served by an existing network of footpaths. Connections can be made to surrounding land uses including residential, commercial and retail. Away from the Pacific Highway pedestrian crossing facilities are currently limited with no formal facilities provided on Hume Street, Clarke Street, Clarke Lane or Oxley Street in the vicinity of the site. The existing key pedestrian desire lines are towards St Leonards Station and the St Leonards commercial core, and towards the Crows Nest retail and leisure precinct on Willoughby Road.

On-road marked bicycle routes near the proposed site run parallel to the eastern side of Pacific Highway along Alexander Street, Burlington Street, Willoughby Road, Clarke Street and Oxley Street, as well as Nicholson Street and Sinclair Street on the western side of Pacific Highway. On-road marked cycle routes are also provided on Shirley Road and Nicholson Street on the southern side of the Pacific Highway. In St Leonards, on-road marked bicycle routes run east-west parallel to the Pacific Highway along Atchinson Street (between Christie Street and Mitchell Street).

Public transport services

Crows Nest is currently served by a number of buses operated by Sydney Buses and Hillsbus, with 21 bus routes passing through the area. Major bus stops within the vicinity of the proposed site are located along the Pacific Highway, Willoughby Road and Falcon Street. During the morning peak period the majority of routes passing through Crows Nest along the Pacific Highway are generally bound for North Sydney or the Sydney CBD. Routes servicing the Crows Nest town centre tend to travel along Willoughby Road, Alexander Street and Falcon Street. Bus service frequencies in Crows Nest run regularly throughout the day, with around 300 services during the weekday morning peak (6 am to 10 am) and 360 services during the evening peak (3 pm to 7 pm).

Traffic volumes and patterns

Crows Nest currently experiences low to moderate levels of traffic congestion during peak periods. The intersection of Pacific Highway, Falcon Street, Willoughby Road and Shirley Street has been observed to operate at capacity during peak periods, with subsequent queuing along Falcon Street and the Pacific Highway.

The existing traffic volumes on the surrounding road network are provided in Table 8-7. In Crows Nest, traffic on the Pacific Highway does not exhibit strong tidal characteristics (ie there is no strong directional preference in the AM or PM peak period). This section of the Pacific Highway has at least two lanes available in each direction at all times. There is an additional T3 lane, and associated clearway restrictions, in the southbound direction during the AM peak and in the northbound direction during the PM peak.

Currently, the intersections at Pacific Highway / Oxley Street and Pacific Highway / Hume Street operate at level of service B or better, and the intersection at Pacific Highway / Falcon Street / Shirley Road operates at level of service D and experience longer delays during both peak periods. These delays are primarily experienced by vehicles on side streets (Falcon Street and Shirley Road).

Table 8-7 Crows Nest Station existing traffic volumes

Road	Direction	AM peak hour (vehicles per hour)	PM peak hour (vehicles per hour)
Pacific Highway Between Oxley Street and Hume Street	Southbound	1,340	1,360
	Northbound	1,480	1,410
Pacific Highway Between Hume Street and Falcon Street	Southbound	1,290	1,290
	Northbound	1,480	1,400
Hume Street East of the Pacific Highway	Westbound	150	190
	Eastbound	140	140
Oxley Street East of the Pacific Highway	Westbound	225	145
	Eastbound	145	150

8.3.5 Victoria Cross Station

Victoria Cross Station would be located on Miller Street in North Sydney in the vicinity of Berry Street and McLaren Street. The location of the construction site and the surrounding road network are shown on Figure 8-4.

Figure 8-4 Victoria Cross Station road network

Active transport network

The area around the site forms the commercial core of the North Sydney CBD and, as such, generates high pedestrian volumes, particularly during the commuter peak hours. At busy times, formal pedestrian crossing facilities within the North Sydney CBD become congested with pedestrians due to the lack of footpath space provided at some intersections (such as the Pacific Highway / Miller Street intersection and Pacific Highway / Walker Street intersection). Locally there are key pedestrian desire lines crossing the Pacific Highway at both Walker Street and Miller Street as pedestrians move from North Sydney Station to the commercial precincts of the North Sydney CBD.

Underground pedestrian connections are provided through Greenwood Plaza in the vicinity of the existing North Sydney Station, providing connections to nearby commercial developments.

In the immediate vicinity of the site, a pedestrian bridge across Denison Street provides a connection between the retail areas of Tower Square and Berry Square.

School children also use pedestrian footpaths and crossing facilities in the vicinity of the site between Monte Sant' Angelo Mercy College and public transport services.

Public transport services

North Sydney is a major thoroughfare for buses with 44 bus routes passing through the area. Bus services are currently provided by Sydney Buses, Hillsbus and Forest Coach Lines. Major outbound bus stops are located on Miller Street, Pacific Highway and Blue Street, with services connecting North Sydney with the Northern Beaches and lower North Shore, including Mosman, Northbridge and Chatswood. The majority of inbound routes operating within the area terminate in North Sydney, Milsons Point or the Sydney CBD. Most routes run regularly throughout the day, with approximately 420 services during the weekday morning peak (6 am to 10 am) and 450 services during the evening peak (3 pm to 7 pm).

North Sydney is also served by the existing North Sydney Station located on Blue Street south of the construction site. North Sydney Station is on the T1 North Shore Rail Line, providing connections towards Hornsby, Chatswood and Macquarie Park in the north, the Sydney CBD to the south, and Parramatta, Blacktown and Penrith to the west.

Traffic volumes and patterns

The existing traffic volumes on the surrounding road network are provided in Table 8-8. During the AM peak hour, the Pacific Highway carries a large number of vehicles southbound between McLaren Street and Berry Street. South of this intersection vehicle numbers drop significantly due to the large left turn movement into Berry Street for vehicles heading towards the Sydney Harbour Bridge and the Warringah Freeway. As a result, Berry Street also experiences high traffic volumes. Miller Street generally has lower traffic volumes with a relatively even split in each direction.

All intersections currently operate at a level of service C or better. However, at some intersections, vehicles performing minor conflicting movements experience delays. These intersections are:

- Berry Street / Walker Street (AM peak)
- Falcon Street / Miller Street (AM and PM peaks)
- Falcon Street / Warringah Freeway ramps (AM and PM peaks).

Table 8-8 Victoria Cross Station existing traffic volumes

Road	Direction	AM peak hour (vehicles per hour)	PM peak hour (vehicles per hour)
Pacific Highway Between McLaren Street and Berry Street	Southbound	1,390	1,060
	Northbound	1,000	790
Pacific Highway Between Berry Street and Miller Street	Southbound	520	620
	Northbound	1,210	1,160
Miller Street Between McLaren Street and Berry Street	Southbound	630	530
	Northbound	470	500
Miller Street Between Berry Street and Pacific Highway	Southbound	540	370
	Northbound	550	640
McLaren Street Between Pacific Highway and Miller Street	Eastbound	240	190
	Westbound	290	250
Berry Street Between Pacific Highway and Miller Street	Eastbound	1,220	940

Road	Direction	AM peak hour (vehicles per hour)	PM peak hour (vehicles per hour)
Berry Street Between Miller Street and Walker Street	Eastbound	1,280	1,700
Walker Street Between Arthur Street and Mount Street	Southbound	160	100
	Northbound	1,170	940

8.3.6 Blues Point temporary site

The Blues Point temporary site would be located at the end of Blues Point Road, near the intersection with Henry Lawson Drive. The location of the construction site and the surrounding road network are shown on Figure 8-5.

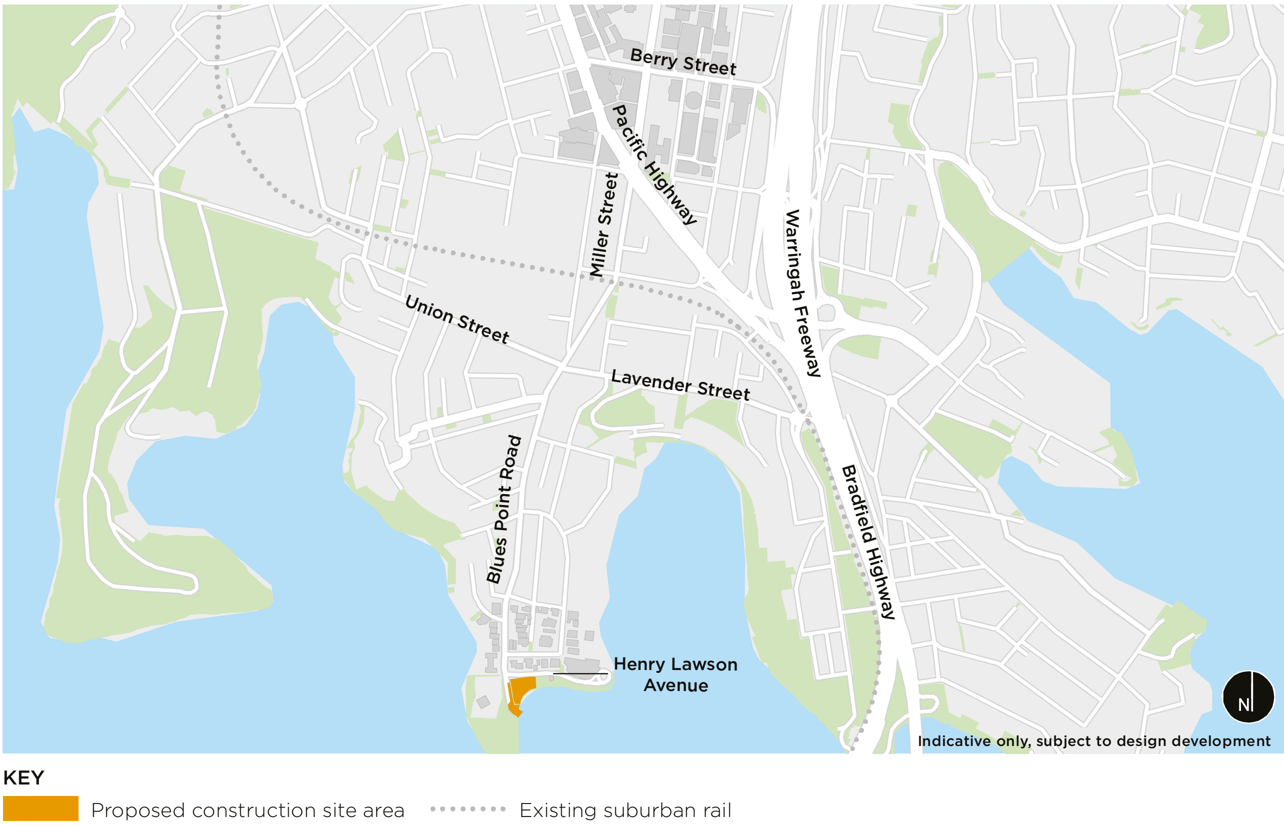


Figure 8-5 Blues Point temporary site road network

Active transport network

Henry Lawson Avenue acts as a pedestrian and cyclist desire line between McMahons Point Wharf and the foreshore reserve, access to parking at Blues Point Reserve and residential areas surrounding Blues Point Road. There is a footpath on the southern side of Henry Lawson Avenue and on both sides of Blues Point Road. There is a marked on-road cycle route on Blues Point Road south of Lavender Street and on Henry Lawson Avenue.

Informal pedestrian paths also exist through Blues Point Reserve, providing Sydney Harbour foreshore access.

Public transport services

Bus services currently operate along Blues Point Road and Henry Lawson Avenue, performing a U-turn at the roundabout at the eastern end of Henry Lawson Avenue. There is a bus stop located in the westbound direction on Henry Lawson Avenue and buses currently operate at this bus stop on average every 30 minutes.

McMahons Point Wharf is located at the eastern end of Henry Lawson Avenue; the wharf is used by ferries on the F3 Parramatta River and F4 Darling Harbour routes, with six services in peak periods, services every 30 minutes during weekdays and every 20 minutes during weekend.

Traffic volumes and patterns

The existing traffic volumes on the surrounding road network are provided in Table 8-9. Blues Point Road has relatively low traffic volumes and does not exhibit strong tidal flow patterns.

Currently, intersections along Blues Point Road show good performance with a level of service B, except for the Blues Point Road / Union Street / Lavender Street intersection during the AM peak which operates at a level of service C.

Table 8-9 Blues Point temporary site existing traffic volumes

Road	Direction	AM peak hour (vehicles per hour)	PM peak hour (vehicles per hour)
Blues Point Road Between Blues Street and Union Street	Southbound	440	440
	Northbound	400	460
Blues Point Road South of Union Street	Southbound	320	300
	Northbound	360	360

8.3.7 Barangaroo Station

Barangaroo Station would be located adjacent to the Central Barangaroo precinct alongside Hickson Road. The location of the construction site and the surrounding road network are shown on Figure 8-6.

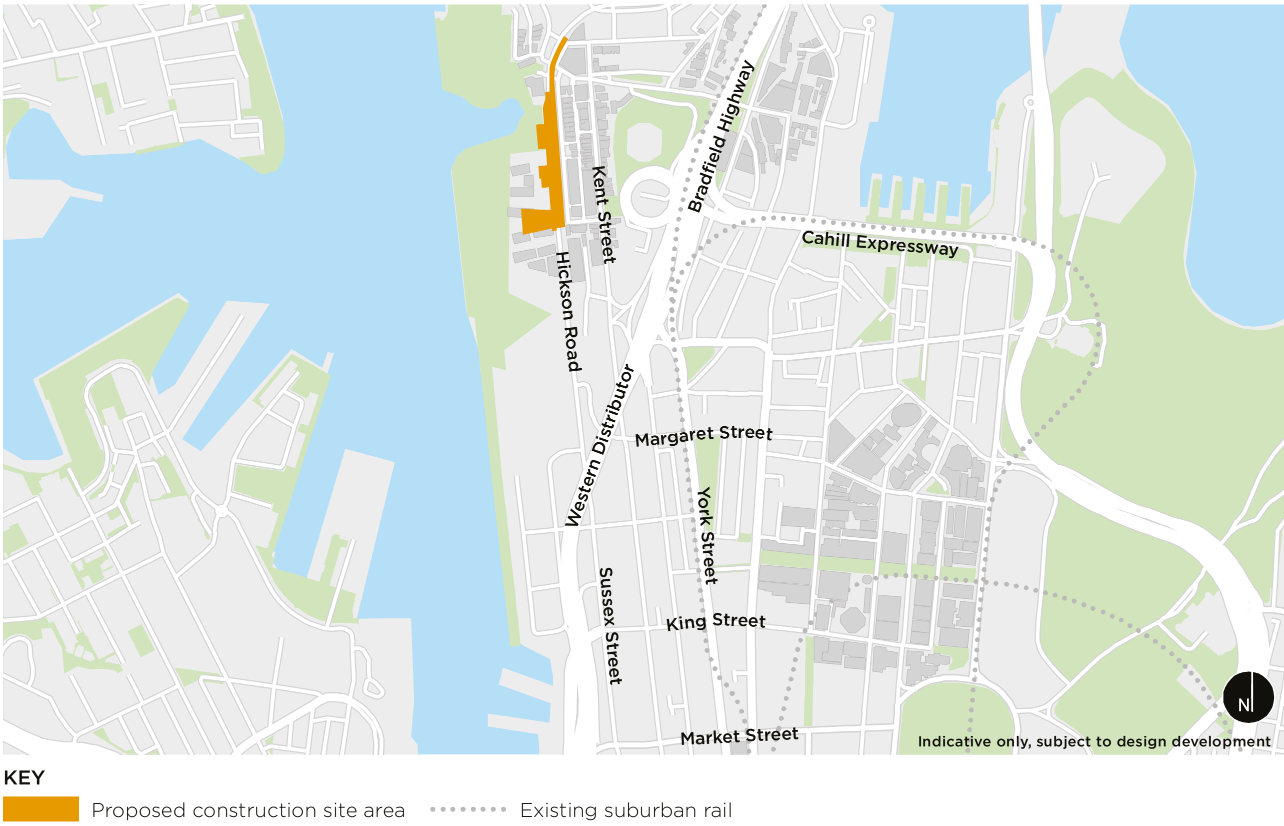


Figure 8-6 Barangaroo Station road network

Active transport network

Hickson Road currently has a pedestrian footpath on both its eastern and western sides. An on-road marked cycle route is also provided on Hickson Road, offering connections to the Sydney Harbour Bridge and the dedicated cycle path along Kent Street.

Walking and cycling facilities in the area are expected to be improved as part of the Barangaroo development. This is expected to include improved connectivity to the Sydney CBD via improvements to the Sydney Steps, a continuous foreshore walk and new public open space. In addition to Wynyard Walk, pedestrian connections to Martin Place and Town Hall are planned to be enhanced as well as improvements to the foreshore connectivity linking Darling Harbour and Circular Quay.

Public transport services

Bus services currently operate to and from Barangaroo along Hickson Road, with three routes servicing the area, the 311, 324 and 325. These routes are regular, with 60 services operating during the morning peak period (6am to 10am), and 70 services operating during the evening peak period (3 pm to 7 pm).

Wynyard Station is located approximately 850 metres southeast of the proposed site and serves the T1 North Shore, Northern and Western Line, T2 Airport, Inner West and South Line and T3 Bankstown Line. The new ferry hub at Barangaroo, expected to be open to customers in 2016, would provide interchange opportunities to ferry services from Parramatta River and Inner Harbour, as well as direct access to and from the eastern suburbs at Double Bay, Rose Bay and Watsons Bay.

Traffic volumes and patterns

The existing traffic volumes on the surrounding road network are provided in Table 8-10. Sussex Street shows a stronger southbound movement in both peak periods, with particularly high volumes in the PM peak Conversely Kent Street shows a stronger northbound movement associated with vehicles accessing the Harbour Bridge.

All intersections near the proposed Barangaroo Station construction site currently operate at a level of service C or better except for the Kent Street / Clarence Street / Sydney Harbour Bridge entry ramp intersection which is currently operating at capacity. At this intersection the majority of vehicles perform right-turn movements from either Kent Street (northbound) or Clarence Street (westbound). Conflict between these major movements causes delays, particularly in the AM peak.

Access to the Overseas Passenger Terminal at Circular Quay for delivery trucks and coaches on days that a ship is docked is gained via Hickson Road. These movements typically occur over a short duration associated with the arrival and departure times for cruise ships (typically early morning and evening).

Table 8-10 Barangaroo Station existing traffic volumes

Road	Direction	AM peak hour (vehicles per hour)	PM peak hour (vehicles per hour)
Hickson Road North of Napoleon Street	Southbound	190	430
	Northbound	420	410
Kent Street Between Clarence Street and Margaret Street	Southbound	230	270
	Northbound	610	820
Sussex Street Between Napoleon Street and Erskine Street	Southbound	400	500
	Northbound	570	480
Sussex Street Between Erskine Street and King Street	Southbound	810	1,020
	Northbound	380	320
Sussex Street Between King Street and Market Street	Southbound	840	1,200

8.3.8 Martin Place Station

The Sydney Metro Martin Place Station would be located to the north and south of Martin Place, bounded by Castlereagh Street to the west and Elizabeth Street to the east. The location of the construction site and the surrounding road network are shown on Figure 8-7.

KEY

Proposed construction site area   Existing suburban rail

Figure 8-7 Martin Place Station road network

Active transport network

Martin Place is pedestrian-only between George Street and Macquarie Street. As part of the CBD and South East Light Rail project, George Street in the vicinity of Martin Place, will also be pedestrianised enhancing the pedestrian environment from what is currently available. Surveys were carried out in December 2015 of the Martin Place / Castlereagh Street and Martin Place / Elizabeth Street pedestrian crossings. These surveys showed:

- Around 44,300 pedestrians crossed at Castlereagh Street throughout the day, with around 20,950 travelling eastbound and 23,350 travelling westbound. In the AM period the dominant pedestrian movement was westbound towards commercial buildings and George Street, whilst in the PM period the dominant movement was eastbound towards the Sydney Trains Martin Place Station
- Around 33,900 pedestrians crossed at Elizabeth Street throughout the day, with around 13,700 travelling eastbound and 17,200 travelling westbound. As with Castlereagh Street, the majority of pedestrians travel westbound in the AM period and eastbound in the PM period.

Within the immediate vicinity of Martin Place, a number of bicycle parking facilities are currently available, however, there is no provision or planned provision of on-road separated or shared bicycle paths.

Public transport services

The Martin Place precinct experiences high volumes of bus traffic during peak and off-peak times, particularly along Elizabeth Street and Castlereagh Street which, since the closure of George Street, are the main north-south bus corridors through the Sydney CBD. Buses from all over Sydney converge and diverge at bus stops located adjacent to and near the proposed station.

Martin Place Station on the T4 Eastern Suburbs and Illawarra Line and the South Coast Line provides a key Sydney CBD access point for customers travelling from the eastern suburbs and southern regions of Sydney.

Traffic volumes and patterns

The existing traffic volumes on the surrounding road network are provided in Table 8-11. Elizabeth Street northbound experiences heavy traffic volumes during both peak periods. There is a strong movement from Macquarie Street (southbound) in the east to Castlereagh Street (southbound) via Hunter Street, which contributes to relatively heavy westbound traffic on Hunter Street.

Currently, the Macquarie Street / Bent Street / Eastern Distributor ramps intersection is extremely congested during the AM and PM peaks with the intersection performing above its theoretical capacity at level of service F. Long delays are caused by conflict between high volumes of traffic on the Eastern Distributor ramps (westbound) and Macquarie Street (southbound).

All other intersections near the Martin Place Station construction sites currently operate at level of service B or better. However, at the Elizabeth Street / Phillip Street / Hunter Street intersection, signal coordination along Elizabeth Street causes delays for conflicting right turn movements and vehicles on side-streets.

Table 8-11 Martin Place Station existing traffic volumes

Road	Direction	AM peak hour (vehicles per hour)	PM peak hour (vehicles per hour)
Castlereagh Street **Between King Street and Hunter Street**	Southbound	380	510
Elizabeth Street **Between King Street and Hunter Street**	Southbound	1,130	1,110
	Northbound	410	590
Hunter Street **Between Castlereagh Street and Elizabeth Street**	Eastbound	190	190
	Westbound	790	630

8.3.9 Pitt Street Station

Pitt Street Station would be located between the existing Town Hall Station and Museum Station. The station access would be at two locations, one at the intersection of Pitt Street and Park Street to the north and one on Bathurst Street to the south. The location of the construction site and the surrounding road network are shown on Figure 8-8.

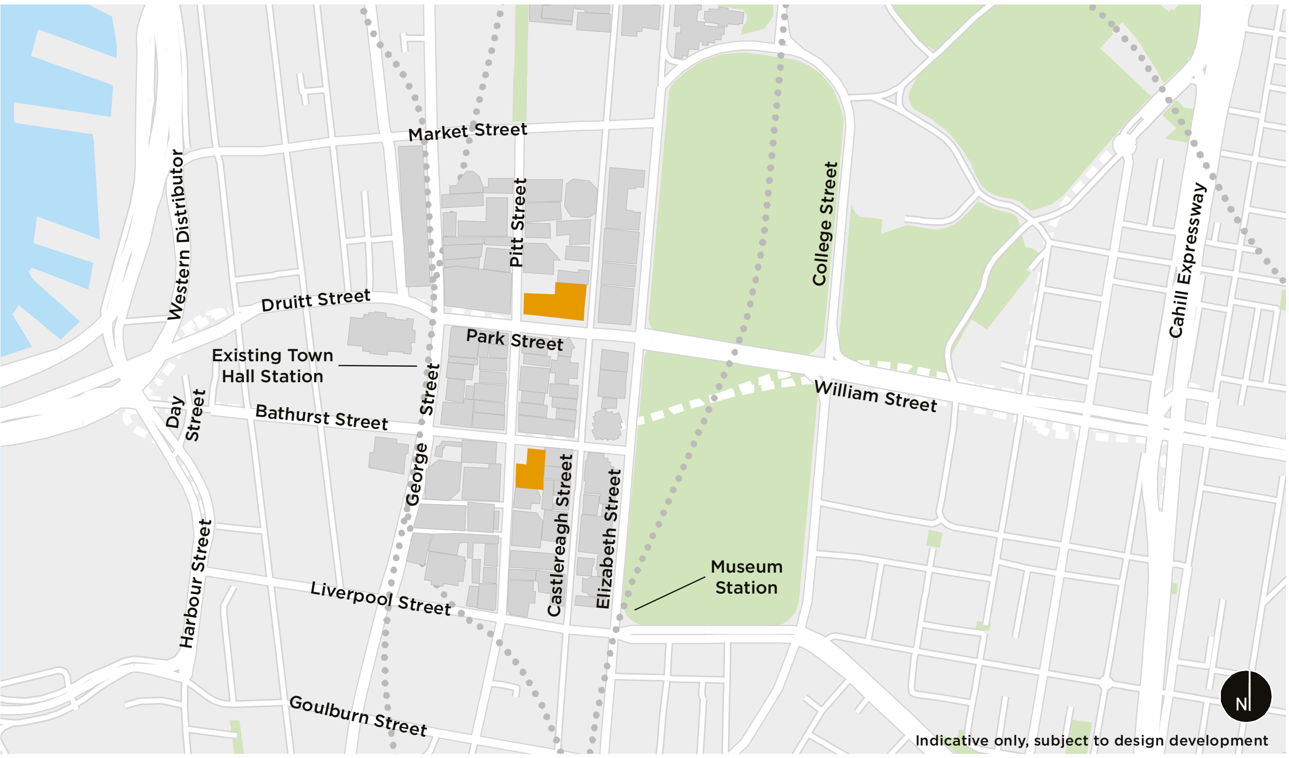


Figure 8-8 Pitt Street Station road network

Active transport network

The Pitt Street / Park Street intersection currently experiences high volumes of pedestrian traffic, predominantly in the east-west direction along Park Street. The pedestrian demand in this direction is driven by bus passengers with some additional movements from Town Hall and Museum station and general circulation.

Bicycle parking facilities are located throughout the Sydney CBD and the City of Sydney provides free bicycle parking at its Goulburn Street carpark. A marked cycle lane exists on Park Street, however this currently stops at its intersection with Elizabeth Street.

Public transport services

A number of bus routes operate within the vicinity of the proposed Pitt Street Station, particularly those that run north-south along Elizabeth Street and Castlereagh Street and services running east-west along Park Street. These routes primarily serve the east and southeast continuing towards Oxford Street or Central Station, services which pass through Broadway, and also the Metrobus Network. Bus services operating along Victoria Road also use Park and Druitt streets. Bus stops associated with these routes are located adjacent to the site on Park Street and nearby on Castlereagh and Elizabeth streets.

Town Hall Station located near the proposed Sydney Metro Pitt Street Station is currently the second-busiest railway station in the Sydney Trains network during the morning peak (behind Central Station). Town Hall also serves as a significant interchange station that is traversed by all train lines through the Sydney CBD.

Museum Station is located around the Elizabeth Street / Liverpool Street intersection. Trains on the T2 Airport, Inner West and South Line, T3 Bankstown Line and the Southern Highlands Line operate through Museum Station.

Traffic volumes and patterns

The existing traffic volumes on the surrounding road network are provided in Table 8-12. Traffic movement was observed to be generally congested along Park Street during peak periods, due to the close proximity of intersections, particularly George Street, and the competing heavy traffic demands on the north south corridors. Bathurst Street shows high volumes of traffic in both the morning and evening peak hours, with higher volumes observed in the evening peak. Park Street (westbound) also experiences relatively high volumes, particularly during the morning peak hour.

Currently, all intersections perform at a level of service C or better except for the following:

- Bathurst Street / Harbour Street (level of service D in both the AM and PM peaks)
- Bathurst Street / Day Street (level of service F in the AM peak).

The Bathurst Street / Day Street intersection operates with a degree of saturation of greater than 1.0, therefore, this intersection is currently operating above its theoretical capacity.

Table 8-12 Pitt Street Station existing traffic volumes

Road	Direction	AM peak hour (vehicles per hour)	PM peak hour (vehicles per hour)
Castlereagh Street **Between Park Street and Bathurst Street**	Southbound	300	490
Pitt Street **Between Bathurst Street and Park Street**	Northbound	530	480
Park Street **Between Castlereagh Street and Pitt Street**	Eastbound	170	270
	Westbound	610	530
Bathurst Street **Between Castlereagh Street and Pitt Street**	Eastbound	1,110	1,120

8.3.10 Central Station platforms

The new metro underground platforms at Central Station would be located within the existing Central Station below intercity rail service platforms 13, 14 and 15. The location of the construction site and the surrounding road network are shown on Figure 8-9.

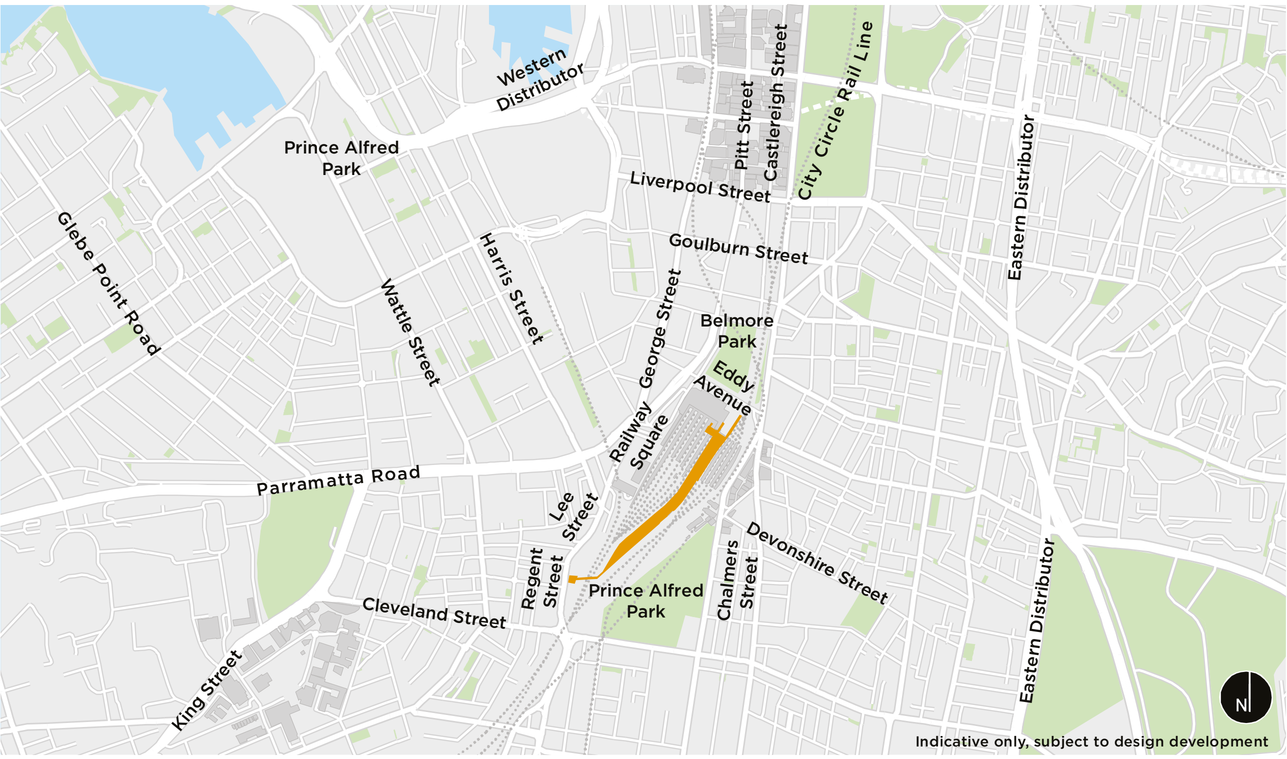


Figure 8-9 Central Station road network

Active transport network

Pedestrian access to Central Station via Eddy Avenue has wide footpaths on both sides. Pedestrian access is also available from Lee Street to the northwest and Devonshire Street to the southeast, which are connected by the Devonshire Street Tunnel, providing subsurface access to the station from its southern approaches. Surveys of Devonshire Street Tunnel were carried out in November 2015. This survey showed:

- The total number of pedestrians using Devonshire Street Tunnel throughout the day was around 25,440 in the eastbound direction and 22,330 in the westbound direction
- In the AM peak period around 1,400 pedestrians travelled eastbound and 4,500 pedestrians travelled westbound
- The majority of users of the Devonshire Street Tunnel passed through the ticket gates at the southern end of Central Station.

The Central Station precinct currently has a shared off-road cycle path along Chalmers Street and throughout Prince Alfred Park and Belmore Park. As part of the City Centre Access Strategy, a new cycle path on Castlereagh Street, connecting to Chalmers Street and Liverpool Street has recently opened. Free bicycle parking is available at the Goulburn Street car park operated by the City of Sydney.

Public transport services

Central Station is located at the southern end of the Sydney CBD, and is the busiest station in NSW. Central Station is the primary destination for intercity services with the majority of these services terminating at Central Station. Central Station is a major interchange hub between rail, light rail, bus and coach services. Eddy Avenue, Chalmers and Elizabeth streets, and Railway Square experience high volumes of bus traffic throughout the day.

Central Station currently provides a number of underground pedestrian connections, running mainly east-west, providing interchange connectivity between platforms. These underground pedestrian connections currently experience high pedestrian volumes.

Traffic volumes and patterns

The existing traffic volumes on the surrounding road network are provided in Table 8-13. Currently there are very high volumes on all nearby major roads including on George Street and Regent Street. In the evening peak, Elizabeth Street (southbound) experiences similarly high volumes.

Cleveland Street is a major east-west arterial route that allows vehicles to by-pass George Street and the Sydney CBD. As such, a large number of vehicles currently travel from Cleveland Street (eastbound) to Elizabeth Street (northbound) via Chalmers Street. A corresponding movement is evident in the southbound direction as vehicles turn right from Elizabeth Street (southbound) into Cleveland Street.

Currently, a number of intersections near the Central Station construction sites operate near, at or over capacity particularly in the AM peak period. These include:

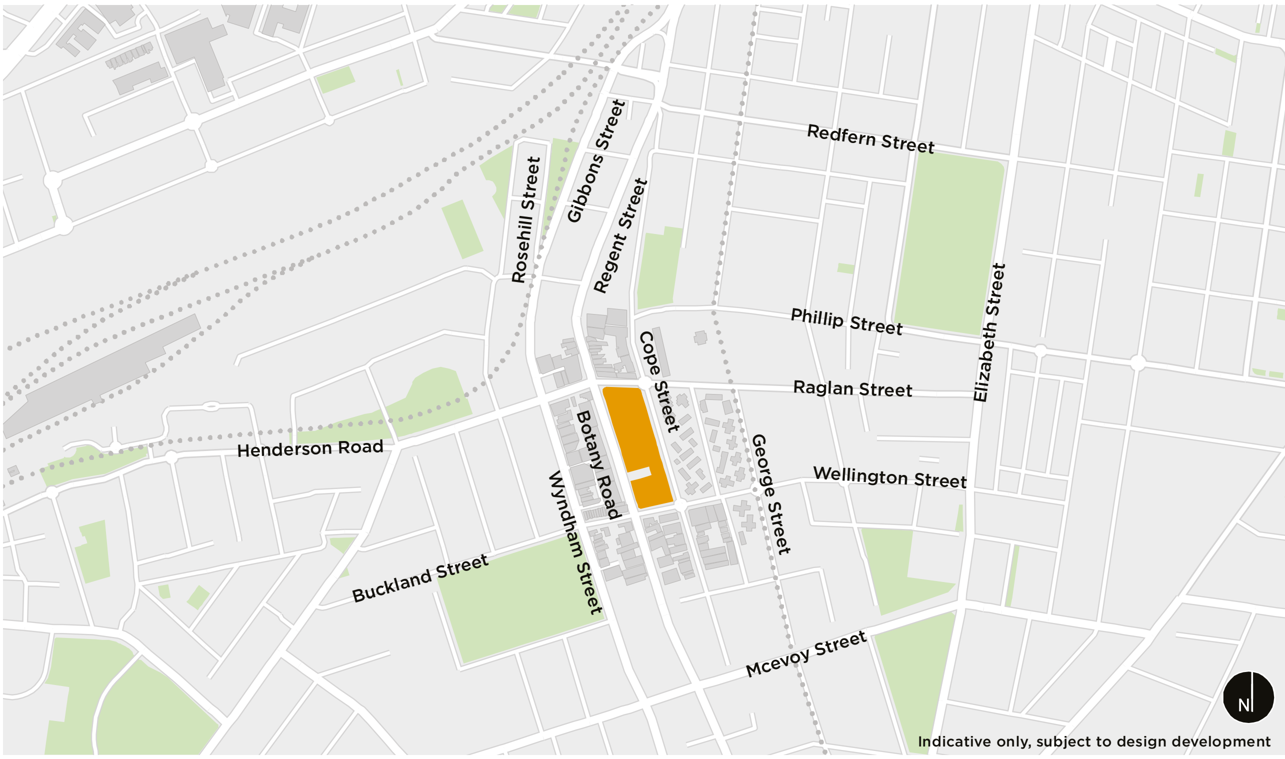
- George Street / Pitt Street / Lee Street / Quay Street (AM peak)
- Pitt Street / Eddy Avenue / Rawson Parade (AM peak)
- Chalmers Street / Cleveland Street (AM peak and PM peak)
- Regent Street / Cleveland Street (AM peak and PM peak)
- Cleveland Street / South Dowling Street (AM peak and PM peak).

Table 8-13 Central existing traffic volumes

Road	Direction	AM peak hour (vehicles per hour)	PM peak hour (vehicles per hour)
George Street Between Pitt Street and Harris Street	Northbound	1,730	1,340
	Southbound	890	1,480
Regent Street Between Kensington Street and Lee Street	Northbound	780	550
	Southbound	1,560	2,000
Cleveland Street Between Regent Street and Chalmers Street	Eastbound	1,190	1,200
	Westbound	1,350	1,540
Chalmers Street Between Devonshire Street and Foveaux Street	Northbound	1,160	1,100
Elizabeth Street Between Devonshire Street and Foveaux Street	Southbound	1,040	1,520
Pitt Street Between George Street and Eddy Avenue	Northbound	1,410	1,150

8.3.11 Waterloo Station

Waterloo Station would be located on Cope Street between Raglan and Wellington Streets, Waterloo. The location of the construction site and the surrounding road network are shown on Figure 8-10.



KEY
Proposed construction site area
Existing suburban rail

Figure 8-10 Waterloo Station road network

Active transport network

Footpaths are located on all streets in the vicinity of the station location. Pedestrian refuges are located on all arms of the roundabouts at Cope and Ragland streets and Cope and Wellington streets and signalised crossing facilities are located at the intersections of Botany Road and Raglan Street and Botany Road and Wellington Street.

There is a short dedicated cycleway on Buckland Street between Botany Road and Wyndham Street in the westbound direction and a two-way dedicated cycleway on George Street. Cyclists may link these sections via Wellington Street on the southern boundary of the site.

Public transport services

Bus services currently operate along Cope Street, Wellington Street and Botany Road serving the Sydney CBD, Marrickville, Bondi Junction, Mascot, Matraville and Eastgardens.

There are bus stops located nearby on Botany Road, Cope Street, Raglan Street and Wellington Street.

Traffic volumes and patterns

The existing traffic volumes on the surrounding road network are provided in Table 8-14.

High traffic volumes are experienced during both AM and PM peak periods on Botany Road, Henderson Road and McEvoy Street. Botany Road and Wyndham Street operate as a north-south one-way pair between Cleveland Street and Henderson Road and provides a key link between

Sydney Airport and its surrounding suburbs to the Sydney CBD and inner west. High southbound volumes are currently experienced during AM and PM peak hours. McEvoy Street and Henderson Road both run east-west, providing a major link between the inner west and the Sydney CBD or eastern suburbs.

Currently, intersections to the north of the Waterloo Station construction site operate at a level of service C or better, except for:

- Regent Street / Lawson Square / Redfern Street (level of service D in the AM peak)
- Cleveland Street / Regent Street (level of service D in the AM peak)
- City Road / Cleveland Street (level of service F in the AM peak).

Three intersections to the south of the Waterloo Station construction site currently operate over capacity and with a level of service F. These are:

- Botany Road / Bourke Street / Bourke Road / O'Riordan Street (AM and PM peak)
- Botany Road / Coward Street (PM peak)
- Botany Road / Wentworth Avenue (AM peak).

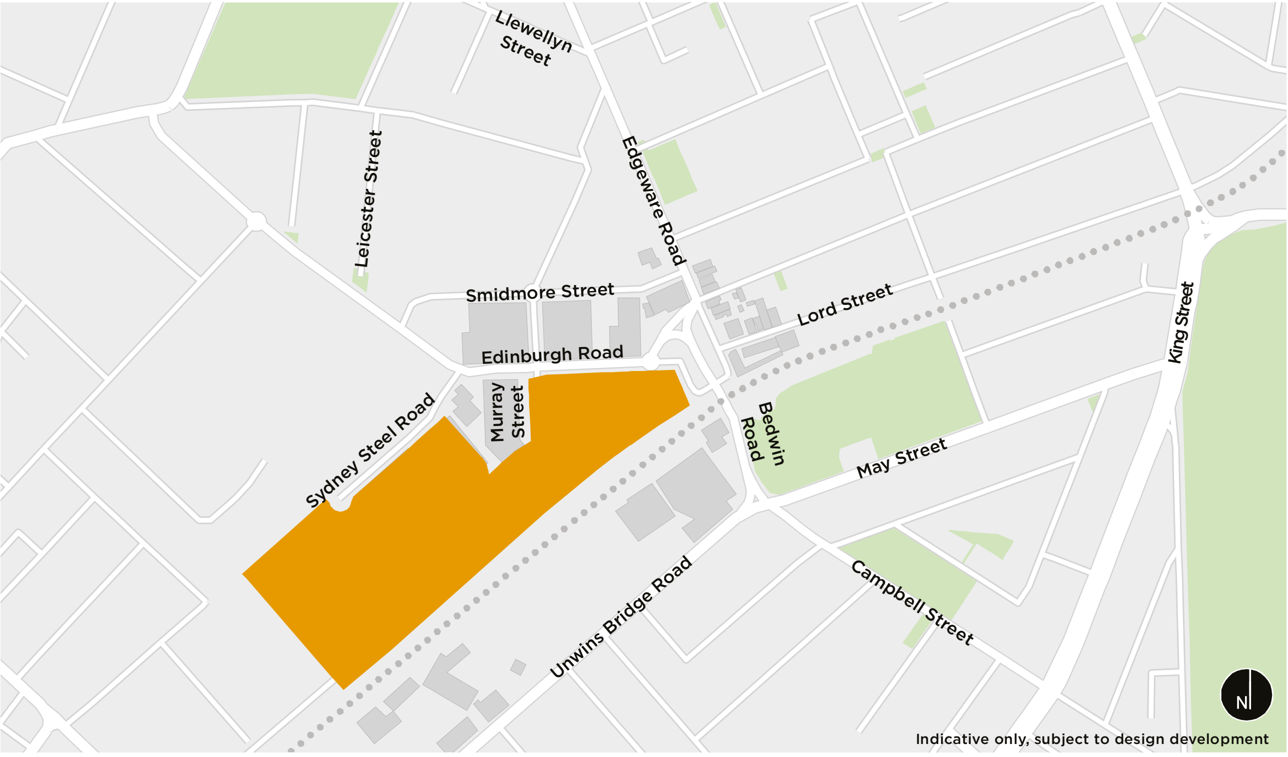
A number of other intersections along Botany Road, as well as the General Holmes Drive / Mill Pond Road intersection are also operating near or at capacity.

Table 8-14 Waterloo existing traffic volumes

Road	Direction	AM peak hour (vehicles per hour)	PM peak hour (vehicles per hour)
Botany Road **Between Mandible Street and McEvoy Street**	Northbound	870	840
	Southbound	1,030	1,070
Botany Road **Between McEvoy Street and Wellington Street**	Northbound	810	780
	Southbound	1,140	1,210
Botany Road **Between Wellington Street and Raglan Street**	Northbound	670	640
	Southbound	1,140	1,080
Wyndham Street **Between Henderson Road and Buckland Street**	Northbound	470	420
	Southbound	190	190
Henderson Road **Between Wyndham Street and Botany Road**	Eastbound	230	180
	Westbound	1,520	1,760
Henderson Road **West of Wyndham Street**	Eastbound	680	650
	Westbound	610	830
Buckland Street **Between Wyndham Street and Botany Road**	Eastbound	140	110
McEvoy Street **Between Wyndham Street and Botany Road**	Eastbound	790	730
	Westbound	960	1,200
Bourke Road **Between Wyndham Street and Botany Road**	Eastbound	360	410
	Westbound	400	390

8.3.12 Marrickville dive site (southern)

The Marrickville dive site would be located to the north of the T3 Bankstown Line; and adjacent to Murray Street, Edinburgh Road and Sydney Steel Road in Marrickville. The location of the construction site and the surrounding road network are shown on Figure 8-11.



KEY

Proposed construction site area · Existing suburban rail

Figure 8-11 Marrickville dive site (southern) road network

Active transport network

The area around the proposed site has well developed pedestrian connections. Edinburgh Road, Murray Road, Sydney Steel Road and Bedwin Road have paved footpaths on both sides of the street. Nearby Smidmore Street provides a pedestrian access route to Marrickville Metro Shopping Centre, while Lord Street provides access to St Peters Station. The nearest signalised pedestrian crossing is at Edinburgh Road / Smidmore Street to the west.

Edinburgh Road is also used as a cycle route to access St Peters Station from residential areas in Marrickville or to access Marrickville Metro Shopping Centre from St Peters, however heavy traffic, on-street parking and a large number of driveways to vehicle workshops make it less suitable than alternative direct routes on nearby Llewellyn Street and Leicester Street.

Public transport services

Several bus routes operate within the immediate vicinity of the site. These buses travel along Edinburgh Road and Edgeware Road, servicing Marrickville Metro Shopping Centre and terminating at Bondi Junction or the Sydney CBD. Services run every 20 to 30 minutes throughout the day on weekdays and weekends.

Traffic volumes and patterns

The existing traffic volumes on the surrounding road network are provided in Table 8-15.

The Princes Highway between May Street and Campbell Street experiences heavy traffic volumes southbound during the morning and evening peak periods. Bedwin Road also experiences high traffic volumes in both directions during the morning and evening peak hours.

Low traffic volumes were recorded on Campbell Street between Princes Highway and May Street since only a single lane is provided in each direction. Similarly, low traffic volumes were observed on Edinburgh Road between Edgeware Road and Murray Street.

Currently, all intersections in the vicinity of the Marrickville dive site operate at level of service D or better and the unsignalised intersections operate at level of service A. The worst performing are:

- Bedwin Road / Unwins Bridge Road / Campbell Street / May Street (level of service D in the AM peak and level of service C in the PM peak)
- Princes Highway / Capbell Street (level of service C in the AM and PM peak)
- Princes Highway / May Street (level of service C in the AM peak).

The signalised intersections of Princes Highway / Campbell Street and Bedwin Road / Unwins Bridge Road / Campbell Street / May Street currently operates at or over capacity.

The WestConnex project is located in close proximity to the Marrickville dive site and would involve the construction of a major road interchange at St Peters and associated local road upgrade works. This includes the proposed upgrade of Campbell Street between the Princes Highway and May Street. Construction of WestConnex is likely to occur concurrently with construction of this project. The potential cumulative traffic impacts associated with WestConnex are addressed in Chapter 26 (Cumulative impacts).

Table 8-15 Marrickville dive site existing traffic volumes

Road	Direction	AM peak hour (vehicles per hour)	PM peak hour (vehicles per hour)
Princes Highway Between May Street and Campbell Street	Southbound	570	1,840
	Northbound	1,520	940
Campbell Street Between Princes Highway and May Street	Eastbound	390	390
	Westbound	170	270
May Street Between Princes Highway and Campbell	Eastbound	730	510
	Westbound	420	990
Bedwin Road Between May Street and Edinburgh Road	Southbound	830	870
	Northbound	890	1,060
Edinburgh Road Between Murray Street and Edgeware Road	Eastbound	330	380
	Westbound	400	570

8.4 Potential impacts

Potential construction traffic and transport impacts would primarily relate to the addition of trucks and cars to the road network surrounding the construction sites. The establishment and use of construction sites would also result in some direct and indirect impacts to pedestrian and cyclist facilities, public transport services and existing car parking.

8.4.1 Pedestrian, cyclist and motorist safety

The introduction of additional heavy vehicles to the network has the potential to result in safety impacts to pedestrians, cyclists and other motorists, especially where there is an increased likelihood for interaction with pedestrians and cyclists.

Key locations where pedestrian and cyclist safety issues may arise include:

- Construction site access and egress points where construction vehicles would interface with pedestrians using surrounding footpaths. This would be especially important in the Sydney CBD where high volumes of pedestrians are expected
- Construction sites where access and egress points, or haul routes would interface with marked cycle routes. This would occur at Chatswood dive site, Victoria Cross, Crows Nest, Blues Point, Barangaroo, Pitt Street, Central, Waterloo and Marrickville dive site
- Locations where footpath widths are reduced around the construction sites
- At Victoria Cross Station construction site where the haul route or haul routes would be located near the Monte Sant' Angelo Mercy College and could interface with school drop off and pick up points, or the route for school children from nearby bus stops. Further information on potential construction traffic issues around this school are provided in Section 8.4.9.

Access and egress arrangements at construction sites have been developed with consideration for pedestrian, cyclist and motorist safety. For example, the need for construction vehicles to turn right to or from arterial roads to access construction sites has been avoided where possible.

Appropriate controls would be established where vehicles are required to cross footpaths to access construction sites. This may include manual supervision, physical barriers or temporary traffic signals as required. Safety audits would be carried out at each of the construction site traffic access and egress points.

In addition, the Sydney Metro project is currently investigating options to further enhance pedestrian, cyclist and motorist safety in the vicinity of construction sites. This would include measures such as:

- Use of speed awareness signs in conjunction with variable message signs near construction sites to provide alerts to drivers
- Shared experience educational events that allow pedestrians, cyclists or motorists to sit in trucks and understand the visibility restrictions of truck drivers, and for truck drivers to understand the visibility from a bicycle
- Specific construction driver training to understand route constraints, expectations, safety issues and to limit the use of compression braking
- Safety devices on construction vehicles that warn drivers of the presence of a vulnerable road user located in the vehicles' blind spots and warn the vulnerable road user that a vehicle is about to turn.

8.4.2 Emergency services access

As identified in the following sections, the introduction of construction traffic is anticipated to result in minor to negligible impacts to surrounding intersection performance. As such, there is not anticipated to be any substantial change to emergency vehicle access during the construction period. Further, construction sites would be arranged to ensure emergency vehicle access to nearby buildings and precincts is maintained. Construction sites may also be made available for emergency vehicle passage if required.

Ongoing consultation would be carried out with emergency service providers in relation to changed traffic conditions around the construction sites.

8.4.3 Major special events

The Sydney CBD hosts a number of major special events as identified in Table 8-16.

Table 8-16 Major special events in the Sydney CBD

Indicative month	Event	Location
December / January	New Year's Eve celebrations	Primarily Circular Quay, Blues Point and Barangaroo areas. Whole Sydney CBD would be affected.
January	Field Day	The Domain
January	Sydney Festival	Sydney CBD
January	Australia Day celebrations	Primarily Sydney Harbour foreshore areas
February	Opera in The Domain	The Domain
February	Tropfest	The Domain
March	Mardi Gras Parade / Party	Oxford Street and Hyde Park area
April	ANZAC Day Parade	Martin Place, Pitt Street, George Street, Bathurst Street, Elizabeth Street and Hyde Park
May	Mother's Day Classic	Martin Place, Hyde Park and The Domain
May / June	Vivid Festival	Sydney CBD and Chatswood
June	Sydney Film Festival	Sydney CBD
July	Reserve Forces Day	Macquarie Street
August	City 2 Surf	Hyde Park, Park Street and William Street
September	Sydney Marathon	Milsons Point, Circular Quay, Sussex Street, Macquarie Street, Phillip Street, The Domain, Hyde Park, Oxford Street and Darling Harbour
October	Sydney Spring Cycle	Milsons Point, Barangaroo, Cahill Expressway and Sussex Street
November	Sydney to Gong	Sydney Park
December	Carols in The Domain	The Domain

In addition, there are various events within the Moore Park Entertainment precinct throughout the year (such as sporting events and music concerts) with Central Station being a major transport focus for access to and from these events. Where there would be a forecast attendance of over 25,000 people within the Moore Park Entertainment precinct, these events would also be included within construction planning and management.

The Roads and Maritime special events management guidelines identify the following classes of special events:

- Class 1: an event that impacts major traffic and transport systems and there is significant disruption to the non-event community. For example, an event that affects a principal transport route in Sydney such as the Mardi Gras Parade and City 2 Surf
- Class 2: is an event that impacts local traffic and transport systems and there is low scale disruption to the non-event community. For example, an event that blocks off the main town street or shopping centre but does not impact a principal transport route
- Class 3: is an event with minimal impact on local roads and negligible impact on the non-event community
- Class 4: is an event conducted entirely under Police control (but is not a protest or demonstration).

Liaison would occur with event organisers of Class 1 and 2 events, and (as relevant) the CBD Coordination Office and Roads and Maritime Services to provide appropriate management of construction vehicle movements to manage potential impacts to event goers, the general public and the construction works. This may involve measures such as temporary adjustment to haul routes, working hours or potentially stopping works for the duration of the event.

8.4.4 Construction worker parking

Due to the generally constrained nature of the construction sites, car parking for construction workers would not be provided at the majority of the sites. With the exception of the Chatswood and Marrickville dive sites, each construction site would typically provide between four to ten parking spaces intended to be used by engineers and other construction management staff.

The majority of the construction sites are located in close proximity to public transport services and construction workers would be encouraged to use these services. This may include incentive systems. The Chatswood dive site and the Marrickville dive site would each provide about 300 car parking spaces. These facilities may be used to provide worker parking and shuttle bus transfers to other nearby construction sites.

In addition, consideration would be given to remote car parking in existing under-used car parks and shuttle bus transfers to the construction sites. For the Sydney CBD construction sites these car parks could include The Domain, Goulburn Street and Darling Harbour.

8.4.5 Power supply routes

The majority of the power supply routes would be constructed by trenching within the road reserve. Roads which are likely to be impacted by the construction of the power supply routes are identified in Chapter 7 (Project description – construction). Where major roads are crossed by the route (such as Mowbray Road for the Chatswood dive site power supply), alternative construction methods would be used such as under boring in order to avoid impacts to the road network.

This trenching work would result in temporary changes to traffic arrangements potentially including the occupation of traffic lanes, parking areas or the footpath.

For the majority of the construction period two-way traffic would be maintained, however there may be some periods when full road or lane closures are required. These are most likely to occur at night when traffic volumes are lower. Where pedestrian footpaths are impacted, a suitable alternative route around the work area would be provided and signposted.

In addition, the work may result in reduced access to some properties for short periods of time (typically less than one day). In this event, suitable alternative arrangements would be discussed with the land owner.

As the works would progress along the power supply route alignment, the potential impacts in a particular location would be short-lived, typically occurring for up to two weeks.

8.4.6 Chatswood dive site (northern) and northern surface works

Vehicle movement forecasts and routes

The anticipated vehicle numbers (heavy and light vehicles) at the Chatswood dive site over a typical day are provided in Figure 8-12. This graph shows that the peak heavy vehicle movements in the AM peak period (7am to 10am) would be six heavy vehicles per hour during the demolition, dive excavation and tunnel excavation phases.

The proposed haul routes are shown in Figure 8-13. Access to and egress from the site would be right in from Nelson Street; and left in, right out via Mowbray Road at a new signalised intersection.

In addition, access to the northern surface track works site (metro tracks and the adjustments to the T1 North Shore Line) would be provided by existing access points on Hopetoun Avenue, Chatswood and Drake Street, Artarmon as well as a proposed new access point at Brand Street, Artarmon. It is anticipated that there would be about six vehicles per hour using these access and egress points on an occasional basis to carry out construction of the northern surface works. This volume is relatively minor and would not result in impacts to the performance of the surrounding road network.

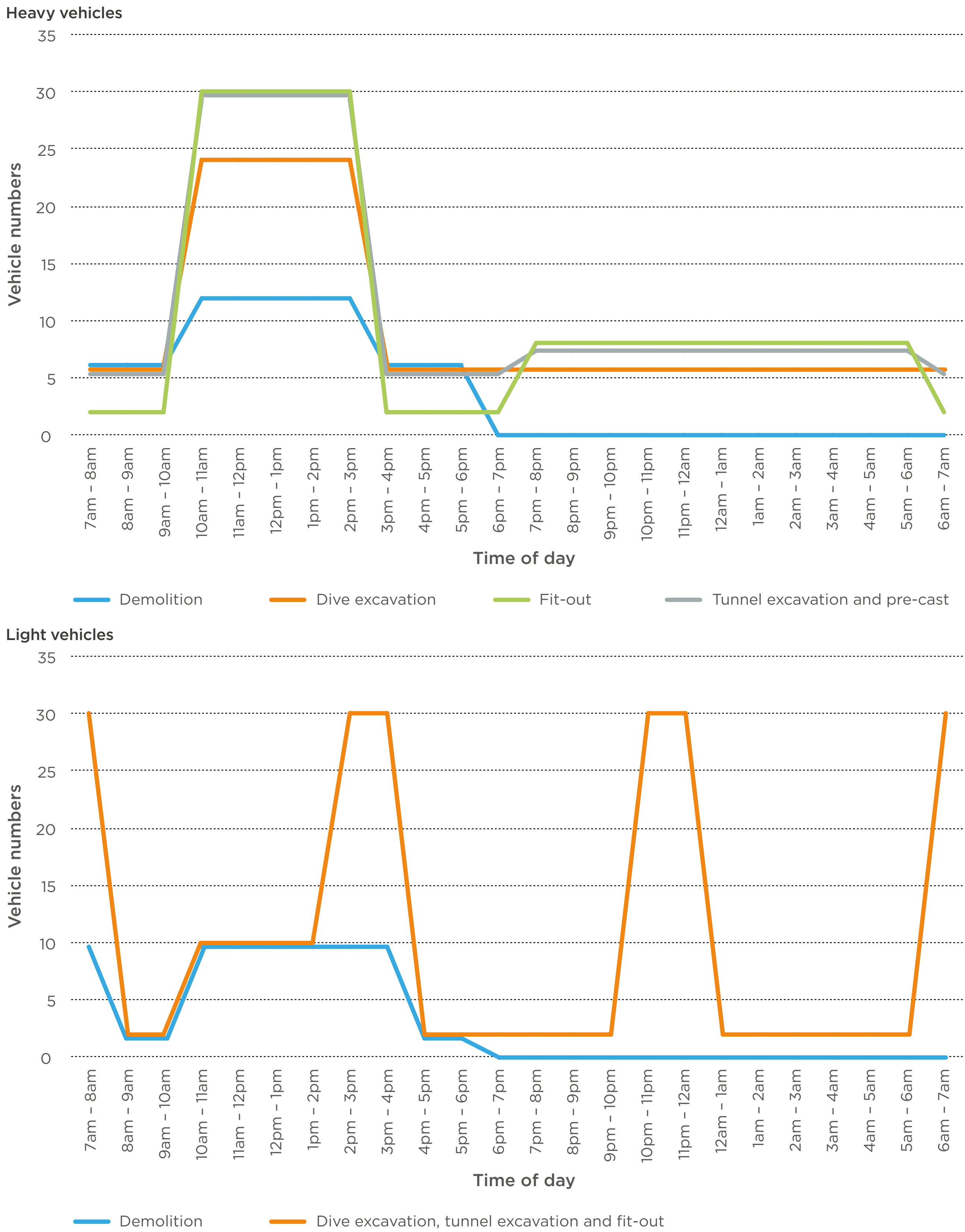


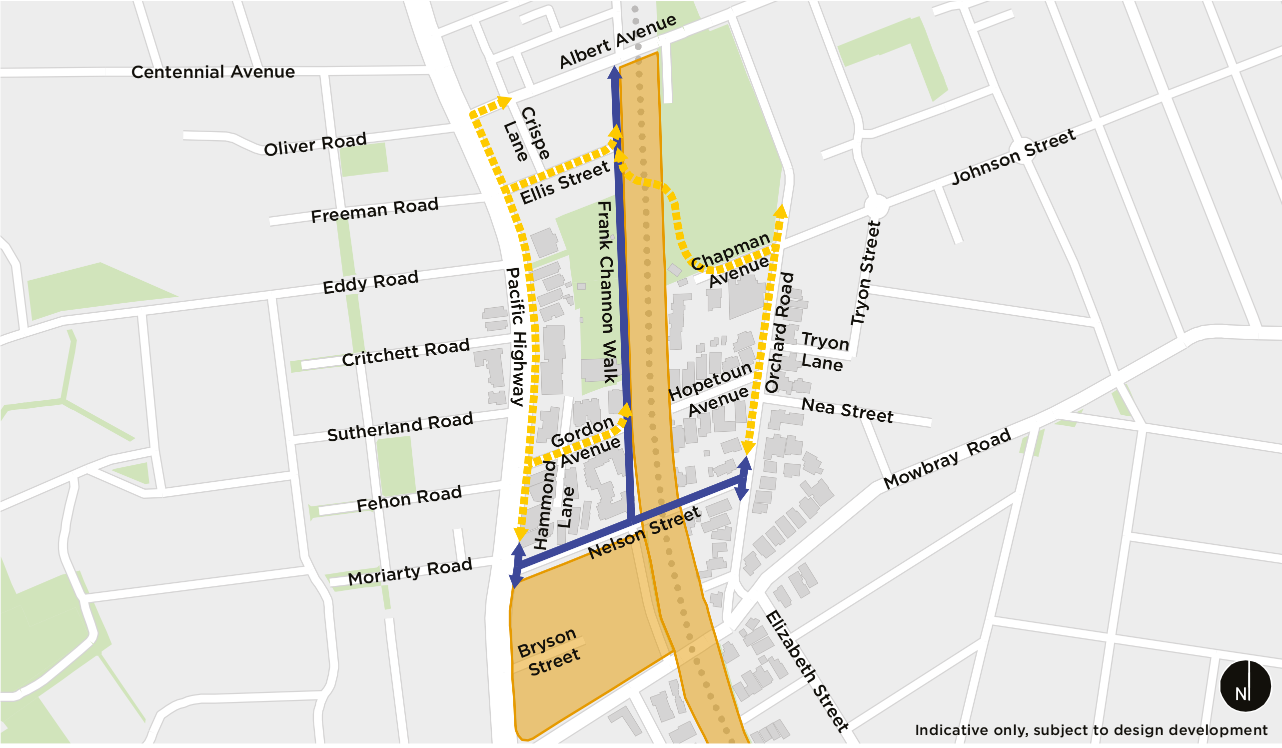
Figure 8-12 Chatswood dive site (northern) construction vehicle movements

Figure 8-13 Chatswood dive site (northern) haul routes

Active transport network

The closure of the Nelson Street bridge would remove the east-west cyclist and pedestrian connections across the T1 North Shore Rail Line. Pedestrians and cyclists would be able to use Mowbray Road to cross the rail line or Frank Channon Walk (a shared path connecting Chatswood Station and Nelson Street) and the underpass adjacent to Chatswood Oval. For a pedestrian or cyclist travelling between Chatswood Station and residential areas to the south, this would result in an additional travel distance of around 50 to 100 metres.

Short-term temporary closures of Frank Channon Walk would be required to safely carry out construction of the northern surface track works. These closures would typically occur over several weekends associated with work carried out during track possessions. During these periods, pedestrians and cyclists would need to use either the Pacific Highway or Orchard Road to access Chatswood Station from areas to the south. Alternative pedestrian and cyclist routes during the temporary closures of Frank Channon Walk are shown on Figure 8-14.



KEY

Proposed construction site area

Existing pedestrian and cycle route

Alternate pedestrian and cycle route during construction

Figure 8-14 Chatswood dive site (northern) – alternative pedestrian and cyclist routes

Public transport services

The southbound bus stop located on the Pacific Highway between Bryson Street and Mowbray Road may need to be relocated during the construction phase. The relocation of this bus stop would be carried out by Transport for NSW in consultation with the bus operators, Roads and Maritime Services and Willoughby Council. The relocation of this bus stop would not impact on the operation of any bus services, however it may result in some passengers having to walk a short distance further to access an alternative bus stop.

The surface track works (adjustment to the T1 North Shore Line and the metro tracks) would require some works to be carried out during rail track possessions. These works would be coordinated with the Sydney Trains rail track possession schedule and possessions required for the conversion of the Epping to Chatswood Rail Line to reduce impacts to customers and alternative bus services would be provided during these possession works.

Parking and taxis

The Chatswood dive site and the northern surface track works are not anticipated to result in any loss of parking or impacts to taxi facilities.

Road network performance

As described in Chapter 7 (Project description – construction), the project would require the permanent demolition of the Nelson Street bridge over the T1 North Shore Rail Line. Nelson Street's primary role is for motorists travelling southbound on the Pacific Highway to access Mowbray Road westbound via Orchard Road. Nelson Street also provides local vehicle access to residents of Nelson Street. To maintain the primary movement, it is proposed to construct an all vehicle right-turn movement from the Pacific Highway southbound to Mowbray Road westbound. For the purposes of the traffic assessment, two right turn lanes have been assumed, however the exact nature of this right turn provision would be determined during detailed construction planning. This would also require the localised widening of the Pacific Highway to the north of the Mowbray Road intersection and changes to the traffic signal phasing.

Roads and Maritime are currently investigating further upgrades to the Pacific Highway / Mowbray Road intersection. Sydney Metro would continue to consult with Roads and Maritime Services in relation to coordination of these works and any opportunities to carry out these works concurrently.

Table 8-17 and Figure 8-15 shows the existing performance and the anticipated performance of key intersections during construction. This shows that a number of intersections currently experience long delays and a poor level of service due to high through traffic volumes and conflicting right-turn movements. With construction traffic, there would be a minor increase in the degree of saturation and the average delay at some intersections, but no change to the level of service in the peak periods. Overall, the addition of construction traffic would not have any major impacts on surrounding intersection performance.

Table 8-17 Chatswood dive site (northern) intersection performance

Peak period	Without construction			With construction		
	Average delay (second per vehicle)	Level of Service	Degree of saturation	Average delay (second per vehicle)	Level of Service	Degree of saturation
Pacific Highway / Fuller Road / Help Street						
AM	83	F	1.14	83	F	1.14
PM	39	C	0.93	41	C	0.95
Pacific Highway / Victoria Avenue						
AM	101	F	0.90	101	F	0.90
PM	87	F	0.77	83	F	0.78
Pacific Highway / Centennial Avenue						
AM	17	B	0.89	18	B	0.89
PM	23	B	0.89	21	B	0.89
Pacific Highway / Albert Avenue / Oliver Road						
AM	24	B	0.75	23	B	0.74
PM	29	C	0.94	29	C	0.94
Pacific Highway / Mowbray Road						
AM	72	F	1.06	81	F	1.07
PM	119	F	1.14	142	F	1.18
Pacific Highway / Howarth Road / Norton Lane						
AM	5	A	0.59	6	A	0.62
PM	8	A	0.75	8	A	0.75
Pacific Highway / Gore Hill Freeway ramps						
AM	77	F	1.12	76	F	1.12
PM	74	F	1.13	75	F	1.13
Pacific Highway / Longueville Road						
AM	31	C	0.83	32	C	0.80
PM	27	B	0.77	27	B	0.75
Mowbray Road / Orchard Road / Elizabeth Street						
AM	49	D	1.02	49	D	1.02
PM	45	D	0.84	44	D	0.84
Mowbray Road / Hampden Road / Site Access						
AM	25	B	0.80	25	B	0.79
PM	25	B	0.71	25	B	0.69

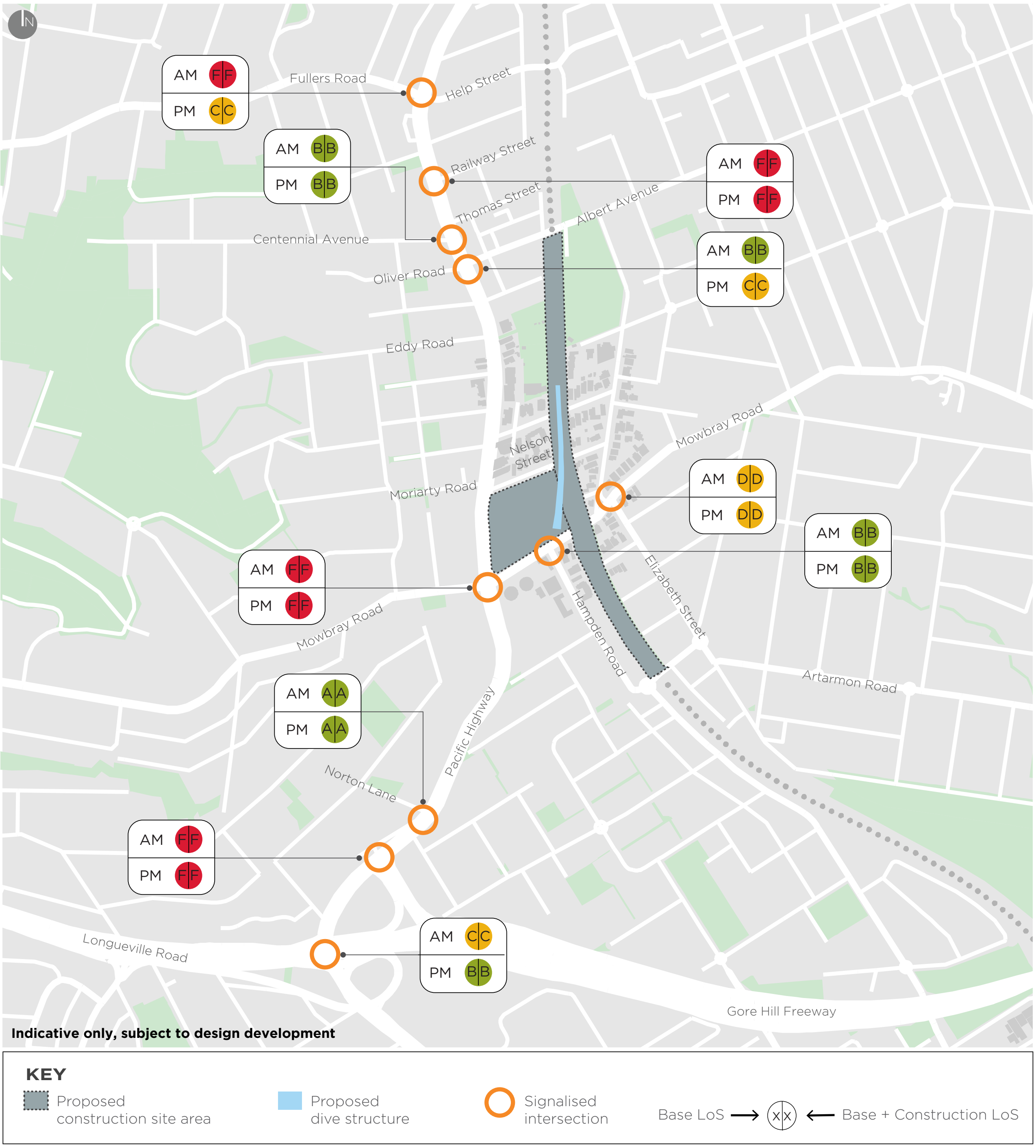


Figure 8-15 Chatswood dive site (northern) intersection performance

8.4.7 Artarmon substation

Vehicle movement forecasts and routes

The anticipated vehicle numbers (heavy and light vehicles) at the Artarmon substation construction site over a typical day are provided in Figure 8-16. This graph shows that the peak heavy vehicle movements in the AM peak period (7am to 10am) would be four heavy vehicles per hour during the site establishment and excavation phases.

The proposed haul routes are shown in Figure 8-17. Access to and egress from the site would be via Barton Road.

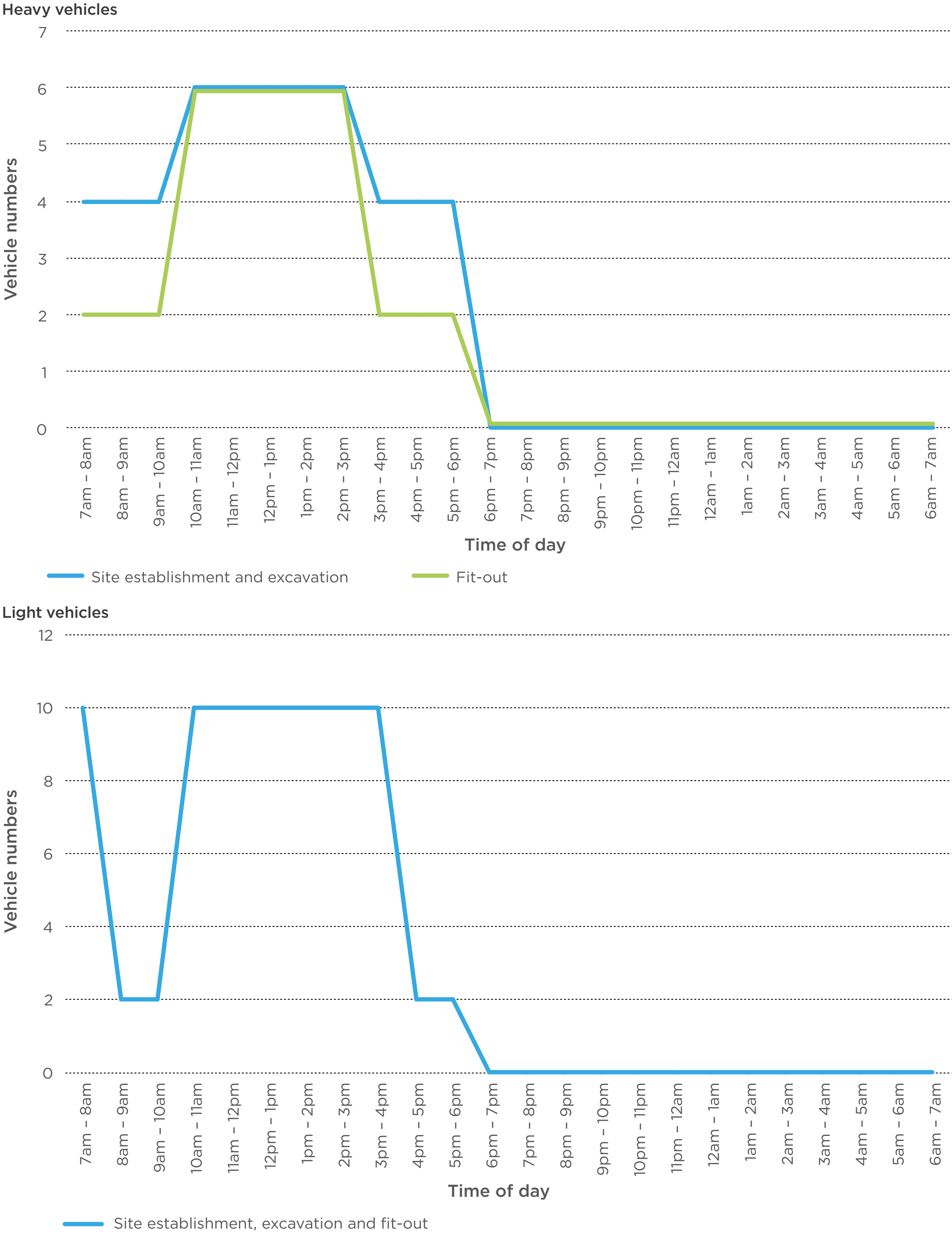


Figure 8-16 Artarmon substation construction vehicle movements

Figure 8-17 Artarmon substation construction site haul route

Active transport network

The Artarmon substation construction site is not anticipated to result in any impacts to nearby pedestrian footpaths or crossings. There are no cyclist facilities in the vicinity of the site.

Public transport services

As the Artarmon Loop only provides services every 30 minutes and the impact of construction vehicles at Artarmon substation is anticipated to be minor, any impacts to this service would be negligible.

Parking and taxis

The Artarmon substation construction site is not anticipated to result in any loss of parking or impacts to taxi facilities.

Road network performance

Table 8-18 and Figure 8-18 shows the existing performance and the anticipated performance of key intersections during construction. The intersection of Reserve Road / Gore Hill Freeway is expected to deteriorate from level of service B to level of service C in the PM peak period however the deterioration in the average delay and degree of saturation would be minimal therefore no significant impact is expected at this location. All other intersections maintain their without construction level of service.

Table 8-18 Artarmon substation construction site intersection performance

Peak period	Without construction			With construction		
	Average delay (second per vehicle)	Level of Service	Degree of saturation	Average delay (second per vehicle)	Level of Service	Degree of saturation
Reserve Road / Gore Hill Freeway ramps						
AM	25	B	0.93	25	B	0.93
PM	28	B	0.93	31	C	0.98
Reserve Road / Barton Road						
AM	4	A	0.51	4	A	0.51
PM	6	A	0.63	6	A	0.65
Reserve Road / Butchers Lane						
AM	3	A	0.01	3	A	0.01
PM	4	A	0.01	4	A	0.01

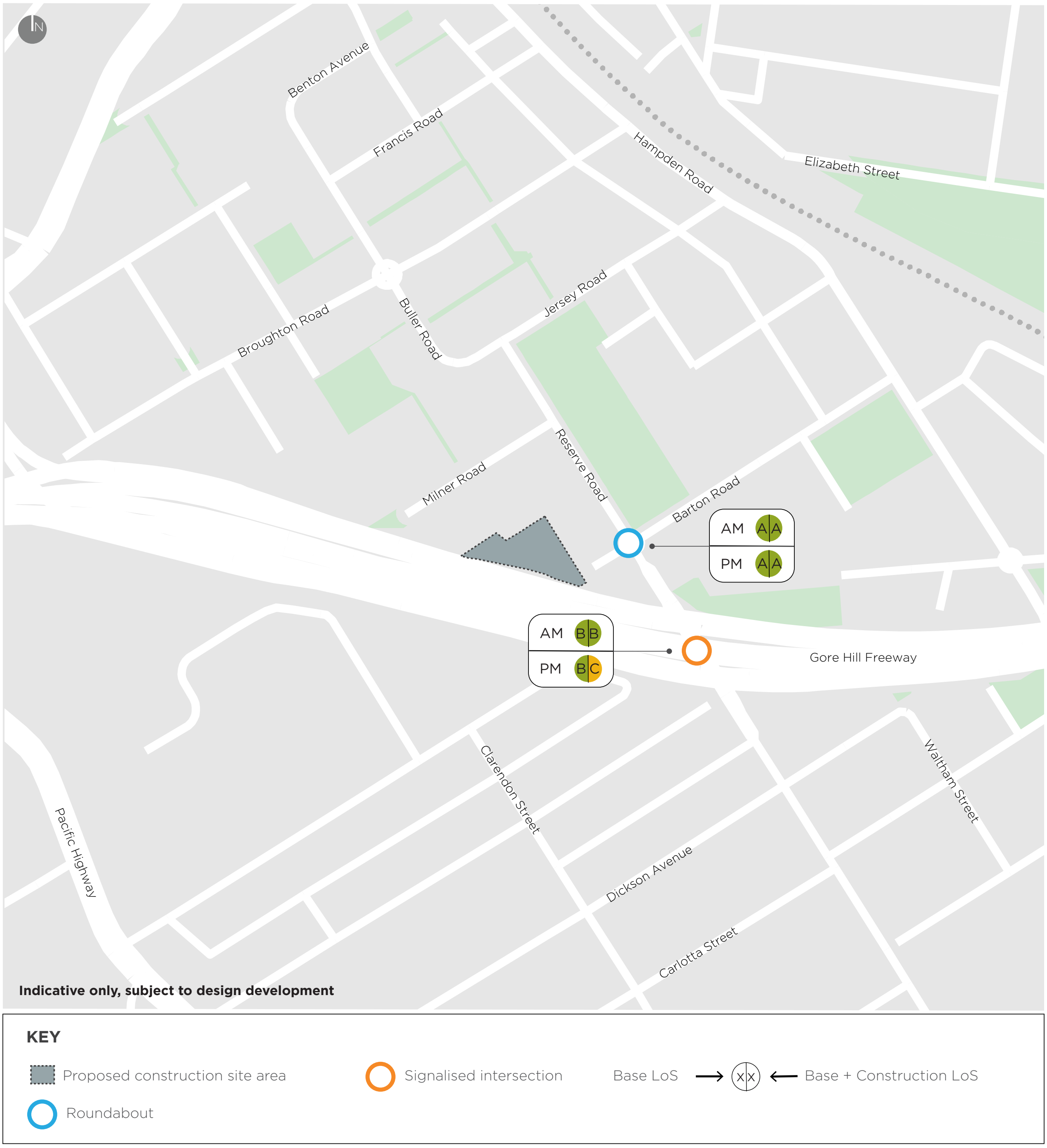


Figure 8-18 Artarmon substation intersection performance

8.4.8 Crows Nest Station

Vehicle movement forecasts and routes

The anticipated vehicle numbers (heavy and light vehicles) at the Crows Nest Station construction site over a typical day are provided in Figure 8-19. This graph shows that the peak heavy vehicle movements in the AM peak period (7am to 10am) would be five heavy vehicles per hour during the demolition and excavation phases.

The proposed haul routes are shown in Figure 8-20. Access to and egress from the site would be via Hume Street and Clarke Lane.

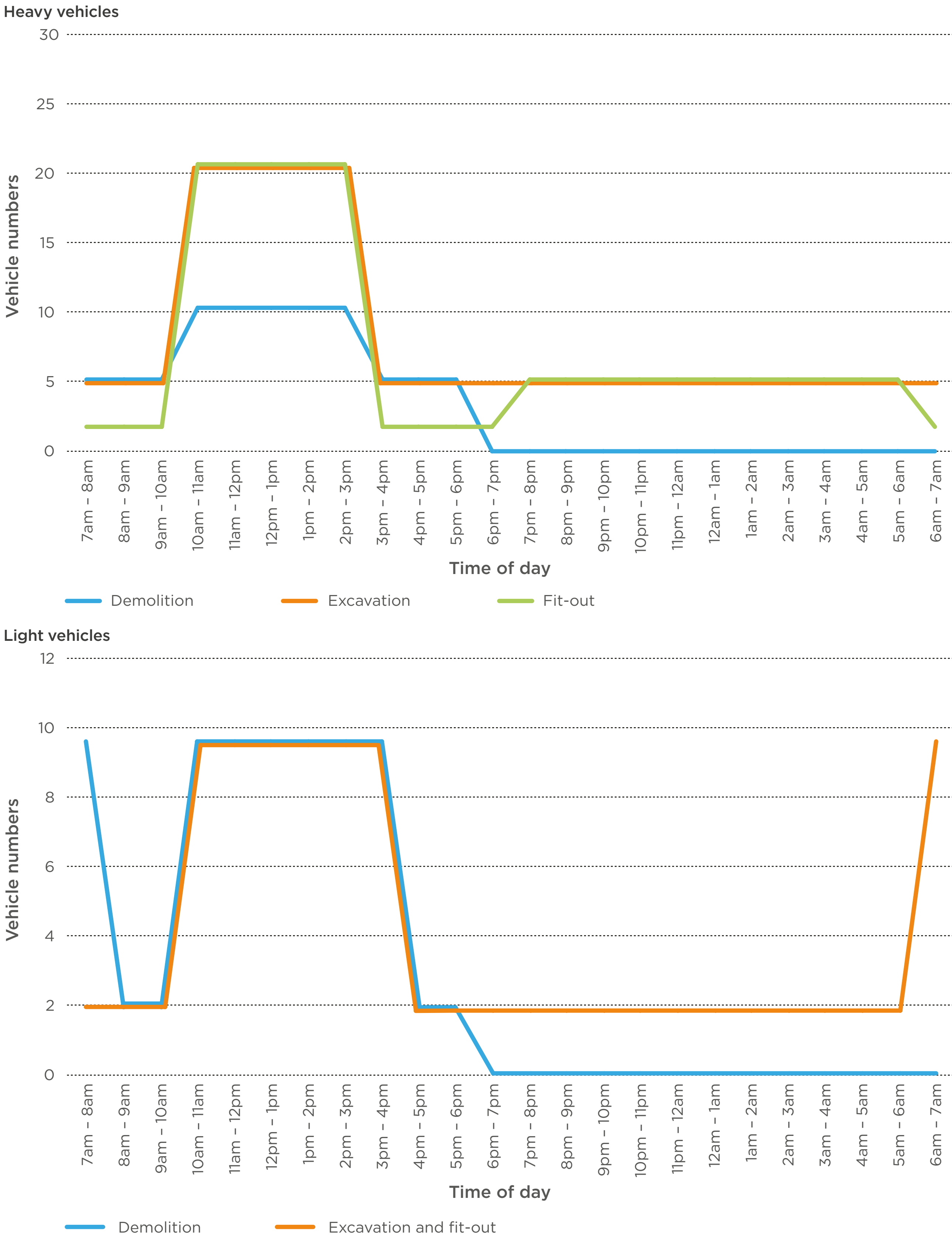


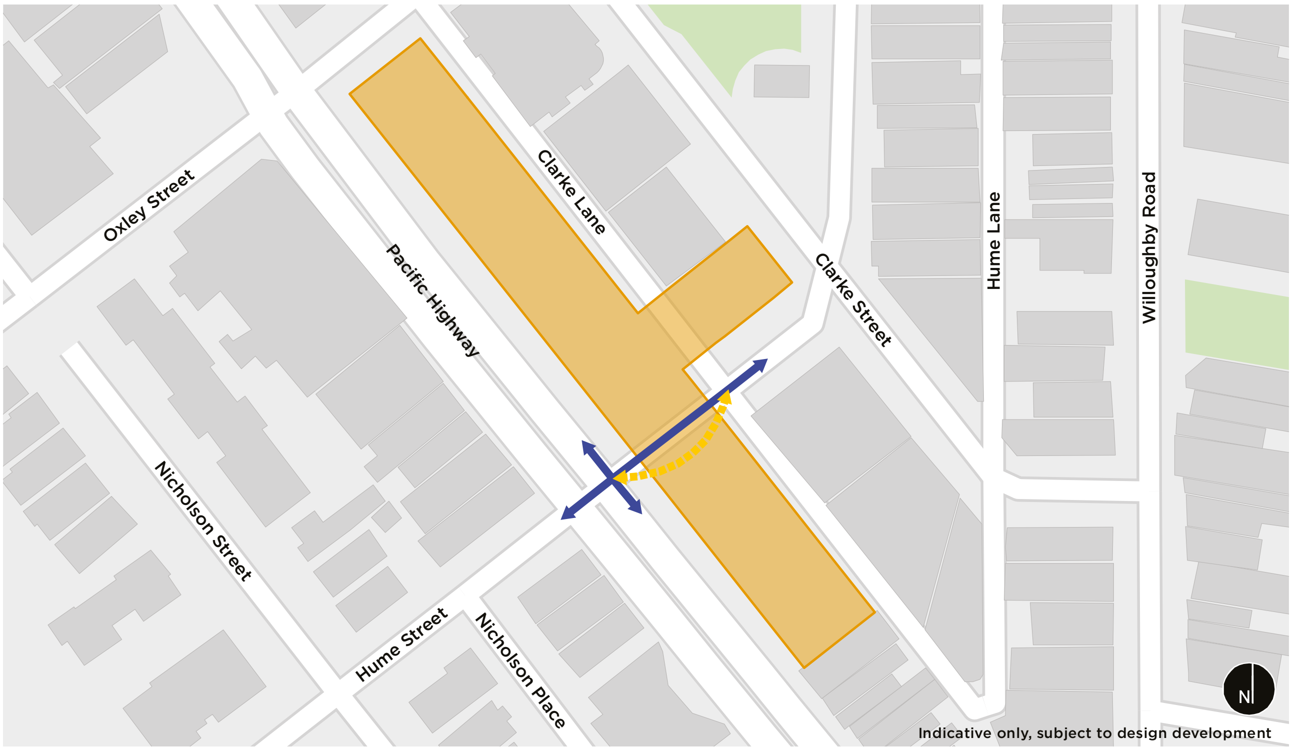
Figure 8-19 Crows Nest Station construction vehicle movements

Figure 8-20 Crows Nest Station construction site haul routes

Active transport network

Excavation of the station would involve the temporary closure of Hume Street (around six months) to carry out the cut-and-cover works. During this stage of the works, an alternate safe pedestrian and cyclist access would be provided to the south of Hume Street across the site of the previously demolished building. Alternative pedestrian and cyclist routes during the temporary closure of Hume Street are shown on Figure 8-21.

Additionally, footpaths surrounding the site on the Pacific Highway and Hume Street would be reduced in width by around 600 millimetres during the construction works. The existing footpath width is greater than three metres (building frontage to kerb), however, the footpath includes street furniture such as lighting poles and parking metres. A 2.4 metre footpath would be able to be maintained, in line with Austroads guidelines however some street furniture may need to be relocated.



KEY

Proposed construction site area

Existing pedestrian and cycle route

Alternate pedestrian and cycle route during construction

Figure 8-21 Crows Nest Station construction site – alternative pedestrian and cyclist route

Public transport services

A bus stop on the eastern side of the Pacific Highway north of Hume Street would need to be relocated during the construction works. The relocation of this bus stop would be carried out by Transport for NSW in consultation with the bus operators, Roads and Maritime Services and North Sydney Council. The relocation of this bus stop would not impact the operation of any bus services, however it may result in some passenger having to walk a short distance further to access the bus stop.

One bus service, route 265, may be impacted by delays due to construction activity and vehicle movements. This route currently runs along Oxley Street and continues to Willoughby Road, and operates on an hourly basis for most of the weekday, and every 30 minutes between 2:30 pm and 4:30 pm. Due to the limited frequency of the service, the construction traffic impact on this service would be negligible.

Parking and taxis

Around two to four on street car parking spaces on Hume Street would be removed for the duration of the construction phase. The temporary loss of up to four spaces would not have any major impacts on parking considering the proximity and availability of other spaces.

There is not anticipated to be any impacts to formal taxi facilities in the vicinity of Crows Nest Station construction site.

Road network performance

Excavation of the station would involve the temporary closure of Hume Street (around six months) to carry out the cut-and-cover works. During this period, vehicle access to Clarke Street and the remaining portion of Hume Street would be possible via Oxley Street. To maintain the movements available at the Hume Street an additional phase would be added to the Pacific Highway / Oxley Street intersection to allow a right turn movement from Oxley Street to the Pacific Highway northbound.

Construction works at this station would also require the closure of Clarke Lane in the area immediately to the north of its intersection with Hume Street. The remaining section of Clarke Lane would remain open and be converted to two way flow to retain access to the remaining properties on Clarke Street.

Table 8-19 provides the worst-case performance of nearby key intersections during the construction phase. This shows that all intersections would continue to function at a similar level as existing with construction activities.

Table 8-19 Crows Nest Station construction site intersection performance

Peak period	Without construction			With construction		
	Average delay (second per vehicle)	Level of Service	Degree of saturation	Average delay (second per vehicle)	Level of Service	Degree of saturation
Pacific Highway / Falcon Street / Shirley Road						
AM	51	D	0.86	51	D	0.86
PM	51	D	0.92	50	D	0.92
Pacific Highway / Hume Street						
AM	13	A	0.59	13	A	0.61
PM	12	A	0.61	13	A	0.64
Pacific Highway / Oxley Street						
AM	17	B	0.74	18	B	0.71
PM	21	B	0.74	22	B	0.77

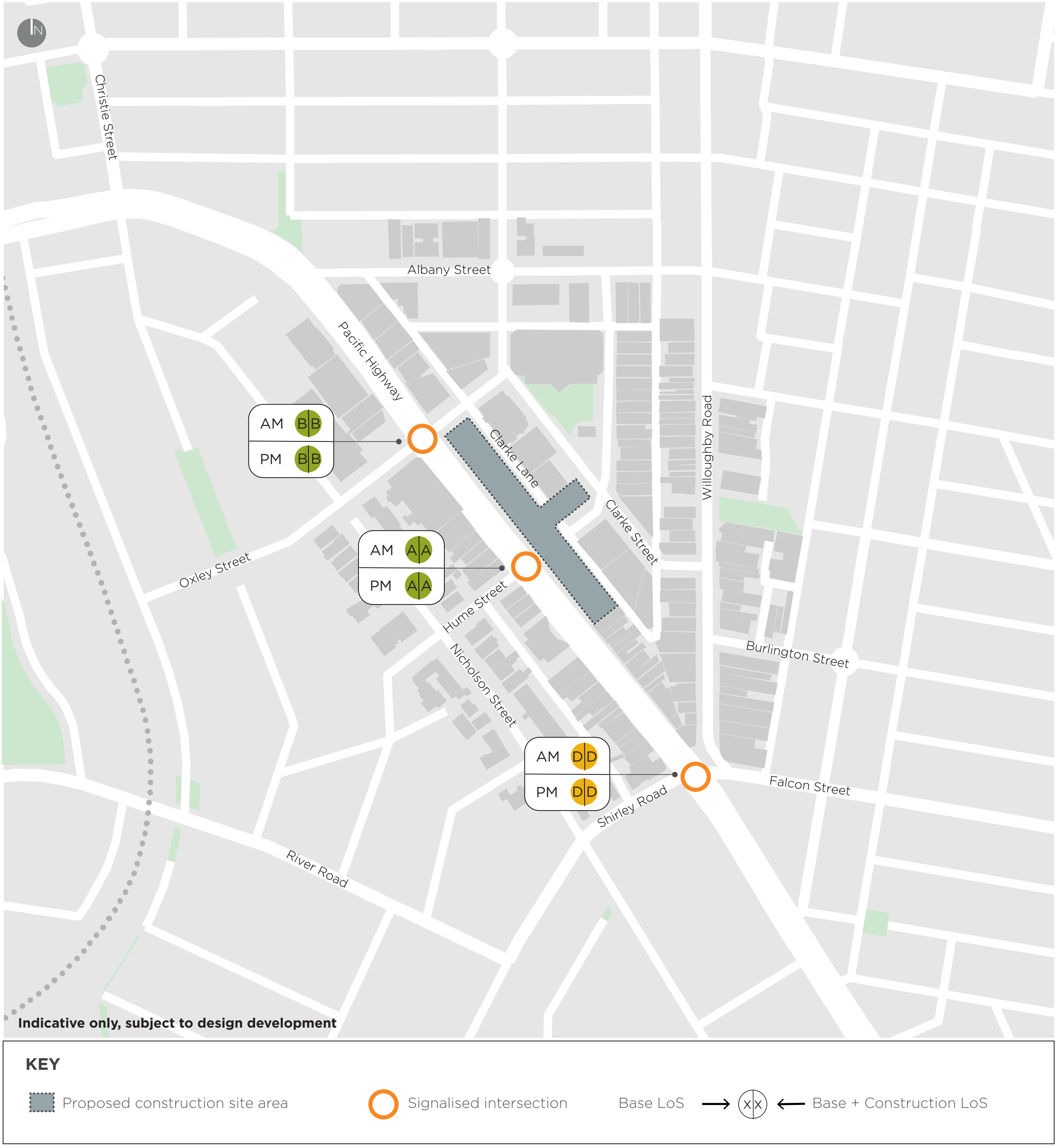


Figure 8-22 Crows Nest Station intersection performance

8.4.9 Victoria Cross Station

Vehicle movement forecasts and routes

The anticipated vehicle numbers (heavy and light vehicles) at the Victoria Cross Station construction site over a typical day are provided in Figure 8-23. This graph shows that the peak heavy vehicle movements in the AM peak period (7am to 10am) would be six heavy vehicles per hour during the demolition and excavation phases.

The proposed haul routes are shown in Figure 8-24. Access to and egress from the Victoria Cross north site would be left in, left out via Miller Street. Access to and egress from the Victoria Cross south site would be left in from Miller Street and left out to Denison Street.

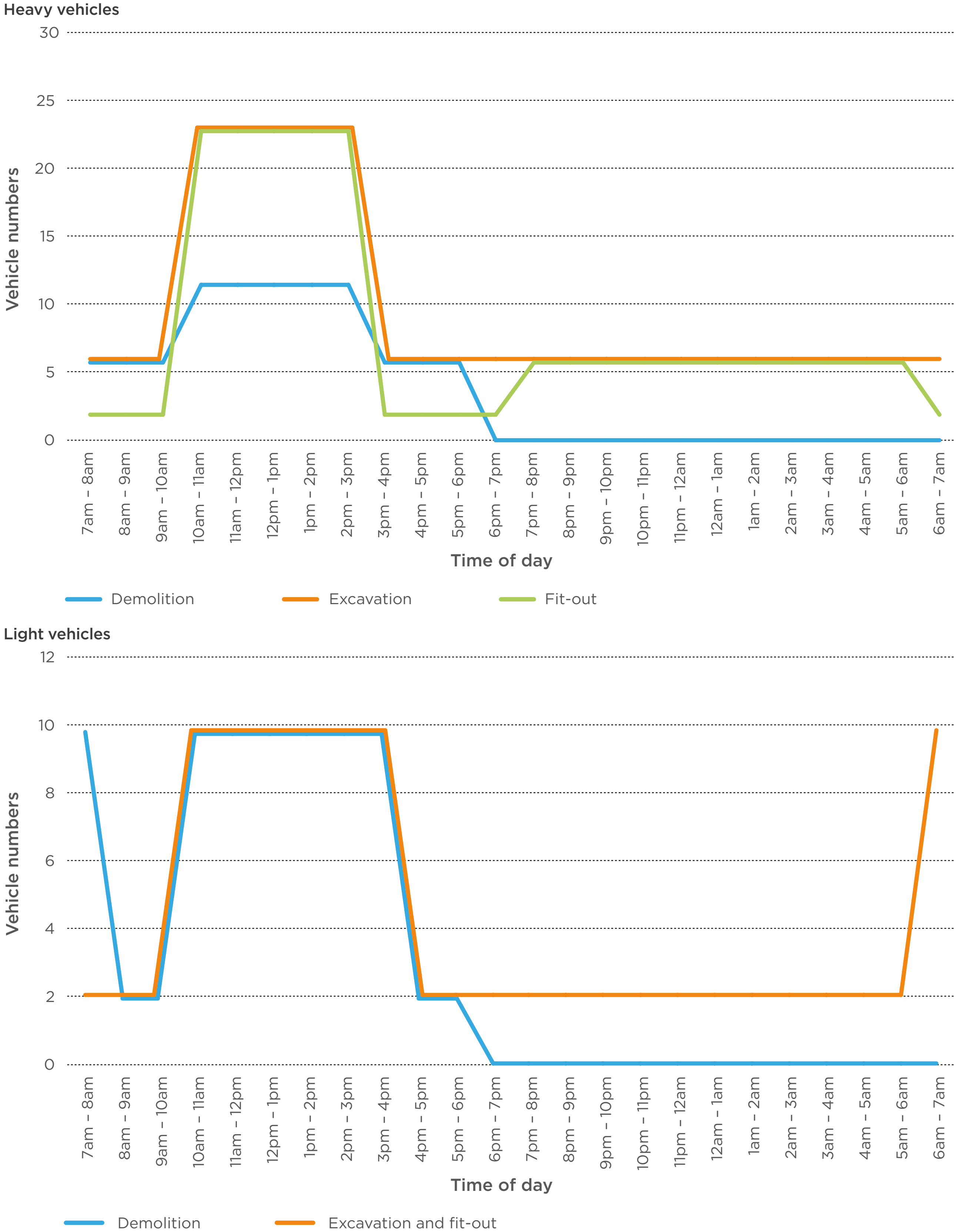


Figure 8-23 Victoria Cross Station construction vehicle movements

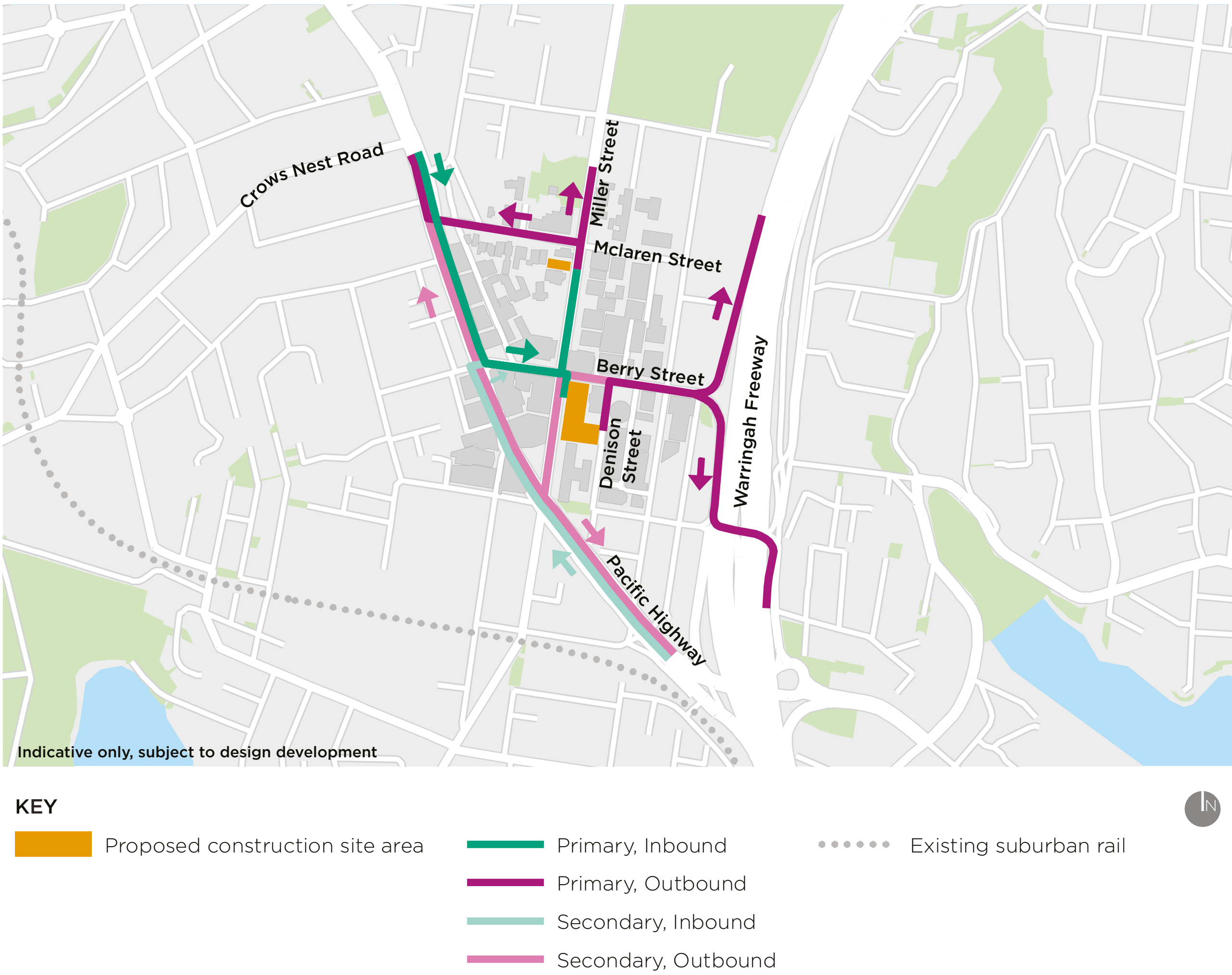


Figure 8-24 Victoria Cross Station construction site haul routes

Active transport network

The on-road amenity for cyclists along Miller Street and Berry Street would be reduced during the construction phase due to the introduction of heavy vehicle movements, although cyclists currently using this route share the road with vehicles and buses. Alternative cycle paths in the area include Mount and Edward streets on the western side of the Pacific Highway.

Pedestrian footpaths on Miller Street in the vicinity of each of the construction sites would be reduced in width by around 600 millimetres during the construction works. Miller Street, between the Pacific Highway and Berry Street, has a footpath width greater than three metres (building frontage to kerb), however, the footpath includes street furniture such as lighting poles and parking metres. A 2.4 metre footpath would be able to be maintained, in line with Austroads guidelines however some street furniture may need to be relocated. In the vicinity of the Victoria Cross north construction site, the existing footpath is around 3.6 metres wide and includes trees, street furniture and a bus stop. As this bus stop would be temporarily relocated as part of the construction works, a footpath width of 2.4 metres would be maintained.

Monte Sant' Angelo Mercy College is located close to the proposed construction sites on Miller Street. School children currently use footpaths around the sites to travel between public transport services and the school. School drop off area are also located close to the sites on Berry and Miller streets. Sydney Metro would consult with Monte Sant' Angelo Mercy College to ensure safe pedestrian and drop off arrangements are provided for school children during construction. In addition, haulage of materials to and from the construction site would be scheduled to minimise movements during school pick up and drop off times.

Public transport services

The bus stop on the south western corner of the Miller Street / McLaren Street intersection adjacent to the Victoria Cross north site would need to be relocated during the construction works. This bus stop is used by students attending Monte Sant' Angelo Mercy College. The relocation of this bus stop would be carried out by Transport for NSW in consultation with the bus operators, Roads and Maritime Services, North Sydney Council and Monte Sant' Angelo Mercy College. The relocation of this bus stop would not impact the operation of any bus services, however it may result in some passenger having to walk a short distance further to access the bus stop.

The addition of construction vehicles on Berry and Miller streets may result in some minor delays for bus services.

Parking and taxis

Around two to four on street car parking spaces on Miller Street would be removed during the construction phase. The temporary loss of up to four spaces would not have any major impacts on parking considering the proximity and availability of other spaces.

There is not anticipated to be any impacts to formal taxi facilities in the vicinity of the Victoria Cross Station construction sites.

Road network performance

Table 8-20 and Figure 8-25 shows the impacts of construction of nearby key intersections. In summary, this shows that the level of service at each intersection modelled does not deteriorate with the addition of the construction vehicles. Minor improvements in the average delay or degree of saturation are evident for some intersections which are likely to be the result of the model optimising the operation of the intersection with the additional construction traffic on certain movements.

Table 8-20 Victoria Cross Station construction site intersection performance

Peak period	Without construction			With construction		
	Average delay (second per vehicle)	Level of Service	Degree of saturation	Average delay (second per vehicle)	Level of Service	Degree of saturation
Pacific Highway / McLaren Street						
AM	17	B	0.85	16	B	0.85
PM	13	A	0.77	13	A	0.77
McLaren Street / Miller Street						
AM	25	B	0.75	25	B	0.78
PM	26	B	0.84	26	B	0.84

Peak period	Without construction			With construction		
	Average delay (second per vehicle)	Level of Service	Degree of saturation	Average delay (second per vehicle)	Level of Service	Degree of saturation
Pacific Highway / Berry Street						
AM	7	A	0.71	14	A	0.74
PM	11	A	0.80	11	A	0.79
Berry Street / Miller Street						
AM	27	B	0.81	24	B	0.78
PM	23	B	0.57	23	B	0.56
Pacific Highway / Miller Street						
AM	25	B	0.74	26	B	0.77
PM	27	B	0.78	27	B	0.78
Berry Street / Walker Street						
AM	31	C	0.84	31	C	0.85
PM	27	B	0.75	27	B	0.75
Pacific Highway / Walker Street						
AM	22	B	0.74	23	B	0.74
PM	21	B	0.65	21	B	0.65
Mount Street / Walker Street						
AM	19	B	0.64	19	B	0.65
PM	26	B	0.60	26	B	0.56
Arthur Street / Mount Street						
AM	10	A	0.68	10	A	0.66
PM	25	B	0.78	25	B	0.78
Miller Street / Ridge Street						
AM	15	B	0.44	16	B	0.50
PM	19	B	0.45	19	B	0.45
Miller Street / Carlow Street						
AM	27	B	0.79	26	B	0.79
PM	28	B	0.72	28	B	0.72
Falcon Street / Miller Street						
AM	30	C	0.93	31	C	0.82
PM	32	C	0.95	32	C	0.95
Falcon Street / Warringah Freeway ramps						
AM	32	C	0.90	32	C	0.90
PM	31	C	0.92	31	C	0.92

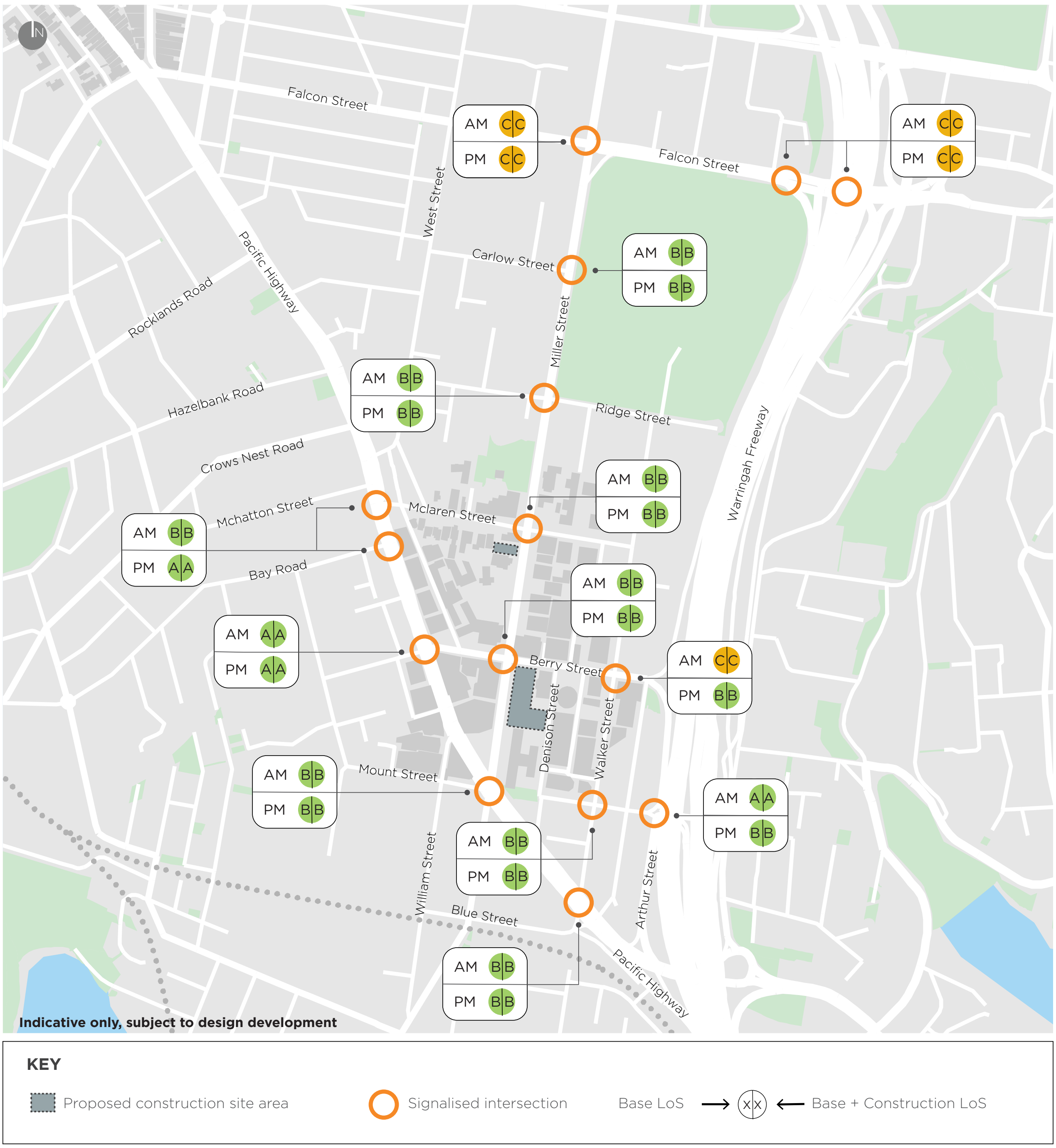


Figure 8-25 Victoria Cross Station intersection performance

8.4.10 Blues Point temporary site

As described in Chapter 7 (Project description – construction) the Blues Point temporary site would be used intermittently – firstly for site establishment and excavation of the shaft, and then on occasions for the retrieval of the cutter heads of tunnel boring machines. Site establishment and shaft excavation works would occur over a period of about 12 months and then the site would remain inactive until retrieval is required. Each retrieval would take about four weeks.

For each retrieval, construction vehicle numbers would be less and over a shorter duration compared to the site establishment and shaft excavation stage. As such, the traffic impacts associated with the site establishment and shaft excavation stage are considered to represent the worst-case at this site.

In addition, oversize vehicle movements would be required to transport the cutter heads of the tunnel boring machines away from the site. This is likely to occur mostly overnight to minimise the potential impacts to traffic on Blues Point Road.

Vehicle movement forecasts and routes

The anticipated vehicle numbers (heavy and light) at the Blues Point temporary site over a typical day are provided in Figure 8-26. This graph shows that the peak heavy vehicle movements in the AM peak period (7am to 10am) would be four heavy vehicles per hour during the shaft excavation phase.

The proposed haul routes are shown in Figure 8-27. Access to and egress from the Blues Point temporary site would be left in from Blues Point Road and left out to Henry Lawson Drive.

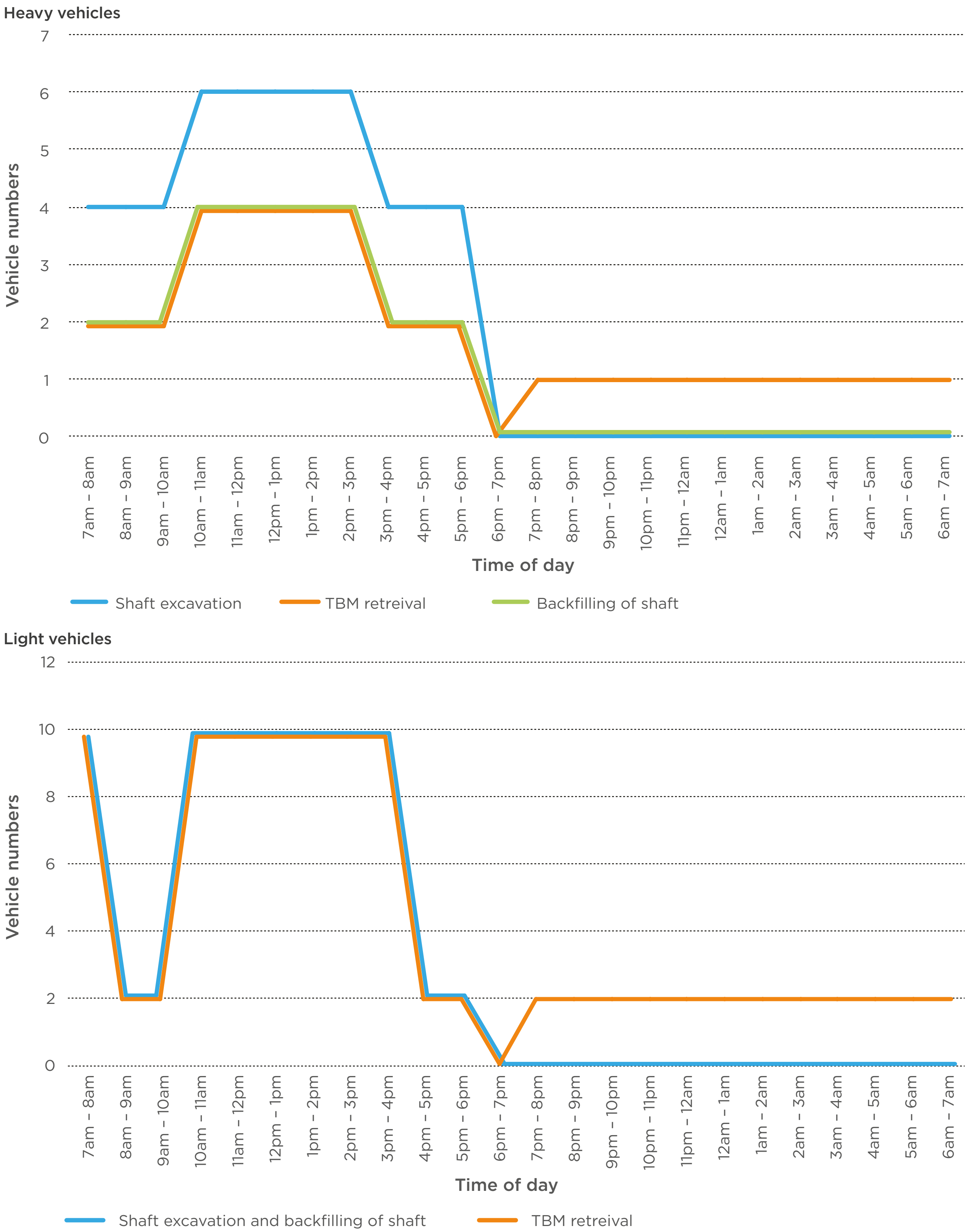


Figure 8-26 Blues Point temporary site vehicle movements

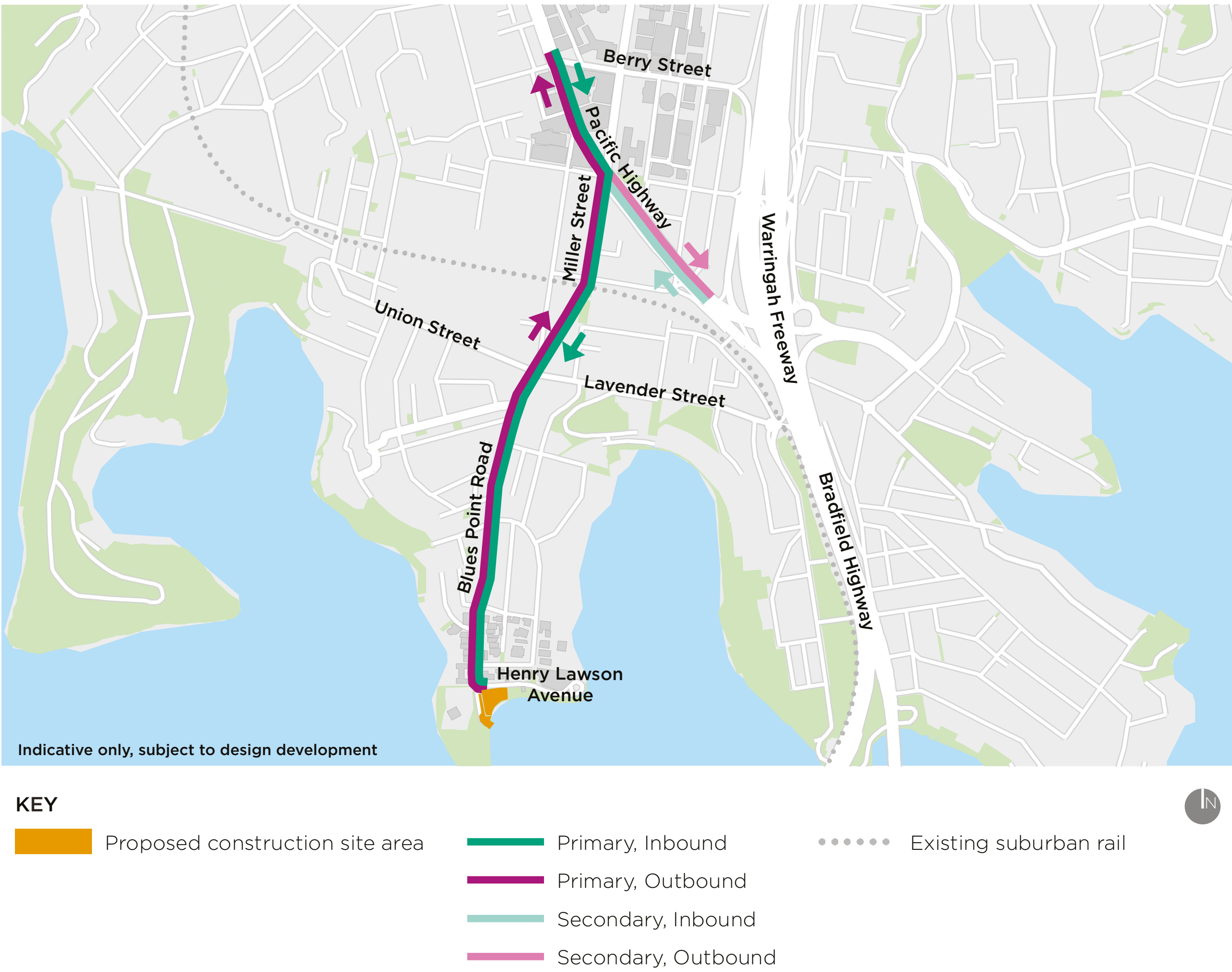


Figure 8-27 Blues Point temporary site haul routes

Active transport network

The footpaths around the site would generally be maintained during construction. During the tunnel boring machine retrieval, the footpath along Blues Point Road adjacent to the site would be temporarily closed. During these periods, safe alternative pedestrian arrangements or detours would be provided.

A five metre wide zone would be maintained within the park along the foreshore and along the eastern side of the site from Henry Lawson Drive to the foreshore. This would maintain the existing pedestrian access to the harbour foreshore.

Public transport services

The bus stop located on the southern side of Henry Lawson Avenue would need to be relocated during the construction works. The temporary relocation of this bus stop would be carried out by Transport for NSW in consultation with the bus operators, Roads and Maritime Services and North Sydney Council. The temporary relocation of this bus stop would not impact on the operation of any bus services, however it may result in some passenger having to walk a short distance further to access the bus stop.

Parking and taxis

Around four on street car parking spaces on Blues Point Road would be removed during the site establishment and shaft excavation stage. During each tunnel boring machine retrieval, all on street car parking spaces (around 23 spaces in total) on the eastern side of Blues Point Road adjacent to the site would also need to be removed. This loss of parking would be for a period of around four weeks and on four occasions. It is recognised that this temporary loss of parking would impact the ability for some visitors to access this area. Alternative on-street parking (around eight spaces) is available on the opposite side of Blues Point Road and about 50 metres further north of Blues Point Road. Options to retain some car parking at the end of Blues Point Road, including a disabled parking space, would be investigation during detailed design.

Road network performance

Table 8-21 and Figure 8-28 shows the impact of construction on nearby key intersections. In summary, it shows that the level of service observed at each intersection in the base scenario is maintained once the construction traffic is included on the network. Any minor improvements in the average delay or degree of saturation are likely to be the result of the model optimising the operation of the intersection with the additional construction traffic on certain movements.

The removal of the tunnel boring machine components is anticipated to be via Blues Point Road however the option of transporting these large components by barge using the existing wharf facilities at the end of Blues Point Road would be further investigated during detailed construction planning. The removal of the tunnel boring machine components via Blues Point Road would occur on four occasions and require oversized truck movements. This would involve the temporary short-term closure of the road (most likely overnight) and the temporary removal of street furniture, such as signage, pedestrian islands and bollards. During these closures, access to properties would be provided however delays may be experienced.

Table 8-21 Blues Point temporary site intersection performance

Peak period	Without construction			With construction		
	Average delay (second per vehicle)	Level of Service	Degree of saturation	Average delay (second per vehicle)	Level of Service	Degree of saturation
Blues Point Road / Union Street / Lavender Street						
AM	33	C	0.70	33	C	0.68
PM	24	B	0.67	24	B	0.67
Blues Point Road / Miller Street / Blue Street						
AM	19	B	0.67	18	B	0.64
PM	15	B	0.59	15	B	0.59

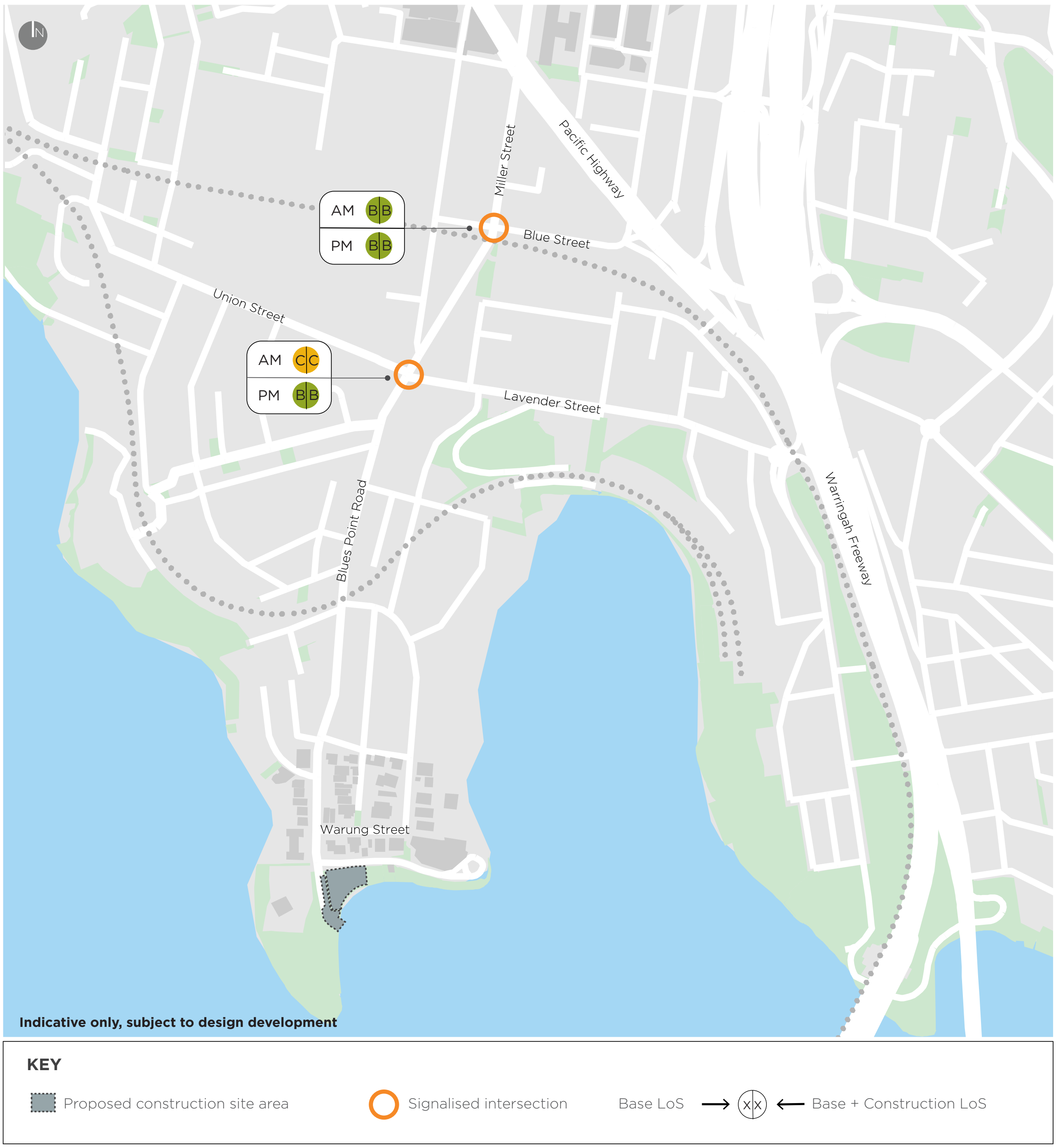


Figure 8-28 Blues Point temporary site intersection performance

8.4.11 Sydney Harbour ground improvement works

Ground improvement works, as described in Chapter 7 (Project description – construction), are likely to be required across Sydney Harbour prior to excavation of the tunnels.

The location of the ground improvement works is located in one of the narrowest sections of the harbour. Important maritime movements occur through this section of the harbour including cruise ships access the White Bay Cruise Passenger Terminal, tankers access the Viva Energy facilities at Gore Bay and Clyde, Sydney Ferries services and recreational boating activities.

The current preferred method of ground improvement works is a jet grouting approach. The grout would be delivered to the barges from an on-shore facility and would be injected from the barge via a crane and drilling lead. This would be achieved through the use of three barges on the harbour. One barge would be used to carry out the grout works which would generally remain in the harbour for the duration of the works. The other two barges would be used to transport grout to and spoil from the works area to an on-shore facility (likely to occur once per day). In addition, tug boats would be required to move the barges and small boats would transport construction workers as required. The anticipated boat movements associated with the harbour ground improvement work include:

- Jet grouting barge would travel back to the on-shore facility once per week
- Grout delivery and spoil barges would travel to and from the on-shore facility once per day
- Small boats would transfer workers between the on-shore facility and the jet grout barge multiple times per day.

This relatively small number of boat movements, compared to existing movements within the operational harbour, is not anticipated to result in any impacts to recreational, commercial or transport related maritime movements.

The physical presence of the barges within the harbour could result in impacts to shipping channels, especially large tankers accessing Viva Energy's facilities at Gore Bay and Clyde, or pose a navigational safety hazard. The proposed method for the ground improvement work has been subject to ongoing discussions with the Harbour Master. This consultation has determined that the two grout blocks would be carried out at separate times in order to keep shipping channels open. At this stage it is expected that the southern grout block would be carried out first, followed by the northern grout block. This would allow sufficient navigational space around the barges to permit safe passage of these tankers.

In relation to potential navigational safety impacts, appropriate warning signals and demarcation would be provided for all harbour activity. The nature of these warning signals would be determined in consultation with the Harbour Master to ensure harbour safety is not affected.

Consultation prior to and during the ground improvement work would continue to be carried out with the Port Authority of NSW (Harbour Master), Roads and Maritime Services and Sydney Ferries in relation to maintaining open shipping channels and ensuring the proposed work does not impact the safety of other harbour users.

8.4.12 Sydney CBD

The project would include four construction sites within the Sydney CBD. The combined haul routes for these sites are shown on Figure 8-29. These haul routes have been defined with the aim of exiting the Sydney CBD as efficiently as possible and minimising the combined use of roads by trucks accessing each construction site. The potential traffic impacts of construction at each of these sites are described in the following sections.

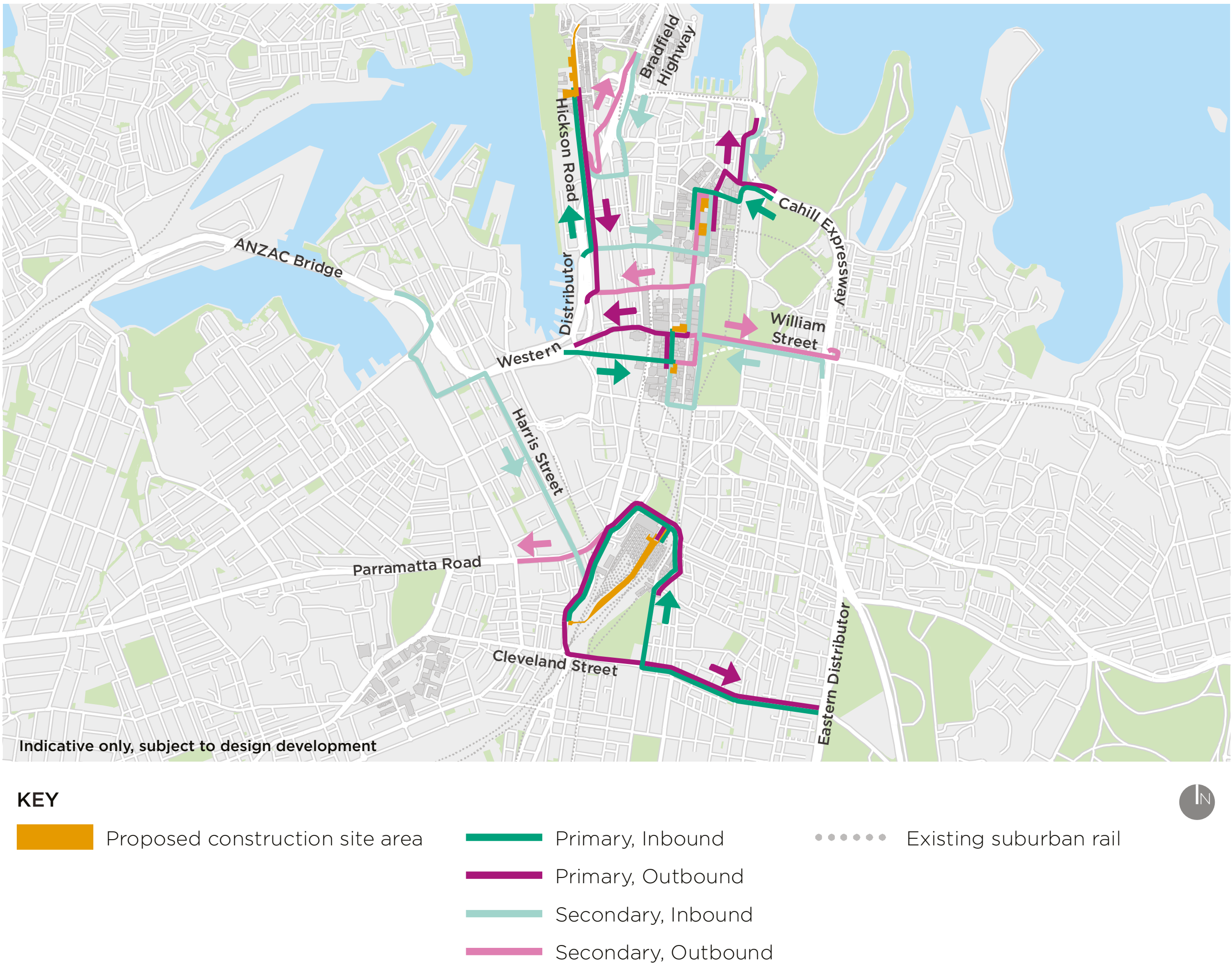


Figure 8-29 Sydney CBD combined haul routes

8.4.13 Barangaroo Station

Vehicle movement forecasts and routes

The anticipated vehicle numbers (heavy and light vehicles) at the Barangaroo Station construction site over a typical day are provided in Figure 8-30. This graph shows that the peak heavy vehicle movements in the AM peak period (7am to 10am) would be six heavy vehicles per hour during the station excavation and tunnel excavation phases.

The proposed haul routes are shown in Figure 8-31. Access to and egress from the Barangaroo Station construction site would be via Hickson Road.

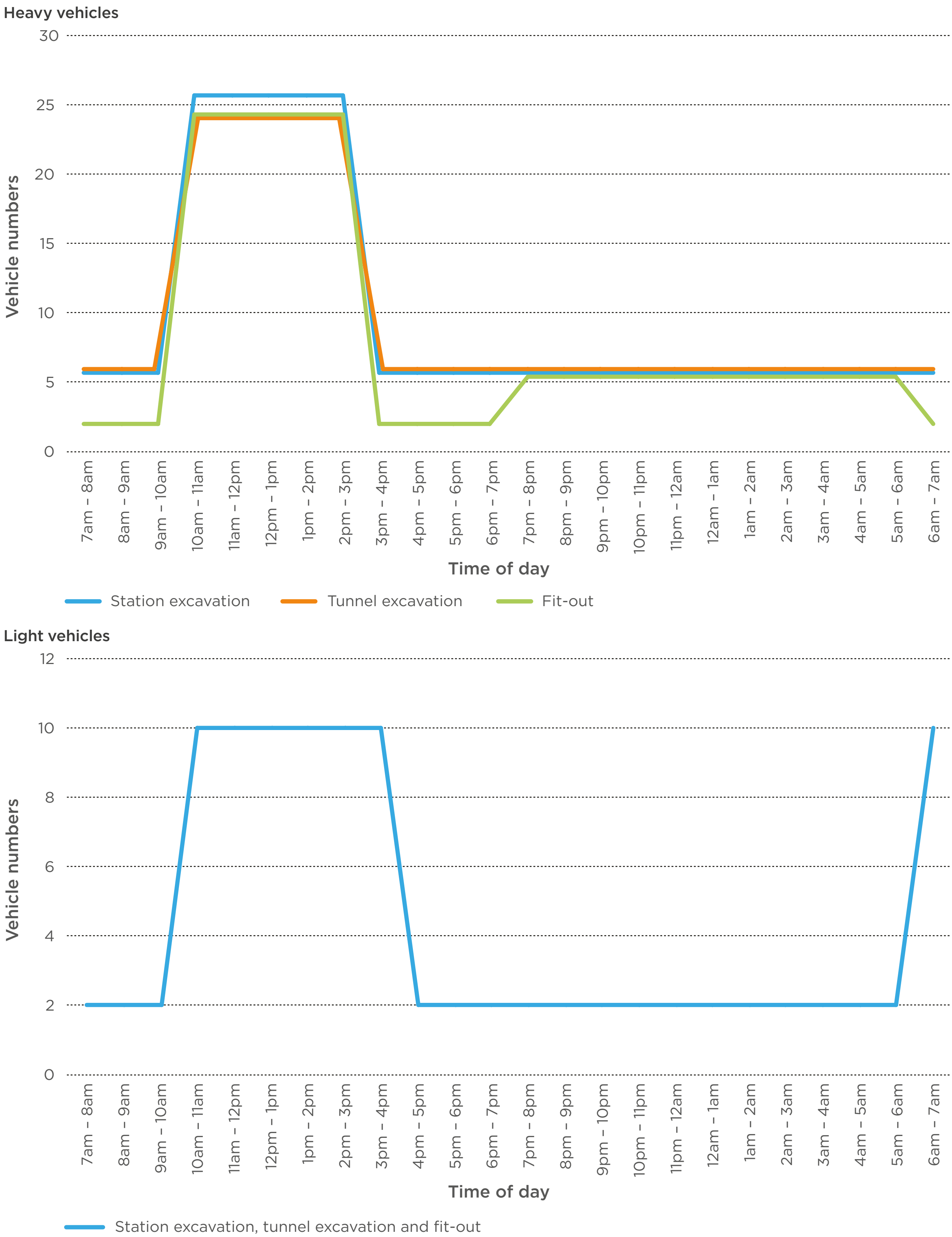


Figure 8-30 Barangaroo Station construction vehicle movements

Figure 8-31 Barangaroo Station construction site haul routes

Active transport network

The construction works would result in temporary closures of the footpaths along Hickson Road. The construction would be staged to generally maintain one footpath open to pedestrians at all times. Full overnight closures may be required during tunnel boring machine launch and retrieval works. In the event that closure of both footpaths are required, alternative pedestrian facilities or detours would be provided.

Cyclists using Hickson Road currently share it with high numbers of construction vehicles from the Barangaroo development. The construction would be staged to generally maintain one lane in each direction, providing access for cyclists. Any full closures are anticipated to occur at night when cycle numbers are expected to be negligible. As a result, the addition of Sydney Metro construction vehicles is not anticipated to further impact on cyclists.

Public transport services

Bus services would continue to operate along Hickson Road during the construction period. Some bus stops on Hickson Road may need to be temporarily relocated. The relocation of any bus stops would be carried out by Transport for NSW in consultation with the bus operators, Roads and Maritime Services, the CBD Coordination Office and the Barangaroo Delivery Authority. Any relocation of bus stops would not impact the operation of any bus services, however it may result in some passengers having to walk a short distance further to access bus stops.

Parking and taxis

Around 125 on-street car parking spaces on Hickson Road would be removed during the construction phase. The main users of these car parking spaces are currently construction workers at the adjacent Barangaroo development, although some spaces may be used by local residents and visitors. Sydney Metro would consult with the Barangaroo Delivery Authority to identify locations for alternative car parking spaces, or to implement alternative strategies to reduce the demand for parking by construction workers across the two projects.

Road network performance

Barangaroo Station is proposed to be constructed using a cut-and-cover technique below Hickson Road. This would be carried out in a staged manner to generally maintain one traffic lane in each direction. Traffic arrangements in this location would be coordinated with works being carried out by Barangaroo Delivery Authority. There may also be a requirement for temporary full closures of Hickson Road during launch and retrieval of the tunnel boring machines. This would be coordinated with the CBD Coordination Office and Barangaroo Delivery Authority and is likely to occur at night when traffic volumes are expected to be very low.

Table 8-22 and Figure 8-32 shows the impact of construction on nearby key intersections. In summary, this shows that all intersections would maintain their pre-construction level of service with the addition of the construction traffic.

With regard to the coaches and delivery vehicles using Hickson Road to access the Overseas Passenger Terminal at Circular Quay, these vehicle movements are expected occur over a short duration when a ship is either arriving or departing, which is typically early morning and evening. Construction movements during these periods of the day have been minimised in order to manage potential traffic impact during the AM and PM peak traffic periods. The Port Authority of NSW would be consulted throughout the construction phase, particularly with regard to the launch and retrieval of the tunnel boring machines (when full closures of Hickson Road are likely to be required) to ensure access to the Overseas Passenger Terminal via Hickson Road is maintained.

Table 8-22 Barangaroo Station construction site intersection performance

Peak period	Without construction			With construction		
	Average delay (second per vehicle)	Level of Service	Degree of saturation	Average delay (second per vehicle)	Level of Service	Degree of saturation
Shelley Street / Sussex Street						
AM	14	A	0.61	14	A	0.63
PM	12	A	0.35	12	A	0.37
Sussex Street / Napoleon Street						
AM	22	B	0.70	22	B	0.68
PM	18	B	0.55	18	B	0.55
Kent Street / Napoleon Street / Margaret Street						
AM	20	B	0.52	20	B	0.52
PM	15	B	0.37	15	B	0.37
Kent Street / Clarence Street / Harbour Bridge on-ramp						
AM	63	E	1.00	63	E	1.00
PM	47	D	0.93	47	D	0.93
Sussex Street / Erskine Street						
AM	34	C	0.80	34	C	0.77
PM	28	B	0.59	28	B	0.59
Sussex Street / King Street						
AM	35	C	0.90	36	C	0.92
PM	25	B	0.72	25	B	0.73
Sussex Street / Market Street						
AM	23	B	0.82	23	B	0.83
PM	20	B	0.76	20	B	0.77

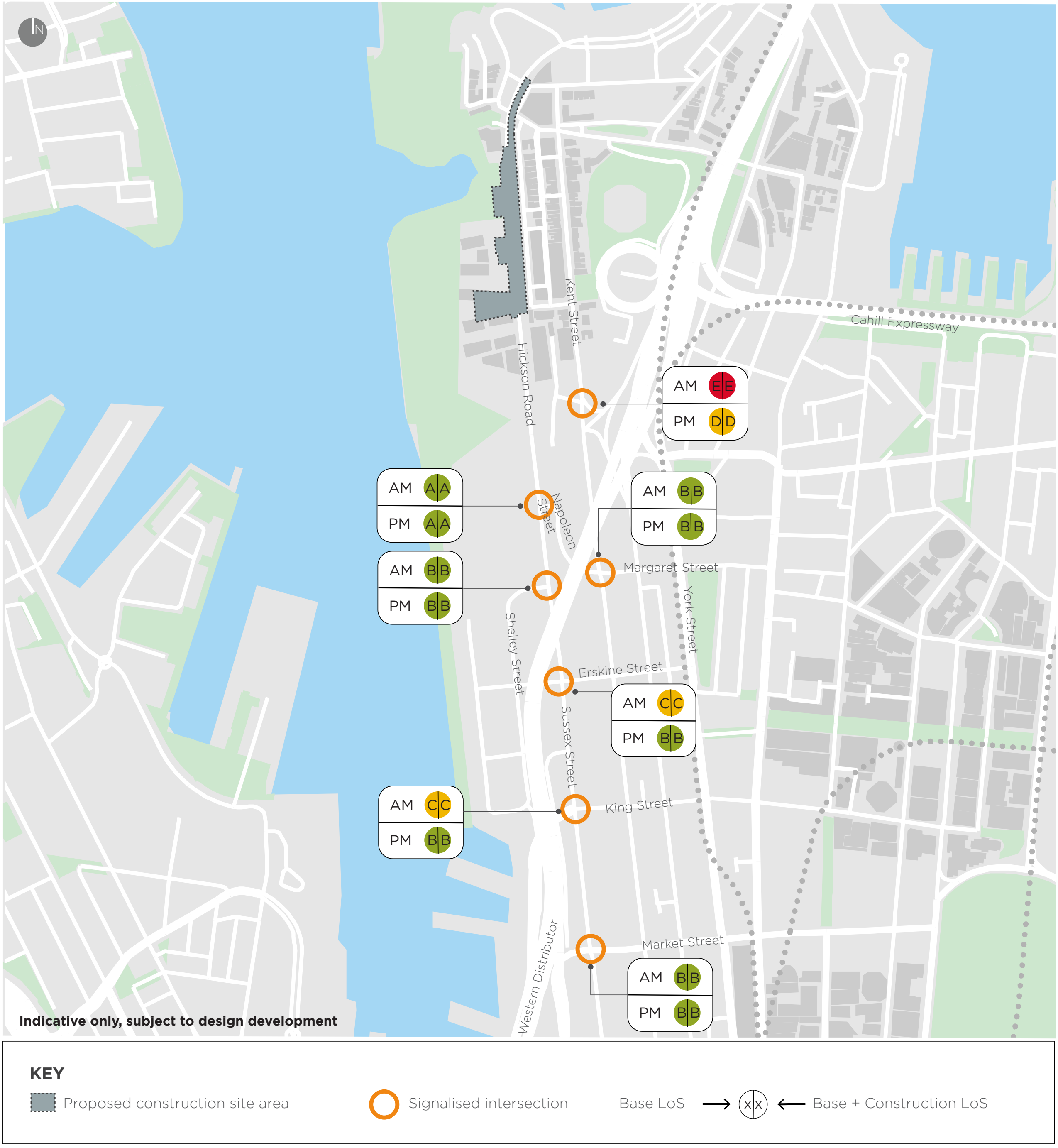


Figure 8-32 Barangaroo Station intersection performance

8.4.14 Martin Place Station

Vehicle movement forecasts and routes

The anticipated vehicle numbers (heavy and light vehicles) at the Martin Place Station construction site over a typical day are provided in Figure 8-33. This graph shows that the peak heavy vehicle movements in the AM peak period (7am to 10am) would be six heavy vehicles per hour during the demolition and excavation phases.

The proposed haul routes are shown in Figure 8-34. Access to and egress from the two Martin Place Station construction sites would be left in from Castlereagh Street (from the east via Hunter Street) and left out to Elizabeth Street.

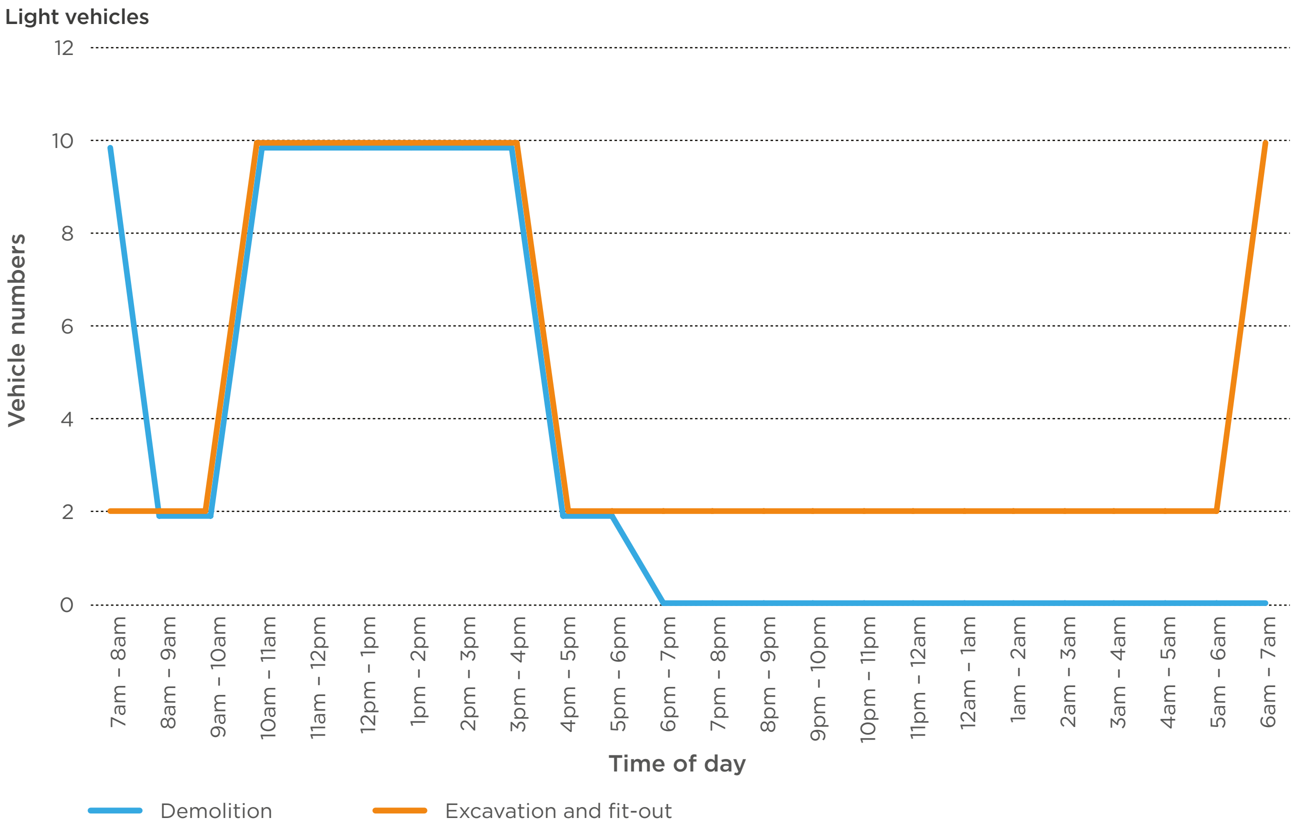


Figure 8-33 Martin Place Station construction vehicle movements

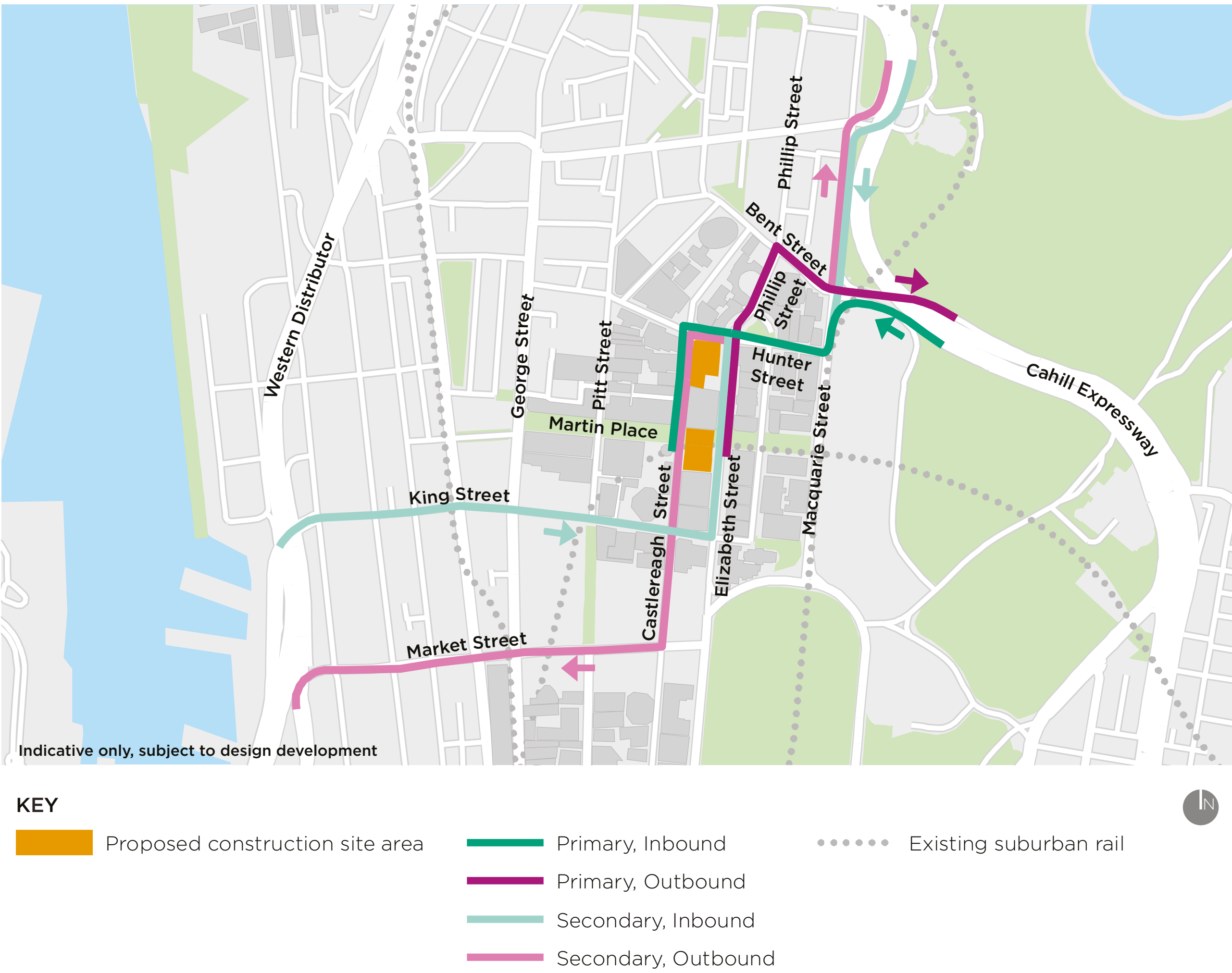


Figure 8-34 Martin Place Station haul routes

Active transport network

Martin Place, between Castlereagh and Elizabeth streets, would be closed to pedestrians and cyclists for a period of around six months. Alternative surface pedestrian and cyclist access would be provided to the south through the site of the previously demolished building. The width of this access would be sufficient to cater for the anticipated peak pedestrian and cyclist movements through Martin Place. Alternative pedestrian and cyclist routes during the temporary partial closure of Martin Place are shown on Figure 8-35.

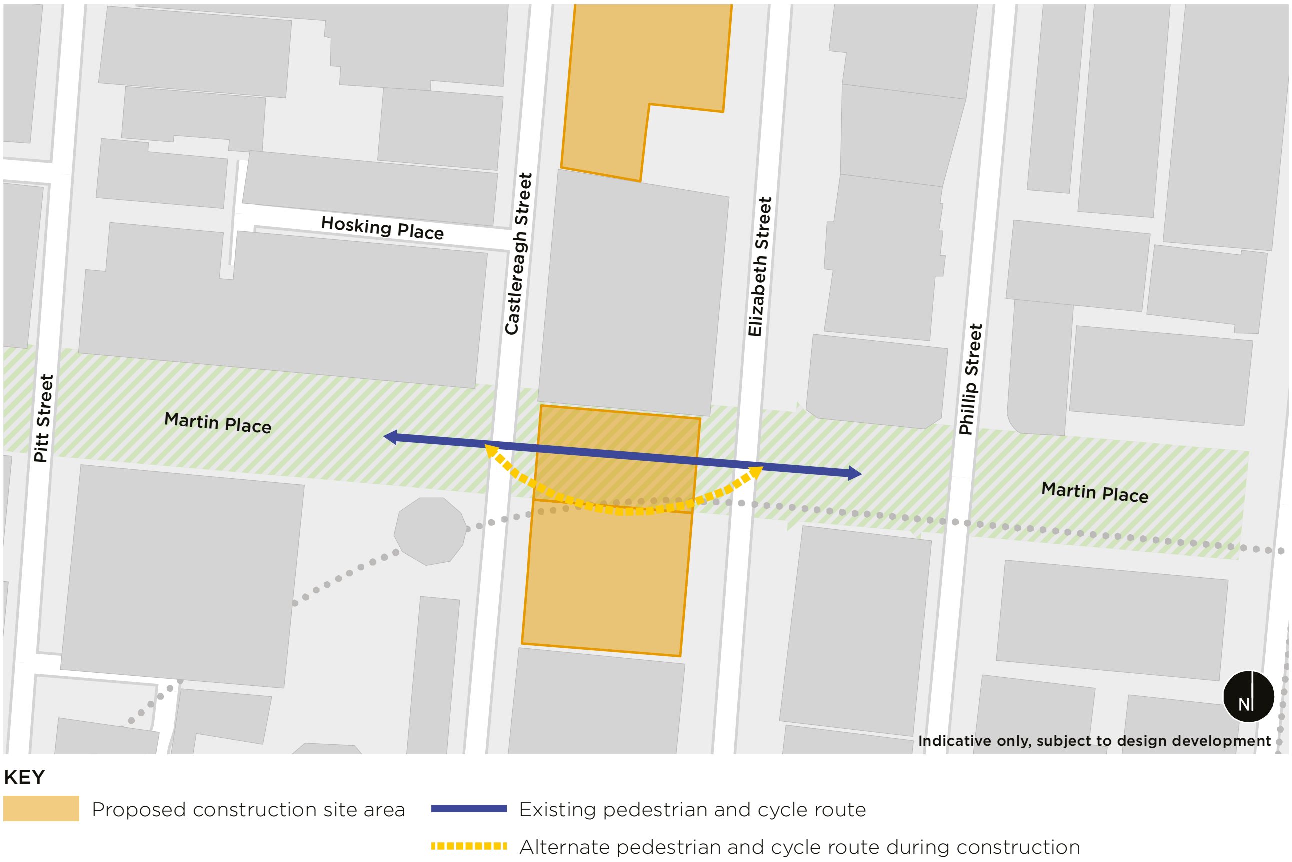


Figure 8-35 Martin Place Station construction site – alternative pedestrian and cyclist route

The existing underground pedestrian concourse between Castlereagh and Elizabeth streets, and the associated connections to Martin Place would also be closed during these cut-and-cover works. The primary function of the underground concourse is to provide access to the existing Martin Place Station. During this period, suburban rail customers would be able to use the existing Martin Place Station entry points to the east of Elizabeth Street and the east of Philip Street. This would result in additional pedestrians using the pedestrian crossing facilities at Castlereagh and Elizabeth streets. There is sufficient pedestrian storage space within Martin Place to accommodate these additional peak pedestrian movements. The pedestrian access points which would be closed during this construction period are shown on Figure 8-36. During the construction period. 60 Martin Place will also be undergoing redevelopment resulting in the Martin Place Station staircase adjacent to 60 Martin Place (east of Phillip Street) also being closed for a three year period.

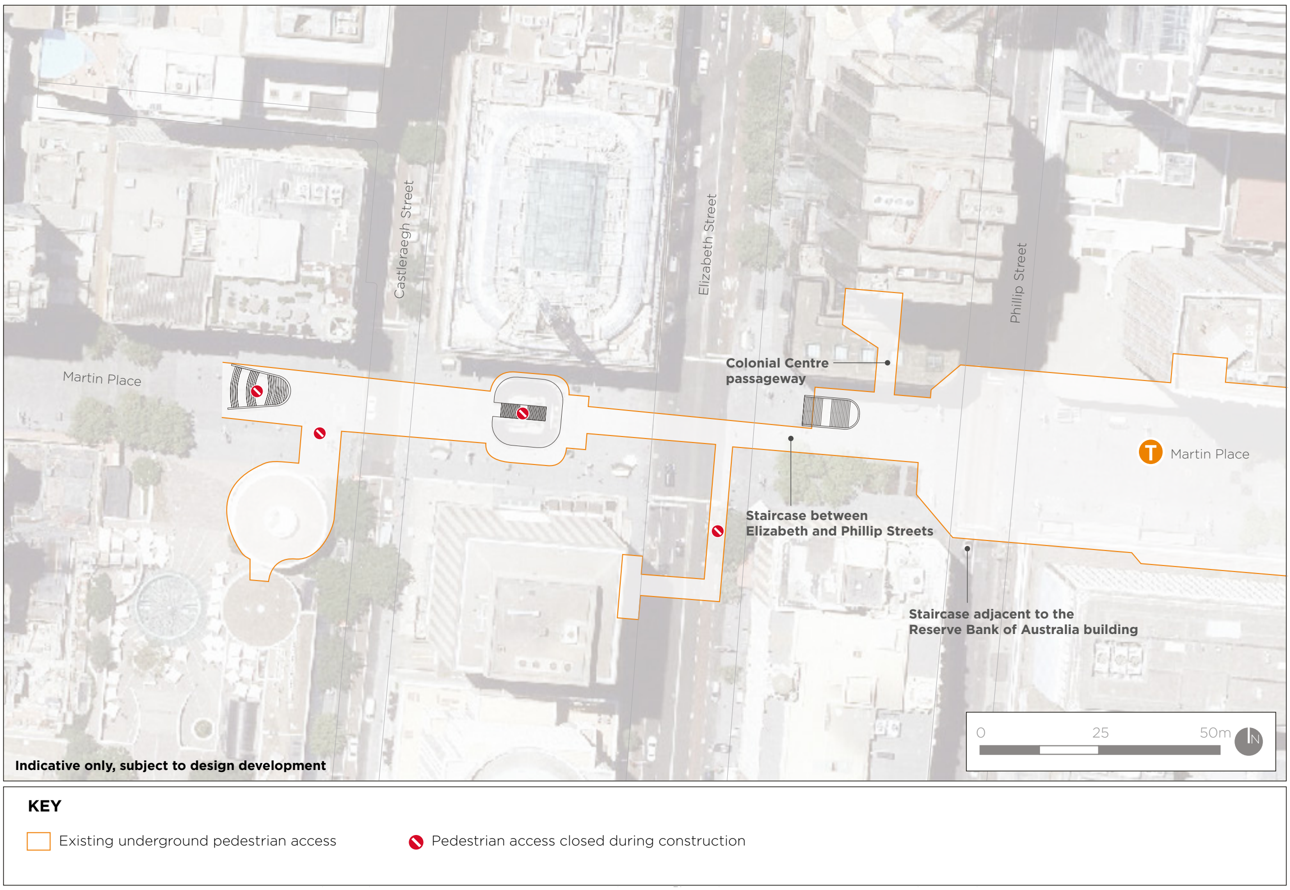


Figure 8-36 Martin Place Station construction pedestrian access arrangements

Using pedestrian survey data collected in November 2015, the level of service for pedestrians at each remaining access point has been calculated for this stage of construction. The peak minute (representing a worst case scenario) pedestrian level of service is presented in Table 8-23.

Table 8-23 Martin Place construction pedestrian level of service

Location	AM peak minute		PM peak minute	
	Base	Construction	Base	Construction
Staircase adjacent to the Reserve Bank of Australia building	C	F	A	D
Colonial Centre passageway	A	B	A	B
Staircase between Elizabeth and Phillip streets	D	F	A	F

During construction work, guidance recommends maintaining a level of service D or better for staircases and passageways. The modelling shows that one access point maintains a level of service D or better and therefore operate within an acceptable level of service during construction. However the staircase in Martin Place between Elizabeth and Phillip Streets would operate at level of service F in the AM and PM peak minute and the staircase adjacent to the Reserve Bank of Australia would also operate at a LOS F in the AM peak minute. A level of service F represents a breakdown in pedestrian flow with many stoppages. This result represents the peak minute and the average minute during the AM and PM peak period is predicted to have a better performance. This impact would also only be temporary, for around six months, whilst the four western access points are closed.

During the closure of existing entrances to Martin Place Station, Marshalls would be provided during the AM and PM peak periods to direct customers to available access and egress points.

The closure of these access and egress points to and from Martin Place Station may also necessitate changes to the emergency evacuation procedures for Martin Place Station. Transport for NSW would work with Sydney Trains in the planning of emergency evacuation procedures for Martin Place Station.

Martin Place provides an important function during certain major events in the Sydney CBD. As outlined in Section 8.4.3, liaison would occur with the CBD Coordination Office, Roads and Maritime Services and the event organisers regarding appropriate management of pedestrians in and around Martin Place Station during these events.'

Footpaths surrounding the site on Elizabeth and Castlereagh streets would be reduced in width by around 600 millimetres during the construction works. The existing footpaths are greater than three metres wide and, therefore, a 2.4 metre wide footpath would be maintained. Street furniture such as post boxes, parking metres and street signs may need to be relocated.

Public transport services

Elizabeth and Castlereagh streets form the main north-south route for bus services through the Sydney CBD. The addition of construction vehicles and site access points on these streets may result in impacts on bus services including minor delays to travel times. To minimise these potential impacts, the Martin Place construction sites would be arranged to ensure construction vehicles are loaded and unloaded off the street.

In the event that any bus stops on Castlereagh or Elizabeth streets are required to be temporarily relocated during the construction works, this would be carried out by Transport for NSW in consultation with the bus operators and the CBD Coordination Office. The temporary relocation of any bus stops would not impact the operation of any bus services, however it may result in some passengers having to walk a short distance further to access bus stops.

The underground platform to platform connection between the existing Martin Place Station and the Sydney Metro Martin Place Station would mainly be carried out by excavating new pedestrian tunnels from the Sydney metro construction site. During the final connection to the existing Martin Place Station, occupation of some space at the western end of the Sydney Trains and NSW Trains platforms would be required. Hoarding would be established to provide a separated work zone for the breakthrough works. These works are likely to be carried out without the need for rail possessions and without impacting on any suburban and intercity rail services. Sufficient space for pedestrian circulation would be maintained on the Sydney Trains Martin Place platforms during this work.

Parking and taxis

The Martin Place Station construction sites would not result in any loss of parking or impacts to taxi facilities.

Road network performance

Table 8-24 and Figure 8-37 shows the impacts of construction on nearby key intersections. This shows a minor deterioration in performance at the Castlereagh Street / Hunter Street / Blight Street in the AM peak from level of service A to level of service B. However, the average delay and degree of saturation at the intersection does not change with the addition of the construction traffic and, therefore, the overall impact on the performance of the intersection would be negligible.

The remaining intersections maintain their base level of service during the construction of the project and therefore the impact of the construction traffic on these intersections would not be significant.

Table 8-24 Martin Place Station construction site intersection performance

Peak period	Without construction			With construction		
	Average delay (second per vehicle)	Level of Service	Degree of saturation	Average delay (second per vehicle)	Level of Service	Degree of saturation
Elizabeth Street / Phillip Street / Hunter Street						
AM	23	B	0.84	23	B	0.83
PM	26	B	0.79	23	B	0.81
Elizabeth Street / Martin Place						
AM	5	A	0.42	7	A	0.42
PM	4	A	0.40	7	A	0.41
Elizabeth Street / King Street						
AM	26	B	0.73	26	B	0.73
PM	24	B	0.73	25	B	0.71
Hunter Street / Macquarie Street						
AM	20	B	0.83	21	B	0.86
PM	20	B	0.82	20	B	0.83
Macquarie Street / Bent Street / Eastern Distributor ramps						
AM	155	F	1.27	156	F	1.27
PM	161	F	1.19	167	F	1.29
Castlereagh Street / Hunter Street / Bligh Street						
AM	15	A	0.45	15	B	0.45
PM	16	B	0.52	16	B	0.50
Castlereagh Street / Martin Place						
AM	6	A	0.23	6	A	0.24
PM	6	A	0.28	6	A	0.28
Castlereagh Street / King Street						
AM	21	B	0.50	21	B	0.50
PM	22	B	0.61	21	B	0.64
Bent Street / Phillip Street						
AM	17	B	0.74	17	B	0.74
PM	18	B	0.63	25	B	0.71

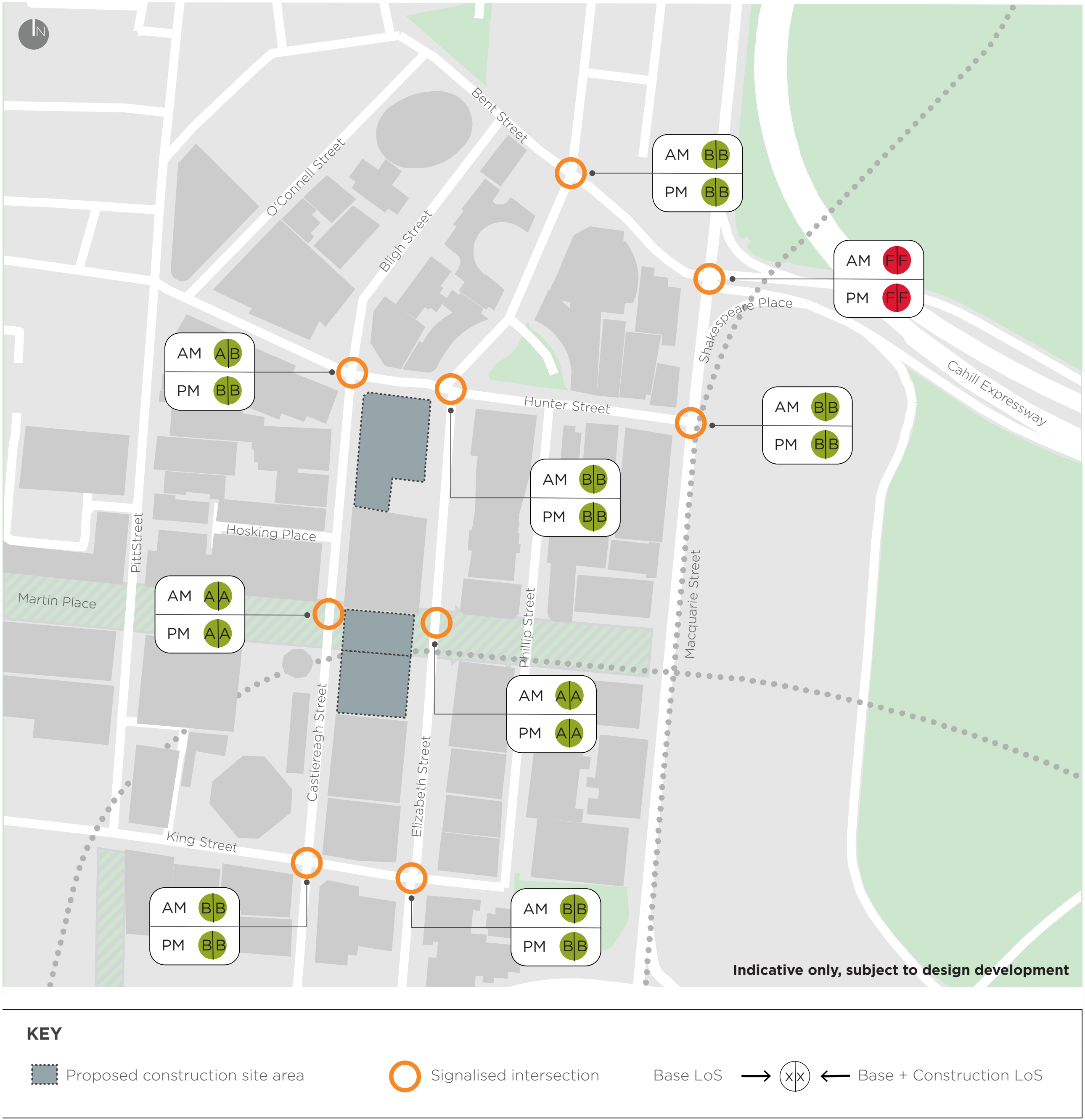


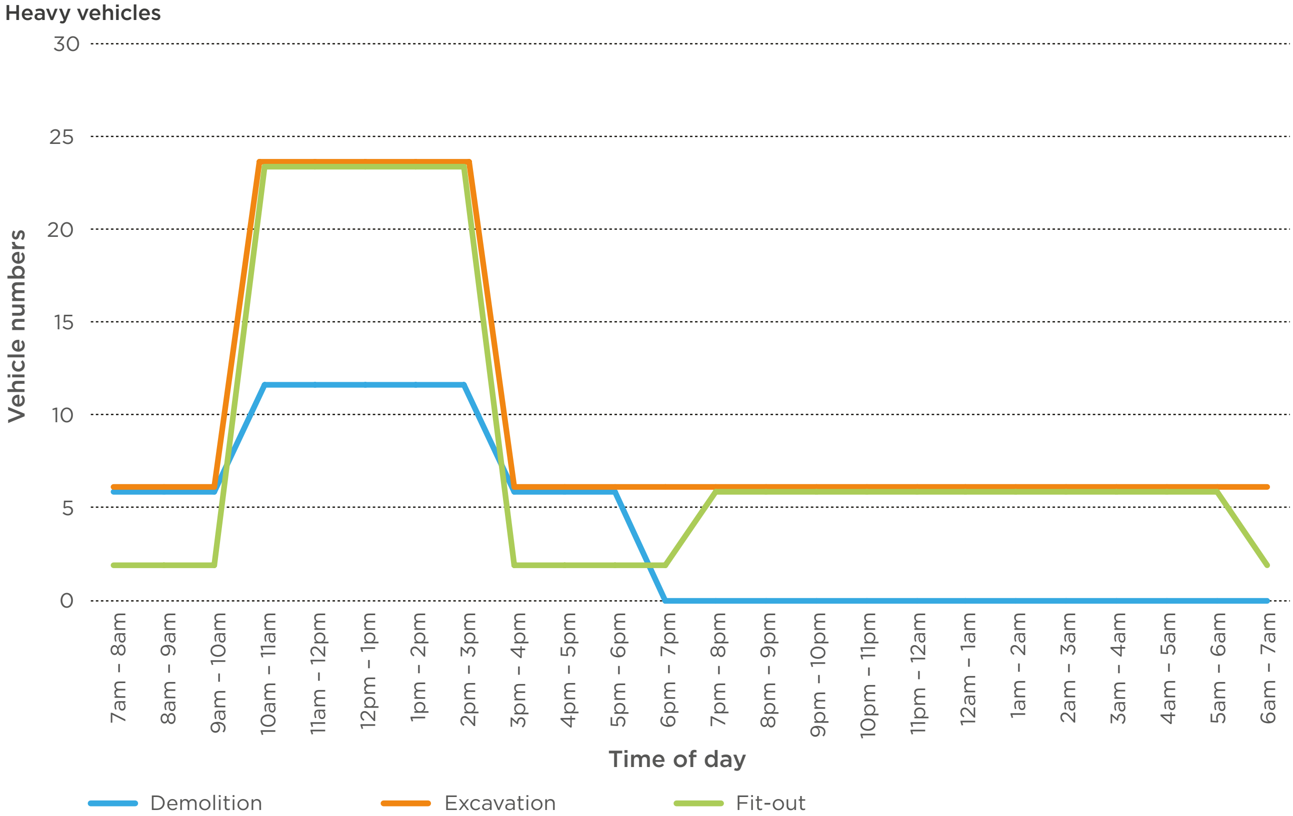
Figure 8-37 Martin Place Station intersection performance

8.4.15 Pitt Street Station

Vehicle movement forecasts and routes

The anticipated vehicle numbers (heavy and light vehicles) at the Pitt Street Station construction site over a typical day are provided in Figure 8-38. This graph shows that the peak heavy vehicle movements in the AM peak period (7am to 10am) would be six heavy vehicles per hour during the demolition and excavation phases.

The proposed haul routes are shown in Figure 8-39. Access and egress to and from the Pitt Street north site would be right in from Pitt Street, and right in, right out via Castlereagh Street. Access and egress to and from the Pitt Street south site would be right in from Bathurst Street, and right out to Pitt Street.



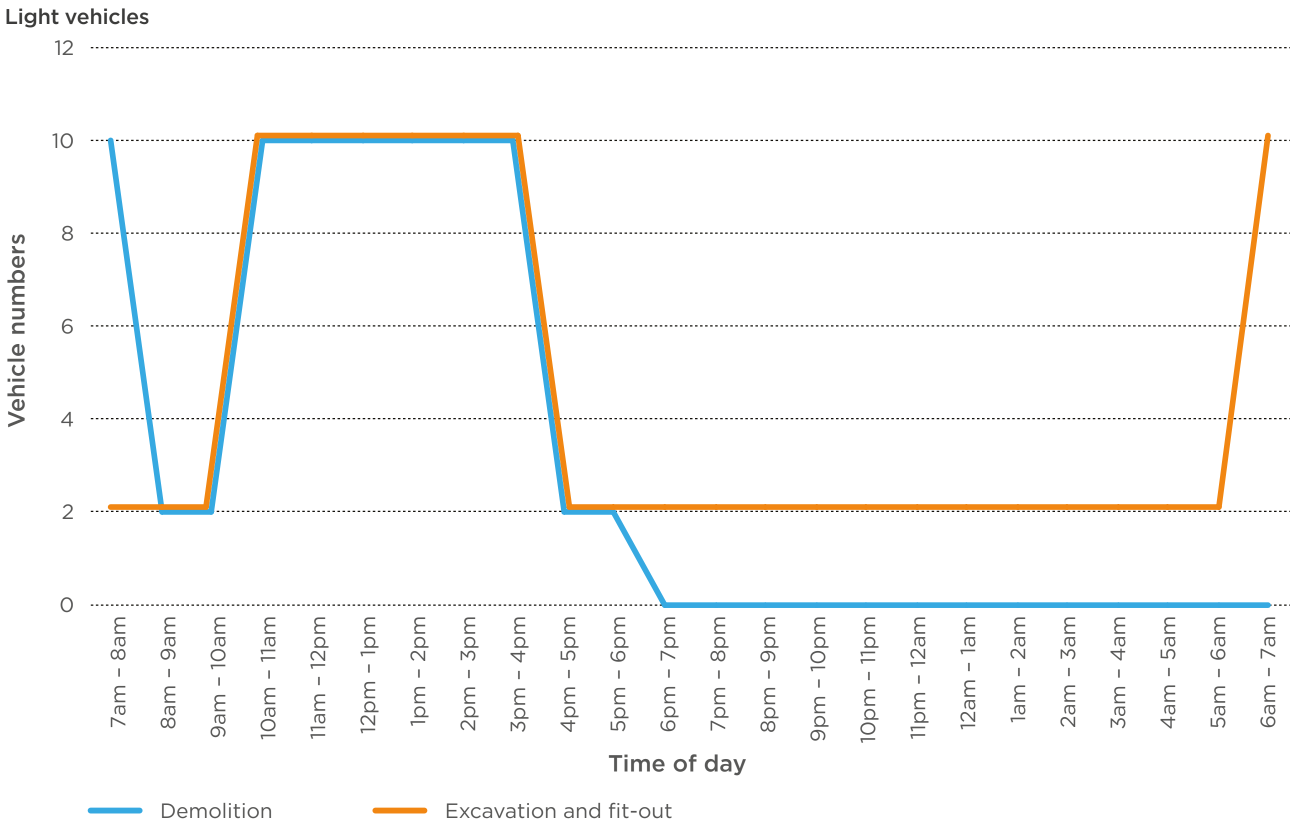


Figure 8-38 Pitt Street Station construction vehicle movements

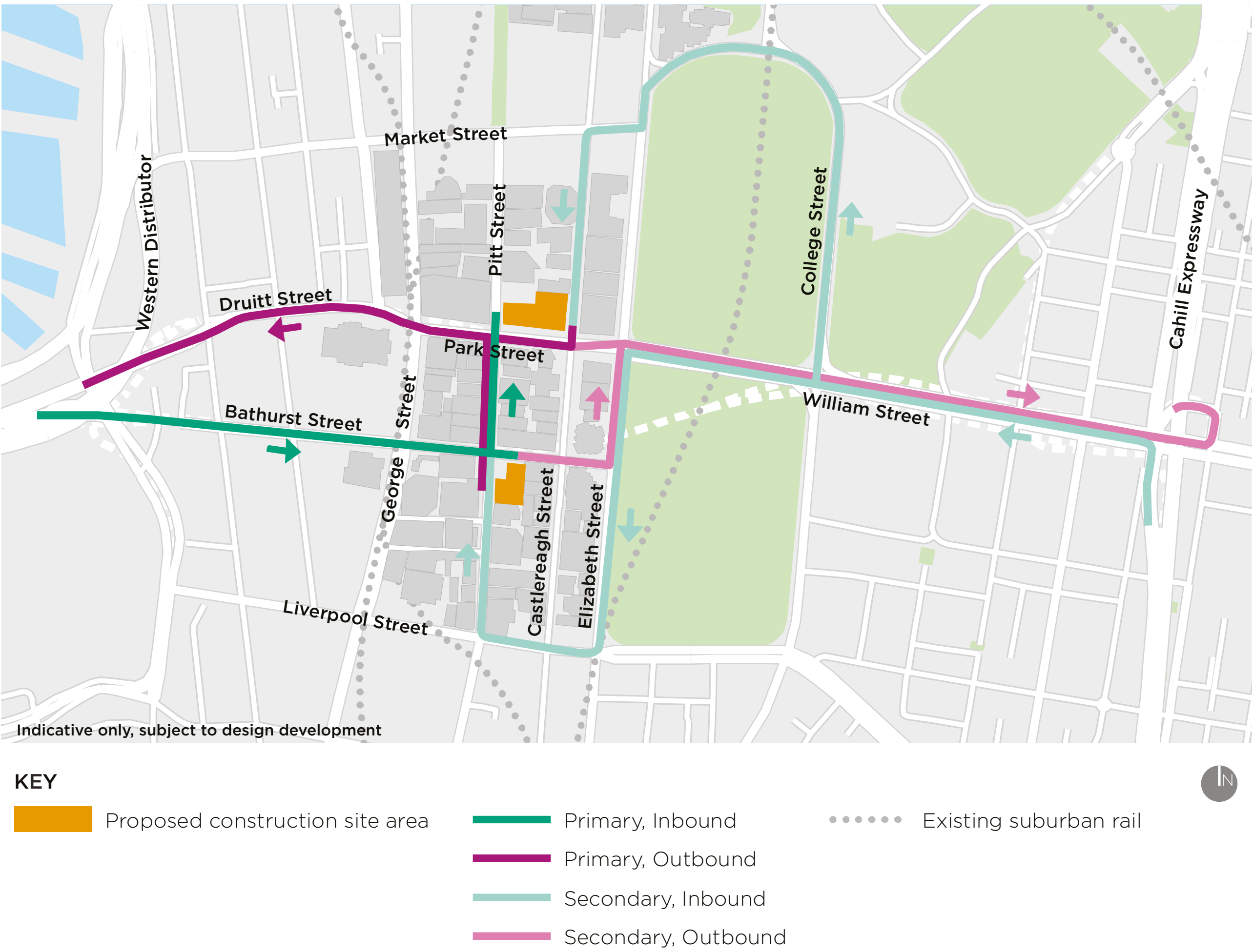


Figure 8-39 Pitt Street Station construction site haul routes

Active transport network

The City Centre Access Strategy (Transport for NSW, 2013a) identifies Castlereagh Street as a future strategic cycle route. Depending on the timing of the implementation of this cycle facility, Sydney Metro would liaise with the CBD Coordination Office and the City of Sydney Council to manage the potential impacts to cyclists on this section of the cycle route, and the provision of any alternative facilities should they be necessary.

Footpaths surrounding the sites on Pitt, Bathurst and Castlereagh streets would be reduced in width by around 600 millimetres during the construction works. These footpaths are currently greater than three metres wide and, therefore, a 2.4 metres wide footpath would be maintained, in line with the width requirements for footpaths set out in the Austroads guidelines

Public transport services

Elizabeth, Castlereagh and Park streets provide part of the major routes for bus services through the Sydney CBD. The addition of construction vehicle routes on these streets may result in impacts to these bus services such as minor delays to travel times. In order to minimise these potential impacts, the Pitt Street construction sites would be arranged to ensure construction vehicles are loaded and unloaded off the street. Additionally, the Pitt Street Station north site has been arranged to avoid an access or egress point via Park Street to reduce the potential for impacts to bus services.

In the event that any bus stops around the Pitt Street construction sites are required to be temporarily relocated during the construction works, this would be carried out by Transport for NSW in consultation with the bus operators and the CBD Coordination Office. The temporary relocation of any bus stops would not impact the operation of any bus services, however it may result in some passenger having to walk a short distance further to access bus stops.

Parking and taxis

The Pitt Street Station construction sites would not result in any loss of parking or impacts to taxi facilities.

Road network performance

Table 8-25 and Figure 8-40 shows the impact of construction on nearby key intersections during construction. In summary, this shows that the intersection performance is maintained at all intersections during the construction phase of the project except for the Bathurst Street / Day Street intersection. At this intersection, the level of service deteriorates from C to D in the PM peak. This is likely due to the intersection currently operating close to its theoretical capacity (at a degree of saturation 0.93). The average delay only deteriorates from 41 to 46 seconds per vehicle and the degree of saturation deteriorates from 0.93 to 0.95. It is therefore considered that the impact of the construction traffic on the operational performance of this intersection would be minimal.

The Pitt Street Station and Barangaroo Station construction sites would both use the Western Distributor as their primary haul route. However, given the low volumes of anticipated hourly heavy and light vehicles generated by each site, the combined impact of vehicles travelling to and from both sites is not considered to cause a material impact on the performance of the Western Distributor.

Table 8-25 Pitt Street Station construction site intersection performance

Peak period	Without construction			With construction		
	Average delay (second per vehicle)	Level of Service	Degree of saturation	Average delay (second per vehicle)	Level of Service	Degree of saturation
Druitt Street / Sussex Street						
AM	22	B	0.51	22	B	0.52
PM	26	B	0.70	26	B	0.69
Druitt Street / Kent Street						
AM	17	B	0.67	17	B	0.65
PM	14	A	0.65	14	A	0.65
Druitt Street / Clarence Street						
AM	20	B	0.87	18	B	0.87
PM	15	B	0.77	15	B	0.77
Druitt Street / Park Street / George Street / York Street						
AM	18	B	0.80	18	B	0.79
PM	15	B	0.67	15	B	0.67
Park Street / Pitt Street						
AM	18	B	0.63	18	B	0.63
PM	15	A	0.50	15	A	0.51

Peak period	Without construction			With construction		
	Average delay (second per vehicle)	Level of Service	Degree of saturation	Average delay (second per vehicle)	Level of Service	Degree of saturation
Park Street / Castlereagh Street						
AM	23	B	0.67	23	B	0.67
PM	30	C	0.72	30	C	0.72
Park Street / Elizabeth Street						
AM	35	C	0.72	35	C	0.72
PM	38	C	0.82	38	C	0.82
Bathurst Street / Harbour Street						
AM	49	D	0.93	50	D	0.93
PM	43	D	0.93	44	D	0.93
Bathurst Street / Day Street						
AM	307	F	1.19	324	F	1.20
PM	41	C	0.93	46	D	0.95
Bathurst Street / Sussex Street						
AM	14	A	0.75	14	A	0.61
PM	16	B	0.76	16	B	0.74
Bathurst Street / Kent Street						
AM	21	B	0.78	20	B	0.79
PM	22	B	0.72	22	B	0.71
Bathurst Street / George Street						
AM	10	A	0.45	10	A	0.45
PM	10	A	0.47	10	A	0.49
Bathurst Street / Pitt Street						
AM	20	B	0.54	20	B	0.54
PM	26	B	0.55	27	B	0.57
Bathurst Street / Castlereagh Street						
AM	22	B	0.55	22	B	0.55
PM	10	A	0.54	10	A	0.54
Bathurst Street / Elizabeth Street						
AM	27	B	0.73	27	B	0.73
PM	18	B	0.64	17	B	0.66

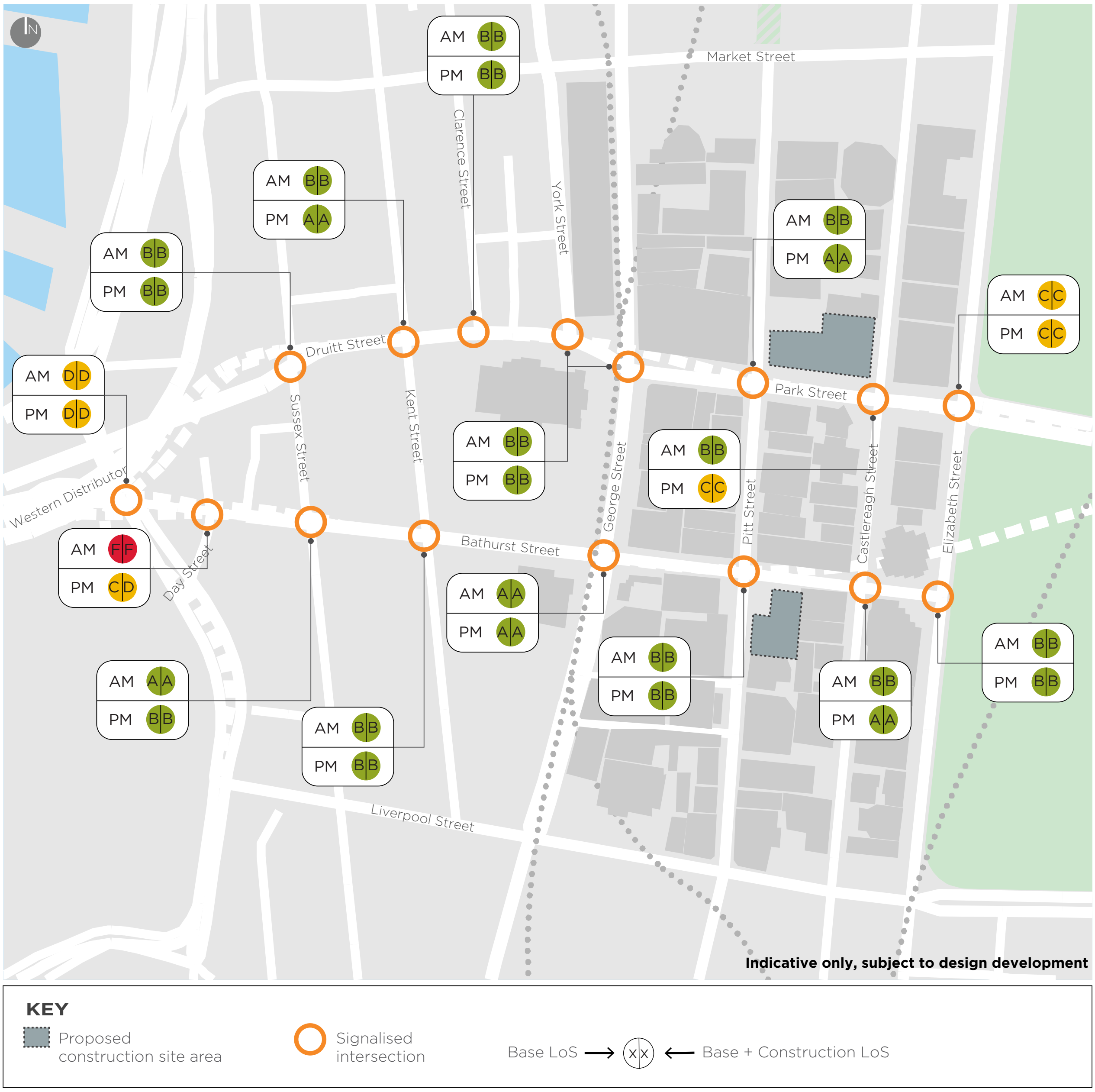


Figure 8-40 Pitt Street Station intersection performance

8.4.16 Central Station platforms

Vehicle movement forecasts and routes

The anticipated vehicle numbers (heavy and light vehicles) at the Central Station construction site over a typical day are provided in Figure 8-41. This graph shows that the peak heavy vehicle movements in the AM peak period (7am to 10am) would be six heavy vehicles per hour during the demolition and excavation phases.

The proposed haul routes are shown in Figure 8-42. Access and egress to and from the Central Station Sydney Yard site would initially be provided as a left in, left out arrangement via Eddy Avenue. Once the road bridge from Regent Street to Sydney Yard is constructed, access would be left in and left out via Regent Street (between Queen and Meagher streets).

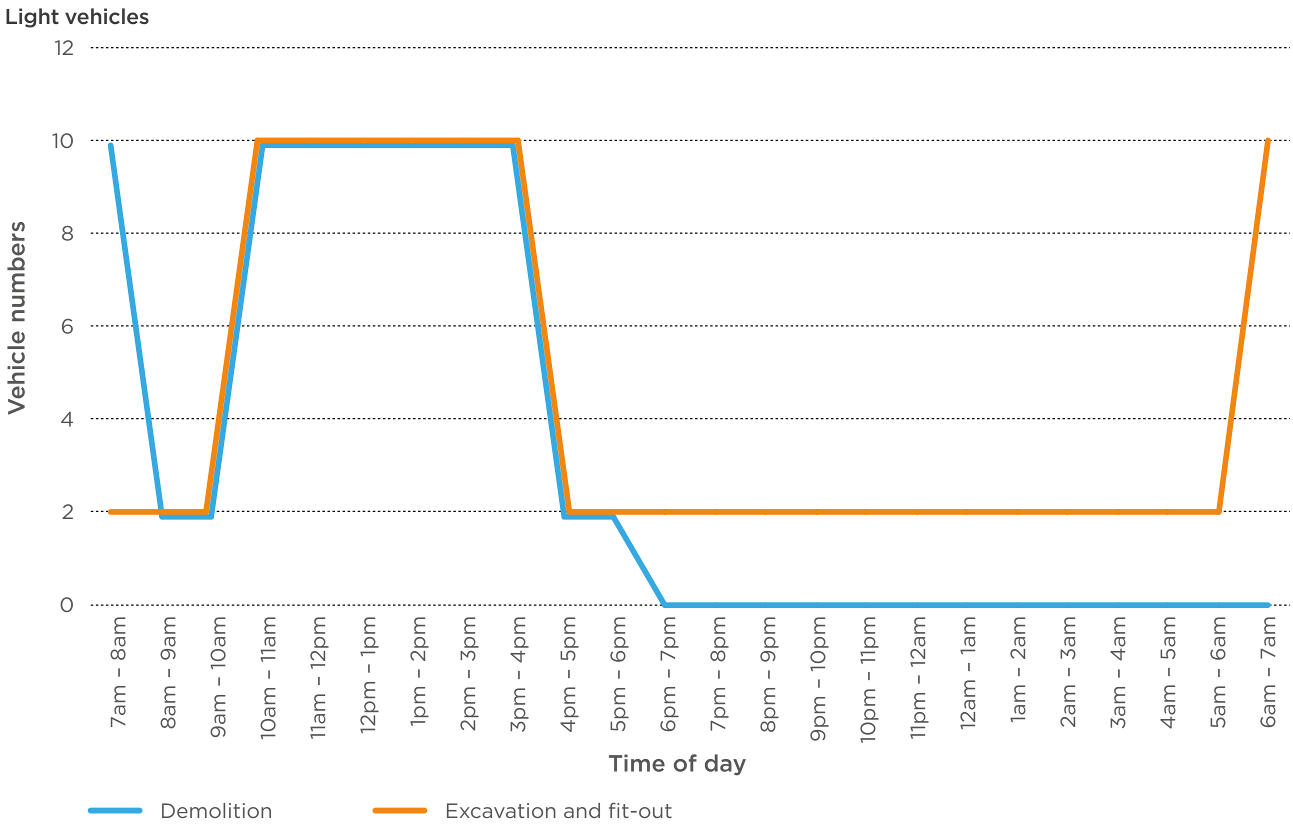


Figure 8-41 Central Station construction vehicle movements

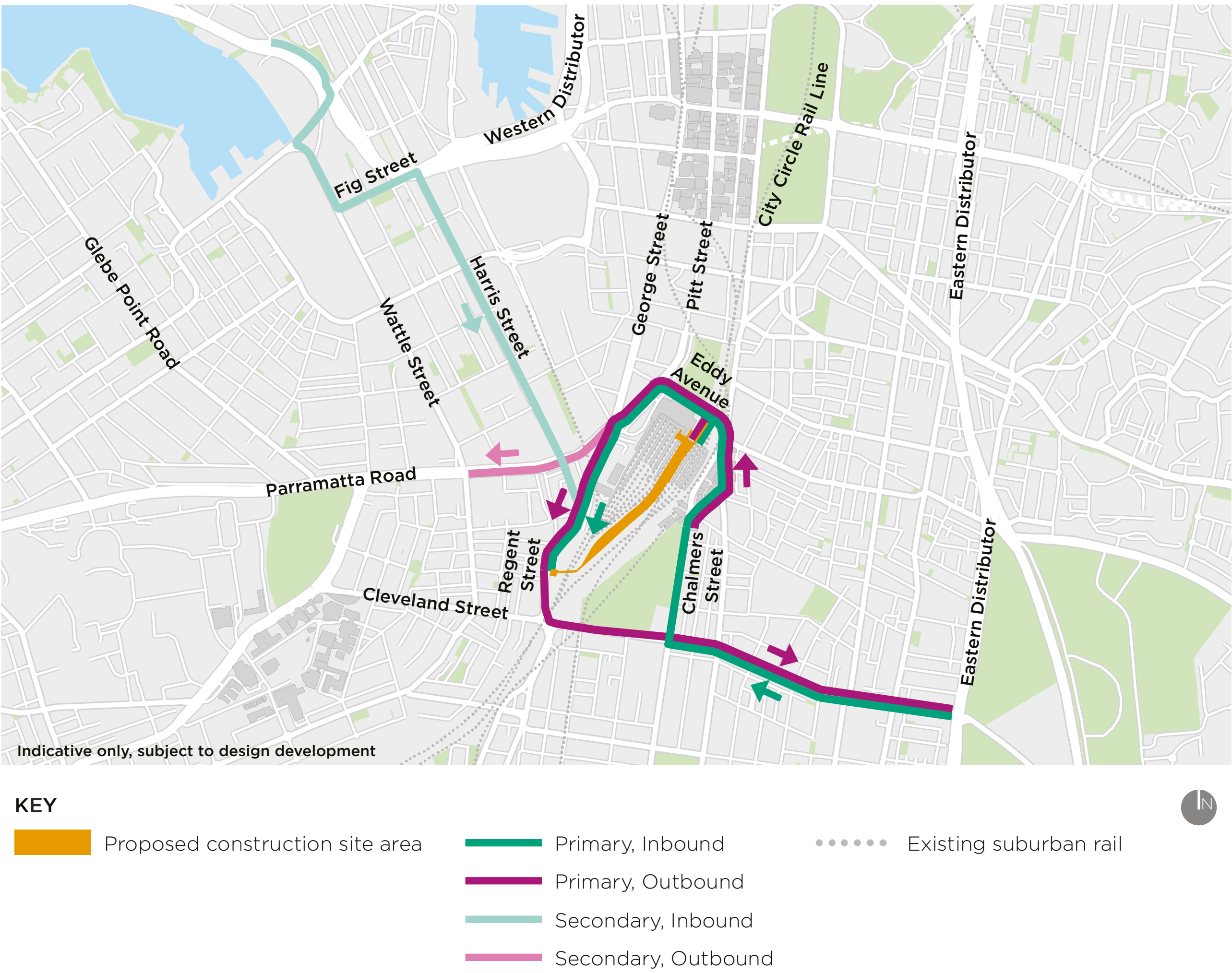
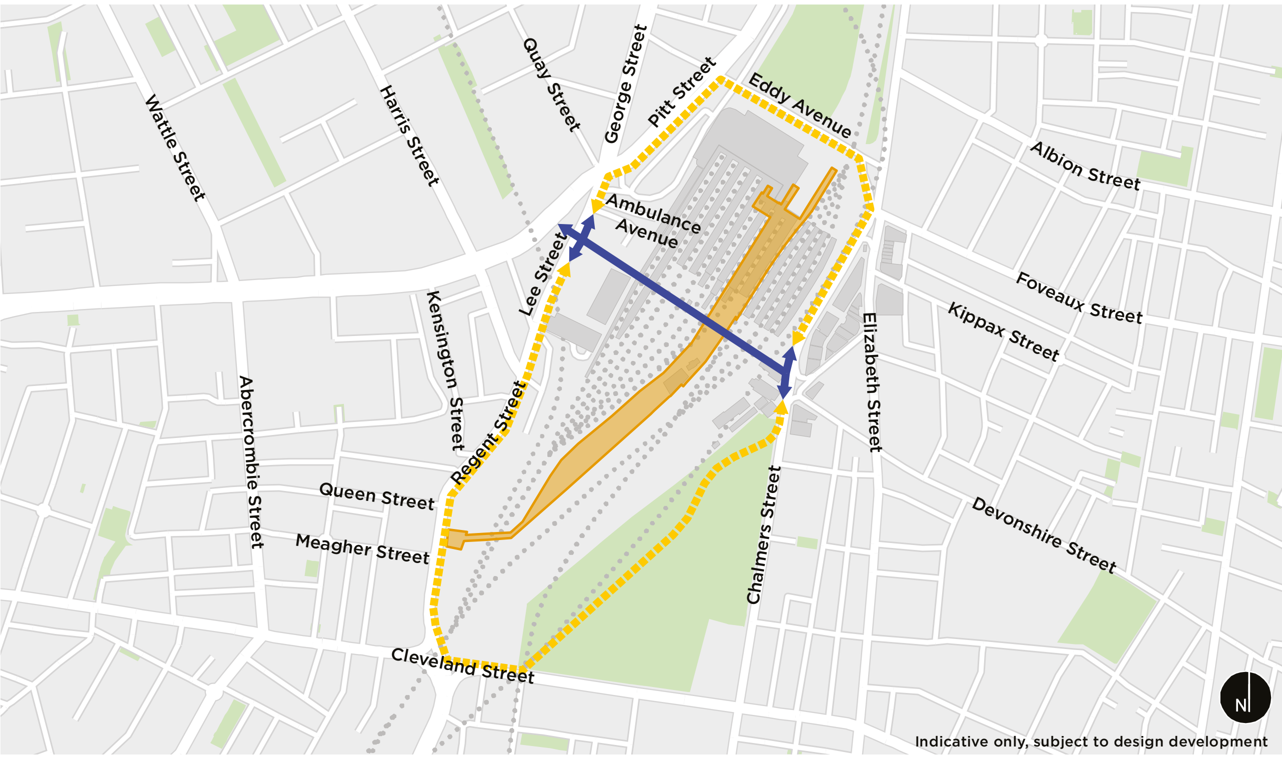


Figure 8-42 Central Station construction sites haul routes

Active transport network

Construction of the platforms at Central Station would require the closure of the Devonshire Street pedestrian tunnel for a period of around two weeks. During this closure, east-west pedestrian connectivity would be provided via Eddy Avenue, the northern station concourse or Cleveland Street. The shortest alternative route around Central Station for pedestrians would be to the south via Eddy Avenue, which would require a pedestrian to walk around 320 metres further. Alternative pedestrian and cyclist routes during the temporary closure of Devonshire Street tunnel are shown on Figure 8-43.



KEY

Proposed construction site area

Existing pedestrian and cycle route

Alternate pedestrian and cycle route during construction

Figure 8-43 Central Station construction sites – alternative pedestrian and cyclist route

The construction of the platforms would also result in the temporary closure of the existing underground pedestrian connections within Central Station. These underground pedestrian connections are used by customers to interchange at Central Station. To provide for this interchange functionality, a temporary pedestrian overbridge would be provided between platforms 4 and 23 with stair connections to each platform. This is shown in Figure 8-44. The existing lift access at the northern concourse at Central Station would be maintained.

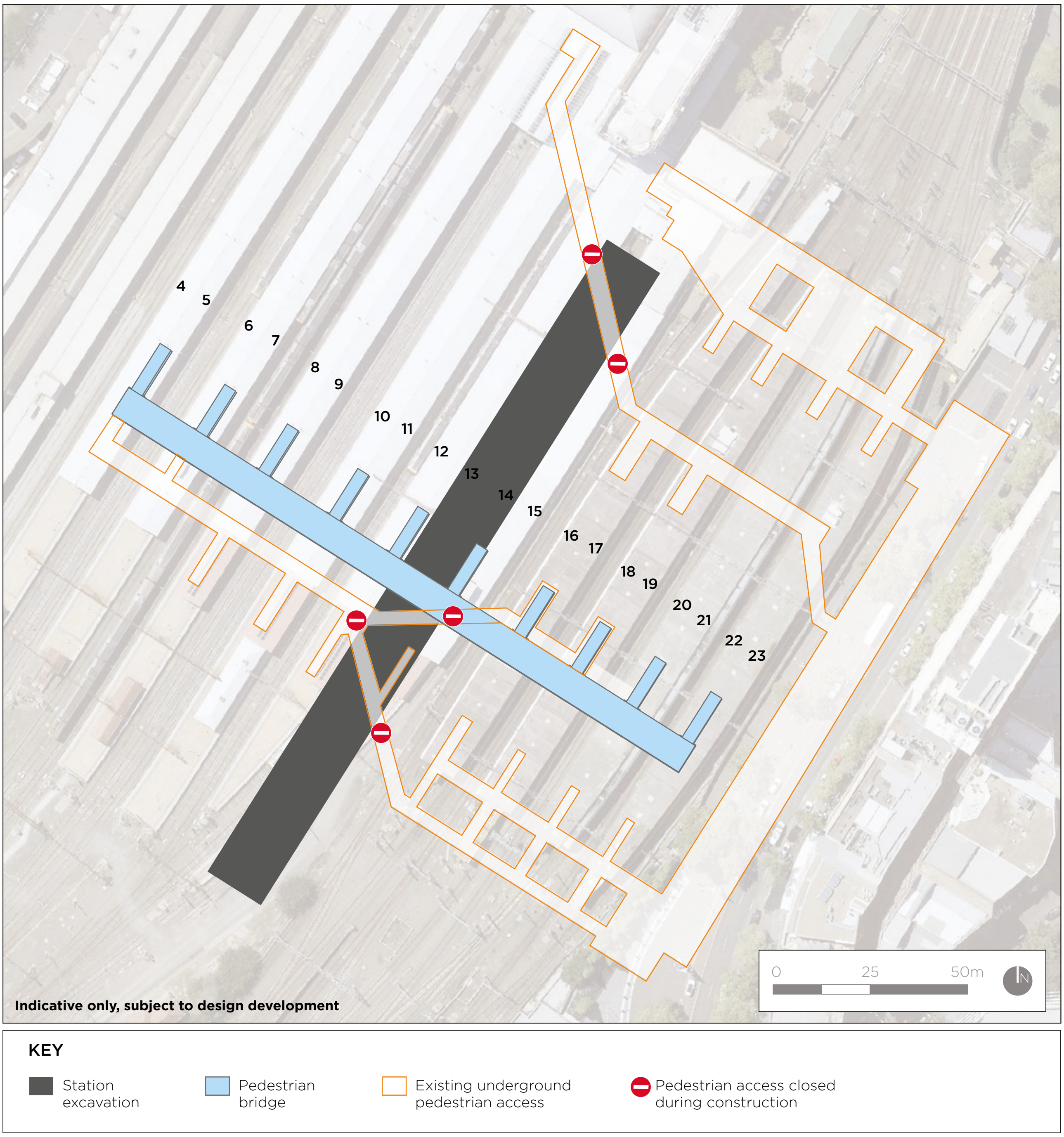


Figure 8-44 Central Station construction pedestrian arrangement

Public transport services

The construction of the platforms at Central Station is likely to result in alterations to the Sydney Trains and NSW Trains timetable due to the closure of platforms 13, 14 and 15 for the duration of construction. Transport for NSW would liaise with Sydney Trains and NSW Trains in relation to the necessary timetable alterations. Customers would be advised of any timetable changes.

A number of rail track possessions would be required to carry out the works at Central Station, including for:

- Construction of the access bridge from Regent Street to Sydney Yard and associated adjustments to existing rail systems
- Construction of the temporary pedestrian overbridge
- Adjustments to rail systems around platforms 13, 14 and 15 to facilitate cut-and-cover construction of the station
- Adjustments to rail systems around platforms, the paid underground pedestrian connections and Devonshire Street tunnel to facilitate cut-and-cover construction of the station.

Wherever possible, these works would be carried out within the standard Sydney Trains track possession schedule. However additional possessions, potentially including some extended track possessions, are likely to be required to facilitate these works. Alternative bus services would be provided during these possession works.

Parking and taxis

The Central Station construction sites are not anticipated to result in any loss of parking or impacts to taxi facilities.

Road network performance

Table 8-26 and Figure 8-45 shows the impact of construction to nearby key intersections.

With the construction traffic included on the network, the majority of intersections maintain their base level of service. The exceptions are:

- Chalmers Street / Cleveland Street intersection which deteriorates from level of service E to level of service F in the AM peak and from level of service D to level of service E in the PM peak. This intersection is already operating at or over capacity and therefore is sensitive to the minor addition of the construction traffic
- Cleveland Street / Crown Street / Baptist Street intersection deteriorates from a level of service B to level of service C in the AM peak. The degree of saturation at the intersection however remains unchanged and, therefore this impact would be minimal.

The Cleveland Street / Wilton Street / Walker Street intersection was seen to improve its level of service from B to A in the AM peak. This is likely due to the model being able to optimise this intersection to improve its operation.

The proposed Central Station haul route includes a number of intersections that are already operating at or over capacity. The addition of construction traffic to the network results in a marginal deterioration in the performance of those intersections currently experiencing congestion during the AM and PM peak periods.

Table 8-26 Central Station construction site intersection performance

Peak period	Without construction			With construction		
	Average delay (second per vehicle)	Level of Service	Degree of saturation	Average delay (second per vehicle)	Level of Service	Degree of saturation
Regent Street / Harris Street / Broadway / George Street						
AM	26	B	0.79	26	B	0.79
PM	24	B	0.85	24	B	0.85
Regent Street / Lee Street						
AM	17	B	0.76	17	B	0.75
PM	16	B	0.78	17	B	0.75
George Street / Pitt Street / Lee Street / Quay Street						
AM	122	F	1.20	122	F	1.20
PM	29	C	0.89	37	C	0.97
Pitt Street / Eddy Avenue / Rawson Parade						
AM	89	F	1.13	88	F	1.13
PM	31	C	0.82	33	C	0.87
Eddy Avenue / Elizabeth Street / Foveaux Street						
AM	31	C	0.87	30	C	0.88
PM	37	C	0.96	39	C	0.96
Elizabeth Street / Devonshire Street						
AM	7	A	0.50	7	A	0.50
PM	8	A	0.77	9	A	0.77
Elizabeth Street / Cleveland Street						
AM	31	C	0.83	32	C	0.81
PM	33	C	0.82	34	C	0.82
Chalmers Street / Cleveland Street						
AM	62	E	1.11	75	F	1.22
PM	51	D	0.99	59	E	1.04
Chalmers Street / Devonshire Street						
AM	13	A	0.78	13	A	0.79
PM	9	A	0.51	9	A	0.49
Regent Street / Cleveland Street						
AM	53	D	1.00	52	D	1.00
PM	48	D	0.98	49	D	0.98
Regent Street / Kensington Street						
AM	6	A	0.44	6	A	0.44
PM	5	A	0.48	5	A	0.48

Peak period	Without construction			With construction		
	Average delay (second per vehicle)	Level of Service	Degree of saturation	Average delay (second per vehicle)	Level of Service	Degree of saturation
Cleveland Street / George Street						
AM	8	A	0.57	8	A	0.57
PM	9	A	0.57	8	A	0.57
Cleveland Street / Pitt Street						
AM	10	A	0.64	8	A	0.61
PM	10	A	0.62	10	A	0.62
Cleveland Street / Wilton Street / Walker Street						
AM	15	B	0.61	9	A	0.49
PM	7	A	0.45	16	B	0.62
Cleveland Street / Marlborough Street / Young Street						
AM	9	A	0.51	7	A	0.45
PM	9	A	0.51	8	A	0.47
Cleveland Street / Crown Street / Baptist Street						
AM	27	B	0.88	32	C	0.88
PM	24	B	0.71	27	B	0.83
Cleveland Street / Bourke Street						
AM	19	B	0.75	18	B	0.71
PM	20	B	0.63	17	B	0.67
Cleveland Street / South Dowling Street						
AM	46	D	0.97	47	D	0.97
PM	44	D	0.95	48	D	0.95

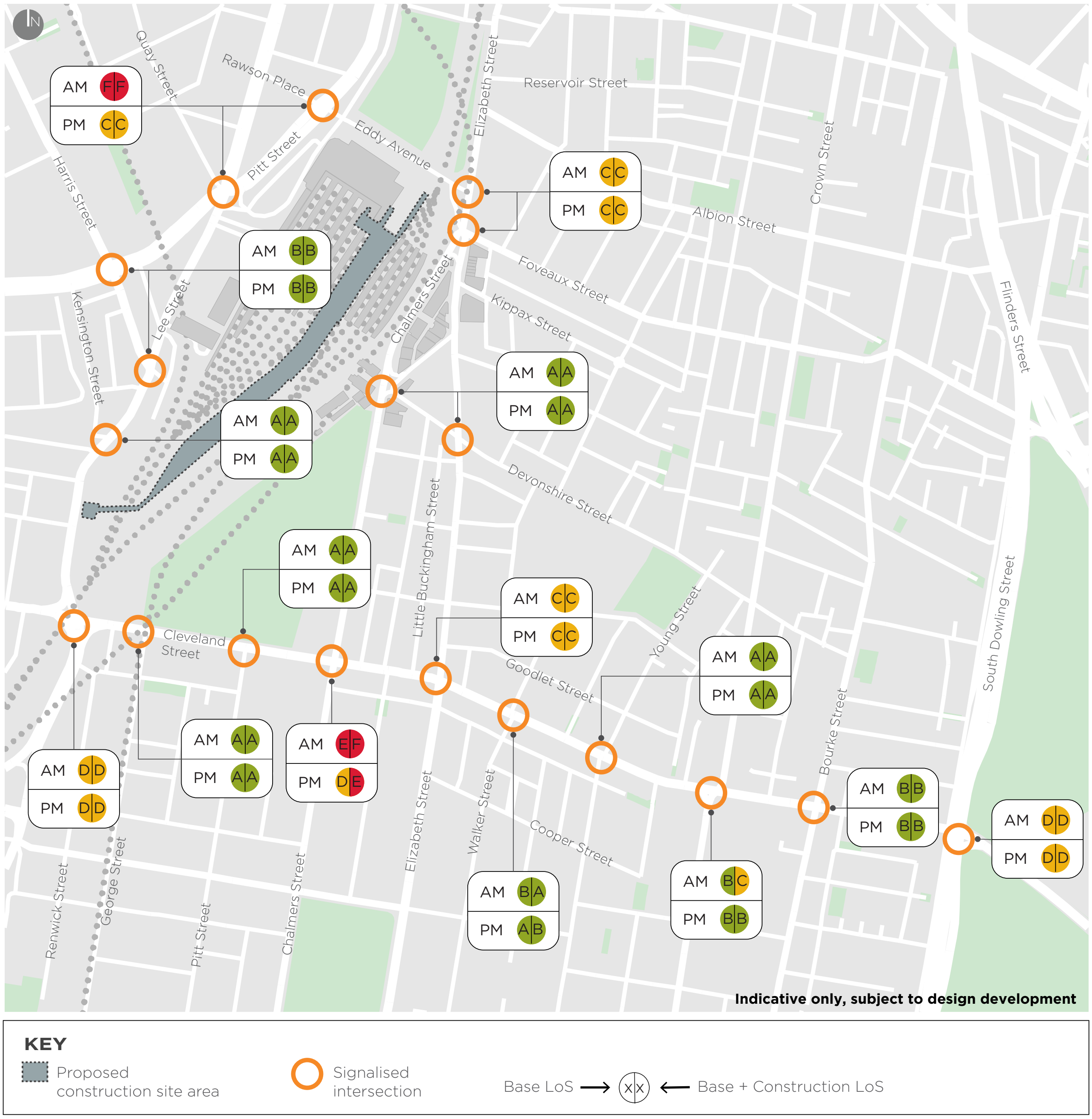


Figure 8-45 Central Station intersection performance

8.4.17 Waterloo Station

Vehicle movement forecasts and routes

The anticipated vehicle numbers (heavy and light vehicles) at the Waterloo Station construction site over a typical day are provided in Figure 8-46. This graph shows that the peak heavy vehicle movements in the AM peak period (7am to 10am) would be six heavy vehicles per hour during the demolition and excavation phases.

The proposed haul routes are shown in Figure 8-47. Access and egress to and from the Waterloo Station construction site would be left in, left out via Botany Road; and right in, left in, left out via Raglan Street. To provide flexibility, this assessment has included all construction vehicles using the northern haul route and all construction vehicles using the southern haul route. As such, the assessment is considered to be conservative.

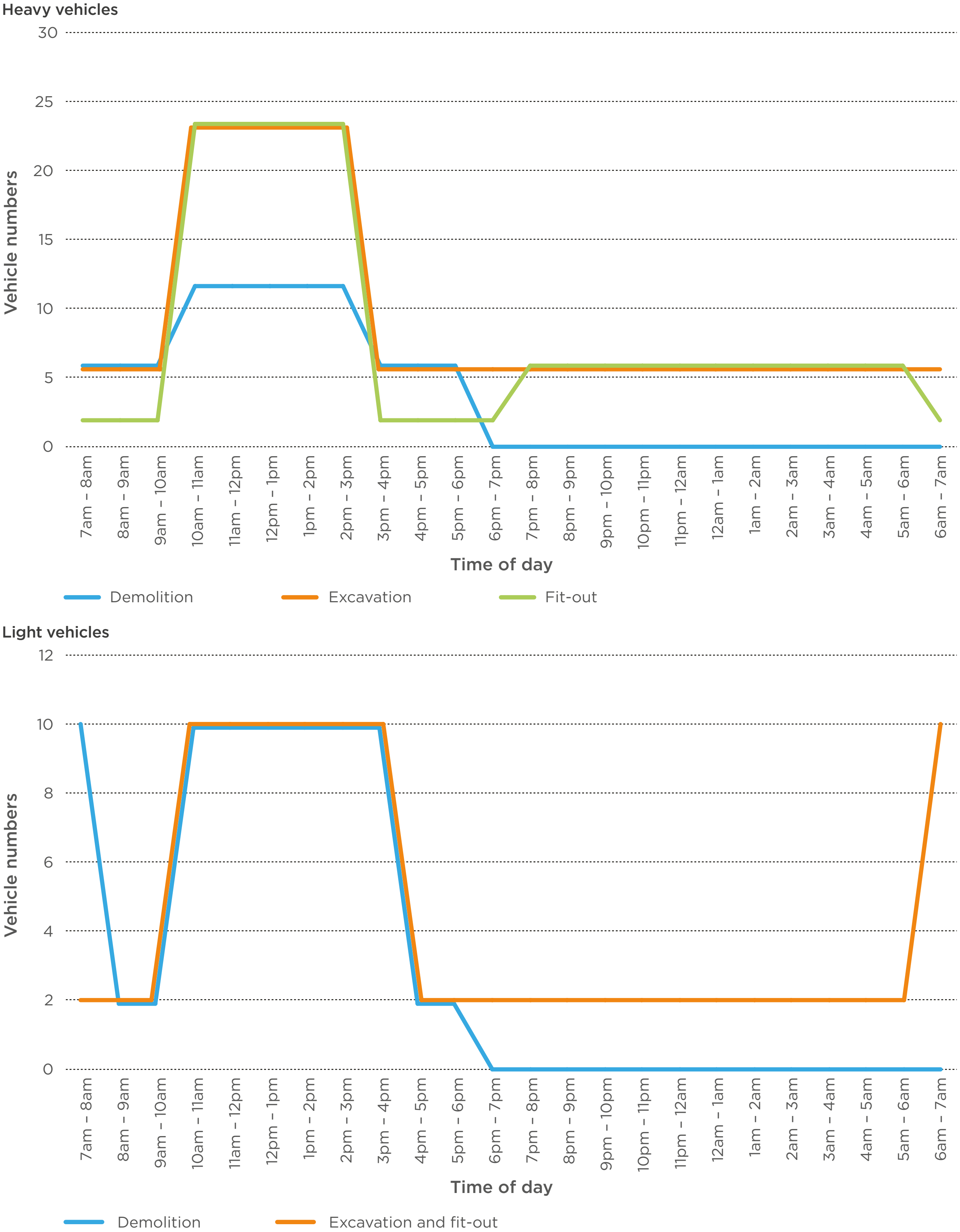


Figure 8-46 Waterloo Station construction vehicle movements

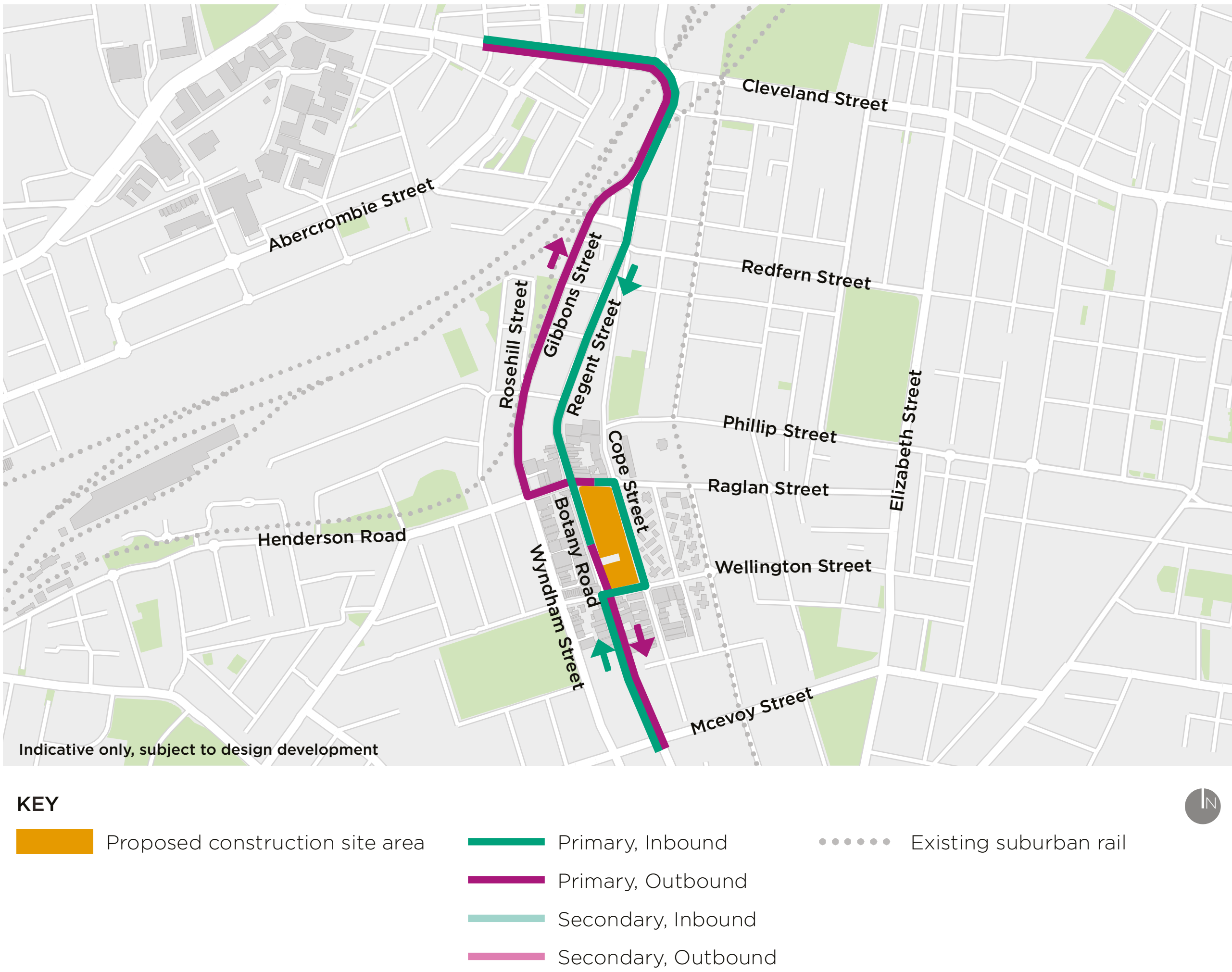


Figure 8-47 Waterloo Station construction site haul routes

Active transport network

Existing footpaths long Botany Road, Cope Street, Raglan Street and Wellington Street (bounding the construction site) would be reduced by around 600 millimetres adjacent to the proposed construction site. Footpaths along Botany Road, Raglan Street and Cope Street are currently greater than three metres wide, within which there are various items of street furniture such as trees, a rubbish bin and road signs. Therefore, a 2.4 metre wide footpath would be maintained, in line with Austroads guidelines, however some items of street furniture may need to be temporarily relocated. The footpath on Wellington Street is around 1.9 metres wide with a grass verge of around 1.6 metres wide giving a combined width of around 3.5 metres. An appropriate footpath width (of up to 2.9 metres) would be maintained along Wellington Street.

Existing cycle facilities on Botany Road (south of Wellington Street), Buckland Street and George Street in the vicinity of the site would not be impacted.

Public transport services

The bus stop currently located near 103 Botany Road may need to be temporarily relocated during the construction works. The relocation of this bus stop would be carried out by Transport for NSW in consultation with the bus operators, Roads and Maritime Services and City of Sydney Council. The temporary relocation of the bus stop would not impact the operation of any bus services however it may result in some passenger having to walk a short distance further to access bus stops.

Parking and taxis

Around two to four on street car parking spaces on Raglan Street would be removed for the duration of the construction phase. On-street car parking spaces along Cope and Wellington streets would also be temporarily removed during the demolition works. The temporary loss of these parking spaces would not have any major impacts on parking considering the proximity and availability of other spaces.

There is not anticipated to be any impacts to formal taxi facilities in the vicinity of Waterloo Station construction site.

Road network performance

Table 8-27 and Figure 8-48 shows the impact of construction on nearby key intersections for the northern haul route. This shows that during construction the majority of intersections maintain their current level of service except for the Cleveland Street / Regent Street intersection which deteriorates from a level of service D to E in the AM peak and level of service C to D in the PM peak. This intersection is already operating close to its theoretical capacity. However, the deterioration of the degree of saturation in both the AM and PM peaks is minor and, therefore, the overall operational impact on the network would be minimal.

The operational performance of the Cleveland Street / Shepherd Street intersection was seen to improve from level of service B to A in the AM peak. Any minor improvements in the average delay or degree of saturation are likely to be the result of the model optimising the operation of the intersection with the additional construction traffic on certain movements.

If the northern haul route is adopted, construction vehicles from the Waterloo Station and Central Station construction sites would both use the Regent Street / Cleveland Street intersection. Given the low construction vehicles anticipated during the morning peak hour, this combined impact is not considered to have a material impact on the performance of the intersection.

Table 8-27 Waterloo Station construction site intersection performance – northern haul route

Peak period	Without construction			With construction		
	Average delay (second per vehicle)	Level of Service	Degree of saturation	Average delay (second per vehicle)	Level of Service	Degree of saturation
Wyndham Street / Gibbons Street / Boundary Street						
AM	18	B	0.63	18	B	0.63
PM	6	A	0.48	5	A	0.48
Gibbons Street / Lawson Street						
AM	20	B	0.87	20	B	0.87
PM	17	B	0.79	17	B	0.79
Regent Street / Lawson Square / Redfern Street						
AM	47	D	1.03	45	D	1.03
PM	25	B	0.98	28	B	0.99
Cleveland Street / Regent Street						
AM	56	D	1.06	63	E	1.08
PM	42	C	0.94	44	D	0.96
Cleveland Street / Abercrombie Street						
AM	33	C	0.85	32	C	0.85
PM	29	B	0.77	29	B	0.77
Cleveland Street / Boundary Street / Beaumont Street						
AM	6	A	0.44	4	A	0.46
PM	3	A	0.43	4	A	0.44
Cleveland Street / Shepherd Street						
AM	19	B	0.54	13	A	0.51
PM	14	A	0.54	14	A	0.57
City Road / Cleveland Street						
AM	92	F	1.16	99	F	1.19
PM	31	C	0.91	33	C	0.93
City Road / Parramatta Road / Broadway / Bay Street						
AM	34	C	0.92	34	C	0.92
PM	35	C	0.92	36	C	0.94

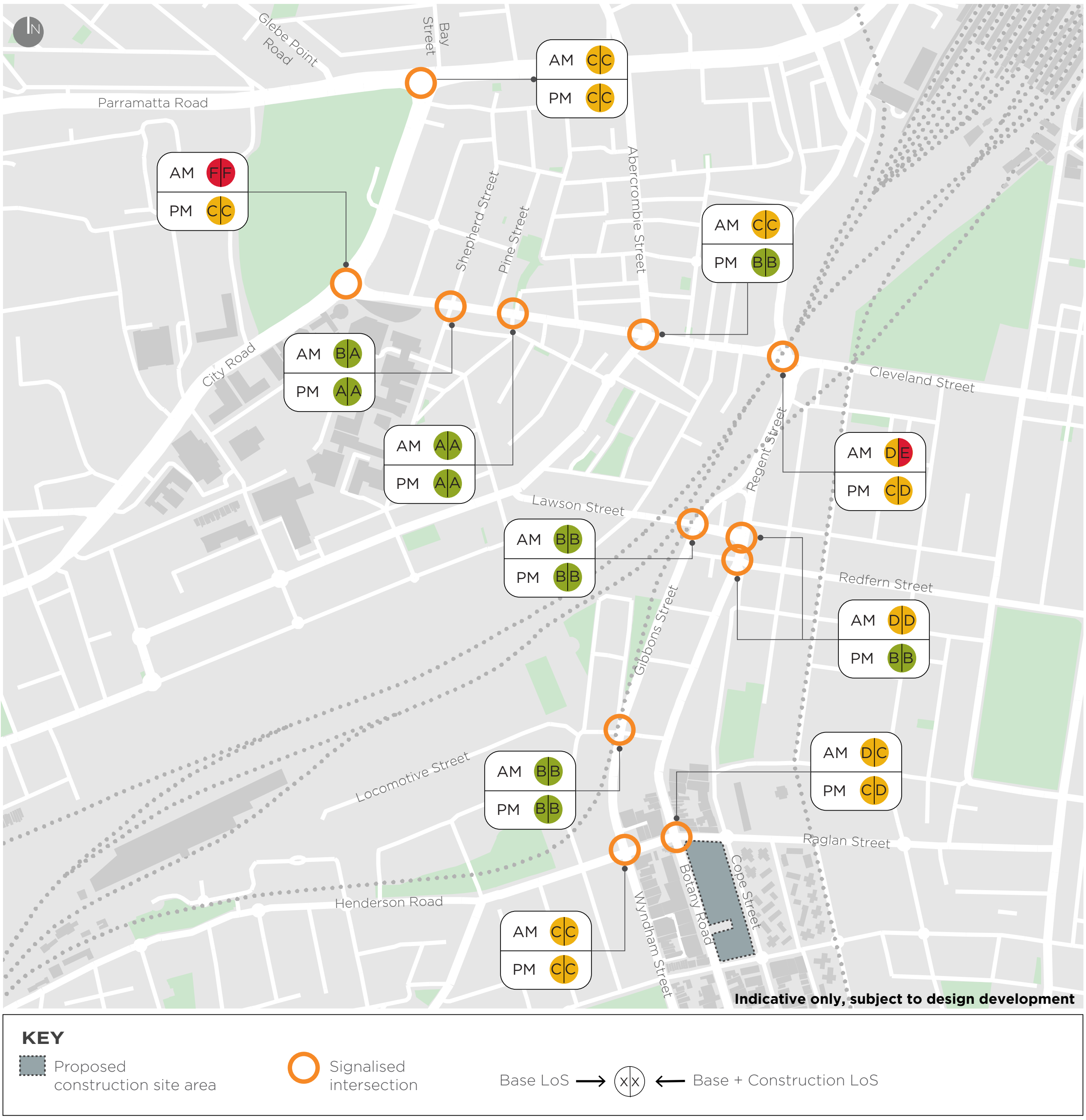


Figure 8-48 Waterloo Station intersection performance – northern haul route

Table 8-28 and Figure 8-49 shows the impact of construction on nearby key intersections for the southern haul route. The addition of the construction traffic results in the level of service of five intersections deteriorating, namely:

- Botany Road / Mandible Street from C to D in the AM peak
- Botany Road / Henderson Road / Raglan Street from C to D in the PM peak
- Botany Road / King Street from B to C in the AM peak and A to B in the PM peak
- Botany Road / Mill Pond Road / Southern Cross Drive ramps from C to D in the PM peak
- General Holmes Drive / Mill Pond Road from E to F in the AM peak.

Most of these intersections were operating at or near capacity and the increase in the degree of saturation was either zero or minimal and therefore the impact on the operation of the intersection would be minimal. Further, this assessment assumes that all construction vehicles would use the southern haul route. In reality, it is likely that there would be a split of vehicles between the two haul routes and, as such, this represents a worst-case assessment.

At two intersections, Botany Road / Henderson Road / Raglan Street and Botany Road / Mill Pond Road / Southern Cross Drive ramps, the operational performance was observed to improve in the AM peak. Any minor improvements in the average delay or degree of saturation are likely to be the result of the model optimising the operation of the intersection with the additional construction traffic on certain movements.

Table 8-28 Waterloo Station construction site intersection performance – southern haul route

	Without construction			With construction		
Peak period	**Average delay (second per vehicle)**	**Level of Service**	**Degree of saturation**	**Average delay (second per vehicle)**	**Level of Service**	**Degree of saturation**
Wyndham Street / Mandible Street						
AM	21	B	0.42	20	B	0.42
PM	21	B	0.42	21	B	0.44
Botany Road / Mandible Street						
AM	35	C	1.03	55	D	1.09
PM	6	A	0.56	6	A	0.58
Wyndham Street / McEvoy Street						
AM	22	B	0.63	24	B	0.68
PM	25	B	0.77	24	B	0.77
Botany Road / McEvoy Street						
AM	46	D	0.95	46	D	0.96
PM	38	C	0.92	39	C	0.94
Wyndham Street / Buckland Street						
AM	13	A	0.46	13	A	0.46
PM	11	A	0.46	11	A	0.46

Peak period	Without construction			With construction		
	Average delay (second per vehicle)	Level of Service	Degree of saturation	Average delay (second per vehicle)	Level of Service	Degree of saturation
Botany Road / Buckland Street						
AM	10	A	0.55	12	A	0.49
PM	13	A	0.53	13	A	0.55
Wyndham Street / Henderson Road						
AM	36	C	0.86	35	C	0.86
PM	30	C	0.81	30	C	0.81
Botany Road / Henderson Road / Raglan Street						
AM	44	D	0.89	39	C	0.91
PM	42	C	0.92	43	D	0.92
Raglan Street / Cope Street						
AM	8	A	0.34	7	A	0.34
PM	4	A	0.38	4	A	0.38
Wellington Street / Cope Street						
AM	3	A	0.30	3	A	0.30
PM	3	A	0.31	3	A	0.31
Wyndham Street / O'Riordan Street						
AM	8	A	0.42	8	A	0.42
PM	7	A	0.38	7	A	0.40
Wyndham Street / Bourke Road						
AM	19	B	0.40	19	B	0.40
PM	19	B	0.40	19	B	0.42
Botany Road / Bourke Street / Bourke Road / O'Riordan Street						
AM	109	F	1.14	115	F	1.14
PM	130	F	1.11	130	F	1.11
Botany Road / Epsom Road						
AM	30	C	0.87	30	C	0.89
PM	32	C	0.87	32	C	0.87
Botany Road / Collins Street						
AM	16	B	0.76	16	B	0.79
PM	19	B	0.81	19	B	0.81
Botany Road / Shirley Street						
AM	15	B	0.60	15	B	0.61
PM	19	B	0.82	19	B	0.82

Peak period	Without construction			With construction		
	Average delay (second per vehicle)	Level of Service	Degree of saturation	Average delay (second per vehicle)	Level of Service	Degree of saturation
Botany Road / Harcourt Parade						
AM	47	D	0.96	53	D	0.98
PM	38	C	0.76	38	C	0.78
Botany Road / Gardeners Road						
AM	37	C	0.97	38	C	0.97
PM	35	C	0.99	35	C	0.99
Botany Road / Coward Street						
AM	57	D	0.96	54	D	0.97
PM	71	F	1.02	75	F	1.01
Botany Road / King Street						
AM	25	B	0.82	33	C	0.90
PM	15	A	0.62	16	B	0.59
Botany Road / High Street						
AM	11	A	0.75	11	A	0.78
PM	4	A	0.39	3	A	0.40
Botany Road / Robey Street						
AM	17	B	0.69	14	A	0.82
PM	16	B	0.65	10	A	0.62
Botany Road / General Holmes Drive						
AM	19	B	0.77	18	B	0.67
PM	17	B	0.73	18	B	0.70
Botany Road / Wentworth Avenue						
AM	112	F	1.18	110	F	1.16
PM	39	C	0.90	32	C	0.93
Botany Road / Mill Pond Road / Southern Cross Drive ramps						
AM	62	E	1.03	55	D	1.01
PM	43	C	0.97	44	D	0.98
General Holmes Drive / Mill Pond Road						
AM	67	E	1.04	80	F	1.07
PM	41	C	0.93	42	C	0.95

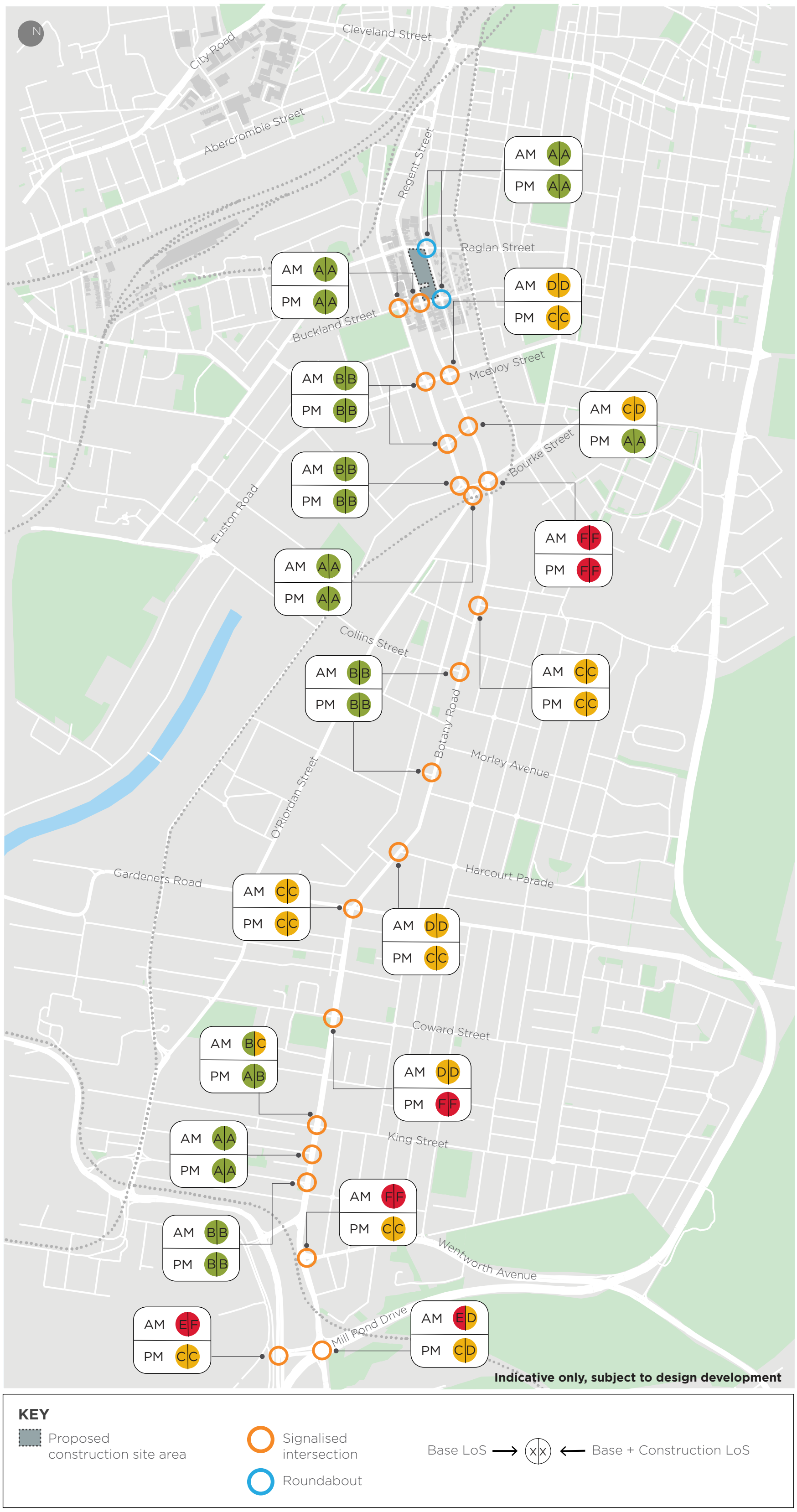


Figure 8-49 Waterloo Station intersection performance – southern haul route

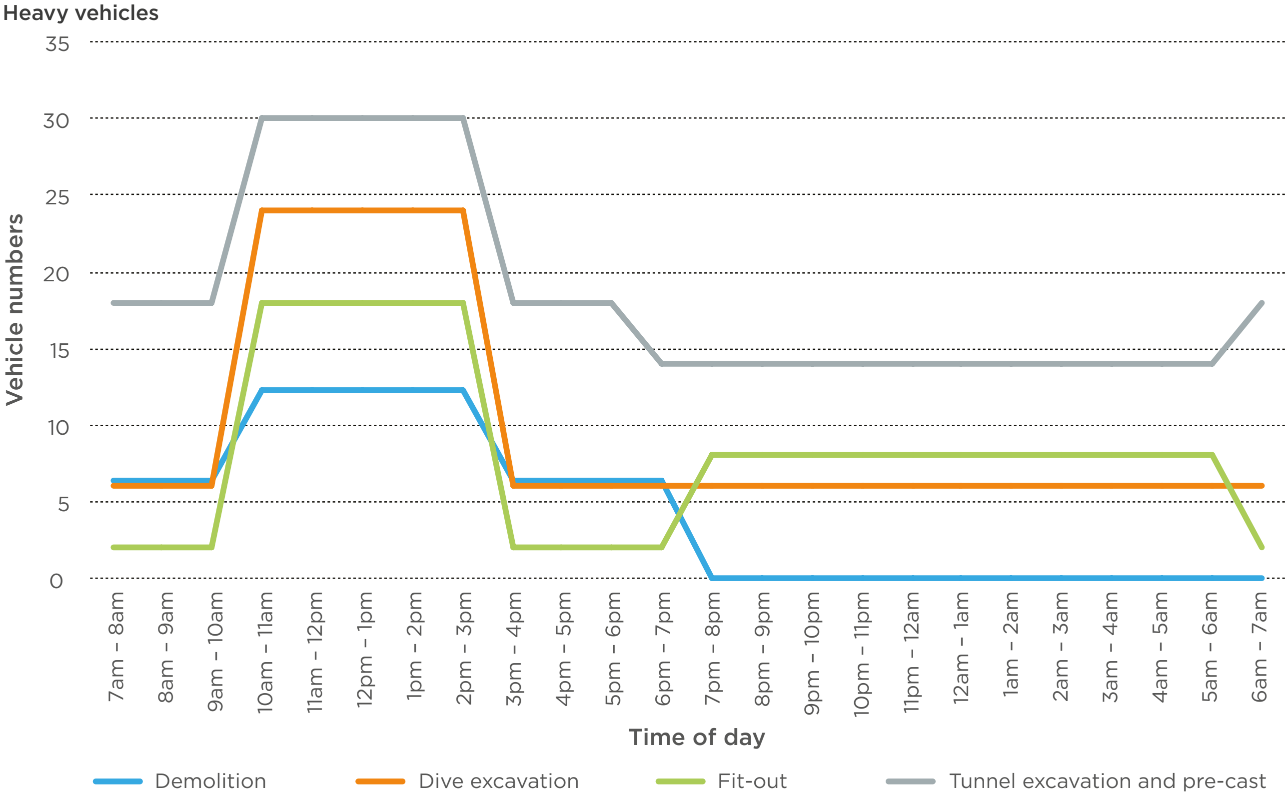
8.4.18 Marrickville dive site (southern)

Vehicle movement forecasts and routes

The anticipated vehicle numbers (heavy and light vehicles) at the Marrickville dive site over a typical day are provided in Figure 8-50. This graph shows that the peak heavy vehicle movements in the AM peak period (7am to 10am) would be 18 heavy vehicles per hour during the tunnel excavation and pre-cast facility phase.

The proposed haul routes are shown in Figure 8-51. Access and egress to and from the Marrickville dive site would be left in, right out via Murray Road; left in, right out via Sydney Steel Road.

The potential cumulative construction traffic impacts associated with WestConnex are addressed in Chapter 26 (Cumulative impacts).



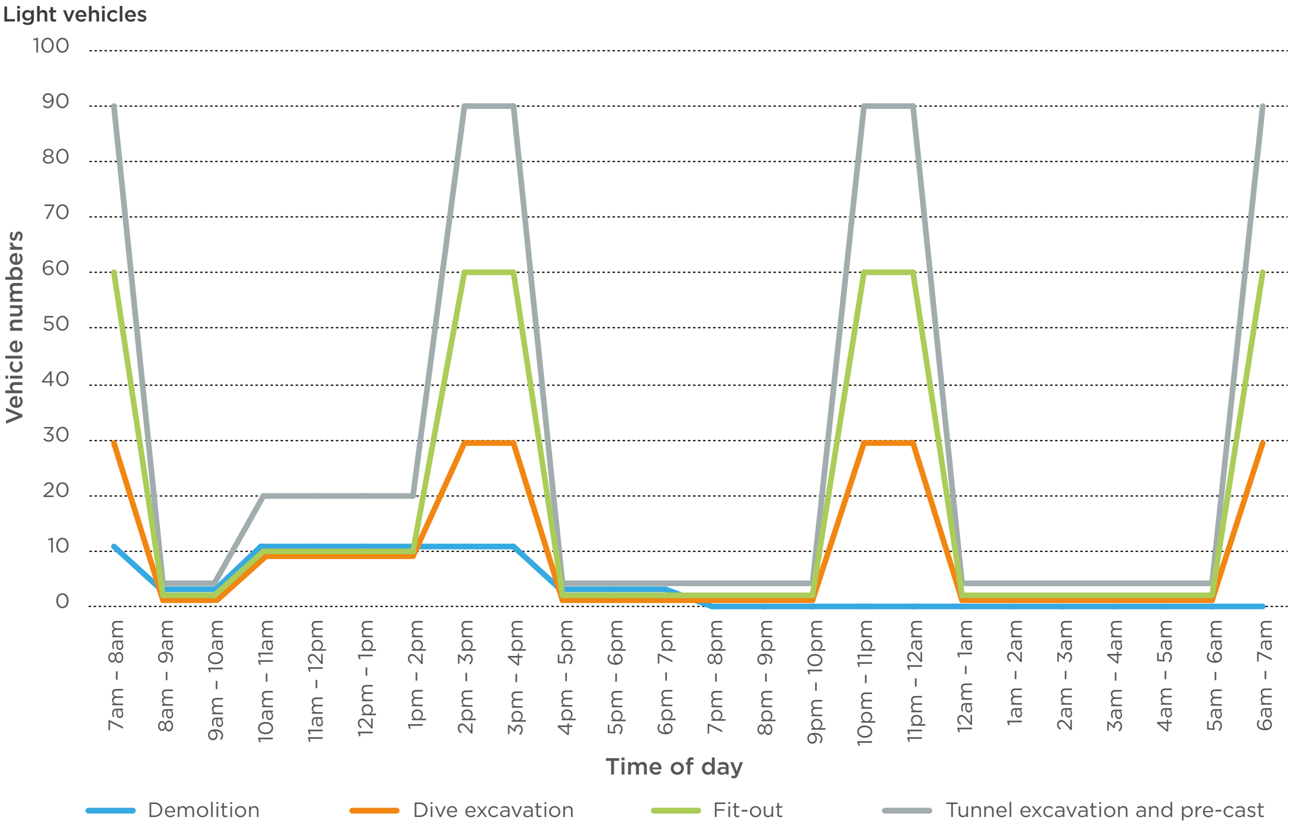


Figure 8-50 Marrickville dive site (southern) construction vehicle movements

Figure 8-51 Marrickville dive site (southern) haul routes

Active transport network

There would be no direct impacts to pedestrian or cyclist facilities at the Marrickville dive site.

Public transport services

Minimal disruption would be expected to bus services operating along Edinburgh Road due to the low number of heavy vehicles trips generated due to construction works. No major track works would occur at this site however there is the potential for rail possessions which would be negotiated with Sydney Trains.

Parking and taxis

Up to four on street car parking spaces on Edinburgh Road would be removed during the construction phase. The temporary loss of up to four spaces would not have any major impacts on parking considering the proximity and availability of other parking spaces.

Road network performance

In order to provide safe egress of construction vehicles, the Edinburgh Road / Edgeware Road intersection is proposed to be signalised as part of the project. The design of this signalised intersection would also consider the need for advance traffic signal warning lights on Edgeware Road to further improve safety. No other upgrades to surrounding roads, including Bedwin Road, are required.

Table 8-29 and Figure 8-52 shows the impact of construction on nearby key intersections. In summary, this shows that all intersections maintain their existing level of service with the construction traffic added onto the network except for the Bedwin Road / Unwins Bridge Road / Campbell Street / May Street intersection which deteriorates from a level of service C to level of service D in the PM peak. However, the increase in the average vehicle delay and degree of saturation is relatively minor. Therefore, the deterioration in the performance of the intersection is not considered to have a material impact on the overall operation of the road network.

Table 8-29 Marrickville dive site (southern) intersection performance

Peak period	Without construction			With construction		
	Average delay (second per vehicle)	Level of Service	Degree of saturation	Average delay (second per vehicle)	Level of Service	Degree of saturation
Edinburgh Road / Murray Street						
AM	4	A	0.48	4	A	0.52
PM	6	A	0.66	6	A	0.71
Edinburgh Road / Edgeware Road						
AM	3	A	0.38	4	A	0.43
PM	3	A	0.40	4	A	0.45
Edinburgh Road / Bedwin Road / Edgeware Road						
AM	11	A	0.55	13	A	0.58
PM	11	A	0.66	13	A	0.69
Bedwin Road / Unwins Bridge Road / Campbell Street / May Street						
AM	45	D	1.01	51	D	1.03
PM	42	C	1.01	47	D	1.03
Princes Highway / Campbell Street						
AM	34	C	1.00	35	C	1.00
PM	30	C	0.86	30	C	0.86
Princess Highway / May Street						
AM	33	C	0.83	35	C	0.80
PM	25	B	0.81	29	C	0.86

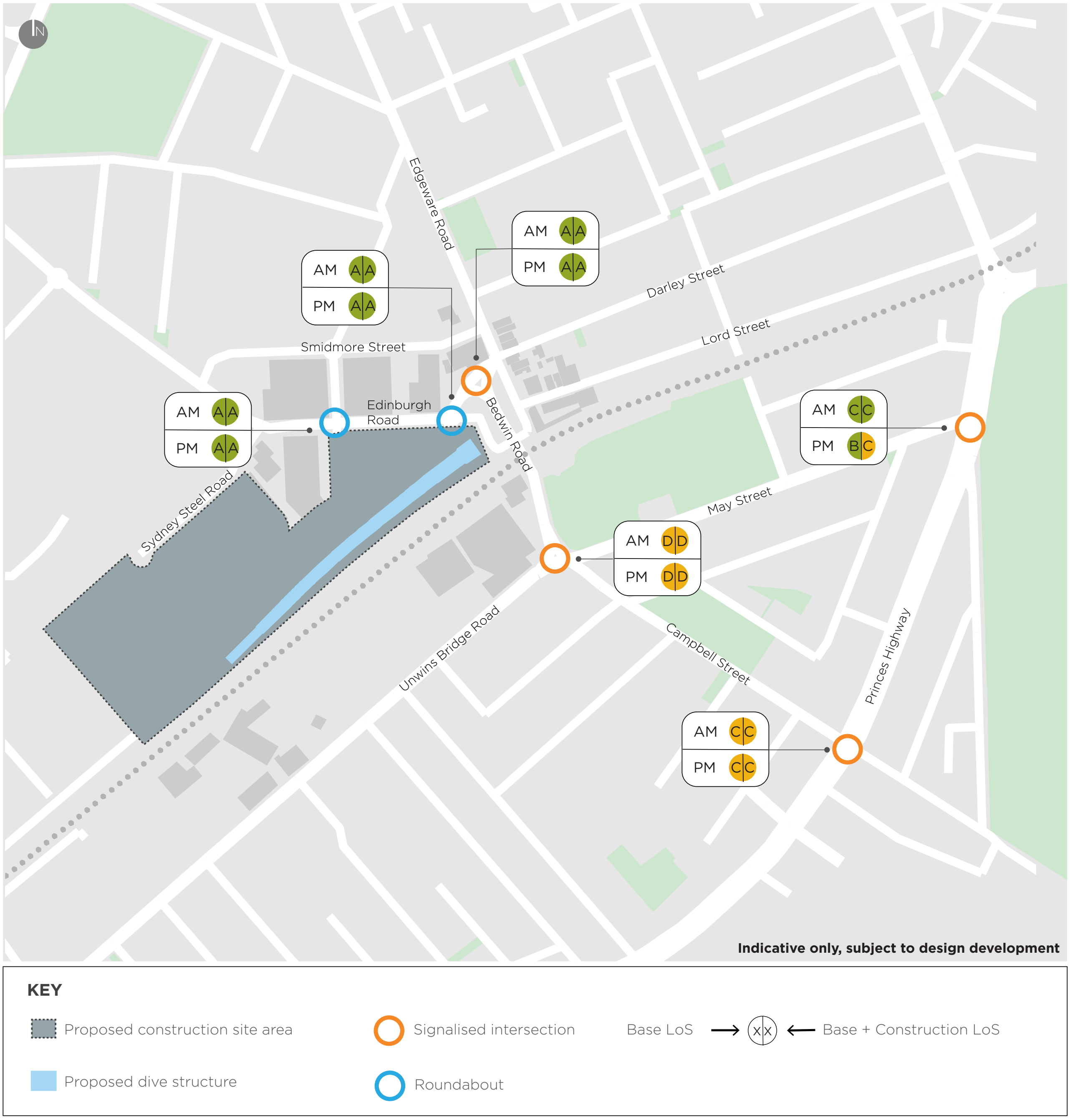


Figure 8-52 Marrickville dive site (southern) intersection performance

8.5 Mitigation measures

The mitigation measures that would be implemented to address potential construction traffic and transport impacts are listed in Table 8-30.

Table 8-30 Mitigation measures – construction traffic and transport

Ref	Mitigation measure	Applicable location(s)[1]
T1	Ongoing consultation would be carried out with (as relevant to the location) the CBD Coordination Office, Roads and Maritime Services, Sydney Trains, NSW Trains, local councils, emergency services and bus operators in order to minimise traffic and transport impacts during construction.	All except metro rail tunnels
T2	Road Safety Audits would be carried out at each construction site. Audits would address vehicular access and egress, and pedestrian, cyclist and public transport safety.	All except metro rail tunnels
T3	Directional signage and line marking would be used to direct and guide drivers and pedestrians past construction sites and on the surrounding network. This would be supplemented by Variable Message Signs to advise drivers of potential delays, traffic diversions, speed restrictions, or alternate routes.	All except metro rail tunnels
T4	In the event of a traffic related incident, co-ordination would be carried out with the CBD Coordination Office and / or the Transport Management Centre's Operations Manager.	All except metro rail tunnels
T5	The community would be notified in advance of proposed road and pedestrian network changes through media channels and other appropriate forms of community liaison.	All except metro rail tunnels
T6	Vehicle access to and from construction sites would be managed to ensure pedestrian, cyclist and motorist safety. Depending on the location, this may require manual supervision, physical barriers, temporary traffic signals and modifications to existing signals or, on occasions, police presence.	All except metro rail tunnels
T7	Additional enhancements for pedestrian, cyclist and motorist safety in the vicinity of the construction sites would be implemented during construction. This would include measures such as: • Use of speed awareness signs in conjunction with variable message signs near construction sites to provide alerts to drivers • Shared experience educational events that allow pedestrians, cyclists or motorists to sit in trucks and understand the visibility restrictions of truck drivers, and for truck drivers to understand the visibility from a bicycle • Specific construction driver training to understand route constraints, expectations, safety issues and to limit the use of compression braking • Safety devices on construction vehicles that warn drivers of the presence of a vulnerable road user located in the vehicles' blind spots and warn the vulnerable road user that a vehicle is about to turn.	All except metro rail tunnels
T8	Access to existing properties and buildings would be maintained in consultation with property owners.	All except metro rail tunnels
T9	All trucks would enter and exit construction sites in a forward gear, where feasible and reasonable.	All except metro rail tunnels
T10	Any relocation of bus stops would be carried out by Transport for NSW in consultation with Roads and Maritime Services, the CBD Coordination Office (for relevant locations), the relevant local council and bus operators. Wayfinding and customer information would be provided to notify customers of relocated bus stops.	All except metro rail tunnels

Ref	Mitigation measure	Applicable location(s)[1]
T11	For special events that require specific traffic measures, those measures would be developed in consultation the CBD Coordination Office (for relevant locations), Roads and Maritime Services, and the organisers of the event.	BN, MP, PS, CS
T12	Construction sites would be managed to minimise construction staff parking on surrounding streets. The following measures would be implemented: • Encouraging staff to use public or active transport • Encouraging ride sharing • Provision of alternative parking locations and shuttle bus transfers where feasible and reasonable.	All except metro rail tunnels
T13	Construction site traffic would be managed to minimise movements in the AM and PM peak periods.	All except metro rail tunnels
T14	Construction site traffic immediately around construction sites would be managed to minimise movements through school zones during pick up and drop off times.	All except metro rail tunnels
T15	Pedestrian and cyclist access would be maintained at Crows Nest during the temporary closure of Hume Street, and at Martin Place during the temporary partial closure of Martin Place. Wayfinding and customer information would be provided to guide pedestrians and cyclists to alternative routes.	CN, MP
T16	Timing for the temporary closure of the Devonshire Street tunnel would avoid periods of peak pedestrian demand. Wayfinding and customer information would be provided to guide pedestrians to alternative routes.	CS
T17	Consultation would occur with the Harbour Master, Roads and Maritime Services and Sydney Ferries to ensure shipping channels are maintained during the Sydney Harbour ground improvement works.	GI
T18	During the closure of existing entrances to Martin Place Station, marshalls would be provided during the AM and PM peak periods to direct customers to available access and egress points.	MP
T19	Where existing parking is removed to facilitate construction activities, alternative parking facilities would be provided where feasible and reasonable.	All except metro rail tunnels
T20	Alternative pedestrian routes and property access would be provided where these are affected during the construction of the power supply routes.	PSR

1 *STW: Surface track works; CDS: Chatswood dive site; AS: Artarmon substation; CN: Crows Nest Station; VC: Victoria Cross Station; BP: Blues Point temporary site; GI: Ground improvement works; BN: Barangaroo Station; MP: Martin Place Station; PS: Pitt Street Station; CS: Central Station; WS: Waterloo Station; MDS: Marrickville dive site; Metro rail tunnels: Metro rail tunnels not related to other sites (eg TBM works); PSR: Power supply routes.*

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OPERATIONAL TRAFFIC AND TRANSPORT

CHAPTER NINE

9 Operational traffic and transport

This chapter assesses the potential operational traffic and transport impact as a result of the project. In particular, it describes how each station would integrate into the surrounding traffic and transport facilities. Technical paper 1 – Traffic and transport provides further details.

9.1 Secretary's environmental assessment requirements

The Secretary's environmental assessment requirements relating to operational traffic and transport, and where these requirements are addressed in this Environmental Impact Statement, are outlined in Table 9-1.

Table 9-1 Secretary's environmental assessment requirement – operational traffic and transport

Ref.	Secretary's environmental assessment requirement	Where addressed
13. Transport and Traffic		
13.2	The proponent must assess the operational transport impacts of the project, including:	
13.2 (m)	forecast travel demand and traffic volumes for the project and the surrounding road, cycle and public transport network;	Patronage forecasts are provided in Section 9.4.
13.2 (n)	travel time analysis;	Travel time savings are provided in Section 9.4.1.
13.2 (o)	performance of interchanges and intersections by undertaking a coordinated level of service analysis at locations affected by stations;	Performance of nearby intersection which could be impacted by operation of the project are provided in Section 9.4.
13.2 (p)	wider transport interactions (local and regional roads, permanent loss of parking, the need for kiss-and-ride facilities, cycling, public and freight transport);	Wider transport impacts and benefits are described in Section 9.4.1. Integration with the road network for each station is provided in Section 9.4.
13.2 (q)	induced traffic and operational implications for public transport connected to stations sites (particularly with respect to strategic bus corridors and bus routes) and consideration of opportunities to improve public transport linkages;	Inducted traffic is discussed in Section 9.4.2. Public transport integration with the project is addressed in Section 9.4.
13.2 (r)	impacts on pedestrian access in and around stations and connecting streets, capacity of streets at peak pedestrian times, including phasing of traffic lights, intersection crossing times and connectivity between stations;	Pedestrian impacts are addressed in Section 9.4.
13.2 (s)	assess the benefits to each station and the general vicinity of walking and cycling catchments and the provision of infrastructure to support sustainable transport options;	Active transport is addressed in Section 9.4.
13.2 (t)	impacts on cyclists, pedestrian access and safety; and	Impacts on pedestrian and cyclist access and safety are addressed in Section 9.4.

Ref.	Secretary's environmental assessment requirement	Where addressed
13.2 (u)	opportunities to integrate cycling and pedestrian elements with surrounding networks and in the project.	Integration of active transport elements with the project is addressed in Section 9.4.
10. Socio-economic, Land Use and Property		
10.3	3. Assess the likely risks of the project to public safety, paying particular attention to subsidence risks, bushfire risks and the handling and use of dangerous goods.	Public safety relating to operational traffic and transport is addressed in Section 9.4.

9.2 Assessment methodology

A qualitative assessment of the operation the project has been carried out, including a description of the transport integration of each station and assessment of the potential traffic and transport impacts.

Two patronage forecast models were configured and run to produce preliminary forecast passenger demand and their anticipated mode of arrival / departure from each station:

- The Public Transport Project Model (PTPM) is informed by a number of assumptions regarding future land and transport use and operations
- The Enhanced Train Crowding Model (ETCM) provides detailed rail modelling analysis for station entries and exits, line loading and platform crowding. Inputs to the ETCM are based on the outputs generated from the PTPM.

Cycling forecasts at each station were determined using the outputs of the patronage modelling and the Transport for NSW Bike and Ride initiative, identified in Sydney's Cycling Future (Transport for NSW, 2013c).

The patronage forecasts were produced for 2036 based on land use planning projections available from the Department of Planning and Environment. However, the design year adopted for the project is 2056 to ensure the design of the stations would be able to accommodate future growth.

9.3 Existing environment

The existing traffic and transport environment around each of the proposed stations, and the regional road network, is described in Chapter 8 (Construction traffic and transport). For the most part, this background environment status as described would also be applicable to the operation stage of the project. The regional transport network is described in Section 9.3.1.

Notwithstanding it is recognised that the traffic and transport environment is currently undergoing major changes particularly in the Sydney CBD as the Sydney City Centre Access Strategy is progressively implemented. This includes the expected operation of major transport projects such as the CBD and South East Light Rail, the pedestrianisation of George Street between Hunter Street and Bathurst Street, and the new CBD Bus Strategy. The implementation of these changes results in alterations to the existing baseline applicable to the operational traffic and transport assessment.

The assumed status of these projects (once Sydney Metro City & Southwest is operational) which was considered as part of the assessment are:

- CBD and South East Light Rail completed and operational
- George Street pedestrianised between Hunter Street and Bathurst Street
- Sydney CBD bus network consistent with the changes implemented on 4 October 2015
- Road network consistent with the changes required by CBD and South East Light Rail including:
  - conversion of Pitt Street to two-way operation between Bridge and Alfred streets
  - conversion of Hunter Street to two-way operation between Pitt and George streets
- Sydney CBD cycle routes implemented consistent with the Sydney City Centre Access Strategy (Transport for NSW, 2013a)
- Central Barangaroo completed and open
- Barangaroo Ferry Hub and Wynyard Walk completed and operational.

9.3.1 Regional transport environment

Regional active transport network

There is a relatively well defined cycle network across the lower North Shore which avoids the most heavily trafficked roads with marked and unmarked on-road cycle routes and off-road paths.

Key links in the cycle network include:

- The Sydney Harbour Bridge crossing, which is accessed from Alfred Street in Milsons Point (on the north) and Kent Street (in the south)
- The dedicated off-road Gore Hill Freeway cycleway, which provides a key regional link between Cammeray, Chatswood, Lane Cove, Macquarie Park and Epping.

Changes to cycle routes within the Sydney CBD are occurring as a result of the CBD and South East Light Rail project and the implementation of the Sydney City Centre Access Strategy (Transport for NSW, 2013a). The implementation of these cycle routes is likely to be ongoing during construction of Sydney Metro.

South of the Sydney CBD, the major cycle routes operate through Waterloo and Alexandria, particularly along Bourke Street.

Pedestrians are generally catered for locally through footpaths and dedicated road crossings. The areas surrounding the project generally have a high volume of pedestrians, especially within the North Sydney, Crows Nest and Sydney CBD areas.

Regional public transport network

Suburban rail

North of Sydney Harbour, the Sydney Trains rail network consists of the T1 North Shore Line. This line forms a key transport corridor connecting major and specialised centres both within Sydney's northern suburbs and south of Sydney Harbour. The T1 North Shore Line is currently constrained by the maximum number of services able to cross the Sydney Harbour Bridge. To the south of Sydney Harbour, the T1 North Shore Line continues through the Sydney CBD before connecting to the T1 Western and T1 Northern Lines.

South of the Sydney CBD, services operating on the T3 Bankstown Line merge with either the T2 Inner West and South Line or the T2 Airport Line. These lines continue through the Sydney CBD using the City Circle. This merging of rail lines to the south of Central Station creates a bottleneck, forcing trains to queue and causing backlogs in the west and southwest.

The T4 Eastern Suburbs and Illawarra Line also operates through the Sydney CBD from Bondi Junction to Cronulla and Waterfall.

Sydney Metro Northwest is currently being built and is due to open in 2019, providing metro services between Chatswood Station and Cudgegong Road Station in Rouse Hill. When it is completed, customers will be able to interchange at either Chatswood (to the T1 North Shore Line) or Epping (to the T1 Northern Line and the Newcastle & Central Coast Line) between metro services and suburban rail services.

Bus network

Buses generally perform two main roles, being cross-regional public transport and local services connecting residential areas to key transport interchanges.

North of Sydney Harbour, major bus routes operate along the Hills M2 Motorway providing express services to the Sydney CBD and North Sydney. The Pacific Highway and Military Road / Spit Road also provide key bus corridors. The Pacific Highway connects areas to the north with key centres including Chatswood, St Leonards, North Sydney and the Sydney CBD. The Military Road / Spit Road corridor provides services from the Northern Beaches to the Sydney CBD via the Warringah Freeway and to the North Sydney CBD and providing links to St Leonards and Chatswood.

There are also a number of local services. These generally connect to rail stations, especially the key transport interchanges at Chatswood, St Leonards and North Sydney. These routes have frequent services both on and off peak.

Changes to the bus network that currently services the Hills District are anticipated following the opening of Sydney Metro Northwest in 2019. This is expected to result in a reduction in the number of buses crossing the Harbour Bridge.

Within the Sydney CBD, buses transport passengers from across Sydney into the CBD with many services running through the Sydney CBD in a north-south direction on Kent, Clarence, York, Castlereagh and Elizabeth streets, and in an east-west direction on Park and Druitt streets. Many bus services have also been redirected away from the core of the Sydney CBD to minimise congestion. Key bus interchanges within the Sydney CBD are provided at Wynyard Station, Town Hall Station and Central Station.

South of the Sydney CBD, key bus routes operate along the Princes Highway and King Street. There are also cross-regional services between Marrickville and Bondi Junction, and a number of local and feeder services that generally connect to rail stations to provide interchange opportunities. These routes have services both on and off peak.

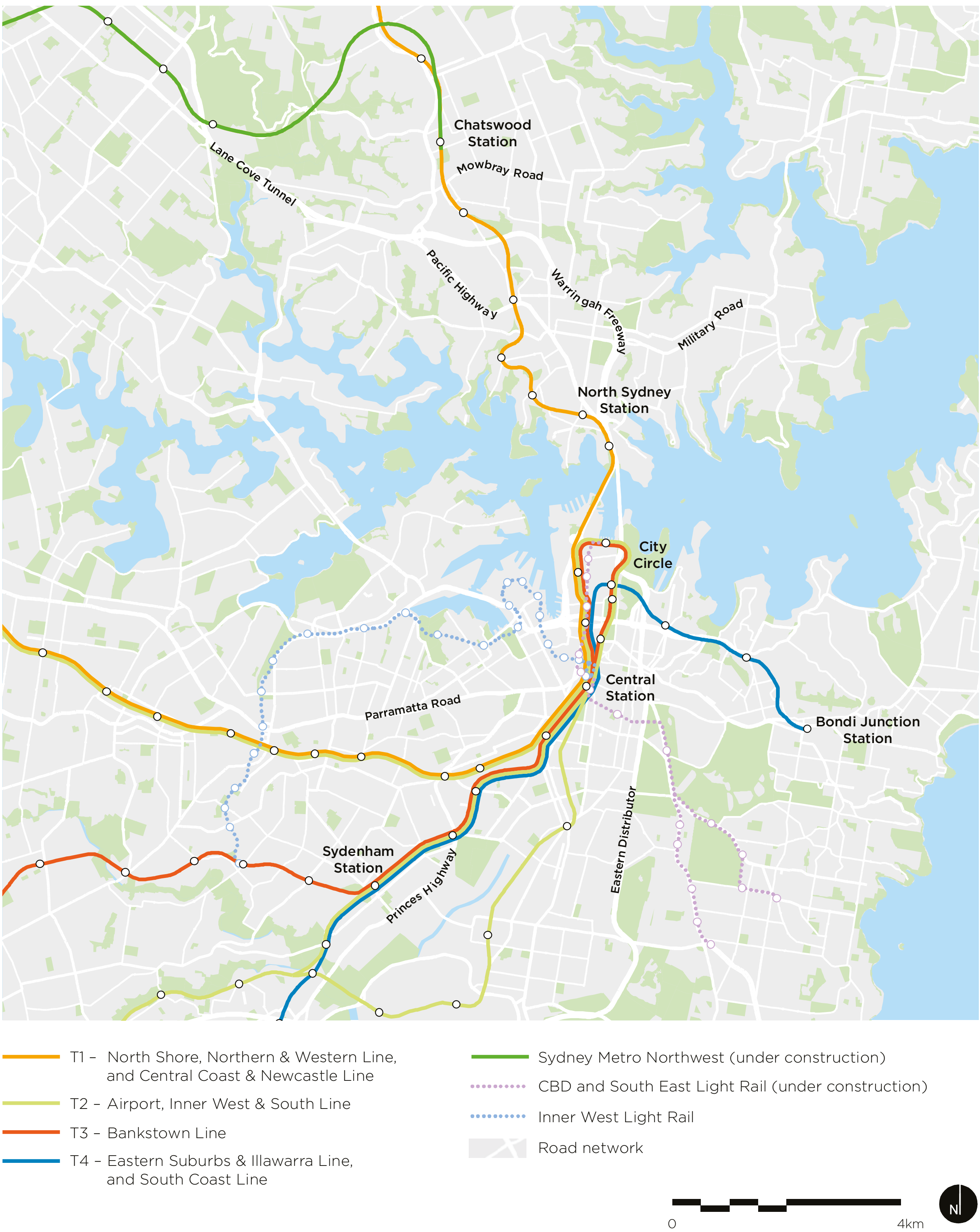


Figure 9-1 Overview of the existing and planned future rail and light rail network in the vicinity of the project

Light rail

The light rail network consists of one line between Dulwich Hill and Central via Lilyfield and Pyrmont (the Inner West Light Rail). It has frequent services over extended periods. Whilst its share of total passengers to the Sydney CBD is limited, it plays an important role in connecting the areas it serves to the Sydney CBD.

Light rail's role and function will be significantly increased following the introduction of the CBD and South East Light Rail (anticipated to begin operations in 2019). This will establish a new light rail network between Circular Quay and Randwick / Kingsford. The route will be along George Street, Eddy Avenue and Chalmers Street to Central Station, through Surry Hills to Moore Park, then to Kensington and Kingsford via Anzac Parade, and Randwick via Alison Road and High Street. Construction of the CBD and South East Light Rail is expected to occur concurrently with the construction of Sydney Metro, between the years of 2017 and 2019.

Ferry

Ferry services within Sydney perform two core functions – serving commuters and serving tourists / leisure customers. Most services connect to the Sydney CBD at Circular Quay. This includes services from the east (such as Watsons Bay), northeast (such as Manly), north (such as McMahons Point) and west (such as Parramatta River and Balmain). King Street Wharf on the western edge of the Sydney CBD is also served by Parramatta River services.

The Barangaroo Ferry Hub (expected to be open in 2016) will provide for new ferry services operating to and from the Barangaroo South area, and customers will have connections to Wynyard Station via Wynyard Walk.

9.4 Potential impacts

9.4.1 Strategic traffic and transport impacts

The design of the project would aim to avoid or reduce impacts associated with operational traffic and transport. It would improve road traffic conditions by providing a convenient and efficient travel alternative to the use of the private car.

Chapter 3 (Strategic need and justification) identifies the anticipated transport benefits following the implementation of the Sydney Metro network, as well as the specific benefits of the Chatswood to Sydenham project. The strategic traffic and transport related impacts and benefits of the operation of the project are outlined below.

Travel time savings

- The project would improve travel times by:
- Providing more direct routes to key destinations
- Reducing crowding on trains and stations, which would improve the reliability of services

Offering an alternative, faster and more reliable public transport trip to the Sydney CBD and North Sydney.

The largest travel time savings would be experienced in areas where new stations are provided (such as Crows Nest), where more direct routes are provided. Travel time savings would be experienced by existing rail customers (who would directly benefit from shorter travel times), new rail customers (who would transfer from road-based transport to rail).

Specifically, travel time savings enabled by the project would be experienced by:

- Sydney Metro Northwest and T1 North Shore Line customers who would have access to more direct Sydney Metro services to key activity areas in the Global Economic Corridor
- Central Coast customers travelling to North Shore and Sydney CBD stations would have significant travel time savings, with these services being able to take advantage of the more direct routes made possible by the introduction of the project
- North Shore and North Sydney customers who would have direct rail access to key destinations in the Global Economic Corridor such as Martin Place and Norwest Business Park
- Eastern suburbs customers who would have more direct access to key destinations in the Global Economic Corridor, interchanging to direct services at Martin Place Station instead of the crowded Town Hall Station.

Travel time savings are also likely to be experienced by road and remaining bus users who would experience less congestion.

Some key forecast travel time savings associated with the Chatswood to Sydenham project are:

- Martin Place to Chatswood – 19 minute savings
- Norwest Business Park to Central – 15 minute savings
- Martin Place to North Sydney (corner Miller Street and Pacific Highway) – 15 minute saving
- Macquarie Park to North Sydney (corner Miller Street and Pacific Highway) – 13 minute savings
- Crows Nest to Central – 21 minute saving
- Bondi Junction to North Sydney (corner Miller Street and Pacific Highway) – 11 minute saving.

Information on how indicative travel time savings have been calculated is provided in Chapter 3 (Strategic need and justification).

Decreased station crowding

The provision of new Sydney CBD stations and platforms at Barangaroo, Martin Place, Pitt Street and Central would spread station loading and decrease crowding at Wynyard and Town Hall stations, and at some platforms at Central Station. The project would also provide relief to North Sydney and St Leonards stations with alternative metro stations at nearby Victoria Cross and Crows Nest. The anticipated change in passenger demand at key platforms within the Sydney CBD and at North Sydney and St Leonards stations is shown in Figure 9-2.

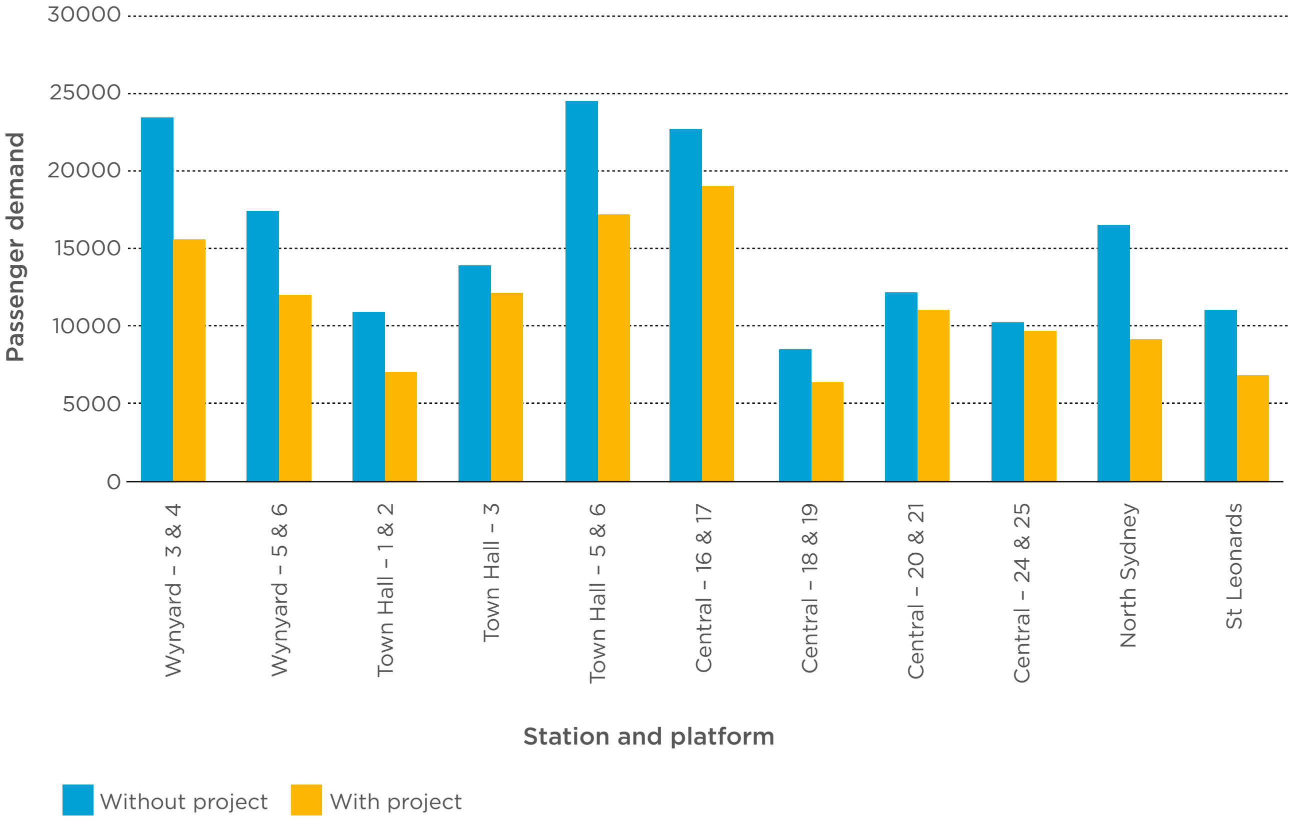


Figure 9-2 Decreased station crowding (AM peak one hour)

Increased rail network reach and use

The project would increase the use and reach of the rail network by providing:

- New stations at Barangaroo, Waterloo, Crows Nest and Victoria Cross would directly increase rail catchment areas
- More direct connections to high-capacity Sydney CBD stations at Martin Place and Pitt Street would increase Sydney CBD rail catchment areas
- Additional interchange capability at Central Station, Martin Place and Pitt Street (to Town Hall Station).

The project would also provide a direct link for Sydney Metro Northwest customers to the Sydney CBD.

Improved network resilience

Suburban rail access through the Sydney CBD and across the harbour is currently limited to the T1 North Shore, Northern and Western Line. Shutdowns during unplanned and planned events currently impact on customer service provision. Closures of the Harbour Bridge for example can cease the provision of public transport services linking the Sydney CBD to key destinations on the lower North Shore and Northern Sydney. The T1 North Shore Line is also subject to periodic maintenance which reduces access for passengers to key stations such as North Sydney, St Leonards and Chatswood.

The project would provide an additional, high-capacity public transport link through the Sydney CBD and across Sydney Harbour. This would provide an alternative option for customers during these unplanned and planned events which may force closure of other Sydney CBD and harbour links.

Bus network benefits

The project would provide bus network benefits by:

- Freeing of bus services by bus customers transferring to rail, enabling the opportunity to redeploy bus services from the north and north west
- Reducing demand for Sydney Harbour Bridge bus services, freeing capacity over the Harbour Bridge.

The project would also provide the opportunity for bus-rail interchange at the new metro stations which could reduce reliance on cross-regional bus routes and potentially reducing congestion and improving travel times for remaining bus customers. Bus network improvements potentially enabled by the project would be considered by Transport for NSW as part of future reviews of the bus network and associated timetabling.

Improved conditions for road users

By encouraging more people to use the rail network, the project would reduce congestion on the road network, including on key road corridors such as the Sydney Harbour Bridge, Sydney Harbour Tunnel and Eastern Distributor.

Erskineville and St Peters rail services

Erskineville and St Peters stations are currently served by trains on the T3 Bankstown Line. After opening of the project, trains on the T3 Bankstown Line would be moved to other lines such as the T2 Inner West and South Line. Erskineville and St Peters stations would continue to be served by Sydney Trains services. Customer demand levels at these stations would be taken into account when new train timetables are being designed over the coming years.

9.4.2 Transport integration strategy

The station access hierarchy identified in Figure 9-3 and described in Table 9-2 has been adopted during the development of the design and the transport integration strategy for each metro station. The objective of the hierarchy is to allow the most prominent locations within an interchange precinct to be allocated to the most efficient and sustainable transport modes.

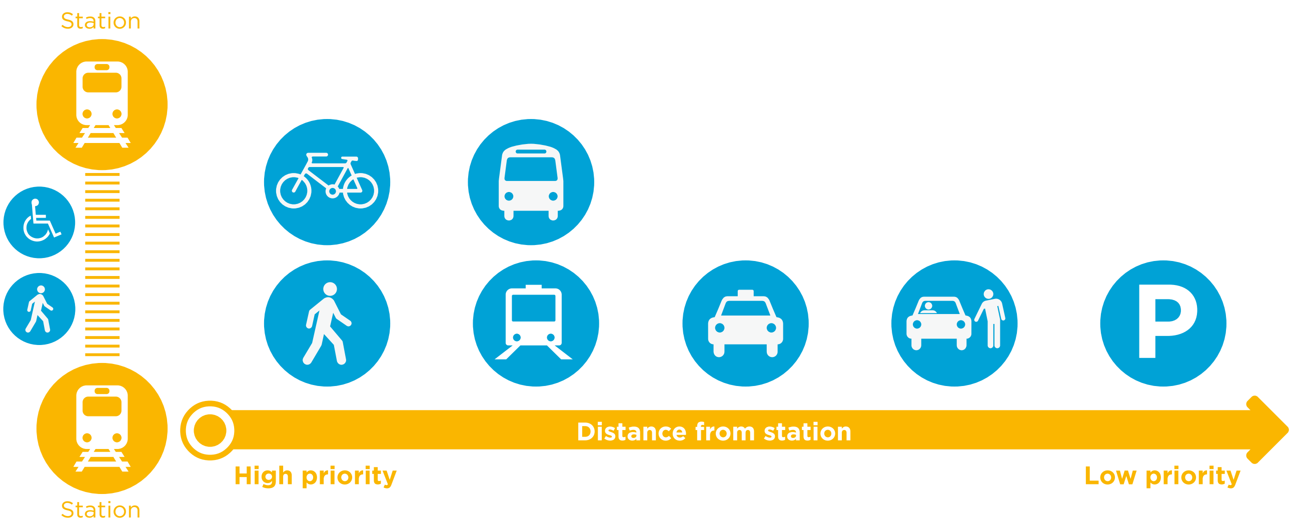


Figure 9-3 Metro station access hierarchy

Due to the location of each station, particularly within the Sydney CBD area, in general metro customers are not anticipated to access the station by car and would be discouraged to do so by the absence of car parking facilities. Although where appropriate kiss-and-ride provisions would be made at some stations. As no car parking is to be provided at any of the metro stations, the project would not induce traffic demand once operational.

Table 9-2 Station access hierarchy

Transport mode	Description
Walking and cycling	Walking and cycling are the highest priority access modes as they are the most sustainable, cost-effective, equitable and accessible. Pedestrians and cyclists have the lowest environmental impact and (typically) spatial requirements whilst they also contribute to personal safety, urban and commercial viability. As the stations are all located within established urban areas, walking and cycling access would be predominantly along existing paths and routes which are extensive around all stations. Given the importance of active transport access to the stations these modes have been expanded on further below.
Public transport (bus and light rail)	Public transport is the second highest priority in station planning and is typically focussed on facilitating interchange to other public transport modes. These services expand the effective catchment area of the rail system. Seamless interchange is required in order to maximise the uptake of linked trips within the public transport network.
Taxis	Taxis are the highest ranked of the car-based modes, supplementing the public transport system for access to destinations separated from the public transport network.
Kiss-and-ride	Kiss-and-ride is the preferred mode of those accessing the station by private vehicle, but a relatively low priority. Kiss-and-ride supports the concept of car sharing and trip chaining and ride sharing, reducing the number of single-occupant trips and in some instances parking demand.
Park-and-ride	Park-and-ride is the lowest priority of all modes. Given the high accessibility to sustainable transport modes in Sydney, formal parking facilities are only suggested outside of major centres. All of the proposed stations within this project are within a 10 kilometre radius of the Sydney CBD, therefore park-and-ride facilities are not proposed for this project.

Walking

The walking objectives include improving the customer experience by providing safe, direct, continuous, high quality and clearly-signposted walking paths to stations, and between the stations and other transport modes. Recent modelling forecasts show that an average of 66 per cent of customers would walk to stations outside the Sydney CBD in 2026 and at the Sydney CBD stations, most people would walk to their final destination.

Appropriate footpath widths and gradients would be provided outside of station exits and throughout the public domain altered at the metro station to link transport modes and provide safe and equitable pedestrian access. Vision and mobility impaired customers would be considered in the pavement designs, for example by keeping one side of the travel path clear of fittings and fixtures and providing Tactile Ground Surface Indicators on travel paths to warn of hazards and assist wayfinding where required.

Cycling

The amount and type of bike parking provided at stations would be based on the Transport for NSW Bike and Ride initiative, identified in Sydney's Cycling Future. The facilities are likely to be similar to those being introduced at several Sydney Trains stations, including Blacktown and Campbelltown. At these stations, secure bike spaces are provided in sheds which are free to use by train customers and can be accessed by OPAL cards.

The bike parking would be located close to the station, connect with the local cycle network and be in secure sheds and shelters so customers can safely leave their bikes and catch a train. The amount of parking would reflect forecast passenger demand at each station.

9.4.3 Chatswood dive

The Chatswood dive structure and tunnel portal would result in the demolition and permanent closure of the Nelson Street overbridge.

Pedestrians and cyclists

Nelson Street currently provides an active transport link between the Pacific Highway and Frank Channon Walk, a shared path running along the western side of the rail corridor from Nelson Street to Chatswood Station and the Chatswood commercial centre. Nelson Street also provides east-west connectivity across the T1 North Shore Rail Line between the Pacific Highway and Orchard Road, along with Mowbray Road to the south and Albert Avenue to the north. Surveys carried out in December 2015 identified in the AM peak hour a total of 16 pedestrians and five cyclists crossing Nelson Street bridge in both directions.

As part of the project, Frank Channon Walk (a shared path currently connecting Chatswood Station to Nelson Street) would be extended from Nelson Street to Mowbray Road on the western side of the rail line to provide an enhanced facility for pedestrians and cyclists and provide continued access between Chatswood Station and residential areas to the south. Those travelling from residential areas to the south-east of the rail line would need to use the underpass adjacent to Chatswood Oval to cross the rail line and access Frank Channon Walk. Orchard Road, running parallel to Frank Channon Walk on the eastern side of the rail line, could also be used as an alternative north-south route for journeys between the Chatswood retail areas and residential areas to the south.

For some pedestrians or cyclists travelling between Chatswood Station and residential areas to the south, this would result in an additional travel distance of around 50 to 100 metres; whilst for others it would result in a reduction in travel distances of around 50 to 100 metres.

Due to the extension of Frank Channon Walk and the availability of alternative facilities in the area the closure of Nelson Street bridge is not anticipated to result in significant impacts for pedestrians and cyclists.

The provision of new traffic signals at the Mowbray Road / Hampden Road intersections would provide additional pedestrian connectivity across Mowbray Road between the existing pedestrian crossings at the Pacific Highway and Orchard Road and a direct link to the extended Frank Channon Walk.

Road network

The primary role of Nelson Street overbridge is for use by motorists travelling southbound on the Pacific Highway to access Mowbray Road westbound via Orchard Road. To maintain this movement, an all vehicle right turn movement would be provided from the Pacific Highway southbound to Mowbray Road westbound and altered traffic light phasing to account for this new movement. For the purposes of this traffic assessment it is assumed that two right turn lanes would be provided. This would also require the localised widening of the Pacific Highway to the north of the Mowbray Road intersection.

Nelson Street also provides local access for properties located to the east of the T1 North Shore Rail Line. Following closure of the Nelson Street bridge, these residents would need to use alternative road to cross the rail line such as Mowbray Road or Albert Avenue which would result in a marginal increase to travel times.

In addition, it is anticipated that the traffic signals introduced at Mowbray Road / Hampden Road for the construction phase would be retained during operation.

Table 9-3 shows the intersection performance with and without the project. The Pacific Highway / Mowbray Road intersection is already operating over its theoretical capacity. The revised layout, including dual southbound right turn lanes from the Pacific Highway into Mowbray Road would result in a deterioration in the overall operational performance of the intersection from level of service E to level of service F. The operational performance in the PM peak would remain unchanged.

Introducing signals at the Mowbray Road / Hampden Road intersection would improve the operational performance in the AM peak from level of service F to level of service B, and improve the intersection from currently operating above its theoretical capacity, to be operating with a degree of saturation of 0.80.

The performance of the majority of the other intersections would remain unchanged.

Table 9-3 Chatswood dive intersection performance

Peak period	Without project			With project		
	Average delay	Degree of saturation	Level of service	Average delay	Degree of saturation	Level of service
Pacific Highway / Fullers Road / Help Street						
AM Peak	86	F	1.14	83	F	1.14
PM Peak	41	C	0.94	39	C	0.93
Pacific Highway / Victoria Avenue						
AM Peak	101	F	0.89	101	F	0.90
PM Peak	90	F	0.77	87	F	0.77
Pacific Highway / Centennial Avenue						
AM Peak	15	B	0.86	17	B	0.89
PM Peak	26	B	0.91	23	B	0.89
Pacific Highway / Albert Avenue / Oliver Road						
AM Peak	23	B	0.73	24	B	0.75
PM Peak	20	B	0.96	29	C	0.94
Pacific Highway / Mowbray Road						
AM Peak	57	E	1.02	72	F	1.06
PM Peak	89	F	1.10	119	F	1.14
Pacific Highway / Howarth Road / Norton Lane						
AM Peak	5	A	0.59	5	A	0.59
PM Peak	8	A	0.76	8	A	0.75
Pacific Highway / Gore Hill Freeway ramps						
AM Peak	74	F	1.09	77	F	1.12
PM Peak	79	F	1.15	74	F	1.13
Pacific Highway / Longueville Road						
AM Peak	32	C	0.80	31	C	0.83
PM Peak	27	B	0.74	27	B	0.77
Mowbray Road / Orchard Road / Elizabeth Street						
AM Peak	52	D	1.02	49	D	1.02
PM Peak	76	F	1.15	45	D	0.84
Mowbray Road / Hampden Road						
AM Peak	292	F	1.12	25	B	0.80
PM Peak	22	B	0.55	25	B	0.71

9.4.4 Crows Nest Station

The location and proposed transport integration of the Crows Nest Station is shown on Figure 9-4.

Figure 9-4 Crows Nest Station transport integration

Passenger demand

Preliminary forecasts for the 2036 AM peak hour indicate that around 4,600 customers would be entering and around 5,650 customers would be exiting the station, reflecting the mixed use nature of the area serving both residents and commercial workers.

The forecast arrival modes for the station are:

- Walking – 75 per cent
- Cycling – 1 per cent
- Bus – 17 per cent
- Kiss-and-ride – 7 per cent.

This demonstrates the need to provide appropriate pedestrian facilities in the vicinity of the site and efficient and seamless transfer between bus stops in the precinct and station entrances.

Pedestrian integration

Patronage forecasts indicate that the station would significantly increase pedestrian flows in the local precinct.

Patronage analysis of the station and streetscape indicates there would be limited impacts to pedestrians and road traffic due to the presence of the station. As a suburban station, the patronage is significantly lower than most Sydney CBD stations, with anticipated volumes being less than 10 people per minute along most footpaths and crossings.

With the exception of some locations, the majority of footpaths in the area would continue to operate at a level of service A. In both the AM and PM peak periods, the most heavily used footpaths and crossings to access the station would include:

- Oxley Street (southern side) between Clarke Street and Pacific Highway which would operate at a level of service D immediately around the station entry
- North-south pedestrian crossing at the intersection of the Pacific Highway and Oxley Street
- Pacific Highway (eastern side) north of Oxley Street which would operate at a level of service C.

Pedestrian arrivals and departures are expected to be the highest proportion of journeys to and from the station.

The following design features would be provided to accommodate the future pedestrian demand and ensure easy and safe interchange for pedestrians:

- Station entrance via plazas on the corner of Clarke and Hume streets, and the corner of the Pacific Highway and Oxley Street
- New crossing facilities around the Hume Street / Clarke Street intersection
- New crossing facility on Oxley Street near Clarke Street
- A midblock pedestrian crossing facility on Clarke Street between Hume Street and Oxley Street
- A new signalised crossing facility on the northern arm of the Pacific Highway at the Pacific Highway / Oxley Street intersection providing improved pedestrian connections to and from the west of the station
- Installation of wayfinding signage and Sydney Metro information.

Cyclist integration

An existing on-road marked bicycle route along Clarke Street, directly adjacent to the metro station would provide convenient connections to the cycle routes that are currently well used by cyclists.

The following would be provided to enable efficient cyclist access to the station:

- A new on-road marked cycle route along Hume Street between Clarke Street and Nicholson Street connecting to existing on-road marked cycle routes
- Bicycle parking at the Hume Street / Clarke Street entrance and the Pacific Highway / Oxley Street entrance.

Public transport integration

The existing bus network in the vicinity of the station currently has comprehensive coverage of the potential catchment for the proposed station. The existing bus network, with bus stops located on the Pacific Highway, within 100 metres of the station entrances would provide convenient access to Crows Nest Station. Short and convenient links between bus services and the station would be available via the existing bus facilities in the vicinity of the site.

Road network integration

Crows Nest currently experiences low to moderate levels of traffic congestion during peak periods, particularly along the Pacific Highway. Traffic forecasts indicate moderate growth between now and 2036, with traffic demand estimated to grow by approximately 16 per cent by 2036.

To cater for the expected low volume of customers wanting to kiss-and-ride at the station, facilities would be provided on both frontages of Clarke Street.

To meet the likely increase in demand for taxi and kiss-and-ride the following would be provided:

- A taxi rank on the south western side of Clarke Street
- Kiss-and-ride facilities on both sides of Clarke Street between Oxley Street and Hume Street.

Given the low forecast vehicular arrivals, the metro station is not anticipated to have a material impact on the operation of the road network in the vicinity of the station.

The predicted intersection performance with this signalised pedestrian crossing is provided in Table 9-4.

The operational performance of the Pacific Highway / Oxley Street intersection deteriorates marginally in the AM peak hour, however is unchanged in the PM peak hour. In both peak hours the intersection would operate at a level of service B with the new signalised pedestrian crossing. Therefore, it can be concluded that the introduction of a pedestrian crossing across the northern arm of the Pacific Highway in the vicinity of the station would have a minimal impact on the local road network. Further, the addition of a signalised pedestrian crossing on this arm of the intersection improves the level of access of pedestrians travelling to or from the north west corner of the intersection.

Table 9-4 Crows Nest Station operational intersection performance

Peak period	Without project			With project		
	Average delay	Degree of saturation	Level of service	Average delay	Degree of saturation	Level of service
Pacific Highway / Oxley Street						
AM Peak	13	A	0.63	17	B	0.74
PM Peak	15	B	0.73	21	B	0.70
Pacific Highway / Hume Street						
AM Peak	13	A	0.59	8	A	0.55
PM Peak	12	A	0.61	7	A	0.49
Pacific Highway / Falcon Street / Shirley Road						
AM Peak	50	D	0.86	51	D	0.86
PM Peak	52	D	0.91	52	D	0.91

9.4.5 Victoria Cross Station

The location and proposed transport integration of the Victoria Cross Station is shown on Figure 9-5.

KEY

- Proposed Metro entry
- Operational area
- Proposed cycle parking
- Existing train station entry/exit
- Existing bus stop
- Existing taxi rank
- Proposed kiss-and-ride
- Existing key pedestrian crossing
- Existing underground pedestrian connection
- Existing cycle route
- Existing bus route
- Services
- Metro Alignment

Figure 9-5 Victoria Cross Station transport integration

Passenger demand

Preliminary forecasts for the 2036 AM peak hour indicate that around 2,600 customers would be entering the station and around 12,550 customers would be exiting the station.

The forecast modes of arrival at the station are:

- Walking – 67 per cent
- Cycling – 1 per cent
- Bus – 26 per cent
- Kiss-and-ride – 6 per cent.

The forecasts indicate that for the relatively small portion of residents accessing the station in the morning, the majority would do so via walking.

The majority of morning exits (about 66 per cent) from the station are expected to travel to the south towards the commercial core while 12 per cent are expected to exit the station to the north to commercial and educational land uses, 10 per cent to the east and 12 per cent to the west.

Pedestrian integration

With a strong existing public transport network of bus and rail, the areas of employment, residential and educational land-uses generate a high volume of localised pedestrian trips accessing public transport modes.

Strong pedestrian desire lines are anticipated from the cluster of bus stops along Miller Street, and the educational facilities to the west. Mount Street also acts as a key pedestrian route to provide east-west access to the commercial uses on either side of the Pacific Highway.

The high proportion of walking journeys expected at the Victoria Cross Station means the pedestrian movement and access to the site has been considered a priority as part of the station design. The following design features are proposed to ensure smooth interchange for pedestrians:

- A pedestrian plaza forming the access to the station from Miller Street and Berry Street
- Direct pedestrian links to Denison Street, providing access to and from the commercial area to the east of the station
- Wayfinding signage and Sydney Metro information within the North Sydney CBD.

Pedestrian modelling of the station and streetscape identified that the majority of the footpaths in the area would operate at a level of service B or better. However, two locations have been identified where there would be potential for safety risks or impacts to pedestrians and / or traffic due to the siting of the Metro station. These locations include:

- Intersection of Miller Street and Berry Street
- Denison Street which would operate at a level of service E.

At the intersection of Miller Street and Berry Street, pedestrian movements are increased due to the proximity of the station access to the intersection. Although the intersection is in a comparatively low-speed environment, if the crossing capacity is not increased there may be an increase in informal crossing, which may lead to pedestrian safety issues and delays to traffic.

Options to mitigate the impact may include:

- Widening of the pedestrian crossing, which would increase the pedestrian throughput without effecting cycle-times
- Increase the pedestrian green-time, which would increase the pedestrian throughput by extending the proportion of green-time per cycle at the intersection. However, this would consequently reduce green-time available for vehicle movements
- Providing a mid-block crossing on Miller Street immediately outside of the station entrance.

At the eastern access to the station, a large proportion of the station demand is expected to traverse along Denison Street. Currently Denison Street is a Shared Zone south of Spring Street, however between the proposed station exit and Spring Street, Denison Street only has a narrow footpath with several driveways. Consequently, with the significant increase in pedestrian volumes, the road may no longer be suitable for both pedestrians and vehicles without significantly compromising pedestrian safety and/or traffic delays.

To mitigate this potential risk, an option would be the pedestrianisation of Denison Street between Berry and Spring Streets, and if vehicle access is required for loading, vehicle movements could be limited to off-peak periods.

Additionally, the existing pedestrian islands located between the Pacific Highway and Miller Street to the north and south of the intersection currently experience high levels of pedestrian use. Their capacity to accommodate the anticipated increased demand would be further investigated during detailed design.

The above mitigation options would be investigated further in consultation with Roads and Maritime Services and North Sydney Council.

Cyclist integration

Existing on road bicycle routes along the Pacific Highway, Berry Street, Angelo Street and Miller Street would provide convenient cycle access to the station. Existing cycle parking facilities located on Mount Street (adjacent to the subsurface entrance to Greenwood Plaza) would also be available to metro customers.

These existing facilities would be complimented by additional cycle parking on Miller Street to the north of the station entrance.

Public transport integration

The North Sydney area is a major thoroughfare for buses with services connecting the area to the Northern Beaches and lower North Shore, including Mosman, Northbridge and Chatswood and to the Sydney CBD. The majority of these bus services operate along either Miller Street or the Pacific Highway.

Bus stops serving many of the routes to North Sydney are currently located on Miller Street between the Pacific Highway and Berry Street, immediately opposite and to the south of the metro entrance plaza.

Bus stops on the Pacific Highway are located around 250 metres walking distance from the metro entrance and would also provide interchange opportunity with the small number of buses on this route.

Road network integration

The existing taxi stands on Berry Street, to the west of Denison Street, would be maintained and provide taxi facilities adjacent to the station plaza.

To cater for the low volumes of customers anticipated to arrive at the station by car, kiss-and-ride facilities would be provided on the southern side of Berry Street to the east of Dennison Street.

Given the low forecast vehicular arrivals (around six per cent), the metro station is not anticipated to have a material impact on the operational performance of the road network in the vicinity of the site during operation.

9.4.6 Barangaroo Station

The location and proposed transport integration of the Barangaroo Station is shown on Figure 9-6.

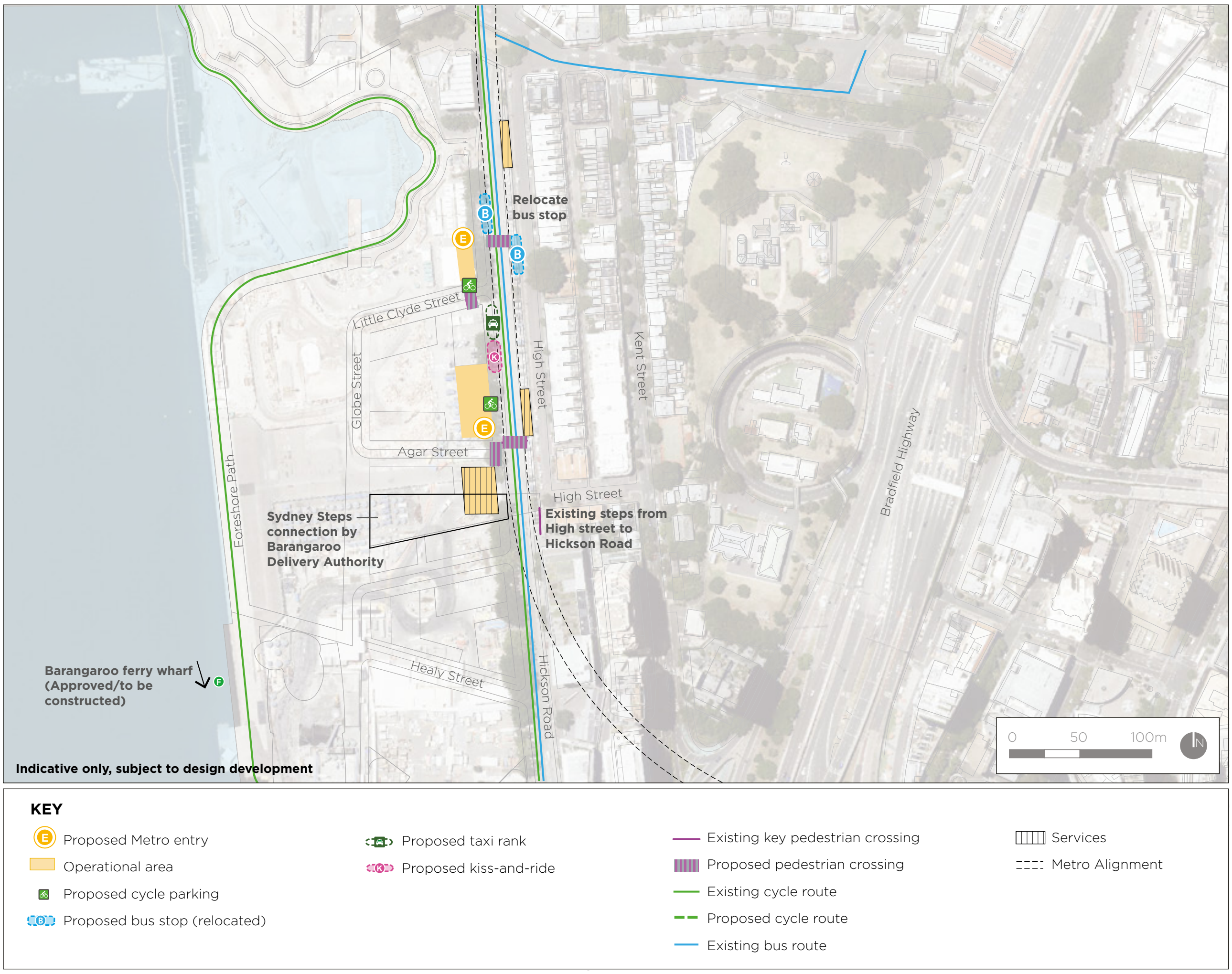


Figure 9-6 Barangaroo Station transport integration

Passenger demand

Preliminary forecasts for the 2036 AM peak hour indicate that around 900 customers would be entering the station and around 6,525 customers would be exiting station. This reflects the predominant commuter use of the station to access employment centres within Barangaroo and in the Sydney CBD

The forecast modes of arrival at the station are:

- Walking – 57 per cent
- Cycling – 3 per cent
- Bus – 39 per cent
- Kiss-and-ride – 1 per cent.

It is anticipated that the majority of the departures from the station would be walking trips to local commercial buildings, with minimal transfer to bus or ferry and negligible volumes by private vehicle.

Pedestrian integration

Based on the future residential and employment populations for travel zones within the walking catchment of the proposed station, the forecast direction of walk only arrivals and departures indicates that arrivals to the station would be primarily from the south from future residents of Central Barangaroo and Barangaroo South precincts. Ninety per cent of all station exits during the morning peak hour are anticipated to travel to the south towards the Barangaroo South commercial precinct.

Pedestrians would use the footpaths along Hickson Road, as well as the new network of footpaths through Central Barangaroo and Barangaroo South and the Foreshore Walkway. As part of the Barangaroo development, enhanced east-west pedestrian connectivity would be provided through improvements to the Sydney Steps, providing connectivity to the station from the east.

The high proportion of walking journeys expected at the Barangaroo Station means the pedestrian movement and access to the site has been considered a priority as part of the station design. Pedestrian facilities in the vicinity of the station would be developed in consultation with the Barangaroo Delivery Authority. At this stage, these are anticipated to include:

- Pedestrian crossing facilities on Hickson Road to the north of Agar Street and near the northern station entry
- Pedestrian crossing facility on Little Clyde Street adjacent to Hickson Road
- Pedestrian crossing facility on Agar Street adjacent to Hickson Road
- Wayfinding signage and Sydney Metro information within the Barangaroo area.

The northern station entry would also provide convenient access to special events at Barangaroo Reserve. During these events, pedestrian management would occur at street level to control the flow of pedestrians into the station environment.

As the streetscape surrounding the proposed Barangaroo Station is currently being redeveloped, pedestrian modelling concluded that the pedestrian infrastructure (including footpaths and crossings) designed as part of the redevelopment would provide a satisfactory pedestrian environment including flow, manoeuvrability and spacing between individuals.

Cyclist integration

An existing on-road cycle path exists along Hickson Road adjacent to the station. Cycle paths are also currently provided throughout Barangaroo Reserve and are planned to be integrated within the Barangaroo development along the foreshore to Pyrmont Bridge, which would provide additional cycle links to the station.

To enable integration of these cycle paths with the station, cycle parking facilities would be provided on Little Clyde and Agar streets at both station entry points.

Public transport integration

A number of bus services operate along Hickson Road which would provide interchange potential with metro. The closest bus stops to the north of the station would be relocated closer to the northern station entry.

Customer interchange would also be possible with the new Barangaroo Ferry Hub via pedestrian footpaths within Central Barangaroo including Foreshore Walk.

Road network integration

To cater for the very low volumes of customers anticipated to arrive or depart the station by car, the following design features are proposed at the station:

- A taxi stand on the western side of Hickson Road between to two station entries
- A kiss-and-ride facility located on the western side of Hickson Road between to two station entries.

The provision of these design features would be developed further in consultation with Barangaroo Delivery Authority.

The mode split of customers entering and exiting the station by car is anticipated to be very low. As such, impacts on the road network are expected to be negligible.

9.4.7 Martin Place Station

The location and proposed transport integration of the Martin Place Station is shown on Figure 9-7.

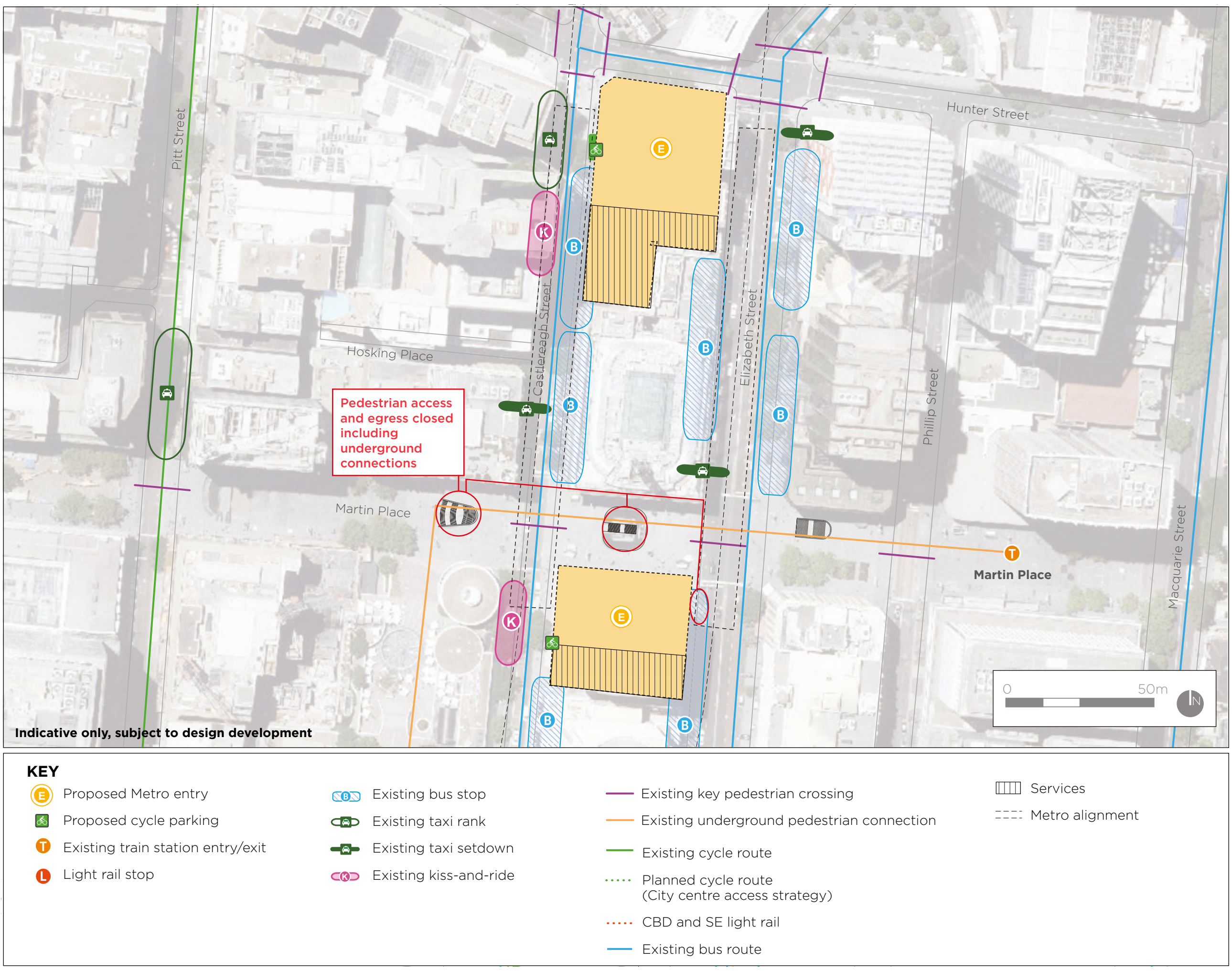


Figure 9-7 Martin Place Station transport integration

Passenger demand

Preliminary forecasts for the 2036 AM peak hour indicate that around 800 customers would be entering the station and around 14,500 customers would be exiting the station. This reflects the heavy employment density within the precinct.

The forecast modes of arrival at the station are:

- Walking – 32 per cent
- Cycling – 2 per cent
- Bus – 66 per cent.

It is anticipated that almost all exits would be walking trips to local commercial land uses, with some transfer to bus.

In addition, it is expected that around 4,100 customers would interchange between Sydney Metro and other rail services.

Pedestrian integration

Direct pedestrian access would be provided to Martin Place, which provides a pedestrianised east-west link. Existing footpaths on Castlereagh and Elizabeth streets form north-south connections in the vicinity of the station. Signalised pedestrian crossing facilities are located at Martin Place on Elizabeth Street and Castlereagh Street, as well as at the Hunter Street intersections with Elizabeth and Castlereagh Streets. In the vicinity of Martin Place, George Street will also be pedestrianised as part of the CBD and South East light rail project which would provide an additional pedestrian friendly link for passengers.

A new underground pedestrian link between the existing suburban Martin Place Station platforms and the metro station platforms would be provided to facilitate suburban train – metro interchange without the need for customers to travel to the surface.

The following design measures would be provided to accommodate the future pedestrian demand and ensure easy and safe interchange for pedestrians:

- Open plaza entrances to the station with ample footpath space within the site to accommodate the anticipated pedestrian demand
- A new underground pedestrian link between the suburban Martin Place Station platforms and the metro station platforms
- Installation of wayfinding signage and Sydney Metro information within the Sydney CBD.

Additionally, the existing access and egress points to the west of Elizabeth Street from Martin Place to the underground concourse connection to the existing Martin Place Station would be closed. Customers travelling to and from the west wishing to access the existing Martin Place Station would be able to use the remaining access points to the east of Elizabeth Street and the new southern metro entrance.

With the exception of some locations, the majority of footpaths in the area would continue to operate at a level of service B or better. However based on site observations and pedestrian modelling of the station and streetscape around Martin Place, three locations were identified where there is potential for safety risks or impacts to pedestrian flow and / or traffic as a result of the metro station. These locations include:

- Intersection of Hunter Street, Castlereagh Street and Bligh Street
- Hunter Street (west of Castlereagh Street) which would operate at a level of service C in the AM and PM peak hours
- Martin Place mid-block crossing of Castlereagh Street.

At the intersection of Hunter and Castlereagh Streets, actions may need to be taken to provide additional pedestrian facilities to increase crossing capacity to reduce queue lengths, particularly on the southeast corner during the AM peak hour, and deter informal crossing. This includes the provision of an underground pedestrian connection from the station platforms to O'Connell Street and / or Bligh Street. The location of this underground connection is identified in Chapter 6 (Project description – operation). In addition, other treatments could include:

- Widening of the pedestrian crossing at Castlereagh Street, which would increase the pedestrian throughput without effecting cycle-times
- Increase the pedestrian green-time, which would increase the pedestrian throughput by extending the proportion of green-time per cycle at the intersection. However, this consequently reduces green-time available for vehicle movements
- Decrease overall cycle-time, which would increase the frequency of green-time for pedestrians over a given period of time. However, this could lead to losses in effective green-time for vehicles, as more time is lost in inter-green periods between movements.

With regard to the footpaths running along both frontages of Hunter Street west of Castlereagh Street, site observations and modelling indicate that pedestrian movements occur in platoons which are dependent on green-time at intersection crossings. This results in an uneven distribution over the hour, increased congestion and deterioration of the pedestrian environment.

To mitigate the impact to the footpath, an option may involve removing or reducing street furniture (such as trees) to increase the effective width of the footpath.

Towards the southern end of the station, the main impact from the project would be the Martin Place mid-block crossing with Castlereagh Street. The majority of existing Martin Place Station users use the pedestrian crossing to travel west in the AM peak, and the reverse in the PM peak. The metro station would result in a significant increase of these movements. Nevertheless, with 2026 and 2036 demands, the crossing was found to provide sufficient space for queuing without blocking background pedestrian flows, and the green-time allows the queue to clear each cycle.

The above mitigation options would be investigated further in consultation with the CBD Co-ordination Office, the City of Sydney Council and Roads and Maritime Services.

Cyclist integration

A number of cycle facilities are currently being implemented as part of the City Centre Access Strategy in the Sydney CBD area which would improve safety and convenience for cyclists.

Some on-street cycle parking facilities are currently available at the intersection of Martin Place and Castlereagh Street. This facility could be used by metro customers.

To enable cycle interchange with the station, new cycle parking facilities would also be provided on Castlereagh Street at both station entrances.

Public transport integration

The project would provide a new underground pedestrian link between the existing Martin Place train station platforms and the Martin Place Metro station platforms, ensuring convenient integration between suburban rail and the metro.

Following implementation of the new CBD Bus Network in 2015, Elizabeth Street is now a key north-south bus route through the Sydney CBD. Castlereagh Street is also a designated north-south bus route. These bus routes, and associated bus stops would provide convenient interchange opportunities between bus and metro services.

The northern station entrance on Castlereagh Street would provide a connection to the new light rail station located on George Street, near its intersection with Hunter Street. Alternatively, connections could be made from the southern station entrance, along Martin Place and the pedestrianised George Street. This would provide an appropriate connection for the small proportion of passengers expected to interchange between the metro and light rail.

Road network integration

Existing taxi facilities on Castlereagh and Elizabeth streets in the vicinity of the station entrances would be retained and could be used by metro customers to interchange between metro and taxi services.

As no customers are anticipated to access to station by vehicle, the impact on operational performance of the road network in the vicinity of the site would be insignificant.

9.4.8 Pitt Street Station

The location and proposed transport integration of the Pitt Street Station is shown on Figure 9-8.

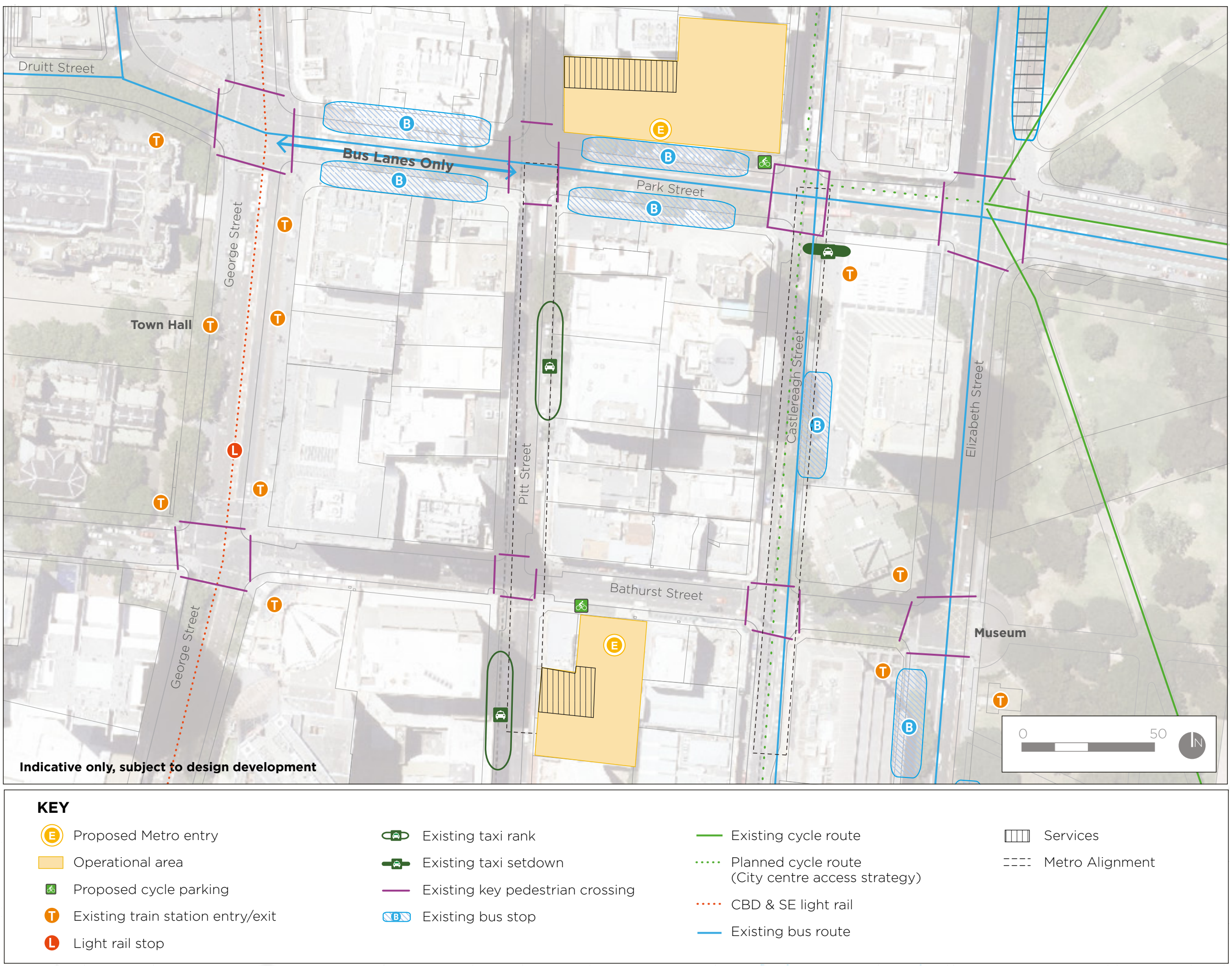


Figure 9-8 Pitt Street Station transport integration

Passenger demand

Preliminary forecasts for the 2036 AM peak hour indicate that around 1,500 customers would be entering the station and around 7,575 customers would be exiting the station. This reflects the mix of residential, commercial and retail uses within the area.

The forecast modes of arrival at the station are:

- Walking – 45 per cent
- Cycling – 2 per cent
- Bus – 52 per cent
- Kiss-and-ride – 1 per cent.

It is anticipated that almost all exits would be walking trips to local commercial land uses, with some transfer to bus.

Pedestrian integration

The northern station entrance would be a plaza entrance that would incorporate sufficient pedestrian space to accommodate the forecast number of entries and exits at the station. Similarly, the southern entrance off Bathurst Street would accommodate pedestrian space to accommodate the forecast customer numbers.

With the exception of some locations, the majority of footpaths in the area would continue to operate at a level of service B or better. However, patronage analysis and pedestrian modelling of the station and streetscape have identified three locations where there is potential for impacts to pedestrians and/or traffic due to the presence of the station. These locations are:

- Park Street mid-block near the station access due to the presence of a major bus interchange
- Intersection of Pitt Street and Park Street
- Intersection of Pitt Street and Bathurst Street.

The highest pedestrian volumes occur along the footpaths connecting to both the northern and southern station entries, particularly west of the station entries towards the Pitt Street intersections. These pedestrian volumes are however less than 100 people per minute in both directions, a flow rate typical of the Sydney CBD pedestrian environment.

This could however be a potential issue at the mid-block on Park Street between Pitt and Castlereagh streets, which acts as a major interchange with bus services. In addition to queuing and alighting customers, the bus stop infrastructure significantly reduces the effective width of the footpath, further reducing the space available to pedestrians.

At the Pitt Street intersections with Park Street and Bathurst Street, the east-west pedestrian crossing volumes nearest to the station entries may double in both peak periods. This however is not anticipated to be a significant issue as the crossing operates in parallel with the primary vehicle movement of the intersection and therefore pedestrian green time could be extended to the length of the east-west vehicle green time (if required) without compromising the intersection performance.

Wayfinding signage and metro information would be provided in the Sydney CBD to enable pedestrian interchange.

Cyclist integration

To enable cycle interchange with the station, cycle parking would be provided:

- At the northern station entrance near the Park Street / Castlereagh Street intersection
- At the southern station entrance near the Pitt Street / Bathurst Street intersection.

Public transport integration

Existing bus stops are located outside the northern station entrance on Park Street, which would provide direct interchange opportunities with the metro station. Bus stops are also located on Castlereagh and Elizabeth streets north and south of the station.

Direct connections would be possible to the new light rail station on George Street. The distance between this southern station entry and the light rail station would be less than 200 metres, providing an efficient interchange.

Road network integration

Existing taxi facilities are available on Pitt Street between Park and Bathurst streets, south of the intersection with Bathurst Street and on Castlereagh Street immediately south of the Park Street intersection. These provide easy and convenient taxi connections to both the northern and southern station entrances.

The mode split of customers entering and exiting the station by car is anticipated to be very low. As such, impacts on the road network are expected to be negligible.

9.4.9 Central Station

The location and proposed transport integration of the Central Station metro platforms is shown on Figure 9-9.

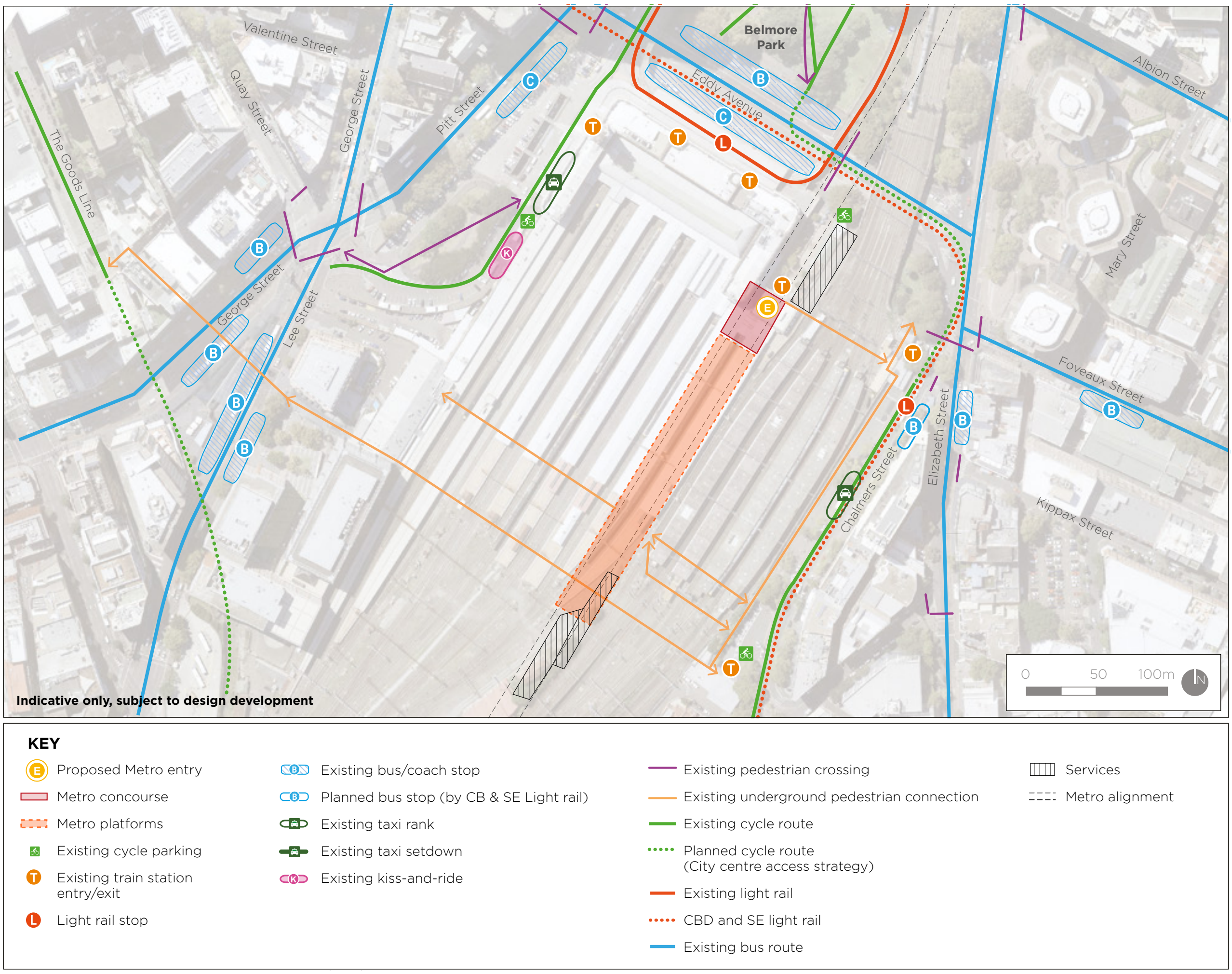


Figure 9-9 Central Station metro platform transport integration

Passenger demand

Preliminary forecasts for the 2036 AM peak hour indicate that around 2,100 metro customers would be entering at the station and around 9,650 metro customers would be departing the station.

The forecast modes of arrival at the station are:

- Walking – 46 per cent
- Cycling – 1 per cent
- Bus – 52 per cent
- Kiss-and-ride – 1 per cent.

It is anticipated that almost all exits would be walking trips to local commercial land uses.

In addition, it is expected that around 9.600 customers would interchange between Sydney Metro and other rail services.

Pedestrian integration

Pedestrians would be able to interchange between metro and suburban train lines via the existing northern concourse and the existing paid underground pedestrian connections at Central Station which would be connected to the metro concourse. The metro platforms and concourse have been designed using forecast patronage data and therefore would accommodate the anticipated pedestrian movements within Central Station.

Pedestrian analysis at Central concluded that a maximum of eight people per minute would be added to any exit during the AM peak hour and subsequent street level footpaths. Therefore, based on this relatively insignificant increase, it is unlikely that any issues related to pedestrian capacity on the local pedestrian network would arise as a result of the project.

Cyclist integration

A new cycle path has recently been completed along Castlereagh Street between Belmore Park and Liverpool Street, as well as along Liverpool Street from Castlereagh Street to Sussex Street. These paths improve the existing and any future north-south and east-west connections to and from the Central Station. Metro customers would be able to use the existing cycle parking facilities at Central Station.

Public transport integration

A high proportion of public transport interchange is expected at Central Station. Customers would be able to interchange with suburban and intercity train lines via the existing northern concourse and the existing underground pedestrian connections at Central Station which would be connected to the metro concourse.

Within Central Station, metro customers would be able to use existing access options to interchange with bus services in the vicinity of Central Station as well as with light rail services and coach services providing regional connections.

Road network integration

Customers accessing the metro platforms at Central Station would be able to use existing drop-off facilities such as the drop-off area within the western forecourt of Central Station.

The mode split of customers entering and exiting the metro platforms by car is anticipated to be very low. As such, impacts on the road network are expected to be negligible.

9.4.10 Waterloo station

The location and proposed transport integration of the Waterloo Station is shown on Figure 9-10.

Figure 9-10 Waterloo Station transport integration

Passenger demand

Preliminary forecasts for the 2036 AM peak hour indicate that around 3,700 customers would be entering the station and around 2,350 customers would be exiting the station. This reflects the residential and commercial catchment of the station.

The forecast modes of arrival at the station are:

- Walking – 76 per cent
- Cycling – 1 per cent
- Bus – 19 per cent
- Kiss-and-ride – 4 per cent.

It is anticipated that almost all exits would be walking trips, mainly to local commercial land uses.

Pedestrian integration

The station entrance would be a plaza entrance that would incorporate sufficient pedestrian space to accommodate the forecast number of entries and exits at the station. Adjacent to the station entry marked pedestrian crossing facilities would be provided across Raglan Street to provide a safe north – south pedestrian connection and across Cope Street to provide a safe east – west pedestrian connection to the station entry.

The highest pedestrian volumes are anticipated to occur along the southern Raglan Street footpath where the station entry would be located. Currently the footpath and the retail frontage provide sufficient width to accommodate the metro patronage demand.

Cyclist integration

A new on-road cycle route would be provided along Raglan Street and Henderson Street, between George Street to the east and the shared path through the Vice Chancellors Oval to the west. This would provide direct access past the station entry, connecting existing cycle route facilities to the east and west of the station. To the east of the station, George Street has a separated cycle route providing safe and convenient north – south connections and the shared path via the Vice Chancellors Oval provides cycle connections to the west of the station.

To enable easy cycle interchange, cycle parking would be provided near the station entry at Raglan Street.

Public transport integration

Existing bus stops on Botany Road between Raglan Street and Wellington Street are generally located within an easy walking distance of the station entry on Botany Road. To enable better integration with the metro station entry, the southbound bus stop on Botany Road would be relocated further north and the bus stops on Cope Street would be relocated to Botany Road. The northbound and southbound bus stops provide convenient interchange to and from the Sydney CBD to the north and Mascot, Matraville and East Gardens to the south.

Road network integration

To accommodate the small number (four per cent in the AM peak hour) of customers anticipated to access the station by road, kiss-and-ride facilities and a taxi rank would be provided on Cope Street, just south of its intersection with Raglan Street, providing convenient access to the station entry.

This volume of drop-off during the peak hour is not anticipated to have a material impact on the operation of the road network in the vicinity of the station.

9.4.11 Marrickville dive

Traffic signals would be introduced at the Edinburgh Road / Bedwin Road / Edgeware Road intersection to improve traffic safety during the construction phase. It is anticipated that these signals would be retained during operation.

Table 9-5 shows the intersection performance with and without the project. The Edinburgh Road / Bedwin Road / Edgeware Road intersection shows a deterioration in the degree of saturation, however it would continue to operate at a level of service A. All surrounding intersections in the vicinity maintain their existing level of operation.

Table 9-5 Marrickville dive intersection performance

Peak period	Without project			With project		
	Average delay	Degree of saturation	Level of service	Average delay	Degree of saturation	Level of service
Edinburgh Road / Murray Street						
AM Peak	4	A	0.48	4	A	0.48
PM Peak	6	A	0.66	6	A	0.66
Edinburgh Road / Edgeware Road						
AM Peak	3	A	0.38	3	A	0.38
PM Peak	3	A	0.40	3	A	0.40
Edinburgh Road / Bedwin Road / Edgeware Road						
AM Peak	4	A	0.12	11	A	0.55
PM Peak	12	A	0.49	11	A	0.66
Bedwin Road / Unwins Bridge Road / Campbell Street / May Street						
AM Peak	47	D	1.01	45	D	1.01
PM Peak	43	C	1.01	42	C	1.01
Princes Highway / Campbell Street						
AM Peak	34	C	1.00	34	C	1.00
PM Peak	30	C	0.86	30	C	0.86
Princess Highway / May Street						
AM Peak	33	C	0.81	33	C	0.83
PM Peak	25	B	0.81	25	B	0.81

9.4.12 Maintenance access

Vehicles would be required to access operational ancillary infrastructure, stations and tunnel portals to undertake periodic maintenance activities. The expected maintenance access frequency is outlined in Table 9-6. Due to the anticipated number of vehicles and the expected frequency of access, maintenance access is not expected to result in any impacts to the surrounding road network.

Table 9-6 Maintenance access requirements

Location	Access requirement	Vehicle type	Frequency
Stations and services buildings	Delivery of consumables and minor waste removal	Light and utility vehicles	Daily
	Maintenance inspections	Light and utility vehicles	Weekly to fortnightly
	Significant deliveries and waste removal	Tipper trucks	Weekly
	Major maintenance and replacement of large plant items	Heavy rigid trucks andcranes	Occasional
Substations (Artarmon substation, Victoria Cross Station, Barangaroo Station, Pitt Street Station and southern services facility)	Visual inspections	Light vehicles	Fortnightly
	Replacement of consumables	Light and utility vehicles	Quarterly
	Major maintenance and replacement of large plant items	Heavy rigid trucks and cranes	Yearly
Water treatment plant (southern services facility)	Delivery of consumables and waste removal	Light vehicles and heavy rigid trucks	Weekly
Tunnel portals	Inspections and testing of track and in-tunnel equipment	Light vehicles	Weekly
	Track and equipment maintenance	Light and utility vehicles	Occasional

9.5 Mitigation measures

The project has been designed to provide efficient interchange between Sydney Metro and other forms of transport. In addition to the measures which have already been applied to the project, mitigation measures that would be implemented to address potential operational traffic and transport impacts are listed in Table 9-7.

Table 9-7 Mitigation measures – operational traffic and transport

Ref	Mitigation measure	Applicable location(s)[1]
OpT1	Enhancement of pedestrian infrastructure in the vicinity of Victoria Cross and Martin Place stations would be investigated further in consultation with (as relevant to the location) the CBD Coordination Office, Roads and Maritime Services and the relevant local council.	VC, MP
OpT2	Access would be maintained to neighbouring properties.	All except metro rail tunnels

1 *STW: Surface track works; CDS: Chatswood dive site; AS: Artarmon substation; CN: Crows Nest Station; VC: Victoria Cross Station; BP: Blues Point temporary site; GI: Ground improvement works; BN: Barangaroo Station; MP: Martin Place Station; PS: Pitt Street Station; CS: Central Station; WS: Waterloo Station; MDS: Marrickville dive site; Metro rail tunnels: Metro rail tunnels not related to other sites (eg TBM works); PSR: Power supply routes.*

CONSTRUCTION NOISE AND VIBRATION

CHAPTER TEN

10 Construction noise and vibration

This chapter assesses the potential impact of noise and vibration during the construction stage of the project. It describes the existing noise and vibration environment and identifies the potential significance of impacts to sensitive receivers. Mitigation measures to address the potential impacts are also identified. Technical paper 2 – Noise and vibration provides further details.

10.1 Secretary environmental assessment requirements

The Secretary's environmental assessment requirements relating to construction noise and vibration, and where these requirements are addressed in this Environmental Impact Statement, are outlined in Table 10-1.

Table 10-1 Secretary's environmental assessment requirements – construction noise and vibration

Ref.	Secretary's environmental assessment requirements	Where addressed
8. Noise and vibration – amenity		
8.1	The Proponent must assess construction and operational noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. The assessment must include consideration of impacts to sensitive receivers including commercial premises, and include consideration of sleep disturbance and, as relevant, the characteristics of noise and vibration (for example, low frequency noise).	Construction noise and vibration impacts are assessed in this chapter. Operational noise and vibration impacts are assessed in Chapter 11 (Operational noise and vibration).
8.2	If blasting is required, the relevant requirements of Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration are to be assessed.	Consideration and assessment of blasting scenarios is provided in Section 10.4.
9. Noise and vibration – structural		
9.1	The Proponent must assess construction and operational noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. The assessment must include consideration of impacts to the structural integrity and heritage significance of items (including Aboriginal places and items of environmental heritage).	Construction noise and vibration impacts, including potential structural damage impacts are assessed in this chapter. Potential vibration impacts to heritage items are assessed in Chapter 14 (Non-Aboriginal heritage) and Chapter 15 (Aboriginal heritage).
9.2	The proponent must demonstrate that blast impacts are capable of complying with the current guidelines, if blasting is required.	Consideration and assessment of blasting scenarios is provided in Section 10.4.

10.2 Assessment methodology

The assessment methodology for noise and vibration impacts generally involved:

- Identifying and classifying of sensitive receivers
- Characterising the existing noise environment based on attended and unattended noise measurements at specific locations across the project area
- Determining noise and vibration management levels in accordance with relevant guidelines
- Modelling to quantify the potential noise and vibration impacts
- Assessing the significance of potential impacts identified
- Examining the proposed construction methodologies and identifying mitigation measures that are likely to be required to minimise construction noise and vibration impacts
- Preparing and documenting mitigation measures that would be implemented during construction.

The construction noise and vibration assessment has been carried out in accordance with:

- The *Interim Construction Noise Guideline* (Department of Climate Change, 2009a) for airborne and ground-borne construction noise
- The NSW *Road Noise Policy* (Department of Environment, Climate Change and Water, 2011a) for construction road traffic noise
- *Assessing Vibration: a technical guideline* (Department of Environment and Conservation, 2006a) for construction vibration.

10.2.1 Construction noise metrics

Noise parameters most relevant to construction noise are described below and were evaluated for daytime (7 am to 6 pm), evening (6 pm to 10 pm) and night-time (10 pm to 7 am) periods:

- RBL – Rating Background Level – the background noise level in the absence of proposed construction activities. This parameter represents the average minimum noise level during the daytime, evening and night-time periods and is used to set the $L_{Aeq(15\ minute)}$ Noise Management Levels (NMLs) for residential receivers
- $L_{Aeq\ (period)}$ – the Energy Average Noise Level evaluated over a defined measurement period (typically 15 minutes for construction noise or the relevant daytime, evening or night-time period for ambient noise monitoring)
- L_{Amax} or $L_{A1(1min)}$ – the ‘typical maximum noise level’ for an event, used in the assessment of potential sleep disturbance during night-time periods.

10.2.2 Sensitive receivers

The sensitivity of occupants to noise and vibration varies according to the nature of the occupancy and the activities performed within the affected premises. For example, recording studios are more sensitive to vibration and ground-borne noise than residential premises, which in turn are more sensitive than typical commercial premises.

Properties within about 100 metres of the metro corridor and about 200 metres from construction sites have been classified into one of the following receiver categories:

- Commercial
- Educational
- Industrial
- Mixed commercial / residential
- Residential
- Place of worship
- Child care
- Recreation (passive and active)
- Special sensitive (eg hospital, precision laboratories, recording studios).

Receivers greater than these distances are unlikely to hear any construction noise. Commercial and industrial receivers are generally considered to be less sensitive to noise and vibration compared to residential receivers.

10.2.3 Construction noise management levels

Airborne construction noise

Airborne noise would occur at all construction sites and would primarily be associated with surface activities or underground activities where there is an airborne noise path between the source and receiver (ie not fully shielded).

The *Interim Construction Noise Guideline* (ICNG) (Department of Environment and Climate Change, 2009a) sets out ways to deal with the impacts of construction noise on residential receivers and other sensitive land uses by presenting assessment approaches that are tailored to the scale of construction projects.

The ICNG sets out a quantitative assessment method involving predicting noise levels at sensitive receivers and comparing them with the proposal specific NMLs established for noise affected receivers. In the event that construction noise levels are predicted to be above the NMLs, all feasible and reasonable mitigation and work practices are required to be investigated to minimise noise emissions.

Residential receivers

The ICNG provides an approach for determining $L_{Aeq(15minute)}$ NMLs at residential receivers by applying the measured $L_{A90(15minute)}$ background noise levels, as described in Table 10-2.

Table 10-2 Determination of NMLs for residential receivers

Time of Day	Noise Management Level $L_{Aeq(15minute)}$	How to apply
Recommended standard hours: **Monday to Friday 7 am to 6 pm** **Saturday 8 am to 1 pm** **No work on Sundays or public holidays**	Noise affected RBL + 10 dBA	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq(15minute)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75 dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restructuring the hours that the very noisy activities can occur, taking into account: • Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools or mid-morning or mid-afternoon for works near residences) • If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5 dBA	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practice have been applied and noise is more than 5 dB above the noise affected level, the proponent should negotiate with the community.

Other sensitive land uses

The project specific $L_{Aeq(15minute)}$ NMLs for other non-residential noise sensitive receivers from the ICNG are provided in Table 10-3.

Table 10-3 NMLs for other sensitive receivers

Land use	NML $L_{Aeq(15minute)}$ (Applied when the land use is in use)
Classrooms at schools and other education institutions	Internal noise level 45 dBA
Hospital wards and operating theatres	Internal noise level 45 dBA
Places of worship	Internal noise level 45 dBA
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion)	External noise level 65 dBA

Land use	NML $L_{Aeq(15minute)}$ (Applied when the land use is in use)
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, e.g. reading, meditation)	External noise level 60 dBA
Community centres	Depends on the intended use of the centre. Refer to the recommended 'maximum' internal levels in *Australian Standard 2107 – Acoustics – Recommended design sound levels and reverberation times for building interiors* for specific uses.

Other noise-sensitive businesses require separate project specific noise goals. The *Interim Construction Noise Guidelines* recommends that the internal construction noise levels at these premises are determined based on the 'maximum' internal levels presented in *AS 2107*. These recommended 'maximum' internal noise levels are provided in Table 10-4.

Table 10-4 NMLs for other receivers

Description	Time period	AS 2107 Classification	Recommended 'Maximum' Internal L_{Aeq} (dBA)
Hotel	Daytime and evening	Bars and lounges	50
	Night-time	Sleeping areas (hotels near major roads)	40
Café	When in use	Coffee bar	50
Bar / restaurant	When in use	Bars and lounges / restaurant	50
Library	When in use	Reading areas	45
Recording studio	When in use	Music recording studios	25
Theatre / auditorium	When in use	Drama theatres	30

The *Interim Construction Noise Guidelines and AS 2107* do not provide specific guideline noise levels for childcare centres. Childcare centres generally have internal play areas and sleep areas. The *Technical Guideline Child Care Centre Noise Assessment* (Association of Australian Acoustical Consultants, 2008) provides criteria for road, rail traffic and industry. This guideline recommends a $L_{Aeq(1hour)}$ of 55 dBA for external play areas and a $L_{Aeq(1hour)}$ of 40 dBA for indoor play areas and sleeping areas. For internal play areas an internal NML of $L_{Aeq(15minute)}$ 55 dBA has been adopted and for sleeping areas an internal NML of $L_{Aeq(15minute)}$ 40 dBA (when in use) has been adopted. On the assumption that windows and doors of childcare centres may be opened, an external NML of $L_{Aeq(15minute)}$ 65 dBA for play areas has been applied at the facade and would also be applicable to external play areas. For sleeping areas on the assumption that windows are open, the external NML of $L_{Aeq(15minute)}$ 50 dBA has been applied.

Commercial and industrial premises

NMLs for commercial and industrial premises have been set based on the *Interim Construction Noise Guidelines*. For commercial premises, including offices, retail outlets and small commercial premises an external NML of $L_{Aeq(15minute)}$ 70 dBA has been adopted. An external NML of $L_{Aeq(15minute)}$ 75 dBA has been adopted for industrial premises. For both land use types, the external noise levels should be assessed at the most affected occupied point on the premises.

Ground-borne construction noise

Ground-borne noise during construction may be experienced by sensitive receivers located close to tunnels or other underground excavations (including stations and service facilities). Whilst ground-borne noise may also be audible during construction activities on the surface, the airborne noise levels are likely to be higher and more prominent.

Ground-borne NMLs for residential receivers, based on levels provided in the ICNG, are presented in Table 10-5.

Ground-borne noise is usually not a significant disturbance to building occupants during the day due to high ambient levels which mask the audibility of ground-borne noise emissions. For daytime periods, the ICNG does not provide NMLs, but instead specifies that the human comfort vibration guidelines are applicable.

During evening and night-time periods however, when ambient noise levels are lower, ground-borne noise is more prominent and may result in adverse comment from building occupants.

Table 10-5 Ground-borne NMLs for residential receivers

Time of day	Ground-borne NMLs $L_{Aeq(15\ minute)}$
Daytime 7 am to 6 pm	45 dBA – internal
Evening 6 pm to 10 pm	40 dBA – internal
Night-time 10 pm to 7 am	35 dBA – internal

At locations where the construction noise levels are predicted to exceed the NMLs, consideration must be given to applying all feasible and reasonable work practices for each site and activity to minimise potential noise impacts.

10.2.4 Construction ground-borne vibration

The effects of vibration in buildings can be divided into three main categories:

- Those in which the occupants or users of the building are inconvenienced or possibly disturbed
- Those where the building contents may be affected
- Those in which the integrity of the building or the structure itself may be compromised.

People are able to "feel" vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). Relevant vibration dose values for human comfort are provided in *Technical paper 2 – Noise and vibration*. People tend of hear vibration before they feel vibration; that means that if the ground-borne noise criteria are exceeded then the human comfort criteria for vibration would also be exceeded. This assessment has taken a conservative approach by assessing ground-borne noise impacts to determine exceedances and the requirement to implement mitigation measures.

In relation to structural and cosmetic damage, *Australian Standard AS 2187:2 – 2006* recommends use of the guidelines values and assessment methods provided in *British Standard BS 7385:2 – 1993*. The guidelines values for minimal risk of cosmetic damage from the BS 7385:2 – 1993 are provided in Table 10-6.

Table 10-6 BS 7385 cosmetic damage guideline values

Type of building	Peak component particle velocity in frequency range of predominant pulse: 4 Hz to 15 Hz	Peak component particle velocity in frequency range of predominant pulse: 15 Hz and above
Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

Where dynamic loading caused by continuous vibration may result in magnification of vibration through a building structure the guideline values may need to be reduced by up to 50 per cent. Rock breaking, rock hammering and sheet piling activities are considered to have the potential to cause dynamic loading in some structures (eg residences).

For construction activities involving intermittent vibration sources such as rock breakers, piling rigs, vibratory rollers, excavators and the like, the predominant vibration energy occurs at frequencies greater than 4 Hz (and usually in the 10 Hz to 100 Hz range). On this basis, and consistent with the guidance from *BS 7385*, the following conservative vibration damage screening level per receiver type have been adopted for the project:

- Reinforced or framed structures: 25.0 mm/s
- Unreinforced or light framed structures: 7.5 mm/s.

Heritage items

Heritage listed structures should not be assumed to be more sensitive to vibration. Notwithstanding, a conservative vibration screening criterion of 7.5 mm/s has been adopted for heritage structures.

10.2.5 Blasting

The ICNG recommends that vibration and overpressure from blasting be assessed against the levels presented in the *Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration* (Australia and New Zealand Environment Council, 1990).

The criteria set by this standard are targeted for operations that occur for long periods of time such as those at mining sites and hence are targeted to protect human comfort from vibration. As a result the vibration levels are conservative and can introduce unnecessary constraints when applied to construction projects which typically occur for much shorter time periods.

Recent NSW infrastructure project approvals have recognised the restrictive nature of these blasting criteria when applied to construction projects and have allowed higher limits. Consistent with these recent approvals, the vibration and overpressure limits for blasting applied to this project are:

- Vibration (PPV): 25 mm/s
- Overpressure: 125 dBL.

These upper limits of vibration and overpressure are intended to target the protection of building structures from cosmetic damage rather than human comfort criteria as construction works are considered short-term. Since these criteria are analogous to the cosmetic damage screening criteria it is appropriate to add an additional conservative criteria which is specific to heritage buildings. A vibration (PPV) of 7.5 mm/s would be used to screen potential vibration impacts from blasting at heritage buildings.

The blasting scenarios developed for consideration in this assessment have been designed (based on preliminary information) to comply with the above criteria. The assessment then considers the potential reduction in periods of ground-borne noise impacts associated with the adoption of blasting as an excavation method.

10.2.6 Construction traffic noise

During construction, spoil removal and product deliveries would result in additional heavy vehicle movements on public roads. Whilst specific guidance on acceptable noise levels associated with construction traffic is not provided by the Environment Protection Authority, the potential noise impacts have been identified using guidance in the *NSW Road Noise Policy* (RNP) (Department of Environment, Climate Change and Water, 2011a).

One of the objectives of the RNP is to protect against excessive reduction in amenity as the result of a project by comparing traffic noise levels to the following relevant road traffic noise criteria:

- Existing freeway / arterial / sub-arterial roads:
  - $L_{Aeq(15hour)}$ 60 dBA day
  - $L_{Aeq(9hour)}$ 55 dBA night
- Existing local roads:
  - $L_{Aeq(1hour)}$ 55 dBA day
  - $L_{Aeq(1hour)}$ 50 dBA night.

Where traffic noise levels from the existing traffic plus the additional traffic generated by the project exceeds the criteria, any increase in the total traffic noise level should be limited to 2 dB above that of the corresponding 'no project option'.

In considering feasible and reasonable mitigation measures where the relevant noise increase is greater than 2 dB, consideration is also given to the actual noise levels associated with construction traffic.

10.2.7 Sleep disturbance

Sleep disturbance is considered as the emergence of the maximum level ($L_{A1(1minute)}$ or L_{Amax}) above the $L_{A90(15minute)}$ background level at the time. The appropriate screening criterion for sleep disturbance is determined to be a maximum level 15 dB above the RBL, normally during the night-time period (10 pm to 7 am). Where this criterion is met, sleep disturbance is not likely, but where it is not met, a more detailed analysis is required.

Additional guidance is provided in the RNP which concludes that:

- Maximum internal noise levels below 50 dBA to 55 dBA are unlikely to cause awakening reactions
- One or two events per night, with maximum internal noise levels of 65 dBA to 70 dBA, are not likely to affect health and wellbeing significantly.

On the basis of the above guidance, a sleep disturbance NML of 55 dBA (internal) has been adopted, which equates to an external noise level of 65 dBA (assuming open windows).

10.3 Existing environment

The project would cross a well-established urban environment that contains a wide range of commercial, residential and industrial land uses of varying densities interspersed with recreational areas and community facilities (such as schools, childcare centres, places of worship and medical facilities).

The existing noise environment varies considerably along the length of the project. The dominant noise sources that are likely to influence background noise levels include:

- Road traffic noise
- Suburban rail line operations and associated station activities
- Industrial activities occurring within existing industrial areas (such as at Artarmon and Marrickville)
- Other construction activities (such as the CBD and South East Light Rail, building redevelopments, road and housing construction)
- Sydney Harbour maritime traffic
- Aircraft noise.

10.3.1 Ambient noise surveys and monitoring locations

To characterise the existing ambient noise environment across the project area and to establish ambient noise levels on which to base the construction NMLs, noise monitoring was carried out at 25 representative locations during June to July and August to September 2015. This information has been supplemented with ambient noise data collated during the investigations for other recent projects, resulting in a database for a total of 29 representative locations across the project area.

Unattended noise monitors were placed at sensitive receiver locations in the vicinity of all construction sites for a minimum period of one week. The location of unattended noise surveys are shown on the respective figures in Section 10.4. The results of the unattended noise survey are summarised in Table 10-7.

Table 10-7 Summary of unattended noise monitoring

Location ID	Noise Level (dBA) [1,2]					
	Daytime 7 am to 6 pm		Evening 6 pm to 10 pm		Night-time 10 pm to 7 am	
	RBL	L_{Aeq}	RBL	L_{Aeq}	RBL	L_{Aeq}
Chatswood dive site (northern)						
B.22	42	55	41	50	34	48
B.23	63	71	60	70	45	67
B.24	50	59	47	58	39	55
B.25	41	54	40	53	35	49
Artarmon substation						
B20	45	56	45 (46) [3]	54	38	50
B.21	49	55	46	50	41	48
Crows Nest Station						
B.19	59	68	55	67	50	62

Location ID	**Noise Level (dBA) [1,2]**					
	Daytime 7 am to 6 pm		**Evening 6 pm to 10 pm**		**Night-time 10 pm to 7 am**	
	RBL	**L_{Aeq}**	**RBL**	**L_{Aeq}**	**RBL**	**L_{Aeq}**
Victoria Cross Station						
B.16	65	68	63	65	52	62
B.17	55	61	50	55	44	51
B.18	65	74	57	71	51	66
Blues Point temporary site						
B.14	51	62	49	61	40	54
B.15	38	51	38	47	36	45
Sydney Harbour ground improvement works						
B.13	62	66	62	65	52	63
Barangaroo Station						
B.12	50	61	45	64	40	51
B.28 (2014)	51	56	46	52	41	47
B.29 (2013)	49	55	49	55	41	49
Martin Place Station						
B.11	61	66	56	62	52	63
Pitt Street Station						
B.27 (2009)	66	71	64	70	61	68
Central Station						
B.09	56	68	53	66	45	64
B.10	51	65	50	64	49	62
B.26 (2009)	58	70	56	69	52	66
Waterloo Station						
B.06	54	65	47	62	39	58
Marrickville dive site (southern)						
B.01	59	71	53	69	41	65
B.02	58	69	52	66	38	62
B.03	52	66	43	64	38	58
B.04	47	61	47	59	47	53

1 *The RBL and L_{Aeq} noise levels have been obtained using the calculation procedures documented in the Industrial Noise Policy (INP) (Environment Protection Authority, 2000)*

2 *In accordance with the INP, where the RBL is found to be less than 30 dBA, then it is set to 30 dBA*

3 *Evening RBL reduced to equal daytime RBL in accordance with INP application notes*

10.4 Potential impacts

The noise modelling scenarios are based on the construction methods described in Chapter 7 (Project description – construction). Chapter 7 (Project description – construction) also provides indicative timeframes for each of the construction activities at each construction site. Notwithstanding, the following sections provide a brief description of the construction noise scenarios modelled and the anticipated durations of each activity.

Construction planning has identified the need for measures at construction sites to manage potential noise impacts. Based on this the following has been included as part of the project and within the noise modelling:

- Standard attenuation acoustic sheds at Chatswood dive site, Crows Nest Station, Victoria Cross Station, Barangaroo Station, Martin Place Station, Pitt Street Station, Waterloo Station and Marrickville dive site to manage out of hours underground construction works. The same noise outcome may be achieved through alternative measures, such as acoustic panels over the station excavations. The specific noise mitigation measures would be determined during detailed construction planning taking into account construction program, construction working hours and construction traffic management in accordance with the Construction Noise and Vibration Strategy
- Noise barriers (indicatively three metres high) around all construction sites. The same noise outcome may be achieved through a range of noise barrier heights and the specific height of construction noise barriers would be identified during detailed construction planning through the implementation of the Construction Noise and Vibration Strategy.

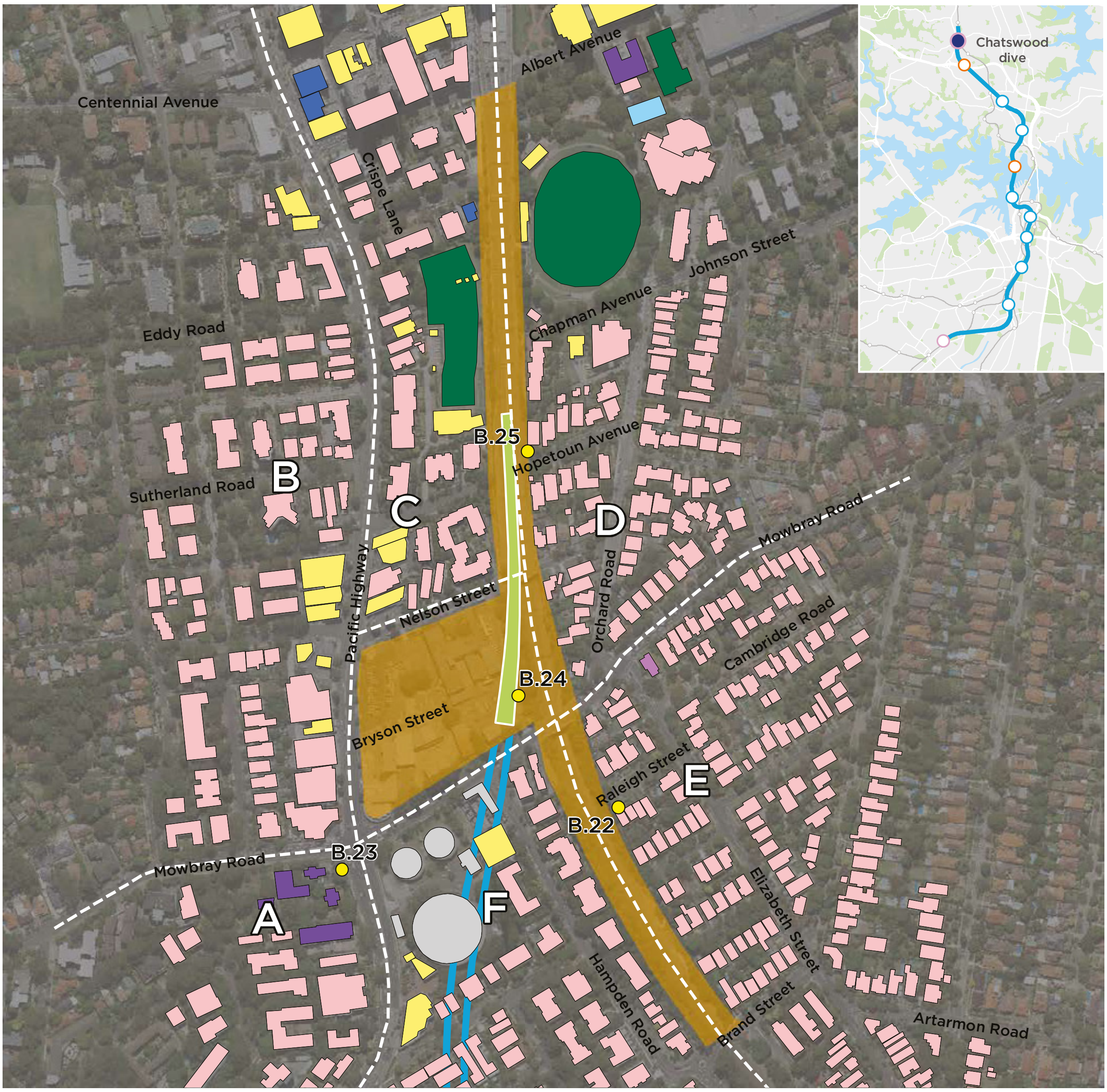
The above measures are included in the noise predicitions in the following sections.

10.4.1 Chatswood dive site (northern) and northern surface works

The nearest sensitive receivers to the proposed construction site are shown in Figure 10-1.

The construction scenarios at the Chatswood dive site and northern surface works, and the anticipated timeframes, include:

- Demolition and site establishment (about 12 months) – the demolition of buildings on the site, demolition of the Nelson Street bridge, constructing site access and egress points, delivery and placement of site sheds and establishment of site compound facilities
- Track works (periodic over about four and a half years) – modifications to the T1 North Shore Line between Brand Street, Artarmon and Chatswood Station and the laying of metro tracks from the tunnel portal to Chatswood Station
- Earthworks (about 12 months) – initial surface excavation and excavation of the dive structure
- Acoustic shed construction (about one month) – piling and erection of the acoustic shed
- Tunnelling (about one and a half years) – excavation of the main tunnels and associated support services including spoil handling and removal
- Fit-out (about one and a half years) – fit of the track and the rail systems in the tunnels.



KEY

Chatswood to Sydenham

Proposed dive structure

Monitoring location

Proposed construction site area

Receiver area boundary

Receiver types

Residential

Other (Medical)

Other (Education)

Commercial

Other (Worship)

Active Recreation

Industrial

Other (Child Care)

Indicative only, subject to design development

0 200 m

N

Figure 10-1 Location of sensitive receivers near Chatswood dive site (northern) and northern surface works

Airborne construction noise

A summary of the predicted noise level exceedances at the nearest sensitive receivers is provided in Table 10-8 for each construction scenario.

Table 10-8 Predicted airborne noise level exceedances at Chatswood dive site (northern) and northern surface works

Noise modelling scenario	Demolition and site establishment	Track works	Earthworks	Acoustic shed construction	Tunnelling					Fit-out				
Receiver area	Day	Day	Day	Day	Day	DOOH[1]	Evening	Night	Sleep	Day	DOOH[1]	Evening	Night	Sleep
A Church to the south west on Pacific Highway	10–20 dB	10–20 dB	<10 dB	Compliance	<10 dB	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance
B Residential to the west on Pacific Highway	10–20 dB	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	<10 dB	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance
B Commercial to the west on the Pacific Highway	10–20 dB	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance
C Residential to the north on Nelson Street	>20 dB	>20 dB	>20 dB	<10 dB	>20 dB	<10 dB	<10 dB	10–20 dB	<10 dB	Compliance	Compliance	Compliance	<10 dB	Compliance
C Commercial to the north on Nelson Street	>20 dB	>20 dB	10–20 dB	Compliance	<10 dB	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance
C Active recreation to the north, west of the T1 North Shore Rail Line	>20 dB	>20 dB	10–20 dB	Compliance	<10 dB	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance
D Active recreation to the north, east of the T1 North Shore Rail Line	<10 dB	10–20 dB	<10 dB	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance
D Residential to the east, east of the T1 North Shore Rail Line	>20 dB	>20 dB	>20 dB	<10 dB	>20 dB	Compliance	<10 dB	10–20 dB	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance
E Residential to the east, east of the T1≈North Shore Rail Line	>20 dB	>20 dB	>20 dB	<10 dB	10–20 dB	<10 dB	<10 dB	10–20 dB	<10 dB	Compliance	Compliance	Compliance	Compliance	Compliance
F Residential to the south on Mowbray Road	>20 dB	>20 dB	>20 dB	<10 dB	>20 dB	10–20 dB	10–20 dB	10–20 dB	<10 dB	Compliance	<10 dB	<10 dB	<10 dB	Compliance
F Commercial to the south on Mowbray Road	<10 dB	<10 dB	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance
F Industrial receivers to the south on Mowbray Road	<10 dB	<10 dB	<10 dB	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance

Legend

- NML compliance
- NML exceedance of less than 10 dB
- NML exceedance between 10 dB and 20 dB
- NML exceedance of more than 20 dB

1 *DOOH = Daytime out of hours (i.e Saturdays 1pm to 6pm and Sundays 7am to 6pm)*

The preliminary findings of the construction noise impact assessment at Chatswood dive site indicate:

- For demolition and site establishment works during the daytime high exceedances of more than 20 dB of the NMLs are predicted at residential receivers in Area C, D, E and F and at the commercial receivers and active recreation in Area C. Moderate exceedances of more than 10 dB are predicted for the church in Area A, and at the residential and commercial receivers in Area B. Minor exceedances are predicted at the active recreation Area D. These are a direct result of the relative close proximity of receivers to the construction activities and the absence of any appreciable shielding between sites and receivers
- For track works during the daytime high exceedances of more than 20 dB of the NMLs are predicted at residential receivers in Area C, D, E and F and at the commercial receivers and active recreation of Area C. Moderate exceedances of more than 10 dB are predicted at the church and at the active recreation Area D
- For earthworks during the daytime high exceedances of more than 20 dB of the NMLs are predicted at residential receivers in Area C, D, E and F. Moderate exceedances of more than 10 dB are predicted at the commercial receivers in Area C and at the active recreation Area C
- For acoustic shed construction during the daytime minor exceedances of less than 10 dB are predicted at the residential receivers in Areas C, D, E and F
- During tunnelling a high exceedance of the NMLs by more than 20 dB is predicted at the residential receivers in Area C, D, and F, and a moderate exceedance is predicted in Area E during the daytime, from activities outside the shed. During the night-time moderate exceedances of more than 10 dB are predicted at the residential receivers in Area C, D, E, and F, and minor exceedances in Area A. An acoustic shed with higher noise insulation (such as a double wall construction) would be required to reduce night-time non-compliance
- During fitout compliance is generally predicted during daytime and evening, with minor exceedances at residences in Areas C (during the night time) and F (during the evening and night time).

On site night-time L_{Amax} truck noise

The L_{Amax} noise levels associated with individual truck movements on site exceed the sleep disturbance screening level during tunnelling at residential receivers in Areas C, E and F. Opportunities to minimise noise from heavy vehicles, such as consideration of site layouts and screening, would be considered during detailed construction site planning.

Ground-borne noise

Rock breaking and dive excavation works are proposed to be carried out during the daytime period at this site. The ground-borne noise assessment indicated that:

- Three residences located to the east of the dive structure, would exceed the NML by 20 dB to 25 dB
- Seven residences, located to the east and west of the dive structure, would exceed the NML by 10 dB to 20 dB. This includes Mowbray House which would form part of the construction site but be retained
- Nine residences, located east and south of the dive structure, would exceed the NML by up to 10 dB
- One commercial receiver, located to the west of the dive structure, would exceed the NML by 10 dB to 20 dB.

These exceedances are a direct result of the relative close proximity of receivers to the construction activities and the use of large rock breakers. The potential ground-borne noise impacts associated with excavation of the tunnels is discussed in Section 10.4.13.

Ground-borne vibration

The heritage listed Mowbray House is located on the construction site, and predicted vibration levels exceed the vibration screening level for an unreinforced or light framed structure. A more detailed assessment of the structure and attended vibration monitoring would be carried out to ensure vibration levels remain below appropriate limits for that structure.

Construction vibration levels are anticipated to remain well below the vibration screening levels associated with minor cosmetic building damage at all other receivers.

Construction traffic noise

The predicted L_{Aeq} increase and sleep disturbance noise levels have been assessed for the access routes to the Chatswood dive site and are presented in Table 10-9.

On the Pacific Highway and Mowbray Road construction traffic exceeds the base criteria, however the predicted noise level increase complies with the 2 dB allowance. Whilst there is an exceedance of the sleep disturbance screening criterion (of up to 10 dB) and external sleep disturbance NML of 65 dBA (by up to 10 dB), the L_{Amax} levels would be similar to other heavy vehicles using the Pacific Highway and Mowbray Road. Therefore sensitive receivers on these roads are not likely to notice an increase in the average road traffic noise levels during construction.

On Nelson Street baseline noise levels of 58 dBA (daytime) and 52 dBA (night-time) have been predicted. These levels exceed the RNP base criteria of 55 dBA (daytime) and 50 dBA (night-time) for local roads. There is an exceedance of the sleep disturbance screening criterion (of up to 16 dB) and external sleep disturbance NML of 65 dBA (by up to 5 dB) resulting in a sleep disturbance risk. Unless compliance with the road traffic noise criteria can be achieved on Nelson Street, night time heavy vehicle movements at the Chatswood dive site would be restricted to the Pacific Highway and Mowbray Road.

Table 10-9 Chatswood dive site (northern) – road traffic noise

Road	Base criteria (dB) day / night ($L_{Aeq(15hr/9hr)}$)	Predicted Road Traffic Noise (dB) day / night	Predicted Road Traffic Noise Increase (dB) day / night	RBL + 15 dB Screening Criterion (dBA)	External L_{Amax} NML Level (dBA)	Predicted L_{Amax} Noise Level (dBA)
Pacific Highway	60 / 55	74 / 68	0.1 / 0.2	65	65	74
Mowbray Road	60 / 55	73 / 67	0.1 / 0.2	65	65	75
Nelson Street	55 / 50	58 / 52	N/A [1]	54	65	70

1 *Existing traffic flows are not available for Nelson Street*

10.4.2 Artarmon substation construction site

The nearest sensitive receivers to the proposed construction site are shown in Figure 10-2. The construction scenarios at the Artarmon substation, and the anticipated timeframes, include:

- Site establishment (about one month) – vegetation clearing and establishment of the site compound
- Earthworks (about one month) – initial surface excavation and site levelling
- Excavation (about nine months) – excavation of the shaft to the tunnels below
- Building construction (about 12 months) – construction and fit-out of the aboveground substation building.

Figure 10-2 Location of sensitive receivers near Artarmon substation construction site

Airborne construction noise

A summary of the predicted noise level exceedances at the nearest sensitive receivers is provided in Table 10-10 for each construction scenario.

Table 10-10 Predicted airborne noise level exceedances at Artarmon substation construction site

Receiver area / Noise modelling scenario	Site establishment	Earthworks	Excavation	Building constuction
	Day	Day	Day	Day
A Residential to the north of Butchers Lane	🔴	🔴	🔴	🟠
B Residential to the north east on Reserve Road	🔴	🟠	🟠	🟠
C Residential to the east on Barton Road	🟠	🔵	🔵	🔵
D Commercial to the south on Hotham Parade	🔵	🔵	🔵	🟢

Legend

🟢 NML compliance

🔵 NML exceedance of less than 10 dB

🟠 NML exceedance between 10 dB and 20 dB

🔴 NML exceedance of more than 20 dB

The preliminary findings of the construction noise impact assessment at Artarmon Substation indicate:

- For site establishment works high exceedances of more than 20 dB of the NMLs are predicted at residential receivers in area A and B and moderate exceedances of more than 10 dB in Area C. There are minor exceedances of less than 10 dB on the commercial receivers in Area D. These are a direct result of the relative close proximity of receivers to the construction activities and the absence of any appreciable shielding between sites and receivers
- For earthworks and shaft excavation high exceedances of more than 20 dB are predicted at the residential receivers in Area A and moderate exceedances of more than 10 dB are predicted at Area B. There are minor exceedances at the residential receivers in Area C and at the commercial receivers in Area D
- For building construction moderate exceedances of more than 10 dB are predicted at the residential receivers in Area A and B and minor exceedances in Area C. At the commercial receivers in Areas D, compliance is predicted.

On site night-time L_{Amax} truck noise

No night-time L_{Amax} truck noise impacts are predicted at the Artarmon substation construction site as construction would occur during the daytime.

Ground-borne noise

Rock breaking and excavation works are proposed to be carried out during the daytime period at this site. The ground-borne noise assessment indicated that minor exceedances minor of the NML of up 10 dB would occur at the nearest receivers.

The potential ground-borne noise impacts associated with excavation of the tunnels is discussed in Section 10.4.13.

Ground-borne vibration

During rock breaker activities at the Artarmon substation construction site, vibration levels may be perceptible at the nearest residential receivers. As the nearest buildings are around 25 metres from the proposed shaft, vibration levels are anticipated to remain below the vibration screening levels associated with minor cosmetic building damage.

Construction traffic noise

The predicted L_{Aeq} increase noise levels have been assessed for the access routes to the Artarmon substation construction site. As no night-time works are proposed at this site, a sleep disturbance assessment has not been carried out.

Reserve Road has significant daytime flows, and the predicted traffic noise increase is 0.2 dB which complies with the 2 dB increase criteria.

Barton Road is a cul-de-sac which does not provide access to any residences and, as such, has negligible existing flows. Therefore traffic noise levels from site traffic movements have been predicted for comparison with the RNP baseline criteria (presented in Table 10-11). Traffic noise levels from the project comply with the baseline criteria on Barton Road.

Table 10-11 Artarmon substation – road traffic noise

Road	Base criteria daytime (dB)	Predicted project daytime traffic noise (dB)
Barton Road	55	51

10.4.3 Crows Nest Station

The nearest sensitive receivers to the proposed construction site are shown in Figure 10-3.

The construction scenarios at the Crows Nest Station construction site, and the anticipated timeframes, include:

- Demolition and site establishment (about 12 months) – the demolition of buildings on the site and establishment of the site compound facilities
- Earthworks (about two months) – initial surface excavation
- Acoustic shed construction (about one month) – piling and erection of the acoustic shed
- Excavation and structural works (about three years) – excavation of the station and structural works
- Building construction (about one and a half years) – aboveground station and services building construction and fit-out.

KEY

- Chatswood to Sydenham
- Monitoring location
- Proposed construction site area
- Receiver area boundary

Receiver types

- Residential
- Other (Worship)
- Commercial
- Other (Child Care)

Indicative only, subject to design development

0 100 m

N

Figure 10-3 Location of sensitive receivers near Crows Nest Station

Airborne construction noise

A summary of the predicted noise level exceedances at the nearest sensitive receivers is provided in Table 10-12 for each construction scenario.

Table 10-12 Predicted airborne noise level exceedances at Crows Nest Station

Receiver area \ Noise modelling scenario	Demolition and site establishment – Day	Earthworks – Day	Acoustic shed construction – Day	Excavation and structural works – Day	Excavation and structural works – DOOH[1]	Excavation and structural works – Evening	Excavation and structural works – Night	Excavation and structural works – Sleep	Building construction – Day
A Residential to the west on Pacific Highway	10 dB to 20 dB	less than 10 dB	compliance	compliance	compliance	compliance	less than 10 dB	compliance	less than 10 dB
A Commercial to the west on Pacific Highway	10 dB to 20 dB	10 dB to 20 dB	compliance	compliance	compliance	compliance	compliance	compliance	
B Commercial to the north on Oxley Street	10 dB to 20 dB	10 dB to 20 dB	compliance	compliance	compliance	compliance	compliance	compliance	less than 10 dB
B Church to the north on Oxley Street	10 dB to 20 dB	10 dB to 20 dB	less than 10 dB	less than 10 dB	less than 10 dB	compliance	compliance	compliance	10 dB to 20 dB
C Residential to the north east on Clarke Street	more than 20 dB	more than 20 dB	less than 10 dB	compliance	less than 10 dB	less than 10 dB	10 dB to 20 dB	less than 10 dB	10 dB to 20 dB
C Commercial to the north east on Clarke Street	more than 20 dB	more than 20 dB	10 dB to 20 dB	less than 10 dB	less than 10 dB	compliance	compliance	compliance	10 dB to 20 dB
C Active recreation to the north on Hume Street	10 dB to 20 dB	10 dB to 20 dB	compliance	compliance	compliance	compliance	compliance	compliance	less than 10 dB
D Residential to the north east on Clarke Street	less than 10 dB	less than 10 dB	compliance	compliance	compliance	compliance	compliance	compliance	compliance
D Commercial to the north east on Clarke Street	more than 20 dB	more than 20 dB	less than 10 dB	compliance	compliance	compliance	compliance	compliance	10 dB to 20 dB
E Residential to the south on Pacific Highway	more than 20 dB	10 dB to 20 dB	compliance	compliance	compliance	compliance	compliance	compliance	10 dB to 20 dB
E Commercial to the south on Pacific Highway	less than 10 dB	compliance	compliance	compliance	compliance	compliance	compliance	compliance	compliance

Legend

- NML compliance
- NML exceedance of less than 10 dB
- NML exceedance between 10 dB and 20 dB
- NML exceedance of more than 20 dB

1 *DOOH = Daytime out of hours (i.e Saturdays 1pm to 6pm and Sundays 7am to 6pm)*

The preliminary findings of the construction noise impact assessment at Crows Nest Station indicate:

- For demolition and site establishment during the daytime high exceedances of more than 20 dB of the NMLs are predicted at residential receivers in Area C and E. Moderate exceedances of more than 10 dB are predicted at residential receivers in Area A, at the church in Area B and the active recreation in Area C. At residential receivers in Area D minor exceedances are predicted.

  High exceedances of more than 20 dB of the NMLs are predicted at the nearest commercial receivers in Areas C and D, moderate exceedances of more than 10 dB are predicted at commercial receivers in Areas A and B, and minor exceedances are predicted at commercial receivers in Area E
- For earthworks during the daytime high exceedances of more than 20 dB of the NMLs are predicted at the residential receivers in Area C. Moderate exceedances are predicted at the church in Area B, the residential receivers in Area E and the active recreation in Area C. Minor exceedances are predicted at the residential receivers in Area A and D.

  High exceedances of more than 20 dB of the NMLs are predicted at the nearest commercial receivers in Areas C and D, and moderate exceedances of more than 10 dB are predicted at commercial receivers in Areas A and B
- For acoustic shed construction during the daytime moderate exceedances are predicted at commercial receivers in Area C, and minor exceedances are predicted at the church in Area B, the residential in Area C and the commercial in Area D
- For station excavation and structural works minor exceedances of up to 10 dB of the NMLs are predicted at the commercial receivers in Area C, and the church in Area B during daytime. During the night-time period moderate exceedances are predicted at residences in Area C, and minor exceedances are predicted at residences in Area A. An acoustic shed with higher noise insulation (such as a double wall construction) would be required to reduce night-time non compliance
- During station building construction during the daytime moderate exceedances of more than 10 dB of the NMLs are predicted at the residential receivers in Area C and E, commercial receivers at Area C and D, and at the church in Area B. Minor exceedances are predicted at residential receivers in Area A, and at commercial receivers in Area A and B and the active recreation in Area C.

On site night-time L_{Amax} truck noise

The L_{Amax} noise levels associated with individual truck movements on site exceed the sleep disturbance screening level by up to 10 dB during excavation. Opportunities to minimise noise from heavy vehicles, such as consideration of site layouts and screening, would be considered during detailed construction site planning.

Ground-borne noise

The ground-borne noise assessment indicated:

- During the daytime period seven buildings (four commercial buildings located to the east of the site, one residential building located to the east of the site and two residential buildings located to the south of the site) are predicted to have ground-borne noise levels potentially higher than 75 dBA for several floors in each building
- During the night-time period 15 residential buildings, located to the east, south and west of the site, are predicted to have ground-borne noise levels potentially higher than 45 dBA on one or more floors.

Feasible and reasonable measures would be implemented to minimise ground-borne noise where exceedances are predicted. Where exceedances of ground-borne noise levels are predicted, mitigation measures would be implemented in accordance with the Sydney Metro Construction Noise and Vibration Strategy (Appendix E).

The potential ground-borne noise impacts associated with excavation of the tunnels is discussed in Section 10.4.13.

Blasting

Due to the level and duration of ground-borne noise exceedances associated with rock breaking, consideration has been given to blasting as an alternative excavation method. Table 10-13 shows the anticipated reduction in the number of periods when the NML would be exceeded. The table shows three scenarios: no blasting, blasting plus a large rock breaker, blasting plus a medium rock breaker.

Table 10-13 Crows Nest Station blasting scenarios

Scenario	Number of periods above NMLs			
	Residential			Commercial
	Day	Evening	Night	Day
No blasting	80	136	185	67
Blasting plus large rock breaker	30	45	60	27
Blasting plus medium rock breaker	15	29	49	8

The potential change in duration of impacts is:

- **Residential day:** the use of large rock breakers with no blasting generates 80 daytime periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 30 daytime periods. The inclusion of blasting combined with medium rock breakers reduces the duration of impacts to 15 daytime periods
- **Residential evening:** the use of large rock breakers with no blasting generates 136 evening periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 45 evening periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to 29 evening periods
- **Residential night:** the use of large rock breakers with no blasting generates 185 night-time periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 60 night-time periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to 49 night-time periods
- **Commercial day:** the use of large rock breakers with no blasting generates 67 daytime periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 27 daytime periods. The inclusion of blasting combined with medium rock breakers reduces the duration of impacts to eight daytime periods.

Further detailed construction planning, through the development of Construction Noise Impact Statements (as required by the *Sydney Metro Construction Noise and Vibration Strategy* in Appendix E) would determine the exact construction activities with the aim of reducing ground-borne noise impacts to receivers. For example, this could involve the consideration of different sized rock breakers at different periods, and the positioning of rock breakers within the site during different periods.

With careful planning and positioning of the rock breakers it may be possible to avoid consecutive periods of NML exceedances to any one receiver, effectively providing respite periods. For any residual exceedances of the NMLs, additional mitigation measures would be implemented in accordance with the *Sydney Metro Construction Noise and Vibration Strategy* (Appendix E).

Ground-borne vibration

During excavation, vibration levels are anticipated to exceed the cosmetic damage vibration screening criteria at three buildings adjacent to the site (one building located to the east on Clarke Street and two building located to the south of the Pacific Highway). A more detailed assessment of the structure and attended vibration monitoring would be carried out to ensure vibration levels remain below appropriate limits for those structures.

Construction traffic noise

The predicted L_{Aeq} increase and sleep disturbance noise levels have been assessed for the access routes to the Crows Nest Station construction site and are presented in Table 10-14. No sensitive receivers are located on the sections of Oxley Street and Hume Street proposed to be used as haul routes.

On the Pacific Highway predicted noise level exceed the base criteria, however the increase associated with construction traffic complies with the 2 dB allowance. Whilst there is an exceedance of the sleep disturbance screening criterion (of up to 14 dB) and external sleep disturbance NML of 65 dBA (by up to 14 dB), the L_{Amax} levels would be similar to other heavy vehicles using the Pacific Highway. Therefore sensitive receivers are not likely to notice an increase in the average road traffic noise levels during construction.

On Clarke Street noise levels of 59 dBA (daytime) and 56 dBA (night-time) have been predicted. These levels exceed the RNP baseline criteria of 55 dBA (daytime) and 50 dBA (night-time) for local roads. There is an exceedance of the sleep disturbance screening criterion (of up to 9 dB) and external sleep disturbance NML of 65 dBA (of up to 10 dB), resulting in a sleep disturbance risk. Unless compliance with the road traffic noise criteria can be achieved on Clarke Street, night time heavy vehicle movements at the Crows Nest Station construction site would be restricted to the Pacific Highway, Hume Street and Oxley Street.

Table 10-14 Crows Nest Station – road traffic noise

Road	Base criteria (dB) day / night ($L_{Aeq(15hr/9hr)}$)	Predicted Road Traffic Noise (dB) day / night	Predicted Road Traffic Noise Increase (dB) day / night	RBL + 15 dB Screening Criterion (dBA)	External L_{Amax} NML Level (dBA)	Predicted L_{Amax} Noise Level (dBA)
Pacific Highway	60 / 55	75 / 68	0.2 / 0.5	65	65	79
Clarke Street	55 / 50	59 / 56	N/A[1]	66	65	75

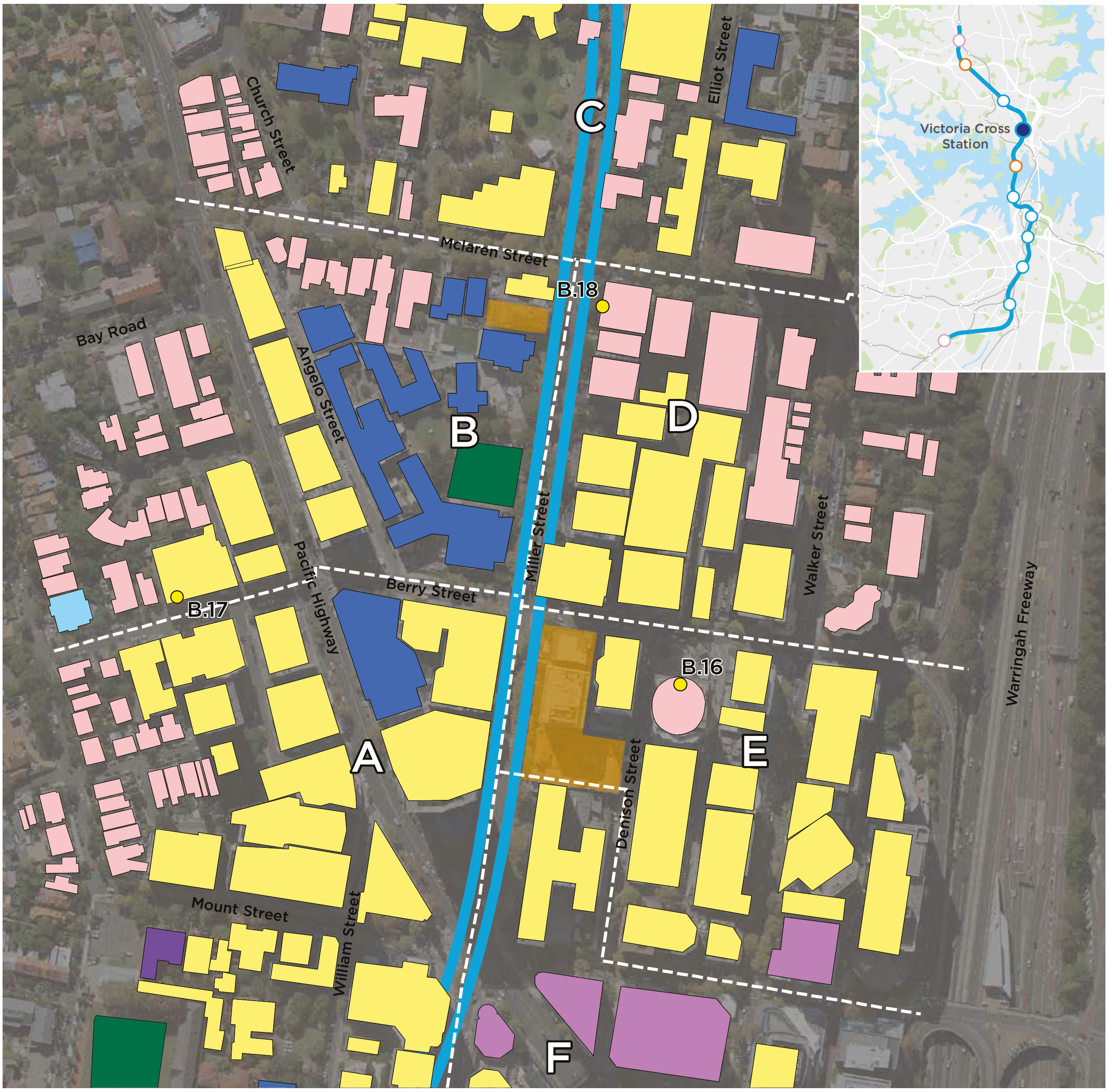
1 *Existing traffic flows are not available for Clarke Street*

10.4.4 Victoria Cross Station

The nearest sensitive receivers to the proposed construction site are shown in Figure 10-4.

The construction scenarios at the Victoria Cross Station construction site, and the anticipated timeframes, include:

- Demolition and site establishment (about 12 months) – the demolition of buildings on the site and establishment of the site compound facilities
- Earthworks (about two months) – initial surface excavation
- Acoustic shed construction (about one month) – piling and erection of the acoustic shed
- Excavation and structural works (about three years) – excavation of the station and structural works
- Building construction (about one a half years) – aboveground station and services building construction and fit-out.



KEY

Chatswood to Sydenham	Monitoring location
Proposed construction site area	Receiver area boundary

Receiver types

Residential	Other (Worship)	Active Recreation
Commercial	Other (Child Care)	
Other (Medical)	Other (Education)	

Indicative only, subject to design development

0 100 m

N

Figure 10-4 Location of sensitive receivers near Victoria Cross Station

Airborne construction noise

A summary of the predicted noise level exceedances at the nearest sensitive receivers is provided in Table 10-15 for each construction scenario.

Table 10-15 Predicted airborne noise level exceedances at Victoria Cross Station

Noise modelling scenario / Receiver area	Demolition and site establishment	Earthworks	Acoustic shed construction	Excavation and structural works					Building construction
	Day	Day	Day	Day	DOOH[1]	Evening	Night	Sleep	Day
A Commercial to the west on Miller Street	🟠	🔵	🟢	🟢	🟢	🟢	🟢	🟢	🔵
A Educational to the west on Pacific Highway	🟠	🟠	🟢	🟢	🟢	🟢	🟢	🟢	🔵
B Commercial to the west on Miller Street	🔴	🟠	🔵	🟢	🟢	🟢	🟢	🟢	🟠
B Residential to the west on McLaren Street	🟠	🟠	🟢	🟢	🟢	🔵	🟠	🔵	🔵
B Educational to the west on Miller Street	🔴	🔴	🔴	🟠	🔵	🟢	🟢	🟢	🔴
C Residential to the north on McLaren Street	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
C Commercial to the north on McLaren Street	🔵	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
D Residential to the east on Miller Street	🔵	🔵	🟢	🟢	🟢	🟢	🔵	🟢	🔵
D Commercial to the east on Miller Street	🟠	🟠	🔵	🟢	🟢	🟢	🟢	🟢	🔵
E Residential to the east on Miller Street	🔵	🔵	🟢	🟢	🟢	🟢	🔵	🟢	🟢
E Commercial to the east on Miller Street	🔴	🔴	🟠	🟢	🟢	🟢	🟢	🟢	🟠
F Commercial adjacent to the south	🔴	🔴	🟠	🟢	🟢	🟢	🟢	🟢	🔵

Legend

🟢 NML compliance
🔵 NML exceedance of less than 10 dB
🟠 NML exceedance between 10 dB and 20 dB
🔴 NML exceedance of more than 20 dB

1 *DOOH = Daytime out of hours (i.e Saturdays 1pm to 6pm and Sundays 7am to 6pm)*

The preliminary findings of the construction noise impact assessment at Victoria Cross Station indicate:

- For demolition and site establishment works during the daytime high exceedances of more than 20 dB of the NMLs are predicted at educational receivers in Area B and at the commercial receivers in Areas B, E and F. Moderate exceedances of more than 10 dB are predicted at commercial receivers in Areas A and D, at residential receivers in Area B and educational receivers in Area in A. At residential receivers in Area D and E and commercial receivers in Area C minor exceedances are predicted
- For earthworks during the daytime high exceedances of more than 20 dB of the NMLs are predicted at the educational receivers in Area B and commercial receivers in Areas E and F. Moderate exceedances are predicted at the educational receivers in Area A, and the commercial receivers in Areas B and D.

  At the nearest residential receivers moderate exceedances are predicted in Area B and minor exceedances are predicted in Areas D and E
- For acoustic shed construction during the daytime high exceedances of more than 20 dB are predicted at educational receivers in Area B and moderate exceedances of more than 10 dB at commercial receivers in Areas E and F
- For excavation during the daytime moderate exceedances are predicted at the educational receivers in Area B. For night-time excavation moderate exceedances are predicted at residential receivers in Area B and a minor exceedance is predicted at residential receivers in Areas D and E. An acoustic shed with higher noise insulation (such as a double wall construction) would be required to reduce night-time non compliance
- For station building construction during the daytime high exceedances of more than 20 dB are predicted at the educational receivers in Area B, and moderate exceedances of more than 10 dB of the NMLs are predicted at the commercial receivers at Areas B and E. Minor exceedances are predicted at residential receivers in Areas B and D, educational receivers in Area A and at commercial receivers in Areas A, D and F.

On site night-time L_{Amax} truck noise

The L_{Amax} noise levels associated with individual truck movements on site exceed the sleep disturbance screening level by up to 10 dB during excavation. Opportunities to minimise noise from heavy vehicles, such as consideration of site layouts and screening, would be considered during detailed construction site planning.

Ground-borne noise

The ground-borne noise assessment indicated:

- During the daytime the three buildings immediately adjacent to the northern site to the south, west and north and one building to the east of the southern site are predicted to have ground-borne noise levels potentially higher than 75 dBA on several floors in each building
- During night-time the five residential buildings near the northern site (to the east and west) and one residential building to the east of the southern site have ground-borne noise levels potentially higher than 45 dBA on several floors.

Feasible and reasonable measures would be implemented to minimise ground-borne noise where exceedances are predicted. Where exceedances of ground-borne noise levels are predicted, mitigation measures would be implemented in accordance with the Sydney Metro Construction Noise and Vibration Strategy (Appendix E).

The potential ground-borne noise impacts associated with excavation of the tunnels is discussed in Section 10.4.13.

Blasting

Due to the level and duration of ground-borne noise exceedances associated with rock breaking, consideration has been given to blasting as an alternative excavation method. Table 10-16 shows the anticipated reduction in the number of periods when the NML would be exceeded. The table shows three scenarios: no blasting, blasting plus a large rock breaker, blasting plus a medium rock breaker.

Table 10-16 Victoria Cross Station blasting scenarios

Scenario	Number of periods above NMLs			
	Residential			Commercial
	Day	Evening	Night	Day
Northern site				
No blasting	62	172	268	283
Blasting plus large rock breaker	32	71	101	131
Blasting plus medium rock breaker	9	31	77	111
Southern site				
No blasting	0	16	55	37
Blasting plus large rock breaker	0	8	22	22
Blasting plus medium rock breaker	0	0	7	8

The potential change in duration of impacts is:

- **Residential day:** the use of large rock breakers with no blasting generates 62 daytime periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 32 daytime periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to nine daytime periods
- **Residential evening:** the use of large rock breakers with no blasting generates 192 evening periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 79 evening periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to 31 evening periods
- **Residential night:** the use of large rock breakers with no blasting generates 323 night-time periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 123 night-time periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to 84 night-time periods
- **Commercial day:** the use of large rock breakers with no blasting generates 324 daytime periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 153 daytime periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to 119 daytime periods.

Further detailed construction planning, through the development of Construction Noise Impact Statements (as required by the *Sydney Metro Construction Noise and Vibration Strategy* in Appendix E) would determine the exact construction activities with the aim of reducing ground-borne noise impacts to receivers. For example, this could involve the consideration of different sized rock breakers at different periods, and the positioning of rock breakers within the site during different periods.

With careful planning and positioning of the rock breakers it may be possible to avoid consecutive periods of NML exceedances to any one receiver, effectively providing respite periods. For any residual exceedances of the NMLs, additional mitigation measures would be implemented in accordance with the *Sydney Metro Construction Noise and Vibration Strategy* (Appendix E).

Ground-borne vibration

During excavation of the shafts vibration levels are anticipated to remain below the cosmetic damage vibration screening criteria, except for:

- The three buildings immediately adjacent to the northern site to the south, west and north
- One commercial building to the east of the southern site.

A more detailed assessment of the structure and attended vibration monitoring would be carried out to ensure vibration levels remain below appropriate limits for these structures.

The use of road headers to excavate a low level pedestrian walkway from the southern site to the mined station cavern is predicted to remain below the cosmetic damage vibration screening criteria screening levels.

Construction traffic noise

The predicted L_{Aeq} increase and sleep disturbance noise levels have been assessed for the access routes to the Victoria Cross Station construction site and are presented in Table 10-17.

On McLaren Street, Miller Street and Berry Street the predicted noise level exceeds the base criteria, however the increase associated with construction traffic complies with the 2 dB allowance. Whilst there is an exceedance of the sleep disturbance screening criterion (of up to 10 dB) and external sleep disturbance NML of 65 dBA (of up to 11 dB), the L_{Amax} levels would be similar to other heavy vehicles using McLaren Street, Miller Street and Berry Street. Therefore sensitive receivers are not likely to notice an increase in the average road traffic noise levels during construction.

On Denison Street baseline noise levels of 54 dBA (daytime) and of 50 dBA (night-time) have been predicted. These levels comply with the RNP baseline criteria of 55 dBA (daytime) and 50 dBA (night-time) for local roads. However, there is an exceedance of the sleep disturbance screening criteria and, as there are limited existing heavy vehicles using this road, there is a risk of sleep disturbance impacts. Unless compliance with the road traffic noise criteria can be achieved on Denison Street, night time heavy vehicle movements at the Victoria Cross Station construction site would be restricted to McLaren Street, Miller Street and Berry Street.

Table 10-17 Victoria Cross Station – road traffic noise

Road	Base criteria (dB) day / night ($L_{Aeq(15hr/9hr)}$)	Predicted Road Traffic Noise (dB) day / night	Predicted Road Traffic Noise Increase (dB) day / night	RBL + 15 dB Screening Criterion (dBA)	External L_{Amax} NML Level (dBA)	Predicted L_{Amax} Noise Level (dBA)
McLaren Street	60 / 55	66 / 62	0.6 / 0.8	66	65	76
Miller Street	60 / 55	66 / 59	0.3 / 0.7	66	65	72

Road	Base criteria (dB) day / night ($L_{Aeq(15hr/9hr)}$)	Predicted Road Traffic Noise (dB) day / night	Predicted Road Traffic Noise Increase (dB) day / night	RBL + 15 dB Screening Criterion (dBA)	External L_{Amax} NML Level (dBA)	Predicted L_{Amax} Noise Level (dBA)
Berry Street	60 / 55	69 / 62	0.3 / 0.8	67	65	76
Denison Street	55 / 50	54 / 50	N/A [1]	67	65	72

1 *Existing traffic flows are not available for Denison Street*

10.4.5 Blues Point temporary site

The nearest sensitive receivers to the proposed construction site are shown in Figure 10-5.

The construction scenarios at the Blues Point temporary site, and the anticipated timeframes, include:

- Site establishment (about one month) – stripping to grass and topsoil and establishment of site compound facilities
- Earthworks (about one month) – initial surface excavation and site levelling
- Excavation (about 12 months) – excavation of the shaft to tunnel level
- Site rehabilitation (about six months) – rehabilitation of Blues Point Reserve including re-contouring of the site and landscaping.

KEY

Chatswood to Sydenham

Proposed construction site area

Receiver types

Residential

Commercial

Passive Recreation

Monitoring location

Receiver area boundary

Indicative only, subject to design development

0 100 m

N

Figure 10-5 Location of sensitive receivers near Blues Point temporary site

Airborne construction noise

A summary of the predicted noise level exceedances at the nearest sensitive receivers is provided in Table 10-18 for each construction scenario.

Table 10-18 Predicted airborne noise level exceedances at Blues Point temporary site

Noise modelling scenario	Site establishment	Earthworks	Excavation	Site rehabilitation
Receiver area	Day	Day	Day	Day
A Residential to the west in Blues Point Tower	NML exceedance between 10 dB and 20 dB	NML exceedance between 10 dB and 20 dB	NML exceedance between 10 dB and 20 dB	NML exceedance of less than 10 dB
A Passive recreation to the south west	NML exceedance between 10 dB and 20 dB	NML exceedance of less than 10 dB	NML exceedance of less than 10 dB	NML exceedance of less than 10 dB
B Residential to the north, east of Blues Point Road	NML exceedance between 10 dB and 20 dB	NML exceedance between 10 dB and 20 dB	NML exceedance between 10 dB and 20 dB	NML exceedance of less than 10 dB
C Residential to the north on Warung Street	NML exceedance of more than 20 dB	NML exceedance of more than 20 dB	NML exceedance of more than 20 dB	NML exceedance between 10 dB and 20 dB
D Commercial to the east on Henry Lawson Avenue	NML exceedance between 10 dB and 20 dB	NML exceedance of less than 10 dB	NML exceedance of less than 10 dB	NML compliance
D Passive recreation to the east	NML exceedance between 10 dB and 20 dB	NML exceedance of less than 10 dB	NML exceedance of less than 10 dB	NML exceedance of less than 10 dB

Legend

- NML compliance
- NML exceedance of less than 10 dB
- NML exceedance between 10 dB and 20 dB
- NML exceedance of more than 20 dB

The preliminary findings of the construction noise impact assessment at Blues Point temporary site indicate:

- For site establishment works high exceedances of more than 20 dB of the NMLs are predicted at residential receivers in Area C, and moderate exceedances of more than 10 dB are predicted in at residential receivers in Areas A and B and at the commercial and recreation receivers in Area D. A moderate exceedance is also predicted in the passive recreation in Areas A and D, and at the commercial receiver in Area D. These are a direct result of the relative close proximity of receivers to the construction activities and the absence of any appreciable shielding between sites and receivers
- For earthworks and excavation high exceedances of more than 20 dB are predicted at the residential receivers in Area C, a moderate exceedance at residences in Areas A and B and minor exceedances of less than 10 dB at the passive recreation in Areas A and D, and the commercial receiver in Area D
- For site rehabilitation moderate exceedances of more than 10 dB are predicted at the residential receivers in Area C. There are minor exceedances in the residential receivers in Areas A and B and the passive recreation in Areas A and D.

On site night-time L_{Amax} truck noise

With the exception of the four occasions when transport of the tunnel boring machine cutter heads would be carried out, no night-time L_{Amax} truck noise impacts are predicted at the Blues Point temporary site as construction would generally occur during the daytime.

Ground-borne noise

Rock breaking and excavation works are proposed to be carried out during the daytime period at this site. The ground-borne noise assessment indicated that:

- One receiver, located on Warung Street, is predicted to have a high exceedance of the NML (of between 20 dB to 25 dB)
- Three receivers, located on Warung Street, are predicted to have a moderate exceedance of the NML (of up to 10 dB).

The potential ground-borne noise impacts associated with excavation of the tunnels is discussed in Section 10.4.13.

Ground-borne vibration

During excavation of the shafts vibration levels are anticipated to remain below the cosmetic damage vibration screening criteria.

Construction traffic noise

The predicted L_{Aeq} increase noise levels have been assessed for the access routes to the Blues Point temporary site. As no night-time works are proposed at this site (with the exception of the four occasions when transport of the tunnel boring machine cutter heads would be carried out), a sleep disturbance assessment has not been carried out. Traffic noise levels from the project comply with the baseline criteria on Henry Lawson Avenue and exceed by 1 dB on Blues Point Road.

Table 10-19 Blues Point temporary site – road traffic noise

Road	Base criteria daytime (dB)	Predicted project daytime traffic noise (dB)
Blues Point Road	55	56
Henry Lawson Avenue	55	52

10.4.6 Sydney Harbour ground improvement works

The nearest sensitive receivers to the proposed construction site are shown in Figure 10-6. Due to the nature of works at this site, the assessment has considered potential airborne noise impacts only.

The construction scenario for the ground improvement work involves the use of the grout barge on the harbor in two location. The works are anticipated to occur for about 12 months.

Figure 10-6 Location of sensitive receivers near Sydney Harbour ground improvement works

Airborne construction noise

A summary of the predicted noise level exceedances at the nearest sensitive receivers is provided in Table 10-20 for the construction scenario.

Table 10-20 Predicted airborne noise level exceedances – ground improvement work

Noise modelling scenario	Grout barge				
Receiver area	Day	DOOH	Evening	Night	Sleep
A Residential to the west in Blues Point Tower	NML compliance	NML compliance	NML compliance	NML compliance	NML compliance
A Passive recreation to the south west	NML compliance	NML compliance	NML compliance	NML exceedance of less than 10 dB	NML compliance
B Residential to the north, east of Blues Point Road	NML compliance	NML compliance	NML compliance	NML compliance	NML compliance
C Residential to the north on Warung Street	NML compliance	NML compliance	NML compliance	NML compliance	NML compliance
D Commercial to the east on Henry Lawson Avenue	NML compliance	NML compliance	NML compliance	NML compliance	NML compliance
D Passive recreation to the east	NML compliance	NML compliance	NML compliance	NML compliance	NML compliance

Legend

- NML compliance
- NML exceedance of less than 10 dB
- NML exceedance between 10 dB and 20 dB
- NML exceedance of more than 20 dB

1 DOOH = Daytime out of hours (i.e Saturdays 1pm to 6pm and Sundays 7am to 6pm)

The preliminary findings of the construction noise impact assessment of the Sydney Harbour ground improvement works predicts compliance for the daytime at evening periods at all receiver areas. During night-time there is a minor exceedance of up to 10 dB at residential receivers in Area A.

10.4.7 Barangaroo Station

The nearest sensitive receivers to the proposed construction site are shown in Figure 10-7.

The construction scenarios at the Barangaroo Station construction site, and the anticipated timeframes, include:

- Site establishment (about 12 months) – establishment of site compound facilities
- Earthworks (about two months) – initial surface excavation
- Acoustic shed construction (about one month) – piling and erection of the acoustic shed
- Station excavation and tunnelling works (about 12 months for station excavation and one and half years for tunnelling) – excavation of the station, excavation of the main tunnel beneath Sydney Harbour and associated support services such as spoil handling and removal
- Building construction (about one and a half years) – aboveground station and services building construction and fit-out.

KEY

Chatswood to Sydenham
Proposed construction site area
Monitoring location
Receiver area boundary

Receiver types

Residential
Commercial
Other (Worship)
Other (Education)
Passive Recreation

Indicative only, subject to design development

0 100 m

N

Figure 10-7 Location of sensitive receivers near Barangaroo Station

Airborne construction noise

A summary of the predicted noise level exceedances at the nearest sensitive receivers is provided in Table 10-21 for each construction scenario.

Table 10-21 Predicted airborne noise level exceedances at Barangaroo Station

Noise modelling scenario	Site establishment	Earthworks	Acoustic shed construction	Station excavation and tunnelling works					Building construction
Receiver area	Day	Day	Day	Day	DOOH[1]	Evening	Night	Sleep	Day
A Commercial (future) to the west and south	NML exceedance of more than 20 dB	NML exceedance of less than 10 dB	NML compliance	NML compliance	NML compliance	NML compliance	NML compliance	NML compliance	NML exceedance of less than 10 dB
A Residential (future) to the west and south	NML exceedance of less than 10 dB	NML exceedance of less than 10 dB	NML compliance	NML compliance	NML compliance	NML exceedance of less than 10 dB	NML exceedance of less than 10 dB	NML compliance	NML exceedance of less than 10 dB
B Residential to the north on Bettington Street	NML exceedance between 10 dB and 20 dB	NML exceedance of less than 10 dB	NML compliance	NML exceedance of less than 10 dB	NML compliance	NML exceedance of less than 10 dB	NML exceedance of less than 10 dB	NML compliance	NML exceedance of less than 10 dB
B Passive recreation to the north at Barangaroo Reserve	NML exceedance of less than 10 dB	NML exceedance of less than 10 dB	NML compliance	NML compliance	NML compliance	NML compliance	NML compliance	NML compliance	NML exceedance of less than 10 dB
C Residential to the east on High Street	NML exceedance of more than 20 dB	NML exceedance between 10 dB and 20 dB	NML exceedance of less than 10 dB	NML exceedance between 10 dB and 20 dB	NML exceedance of less than 10 dB	NML exceedance between 10 dB and 20 dB	NML exceedance between 10 dB and 20 dB	NML exceedance of less than 10 dB	NML exceedance between 10 dB and 20 dB
D Residential to the south on High Street	NML exceedance between 10 dB and 20 dB	NML exceedance between 10 dB and 20 dB	NML exceedance of less than 10 dB	NML exceedance of less than 10 dB	NML exceedance of less than 10 dB	NML exceedance between 10 dB and 20 dB	NML exceedance between 10 dB and 20 dB	NML exceedance of less than 10 dB	NML exceedance between 10 dB and 20 dB
D Commercial to the south on Hickson Road	NML exceedance of less than 10 dB	NML exceedance of less than 10 dB	NML compliance	NML compliance	NML compliance	NML compliance	NML compliance	NML compliance	NML compliance
E Residential to the west in Balmain East	NML compliance	NML compliance	NML compliance	NML compliance	NML compliance	NML compliance	NML compliance	NML compliance	NML compliance

Legend

- NML compliance
- NML exceedance of less than 10 dB
- NML exceedance between 10 dB and 20 dB
- NML exceedance of more than 20 dB

Note 1: DOOH = Daytime out of hours (i.e Saturdays 1pm to 6pm and Sundays 7am to 6pm)

The preliminary findings of the construction noise impact assessment at Barangaroo Station indicate:

- For site establishment works high exceedances of more than 20 dB of the NMLs are predicted at residential receivers in Area C and commercial receivers in Area A. Moderate exceedances of more than 10 dB are predicted at residential receivers in Areas B and D. Minor exceedances are predicted at residential receivers in Area A, commercial receivers in Area D and passive recreation in Area B. These are a direct result of the relative close proximity of receivers to the construction activities and the absence of any appreciable shielding between sites and receivers
- For earthworks a moderate exceedance is predicted at residential receivers in Areas C and D. Minor exceedances are predicted at residential receivers in Areas A and B, commercial receivers in Areas A and D and passive recreation in Area B
- For construction of the acoustic shed minor exceedances are predicted at the residential receivers in Areas C and D
- For excavation and tunnelling during the daytime a moderate exceedance of more than 10 dB is predicted at residences in Area C, and a minor exceedance of up to 10 dB at residential receivers in Areas B and D. For excavation and tunnelling outside standard construction hours moderate exceedances are predicted at residential receivers in Areas C and D and minor exceedances in Areas A and B. An acoustic shed with higher noise insulation (such as a double wall construction) would be required to reduce night-time non compliance
- For station building construction moderate exceedances are predicted at residential receivers in Areas C and D, and minor exceedances at residences in Areas A and B, commercial receivers in Area A and passive recreation in Area B.

On site night-time L_{Amax} truck noise

The L_{Amax} noise levels associated with individual truck movements on site exceed the sleep disturbance screening level by up to 10 dB during excavation with an acoustic shed at residential receivers in Areas C and D. Opportunities to minimise noise from heavy vehicles, such as consideration of site layouts and screening, would be considered during detailed construction site planning.

Ground-borne noise

The ground-borne noise assessment indicated:

- During the daytime one commercial building, located on Hickson Road to the north of the site, is predicted to have high exceedances of the NML (of 20 dB to 25 dB). The remaining commercial and residential buildings, located on High Street and within the Barangaroo development, are predicted to have a moderate exceedance of the NML (of 10 dB to 20 dB)
- During night-time 14 residential buildings, located on High Street and Kent Street to the east of the excavation, are predicted to have ground-borne noise levels potentially higher than 45 dBA on several floors.

Feasible and reasonable measures would be implemented to minimise ground-borne noise where exceedances are predicted. Where exceedances of ground-borne noise levels are predicted, mitigation measures would be implemented in accordance with the *Sydney Metro Construction Noise and Vibration Strategy* (Appendix E).

The potential ground-borne noise impacts associated with excavation of the tunnels is discussed in Section 10.4.13.

Blasting

Due to the level and duration of ground-borne noise exceedances associated with rock breaking, consideration has been given to blasting as an alternative excavation method. Table 10-22 shows the anticipated reduction in the number of periods when the NML would be exceeded. The table shows three scenarios: no blasting, blasting plus a large rock breaker, blasting plus a medium rock breaker.

Table 10-22 Barangaroo Station blasting scenarios

Scenario	Number of periods above NMLs			
	Residential			Commercial
	Day	Evening	Night	Day
No blasting	358	>365	>365	9
Blasting plus large rock breaker	171	277	>365	6
Blasting plus medium rock breaker	63	174	295	1

The potential change in duration of impacts is:

- **Residential day:** the use of large rock breakers with no blasting generates 358 daytime periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 171 daytime periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to 63 daytime periods
- **Residential evening:** the use of large rock breakers with no blasting generates +365 evening periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 277 evening periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to 174 evening periods
- **Residential night:** the use of large rock breakers with no blasting generates greater than 365 night-time periods with exceedances of the NMLs. The inclusion of blasting with large rock breakers would still result in greater 365 night-time periods with exceedances of the NMLs. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts to 295 night-time periods
- **Commercial day:** the use of large rock breakers with no blasting generates nine daytime periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to six daytime periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to one daytime period.

Further detailed construction planning, through the development of Construction Noise Impact Statements (as required by the *Sydney Metro Construction Noise and Vibration Strategy* in Appendix E) would determine the exact construction activities with the aim of reducing ground-borne noise impacts to receivers. For example, this could involve the consideration of different sized rock breakers at different periods, and the positioning of rock breakers within the site during different periods.

With careful planning and positioning of the rock breakers it may be possible to avoid consecutive periods of NML exceedances to any one receiver, effectively providing respite periods. For any residual exceedances of the NMLs, additional mitigation measures would be implemented in accordance with the *Sydney Metro Construction Noise and Vibration Strategy* (Appendix E).

Ground-borne vibration

During excavation of the station vibration levels are anticipated to remain below the cosmetic damage vibration screening criteria, except for one commercial building to the north of the site on Hickson Road. A more detailed assessment of the structure and attended vibration monitoring would be carried out to ensure vibration levels remain below appropriate limits for this structure.

Construction traffic noise

The predicted L_{Aeq} increase and sleep disturbance noise levels have been assessed for the access routes to the Barangaroo Station construction site and are presented in Table 10-23.

The predicted noise level increase associated with construction traffic exceeds the base criteria, however the increase complies with the 2 dB allowance. Whilst there is an exceedance of the sleep disturbance screening criterion (of up to 22 dB) and external sleep disturbance NML of 65 dBA (by up to 12 dB), the L_{Amax} levels would be similar to other heavy vehicles using Hickson Road. Therefore sensitive receivers are not likely to notice an increase in the average road traffic noise levels during construction.

Table 10-23 Barangaroo Station – road traffic noise

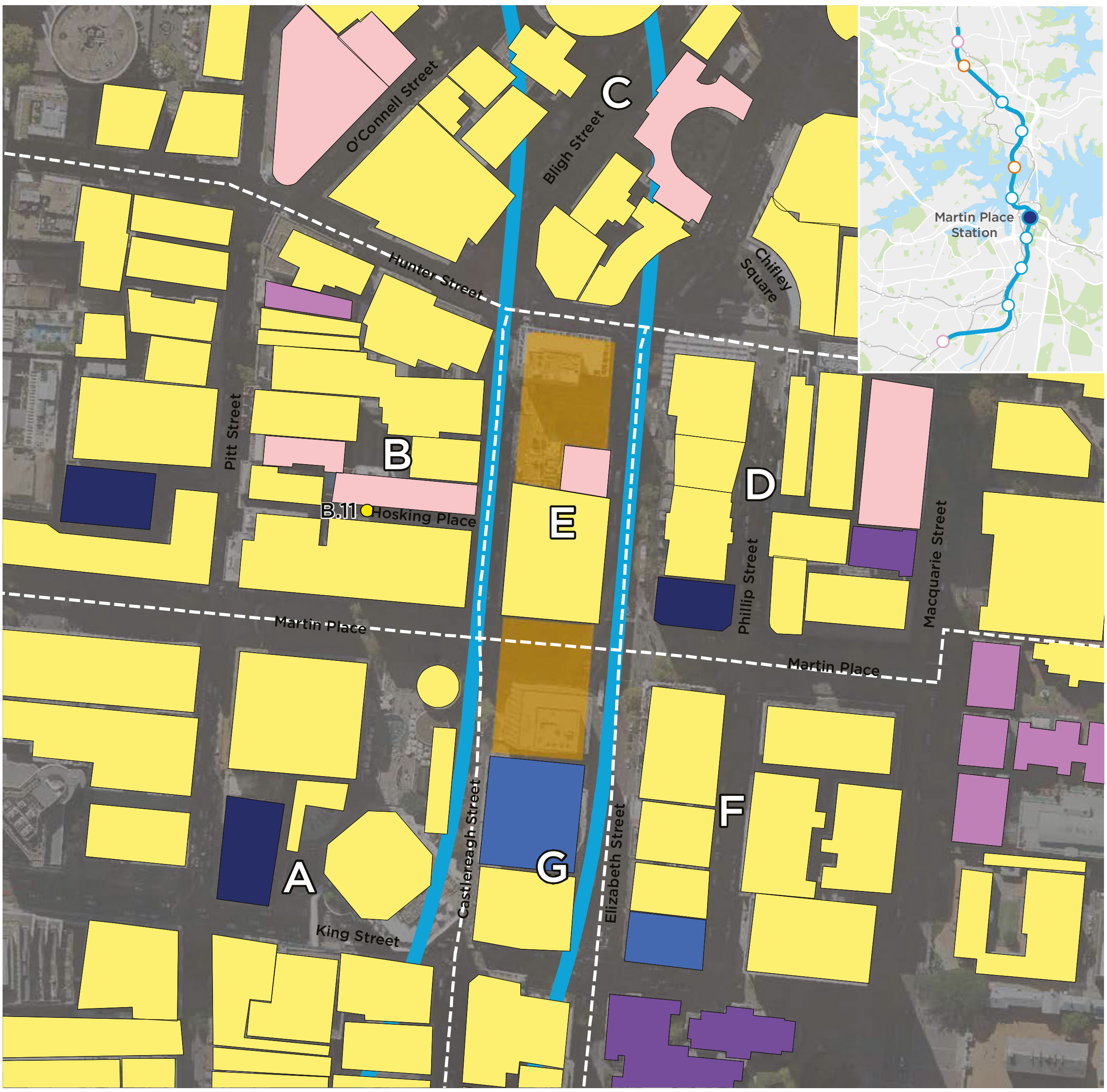
Road	Base criteria (dB) day / night ($L_{Aeq(15hr/9hr)}$)	Predicted Road Traffic Noise (dB) day / night	Predicted Road Traffic Noise Increase (dB) day / night	RBL + 15 dB Screening Criterion (dBA)	External L_{Amax} NML Level (dBA)	Predicted L_{Amax} Noise Level (dBA)
Hickson Road	60 / 55	70 / 64	0.6 / 1.2	55	65	77

10.4.8 Martin Place Station

The nearest sensitive receivers to the proposed construction site are shown in Figure 10-8.

The construction scenarios at the Martin Place Station construction site, and the anticipated timeframes, include:

- Demolition and site establishment (about 12 months) – the demolition of buildings on the site and establishment of site compound facilities
- Earthworks (about two month) – initial surface excavation
- Acoustic shed construction (about one month) – piling and erection of the acoustic shed
- Excavation and structural works (about three years) – excavation of the station and structural works
- Building construction (about one and a half years) – aboveground station and services building construction and fit-out.



KEY

- Chatswood to Sydenham
- Monitoring location
- Proposed construction site area
- Receiver area boundary

Receiver types

- Residential
- Commercial
- Other (Medical)
- Other (Worship)
- Other (Education)
- Other (Theatre)

Indicative only, subject to design development

0 100 m

N

Figure 10-8 Location of sensitive receivers near Martin Place Station

Airborne construction noise

A summary of the predicted noise level exceedances at the nearest sensitive receivers is provided in Table 10-24 for each construction scenario.

Table 10-24 Predicted noise level exceedances at Martin Place Station

Receiver area	Demolition and site establishment – Day	Earthworks – Day	Acoustic shed construction – Day	Excavation and structural works – Day	Excavation and structural works – DOOH[1]	Excavation and structural works – Evening	Excavation and structural works – Night	Excavation and structural works – Sleep	Building construction – Day
A Commercial to the west, west of Pitt Street and south of Martin Place	10–20 dB	10–20 dB	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	<10 dB
B Residential to the west, west of Pitt Street and north of Martin Place	10–20 dB	<10 dB	Compliance	Compliance	Compliance	Compliance	<10 dB	Compliance	<10 dB
B Commercial to the west, west of Pitt Street and north of Martin Place	10–20 dB	10–20 dB	<10 dB	Compliance	Compliance	Compliance	Compliance	Compliance	<10 dB
C Residential to the north, north of Hunter Street	<10 dB	<10 dB	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance
C Commercial to the north, north of Hunter Street	10–20 dB	10–20 dB	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	<10 dB
D Residential to the east, between Hunter Street and Martin Place	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance
D Commercial to the east, between Hunter Street and Martin Place	10–20 dB	10–20 dB	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	<10 dB
E Residential receivers between the two construction sites	>20 dB	10–20 dB	<10 dB	Compliance	Compliance	<10 dB	<10 dB	Compliance	10–20 dB
E Commercial between the two construction sites	>20 dB	10–20 dB	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	10–20 dB
F Commercial to the east, between King Street and Martin Place	<10 dB	<10 dB	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	<10 dB
F Educational to the east, between King Street and Martin Place	10–20 dB	10–20 dB	<10 dB	Compliance	Compliance	Compliance	Compliance	Compliance	<10 dB
G Educational to the south, between Castlereagh Street and Elizabeth Street	>20 dB	>20 dB	10–20 dB	10–20 dB	Compliance	Compliance	Compliance	Compliance	>20 dB
G Commercial to the south, between Castlereagh Street and Elizabeth Street	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance

Legend

- NML compliance
- NML exceedance of less than 10 dB
- NML exceedance between 10 dB and 20 dB
- NML exceedance of more than 20 dB

1 *DOOH = Daytime out of hours (i.e Saturdays 1pm to 6pm and Sundays 7am to 6pm)*

The preliminary findings of the construction noise impact assessment at Martin Place Station indicate:

- For site establishment works during the daytime high exceedances of more than 20 dB of the NMLs are predicted at educational receivers in Area G and the residential receivers in Area E. Moderate exceedances of more than 10 dB are predicted at residential receivers in Area B and educational receivers in Area F. At residential receivers in Area C minor exceedances of less than 10 dB are predicted.

  At the nearest commercial receivers in Area E high exceedances of more than 20 dB of the NMLs are predicted, and at commercial receivers in Areas A, B, C and D moderate exceedances of more than 10 dB are predicted. Minor exceedances are predicted at commercial receivers in Area F
- For earthworks during the daytime high exceedances of more than 20 dB of the NMLs are predicted at the educational receivers in Area G. At the educational receivers in Area F and residences in Area E moderate exceedances are predicted. At residences in Area B and C minor exceedances are predicted.

  At the nearest commercial receivers in Areas A, B, C, D and E moderate exceedances of the NMLs are predicted, with minor exceedances at the commercial receivers in Area F
- For acoustic shed construction during the daytime a moderate exceedance is predicted at educational receivers in Area G and minor exceedances at educational receivers in Area F, the residential receivers in Area E, and commercial receivers in Area B
- For excavation during the daytime a moderate exceedance of more than 10 dB is predicted the educational receivers in Area G. Compliance is predicted at all other receivers during daytime. During night-time works minor exceedances are predicted at residences in Areas B and E
- For station building construction during the daytime major exceedances are predicted at the educational receivers in Area G, and moderate exceedances are predicted at residences in Area E and commercial receivers at Area E. Minor exceedances are predicted at educational receivers in Area F, at residential receivers in Area B and at commercial receivers in Areas A, B, C, D and F
- At the Channel Seven studio on Martin Place noise levels are predicted to be up to 79 dBA, and at the Theatre Royal up to 69 dBA. At both locations these levels would be similar to external noise levels from heavy vehicles on Castlereagh Street, and Pitt Street respectively, and general city noise. The building external to internal noise reduction would therefore adequately attenuate noise from the works to the news room and theatre respectively.

On site night-time L_{Amax} truck noise

The L_{Amax} noise levels associated with individual truck movements on site comply with the sleep disturbance screening level.

Ground-borne noise

The ground-borne noise assessment indicated:

- During the daytime two commercial buildings (one to the south of the northern site and one to the south of the southern site) are predicted to have ground-borne noise levels potentially higher than 75 dBA for several floors, which correlates to very high NML exceedances of greater than 25 dB. A further five commercial buildings, located to the west of both sites, are predicted to have high exceedances of the NML of 20 dB to 25 dB. The nearest residential receiver, located to the west on Castlereagh Street between Hunter Street and Martin Place, is predicted to have a moderate exceedance of the NML of 10 dB to 20 dB
- During night-time one residential building to the west on Castlereagh Street between Hunter Street and Martin Place is predicted to have ground-borne noise levels potentially higher than 45 dBA on one or more floors
- The Theatre Royal (located around 100 metres from the proposed station excavation works) is predicted to have ground-borne noise levels up to $L_{Aeq(15minute)}$ 30 dBA within the theatre during rock breaker works, which complies with the 30 dBA criteria.

Feasible and reasonable measures would be implemented to minimise ground-borne noise where exceedances are predicted. Where exceedances of ground-borne noise levels are predicted, mitigation measures would be implemented in accordance with the *Sydney Metro Construction Noise and Vibration Strategy* (Appendix E).

The potential ground-borne noise impacts associated with excavation of the tunnels is discussed in Section 10.4.13.

Blasting

Due to the level and duration of ground-borne noise exceedances associated with rock breaking, consideration has been given to blasting as an alternative excavation method. Table 10-25 shows the anticipated reduction in the number of periods when the NML would be exceeded. The table shows three scenarios: no blasting, blasting plus a large rock breaker, blasting plus a medium rock breaker.

Table 10-25 Martin Place Station blasting scenarios

Scenario	Number of periods above NMLs			
	Residential			Commercial
	Day	Evening	Night	Day
Northern site				
No blasting	2	5	9	225
Blasting plus large rock breaker	0	1	1	42
Blasting plus medium rock breaker	0	0	1	22
Southern site				
No blasting	0	0	0	32
Blasting plus large rock breaker	0	0	0	18
Blasting plus medium rock breaker	0	0	0	9

The potential change in duration of impacts is:

- **Residential day:** the use of large rock breakers with no blasting generates two daytime periods with exceedances of the NMLs. The inclusion of blasting eliminates the potential exceedances during the daytime period
- **Residential evening:** the use of large rock breakers with no blasting generates five evening periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to one evening period
- **Residential night:** the use of large rock breakers with no blasting generates nine night-time periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to one night-time period
- **Commercial day:** the use of large rock breakers with no blasting generates 257 daytime periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 60 daytime periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to 31 daytime periods.

Further detailed construction planning, through the development of Construction Noise Impact Statements (as required by the *Sydney Metro Construction Noise and Vibration Strategy* in Appendix E) would determine the exact construction activities with the aim of reducing ground-borne noise impacts to receivers. For example, this could involve the consideration of different sized rock breakers at different periods, and the positioning of rock breakers within the site during different periods.

With careful planning and positioning of the rock breakers it may be possible to avoid consecutive periods of NML exceedances to any one receiver, effectively providing respite periods. For any residual exceedances of the NMLs, additional mitigation measures would be implemented in accordance with the *Sydney Metro Construction Noise and Vibration Strategy* (Appendix E).

Ground-borne vibration

During excavation of the station shafts vibration levels are anticipated to remain below the cosmetic damage vibration screening criteria, except for one commercial building located immediately to the south of the southern site. A more detailed assessment of the structure and attended vibration monitoring would be carried out to ensure vibration levels remain below appropriate limits for this structure.

At the Commonwealth Bank building the more stringent 7.5 mm/s screening criterion was applied. Vibration levels at the Commonwealth Bank building are predicted to comply with this screening criterion.

Construction traffic noise

The predicted L_{Aeq} increase and sleep disturbance noise levels have been assessed for the access routes to the Martin Place Station construction site and are presented in Table 10-26.

The predicted noise level associated with construction traffic exceeds the base criteria, however the increase complies with the 2 dB allowance. Whilst there is an exceedance of the sleep disturbance screening criterion (of up to 11 dB) and external sleep disturbance NML of 65 dBA (by up to 13 dB), the L_{Amax} levels would be similar to other heavy vehicles using Hunter Street, Castlereagh Street and Elizabeth Street. Therefore sensitive receivers are not likely to notice an increase in the average road traffic noise levels during construction.

Table 10-26 Martin Place Station – road traffic noise

Road	Base criteria (dB) day / night ($L_{Aeq(15hr/9hr)}$)	Predicted Road Traffic Noise (dB) day / night	Predicted Road Traffic Noise Increase (dB) day / night	RBL + 15 dB Screening Criterion (dBA)	External L_{Amax} NML Level (dBA)	Predicted L_{Amax} Noise Level (dBA)
Hunter Street	60 / 55	70 / 66	0.3 / 0.4	67	65	78
Castlereagh Street	60 / 55	69 / 64	0.4 / 0.6	67	65	78
Elizabeth Street	60 / 55	73 / 69	0.2 / 0.2	67	65	78

10.4.9 Pitt Street Station

The nearest sensitive receivers to the proposed construction site are shown in Figure 10-9.

The construction scenarios at the Pitt Street Station construction site, and the anticipated timeframes, include:

- Demolition and site establishment (about 12 months) – the demolition of buildings on the site and establishment of site compound facilities
- Earthworks (about two months) – initial surface excavation
- Acoustic shed construction (about one month) – piling and erection of the acoustic shed
- Excavation and structural works (about three years) – excavation of the station and structural works
- Building construction (about one and a half years) – aboveground station and services building construction and fit-out.

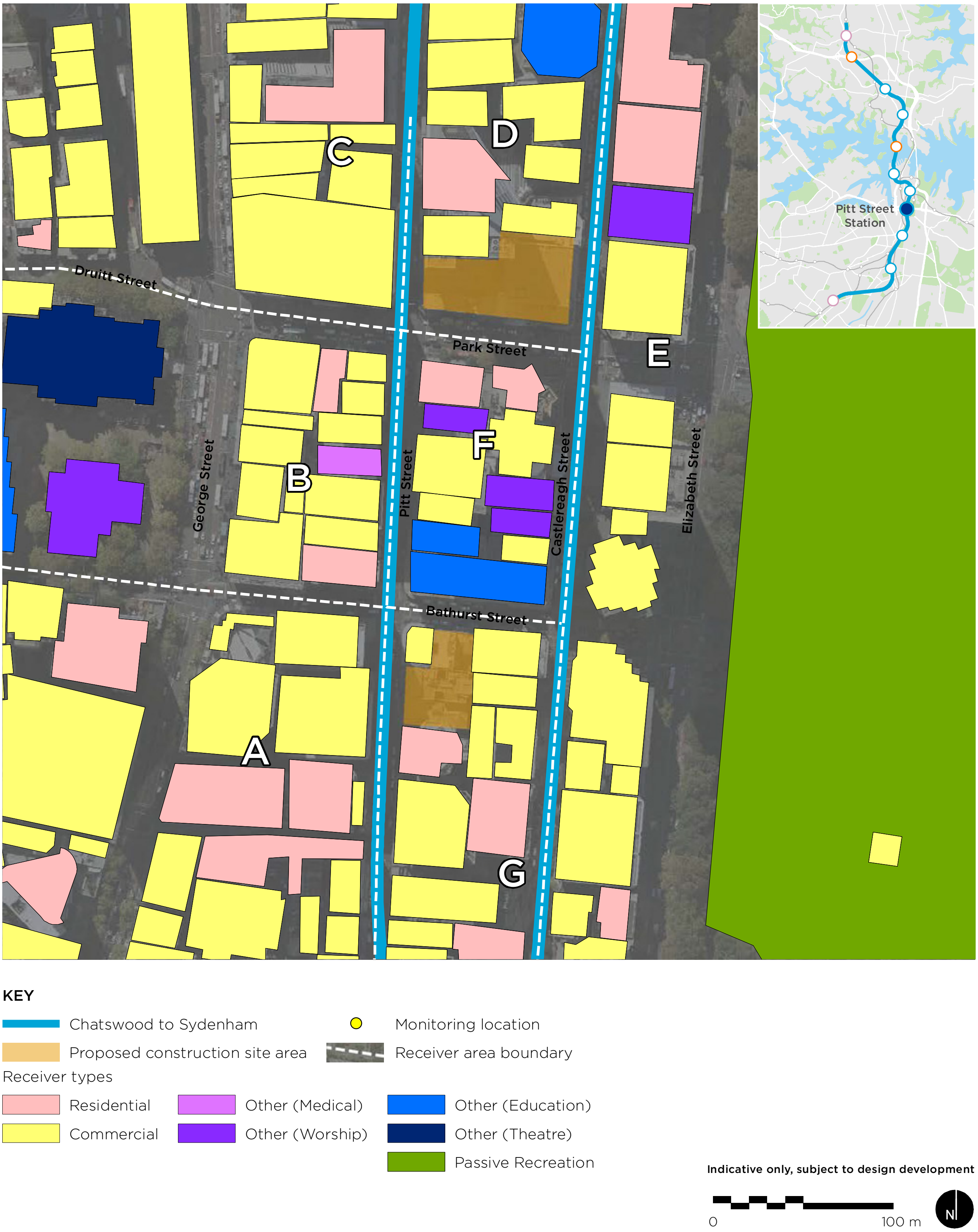


Figure 10-9 Location of sensitive receivers near Pitt Street Station

Airborne construction noise

A summary of the predicted noise level exceedances at the nearest sensitive receivers is provided in Table 10-27 for each construction scenario.

Table 10-27 Predicted airborne noise level exceedances at Pitt Street Station

Receiver area \ Noise modelling scenario	Demolition and site establishment	Earthworks	Acoustic shed construction	Excavation and structural works					Building construction
	Day	Day	Day	Day	DOOH[1]	Evening	Night	Sleep	Day
A Residential to the west, west of Pitt Street and south of Bathurst Street	Green	Green	Green	Green	Green	Green	Green	Green	Green
A Commercial to the west, west of Pitt Street and south of Bathurst Street	Orange	Orange	Green	Green	Green	Green	Green	Green	Blue
B Residential to the west, west of Pitt Street and north of Bathurst Street	Blue	Blue	Green	Green	Green	Green	Green	Green	Green
B Commercial to the west, west of Pitt Street and north of Bathurst Street	Blue	Blue	Green	Green	Green	Green	Green	Green	Blue
C Residential to the west, west of Pitt Street and north of Park Street	Green	Green	Green	Green	Green	Green	Green	Green	Green
C Commercial to the west, west of Pitt Street and north of Park Street	Orange	Orange	Blue	Green	Green	Green	Green	Green	Blue
D Commercial to the north, between Pitt Street and Castlereagh Street	Red	Orange	Blue	Green	Green	Green	Green	Green	Orange
E Residential to the east	Green	Green	Green	Green	Green	Green	Green	Green	Green
E Commercial to the east	Orange	Orange	Green	Green	Green	Green	Green	Green	Blue
F Residential between Park Street and Bathurst Street	Blue	Blue	Green	Green	Green	Green	Green	Green	Blue
F Commercial between Park Street and Bathurst Street	Blue	Blue	Green	Green	Green	Green	Green	Green	Blue
F Educational between Park Street and Bathurst Street	Red	Red	Orange	Blue	Green	Green	Green	Green	Red
G Residential to the south between Pitt Street and Castlereagh Street	Red	Orange	Blue	Green	Green	Green	Blue	Green	Red
G Commercial to the south between Pitt Street and Castlereagh Street	Red	Red	Orange	Green	Green	Green	Green	Green	Red

Legend

- Green: NML compliance
- Blue: NML exceedance of less than 10 dB
- Orange: NML exceedance between 10 dB and 20 dB
- Red: NML exceedance of more than 20 dB

1 *DOOH = Daytime out of hours (i.e Saturdays 1pm to 6pm and Sundays 7am to 6pm)*

The preliminary findings of the construction noise impact assessment at Pitt Street Station indicate:

- For site establishment works during the daytime high exceedances of more than 20 dB of the NMLs are predicted at the residential receivers in Area G and at educational receivers in Area F. At residential receivers in Areas B and F, minor exceedances are predicted.

  At the nearest commercial receivers in Areas D and G high exceedances of more than 20 dB of the NMLs are predicted, and at commercial receivers in Areas A, C and E moderate exceedances of more than 10 dB are predicted. Minor exceedances are predicted at commercial receivers in Areas B and F
- For earthworks during the daytime high exceedances of more than 20 dB of the NMLs are predicted at the educational receivers in Area F. Minor exceedances of more than 10 dB are predicted at residential receivers in Area G. At residential receivers in Areas B and F minor exceedances are predicted.

  At the nearest commercial receivers in Area G high exceedances of more than 20 dB of the NMLs are predicted, and at commercial receivers in Areas A, C, D and E moderate exceedances of more than 10 dB are predicted. Minor exceedances are predicted at commercial receivers in Areas B, and F
- For acoustic shed construction during the daytime a moderate exceedance is predicted at educational receivers in Area F and commercial receivers in Area G. Minor exceedances at residential receivers in Area G and commercial receivers in Areas C and D are predicted
- For excavation during the daytime a minor exceedance of less than 10 dB is predicted at educational receivers in Area F. During the night-time, a minor exceedance of less than 10 dB is predicted at residential receivers in Area G
- For station building construction during the daytime major exceedances are predicted at residential receivers in Area G, the educational receivers in Area F and the commercial receivers in Area G. Moderate exceedances are predicted at commercial receivers at Area D. Minor exceedances are predicted at the residential receivers in Area F, and at commercial receivers in Areas A, B, C, E and F
- At Town Hall external noise levels are predicted to be up to 68 dBA. These levels would be similar to existing noise from heavy vehicles on George Street and other city noise. The buildings external to internal noise reduction would adequately attenuate noise from the works to the performance space.

On site night-time L_{Amax} truck noise

The L_{Amax} noise levels associated with individual truck movements on site comply with the sleep disturbance screening level.

Ground-borne noise

The ground-borne noise assessment indicated:

- During the daytime one building adjacent to the northern site (to the north on Pitt Street) and the four buildings immediately adjacent to the southern site are predicted to have ground-borne noise levels potentially higher than 75 dBA on several floors in each building
- During night-time three residential buildings near the northern site (one to the north on Pitt Street, and two to the south on Park Street) and four residential buildings near the southern site (one to the south on Pitt Street, one to the south on Castlereagh Street and two to the west on Pitt Street) have ground-borne noise levels potentially higher than 45 dBA on several floors in each building.

Feasible and reasonable measures would be implemented to minimise ground-borne noise where exceedances are predicted. Where exceedances of ground-borne noise levels are predicted, mitigation measures would be implemented in accordance with the *Sydney Metro Construction Noise and Vibration Strategy* (Appendix E).

The potential ground-borne noise impacts associated with excavation of the tunnels is discussed in Section 10.4.13.

Blasting

Due to the level and duration of ground-borne noise exceedances associated with rock breaking, consideration has been given to blasting as an alternative excavation method. Table 10-28 shows the anticipated reduction in the number of periods when the NML would be exceeded. The table shows three scenarios: no blasting, blasting plus a large rock breaker, blasting plus a medium rock breaker.

Table 10-28 Pitt Street Station blasting scenarios

Scenario	Number of periods above NMLs			
	Residential			Commercial
	Day	Evening	Night	Day
Northern site				
No blasting	48	123	181	41
Blasting plus large rock breaker	25	52	69	22
Blasting plus medium rock breaker	4	24	54	12
Southern site				
No blasting	76	129	212	116
Blasting plus large rock breaker	33	53	83	60
Blasting plus medium rock breaker	23	35	56	36

The potential change in duration of impacts is:

- **Residential day:** the use of large rock breakers with no blasting generates 124 daytime periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 58 daytime periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to 27 daytime periods
- **Residential evening:** the use of large rock breakers with no blasting generates 252 evening periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 105 evening periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to 59 evening periods
- **Residential night:** the use of large rock breakers with no blasting generates greater than 365 night-time periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 152 night-time periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to 60 night-time periods
- **Commercial day:** the use of large rock breakers with no blasting generates 157 daytime periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 82 daytime periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to 48 daytime periods.

Further detailed construction planning, through the development of Construction Noise Impact Statements (as required by the *Sydney Metro Construction Noise and Vibration Strategy* in Appendix E) would determine the exact construction activities with the aim of reducing ground-borne noise impacts to receivers. For example, this could involve the consideration of different sized rock breakers at different periods, and the positioning of rock breakers within the site during different periods.

With careful planning and positioning of the rock breakers it may be possible to avoid consecutive periods of NML exceedances to any one receiver, effectively providing respite periods. For any residual exceedances of the NMLs, additional mitigation measures would be implemented in accordance with the *Sydney Metro Construction Noise and Vibration Strategy* (Appendix E).

Ground-borne vibration

During excavation of the station shafts vibration levels are anticipated to exceed the cosmetic damage vibration screening criteria at five buildings near the southern site (the buildings immediately adjacent on Bathurst, Pitt and Castlereagh streets) and one building adjacent to the northern site (to the north on Pitt Street). A more detailed assessment of the structure and attended vibration monitoring would be carried out to ensure vibration levels remain below appropriate limits for these structures.

Construction traffic noise

The predicted L_{Aeq} increase and sleep disturbance noise levels have been assessed for the access routes to the Pitt Street Station construction site and are presented in Table 10-29.

The predicted noise level increase associated with construction traffic exceeds the base criteria, however the increase complies with the 2 dB allowance. Whilst there is compliance with the sleep disturbance screening criterion, there is an exceedance of the external sleep disturbance NML of 65 dBA (by up to 11 dB). The L_{Amax} levels would be similar to other heavy vehicles using Pitt Street, Castlereagh Street and Bathurst Street. Therefore sensitive receivers are not likely to notice an increase in the average road traffic noise levels during construction.

Table 10-29 Pitt Street Station – road traffic noise

Road	Base criteria (dB) day / night ($L_{Aeq(15hr/9hr)}$)	Predicted Road Traffic Noise (dB) day / night	Predicted Road Traffic Noise Increase (dB) day / night	RBL + 15 dB Screening Criterion (dBA)	External L_{Amax} NML Level (dBA)	Predicted L_{Amax} Noise Level (dBA)
Pitt Street south	60 / 55	67 / 62	0.5 / 0.7	76	65	76
Pitt Street north	60 / 55	65 / 61	0.5 / 0.4	76	65	76
Castlereagh Street	60 / 55	67 / 61	0.2 / 0.4	76	65	76
Bathurst Street	60 / 55	70 / 67	0.2 / 0.2	76	65	76

10.4.10 Central Station

The nearest sensitive receivers to the proposed construction site are shown in Figure 10-10.

The construction scenarios at the Central Station construction site, and the anticipated timeframes, include:

- Demolition and site establishment (about one a half years) – the demolition of buildings on the site, construction of the Sydney Yard Access Bridge and the temporary pedestrian bridge, establishment of site compound facilities and construction of the combined services ring
- Earthworks (about two months) – initial surface excavation
- Excavation and structural works (about three and a half years) – excavation of the station and structural works
- Building construction (about 12 months) – aboveground station and services building construction and fit-out.

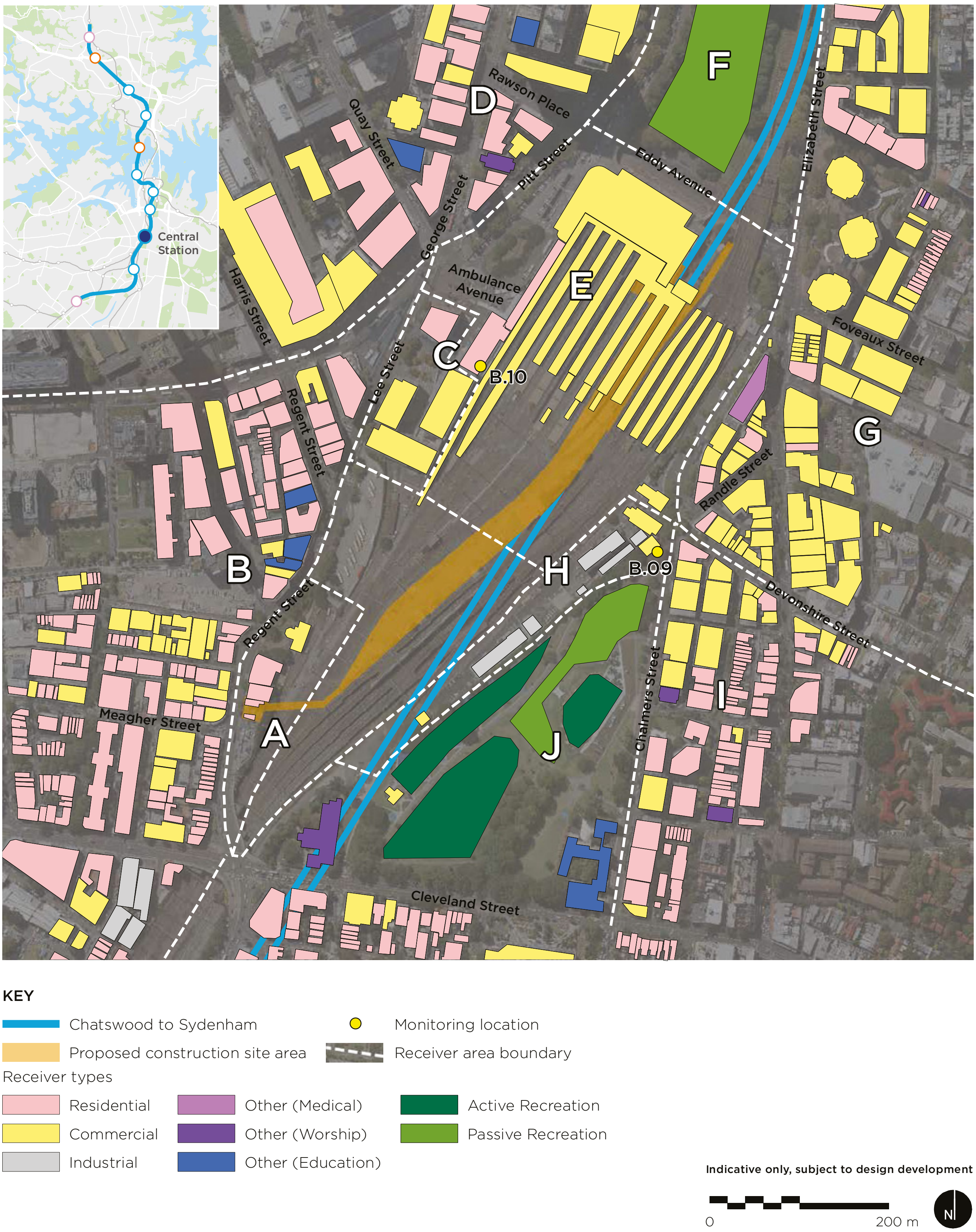


Figure 10-10 Location of sensitive receivers near Central Station

Airborne construction noise

A summary of the predicted noise level exceedances at the nearest sensitive receivers is provided in Table 10-30 for each construction scenario.

Table 10-30 Predicted airborne noise level exceedances at Central Station

Receiver area \ Noise modelling scenario	Demolition and site establishment	Earthworks	Acoustic shed construction	Excavation and structural works					Building construction
	Day	Day	Day	Day	DOOH[1]	Evening	Night	Sleep	Day
A Residential receivers to the west, east of Regent Street.	>20 dB	>20 dB	compliance	compliance	compliance	compliance	<10 dB	compliance	compliance
B Residential receivers to the east, west of Regent Street	10–20 dB	<10 dB	compliance	compliance	compliance	compliance	compliance	compliance	compliance
B Commercial receivers to the west, east of Lee Street	10–20 dB	<10 dB	compliance	compliance	compliance	compliance	compliance	compliance	compliance
C Residential receivers to the east, east of Regent Street	10–20 dB	compliance	compliance	compliance	compliance	compliance	<10 dB	compliance	compliance
C Commercial receivers to the east, east of Regent Street	>20 dB	compliance	compliance	compliance	compliance	compliance	compliance	compliance	compliance
D Residential receivers to the west, west of Lee Street	10–20 dB	compliance	compliance	compliance	compliance	compliance	compliance	compliance	compliance
D Commercial receivers to the west, west of Lee Street	<10 dB	compliance	compliance	compliance	compliance	compliance	compliance	compliance	compliance
E Commercial receivers surrounding at Central Station	>20 dB	>20 dB	10–20 dB	10–20 dB	compliance	compliance	compliance	compliance	>20 dB
F Passive recreation at Belmore Park to the north	<10 dB	compliance	compliance	compliance	compliance	compliance	compliance	compliance	compliance
G Residential receivers to the east, east of Chalmers Street	<10 dB	10–20 dB	compliance	<10 dB	<10 dB	10–20 dB	10–20 dB	compliance	compliance
G Commercial receivers to the east, east of Chalmers Street	<10 dB	<10 dB	compliance	compliance	compliance	compliance	compliance	compliance	compliance
H Commercial receivers to the east, west of Prince Alfred Park	<10 dB	<10 dB	compliance	compliance	compliance	compliance	compliance	compliance	compliance
I Residential receivers to the east, south of Devonshire Street	<10 dB	compliance	compliance	compliance	<10 dB	10–20 dB	<10 dB	compliance	compliance
I Commercial receivers to the east, south of Devonshire Street	compliance	compliance	compliance	compliance	compliance	compliance	compliance	compliance	compliance
J Passive and active recreation at Prince Alfred Park	<10 dB	compliance	compliance	compliance	compliance	compliance	compliance	compliance	compliance

Legend

- NML compliance
- NML exceedance of less than 10 dB
- NML exceedance between 10 dB and 20 dB
- NML exceedance of more than 20 dB

1 *DOOH = Daytime out of hours (i.e Saturdays 1pm to 6pm and Sundays 7am to 6pm)*

The preliminary findings of the construction noise impact assessment at Central Station indicate:

- For site establishment during the daytime high exceedances of more than 20 dB of the NMLs are predicted at the residential receivers in Area A and at the recreation receivers in Area J (Prince Alfred Park). Moderate exceedances of more than 10 dB are predicted at residential receivers in Areas B, C, D and I. At residential receivers in Area G, and at recreation receivers in Area F (Belmore Park) minor exceedances are predicted.

  At the nearest commercial receivers in Areas C, E and H high exceedances of more than 20 dB of the NMLs are predicted, and at commercial receivers in Areas B, D and I moderate exceedances of more than 10 dB are predicted. Minor exceedances are predicted at commercial receivers in Areas D and G

- For earthworks during the daytime high exceedances of more than 20 dB of the NMLs are predicated at the residential receivers in Area A. Moderate exceedances of more than 10 dB are predicted at residential receivers in Area G. At residential receivers in Area B minor exceedances are predicted.

  At the nearest commercial receivers in Area E high exceedances of more than 20 dB of the NMLs are predicted. Minor exceedances are predicted at commercial receivers in Areas B, G and H.

  Compliance is predicted at residential receivers in Areas C, D, I, at recreation receivers at Area F (Belmore Park) and Area J (Prince Alfred Park), and at commercial receivers in Areas C, D, and I

- For excavation during daytime a moderate exceedance of more than 10 dB is predicted at commercial receivers in Area E. Compliance is predicted at all other locations. For excavation during the 'day out of hours' period and evenings a minor exceedance of up to 10 dB is predicted for residences in Areas G and I.

  For night-time excavation works moderate exceedances of more than 10 dB are predicted at residences in Areas G and I and minor exceedances of up to 10 dB at residences in Areas A and C

- For station building construction during the daytime a major exceedance is predicted at commercial receivers in Area E. Compliance is predicted at all other locations.

On site night-time L_{Amax} truck noise

The L_{Amax} noise levels associated with individual truck movements on site exceed the sleep disturbance screening level (by up to 10 dB) during excavation. Opportunities to minimise noise from heavy vehicles, such as consideration of site layouts and screening, would be considered during detailed construction site planning.

Ground-borne noise

The ground-borne noise assessment indicated:

- During the daytime ground-borne noise levels inside the adjacent station buildings and on platforms has the potential to exceed 75 dBA during rock breaking activities. These areas would be subject to existing high ambient noise levels from the operation of the station and, as such, no mitigation measures are deemed necessary
- During the daytime three commercial buildings, located to the east around the northern corner of Prince Alfred Park, are predicted to have ground-borne noise levels potentially higher than 75 dBA on several floors in each building
- During night-time one residential building, located on the corner of Devonshire and Chalmers streets, is predicted to have ground-borne noise levels potentially higher than 45 dBA on several floors.

Feasible and reasonable measures would be implemented to minimise ground-borne noise where exceedances are predicted. Where exceedances of ground-borne noise levels are predicted, mitigation measures would be implemented in accordance with the *Sydney Metro Construction Noise and Vibration Strategy* (Appendix E).

The potential ground-borne noise impacts associated with excavation of the tunnels is discussed in Section 10.4.13.

Ground-borne vibration

During excavation of the station vibration levels are anticipated to exceed the cosmetic damage vibration screening criteria at two station platforms and three commercial buildings (located to the east around the northern corner of Prince Alfred Park). A more detailed assessment of the structure and attended vibration monitoring would be carried out to ensure vibration levels remain below appropriate limits for these structures.

Construction traffic noise

The predicted L_{Aeq} increase and sleep disturbance noise levels have been assessed for the access routes to the Central Station construction site and are presented in Table 10-31.

The predicted noise level increase associated with construction traffic exceeds the base criteria, however the increase complies with the 2 dB allowance. Whilst there is an exceedance of the sleep disturbance screening criterion (of up to 18 dB) and external sleep disturbance NML of 65 dBA (by up to 13 dB), the L_{Amax} levels would be similar to other heavy vehicles using Regent Street and Chalmers Street. Therefore sensitive receivers are not likely to notice an increase in the average road traffic noise levels during construction.

Table 10-31 Central Station – road traffic noise

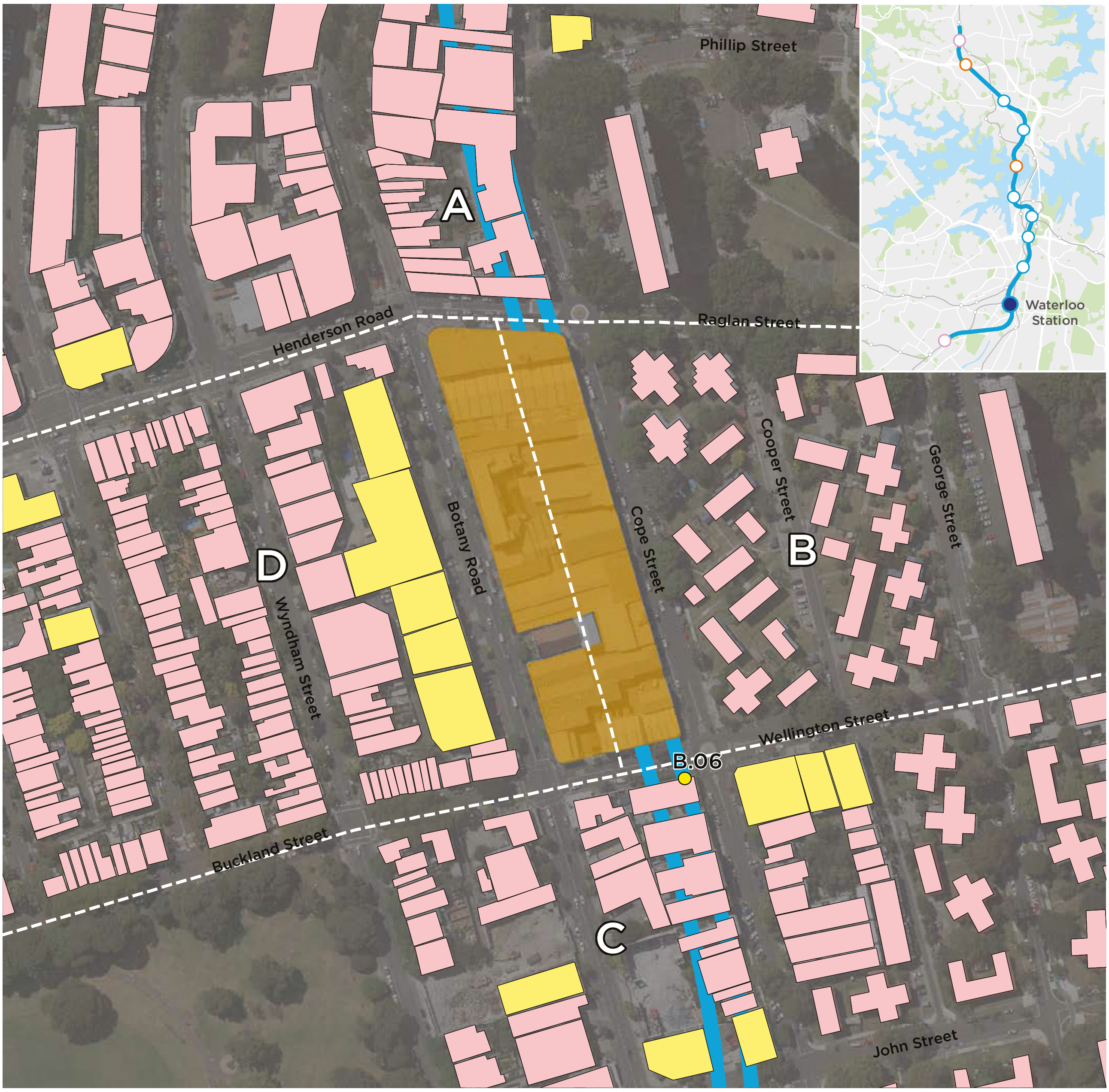
Road	Base criteria (dB) day / night ($L_{Aeq(15hr/9hr)}$)	Predicted Road Traffic Noise (dB) day / night	Predicted Road Traffic Noise Increase (dB) day / night	RBL + 15 dB Screening Criterion (dBA)	External L_{Amax} NML Level (dBA)	Predicted L_{Amax} Noise Level (dBA)
Regent Street	60 / 55	74 / 70	0.1 / 0.2	67	65	78
Chalmers Street	60 / 55	72 / 67	0.2 / 0.3	60	65	78

10.4.11 Waterloo Station

The nearest sensitive receivers to the proposed construction site are shown in Figure 10-11.

The construction scenarios at the Waterloo Station construction site, and the anticipated timeframes, include:

- Demolition and site establishment (about 12 months) – the demolition of buildings on the site and establishment of site compound facilities
- Earthworks (about two months) – initial surface excavation
- Acoustic shed construction (about one month) – piling and erection of the acoustic shed
- Excavation and structural works (about three years) – excavation of the station and structural works
- Building construction (about one and a half years) – aboveground station and services building construction and fit-out.



KEY

Chatswood to Sydenham

Proposed construction site area

Monitoring location

Receiver area boundary

Receiver types

Residential

Commercial

Indicative only, subject to design development

0 100 m N

Figure 10-11 Location of sensitive receivers near Waterloo Station

Airborne construction noise

A summary of the predicted noise level exceedances at the nearest sensitive receivers is provided in Table 10-32 for each construction scenario.

Table 10-32 Predicted airborne noise level exceedances at Waterloo Station

Noise modelling scenario	Demolition and site establishment	Earthworks	Acoustic shed construction	Excavation and structural works					Building construction
Receiver area	Day	Day	Day	Day	DOOH[1]	Evening	Night	Sleep	Day
A Residential to the north of Raglan Street	Red	Orange	Blue	Green	Blue	Blue	Orange	Blue	Blue
B Residential to the east of Cope Street	Orange	Orange	Blue	Green	Blue	Blue	Orange	Blue	Orange
C Residential to the south of Buckland Street	Orange	Orange	Blue	Green	Green	Blue	Orange	Blue	Orange
C Commercial to the south of Buckland Street	Blue	Blue	Green	Green	Green	Green	Green	Green	Blue
D Residential to the west	Red	Orange	Blue	Green	Blue	Blue	Orange	Blue	Blue
D Church adjacent to the west on Botany Road	Red	Red	Orange	Blue	Blue	Green	Green	Green	Red
D Commercial to the west of Botany Road	Orange	Blue	Green	Green	Green	Green	Green	Green	Blue

Legend

- Green: NML compliance
- Blue: NML exceedance of less than 10 dB
- Orange: NML exceedance between 10 dB and 20 dB
- Red: NML exceedance of more than 20 dB

1 *DOOH = Daytime out of hours (i.e Saturdays 1pm to 6pm and Sundays 7am to 6pm)*

The preliminary findings of the construction noise impact assessment at Waterloo Street Station indicate:

- For site establishment works during the daytime high exceedances of more than 20 dB of the NMLs are predicted at the residential receivers in Areas A and D, and at the church in Area D. Moderate exceedances of more than 10 dB are predicted at residential receivers in Areas B and C.

  At the nearest commercial receivers in Area D, moderate exceedances of more than 10 dB of the NMLs are predicted. Minor exceedances of less than 10 dB are predicted at commercial receivers in Area C
- For earthworks during the daytime high exceedances of more than 20 dB of the NMLs are predicted at the church in Area D. Moderate exceedances of more than 10 dB are predicted at residential receivers in Areas A, B, C and D.

  At the nearest commercial receivers in Areas C and D, minor exceedances of less than 10 dB of the NMLs are predicted
- For acoustic shed construction during the daytime a moderate exceedance is predicted at the church in Area D. Minor exceedances are predicted at residential receivers in Areas A, B, C and D
- For excavation during the daytime a minor exceedance of less than 10 dB is predicted at the church in Area D. During the night-time moderate exceedances are predicted at residences in Areas A, B, C and D. An acoustic shed with higher noise insulation would be required to reduce night-time non compliance
- For station building construction during the daytime high exceedances are predicted at the church in Area D. Moderate exceedances are predicted at residential receivers at Areas B and C. Minor exceedances are predicted at residences in Areas A and D, and commercial receivers in Areas C and D.

On site night-time L_{Amax} truck noise

The L_{Amax} noise levels associated with individual truck movements on site exceed the sleep disturbance screening level during excavation by more than 10 dB at residential receivers in Area D and up to 10 dB at residential receivers in Areas A, B and C. Opportunities to minimise noise from heavy vehicles, such as consideration of site layouts and screening, would be considered during detailed construction site planning.

Ground-borne noise

The ground-borne noise assessment indicated:

- During the daytime, moderate exceedances of the NMLs (of 10 to 20 dB) are predicted at the church on Botany Road and residential receivers on Raglan, Cope and Wellington streets
- During night-time 10 residential buildings on Raglan, Cope and Wellington streets are predicted to have ground-borne noise levels potentially higher than 45 dBA on several floors in each building.

Feasible and reasonable measures would be implemented to minimise ground-borne noise where exceedances are predicted. Where exceedances of ground-borne noise levels are predicted, mitigation measures would be implemented in accordance with the *Sydney Metro Construction Noise and Vibration Strategy* (Appendix E).

The potential ground-borne noise impacts associated with excavation of the tunnels is discussed in Section 10.4.13.

Blasting

Due to the level and duration of ground-borne noise exceedances associated with rock breaking, consideration has been given to blasting as an alternative excavation method. Table 10-33 shows the anticipated reduction in the number of periods when the NML would be exceeded. The table shows three scenarios: no blasting, blasting plus a large rock breaker, blasting plus a medium rock breaker.

Table 10-33 Waterloo Station blasting scenarios

Scenario	Number of periods above NMLs			
	Residential			Commercial
	Day	Evening	Night	Day
No blasting	251	>365	>365	14
Blasting plus large rock breaker	139	275	>365	8
Blasting plus medium rock breaker	13	131	294	3

The potential change in duration of impacts is:

- **Residential day:** the use of large rock breakers with no blasting generates 251 daytime periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 139 daytime periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to 13 daytime periods
- **Residential evening:** the use of large rock breakers with no blasting generates greater than 365 evening periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 275 evening periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to 131 evening periods
- **Residential night:** the use of large rock breakers with no blasting generates greater than 365 night-time periods with exceedances of the NMLs. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts 294 night-time periods
- **Commercial day:** the use of large rock breakers with no blasting generates 14 daytime periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to eight daytime periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to three daytime periods.

Further detailed construction planning, through the development of Construction Noise Impact Statements (as required by the *Sydney Metro Construction Noise and Vibration Strategy* in Appendix E) would determine the exact construction activities with the aim of reducing ground-borne noise impacts to receivers. For example, this could involve the consideration of different sized rock breakers at different periods, and the positioning of rock breakers within the site during different periods.

With careful planning and positioning of the rock breakers it may be possible to avoid consecutive periods of NML exceedances to any one receiver, effectively providing respite periods. For any residual exceedances of the NMLs, additional mitigation measures would be implemented in accordance with the *Sydney Metro Construction Noise and Vibration Strategy* (Appendix E).

Ground-borne vibration

During excavation of the station vibration levels are anticipated to remain below the cosmetic damage vibration screening criteria.

Construction traffic noise

The predicted L_{Aeq} increase and sleep disturbance noise levels have been assessed for the access routes to the Waterloo Station construction site and are presented in Table 10-34.

The predicted noise level increase associated with construction traffic exceeds the base criteria, however the increase complies with the 2 dB allowance. Whilst there is an exceedance of the sleep disturbance screening criterion (by up to 24 dB) and external sleep disturbance NML of 65 dBA (by up to 13 dB), the L_{Amax} levels would be similar to other heavy vehicles using Botany Road and Henderson Road. Therefore sensitive receivers are not likely to notice an increase in the average road traffic noise levels during construction.

Table 10-34 Waterloo Station – road traffic noise

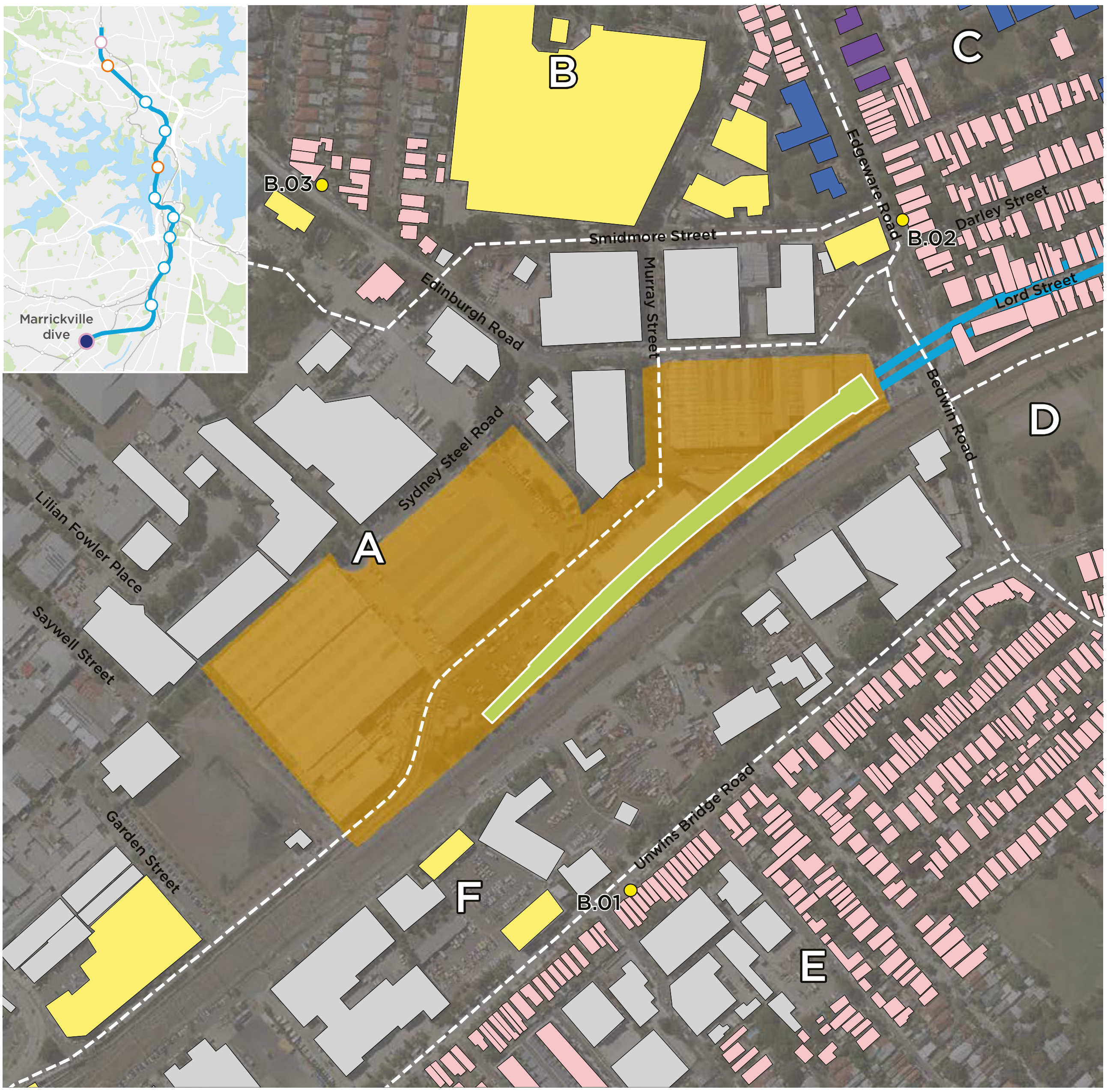
Road	Base criteria (dB) day / night ($L_{Aeq(15hr/9hr)}$)	Predicted Road Traffic Noise (dB) day / night	Predicted Road Traffic Noise Increase (dB) day / night	RBL + 15 dB Screening Criterion (dBA)	External L_{Amax} NML Level (dBA)	Predicted L_{Amax} Noise Level (dBA)
Botany Road	60 / 55	73 / 68	0.1 / 0.2	54	65	78
Henderson Road	60 / 55	72 / 66	0.1 / 0.3	54	65	76

10.4.12 Marrickville dive site (southern)

The nearest sensitive receivers to the proposed construction site are shown in Figure 10-12.

The construction scenarios at the Marrickville dive site, and the anticipated timeframes, include:

- Demolition and site establishment (about 12 months) – the demolition of buildings on the site and establishment of site compound facilities
- Track works (about 12 months) – laying of metro track in the dive structure
- Earthworks (about six months) – initial surface excavation and excavation of the dive structure
- Acoustic shed construction (about one month) – piling and erection of the acoustic shed
- Tunnelling and pre-cast factory (about one a half years) – excavation of the main tunnels and associated support services and operation of the concrete pre-cast factory
- Fit-out (about one and a half years) – fit of the track and the rail systems in the tunnels.



KEY

- Chatswood to Sydenham
- Proposed construction site area
- Proposed dive structure
- Monitoring location
- Receiver area boundary

Receiver types

- Residential
- Commercial
- Industrial
- Other (Worship)
- Other (Education)

Indicative only, subject to design development

0 100 m

N

Figure 10-12 Location of sensitive receivers near Marrickville dive site (southern)

Airborne construction noise

A summary of the predicted noise level exceedances at the nearest sensitive receivers is provided in Table 10-35 for each construction scenario.

Table 10-35 Predicted noise level exceedances at Marrickville dive site (southern)

Noise modelling scenario	Demolition and site establishment	Track works	Earthworks	Acoustic shed construction	Tunnelling and pre-cast facility					Fit-out				
Receiver area	Day	Day	Day	Day	Day	DOOH[1]	Evening	Night	Sleep	Day	DOOH[1]	Evening	Night	Sleep
A Industrial to the north east	10–20 dB	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance
B Commercial to the north	<10 dB	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance
B Educational to the north	10–20 dB	10–20 dB	10–20 dB	Compliance	<10 dB	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance
B Residential to the north on Edinburgh Road	<10 dB	Compliance	Compliance	Compliance	Compliance	Compliance	<10 dB	<10 dB	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance
C Residential to the north, east of Edgeware Road	<10 dB	<10 dB	<10 dB	Compliance	Compliance	Compliance	Compliance	<10 dB	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance
D Active recreation to the east at Camdenville Park	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance
D Residential to the east, on May Street	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	<10 dB	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance
E Residential to the south east on Unwins Bridge Road	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	<10 dB	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance
F Industrial to the south east	<10 dB	<10 dB	<10 dB	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance
G Residential to the south east on Burrows Avenue	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	<10 dB	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance

Legend

- NML compliance
- NML exceedance of less than 10 dB
- NML exceedance between 10 dB and 20 dB
- NML exceedance of more than 20 dB

1 DOOH = Daytime out of hours (i.e Saturdays 1pm to 6pm and Sundays 7am to 6pm)

The preliminary findings of the construction noise impact assessment at the Marrickville dive site indicate:

- For site establishment works during the daytime moderate exceedances of between 10 dB to 20 dB of the NMLs are predicted at the educational receiver in Area B and industrial receivers in Area A. Minor exceedances are predicted at residential receivers in Areas B and C, and commercial and industrial receivers in Areas B and F. These are a direct result of the relative close proximity of receivers to the construction activities and the absence of any appreciable shielding between sites and receivers
- For track works and earthworks during the daytime a moderate exceedance of between 10 dB to 20 dB of the NML is predicted at the educational receiver in Area B. At residential receivers in Area C a minor exceedance at receivers is predicted.
- At commercial and industrial receivers a minor exceedance of up to 10 dB is predicted at the industrial Area F to the south east. Compliance is predicted at other locations
- For acoustic shed construction during the daytime compliance is predicted at all receivers
- For tunnelling and precast factory use during the daytime a minor exceedance is predicted at the educational receiver in Area B. During the night-time a minor exceedance is predicted at the residential receivers in Areas B, C, D, E and G
- For fitout during the daytime compliance is predicted at all receivers.

On site night-time L_{Amax} truck noise

The L_{Amax} noise levels associated with individual truck movements on site comply with the sleep disturbance screening level.

Ground-borne noise

Rock breaking and dive excavation works are proposed to be carried out during the daytime period at this site. The ground-borne noise assessment indicated all receivers would comply with the ground-borne noise NMLs.

The potential ground-borne noise impacts associated with excavation of the tunnels is discussed in Section 10.4.13.

Ground-borne vibration

Construction vibration levels are anticipated to remain well below the vibration screening levels associated with minor cosmetic building damage at all receivers.

Construction traffic noise

The predicted L_{Aeq} increase and sleep disturbance noise levels have been assessed for the access routes to the Marrickville dive site and are presented in Table 10-36.

The predicted noise level increase associated with construction traffic exceeds the base criteria. The increase complies with the 2 dB allowance for the daytime period and on Bedwin Road for the night-time period. On May Street the increase marginally exceeds the 2 dB allowance (by 0.4 dB).

Whilst there is an exceedance of the sleep disturbance screening criterion (by up to 23 dB) and external sleep disturbance NML of 65 dBA (by up to 14 dB), the L_{Amax} levels would be similar to other heavy vehicles using Bedwin Road and May Street. Therefore sensitive receivers are not likely to notice an increase in the average road traffic noise levels during construction.

Table 10-36 Marrickville dive site – road traffic noise

Road	Base criteria (dB) day / night ($L_{Aeq(15hr/9hr)}$)	Predicted Road Traffic Noise (dB) day / night	Predicted Road Traffic Noise Increase (dB) day / night	RBL + 15 dB Screening Criterion (dBA)	External L_{Amax} NML Level (dBA)	Predicted L_{Amax} Noise Level (dBA)
Bedwin Road	60 / 55	68 / 62	0.5 / 1.8	53	65	69
May Street	60 / 55	72 / 68	0.9 / 2.4	56	65	79

10.4.13 Tunnel excavation

Ground-borne noise

The potential impacts of ground-borne noise from the excavation of the main tunnels using tunnel boring machines is discussed in Table 10-37. Ground-borne noise from tunnel excavation during the daytime is expected to be well below background noise levels. As such, the assessment considers the evening and night-time periods.

The ground-borne noise assessment is based on the worst-case predicted internal ground-borne noise level when the tunnelling works are directly below each receiver and the tunnelling works are at their closest point. Given the progression rate of the tunnel boring machines, it is anticipated that this worst-case ground-borne noise impact would only be apparent for a relatively short period of time (ie a few days for each tunnel burning machine) whilst the tunnelling works are directly beneath a particular receiver.

Table 10-37 Ground-borne noise main tunnel excavation

Location	Potential impacts
Chatswood portal to Crows Nest Station	Predicted exceedances of the night-time NML of: • Up to 10dB at residential receivers between the Chatswood portal and Artarmon substation • Up to 6 dB at the few residential receivers between Artarmon substation and Crows Nest Station.
Crows Nest Station to Blues Point temporary site	Predicted exceedances of the night-time NML of: • Up to 5 dB at residential receivers between Crows Nest and Victoria Cross stations • Up to 3 dB from North Sydney Station to around Princess Street • Up to 8 dB in the area around Blues Point.
Barangaroo Station to Central Station	Predicted exceedances of the night-time NML of: • Up to 5 dB in the area around Barangaroo Station • Up to 5 dB in the area around Martin Place Station • Up to 10 dB in the area around Pitt Street Station.
Central Station to Marrickville portal	Predicted exceedances of the night-time NML of: • Up to 10 dB in the area around Waterloo Station • Up to 3 dB in the area between Maddox Street and the Princes Highway • Greater than 10 dB just north of the Marrickville portal.

Ground-borne noise impacts may also arise from the excavation of other features and the use of other equipment within the tunnels. This includes:

- **Cross passages** – expected to be excavated mainly by roadheaders with the anticipated duration being 80 days at each cross passage. The night-time NML would be complied with when the tunnel depth is greater than 30 metres (which generally occurs near the tunnel portals and around Crows Nest Station, Barangaroo Station, Martin Place Station, Pitt Street Station, Central Station and Waterloo Station). Works between 10 pm and 7 am would be precluded where residential receivers are located with a slant distance (the straight line distance between the tunnel and receiver) of less than 30 metres from the tunnels
- **Stub tunnels** – expected to be excavated using roadheaders to the north of Victoria Cross Station and to the north of the Marrickville portal. In these two locations, the depths to the tunnels are around 50 metres and 40 metres respectively. At this depth, there is not expected to any exceedances of the night-time NMLs from roadheader use
- **Use of rock breakers** – rock breakers may be required to excavate cross passages and stub tunnels where hard rock is encountered. Rock hammering works may result in exceedances of the night-time NMLs to a slant distance of less than 70 metres from the excavation site (which would be the case for the majority of the tunnel alignment). Rock hammering would be precluded between 10 pm and 7 am except where there would be no exceedance of the NMLs
- **Use of work trains** – work trains may be used during construction to deliver materials and construction workers within the tunnels. In the event that these are used, they would be designed with the aim of achieving the noise trigger levels in the *Rail Infrastructure Noise Guidelines* (RING) (Environment Protection Authority, 2013). Alternatives may also be considered including the use of rubber tyred vehicles in lieu of work trains.

Ground-borne vibration

During main tunnelling works, it is anticipated that ground-borne vibration would be lower than the 7.5 mm/s screening level (the threshold at which cosmetic damage may occur) at all locations.

Vibration levels may, however be noticeable within surface buildings located close to the main tunnel alignment. The impact at these locations would only be apparent for a relatively short period of time (one or two days) as the tunnel boring machines pass by a particular location. Human comfort vibration impacts would be managed in accordance with the *Sydney Metro Construction Noise and Vibration Strategy* (refer to Appendix E).

10.4.14 Power supply routes

The *Interim Construction Noise Guidelines* (Department of Environment and Climate Change, 2009), suggest a qualitative noise assessment method for works which are unlikely to affect an individual or sensitive land use for more than three weeks in total. As the construction work associated with the power supply routes are not expected to affect any individual receivers for more than three weeks, and these receivers would be minimally impacted by the long term construction works for the project, a qualitative noise assessment has been carried out for these works.

Work along the power supply routes would take place generally within the road corridor and therefore would be close to receivers. In some cases the closest residential receiver would be within 10 metres of the proposed works. The following sections provide a qualitative discussion in relation to the types of activities and potential noise impacts.

Trenching

Receivers along the power supply route are expected to experience elevated noise levels during periods when the trenching work is in their vicinity. The initial phase of trenching is likely to involve the use of a concrete saw to remove road pavement. This would be followed by excavation using a small excavator or bobcat.

During these works, especially during the use of concrete saws, the closest receivers could experience noise levels in excess of 75 dB(A). Additionally, as the works are located within road reserves, a substantial portion of the works may be required to be carried out outside of standard daytime construction hours. The excavation work is anticipated to progress at about 30 metres per day and it is likely that a receiver would be affected for up to two consecutive days at most.

Due to these potential high noise levels, feasible and reasonable mitigation measures would be implemented to minimise impacts to receivers. This would include:

- Carrying out works during the daytime period when in the vicinity of residential receivers, where feasible and reasonable
- Where out of hours works are required, scheduling the noisiest activities to occur in the evening period (up to 10 pm)
- Use of portable noise barriers around particularly noisy equipment such as concrete saws
- Provision of additional mitigation measures in accordance with the Construction Noise and Vibration Strategy (Appendix E).

Under-boring

Where works cross major roads or other infrastructure under-boring may be used instead of trenching. Drilling equipment would typically result in elevated noise levels which, at some receivers, could exceed 75 dB(A). It is anticipated that under boring would generally be restricted to daytime works and would be carried out for up to two weeks in any single location.

Cable installation

Cable installation work is expected to be carried out during standard daytime construction hours and is not expected to cause significant noise impacts. The estimated work rate is around 500 metres per day and therefore any single receivers would only be affected for about one day.

Road and footpath re-instatement

Road and footpath re-instatement works have the potential to cause elevated noise levels in the vicinity of sensitive receivers. Additionally, these works are likely to occur outside of standard daytime construction hours to minimise traffic and pedestrian impacts. Re-instatement works are expected to progress at about 30 metres per day and therefore any single receiver would likely be affected for up to about two days.

10.5 Mitigation measures

10.5.1 Construction noise and vibration strategy

The *Construction Noise and Vibration Strategy* (CNVS) (Appendix E) has been developed to identify how Sydney Metro proposes to manage construction noise and vibration for the City & Southwest project. It is anticipated that construction of City & Southwest would be developed under a number of separate construction contracts. The CNVS defines the strategies by which construction noise and vibration impacts are to be minimised on Sydney Metro projects and aims to provide a consistent approach to management and mitigation across the Sydney Metro projects.

Specifically the CNVS identifies:

- The requirements and methodology to develop Construction Noise Impact Statements. These are prepared prior to specific construction activities and are based on a more detailed understanding of the construction methods, including the size and type of construction equipment. Construction Noise Impact Statement would include:
  - A more detailed understanding of surrounding receivers including particularly sensitive receivers such as education and child care, and vibration sensitive medical, imaging and scientific equipment
  - Application of appropriate noise and vibration criteria for each receiver type
  - An assessment of the potential noise and vibration impacts as a result of the construction activities.

  Two different types of Construction Noise Impact Statements may be developed:
  - General – for construction activities that are consistently the same and progressively move along the alignment, eg tunnelling
  - Location specific – for activities that are specific to a location. This also includes out of hours works and to support applications for variations to the project Environment Protection Licence
- The minimum requirements in relation to standard noise and vibration mitigation measures
- Noise and vibration auditing and monitoring requirements
- Additional mitigation measures to be implemented when exceedances to the NMLs are likely to occur. These measures are primarily aimed at pro-active engagement with potentially affected receivers, and the provision of respite periods and alternative accommodation for defined exceedance levels.

10.5.2 Site specific mitigation measures

The mitigation measures that would be implemented to address potential construction noise and vibration impacts are listed in Table 10-38.

Mitigation measures relevant to driver training and limiting the use of compression braking is provided in Chapter 8 (Construction traffic and transport).

Table 10-38 Mitigation measures – construction noise and vibration

Ref	Mitigation measure	Applicable location(s)[1]
NV1	The Construction Noise and Vibration Strategy would be implemented with the aim of achieving the noise management levels where feasible and reasonable. This would include the following example standard mitigation measures where feasible and reasonable: • Provision of noise barriers around each construction site • Provision of acoustic sheds at Chatswood dive site, Crows Nest, Victoria Cross, Barangaroo, Martin Place, Pitt Street, Waterloo and Marrickville dive site • The coincidence of noisy plant working simultaneously close together would be avoided • Offset distances between noisy plant and sensitive receivers would be increased • Residential grade mufflers would be fitted to all mobile plant • Dampened rock hammers would be used • Non-tonal reversing alarms would be fitted to all permanent mobile plant • High noise generating activities would be scheduled for less sensitive period considering the nearby receivers • The layout of construction sites would consider opportunities to shield receivers from noise.	All
NV2	Unless compliance with the relevant traffic noise criteria can be achieved, night time heavy vehicle movements at the Chatswood dive site, Crows Nest Station and Victoria Cross Station sites would be restricted to: • The Pacific Highway and Mowbray Road at the Chatswood dive site • The Pacific Highway, Hume Street and Oxley Street at the Crows Nest Station construction site • McLaren Street, Miller Street and Berry Street at the Victoria Cross station construction site.	CDS, CN, VC
NV3	Where vibration levels are predicted to exceed the screening criteria, a more detailed assessment of the structure and attended vibration monitoring would be carried out to ensure vibration levels remain below appropriate limits for that structure. For heritage items, the more detailed assessment would specifically consider the heritage values of the structure in consultation with a heritage specialist to ensure sensitive heritage fabric is adequately monitored and managed.	All except metro rail tunnels
NV4	Feasible and reasonable measures would be implemented to minimise ground-borne noise where exceedances are predicted.	All
NV5	Feasible and reasonable mitigation measures would be implemented where power supply works would result in elevated noise levels at receivers. This would include: • Carrying out works during the daytime period when in the vicinity of residential receivers • Where out of hours works are required, scheduling the noisiest activities to occur in the evening period (up to 10 pm) • Use of portable noise barriers around particularly noisy equipment such as concrete saws.	PSR

1 *STW: Surface track works; CDS: Chatswood dive site; AS: Artarmon substation; CN: Crows Nest Station; VC: Victoria Cross Station; BP: Blues Point temporary site; GI: Ground improvement works; BN: Barangaroo Station; MP: Martin Place Station; PS: Pitt Street Station; CS: Central Station; WS: Waterloo Station; MDS: Marrickville dive site; Metro rail tunnels: Metro rail tunnels not related to other sites (eg TBM works); PSR: Power supply routes.*

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OPERATIONAL NOISE AND VIBRATION

CHAPTER ELEVEN

11 Operational noise and vibration

This chapter assesses the potential impact of noise and vibration during the operation of the project. It describes the existing noise and vibration environment and identifies the potential significance of impacts to sensitive receivers. Mitigation measures to address the potential impacts are also identified. Technical paper 2 – Noise and vibration provides further details.

11.1 Secretary environmental assessment requirements

The Secretary's environmental assessment requirements relating to operational noise and vibration, and where these requirements are addressed in this Environmental Impact Statement, are outlined in Table 11-1.

Table 11-1 Secretary's environmental assessment requirements – operational noise and vibration

Ref.	Secretary's environmental assessment requirements	Where addressed
8. Noise and vibration – amenity		
8.1	The Proponent must assess construction and operational noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. The assessment must include consideration of impacts to sensitive receivers including commercial premises, and include consideration of sleep disturbance and, as relevant, the characteristics of noise and vibration (for example, low frequency noise).	Operational noise and vibration impacts are assessed in this chapter. Construction noise and vibration impacts are assessed in Chapter 10 (Construction noise and vibration).
9. Noise and vibration – structural		
9.1	The Proponent must assess construction and operational noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. The assessment must include consideration of impacts to the structural integrity and heritage significance of items (including Aboriginal places and items of environmental heritage).	Operational noise and vibration impacts are assessed in this chapter. Construction noise and vibration impacts are assessed in Chapter 10 (Construction noise and vibration).

11.2 Assessment methodology

The following operational noise and vibration sources have been assessed:

- Ground-borne noise and vibration from trains operating within the project tunnels
- Airborne noise from metro trains operating between the Chatswood tunnel portal and just south of Chatswood Station, suburban and intercity trains operating between Brand Street Artarmon and just south of Chatswood Station, and metro trains operating immediately outside the Marrickville tunnel portal
- Airborne noise from mechanical plant and tunnel ventilation systems at stations and other ancillary facilities.

11.2.1 Terminology

The acoustic terminology used in this chapter is identified and defined in Table 11-2. The subscript 'A' indicates that the noise levels are filtered to match normal human hearing characteristics.

Table 11-2 Acoustic terminology

Term	Definition
Ground-borne noise	
$L_{Amax(slow),95\%}$	The 'typical maximum noise level' for a train passby event. For operational rail noise, the $L_{Amax(slow)}$ refers to the maximum noise level not exceeded for 95 per cent of rail passby events and is measured using the 'slow' response setting on a sound level meter.
Airborne noise	
$L_{Amax,95\%}$	The 'typical maximum noise level' for a train passby event. Refers to the maximum noise level not exceeded for 95 per cent of rail passby events and is measured using the 'fast' response setting on a sound level meter.
$L_{Aeq(24hour)}$	The 'energy averaged noise level' evaluated over a 24 hour period. Represents the cumulative effects of all the train noise events occurring in one day.
$L_{Aeq(15hour)}$	Represents the cumulative effects of all the train noise events occurring in the daytime period from 7 am to 10 pm.
$L_{Aeq(9hour)}$	Represents the cumulative effects of all the train noise events occurring in the night-time period from 10 pm to 7 am.
$L_{Aeq(1hour)}$	Represents the typical L_{Aeq} noise level from all the train noise events during the busiest 1-hour of the assessment period.

11.2.2 Ground-borne noise and vibration

Ground-borne vibration objectives

Ground-borne vibration levels have been assessed in accordance with the requirements of *Assessing Vibration – a technical guideline* (Department of Environment and Conservation, 2006a).

The impacts of ground-borne vibration in buildings fall into three main categories:

- Those in which the occupants or users of the building are inconvenienced or disturbed – termed human perception or human comfort vibration
- Those where the building contents may be affected
- Those in which the integrity of the building or structure itself may be prejudiced.

The vibration design objectives adopted for the project are based on human comfort (amenity) considerations, rather than the less stringent building damage (structural) risk criteria or potential effects on building contents. The proposed vibration design objectives for all sensitive receivers are listed in Table 11-3.

Table 11-3 Human comfort vibration design objectives

Receiver type	Time of day	Vibration design objective[1]
Residential	Day	106 dBv (0.2 mm/s)
	Night	103 dBv (0.14 mm/s)
Commercial (including offices, schools and places of worship)	When in use	112 dBv (0.4 mm/s)
Industrial	When in use	118 dBv (0.8 mm/s)
Theatres	When in use	106 dBv (0.2 mm/s)
Critical working areas[2]	When in use	100 dBv (0.1 mm/s)

1 *The vibration design objectives are based on the maximum 1 second rms vibration level not exceeded for 95% of train passbys*

2 *Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring*

In the case of rail tunnels, the ground-borne noise trigger levels (see Table 11-4 and Table 11-5) almost always require lower vibration levels than would otherwise be required by the vibration objectives as identified in Table 11-3. Hence other than at specific specialist facilities that would have particularly high sensitivity to vibration, compliance with the ground-borne noise trigger levels would ensure that the vibration design objectives would also be achieved.

Ground-borne noise objectives

The ground-borne noise and vibration assessment was carried out in accordance with the requirements of the *Rail Infrastructure Noise Guideline* (NSW Environment Protection Authority, 2013). The noise design objectives contained within this guideline are expressed as non-mandatory 'trigger levels' which, if exceeded, require consideration of feasible and reasonable mitigation measures.

The ground-borne noise levels refer to noise caused by the proposed rail operations only and do not include ambient noise from other sources such as major roads and industry. The train noise levels are evaluated inside buildings at the centre of the most affected habitable room (ie kitchens, bathrooms, laundries and the like are not considered "habitable"). The ground-borne noise trigger levels for residential and other sensitive receiver locations are provided in Table 11-4.

For commercial receivers, shopping centres and industrial buildings, the *Rail Infrastructure Noise Guideline* (EPA, 2013) does not provide guidance on acceptable levels. The previous *Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects* (Department of Environment and Climate Change, 2007a) outlines ground-borne noise design objectives for these other receivers (refer to Table 11-5) which have been adopted for the purposes of this assessment.

Table 11-4 Ground-borne noise design objectives – Rail Infrastructure Noise Guideline

Receiver	Time of day	Noise trigger levels (dBA)
		Development increases existing rail noise levels by 3.0 dB or more AND resulting rail noise levels exceed:
Residential	Day (7am to 10pm)	40 $L_{Amax(slow)}$
	Night (10pm to 7am)	35 $L_{Amax(slow)}$
Schools, educational institutions, places of worship	When in use	40-45 $L_{Amax(slow)}$ [1]

1 *The lower value of the range is most applicable where low internal noise levels are expected, such as in areas assigned to studying, listening and praying.*

Table 11-5 Ground-borne noise design objectives – Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects

Receiver	Time of day	Noise trigger levels (dBA)[1]
Retail areas	When in use	40-50 dBA
General Office Areas	When in use	50 dBA
Private Offices and Conference Rooms	When in use	45 dBA
Cinemas, Public Halls and Lecture Theatres	When in use	35 dBA
Drama Theatres	When in use	NR 25[2]
Film/Television Studios and Sound Recording Studios	When in use	NR 15[2]
Workshops / Industrial Buildings	–	N/A

1 *The ground-borne noise design objectives are based on the maximum $L_{Amax(slow)}$ noise level, not to be exceeded for 95% of train passbys over any 24 hour period.*

2 *NR (Noise Rating) curves are used for rating noise levels and are a set of octave band curves which provide limiting sound pressure level values. NR 15 is equivalent to approximately 20 dBA and NR 25 is approximately 30 dBA.*

Ground-borne noise and vibration modelling

Train noise in buildings adjacent to rail tunnels is predominantly caused by the transmission of ground-borne vibration rather than the direct transmission of noise through the air. After entering a building, this vibration may cause the walls and floors to vibrate and hence to radiate audible noise, which is commonly termed ground-borne or regenerated noise.

International Standard ISO 14837;1 2005 *Mechanical vibration – Ground-borne noise and vibration arising from rail systems – Part 1: General Guidance* provides relevant guidance in relation to the extent of assessment that is normally required for new rail systems.

A computer noise model was developed to predict the ground-borne noise and vibration levels in nearby buildings above or close to the underground project alignment. The model takes into account the source vibration generated by trains operating in a similar rail tunnel environment, the proposed track design and operating speeds, the characteristics of the ground, the tunnel depth and typical building characteristics.

Given the expected similarities of the project to the Epping to Chatswood Rail Link project (in terms of geology, tunnel diameter, concrete lining, slab track design, etc), the source vibration levels for the new fleet of single deck, metro trains for use in the ground-borne noise and vibration modelling have been calibrated from measurements taken of the Epping to Chatswood Rail Link between 2009 and 2011.

In the absence of specific measured data relating to the proposed single-deck trains, source vibration levels have been assumed to be equivalent to A-Set (Waratah) trains – the most modern trains currently operating on the Sydney rail network. This assumption is considered to be conservative as the proposed single-deck passenger trains are likely to have reduced axle loads and unsprung mass compared to the Waratah train, resulting in marginally lower source vibration levels.

Further details on the ground-borne noise and vibration modelling methodology are provided in *Technical Paper 2 – Noise and vibration.*

11.2.3 Airborne noise

Noise emissions from suburban electric passenger trains are predominantly caused by the rolling contact of steel wheels on steel rails. Other noise sources on electric passenger trains (such as air-conditioning plant and air compressors) are generally insignificant in noise level when compared to the wheel rail interaction, unless the train is travelling at a very low speed or is stationary.

Airborne rail noise trigger levels

The NSW EPA provides guidance for the assessment and management of potential airborne noise from railways in the *Rail Infrastructure Noise Guideline* (EPA, 2013). To assess and manage potential noise from rail projects the guideline provides non-mandatory airborne noise triggers for residential and other sensitive receivers. Where rail noise levels are above the noise triggers feasible and reasonable noise mitigation should be identified to achieve the trigger levels.

The *Rail Infrastructure Noise Guideline* (EPA, 2013) requires noise to be assessed at opening and for a future design year (typically ten years after opening). For this project the two timeframes assessed are at opening scenario in 2024 and a future scenario based on forecasts for operations in 2034.

The project related surface track sections north of the Chatswood tunnel portal and south of Marrickville tunnel portal would be categorised as a redevelopment of an existing rail line.

The relevant airborne noise trigger levels for residential land uses surrounding the proposed surface track are presented in Table 11-6.

Table 11-6 Airborne rail noise triggers for residential land use

Sensitive land use	Noise trigger level (dBA)	
	Daytime 7am to 10pm	Night-time 10pm to 7am
Redevelopment of existing rail line	Development increases existing $L_{Aeq(period)}$ [1] rail noise levels by 2 dB or more, or existing L_{Amax} [2] rail noise levels by 3 dB or more AND Resulting rail noise levels exceed:	
	65 $L_{Aeq(15hour)}$ and 85 L_{Amax}	60 $L_{Aeq(9hour)}$ and 85 L_{Amax}

1 *$L_{Aeq(period)}$ means $L_{Aeq(15h)}$ for the day-time period and $L_{Aeq(9h)}$ for the night-time period*

2 *L_{Amax} refers to the maximum noise level not exceeded for 95 per cent of rail pass-by events and is measured using the 'fast' response setting on a sound level meter.*

The *Rail Infrastructure Noise Guideline* (EPA, 2013) noise triggers for non-residential sensitive receivers are shown in Table 11-7 and are applicable when the building or premise is in use. All noise trigger levels are external levels except where otherwise stated. Commercial receivers are not considered sensitive to operational airborne noise impacts.

Table 11-7 Airborne rail noise triggers for sensitive land uses other than residential

Sensitive land use	Noise trigger level (dBA)
	Development increases existing rail noise levels by 2 dB or more in L_{Aeq} in any hour AND Resulting rail noise levels exceed:
Schools, educational institutions and child care centres	45 $L_{Aeq(1hour)}$ internal
Places of worship	45 $L_{Aeq(1hour)}$ internal
Hospital wards	40 $L_{Aeq(1hour)}$ internal
Hospital other uses	65 $L_{Aeq(1hour)}$
Open space – passive use (eg parkland, bush reserves)	65 $L_{Aeq(15hour)}$
Open space – active use (eg sports field, golf course)	65 $L_{Aeq(15hour)}$

Approach to operational noise modelling

SoundPLAN version 7.0 was used to model airborne rail noise. The input data used in the modelling was chosen to reflect the likely metro fleet of single-deck trains. Noise levels for the T1 North Shore Line and T3 Bankstown Line were based on modern electric double-deck suburban passenger trains (similar to A-set 'Waratah' class). Other key inputs into the airborne noise model included:

- Concrete slab track within the dive structures and on the T1 North Shore Line bridge; ballast track in other surface track locations
- Sydney Metro would be constructed with continuously welded rail
- The horizontal radius of curves, especially those less than 600 metre radius
- The track geometry in relation to the adjacent ground terrain
- The Sydney Trains and Sydney Metro train speed profiles for the surface track sections
- Train numbers on metro lines and existing rail lines in the vicinity of the Chatswood and Marrickville dive structures
- The location of sensitive receivers.

The *Rail Infrastructure Noise Guideline* (EPA, 2013) specifies that the noise trigger levels apply both immediately after operations commence and for projected train numbers at an indicative period into the future to represent the expected typical maximum level of train use. To support the noise modelling predictions, estimated train numbers were assessed for the at-opening and 10-years after opening scenarios.

The train number estimates (for Sydney Metro and Sydney Trains) used in the modelling scenarios are provided in Table 11-8. These train numbers are indicative only and are based on estimated passenger demand, minimum service levels and the upper design limit of metro service frequency for future peak times.

Further details of the airborne noise modelling methodology and inputs are provided in *Technical Paper 2 – Noise and vibration*.

Table 11-8 Train numbers for noise assessment

Rail line	Scenario	Train type	Trains per weekday			
			Day (7 am to 10 pm)		Night (10 pm to 7 am)	
			Up	Down	Up	Down
T1 North Shore Line and future metro line	Existing 2015	A/H/M/T-Set	186	190	44	47
	Prior to opening 2024	A/H/M/T-Set	186	190	44	47
	After opening 2024	A/H/M/T-Set	186	190	44	47
		Metro Train	202	202	27	27
	Future 2034 with project	A/H/M/T-Set	186	190	44	47
		Metro Train	222	222	30	30
	Future 2034 without project	A/H/M/T-Set	186	190	44	47
		Metro train	0	0	0	0
T2 Airport Line	Existing 2015	A/H/M/T-Set	6	8	0	1
	Prior to opening 2024	A/H/M/T-Set	6	8	0	1
	After opening 2024	A/H/M/T-Set	6	8	0	1
	Future 2034 with project	A/H/M/T-Set	6	8	0	1
	Future 2034 without project	A/H/M/T-Set	6	8	0	1
T3 Bankstown Line and future metro line	Existing 2015	A/H/M/T-Set	78	84	17	20
	Prior to opening 2024	A/H/M/T-Set	78	84	17	20
	After opening 2024	A/H/M/T-Set	78	84	17	20
		Metro Train	184	184	27	27
	Future 2034 with project	A/H/M/T-Set	78	84	17	20
		Metro Train	202	202	30	30
	Future 2034 without project	A/H/M/T-Set	78	84	17	20
		Metro Train	0	0	0	0
T4 Eastern Suburbs and Illawarra Line	Existing 2015	A/H/M/T-Set	96	85	26	23
		C/K/S/R-Set	9	8	2	2
	Prior to opening 2024	A/H/M/T-Set	105	93	28	25
	After opening 2024	A/H/M/T-Set	105	93	28	25
	Future 2034 with project	A/H/M/T-Set	105	93	28	25
	Future 2034 without project	A/H/M/T-Set	105	93	28	25

11.2.4 Operational noise from stations and ancillary facilities

Noise criteria

The *Industrial Noise Policy* (INP) (Environment Protection Authority, 2000) sets two separate noise criteria to meet environmental noise objectives: one to account for intrusive noise and the other to protect the amenity of particular land uses. These criteria are to be met at the most-affected boundary of the receiver property. The more stringent of the criteria usually defines the proposal specific noise levels. For both amenity and intrusiveness, night-time criteria are more stringent than daytime or evening criteria.

In addition to intrusiveness and amenity, the risk of sleep disturbance must be assessed. Sleep disturbance is assessed in accordance with the screening criterion described in the online Application Notes to the INP and the more detailed review of sleep disturbance contained in the *Road Noise Policy* (RNP) (Department of Environment, Climate Change and Water, 2011a).

To provide for protection against intrusive noise, the INP states that the L_{Aeq} noise level of the source, measured over a period of 15 minutes, should not be more than five decibels above the ambient (background) L_{A90} noise level (or RBL), measured during the daytime, evening and night-time periods at the nearest sensitive residential receiver. In this case, the intrusiveness criteria are determined from the rating background levels, which are outlined in Chapter 10 (Construction noise and vibration), at sensitive receiver locations nearest to the facilities.

To provide protection against impacts on amenity, the INP specifies suitable maximum noise levels for particular land uses and activities during the daytime, evening and night-time periods. The relevant INP external amenity noise criteria are presented in Table 11-9.

Table 11-9 Industrial Noise Policy amenity criteria

Type of receiver	Indicative noise amenity area	Time of day	Recommended L_{Aeq} noise level (dBA)	
			Acceptable	Recommended maximum
Residence	Suburban [1]	Day	55	60
		Evening	45	50
		Night	40	45
Residence	Urban [2]	Day	60	65
		Evening	50	55
		Night	45	50
Commercial	All	When in use	65	70
Active recreation area	All	When in use	55	60
Educational	All	When in use	55 [1]	60 [1]
Place of worship	All	When in use	60 [1]	65 [3]

1 *Suburban area is characterised by local traffic with intermittent traffic flows, decreasing noise levels in the evening period, and/or evening ambient levels defined by the natural environment and infrequent human activity.*

2 *Urban areas are characterised by an acoustic environment dominated by 'urban hum' or industrial noise sources, through traffic with heavy and continuous traffic flows during peak hours, and/or located near commercial or industrial districts.*

3 *External levels, based on the internal levels specified in the INP plus 20 dB (assuming open windows).*

11.3 Existing environment

The existing noise environment varies considerably along the length of the project. The dominant noise sources that are likely to influence background noise levels include:

- Road traffic noise
- Suburban rail line operations and associated station activities
- Industrial activities occurring within existing industrial areas (such as at Artarmon and Marrickville)
- Other construction activities (such as the CBD and South East Light Rail, building redevelopments, road and housing construction)
- Sydney Harbour maritime traffic
- Aircraft noise.

The existing noise environment, including ambient noise levels, is described in Chapter 10 (Construction noise and vibration). This environment status would also be applicable to the operation stage of the project.

11.4 Potential impacts

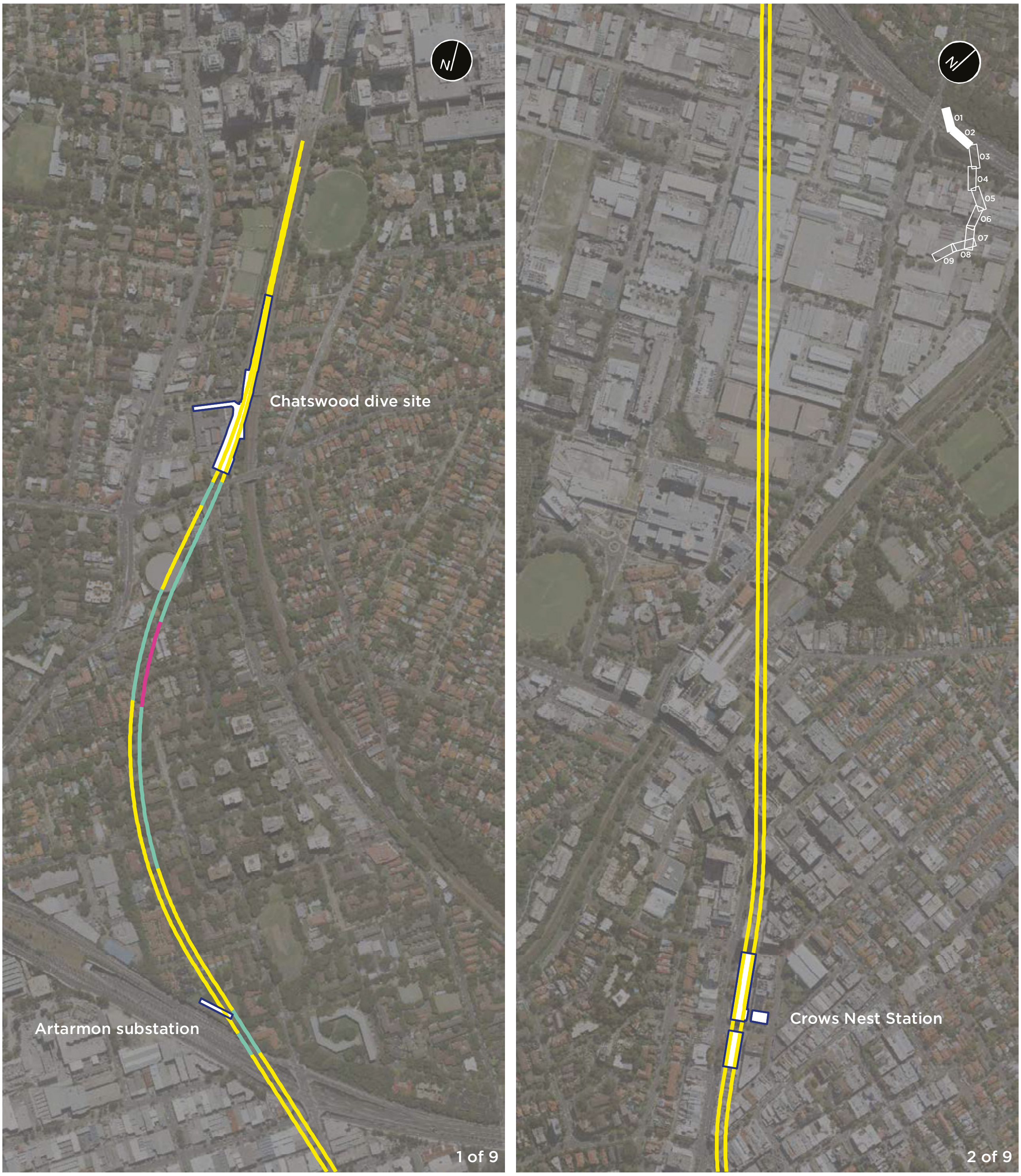
11.4.1 Ground-borne noise and vibration

Ground-borne noise and vibration impacts from operational rail lines in tunnels are generally mitigated by a resilient rubber layer between the rail and the tunnel foundation. This may take the form of resilient rail fasteners, booted sleepers, floating slab track or a combination of measures.

Initial ground-borne noise and vibration modelling was carried out to determine the indicative track form along the tunnel alignment to meet the design objectives at receivers above the tunnels. This modelling determined that the following three track forms would be required:

- **Standard attenuation track** – incorporating a hard resilient baseplates. This track form would be used for around 93 per cent of the tunnels and is the standard specification for Sydney Metro and would be used in areas with low sensitivity to ground-borne noise and vibration, or at locations where there is sufficient tunnel depth to the receivers
- **High attenuation track** – incorporating medium resilient baseplates. This track form would be used for around seven per cent of the tunnels, in sensitive areas where the standard attenuation track is not sufficient to meet the design objectives
- **Very high attenuation track** – incorporating soft resilient baseplates. This track form would only be required for less than one per cent of the tunnels, in very sensitive areas where the depth of the tunnel is particularly shallow.

The indicative track form for the current design of the tunnels, trains and operations are shown on Figure 11-1 (a-e). The proposed track form provides one option to meet the ground-borne noise and vibration objectives. As identified in Chapter 6, the tunnel alignment is indicative at this stage, and has been used for the purposes of the environmental impact assessment including all specialist investigations. During detailed design the alignment may change (horizontally and / or vertically). Any changes to the alignment would be reviewed for consistency with the assessment contained in this Environmental Impact Statement including relevant mitigation measures, performance outcomes and any future conditions of approval. The final track form would be confirmed as part of detailed design.



KEY

- Standard Attenuation
- High Attenuation
- Very High Attenuation
- Proposed operational area at surface

Indicative only, subject to design development

0 400 m

Figure 11-1a Extent of indicative track form in Sydney Metro Chatswood to Sydenham tunnels Map 1

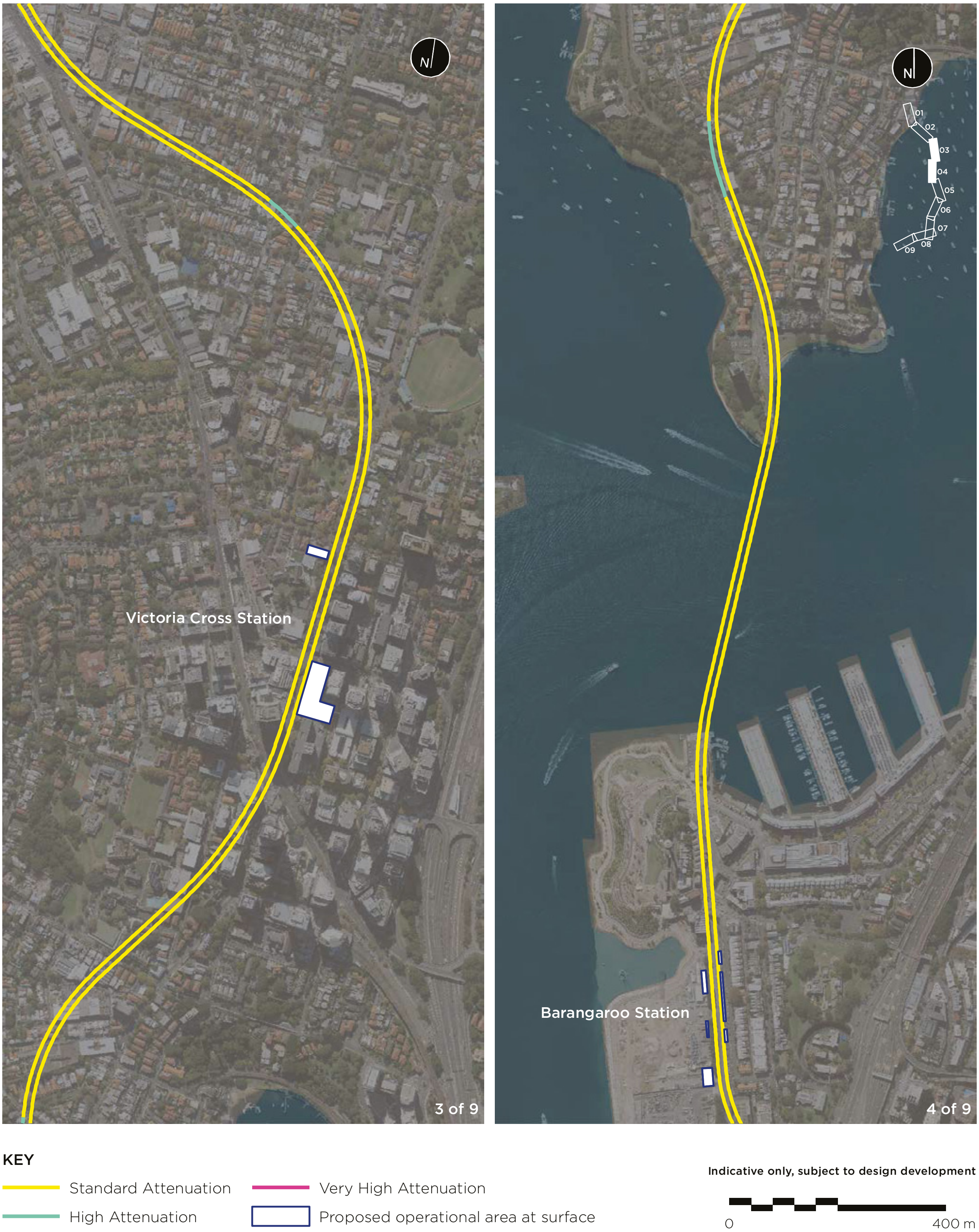
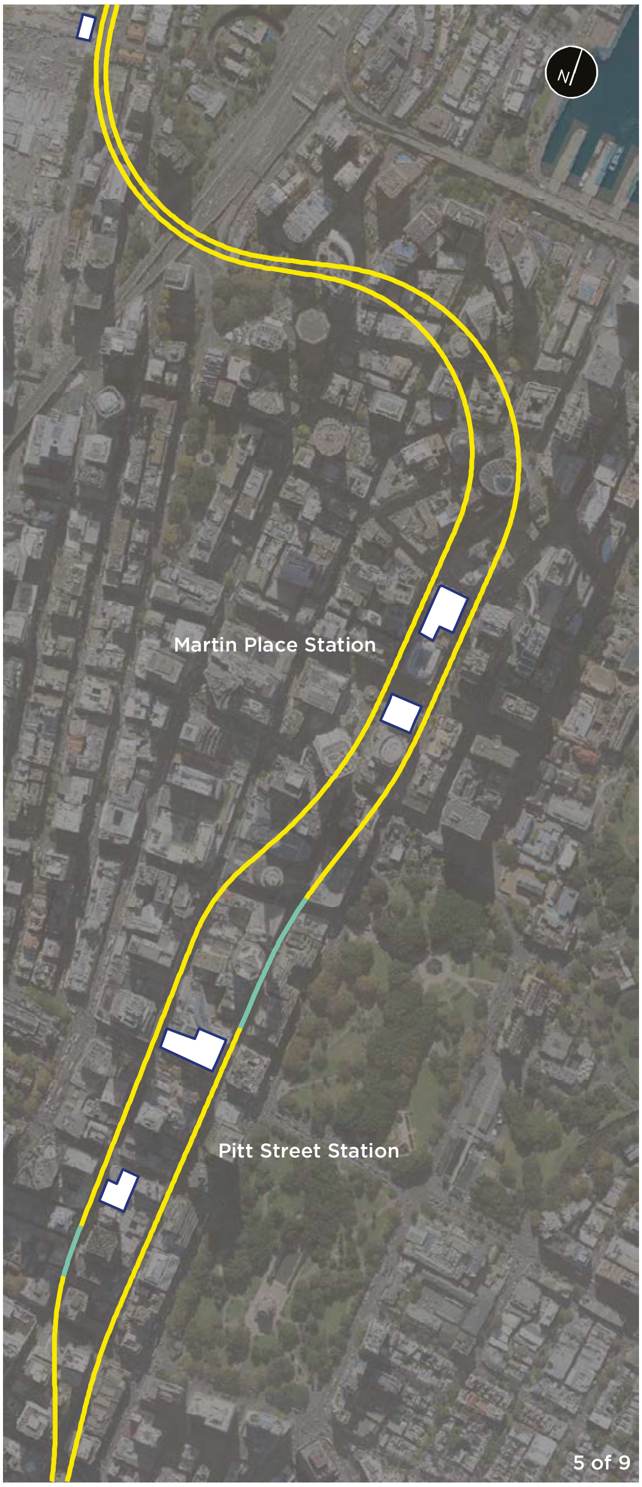
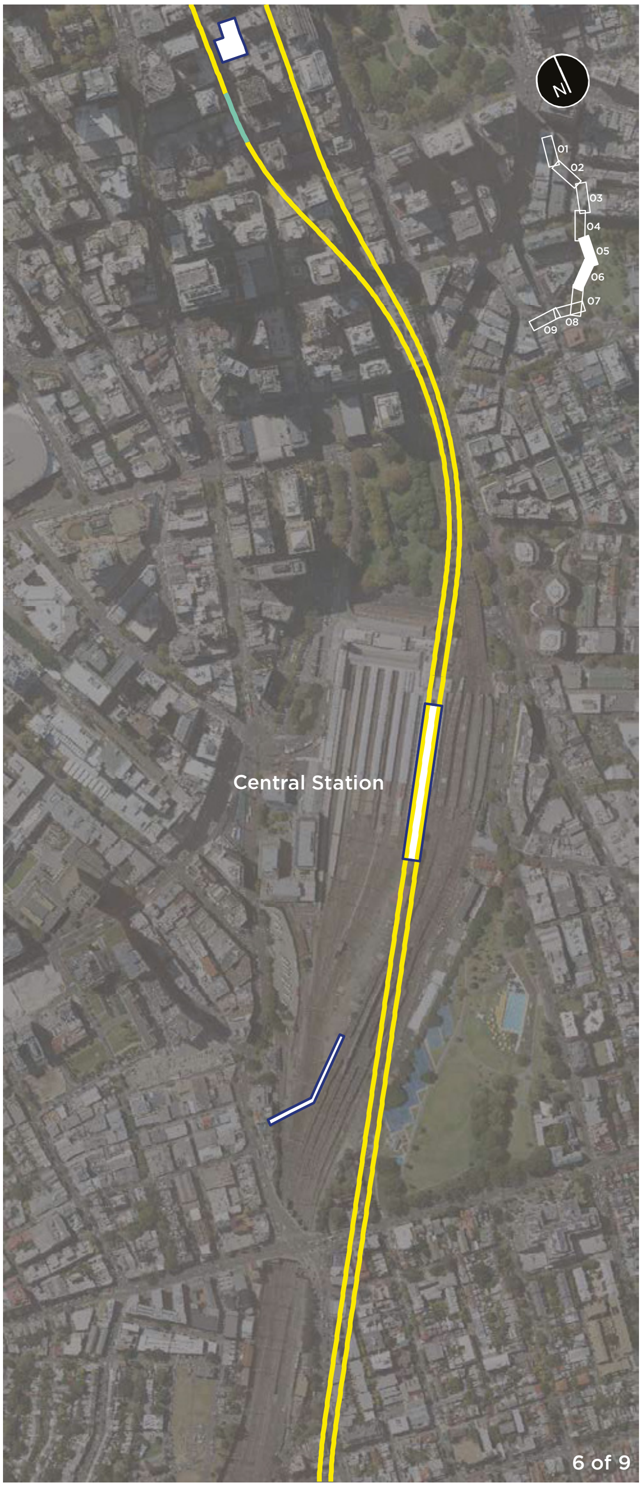


Figure 11-1b Extent of indicative track form in Sydney Metro Chatswood to Sydenham tunnels Map 2





KEY

Standard Attenuation

High Attenuation

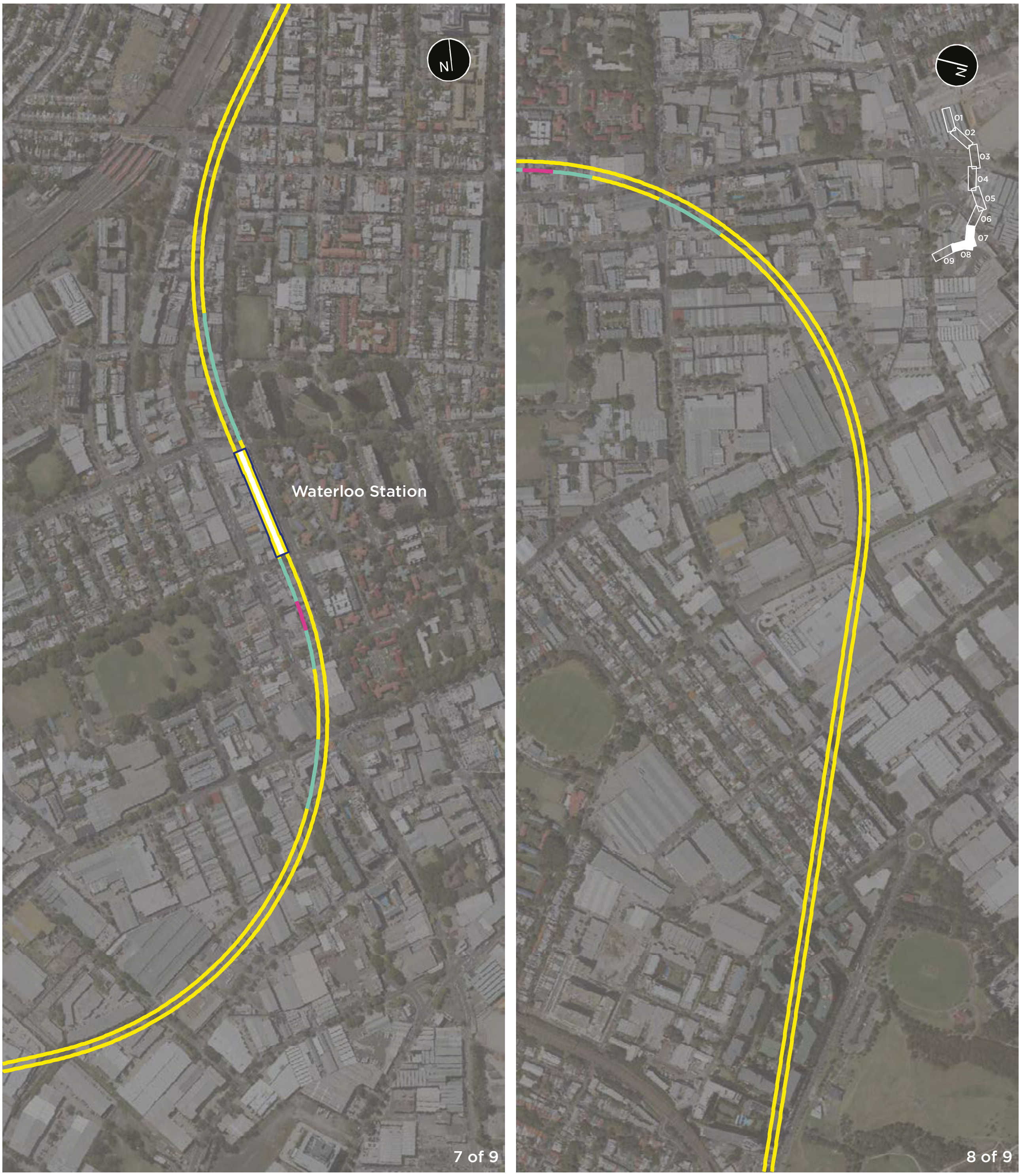
Very High Attenuation

Proposed operational area at surface

Indicative only, subject to design development

0 400 m

Figure 11-1c Extent of indicative track form in Sydney Metro Chatswood to Sydenham tunnels Map 3



KEY

Standard Attenuation

High Attenuation

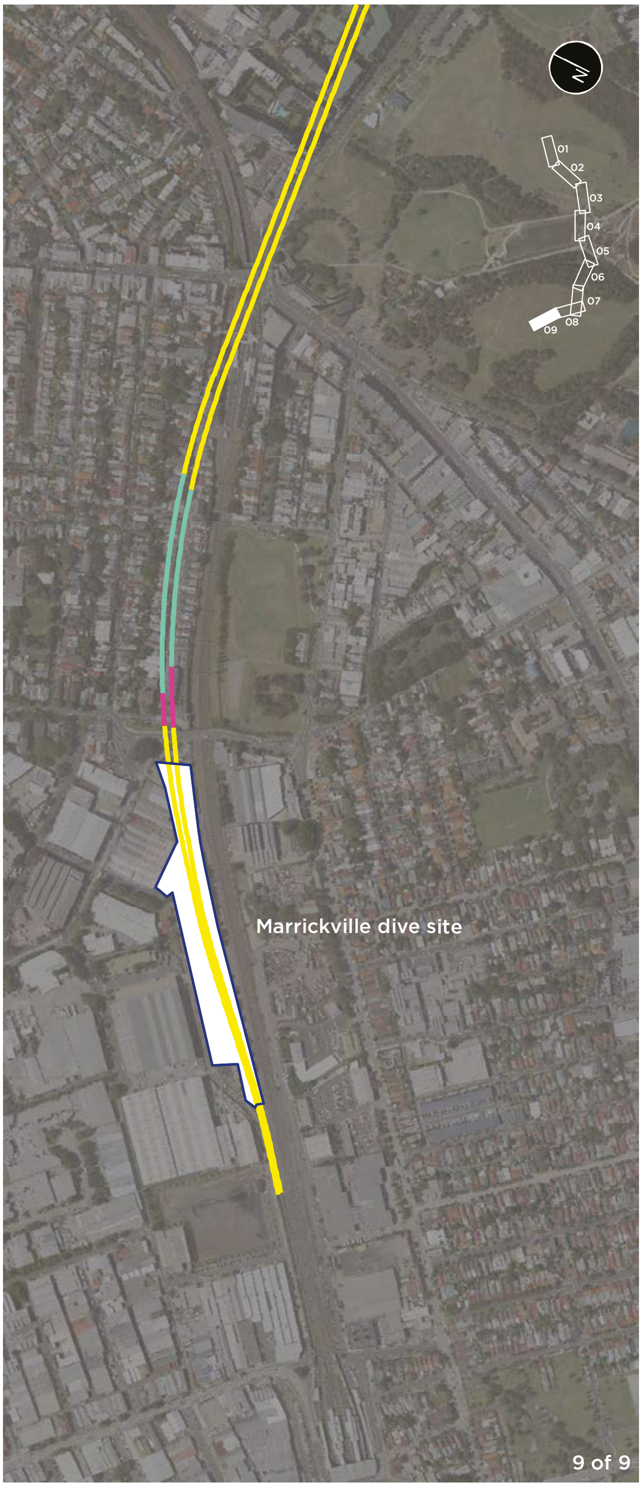
Very High Attenuation

Proposed operational area at surface

Indicative only, subject to design development

0 400 m

Figure 11-1d Extent of indicative track form in Sydney Metro Chatswood to Sydenham tunnels Map 4



KEY

Standard Attenuation
Very High Attenuation
High Attenuation
Proposed operational area at surface

Indicative only, subject to design development

0 400 m

Figure 11-1e Extent of indicative track form in Sydney Metro Chatswood to Sydenham tunnels Map 5

Ground-borne vibration predictions

Figure 11-2 presents a summary of the predicted ground-borne vibration levels for buildings located above or near the proposed tunnel alignment.

The predicted ground-borne vibration levels represent the maximum mid-floor vibration levels within multi-storey buildings.

At this stage it is not known whether any commercial premises contain highly sensitive measurement or fabrication equipment. For preliminary assessment purposes, it has been assumed that all nearby medical facilities may contain highly sensitive equipment such as lithography or optical / electronic inspection equipment with high resolution. Table 11-10 provides the results of ground-borne noise predictions for receivers containing highly sensitive equipment.

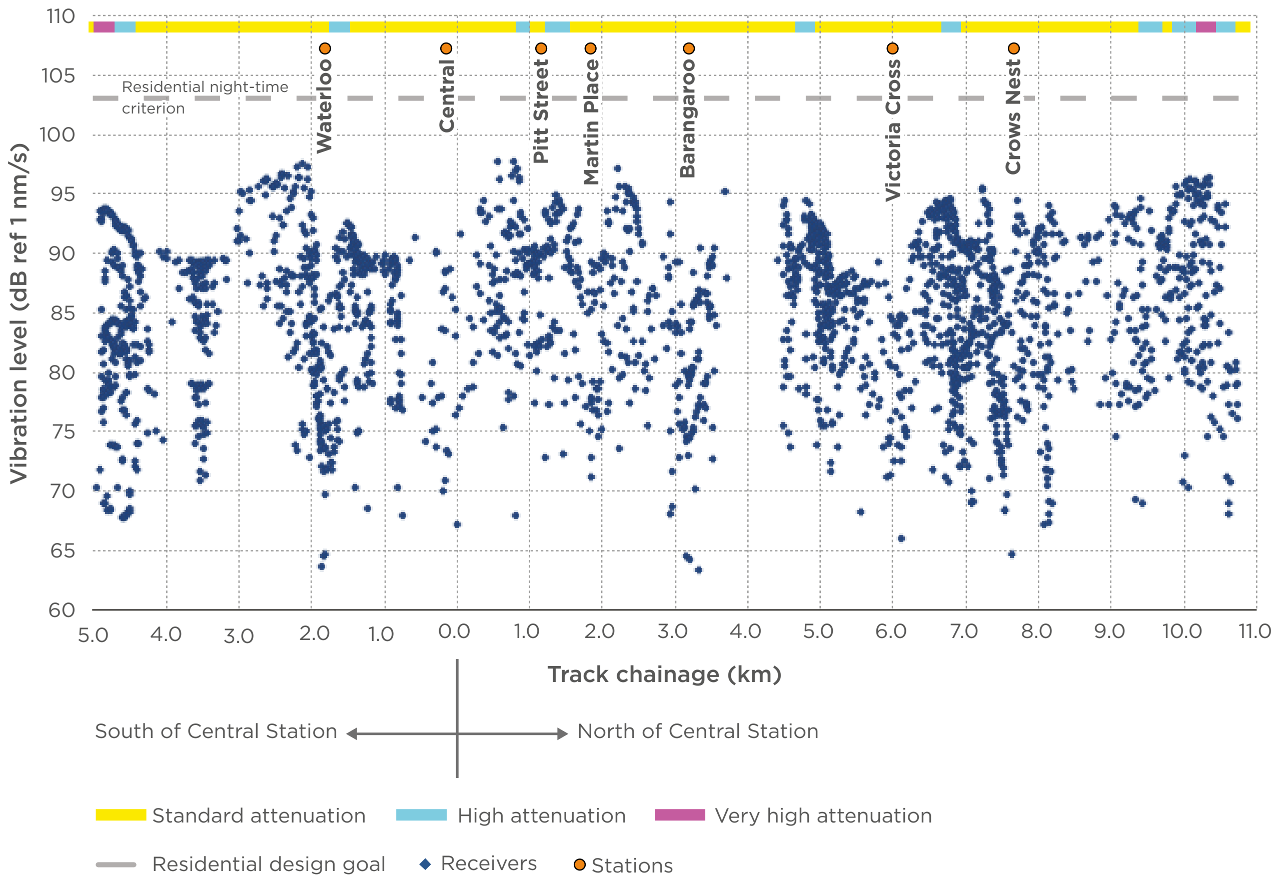


Figure 11-2 Predicted ground-borne vibration levels

Table 11-10 Ground-borne vibration predictions for receivers containing highly sensitive equipment

Receiver	Location	Maximum 1/3 Octave Band Vibration Level (dB ref 1 nm/s)	
		Design objective	Predicted
Royal North Shore Hospital	Near the tunnel alignment between Artarmon substation and Crows Nest Station	82	74
Health Care Imaging Services	Near the tunnel alignment between Pitt Street Station and Central Station	82	75

The human comfort objectives for ground-borne vibration are more stringent than other possible design limits related to building damage risk or the potential effects on building contents.

Compliance with the ground-borne vibration design objectives (and the human comfort vibration criteria from *Assessing Vibration: a technical guideline* – DEC, 2006) is predicted for all receivers located above or near to the proposed tunnel alignment.

Surface track ground-borne vibration

Some residential buildings located immediately adjacent to the surface rail track between Chatswood Station and Chatswood dive may experience an increase in train passby vibration levels. Residential receivers located on the western side of the rail corridor between Mowbray Road and Gordon Avenue, Chatswood are currently around 11 metres from the closest rail track. As a result of the realignment of the T1 North Shore Line, the surface track would be located around eight metres from these receivers (three metres closer). Based on previous investigations of vibration propagation from rail lines undertaken by the US Federal Transit Administration (2006), this change would equate to a potential increase in vibration level of around 2 dB. This increase is expected to be barely noticeable to the receivers.

Ground-borne noise predictions

Predictions of ground-borne noise levels are provided in Figure 11-3 for residential receivers and Figure 11-4 for commercial and other sensitive receivers. The predictions are based on a 'best estimate' plus a 5 dB safety factor. On average, the predicted ground-borne noise levels (for the highest 1 in 20 trains) at the nearest receivers would be around 30 dB which is well below the ground-borne noise design objectives. At most locations the noise levels would be much lower.

The proposed ground-borne noise levels are predicted to comply with the ground-borne noise objectives at all residential, commercial and other sensitive receiver locations.

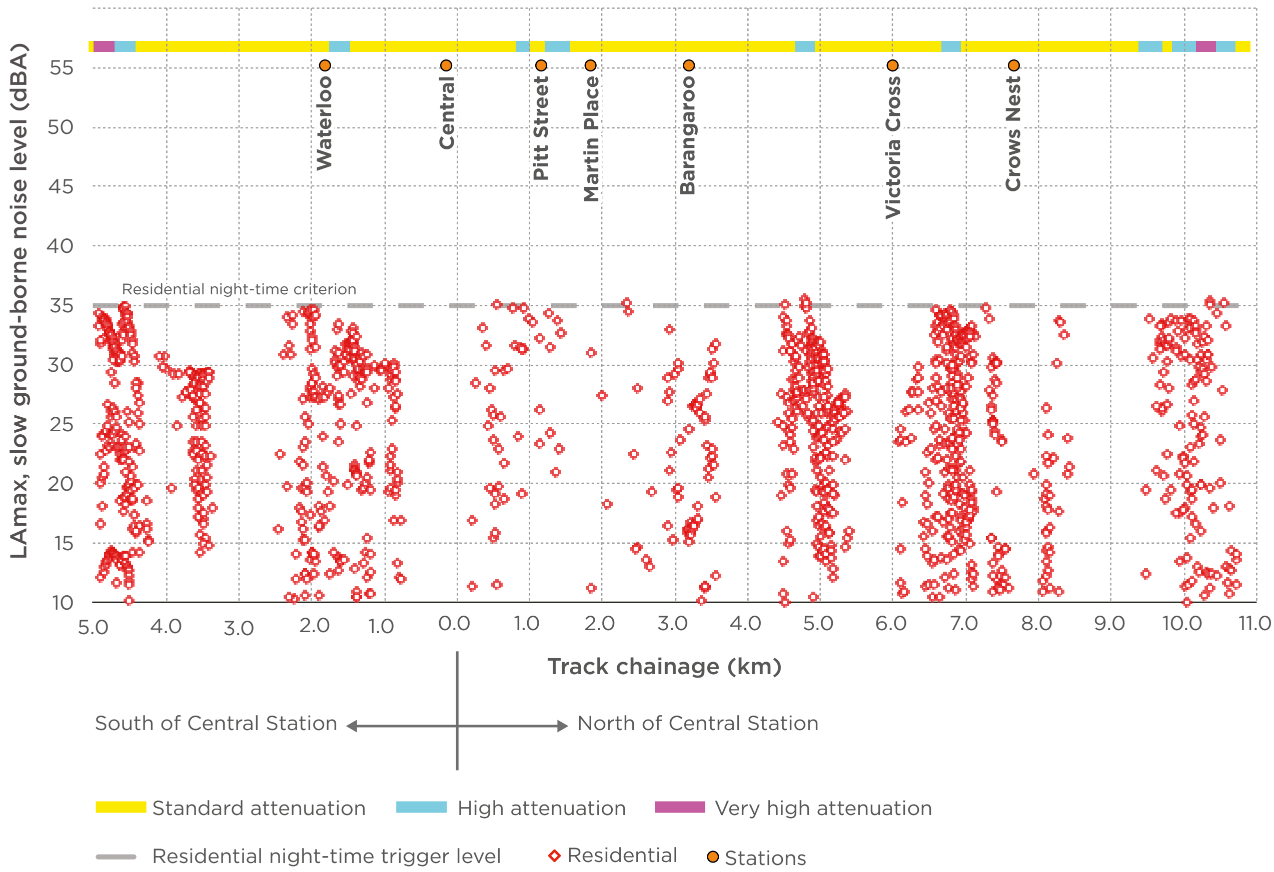


Figure 11-3 Predicted ground-borne noise levels – residential receivers

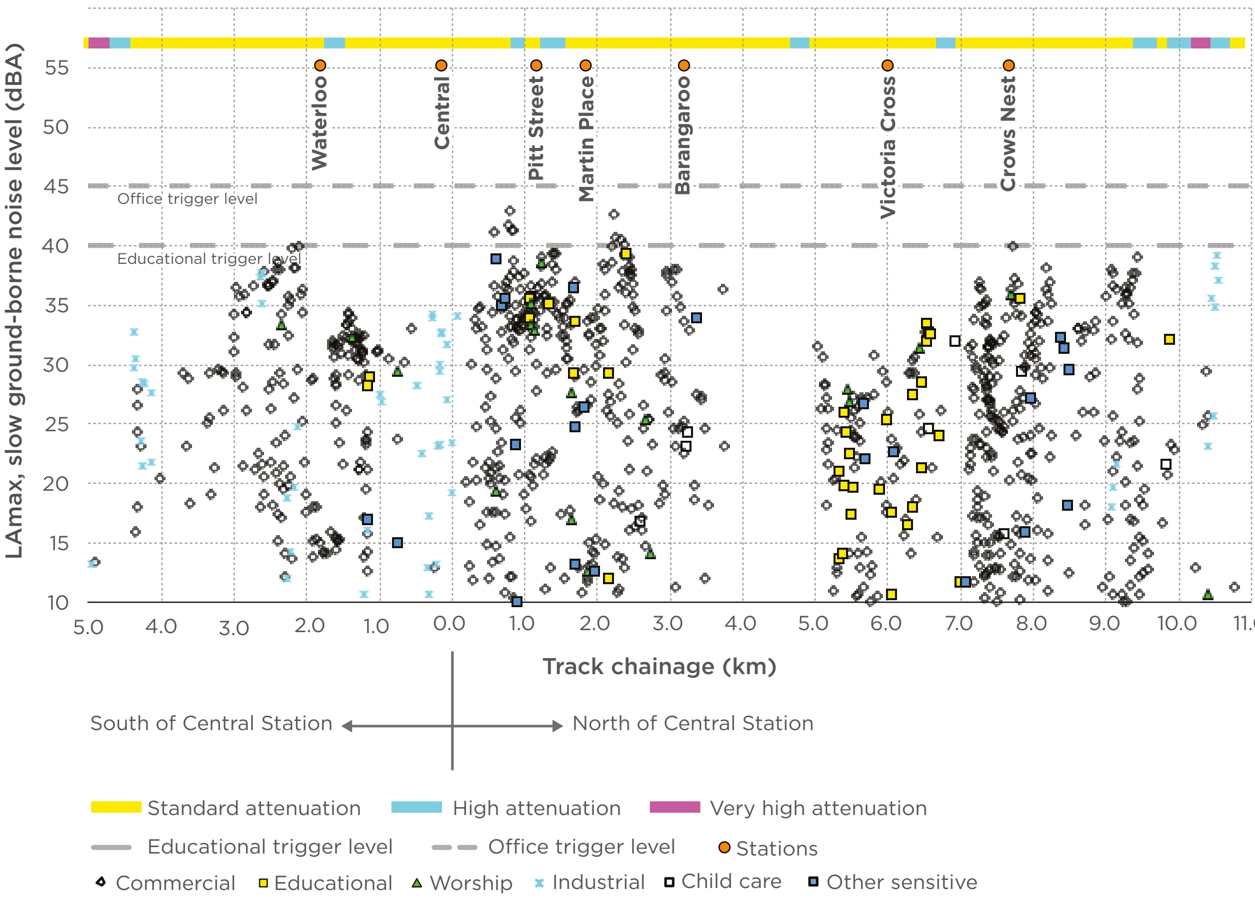


Figure 11-4 Predicted ground-borne noise levels – commercial and other sensitive receivers

11.4.2 Airborne noise

An operational airborne noise assessment has been carried out for the surface track sections at either end of the project, being:

- At the northern end of the project – metro trains operating between Chatswood Station and the Chatswood tunnel portal, and Sydney Trains trains operating on the realigned T1 North Shore Line between Chatswood Station and Brand Street, Artarmon
- At the southern end of the project – metro trains operating in the Marrickville dive structure.

For the purposes of assessment, receivers are broken into a number of noise catchment areas (NCAs). NCAs are determined to reflect the changing land uses and ambient noise environments adjacent to the project.

Northern surface works

In order to mitigate potential airborne noise impacts at the northern end of the project, the design has incorporated the following measures:

- An increase in the height (to four metres) of the noise barrier between Chapman Avenue and Nelson Street on the eastern side of the rail line
- An increase in the height (to four metres) of the noise barrier between the Frank Channon Walk pedestrian underpass and Albert Avenue on the western side the rail line
- An increase in the height (to four metres) of the noise barrier between Nelson Street and Gordon Avenue on the western side the rail line
- A two metre high noise barrier to the south of the Mowbray Road on the western side of the rail line
- Rail dampers and deck absorption within the Chatswood dive structure.

The exact height and extent of the noise barriers in these locations would be further refined during detailed design.

A summary of the predicted worst-case noise levels for residential receivers for the 2034 (future year) scenario are presented in Table 11-11. The future year 2034 scenario has been presented as it results in the highest noise level predictions. Results for the at opening 2024 scenario are provided in *Technical paper 2 – Noise and vibration*.

Table 11-11 Predicted 2034 airborne noise levels – residential receivers Chatswood dive

NCA	Side	Worst-case predicted noise level (dBA)								
		Without project			With project			Increase		RING triggers
		$L_{Aeq(15h)}$	$L_{Aeq(9h)}$	L_{Amax}	$L_{Aeq(15h)}$	$L_{Aeq(9h)}$	L_{Amax}	L_{Aeq}	L_{Amax}	
01	Up	50	46	68	52	47	68	1.6	-0.1	0
	Down	61	58	80	63	58	81	1.2	0.5	0
02	Up	**68**	**64**	**86**	**70**	**65**	**86**	1.9	-0.3	0
	Down	64	60	84	**67**	**62**	**85**	0	1.3	1
03	Up	**69**	**65**	**88**	**68**	**64**	**87**	0.7	0.8	0
	Down	63	59	81	65	60	81	1.8	0.7	0
04	Up	**69**	**65**	**87**	**69**	**65**	**87**	0.3	0	0
	Down	**68**	**64**	**85**	**68**	**64**	**85**	0.1	0	0

1 *Red bold indicates an exceedance of criteria*

2 *For reference the trigger levels are:*

development increases existing $L_{Aeq(period)}$ rail noise levels by 2 dB or more, or existing L_{Amax} rail noise levels by 3 dB or more and predicted rail noise levels exceed: daytime: 65 $L_{Aeq(15hour)}$ or 85 L_{Amax}, night-time: 60 $L_{Aeq(9hour)}$ or 85 L_{Amax}.

The results indicate that noise levels at residential receivers without the project are generally already close to, or exceeding, the overall noise criteria levels.

Comparing the 'with project' and 'without project' noise levels indicates that there is generally no change in noise levels from the project, primarily due to the measures incorporated into the design to minimise operational airborne noise impacts.

From the results it can be seen that there remains a predicted exceedance of the noise trigger levels at one residential receiver building (at address 1-3 Gordon Avenue, Chatswood) on the western side of the rail line. This residential receiver is a multi-storey apartment building and would consist of several dwellings. The upper floors of this receiver would have an unobstructed view of the rail tracks over the noise barrier, even with the proposed increase in barrier height. To break line of sight at the triggered receivers on the upper floor of this building would require a noise barrier in excess of six metres high. Noise barriers of this height are unlikely to be considered reasonable and may not be feasible, particularly since the barrier would need to be located in close proximity to the building facade. Based on the outcomes of noise modelling during detailed design, this property would be considered for at property treatment.

A summary of the predicted worst-case noise levels for other sensitive receivers for the 2034 (future year) scenario are presented in Table 11-12. The future year 2034 scenario has been presented as it results in the highest noise level predictions. Results for the at opening 2024 scenario are provided in *Technical paper 2 – Noise and vibration*.

Table 11-12 Predicted 2034 airborne noise levels – other sensitive receivers Chatswood dive

NCA	Side	Worst-case predicted noise level (dBA)					
		Without project		With project		Increase	RING triggers
		$L_{Aeq(1h)}$ Day	$L_{Aeq(1h)}$ Night	$L_{Aeq(1h)}$ Day	$L_{Aeq(1h)}$ Night	$L_{Aeq(1h)}$	
01	Up	59	55	61	56	2.2	0
	Down	61	58	62	58	1.2	0
02	Up	N/A	N/A	N/A	N/A	N/A	0
	Down	66	62	69	63	3.2	0
03	Up	N/A	N/A	N/A	N/A	N/A	0
	Down	63	59	64	60	1.8	0
04	Up	N/A	N/A	N/A	N/A	N/A	0
	Down	68	64	68	64	0.1	0

Southern surface works

A summary of the predicted worst-case noise levels for residential receivers for the 2034 (future year) scenario are presented in Table 11-13. The future year 2034 scenario has been presented as it results in the highest noise level predictions. Results for the at-opening 2024 scenario are provided in *Technical paper 2 – Noise and vibration*.

Table 11-13 Predicted 2034 airborne noise levels – residential receivers Marrickville dive

NCA	Side	Worst-case predicted noise level (dBA)								
		Without project			With project			Increase		RING triggers
		$L_{Aeq(15h)}$	$L_{Aeq(9h)}$	L_{Amax}	$L_{Aeq(15h)}$	$L_{Aeq(9h)}$	L_{Amax}	L_{Aeq}	L_{Amax}	
32	Up	**67**	**63**	**99**	**67**	**63**	**99**	0	0	0
	Down	**68**	**64**	**93**	**68**	**64**	**93**	0	0	0
33	Up	44	40	63	50	45	68	9.5	13.5	0
	Down	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
34	Up	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
	Down	58	54	76	58	54	76	0	0	0

1 *Red bold indicates an exceedance of criteria*

2 *For reference the trigger levels are:*
development increases existing $L_{Aeq(period)}$ rail noise levels by 2 dB or more, or existing L_{Amax} rail noise levels by 3 dB or more and predicted rail noise levels exceed: daytime: 65 $L_{Aeq(15hour)}$ or 85 L_{Amax}, night-time: 60 $L_{Aeq(9hour)}$ or 85 L_{Amax}.

The results indicate that noise levels at residential receivers without the project are generally already close to, or exceeding, the overall noise criteria levels.

Comparing the 'with project' and 'without project' noise levels indicates that there is generally no change in noise levels from the project, with the exception of NCA33 on the up side of the corridor where the distance to the dive tracks is shortest. However the predicted noise levels in this area are below the RING absolute noise level criteria.

From the results it can be seen that there are no RING noise level triggers for residential receivers surrounding the Marrickville dive structure.

A summary of the predicted worst-case noise levels for other sensitive receivers for the 2034 (future year) scenario are presented in Table 11-14. The future year 2034 scenario has been presented as it results in the highest noise level predictions. Results for the at-opening 2024 scenario are provided in *Technical paper 2 – Noise and vibration*.

Table 11-14 Predicted 2034 airborne noise levels – other sensitive receivers Marrickville dive

NCA	Side	Worst-case predicted noise level (dBA)					
		Without project		With project		Increase	RING triggers
		$L_{Aeq(1h)}$ Day	$L_{Aeq(1h)}$ Night	$L_{Aeq(1h)}$ Day	$L_{Aeq(1h)}$ Night	$L_{Aeq(1h)}$	
32	Up	67	63	67	63	0	0
	Down	68	64	68	64	0	0
33	Up	51	49	55	51	4.8	0
	Down	N/A	N/A	N/A	N/A	N/A	0
34	Up	69	64	69	64	0	0
	Down	68	64	68	64	0	0

The results indicate that there are no RING triggers for other sensitive receivers in the vicinity of the Marrickville dive structure.

Future developments

The future land use of the residual land at the Chatswood dive site is not currently known, however, this may include multi-storey residential developments overlooking the rail corridor. These developments may be exposed to levels of operational airborne rail noise in excess of the RING absolute noise level criteria. Accordingly any future developments on this site should adequately address the noise criteria in the *Infrastructure State Environment Planning Policy 2007*.

The future land use of the residual land at the Marrickville dive site is not currently known, however, this is likely to comprise commercial and industrial developments. In the event that residential developments are considered for this site, such developments should adequately address the noise criteria in the *Infrastructure State Environment Planning Policy 2007*.

11.4.3 Operational noise from stations and ancillary facilities

Mechanical, electrical and ventilation services

The approach to assessment of noise from services at station and ancillary facilities is to calculate the maximum acceptable sound power level at each location based on the location of the proposed facility and the location of the nearest receivers. These maximum acceptable sound power levels would be used to guide the detailed design to ensure compliance with the applicable criteria from the *Industrial Noise Policy* (EPA, 2000).

The nearest receiver type and relevant external noise criteria for each services location are presented in Table 11-15. Based on previous experience on projects such as Epping to Chatswood Rail Line, it is expected that these levels can be achieved through the use of appropriate noise attenuation measures such as equipment selection, positioning of plant and ventilation discharges, in-duct attenuators, and acoustic enclosures.

Table 11-15 External noise criteria applicable to stations and ancillary facilities

Site	Services location	Nearest receiver type	External noise criteria (dBA)
Artarmon substation	Traction substation	Residential	45
Crows Nest Station	North services building	Commercial	65
	South services building	Commercial	65
Victoria Cross Station	North services building	Residential	56
		Commercial	65
	South services building including traction substation	Commercial	65
Barangaroo Station	North services building	Residential	45
	South services building	Residential	45
	Traction substation	Residential	45
Martin Place Station	North services building	Commercial	65
	South services building	Commercial	65
Pitt Street Station	North services building	Hotel (residential)	58
		Commercial	65
	South services building including traction substation	Commercial	65
Central Station	Services building	Hotel (residential)	50
		Commercial	65
Waterloo Station	North services building including traction substation	Residential	44
	South services building	Residential	44
		Place of worship	60
Southern services facility	Water treatment plant	Residential	46
		Commercial	65
	Traction substation	Residential	46
		Commercial	65

Train breakout noise from draught relief shafts

Noise generated during train passbys in the tunnels has the potential to escape from the tunnels via the draught relief shafts.

The noise criteria adopted for train breakout noise from draught relief shafts is L_{Amax} 55 dBA for residential receivers and L_{Amax} 65 dBA for commercial receivers. These noise criteria are comparable with the design criteria adopted for the Sydney Metro Northwest, Epping to Chatswood Rail Line (ECRL) and Sydney Airport Rail Line. They are also more stringent than the maximum noise goal of 80 dBA) applied in the *Rail Infrastructure Noise Guidelines* (EPA, 2013) relating to airborne noise from the operation of trains on new surface track.

The breakout noise has been predicted using the in-tunnel maximum reverberant noise levels, based on noise measurements carried out within the Epping to Chatswood Rail Line tunnels.

Noise breakout from draught relief shafts is not expected to exceed the nominated noise criteria (L_{Amax} of 55 dBA for residential receivers) at any receiver surrounding the proposed stations, with appropriate attenuator selection in place.

11.5 Mitigation measures

The mitigation measures that would be implemented to address potential operational noise and vibration impacts are listed in Table 11-16.

Table 11-16 Mitigation measures – operational noise and vibration

Ref	Mitigation measure	Applicable location(s) [1]
OpNV1	The height and extent of noise barriers adjacent to the northern surface track works would be confirmed during detailed design with the aim of not exceeding trigger levels from the *Rail Infrastructure Noise Guidelines* (Environment Protection Authority, 2013). At property treatments would be offered where there are residual exceedances of the trigger levels.	STW
OpNV2	Track form would be confirmed during the detailed design process in order to meet the relevant ground-borne noise and vibration criteria from the *Rail Infrastructure Noise Guidelines* (EPA, 2013) and the *Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects* (DECC, 2007).	Metro rail tunnels
OpNV3	Stations and ancillary facilities including train breakout noise from draught relief shafts would be designed to meet the applicable noise criteria derived from the *Industrial Noise Policy* (EPA, 2000).	All except metro rail tunnels

1 *STW: Surface track works; CDS: Chatswood dive site; AS: Artarmon substation; CN: Crows Nest Station; VC: Victoria Cross Station; BP: Blues Point temporary site; GI: Ground improvement works; BN: Barangaroo Station; MP: Martin Place Station; PS: Pitt Street Station; CS: Central Station; WS: Waterloo Station; MDS: Marrickville dive site; Metro rail tunnels: Metro rail tunnel related not related to other sites (eg TBM works); PSR: Power supply routes.*

LAND USE AND PROPERTY

CHAPTER TWELVE

12 Land use and property

This chapter considers the potential land use implications of constructing and operating the project and builds on the strategic level discussion presented in Chapter 3 (Strategic need and justification). It describes the framework for integrated land use and transport planning, and provides an assessment of the potential impact on land use and property as a result of the project.

12.1 Secretary's environmental assessment requirements

The Secretary's environmental assessment requirements relating to property and land use, and where these requirements are addressed in this Environmental Impact Statement, are outlined in Table 12-1.

Table 12-1 Secretary's environmental assessment requirements – land use and property

Ref.	Secretary's environmental assessment requirements	Where addressed
10. Socio-economic, Land Use and Property		
10.1	The Proponent must assess social and economic impacts in accordance with the current guidelines.	Business impacts addressed in Chapter 13 (Business impacts). Economic benefits of the project are addressed in Chapter 3 (Strategic need and justification). Social impacts addressed in Chapter 19 (Social impacts and community infrastructure).
10.2	The Proponent must assess impacts from construction and operation on potentially affected properties, approved development applications, businesses, public open space, recreational users and land and water users (for example, recreational and commercial fishers, oyster farmers), including property acquisitions/adjustments, access, amenity and relevant statutory rights	Property impacts are addressed in Section 12.4. Access impacts are addressed in Chapter 8 (Construction traffic and transport). Business impacts are addressed in Chapter 13 (Business impacts). Social impacts are addressed in Chapter 19 (Social impacts and community infrastructure). Cumulative impacts are addressed in Chapter 26 (Cumulative impacts).
10.3	Assess the likely risks of the project to public safety, paying particular attention to subsidence risks, bushfire risks and the handling and use of dangerous goods.	Traffic related public safety risks during construction are addressed in Chapter 8 (Construction traffic and transport). Traffic related public safety risks during operation are addressed in Chapter 9 (Operational traffic and transport). Risks associated with subsidence and settlement are addressed in Chapter 17 (Groundwater and geology). Public safety risks are addressed in Chapter 19 (Social impacts and community infrastructure). Bushfire risks and the handling and use of dangerous goods are addressed in Chapter 23 (Hazard and risk).

12.2 Strategic land use and planning context

12.2.1 Relevant plans, policies and strategies

The project aims to be consistent with goals and objectives of NSW strategic planning and transport infrastructure policies including:

- State and Premier priorities (NSW Government, 2015)
- *NSW 2021: A Plan to Make NSW Number One* (NSW Department of Premier and Cabinet, 2011)
- *A Plan for Growing Sydney* (NSW Government, 2014)
- *Rebuilding NSW: State Infrastructure Strategy 2014* (NSW Government, 2014)
- *NSW Long Term Transport Master Plan* (Transport for NSW, 2012b)
- *Sydney's Rail Future: Modernising Sydney's Trains* (Transport for NSW, 2012a)
- *Sydney City Centre Access Strategy* (Transport for NSW, 2013a).

These strategic plans and policies provide goals and objectives for land use planning within the Sydney metropolitan area over the next 20 years, particularly regarding accommodating future population growth and investing in transport infrastructure. Further discussion on the planning strategies that have guided the development of the project is provided in Chapter 3 (Strategic need and justification).

12.2.2 Integration of land use and transport planning

Land use and transport integration refers to planning and developing transport in ways that encourage development within a station precinct in accordance with local needs while facilitating the use of public transport and justifying the investment in the transport system.

The project presents significant opportunities for city building, particularly in being a catalyst for positive change, supporting broader economic benefits by facilitating strong business-to-business connectivity, and creating attractive, vibrant and highly accessible places. This will require alignment across multiple government planning agencies.

Sydney Metro would implement the project in an integrated manner in direct collaboration with key planning agencies, including the Department of Planning and Environment, the recently formed Greater Sydney Commission and the local Councils.

Outcomes of this work would:

- Establish the strategic framework for urban integration to support an enduring and sustainable legacy for the project
- Identify opportunities to integrate existing and future land uses within and around stations and as a part of transport infrastructure and services within the corridor
- Provide advice on project scope, including urban design and city building solutions
- Facilitate positive change through new stations and maximise opportunities for place making and good urban outcomes
- Manage the interface with local councils and other stakeholders, particularly in relation to the urban and transport integration of the project at new station locations.

The NSW Government will also investigate a Special Infrastructure Contribution around new stations (such as Waterloo Station) to be reserved for the Sydney Metro project and associated infrastructure.

12.3 Existing land use

This section discusses the existing land use and planning controls for each of the proposed construction sites. For the proposed new station locations a general overview on the station precinct planning context is also provided. Detailed planning for any proposed development associated with the proposed new stations will necessitate a separate and more strategic level of involvement between state and local government stakeholders. This would occur as part of the planning process for over station development as described in Chapter 2 (Planning and assessment process) and Chapter 6 (Project description – operation).

12.3.1 Chatswood dive site (northern) and northern surface works

Land use

The Chatswood dive site would be located to the west of the rail corridor and north of Mowbray Road, Chatswood. The northern surface works comprises a length of rail corridor extending about 800 metres from Brand Street, Artarmon to Albert Avenue, Chatswood.

Between Mowbray Road and Nelson Street, and west of the rail corridor towards the Pacific Highway, is an Ausgrid depot including a mix of light industrial buildings and institutional style office buildings. The area between Nelson Street and Albert Avenue is a residential precinct. Within this precinct are the Chatswood Bowls Club and the 'Frank Channon Walk', a wide shared footpath which runs alongside the rail corridor. This pathway connects the Chatswood Station precinct at Albert Avenue with Nelson Street.

To the east of the dive site, between the railway corridor, Elizabeth Street and Orchard Road is a low density residential precinct. To the north of the dive site is Chatswood Park and Oval and high density residential and high-rise commercial buildings at the Chatswood town centre. To the west of the Chatswood dive site, residential dwellings are located above street level retail showrooms along the Pacific Highway.

Land use surrounding the site is shown in Figure 12-1.

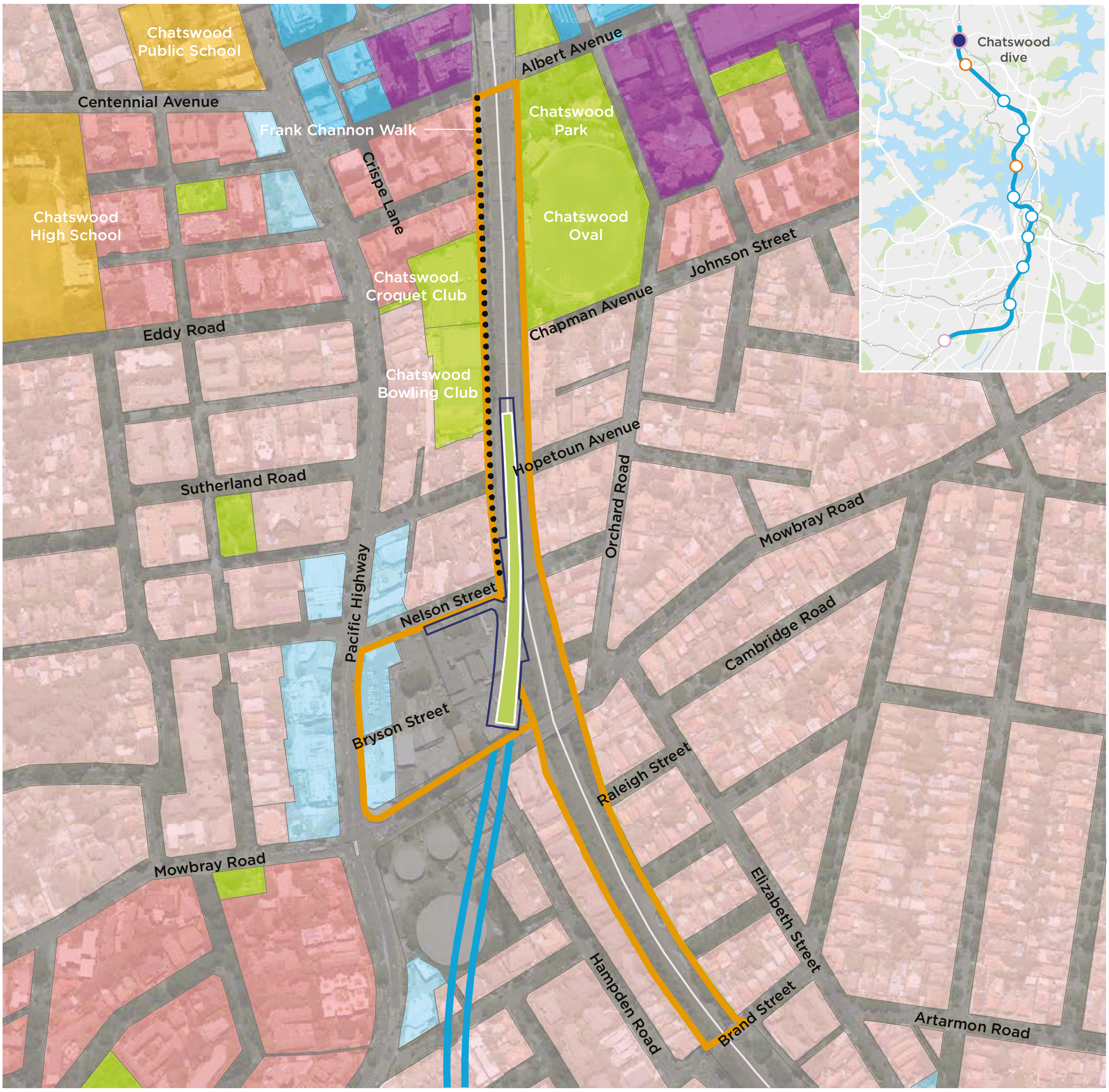
Planning controls

The *Willoughby Local Environmental Plan 2012* (Willoughby LEP 2012) defines the land use zoning surrounding the Chatswood dive site as a mix of the following zones: SP2 Infrastructure, B5 Business Development, R2 Low Density Residential, R3 Medium Density Residential, R4 High Density Residential, and RE1 Public Recreation.

The Chatswood dive site would be located on land zoned SP2 Infrastructure and B5 Business Development. The aims of the SP2 Infrastructure zone are to provide for infrastructure and related uses; and to prevent development that is not compatible with or that may detract from the provision of infrastructure.

The area zoned B5 Business Development aims to enable a mix of business and warehouse uses, and bulky goods premises that require a large floor area, in locations that are close to, and that support the viability of, centres; encourage employment opportunities; enable other land uses that provide facilities or services to meet the day-to-day needs of the community, and promote uses with active street frontages.

The *Willoughby Development Control Plan 2006* (Willoughby DCP 2006) supplements the *Willoughby Local Environmental Plan 2012*, providing more detailed provisions to guide future development, such as building form and site controls (such as site coverage, setbacks, building design, car parking, access, landscaping etc.).



KEY

- Chatswood to Sydenham
- Proposed dive structure
- Proposed operational area at surface
- Proposed construction site area
- Existing suburban rail
- Frank Channon Walk

Land use

- High density residential
- Low to medium density residential
- High density commercial
- Low to medium density commercial
- Educational establishment
- Recreation
- Transportation and infrastructure
- Mixed use

Existing land use represented on this figure may not be consistent with the underlying zoning of that land.
Indicative only, subject to design development

0 200 m

N

Figure 12-1 Chatswood dive site and northern surface works – existing land use

12.3.2 Artarmon substation

Land use

The Artarmon substation would be located on a triangle of land generally located between the Gore Hill Freeway, Butchers Lane and Barton Road.

The site is currently occupied by temporary school buildings associated with the nearby Artarmon Public School (located about 250 metres east of the proposed site). Residential areas are located to the west, north and east of the site and include a mix of low density housing and medium density unit blocks. Thomson Park is located to the east of the site which is used for public recreation. The Gore Hill Freeway forms the southwestern boundary of the site, is about 13 lanes wide in this area and is about 10 metres lower than the substation site. On the southern side of the Gore Hill Freeway is an industrial area.

Land use surrounding the site is shown in Figure 12-2.

Planning controls

The Artarmon substation site is located within land zoned R3 Medium Density Residential. The aims of this zone are to provide for the housing needs of the community within a medium density residential environment; to provide a variety of housing types within a medium density residential environment; and to enable other land uses that provide facilities or services to meet the day-to-day needs of residents.

The Willoughby LEP 2012 defines the land use zoning surrounding the site as a mix of the following zones: R3 Medium Density Residential, R4 High Density Residential, SP2 Infrastructure, RE1 Public Recreation and IN1 General Industrial.

As with the Chatswood dive site, the Willoughby DCP 2006 supplements the Willoughby LEP 2012 at this location, that provides more detailed provisions to guide future development of the site.

KEY

Chatswood to Sydenham
Proposed operational area at surface
Proposed construction site area

Land use

High density residential
Low to medium density residential
Low to medium density commercial
Educational establishment
Recreation
Industrial
Transportation and infrastructure
Temprary educational facility (Artarmon Public School)

Existing land use represented on this figure may not be consistent with the underlying zoning of that land.
Indicative only, subject to design development

0 100 m

N

Figure 12-2 Artarmon substation – existing land use

12.3.3 Crows Nest Station

Land use

Crows Nest Station would be located between the Pacific Highway and Clarke Lane, with station entries close to the intersection of Clarke and Hume streets and on the corner of the Pacific Highway and Oxley Street.

Low scale highway oriented showroom developments are located along the Pacific Highway, alongside a concentration of 19th century two storey shopfront facades to the south of Hume Street.

Oxley, Hume and Clarke streets contain a mixture of office and apartment buildings (up to ten storeys), as well as other uses such as an indoor sports complex, child care centre, community centre and post office.

To the north of the site is a mixed use commercial and retail area that encompasses a large number of businesses in the creative and professional services industries. Hume Street Park provides the only local green space in the vicinity of the project site and is located opposite the station site on Clarke Street.

To the south of the site is a transitional precinct with a mixture of high density housing, office towers, home-office conversions, community facilities, educational institutions and the Mater Hospital. To the west of the proposed station extending along Hume Street are large pockets of medium density housing interspersed with lower density residential areas and pocket parks.

Land use surrounding the site is shown in Figure 12-3.

Planning controls

The *North Sydney Local Environmental Plan 2013* (North Sydney LEP 2013) defines the land use zoning of the station site at Crows Nest and surrounds as B4 Mixed Use. The aims of this zone are to provide a mixture of compatible land uses and integrate suitable business, office, residential, retail and other development in accessible locations so as to maximise public transport patronage and encourage walking and cycling.

North Sydney Development Control Plan 2013 (North Sydney DCP 2013) supplements the North Sydney LEP 2013 and provides more detailed provisions to guide future development, such as building form and controls (ie setbacks, site coverage, building design, parking, access, landscaping etc).

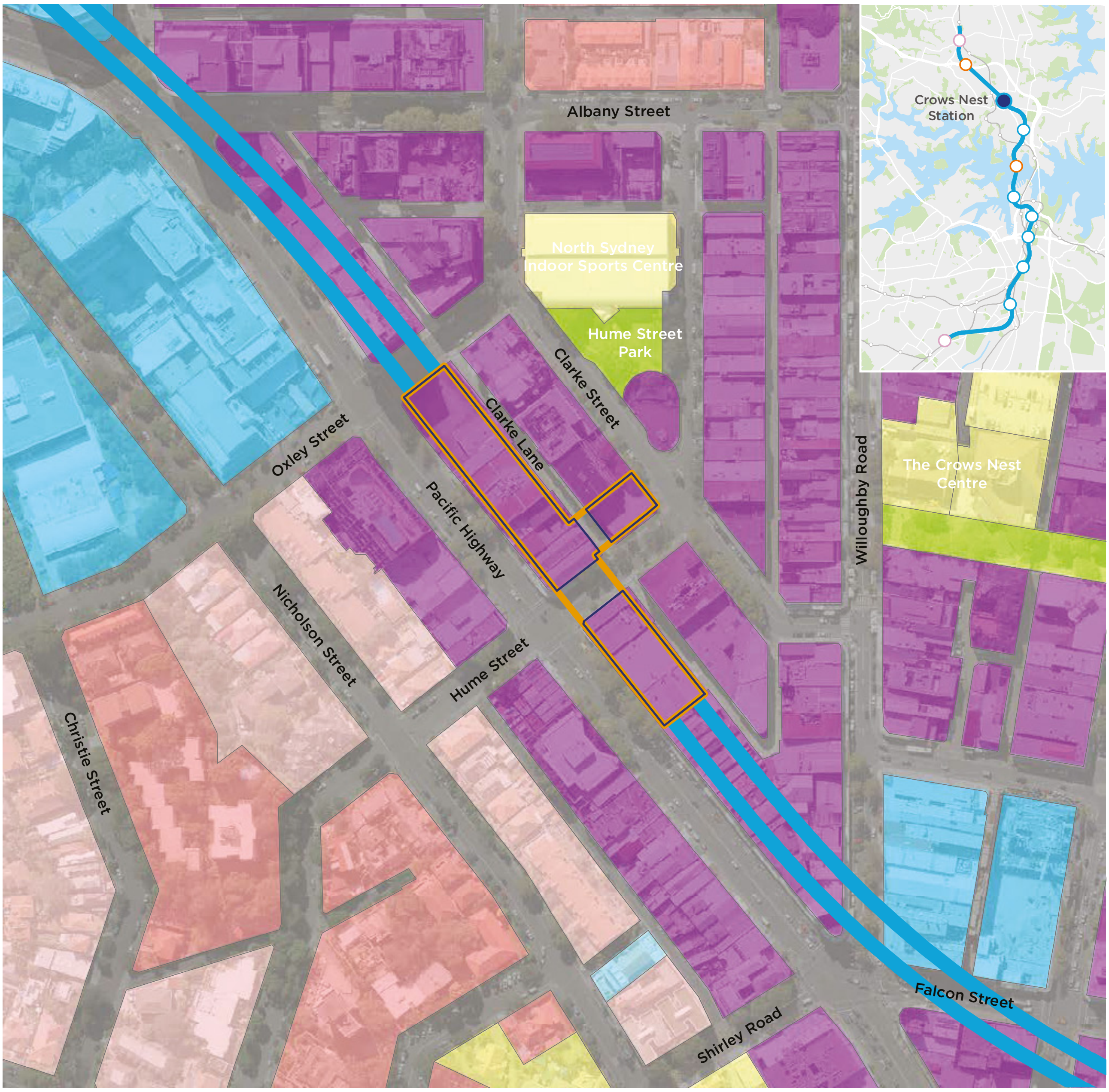
Station precinct – strategic planning context

A Plan for Growing Sydney (NSW Government, 2014) identifies Crows Nest as part of the North Subregion. The following priorities in *A Plan for Growing Sydney* are relevant to the project:

- Improve transit connections through the Global Economic Corridor to better link centres and transport gateways
- Work with councils to identify suitable locations for housing and employment growth coordinated with infrastructure delivery (urban renewal) and train services
- Work with councils to investigate potential future employment and housing opportunities associated with a Sydney Metro station at Crows Nest.

Discussion on the opportunities for future land use and transport integration and opportunities for the proposed station precinct is provided in Section 12.5.

North Sydney Council has also prepared planning precinct studies for the St Leonards / Crows Nest area, including the *St Leonards / Crows Nest Planning Study Precinct 1* (North Sydney Council, 2012) and the *St Leonards / Crows Nest Planning Study Precincts 2 and 3* (North Sydney Council, 2015). These studies identify strategies and initiatives for new open space, investment along the Pacific Highway, improved connectivity, urban design, street-level and residential amenity, and building design in St Leonards and Crows Nest. The study outcome has several options for future development within the precinct, including provisions for preferred built form, pedestrian circulation and amenity and open space.



KEY

Chatswood to Sydenham

Proposed operational area at surface

Proposed construction site area

Land use

- High density residential
- Low to medium density residential
- High density commercial
- Low to medium density commercial
- Community facility
- Recreation
- Transportation and infrastructure
- Mixed use

Existing land use represented on this figure may not be consistent with the underlying zoning of that land.
Indicative only, subject to design development

0 100 m

N

Figure 12-3 Crows Nest Station – existing land use

12.3.4 Victoria Cross Station

Land use

Victoria Cross Station would be located beneath Miller Street (to the north of the Pacific Highway) between Berry and Mount streets, in the commercial core of North Sydney. A station entry would be provided on Miller Street between Berry and Mount streets, and a service building on Miller Street to the south of McLaren Street.

To the north and west of the site is a mixed use precinct comprising education institutions, such as Monte Sant' Angelo Mercy College, and commercial, health, residential, and community facilities. This precinct extends north along Miller Street to Falcon Street and south to the Pacific Highway.

To the east of the station site is the North Sydney CBD including commercial and retail facilities towards the Warringah Freeway. There is also a continuation of commercial and retail facilities, including Greenwood Plaza, to the south of the station site. North Sydney Station is located about 400 metres to the south of the site.

Land use surrounding the site is shown in Figure 12-4.

Planning controls

The majority of the station footprint is within land zoned B3 Commercial Core. The aims of this zone are to provide a wide range of retail, business, office, entertainment, community and other suitable land uses that serve the needs of the local and wider community; to encourage appropriate employment opportunities in accessible locations; and to maximise public transport patronage; and encourage walking and cycling.

A portion of the Victoria Cross Station is also within land zoned B4 Mixed Use. This zone aims to provide a mixture of compatible land uses and integrate suitable business, office, residential, retail and other development in accessible locations so as to maximise public transport patronage and encourage walking and cycling.

The North Sydney LEP 2013 defines the land use zoning in proximity to Victoria Cross Station as a mix of the following zones: B3 Commercial Core, B4 Mixed Use, SP2 Infrastructure, RE1 Public Recreation, B1 Neighbourhood Centre, R2 Low Density Residential, R3 Medium Density Residential and R4 High Density Residential.

As would be the case for the area surrounding Crows Nest Station (see Section 12.3.3 above), North Sydney DCP 2013 may also have potential application to the areas surrounding Victoria Cross Station.

Station precinct – strategic planning context

A Plan for Growing Sydney (NSW Government, 2014) identifies the area surrounding Victoria Cross Station as part of the North Subregion and part of Global Sydney. The following priorities in *A Plan for Growing Sydney* are relevant to the project:

- Enable delivery of key transport projects to facilitate better connections to Global Sydney including Sydney Metro, CBD and South East Light Rail and WestConnex projects
- Work with councils to identify suitable locations for housing intensification and urban renewal, including employment agglomerations, particularly around established and new centres, and along key public transport corridors including Sydney Metro
- Investigate potential future employment and housing opportunities associated with a Sydney Metro station at Victoria Cross.

In addition to the North Sydney DCP 2013 (refer to Section 12.3.3), the *North Sydney Commercial Centre Study 2013* (North Sydney Council, 2013c) and other supporting documents aim to manage the appropriate supply of office development to meet the demand for employment uses appropriate to the area, and support the strategic role of the centre and its overall vitality.

Figure 12-4 Victoria Cross Station – existing land use

12.3.5 Blues Point temporary site

Land use

A temporary site would be required for the removal of tunnel boring machine cutter heads and shields at Blues Point. The temporary site would be located within Blues Point Reserve, a public recreation space on the Sydney Harbour foreshore. Residential areas are located to the north and west of the site and include a mix of low to high density residential dwellings.

The Blues Point temporary site also includes a portion of Crown land.

Land use surrounding the site is shown in Figure 12-5.

Planning controls

The North Sydney LEP 2013 defines the land use zoning within the Blues Point study area as a mix of the following zones: RE1 Public Recreation, R4 High Density Residential, R3 Medium Density Residential and B1 Neighbourhood Centre.

The temporary site and a majority of the area surrounding the site is zoned RE1 Public Recreation. The aims of this zone are to enable land to be used for public open space or recreational purposes; to provide a range of recreational settings and activities and compatible land uses; to protect and enhance the natural environment for recreational purposes; and to ensure sufficient public recreation areas are available for the benefit and use of residents of, and visitors to, North Sydney.

As for the proposed station at Crows Nest (refer Section 12.3.3 above), North Sydney DCP 2013 may also have potential application to the proposed site.

Foreshore Parks and Reserves Plan of Management (North Sydney Council, 2010) applies to the site and identifies objectives and directions for planning, resource management and maintenance of open space within the local government area.

Figure 12-5 Blues Point temporary site – existing land use

12.3.6 Barangaroo Station

Land use

The Barangaroo precinct is located within the western corridor of the Sydney CBD and comprises Barangaroo Reserve, Central Barangaroo and Barangaroo South. Barangaroo Reserve is a six-hectare site located at the northern end of Barangaroo and includes a harbour foreshore park featuring grassed areas, lookouts, walking and cycle paths and a new harbour cove; space for recreation; and a cultural centre. Central Barangaroo, consisting of 5.2 hectares, will be the cultural heart of Barangaroo and include a combination of civic and cultural attractions along with recreational, residential, retail and commercial uses. Barangaroo South will be a mixed use precinct consisting of office buildings, apartments, a hotel, shops, cafes, restaurants, and cultural facilities.

Public transport near the proposed metro station currently includes Wynyard station to the east and ferries at King Street Wharf to the south. Transport for NSW has recently commenced construction of a ferry hub at Barangaroo, which is expected to open in late 2016. Wynyard Walk, a pedestrian tunnel and bridges linking Wynyard Station and Barangaroo is currently under construction and will also be open in 2016.

Barangaroo Station would be located on Hickson Road, south of Munn Street. To the north of the proposed site is Barangaroo Reserve and Walsh Bay. To the west is the Central Barangaroo precinct. To the south is Barangaroo South, King Street Wharf, and the Cockle Bay and Darling Harbour precinct, which has a number of waterfront bars and restaurants, boutique commercial suites, office buildings, luxury apartments and cultural facilities. To the east of the proposed station site is Millers Point with the Sydney CBD further to the east.

Land use surrounding the site is shown in Figure 12-6.

Planning controls

The *State Environmental Planning Policy (Major Development) 2005* (NSW Government, 2005a) Barangaroo Land Zoning Map defines the land use zoning within the Barangaroo precinct as a mix of RE1 Public Recreation (Barangaroo Reserve and public foreshore) and B4 Mixed Use (for the remainder of the precinct).

The *Sydney Local Environmental Plan 2012* (Sydney LEP 2012) defines the land use zoning surrounding the Barangaroo precinct as a mix of the following land use zones: R1 General Residential, B1 Neighbourhood Centre, B8 Metropolitan Centre, RE1 Public Recreation and SP2 Infrastructure.

Most surface elements of Barangaroo Station (station entries and traction substation) would be located within the Central Barangaroo development area and some station elements would be located within Hickson Road. Given that Hickson Road is located within the B4 Mixed Use zone at this location, all elements of Barangaroo Station would be within land zoned B4 Mixed Use. The aims of this zone are to provide a mixture of compatible land uses and integrate suitable business, office, residential, retail and other development in accessible locations so as to maximise public transport patronage and encourage walking and cycling.

Sydney Development Control Plan 2012 (Sydney DCP 2012) supplements Sydney LEP 2012 and provides more detailed provisions to guide future development, such as building form and controls (ie setbacks, site coverage, building design, parking, access, landscaping etc). The Sydney DCP 2012 aims to recognise and reinforce the distinctive characteristics of the City of Sydney's neighbourhoods and centres; protect and enhance the public domain; encourage design that maintains and enhances the character and heritage significance of heritage items and heritage conservation areas; and encourage ecologically sustainable development and reduce the impacts of development on the environment.

KEY

Chatswood to Sydenham

Proposed operational area at surface

Proposed construction site area

Existing suburban rail

Land use

General residential

Metropolitan centre

Low to medium density commercial

Community facility

Recreation

Transportation and infrastructure

Mixed use

Existing land use represented on this figure may not be consistent with the underlying zoning of that land.
Indicative only, subject to design development

0 100 m

N

Figure 12-6 Barangaroo Station – existing land use

Station precinct – strategic planning context

A Plan for Growing Sydney (NSW Government, 2014) identifies Barangaroo as part of the Central Subregion and Global Sydney. The following priorities in *A Plan for Growing Sydney* are relevant to the project:

- Enable delivery of key transport projects to facilitate better connections to Global Sydney including Sydney Metro, CBD and South East Light Rail and WestConnex
- Work with councils to identify suitable locations for housing intensification and urban renewal, including employment agglomerations, particularly around established and new centres, and along key public transport corridors including Sydney Metro
- Facilitate delivery of Barangaroo to increase capacity for mixed uses including employment and housing, a major new area of open space and a new ferry hub
- Improve public transport connections to Barangaroo.

Sustainable Sydney 2030 Strategic Plan (City of Sydney, 2008) also nominates the following key priorities:

- Extend the commercial core to Barangaroo and position Sydney – and Australia – for the next wave of global economic development
- Provide essential public transport and pedestrian and cycling connections between the established commercial core and Barangaroo.

The Barangaroo Current Approved Concept Plan (Modification 7) 2014 also addresses strategic urban design and policy initiatives and provides the statutory planning approvals process to guide the urban renewal of Barangaroo.

12.3.7 Martin Place

Land use

The area around the proposed site for Martin Place Station is influenced by two of Central Sydney's most prominent urban plazas, Chifley Square and Martin Place. The area is traversed by several important civic streets, including Elizabeth, Castlereagh and Hunter streets, which are fronted by office towers with intermittent mature trees creating important streetscape vistas.

The proposed Martin Place Station would serve as the primary transport gateway to the financial core, a precinct of the Sydney CBD that occupies about 50 hectares of the most prestigious real estate in the Sydney CBD.

Martin Place Station would have two entrances between Castlereagh and Elizabeth streets – one south of Hunter Street and the other immediately south of Martin Place.

To the north of the proposed Martin Place Station is the northern Sydney CBD and Circular Quay precinct. To the east are Sydney Hospital and the State Library of NSW and the Botanic Gardens subprecinct including the Royal Botanic Gardens, The Domain and the northern tip of Hyde Park. It is a major cultural, social and leisure destination throughout the working week, on weekends for leisure trips into the Sydney CBD and for major cultural events throughout the year.

To the south of the proposed Martin Place Station, the midtown retail precinct is the major destination for shopping in the Sydney CBD and has a high amount of pedestrian activity. The retail precinct is anchored on Pitt Street Mall and comprises major shopping centres and retail outlets, the Queen Victoria Building and numerous smaller malls and arcades. To the west of Martin Place is the western corridor, which is a mixed commercial precinct offering a different built form and character to that of the financial core.

Key attractors within a five-minute walk of the proposed Martin Place Station include Museum of Sydney, State Library, NSW Parliament, Sydney Hospital, The Mint, Hyde Park Barracks, Hyde Park, Pitt Street Mall.

The construction area for the station includes a portion of Crown land within the Martin Place pedestrian zone.

Land use surrounding the site is shown in Figure 12-7.

Planning controls

The Sydney LEP 2012 defines the land use zoning in proximity to the proposed Martin Place Station as a mix of the following zones: B8 Metropolitan Centre, RE1 Public Recreation and SP2 Infrastructure.

The majority of the proposed station footprint is within land zoned B8 Metropolitan Centre. The aims of this zone are to provide an opportunity for the dominant role of business, office, retail, entertainment and tourist premises, commensurate with Sydney's global status.

As for the proposed Barangaroo Station (refer above) Sydney DCP 2012 may also have potential application to the proposed site.

Station precinct – strategic planning context

A Plan for Growing Sydney (NSW Government, 2014) identifies Martin Place as part of the Central Subregion and Global Sydney. The following priorities in the report would be potentially relevant to the project:

- Preserve a corridor for the Sydney Rapid Transit.
- Enable delivery of key transport projects to facilitate better connections to Global Sydney including Sydney Metro, CBD and South East Light Rail and WestConnex
- Improve access to the CBD including through Sydney Rapid Transit[1] and the CBD and South East Light Rail
- Support the land use requirements of the financial services knowledge hub in the Sydney CBD.

The *City North Public Domain Plan* (City of Sydney, 2015b) is part of the *City Centre Public Domain Plan* and includes specific information on Martin Place. The *City North Public Domain Plan* outlines ideas for improving city streets and open spaces and proposes a range of strategies to improve the experience of Martin Place as a destination in its own right, including ensuring that buildings contribute to an active place, and urban elements provide a high quality background to the human experience of the place.

Sustainable Sydney 2030 Strategic Plan (City of Sydney, 2008) also nominates the following key priorities that are supported by the project:

- A focus on central Sydney as the economic heart of Global Sydney and providing direct connection and accessibility to other economic centres in Sydney's Global Economic Corridor
- Support and plan for enhanced access by public transport from greater Sydney to central Sydney while reducing road congestion.

1 *Sydney Metro City and Southwest was previously called Sydney Rapid Transit*

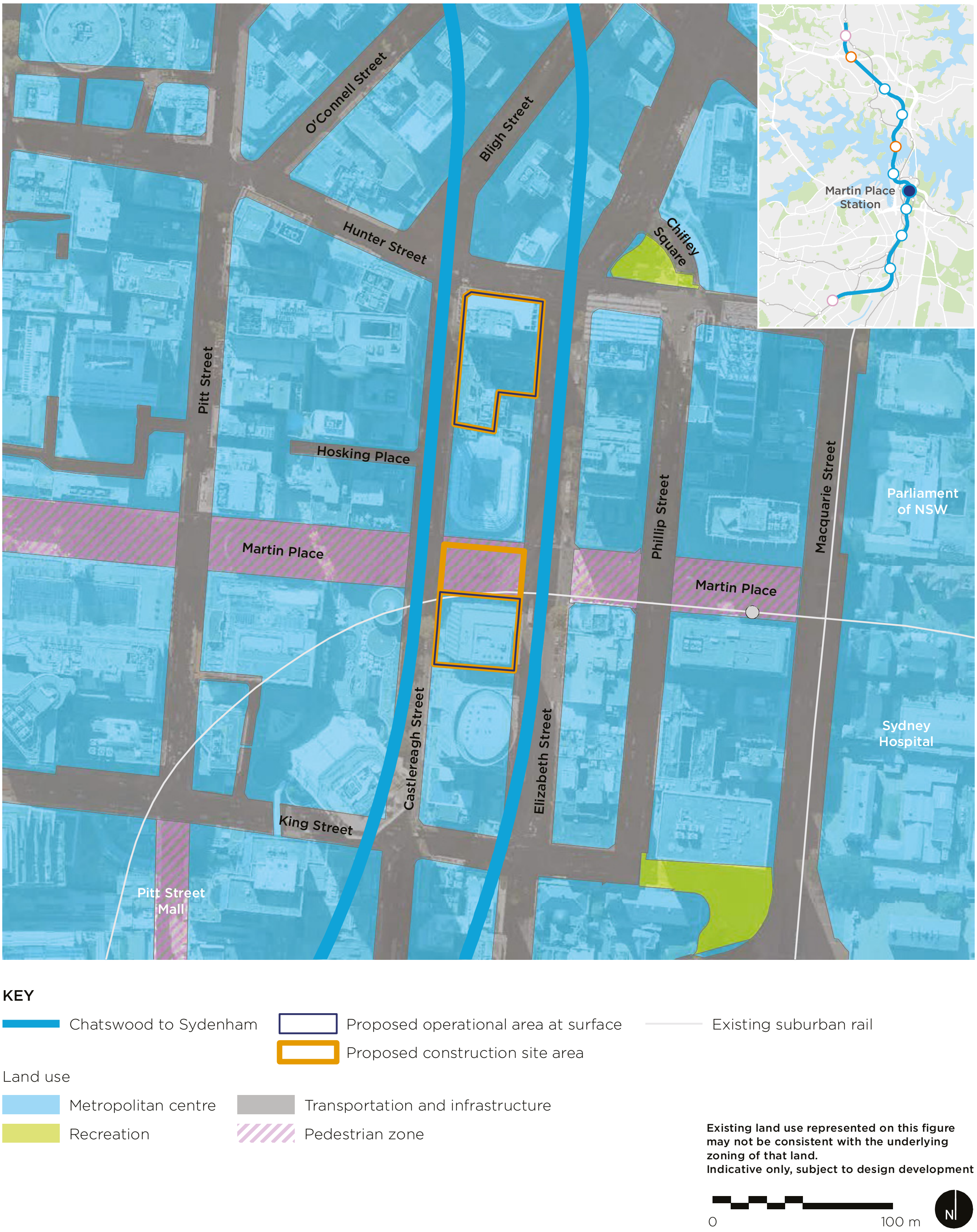


Figure 12-7 Proposed Martin Place Station – existing land use

12.3.8 Pitt Street Station

Land use

Pitt Street station would be located between Castlereagh and Pitt streets, north of Park Street and south of Bathurst Street in the Sydney CBD. This is one of the busiest parts of the city. The site is a short walk from, and in view of, some of Sydney's most prominent landmarks and attractions.

To the north of the proposed site, the midtown retail precinct is the major destination for shopping in the Sydney CBD and has a high amount of pedestrian activity. The retail precinct is anchored on Pitt Street Mall and comprises major shopping centres and retail outlets, the Queen Victoria Building and numerous smaller malls and arcades.

To the north and west is the 'western corridor', the western face of Sydney's CBD. It is a mixed commercial precinct offering a different built form and character to that of the financial core. The western corridor is the location of a number of multi-national corporations. West of the proposed site is Darling Harbour and associated tourist atttactions such as Cockle Bay, King Street Wharf, Darling Quarter, Sydney Aquarium and the new (under construction) Sydney international convention, exhibition and entertainment precinct.

South of the station is Chinatown and the southern Sydney CBD broadly bounded by Bathurst, Elizabeth, Harbour and Hay streets. The southern Sydney CBD and Haymarket is the most diverse and active precinct within the Sydney CBD, comprising cinemas, restaurants, shops, bars, clubs, tourist accommodation, high density residential and office spaces.

East of the station is Hyde Park and Eastern Sydney, encompassing St Mary's Cathedral, the Australian Museum and the western end of Oxford Street.

Key attractors within a five-minute walk of the proposed station include the major shopping centres, Queen Victoria Building, Chinatown, World Square, Town Hall, major cinemas and Hyde Park.

Land use surrounding the site is shown in Figure 12-8.

Planning controls

The Sydney LEP 2012 defines the land use zoning in proximity to the proposed Pitt Street station as a mix of the following land use zones: B8 Metropolitan Centre, RE1 Public Recreation and SP2 Infrastructure

The majority of the station footprint is within land zoned B8 Metropolitan Centre. The aims of this zone are to provide an opportunity for the dominant role of business, office, retail, entertainment and tourist premises, commensurate with Sydney's global status.

As for the proposed Barangaroo Station (refer above) Sydney DCP 2012 may also have some potential application.

Station precinct – strategic planning context

The station strategic planning context for Pitt Street Station is the same as that presented for Martin Place (refer Section 12.3.7).

KEY

Chatswood to Sydenham

Proposed operational area at surface

Proposed construction site area

Existing suburban rail

Land use

Metropolitan centre

Transportation and infrastructure

Recreation

Existing land use represented on this figure may not be consistent with the underlying zoning of that land.
Indicative only, subject to design development

0 100 m

N

Figure 12-8 Pitt Street Station – existing land use

12.3.9 Central Station

Land use

The proposed metro platforms at Central Station would be located underground between intercity rail platforms and suburban rail platforms.

The Central Station precinct is a major interchange between all rail services, buses, coaches and light rail. There is a major bus stop on Eddy Avenue which experiences high bus volumes, with university students travelling to and from the University of NSW in Randwick making up a significant proportion of the demand. Railway Square, bounded by George Street and Lee Street is the site of another large bus interchange. George Street and Elizabeth Street are the main north–south roads through the western and eastern edge of the precinct. They experience high traffic volumes and are major bus routes. The CBD and South East Light Rail will have a stop at Central Station on Chalmers Street.

To the north of Central Station are the precincts of Chinatown and the southern Sydney CBD broadly bounded by Bathurst, Elizabeth, Harbour and Hay streets. The southern Sydney CBD and Haymarket is the most diverse and active precinct within the Sydney CBD, comprising cinemas, restaurants, shops, bars, clubs, tourist accommodation, high density residential and office spaces.

Darling Harbour is northwest of Central Station and includes tourism, entertainment and leisure attractions such as Cockle Bay, King Street Wharf, Darling Quarter, Sydney Aquarium and the new Sydney international convention, exhibition and entertainment precinct. To the west is the Sydney education and health precinct, which is a major driver of economic activity and prosperity within Global Sydney. The precinct extends to the west along Broadway to encompass the Sydney Institute of TAFE, University of Technology, Notre Dame University, The University of Sydney and Royal Prince Alfred Hospital.

To the south and east of the station are Surry Hills and Chippendale, which have become a creative cluster of Global Sydney, attracting advertising, design, architecture, engineering and boutique services.

Some major attractors within a five minute walk of Central Station include World Square, Chinatown, Sydney Entertainment Centre, Sydney Institute of TAFE, UTS, Central Park, Prince Alfred Park and Railway Square.

Land use surrounding the proposed site is shown in Figure 12-9.

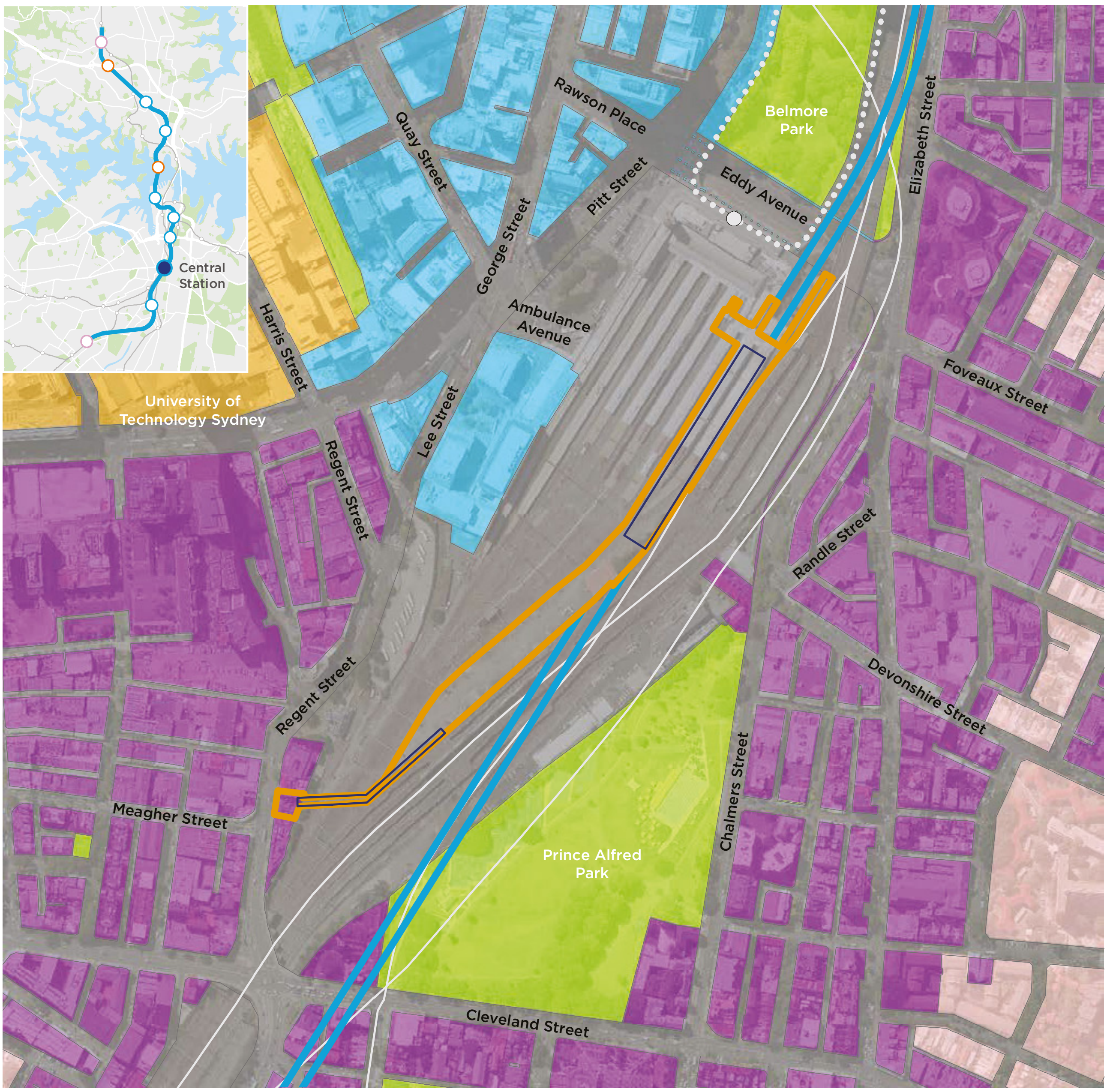
Planning controls

The Sydney LEP 2012 defines the land use zoning within the Central Station study area as a mix of the following zones: SP2 Infrastructure, B8 Metropolitan Centre, RE1 Public Recreation, B4 Mixed Use and R1 General Residential.

With the exception of the proposed access at Regent Street the station footprint is contained within land zoned SP2 Infrastrucure. The aims of this zone are to provide for infrastructure and related uses and to prevent development that is not compatible with, or that may detract from, the provision of infrastructure.

The proposed construction access at Regent Street is zoned B4 Mixed Use. The aims of this zone include to provide a mixture of compatible land uses to integrate suitable business, office, residential, retail and other development in accessible locations so as to maximise public transport patronage, encourage walking and cycling and ensure uses support the viability of centres.

As for the proposed Barangaroo Station (refer above) Sydney DCP 2012 may also have potential application to the proposed site.



KEY

Chatswood to Sydenham

Proposed operational area at surface

Proposed construction site area

Existing suburban rail

Land use

General residential

Metropolitan centre

Educational establishment

Recreation

Transportation and infrastructure

Mixed use

Existing land use represented on this figure may not be consistent with the underlying zoning of that land.
Indicative only, subject to design development

0 200 m

N

Figure 12-9 Central Station – existing land use

Station precinct – strategic planning context

A Plan for Growing Sydney (NSW Government, 2014) identifies Central Station as part of the Central Subregion and Global Sydney. The following priorities in the report are relevant to the project:

- Enable delivery of key transport projects to facilitate better connections to Global Sydney including Sydney Metro, CBD and South East Light Rail and WestConnex
- Work with councils to identify suitable locations for housing intensification and urban renewal, including employment agglomerations, particularly around established and new centres, and along key public transport corridors including Sydney Metro
- Support the land use requirements of the financial services knowledge hub in the Sydney CBD
- Investigate opportunities to expand the Sydney CBD in the Central to Eveleigh corridor and implement the UrbanGrowth NSW urban renewal and transport program for Central to Eveleigh.

The project supports the *Sustainable Sydney 2030 Strategic Plan* (City of Sydney, 2008) by further integrating the public transport network at Central Station, Global Sydney's most important public transport interchange. A connected public transport network improves business competitiveness and supports land use development priorities that strengthen local area economies, including in Chinatown and the southern Sydney CBD as well as globally competitive business clusters.

The benefits identified above for areas in the vicinity of Barangaroo, Martin Place and Pitt Street stations are also applicable to the area surrounding Central Station.

12.3.10 Waterloo Station

Land use

Waterloo Station would be located between Botany Road, Cope Street, Raglan Street and Wellington Street. The proposed station would serve as the link between Waterloo and the Global Economic Corridor.

To the north of the proposed site is a commercial and mixed use area leading to Redfern Station. To the east of the proposed site is a low to medium density residential area leading to Moore Park. To the southwest are low density residential and mixed use areas including Australian Technology Park and public recreation areas such as Alexandria Park.

Existing land use surrounding the proposed site is shown in Figure 12-10.

Planning controls

The Sydney LEP 2012 defines the land use zoning in proximity to the proposed Waterloo Station as a mix of the following zones: SP2 Infrastructure, B4 Mixed Use, RE1 Public Recreation, R1 General Residential and B2 Local Centre.

The majority of the proposed station footprint is within land zoned B4 Mixed Use. The aims of this zone are to provide a mixture of compatible land uses and integrate suitable business, office, residential, retail and other development in accessible locations so as to maximise public transport patronage and encourage walking and cycling.

As for the proposed Barangaroo Station (refer above) Sydney DCP 2012 may also have potential application to the proposed site.

Station precinct – strategic planning context

A Plan for Growing Sydney (NSW Government, 2014) identifies Waterloo as part of the Central Subregion. The following priorities in the report are relevant to the project:

- Enable delivery of key transport projects to facilitate better connections to Global Sydney including Sydney Metro, CBD and South East Light Rail and WestConnex
- Work with councils to identify suitable locations for housing intensification and urban renewal, including employment agglomerations, particularly around established and new centres, and along key public transport corridors including Sydney Metro.

Waterloo Station falls within the Redfern-Waterloo Growth Centre area. This area is a priority for Urban Growth NSW who will be working ensure the ageing Waterloo social housing estate is progressively renewed to create a vibrant and more sustainable community with a mix of private, affordable and social housing and that it reaches its full economic and social potential. The urban revitalisation of the area is a priority for the NSW Government.

The project is also consistent with the following key priorities identified in *Sustainable Sydney 2030 Strategic Plan* (City of Sydney, 2008):

- As a Global City, retain focus on the development and urban renewal of central Sydney, including physical infrastructure, development capacity and clusters of high value economic activity
- Ensure renewal plans for the longer term structure of the local area and makes major contributions to the sustainability of the local area.

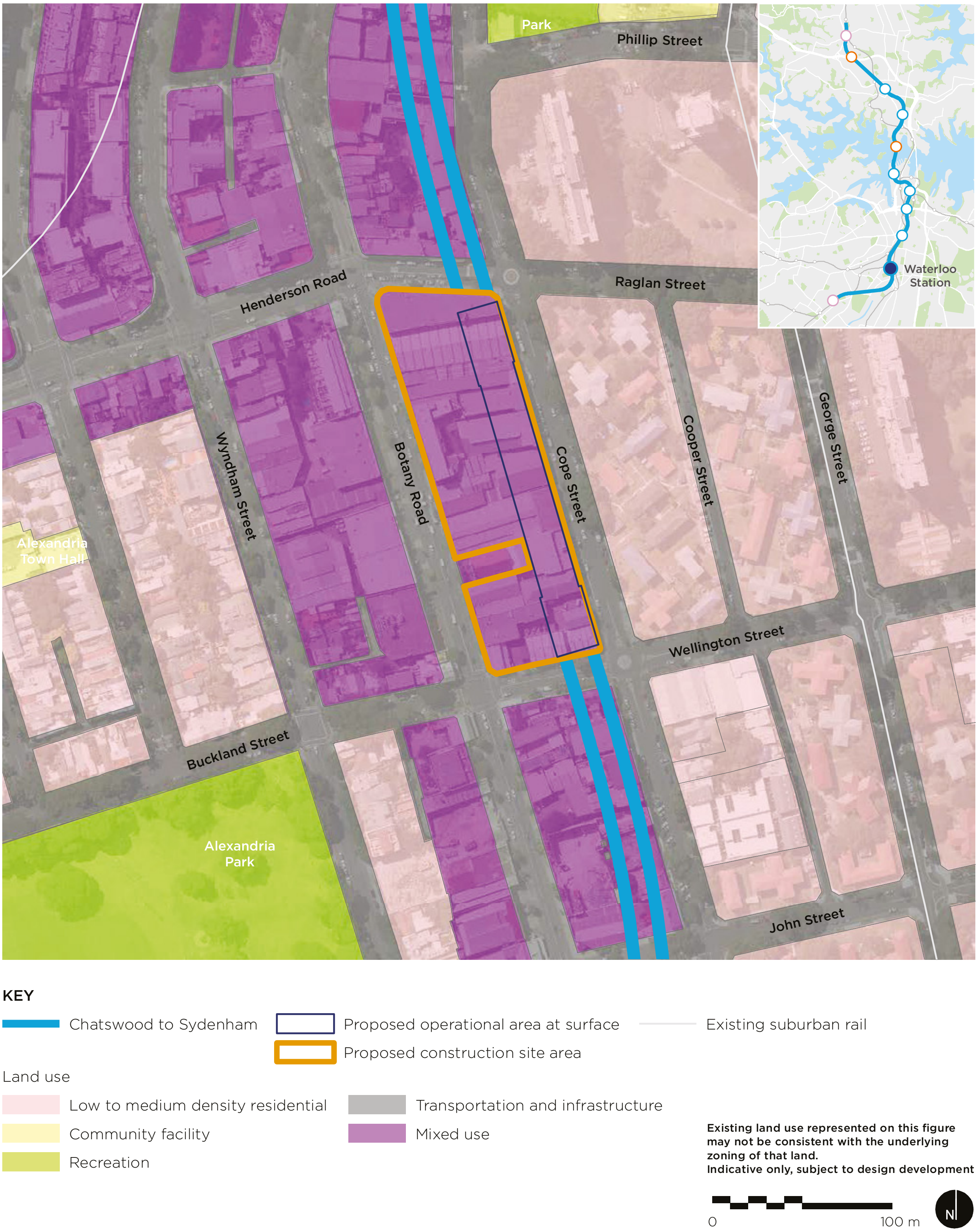


Figure 12-10 Waterloo Station – existing land use

12.3.11 Marrickville dive site (southern) and southern services facility

Land use

The Marrickville dive site would be located northeast of Sydenham Station at Marrickville. The southern services facility would be located adjacent to the Marrickville tunnel portal.

To the north of the proposed dive site is a general industrial area. To the east of the proposed site is generally a low-density residential area interspersed with high density residential. To the south and west of the site is a general and light industrial area followed by a low-density residential area.

The Sydenham Storage Pit, an asset of Sydney Water is located south of the Marrickville dive site. This is a large detention basin that collects urban runoff from areas of Marrickville which is then pumped into the Eastern Channel, and discharges into Cooks River and ultimately to Botany Bay.

Land use surrounding the site is shown in Figure 12-11.

Planning controls

The *Marrickville Local Environmental Plan 2011* (Marrickville Council LEP 2011) defines the land use zoning surrounding the proposed southern tunnel portal site as a mix of the following zones: SP2 Infrastructure, IN1 General Industrial, IN2 Light Industrial, RE1 Public Recreation, R1 General Residential, R2 Low Density Residential and R4 High Density Residential.

The proposed site and immediate surrounds is zoned IN1 General Industrial. The aims of this zone are to provide a wide range of industrial and warehouse land uses, encourage employment opportunities, and minimise any adverse effect of industry on other land uses.

KEY

Chatswood to Sydenham
Proposed dive structure
Proposed operational area at surface
Proposed construction site area
Existing suburban rail

Land use

High density residential
Low to medium density residential
Low to medium density commercial
Educational establishment
Recreation
Industrial
Transportation and infrastructure

Existing land use represented on this figure may not be consistent with the underlying zoning of that land.
Indicative only, subject to design development

0 100 m

N

Figure 12-11 Marrickville dive site and southern services facility – land use

12.4 Potential impacts – property

12.4.1 Surface construction sites

During construction, the main land use and property impacts would relate to property acquisitions. Construction stage land use impacts would largely relate to business and amenity issues (ie visual, noise, air quality, traffic, social impacts etc) and are addressed in other chapters of this Environmental Impact Statement.

The project would require some 98 total property acquisitions and two partial property acquisitions. Property acquisition requirements for the project are summarised in Table 12-2. Many of the station sites would require demolition of buildings and therefore, in addition to acquisition of properties, Transport for NSW would also be required to manage the transfer or cessation of a number of leases within buildings subject to acquisition.

All property acquisition would be managed in accordance with the *Land Acquisition (Just Terms Compensation) Act 1991*. Every effort would be made to acquire the affected properties through negotiated purchase. This requires appropriate compensation to be paid including associated legal costs, valuation fees, relocation and removal expenses, and mortgage costs. For further details see Chapter 2 (Planning and assessment process).

Where the project requires the permanent use of Government owned land (such as at Barangaroo Station, Central Station and at the Marrickville dive site) Transport for NSW would enter into agreements with the relevant Government departments regarding the permanent use of this land – including acquisition or lease arrangements.

Where the project would require temporary use of Government owned land (such as Blues Point temporary site), this would typically be secured by way of a lease or a Memorandum of Understanding. Where privately owned land is temporarily affected, similar options would be available as well as the option for acquisition.

Table 12-2 Property acquisition requirement for the project

Location	Land use (type)	Approx. area of acquisition (m²)	No. of total acquisitions[1]	No. of partial acquisitions[2]
Chatswood dive site (northern)	Mixed use	2371	5	0
	Industrial	20,777	11	0
	Infrastructure – road	605	1	1
Artarmon substation	Temporary education	3164	3	0
Crows Nest Station	Mixed use	4149	5	0
	Commercial / retail	2137	4	1
Victoria Cross Station	Mixed use	177	1	0
	Commercial / retail	5495	7	0
Barangaroo Station	Infrastructure – road	920	0	1
Martin Place Station	Mixed use	3541	4	0
	Commercial / retail	702	3	0
	Residential	241	1	0
Pitt Street Station	Mixed use	980	6	0
	Commercial / retail	1013	2	0
	Hotel	1214	4	0
Central Station	Mixed use	613	10	0
Waterloo Station	Mixed use	12,512	17	0
	Residential	948	1	0
Marrickville dive site (southern)	Industrial	70,000	13	0
Total		131,559	98	3

1 Property acquisition numbers reflect parent lots. Multiple strata titles may exist within parent lots.

2 Number of partial acquisitions to be confirmed based on further consultation with property owners.

12.4.2 Tunnel stratum

It would also be necessary to acquire stratum below the surface of properties for the construction of the project. Under the *Transport Administration Act 1988*, compensation is not payable where stratum is required for the development of underground infrastructure.

This subsurface stratum would be a stratum acquisition envelope around the tunnel, including any tunnel anchors required. The introduction of the subsurface stratum, and the tunnel itself, has the potential to limit development above the alignment. The project alignment is generally shallowest at stations and at tunnel portals (at stations tunnel depths are typically greater than 20 metres) and between stations tunnel depth increases to typically between 25 and greater than 40 metres. Based on proposed tunnel depths there would be a minor impact with respect to limiting future development potential above project infrastructure.

Development applications within the project corridor would be referred to Transport for NSW for concurrence and to ensure that project infrastructure is not impacted by proposed developments.

12.5 Potential impacts – land use

The project would provide the opportunity for future land use change. Sydney Metro has commenced discussions with the Department of Planning and Environment, Urban Growth NSW and local Councils to develop an appropriate land use planning framework for the stations to ensure that any proposed over station development is consistent with strategic planning requirements.

Land use changes would occur largely in response to the introduction of new metro stations at Crows Nest, Victoria Cross and Waterloo. Land use changes associated with new stations at Barangaroo, Pitt Street, Martin Place and Central would be minor given the current intensity and diversity of development on and near to these sites.

The project would have a very minor land use impact with respect to the acquisition of property currently subject to development applications and / or subject to recently approved development applications. Development applications in the vicinity of proposed station sites are typically for residential or mixed use developments, and would be consistent with the relevant strategic land use planning objectives.

A discussion on each of the sites is provided below.

12.5.1 Chatswood dive site (northern)

The impact of the change in land use at the Chatswood dive site from electricity infrastructure and retail property fronting Pacific Highway to railway infrastructure would be minor.

At the completion of construction there is likely to be residual land at this location (land required for construction purposes that is not required for operation of the project). A change in land use may result depending on the proposed future use of the land and Transport for NSW would review opportunities for the appropriate reuse of this land in consultation with the relevant council.

12.5.2 Artarmon substation

The construction of a traction substation would result in a change in land use at the site from an area housing temporary education to transport infrastructure, although the sites use as a temporary education facility would otherwise cease prior to its use by the project. The change in land use would limit or remove the potential for future redevelopment of the site for residential purposes (that may have otherwise been possible given its R3 Medium Density Residential zoning).

The project would create a small area of residual land at the site. This residual land would have limited opportunity for reuse given its size, shape and location. The land use impact at this site would be minor, limited to potentially being unable to redevelop the land for residential purposes in the future.

Details relating to other amenity impacts that may influence (or limit) the future land use at the site (such as visual, noise, traffic, air quality) are discussed in the relevant issue chapters.

12.5.3 Crows Nest Station

Direct impacts on existing land use

The direct impact on land use at this site would be a change from mixed use (commercial / retail) and residential areas to transport infrastructure.

Given the small scale of this change, land use impacts would be minor. This minor impact may be offset by the replacement and / or expansion of mixed use development in the area associated with potential over station development opportunities.

Land use / transport integration and opportunities

A proposed metro station at Crows Nest would support State and local strategic priorities and planning controls by providing an incentive for investment along the Pacific Highway. This would enhance urban design and amenity, and improve connectivity in Crows Nest. It is expected that the station would have the following specific benefits:

- Residential and mixed use land uses surrounding the station would directly benefit from additional transport connectivity to the Global Economic Corridor
- The station would provide the opportunity for further development of the area as a mixed use centre with strong public transport links to North Sydney and the Sydney CBD and other centres throughout the Global Economic Corridor. The station would provide further incentive for the area to evolve as a vibrant and active centre comprising offices, retailing, community facilities, recreation, cultural, leisure, education and housing within walking distance of a station
- The increased utilisation of the existing employment area extending along Willoughby Road, Christie Street and the Pacific Highway could deliver an increase in new jobs in an area with high levels of amenity, recreation opportunities and good access to public transport
- The station would provide opportunities to increase residential densities within walking distance of the station.

As indicated above these strategies and opportunities would be developed in consultation with the Department of Planning and Environment, the Greater Sydney Commission and North Sydney Council.

The project would also provide local opportunities to enhance permeability and accessibility in the locality, including improved connections across the Pacific Highway and pedestrianisation of key retail streets. These opportunities do not form part of this project, but would be subject to council master-planning processes and funding.

12.5.4 Victoria Cross Station

Direct impacts on existing land use

The direct impact on land use at this site would be a change in land use from commerical core / mixed use to transport infrastructure. Given the small scale of the change, the land use impacts would be minor. This minor impact may be mitigated by the replacement and / or expansion of areas of mixed use land associated with potential over station development.

Land use / transport integration and opportunities

A metro station at Victoria Cross would support State and local strategic priorities and planning controls by enhancing North Sydney's character and improving connectivity to employment, residential properties, services, cultural and recreational activities.

It is expected that the proposed Victoria Cross Station would have the following specific benefits:

- The North Sydney commercial core, centered on Berry Street, Miller Street, Walker Street and the Pacific Highway would benefit from additional transport connectivity to the Global Economic Corridor
- The station would benefit significant educational institutions including the Australian Catholic University, Northern Sydney Institute of TAFE Bradfield Campus and the nearby high schools and colleges
- The station would further reinforce North Sydney as the northern anchor of Global Sydney and the largest employment centre for Sydney's north. The station, located within the existing commercial core, would provide further incentive for North Sydney to evolve as an active centre of business for the region, comprising offices, retailing, recreation, cultural facilities, educational institutions and housing
- The station would work in tandem with the existing North Sydney Station, serving the northern periphery of the commercial core and stimulating further growth along the Miller Street corridor
- There may be an opportunity to integrate expanded retailing, community uses and cultural facilities within the North Sydney catchment, which would activate a number of new pedestrian links, plazas and squares and cater for the increased numbers of workers, residents and visitors
- The station would provide opportunities to increase residential densities on the periphery of the North Sydney commercial core, but still within walking distance of the station
- The station would provide the opportunity for the renewal and development of a number of sites, such as commercial premises and under-utilised sites west of the Pacific Highway.

These strategies and opportunities would be further developed in consultation with the Department of Planning and Environment, Greater Sydney Commission and North Sydney Council.

12.5.5 Blues Point temporary site

The site at Blues Point is temporary and would only be required during construction. Therefore, there would be no permanent change to land use at the site as a result of the operation of the project. Following construction, the site's current land use would be retained through rehabilitation and restoration of the site to its pre-construction state (and function) as an important harbour foreshore open space.

12.5.6 Barangaroo Station

Direct impacts on existing land use

Barangaroo Station would be located largely below Hickson Road, with permanent (surface) infrastructure proposed either within Hickson Road or within the Central Barangaroo development area. Although currently undeveloped, mixed use developments will be constructed within the Central Barangaroo development area.

An operational Barangaroo Station would represent a major land use change compared with the 'future existing' land use for the site. This change in land use would be consistent and compatible with the substantial level of new development activity occurring in the immediate vicinity of the proposed station site.

Land use / transport integration and opportunities

A metro station at Barangaroo would support State and local strategic priorities and planning controls by meeting the needs of residents, workers and visitors to the precinct and providing connections between the established commercial core within the Sydney CBD and the development at Barangaroo. It is expected that Barangaroo Station would have the following specific benefits:

- The station would further reinforce the Sydney CBD as the anchor of Global Sydney and the largest employment centre within Australia
- The station would serve a growing and evolving concentration of global economic activities located within the heart of the western extension of the Sydney CBD, including international headquarters, financial institutions, law firms, accountants and insurers
- The broader station catchment would benefit the western corridor of the Sydney CBD, encompassing a vibrant and active precinct of commercial, residential, entertainment, cultural and leisure opportunities
- The station would serve an increasingly diverse role throughout the day and week as an events, cultural, retail, employment and transport interchange precinct. The station would provide a western access to the city – from Barangaroo Reserve to the north to Darling Harbour in the south – and provide direct connections to the Sydney Metro network, ferry services, suburban rail at Wynyard and light rail on George Street
- The station – being an interchange with direct access to multiple modes and services to all regions of metropolitan Sydney – would provide the opportunity for the redevelopment of sites nearby.

These strategies and opportunities would be further developed in consultation primarily with the Department of Planning and Environment and the Barangaroo Delivery Authority to integrate the project into the development planned for the Central Barangaroo precinct.

12.5.7 Martin Place Station

Direct impacts on existing land use

The proposed metro station would change immediate land use from metropolitan centre to transport infrastructure. This impact would be minor given the scale of existing development surrounding the site and considering the opportunities for over station development.

Land use / transport integration and opportunities

The proposed metro station at Martin Place would support State and local strategic priorities and planning controls by reinforcing Sydney CBD as an important location for business, education, cultural activities and tourism, facilitating connections to the Global Economic Corridor, and enhancing the character and heritage of the area.

It is expected that a metro station at Martin Place would have the following specific benefits:

- The proposed station would serve an increasingly diverse role throughout the day and week as an events, cultural, retail, employment and transport interchange precinct. Martin Place would be reinforced as the civic spine of the city bounded by Circular Quay, the Royal Botanic Gardens, The Domain, Hyde Park and numerous cultural institutions on Macquarie Street
- The proposed station would further reinforce the Sydney CBD as the anchor of Global Sydney and Australia's largest employment centre. The station would provide further incentive for Sydney CBD to continue to grow and evolve as a focus of global economic activities, including international headquarters, financial institutions, law firms, accountants and insurers
- The proposed station would further drive the attractiveness of Martin Place as the economic engine of the Sydney CBD, increasing connectivity between Martin Place and the strategic centres of the Global Economic Corridor
- The proposed station would provide the opportunity for the renewal and development of a number of underutilised commercial sites between Castlereagh Street and Pitt Street north of Martin Place.

These strategies and opportunities would be further developed in consultation with the Department of Planning and Environment, Greater Sydney Commission and City of Sydney Council.

12.5.8 Pitt Street Station

Direct impacts on existing land use

The proposed metro station would change immediate land use from metropolitan centre to transport infrastructure. This impact would be minor given the scale of existing development surrounding the site and considering the opportunities for over station development.

Land use / transport integration and opportunities

A metro station at Pitt Street would support State and local strategic and planning controls by encouraging economic growth and facilitating connections to the Global Economic Corridor. It is expected that a metro station at Pitt Street would have the following specific benefits:

- The station would provide greater transport connectivity to the Global Economic Corridor for the western corridor, midtown and Chinatown precincts, in addtion to the existing suburban rail services at Town Hall Station
- The station would further reinforce the Sydney CBD as the anchor of Global Sydney and Australia's largest employment centre. The station would provide further incentive for the Sydney CBD to continue to grow and evolve as a focus of global economic activities, including international headquarters, financial institutions, law firms, accountants and insurers
- The station – being an interchange with direct access to multiple modes and services to all regions of metropolitan Sydney – would provide the opportunity for the redevelopment of sites nearby
- The station is likely to reinforce the midtown retail, southern Sydney CBD and Chinatown precincts as the new growth areas of the Sydney CBD and serve the transitional precinct between the midtown retail precinct and the mixed, employment, residential, entertainment, cultural and events based activities within the southern Sydney CBD and Chinatown
- The station would serve as the transport gateway to Eastern Sydney, Hyde Park and Pitt Street Mall. The station would serve an increasingly diverse role throughout the day and week as an events, cultural, retail, employment and transport interchange precinct
- The station may serve provide the opportunity for the renewal and redevelopment of presently underutilised sites within the midtown and southern Sydney CBD precinct.

These strategies and opportunities would be further developed in consultation with the Department of Planning and Environment, Greater Sydney Commission and City of Sydney Council.

12.5.9 Central Station

Direct impacts on existing land use

There would be no change in land use as a result of the construction of new underground platforms at Central Station as the work would be located wholly within the existing station footprint.

The construction of the bridge at Regent Street (Sydney Yard Access Bridge) would result in the permanent loss of a large proportion of a small residential block located on the eastern side of Regent Street. This change in land use from residential to infrastructure would have a moderate to high local impact on land use. However the broader area surrounding the site on Regent Street contains residential and other mixed uses and proportionately the loss of a large part of a small residential block in this location is considered in a regional context to be minor.

Land use / transport integration and opportunities

New underground platforms at Central Station would support State and local strategic priorities and planning controls by encouraging economic growth in the Central to Eveleigh corridor, facilitating connections to the Global Economic Corridor and enabling a range of services and infrastructure that meets the needs of residents, workers and visitors. It is expected that metro platforms at Central Station would have the following specific benefits:

- The proposed underground platforms would serve the southern Sydney CBD, the fastest growing mixed employment, residential, educational and retail area in Global Sydney, with proximity to Chinatown, Darling Harbour, southern Sydney CBD and the educational institutions of the Sydney Institute of TAFE and the University of Technology Sydney
- The proposed underground platforms would further reinforce the Sydney CBD and the Sydney education and health precinct as the anchor of Global Sydney and Australia's largest employment centre
- The proposed underground platforms would reinforce the role of Central as the heart of Sydney's transport network and provide improved network connectivity with access to suburban rail lines, light rail, intercity trains, intercity coaches and bus services to the inner west and southeast
- The proposed underground platforms would provide an opportunity for the renewal and development of a number of sites adjacent the station, comprising the strip of mixed retail, commercial and recreation on the eastern side of Elizabeth Street. It is also likely to reinforce the southern Sydney CBD, Chinatown, Haymarket, Darling Harbour, Ultimo and the Sydney education and health precincts as new growth areas of the Sydney CBD.

These strategies and opportunities would be further developed in consultation with the Department of Planning and Environment, Greater Sydney Commission and City of Sydney Council.

12.5.10 Waterloo Station

Direct impacts on existing land use

The change in land use at the site would be from mixed use retail and residential to transport infrastructure. Relative to the area of mixed use and residential land use types impacted by the project, there are large areas of these land uses remaining in the immediate vicinity of the station site. Given the small scale of the loss, the land use impact would be minor.

In addition, this area is undergoing a transition to intensification of development as part of the revitalisation of the Redfern and Waterloo area. Urban revitalisation proposed for this area would require transport infrastructure (as provided by the project). The potential over station development opportunities at this site would also be consistent with the land use changes associated with urban revitalisation and would likely offset any potential loss in existing land use in the long term.

Land use / transport integration and opportunities

A metro station at Waterloo would support State and local strategic priorities and planning controls by enabling opportunities for urban renewal including housing diversity and intensification, meeting the needs of residents, workers and visitors, and creating a vibrant, sustainable community that it reaches its full economic and social potential. It is expected that a metro station at Waterloo would have the following specific benefits:

- Provide further incentive for the the progressive renewal of the ageing Waterloo social housing estate including a a mix of private, affordable and social housing
- The potential to provide for the further development of the area as a mixed use centre with strong public transport links to the Sydney CBD and other centres throughout the Global Economic Corridor
- Improve access to the existing employment area and could deliver a significant number of jobs in an area with high levels of amenity, recreation and access to public transport
- Provide opportunities to increase residential densities within walking distance of the station.

These strategies and opportunities would be further developed in consultation with the Department of Planning and Environment, Urban Growth NSW, Greater Sydney Commission, City of Sydney Council and other relevant agencies.

The NSW Government will investigate a Special Infrastructure Contribution around Waterloo station to be reserved for the Sydney Metro project and associated infrastructure.

12.5.11 Marrickville dive site (southern) and southern services facility

The introduction of a tunnel dive and services facility at this location would result in a change in land use to a small area of the site from industrial to transport infrastructure. There are currently other areas of industrial land locally and a change in land use at the Marrickville dive site away from its current industrial use, should this occur, would have a minor land use impact.

At the completion of construction there would be a relatively large area of residual land (land required for construction purposes that is not required for operation of the project). Transport for NSW would review opportunities for the appropriate reuse of this land in consultation with the relevant council.

12.6 Mitigation measures

There are no specific mitigation measures that would be implemented to address potential land use and property impacts. A framework for the implementation of mitigation measures is discussed in Chapter 27 (Consolidated environmental mitigation measures and environmental performance outcomes).

BUSINESS IMPACTS

CHAPTER THIRTEEN

13 Business impacts

This chapter provides an assessment of the potential impacts on local businesses as a result of the project, and identifies mitigation measures to minimise these impacts. This chapter draws on information in Technical paper 3 – Local business.

13.1 Secretary's environmental assessment requirements

The Secretary's environmental assessment requirements relating to business impacts, and where these requirements are addressed in this Environmental Impact Statement, are outlined in Table 13-1.

Table 13-1 Secretary's environmental assessment requirements – business impacts

Ref.	Secretary's environmental assessment requirements	Where addressed
10. Socio-economic, Land Use and Property		
10.1	The Proponent must assess social and economic impacts in accordance with the current guidelines.	Business economic impacts are generally addressed in this Chapter. Economic impacts and benefits are addressed in Chapter 3 (Strategic need and justification). Social impacts are addressed in Chapter 19 (Social impacts and community infrastructure).
10.2	The Proponent must assess impacts from construction and operation on potentially affected properties, approved development applications, businesses, public open space, recreational users and land and water users (for example, recreational and commercial fishers, oyster farmers), including property acquisitions/ adjustments, access, amenity and relevant statutory rights.	Business impacts are addressed in Section 13.4. Access impacts are addressed in Chapter 8 (Construction traffic and transport) and Chapter 9 (Operational traffic and transport). Social impacts are addressed in Chapter 19 (Social impacts and community infrastructure). Cumulative impacts are addressed in Chapter 26 (Cumulative impacts).Property and land use impacts are addressed in Chapter 12 (Land use and property).
10.3	Assess the likely risks of the project to public safety, paying particular attention to subsidence risks, bushfire risks and the handling and use of dangerous goods.	Traffic related public safety risks during construction are addressed in Chapter 8 (Construction traffic and transport). Traffic related public safety risks during operation are addressed in Chapter 9 (Operation traffic and transport). Risks associated with subsidence and settlement are addressed in Chapter 17 (Groundwater and geology). Public safety risks are addressed in Chapter 19 (Social impacts and community infrastructure). Bushfire risks and the handling and use of dangerous goods are addressed in Chapter 23 (Hazard and risk).

13.2 Assessment methodology

The assessment of project related impacts on local businesses occurred in five broad stages:

- Examination of the existing business composition and function in each station precinct, which involved:
  - Visiting sites and scoping of local business uses, their operations including operating hours and their proximity to proposed dive sites and tunnel portals, stations and construction areas
  - Defining the employment characteristics of each station precinct using Bureau of Transport Statistics Journey to Work data
  - Analysing 'Employment by Industry' using Australian and New Zealand Standard Industrial Classification (ANZSIC), a standard classification developed by the Australian Bureau of Statistics for use in Australia and New Zealand for the analysis of industry statistics.
- Identification and survey of local businesses to develop an understanding of current business operations
- Review of local business impact studies for comparable projects, including lessons learned and mitigation strategies
- Assessment of impacts based on analysis of research and feedback to define a list of positive and negative impacts, categorised by business type and location, through project construction and operation
- Development of mitigation strategies to minimise construction phase disruption and maximise leverage of the project for local businesses once the project is operational.

13.3 Existing environment

13.3.1 Chatswood dive site (northern)

The Chatswood dive structure and tunnel portal would be located to the south of Chatswood Station and north of Mowbray Road, Chatswood. There would also be surface metro track work and adjustments to the T1 North Shore Line between Chatswood Station and Brand Street, Artarmon, and this may require occasional access to the rail corridor from Brand Street, Drake Street and Hopetoun Avenue.

Local businesses in the Chatswood dive site local business precinct are a mixture of specific destination shopping, such as Nick Scali Furniture and Dulux, or the Ausgrid depot – a government owned facility. The precinct is largely vacant, especially in the small mixed use development on the northeast corner of the Pacific Highway / Mowbray Road intersection. A retail strip runs from the same intersection (Pacific Highway and Mowbray Road) towards Chatswood, ending at the Fehon Road / Gordon Avenue intersection.

This precinct is positioned just to the south of Chatswood City Centre and is near Westfield Chatswood and the new developments associated with the Chatswood Transport Precinct Project, which comprises residential and retail uses associated with the Chatswood Transport Interchange. The Artarmon shops are located on Hampden Road about 400 metres to the south of the Chatswood dive site.

13.3.2 Artarmon substation

Artarmon substation would be located adjacent to the Gore Hill Freeway. There are no businesses in the vicinity that would be impacted, with the Gore Hill Freeway separating the site from the Artarmon Industrial Area. The land is being temporarily used by Artarmon Public School, but this use is expected to finish before the start of construction.

13.3.3 Crows Nest Station

Overview of the local business precinct

Crows Nest Station would be located between the Pacific Highway and Clarke Lane (on the eastern side of the Pacific Highway).

The local business precinct for assessment purposes has been identified as an area that extends along the Pacific Highway and into surrounding streets from Albany Street in the north to Rocklands Road in the south, spanning both the southern extents of St Leonards and Crows Nest.

Local businesses in the Crows Nest Station precinct are based around two retail strips on the Pacific Highway and Willoughby Road. These two strips meet at the corner of Falcon Street, River Road, Willoughby Road and the Pacific Highway. At present there is a distinguishable gap in the level of retail trade and demand for commercial space between the two main retail areas.

Crows Nest has many small businesses, many of which are retail, food and beverage, or local commercial services. The St Leonards part of the precinct contains the southern extension of the commercial centre of St Leonards with a range of office buildings. Several of these office buildings are under review for redevelopment as mixed-use development (predominantly residential use with a minimum amount of office space).

At the most recent Census (2011), there were 15,857 people working in the Crows Nest Station precinct. The main employment areas were professional services (6097 jobs), IT & media (1024 jobs) and financial and insurance services (912 jobs). This reflects the commercial core of St Leonards which has a strong secondary finance sector and a major IT and media presence. Accommodation and food services (908 jobs) and retail trade (889 jobs) reflect the intensive nature of ground floor retail, especially around Crows Nest.

Willoughby Road

Site analysis indicates that the retail strip along Willoughby Road is a well-performing and patronised retail sub-precinct that, for the most part, has low vacancy and a diverse mixture of businesses including restaurants, cafes, smaller clothes shop, health clubs, special use stores and multiple second and third level offices. The majority of business premises are in two-storey buildings along Willoughby Road with taller, three to four-storey office buildings behind the main retail strip.

The Willoughby Road sub-precinct is relatively close to St Leonards Station, with high levels of amenity and a passive, traffic-calmed main street (Willoughby Road) with shared walking / pedestrian zones.

The Pacific Highway

The retail strip along the Pacific Highway through St Leonards and south into Crows Nest is not experiencing the same level of retail business activity as Willoughby Road. Site analysis indicated considerable vacancy from Albany Street through to the junction of the Pacific Highway with Willoughby Road.

Over the past decade, there has been a considerable shift in business functions in this precinct. Previously, there was a more visible and active presence of furniture and homewares stores, as well as a busy restaurant precinct near the junction with Willoughby Road and Falcon Street. A number of anchor furniture retailers have moved, with a loss of tenants such as Freedom Furniture, Captain Snooze and Carpet Call to the Home HQ homemaker centre in Artarmon.

The majority of the restaurant trade is now focussed on Willoughby Road and the surrounding streets. Similar to other major thoroughfares, including Parramatta Road and the Princes Highway, a considerable proportion of restaurants and cafés have moved to areas with greater amenity and away from the heavily trafficked major roads.

Travel patterns

Parts of the local business precinct have strong public transport connectivity to the Sydney CBD and other centres along the T1 North Shore Line. Parts of the local business precinct fall within the walking catchment of St Leonards Station and this constitutes a high proportion of commuter trips. The precinct is serviced by buses along the Pacific Highway, Falcon Street and Willoughby Road and contains a number of council-owned parking facilities.

It is evident from the Journey to Work data for Crows Nest Station precinct (Bureau of Transport Statistics, 2011) that there is still a heavy reliance on private transport to the precinct with 53 per cent of commuter trips made by private car with only 31 per cent of commuters using public transport (rail 21 per cent and bus 10 per cent). This is a major consideration for business impacts from the project as interruptions to car travel can affect access to businesses for employees, customers and suppliers.

Future vision for this precinct

A *Plan for Growing Sydney* (Department of Planning and Environment, 2014) identifies St Leonards as a Strategic Centre in the North Subregion. The priorities in the plan focus on maintaining a commercial core in addition to bolstering the capacity for mixed-use development. Further, the plan outlines the need to find further capacity for additional employment space and housing around a future station at Crows Nest.

The Crows Nest Station precinct is likely to extend the St Leonards Strategic Centre and support more residential uses, while still maintaining a solid retail strip along Willoughby Road. Support for additional residential uses is illustrated by two recent planning proposals in the Lane Cove Council area for the Leighton and Charter Hall office towers, which propose to convert the majority of the land use to residential. The precinct's proximity to the Royal North Shore Hospital would ensure a retention and possible addition of commercial uses in the fields of health and education, creating a cluster of ancillary health businesses and services around the Hospital.

13.3.4 Victoria Cross Station

Overview of the local business precinct

Victoria Cross Station would be located beneath Miller Street (to the north of the Pacific Highway) between McLaren Street and south of Berry Street within the North Sydney commercial centre. A station entry would be provided on Miller Street between Berry and Mount streets, and a service building on Miller Street to the south of McLaren Street.

The local business precinct identified for assessment purposes comprises much of the North Sydney commercial centre.

At the most recent Census (2011), there were 41,993 people working in the Victoria Cross Station precinct. The main employment areas were professional, scientific and technical services (12,766), financial and insurance services (6528 jobs) and information media and telecommunications (3002 jobs).

The local business precinct includes the commercial centre of North Sydney which is part of Global Sydney. The majority of businesses are housed in office buildings; however, there is a considerable retail presence and a number of health and education uses, many of which are commercial operations.

There is a core local business activity area located around the station bounded generally by Berry Street, Walker Street, Miller Street and the Pacific Highway. The core activity area has some large shopping centres and a considerable retail presence on the Pacific Highway, Miller Street and Berry Street. The area has noticeable street front and shopping centre vacancies, though the spread of vacancies is uneven and some areas are performing better than others.

The major retail and commercial areas in the Victoria Cross Station precinct are:

- North Point Plaza at Victoria Cross, which comprises 16 specialty stores (including hair and beauty, travel agents, gifts and homewares) and a food court. Based on site inspections, there were low vacancy rates in the centre
- Berry Square located at 77 Berry Street, which comprises 36 specialty shops across two levels and is anchored by Officeworks. This centre is underperforming, with a considerable number of vacancies, especially on the second floor
- Greenwood Plaza, which is the busiest retail centre in North Sydney with direct access to North Sydney Station. Greenwood Plaza is owned by Mirvac and benefits from the multiple access and egress points crossing the Pacific Highway, which means many commuters pass through the centre in order to get to and from the station
- Montrose (213–215 Pacific Highway) and The London (156 Pacific Highway), which are two recently completed mixed-use developments with ground floor retail tenancies and first floor commercial tenancies of which nearly all are vacant. These two projects, coupled with Berry Square shopping centre, are key areas that are underperforming
- Miller Street between Victoria Cross and Berry Street, which is performing comparatively well. There is a range of retail, financial services (banks), cafes and restaurants fronting Miller Street. The ground floor shows relatively few vacancies with strong pedestrian foot traffic
- The Pacific Highway between Miller Street and Berry Street, which is performing relatively poorly. There is considerable retail vacancy on both sides of the road as well as visible ground floor vacancy of commercial buildings. A number of commercial buildings have been converted to residential in the last five years.

An ongoing local business issue in the North Sydney CBD has been the lack of strong retail trading outside office hours, especially weekend trading.

Travel patterns

The local business precinct has strong private and public transport connectivity to other parts of Metropolitan Sydney with three main arterial roads and a station that directly connects Sydney's North Shore to the Sydney CBD and multiple other employment centres including Chatswood, Parramatta and North Ryde / Macquarie Park.

North Sydney Station provides good connectivity to various regions around Sydney. It is a major station on the T1 North Shore Line, connecting to the T1 Northern Line via Macquarie Park. The local business precinct is also well serviced by buses connecting to other Sydney regions, including the Northern Beaches and the Lower North Shore.

The Journey to Work data (Bureau of Transport Statistics, 2011) shows the most popular mode of travel for commuters to North Sydney is train (46 per cent), followed by car (30 per cent) and bus (11 per cent).

Future vision for this precinct

A Plan for Growing Sydney (Department of Planning and Environment, 2014) identifies North Sydney CBD as part of Global Sydney and within the bounds of the Sydney CBD. North Sydney CBD is forecast to grow as one of the largest strategic centres in the Sydney metropolitan area. The plan highlights two priorities for the strategic centre:

- Retain a commercial core in North Sydney CBD for long term employment growth
- Investigate potential future employment and housing opportunities associated with a station at Victoria Cross.

It is critical for Global Sydney that North Sydney can increase its commercial presence and become a successful mixed-use centre in its own right. Better connectivity to multiple regions throughout Sydney as a result of Sydney Metro would significantly boost North Sydney's role within Global Sydney and the city more broadly.

13.3.5 Blues Point temporary site

The Blues Point temporary site would be located within Blues Point Reserve at the end of Blues Point Road. The site is currently used as a park and a public car park. The nearest businesses are a restaurant at McMahons Point wharf, the Blues Point Hotel, delicatessen and hairdresser near the Blues Point Road / French Street intersection and the retail strip north of the Blues Point Road / Mill Street intersection.

13.3.6 Barangaroo Station

Overview of the local business precinct

The proposed station at Barangaroo would be located beneath the northern end of Hickson Road. It would be strategically located with a station entrance within Central Barangaroo providing immediate access to commercial, mixed-use and entertainment precincts within the Barangaroo development.

Barangaroo is located within the western corridor of the Sydney CBD and comprises Barangaroo Reserve, Central Barangaroo and Barangaroo South. Barangaroo Reserve is a six-hectare site located at the northern end of Barangaroo and includes a harbour foreshore park featuring grassed areas, lookouts, walking and cycle paths and a new harbour cove; space for recreation; and a cultural centre. Central Barangaroo, consisting of 5.2 hectares, will be the cultural heart of Barangaroo and will include a combination of civic and cultural attractions along with recreational, residential, retail and commercial uses. Barangaroo South is being developed as a mixed use precinct consisting of office buildings, apartments, a hotel, shops, cafes, restaurants, and cultural facilities.

There is already a considerable existing employment base in the Barangaroo local business precinct established by the commercial and retail businesses on the eastern side of Hickson Road / Sussex Street. At the most recent Census (2011), there were 5659 people working in the Barangaroo Station precinct. The main employment areas were professional, scientific and technical services (1333 jobs), financial and insurance services (1193 jobs) and construction (971 jobs) associated with the development of Barangaroo. Employment in Barangaroo is expected grow substantially, with new developments expected to ultimately support over 24,000 permanent jobs.

The proposed Barangaroo Station would be located within and immediately adjacent to Central Barangaroo and a short distance from the neighbouring Barangaroo South.

Travel patterns

While the local business precinct currently has no direct access to rail, indirect access is being improved through the development of Wynyard Walk, which is currently under construction, and will provide a fully accessible pedestrian link between Wynyard Station and the Barangaroo. Other transport connections include:

- Circular Quay and Darling Harbour wharves, which are about 270 metres and 1.1 kilometres from Barangaroo precinct, respectively
- The Barangaroo Ferry Hub, which will begin construction in early 2016, will provide increased capacity for ferry services to meet future demand at Barangaroo and surrounding precincts.

Journey to work data (Bureau of Transport Statistics, 2011) indicates that the most popular mode of commuter travel for workers employed in the precinct is train (42 per cent), followed by bus (22 per cent) and car (21 per cent). The largest portion of workers employed in the precinct live in the Sydney inner city (11.5 per cent) indicating a strong level of self-containment.

Future vision for this precinct

Barangaroo will become Sydney's premier waterfront precinct and provide a hub for Sydney's financial and professional services and considerable flexible employment space for local businesses. It will open a new commercial precinct within the existing Sydney CBD and provide space for over 24,000 permanent jobs and capacity for numerous small and large businesses.

Barangaroo South is becoming one of the largest mixed-use precincts in Sydney comprising office buildings, residential apartments, an international hotel, shops, restaurants, cafes and cultural facilities.

The Sydney Metro would have a major influence in directly connecting Barangaroo to multiple centres across Sydney. This is likely to help drive demand for employment space and expand the night-time economy of Barangaroo.

13.3.7 Martin Place Station

Overview of the local business precinct

Martin Place Station would be positioned between Elizabeth Street and Castlereagh Street on a north-south alignment, with stations entries to the south of Hunter Street and to the south of Martin Place.

The local business precinct used for the purposes of assessment comprises a considerable proportion of the commercial core of the Sydney CBD. The commercial business functions of the precinct are supported by an extensive range of retail, hotel, entertainment and dining businesses, typical of a thriving city centre. The area around the proposed Martin Place Station at ground level is dominated by higher-end retail and food and beverage retail. There are also extensive underground connected shopping centres within this area.

As at the 2011 Census, the Martin Place local business precinct employed 73,077 people of which 52,337 were employed in business jobs, many of which were in the finance, property and legal services sectors.

Martin Place is currently being revitalised by new construction (including 20 Martin Place and 48-50 Martin Place) that will help generate greater retail activity and foot traffic between George Street and Macquarie Street.

Travel patterns

The Martin Place local business precinct is well connected by multiple to transport. The majority of commuter trips are made by public transport including train (43 per cent), followed by bus (23 per cent) and then car (11 per cent).

Future vision for this precinct

The future vision for the Martin Place local business precinct is tied closely to that of the broader Sydney CBD and the concept of Sydney as a global city. A key part of the future vision identified by the City of Sydney Sustainable Sydney 2030 initiative is an integrated transport network that can relieve pressure on the current public transport network.

13.3.8 Pitt Street Station

Overview of the local business precinct

Pitt Street Station would be located underneath Pitt and Castlereagh streets with station entries to the north of Park Street and to the south of Bathurst Street. It would be located almost in the very centre of the Sydney CBD, across one of the busiest intersections in the city.

The local business precinct around the proposed Pitt Street Station is comparable to Martin Place in terms of the distribution and type of businesses. At street level there are a number of retail and dining businesses operating along Pitt Street, Park Street and Bathurst Street. Several hotels / pubs, grocery stores and a theatre also operate in the precinct.

As at the 2011 census, the Pitt Street local business precinct employed 43,306 people, including 30,038 business jobs and 5,934 retail jobs.

Travel patterns

The Pitt Street local business precinct forms part of the city circle area and is well connected by multiple transport nodes which directly link to suburban centres. Accordingly, the majority of commuter trips are made by public transport including train (49 per cent), bus (23 per cent) and car (9 per cent).

Future vision for this precinct

Similar to Martin Place, the future vision for the Pitt Street local business precinct is tied closely to that of the broader Sydney CBD and the concept of Sydney as a global city. As noted in Section 13.3.7, a key part of the future vision identified by the City of Sydney Sustainable Sydney 2030 initiative is an integrated transport network.

13.3.9 Central Station

Overview of the precinct

Central Station local business precinct identified for assessment purposes is formed around the existing Central Station, which would accommodate the proposed metro station within the existing station footprint below existing platforms 13 to 15.

The local business precinct is separated by the station and rail corridor, which is represents a barrier to permeability and connectivity of business areas surrounding the station. For this reason, the following three sub-precincts were identified:

- Central Station area
- Surry Hills, which is located on the eastern side of Central Station
- Haymarket / Chinatown / Chippendale, which is located on the western side of Central Station.

At the most recent Census (2011), there were 25,848 people working in the Central Station precinct. The main employment areas were public administration and safety (5431 jobs), followed by transport, postal and warehousing (4351 jobs) and professional, scientific and technical services (3576 jobs).

The local business precinct has been undergoing significant revitalisation over the past decade with the redevelopment of the Carlton United Brewery site into Central Park Sydney, and new work at The University of Technology Sydney. Surry Hills has also experienced a great deal of activity in terms of urban gentrification, with conversion of older industrial buildings and warehouses into residential apartments. This has driven a marked increase in the number of small businesses in the precinct generating increasing foot traffic, destination retail and small business trade. These developments are also attracting new residents, resulting in significant growth in the local population.

Central Station area

Several long-running businesses are located in and around Central Station, generally along Eddy Avenue and the southern subway between the station (and effectively, Surry Hills) and Henry Deane Plaza and Railway Square. These businesses generally comprise food and beverage premises, small retail outlets (generally factory outlets / reduced stock style retail) and convenience stores. There are also businesses within the main station area, including food and beverage premises, newsagencies and convenience stores. These local food and retail businesses benefit from the strong connectivity between the station, surrounding Sydney CBD businesses and links to educational establishments such as Ultimo TAFE, University of Technology Sydney and Australian Institute of Music.

Surry Hills

Surry Hills is characterised by a vibrant, creative and extensive mix of local businesses including cafes, restaurants, bars, fashion stores, homewares and speciality stores. There is also a considerable number of small to medium sized businesses especially in communications, media, architecture, design and consulting.

Bourke and Crown streets are the two main retail strips, with a considerable number of retail businesses between Albion, Foveaux and Devonshire streets and Central Station along Elizabeth Street. These businesses benefit from the surrounding commercial businesses at the southern end of the Sydney CBD, the proximity to multiple other inner-city suburbs and from being on the walking route between Central Station and major event spaces at the Sydney Cricket Ground, Sydney Football Stadium and other attractions at Moore Park.

Haymarket / Chinatown / Chippendale

The Haymarket / Chinatown/ Chippendale sub-precinct is renowned for its considerable number of Asian restaurants, convenience stores, street markets, small grocery shops and small fashion outlets. The sub-precinct is very popular for the younger demographic due to the proximity to education centres, such as The University of Technology Sydney and NSW TAFE.

The local businesses benefit from this highly connected inner-city suburb with transport nodes such as Central Station, three light rail stations (Paddy's Markets, Central and Capitol Square) and bus links along George Street.

The local businesses in this precinct perform strongly due to adjoining suburbs such as Darling Harbour, Ultimo, Surry Hills and Sydney CBD, which have strong pedestrian links and high volumes of pedestrians. This strong demand also supports night time trade for many of these businesses.

Travel patterns

The Central Station precinct is essentially an extension of the Sydney CBD and serves as a central interchange for Sydney's rail, bus and light rail network as well as NSW's regional and intercity rail and coach fleets. The precinct offers exceptional connectivity to other parts of NSW and interstate.

The precinct contains Central Station and two light rail stations (Central and Capitol Square). Once completed, Sydney's CBD and South East Light Rail will improve access from Circular Quay through the Sydney CBD to sporting and entertainment precincts (via Central Station) and to Randwick and Kingsford.

Main arterial roads such as George Street, Harris Street and Elizabeth Street provide easy accessibility to travel to the precinct via car or bus. The precinct is well serviced with buses along George Street linking to Parramatta Road via Broadway.

According to Journey to Work data (Bureau of Transport Statistics, 2011), the most popular mode of travel for commuters who work in the precinct is train (54 per cent), followed by car (19 per cent) and bus (12 per cent).

Future vision for this precinct

Central Station precinct will continue to serve as a central interchange for suburban rail services, bus and light rail network, and intercity rail services and coach fleets. Surry Hills, Haymarket and Chinatown will continue to grow as highly connected inner-city suburbs supporting local businesses, residents and visitors.

The Central to Eveleigh Corridor is another major project that is influencing change in the area. The project would renew the rail corridor between Central Station and Eveleigh, which in turn would create an inner-city location for new homes, jobs and infrastructure. UrbanGrowth NSW has identified the potential for 29,000–56,000 new residents and 14,000 to 25,000 additional workers in seven new neighbourhoods along the corridor.

13.3.10 Waterloo Station

Overview of the precinct

Waterloo Station would be located adjacent to Cope Street between Raglan Street and Wellington Street.

The local business precinct broadly identified for assessment purposes encompasses the area that extends south from Redfern Street to McEvoy Street and between Young Street (east) and Mitchell Road / Fountain Street (west).

The precinct contains a mixture of employment uses. At the most recent Census (2011), 4150 people were working within the precinct. The main employment areas were professional, scientific and technical services (566 jobs), followed by health care and social assistance (474 jobs) and retail trade (425 jobs).

Local businesses within the precinct include commercial / retail (cafes, hotels, supermarkets, pharmacies, furniture / lighting stores and services businesses), industrial / warehouse (electronics factory outlet, footwear, clothing and automotive services) and educational facilities.

Travel patterns

According to Journey to Work data (Bureau of Transport Statistics, 2011), workers within the precinct relied heavily on private transport to commute to work (48 per cent), with around 26 per cent of workers commuting by train. This is despite the precinct being relatively close to the stations of Erskineville, Macdonaldtown, Redfern and Green Square. The reliance on private transport is a major consideration when identifying project impacts on businesses.

Future vision for the precinct

Transformation of the area over 15-20 years will see the complete renewal and replacement of all social housing as a minimum, integrated with planning for new public parks, community facilities and jobs. The future renewal will also see additional affordable housing alongside social and private housing. This will support and retain a diverse and vibrant community into the future.

The local business precinct is also adjacent to the 278-hectare Green Square Development Area. On completion, the Green Square Development Area will have:

- 30,500 new dwellings, including 10,000 under assessment or in construction.
- A population of 19,000 by 2019, potentially growing to 61,000 by 2030
- 21,000 permanent jobs
- Community facilities and green space
- 14,000 square metres of retail floor space
- 50,000 square metres of commercial office floor space.

13.3.11 Marrickville dive site (southern)

Overview of the precinct

The Marrickville dive site would be located north of Sydenham Station and immediately south of Bedwin Road, Marrickville.

The local business precinct identified for assessment purposes is fairly extensive as the surrounding areas include a large number of businesses. It has been divided into two sub-precincts which differ in terms of land use, employment and layout. These are referred to as the Marrickville industrial sub-precinct and the Sydenham sub-precinct.

At the most recent Census (2011), there were 7417 people working within the local business precinct. The industrial significance of the precinct is highlighted by the fact that manufacturing (2247 jobs) comprises nearly 30 per cent of all jobs in the precinct. Wholesale trade (1074 jobs) is also a prominent source of employment in the precinct.

Marrickville industrial sub-precinct

The Marrickville industrial sub-precinct situated on the northern side of the rail corridor comprises mostly industrial land uses, with food processing and distribution being common. This industrial uses located within this sub-precinct benefit from existing infrastructure as well as relatively close proximity to Sydney Airport, Port Botany and Sydney CBD.

Sydenham sub-precinct

The Sydenham sub-precinct is situated on the southern side of the rail corridor. It is a typical inner west residential suburb comprising mostly medium density residential dwellings, light industrial land uses, small pockets of residential and commercial uses and scattered retail outlets. Local businesses include cafés, a local pub, takeaway food shops, restaurants as well as a small retail strip near the intersection of Unwins Bridge Road and Gleeson Avenue.

Travel patterns

Private vehicle is the preferred mode of transport for people commuting to this precinct (66 per cent). This reflects the fact that the precinct has a strong industrial presence and available parking. Train (17 per cent) and to a lesser extent buses (three per cent) are other important modes for commuters, reflecting the relatively good public transport connections in the area.

Future vision for the precinct

The Marrickville and Sydenham areas will continue to grow as an employment centre and residential suburb. Growth will be stimulated by the precinct's proximity to Sydney CBD, Sydney Airport, Port Botany and Sydenham Station.

The intensive industrial uses, especially on the northern side of Sydenham Station, will likely come under pressure to convert to residential uses, a process which has already begun.

The southern side of the station has considerable scope for development, but it is constrained by aircraft noise, which is a major inhibitor to future development and unlikely to change.

13.4 Potential impacts

The potential impacts of the project have been assessed for each of the identified local business precincts and for both the construction and operation phases (refer to Table 13-2) . The impact assessment considers whether a particular impact is:

- Positive or negative
- Significant, moderate, slight or neutral
- During construction and / or operation.

Table 13-2 Impact assessment ratings

Impact rating	Description
Significant negative	Impacts with serious, long term or possibly irreversible effects. This category also includes localised impacts that can only be addressed through compensatory measures (as in the case of property acquisition).
Moderate negative	Impacts that may be short, medium or long term in duration and most likely to respond to management actions.
Slight negative	Impacts that would have minimal effect, could be short term, can be mitigated, would not cause substantial detrimental effects, and may be confined to a small area.
Neutral	No discernible or predictable positive or negative impact.
Slight positive	Impacts that would have minimal effect, could be short term, and may be confined to a small area.
Moderate positive	Impacts that may be short, medium or long term in duration and may result in a positive outcome in terms of new opportunities and outcomes of enhancement or improvement.
Significant positive	Impacts that would result in substantial and long term improvements or enhancements to the existing environment.

13.4.1 Potential construction phase impacts

While construction of the project is likely to result in broader economic benefits by way of job generation and construction multipliers, local or precinct level businesses and landowners would experience a degree of disruption and other temporary negative impacts, particularly, those located close to the construction sites. Table 13-3 outlines the impacts during construction.

Table 13-3 Construction impact assessment – by precinct

Impacts during construction	Impact
Chatswood dive site (northern) and northern surface works	
Servicing and delivery / access There would be some potential impact on access to the Dulux premises, which is located on the corner of Nelson Street and the Pacific Highway, due additional construction traffic using Nelson Street. Light construction vehicles may occasionally use Hampden Road near the Artarmon shops, but this infrequent use is not expected to have any effect on access to businesses. A number of intersections within and near the local business precinct currently experience long delays. Construction traffic associated with the project is not expected to significantly increase delay at any of these intersections and in turn is not expected to significantly affect the servicing of or access to businesses.	Slight negative
Noise, vibration and dust Construction work, including excavation, could disturb businesses and the work environment.	Moderate negative

Impacts during construction	Impact
Property acquisition There would be a need to acquire an estimated 16 properties (resulting in acquisition or relocation of occupying businesses or other negotiated arrangements). This would result in disturbance to business operations and costs for affected landowners and businesses that would need to be addressed as part of the acquisition process. There would also be a need to relocate the Ausgrid depot.	Significant negative
Trade increase The project's construction workers in the locality would require food and beverage services and other goods, which would benefit businesses such as the Great Northern Hotel and local food retailers around Artarmon and Chatswood stations.	Moderate positive
Artarmon substation	
As there are no businesses located on the site or close to the precinct, no impacts on businesses are expected during construction works at the Artarmon substation.	Neutral
Crows Nest Station	
Servicing and delivery access Businesses could be disrupted by planned or temporary closures of Clarke Lane and the closure of Hume Street for up to six months. The potential impacts would relate to servicing and delivery constraints for business located along the Pacific Highway and in surrounding streets such as Clarke Street, Hume Street and Oxley Street. Many of these businesses rely heavily on servicing and deliveries as they are retail showrooms for furniture, homewares, picture framing and other bulky goods. During the temporary closure of Hume Street, traffic would be redirected via Oxley Street. This would result in a minor deterioration in the performance of the Pacific Highway / Oxley Street intersection, but the intersection would still operate satisfactorily and any resulting delays would not significantly affect the servicing of or access to businesses.	Moderate negative
Customer access / passing trade Construction hoardings, changed access routes and perceived access challenges could disrupt pedestrian access and affect the visibility of businesses. Based on information provided during the survey of local businesses, it is considered that direct access, business visibility and permeability are core drivers of local retail trade in this precinct.	Moderate negative
Supply of and access to car parking The potential loss of up to four car parking spaces on Hume Street may affect local business accessibility as the majority of customers drive and use on-street parking, especially those accessing local services and bulky goods (such as Coco Republic).	Slight negative
Noise, vibration and dust Construction work, including excavation, could disturb businesses and the work environment, although expected impacts would be substantially reduced through the use of an acoustic shed at this construction site. Remaining impacts would be most noticeably experienced by amenity-sensitive businesses such as outdoor cafes, beauticians, child care centres and medical facilities.	Moderate negative
Property acquisition There would be a need to acquire an estimated ten properties (one partial) (resulting in acquisition or relocation of occupying businesses, or other negotiated arrangements).	Significant negative
Increased trade for food and beverage The project's construction workers would require food and beverage services and other goods. This would especially benefit, and potentially offset impacts on, businesses which may otherwise lose some regular trade around Clarke Street, Oxley Street and Hume Street.	Moderate positive

Impacts during construction	Impact
Victoria Cross Station	
Servicing and delivery access Construction would disrupt traffic and pedestrian access. This would have potential impacts on servicing and delivery for business, schools and colleges along Miller Street and surrounding streets such as Denison Street and Berry Street. Many businesses are retail and commercial uses which rely on servicing and deliveries. Delays on the road network associated with addition of construction traffic are not expected within and adjacent to this local business precinct.	Moderate negative
Customer access / passing trade Construction hoardings, changed access routes and perceived access challenges would potentially disrupt pedestrian access and the visibility of businesses within the precinct. It is specifically noted that the pedestrian connection between Miller Street and Berry Square would no longer be available once construction starts.	Moderate negative
Supply of and access to car parking The potential loss of up to four spaces on Miller Street could have a modest impact on local businesses.	Slight negative
Noise, vibration and dust Construction work, including excavation, could disturb businesses and the work environment, although expected impacts would be substantially reduced through the use of an acoustic shed at this construction site. Remaining impacts would be most noticeably experienced by amenity-sensitive businesses such as outdoor cafes, beauticians and medical facilities.	Moderate negative
Traffic congestion North Sydney is a major access point between multiple suburbs of the inner north and the Sydney Harbour Bridge and Tunnel. While the addition of construction vehicles would result in only minor changes to existing intersection performance, any localised congestion could affect business operations.	Moderate negative
Property acquisition There would be a need to acquire an estimated eight properties (resulting in acquisition or relocation of occupying businesses, or other negotiated arrangements).	Significant negative
Increased trade for food and beverage The increase in workers associated with construction of the project would benefit – and potentially offset impacts on – businesses that may otherwise lose some regular trade around Miller Street, Berry Street and McLaren Street.	Moderate positive
Blues Point temporary site	
Servicing and delivery access As there are no businesses located within the immediate vicinity of the temporary site, no major impacts have been identified as a result of the proposed works. Transport of equipment and associated traffic movements to and from the temporary site would add some traffic to Blues Point Road, but would be unlikely to cause delays affecting the operation of businesses. Temporary traffic controls and delays associated with the transport of oversize tunnel boring machine components would very short-term and limited to only four occasions during the construction period. Access to businesses would be retained.	Slight negative

Impacts during construction	Impact
Sydney Harbour ground improvement works	
A range of businesses use Sydney Harbour in the vicinity of the proposed ground improvement works locations (refer Chapter 7 (Project description – construction) for the locations of ground improvement work), including tourism operators, water taxis and commercial shipping. A ban was placed on commercial fishing in Sydney Harbour in 2006 so it is not expected these types of activities would be affected. As noted in Chapter 8 (Construction traffic and transport), potential impacts on some commercial shipping may need to be managed, however impacts on marine traffic are generally not expected.	Neutral
Barangaroo Station	
Servicing and delivery access Although construction of the station would be adjacent to an existing Barangaroo construction site, the cumulative impact of the work could adversely affect servicing and delivery for businesses within Barangaroo that are already operating, and in surrounding areas such as Walsh Bay that are located at the end of a peninsula via Hickson Road.	Moderate negative
Noise, vibration and dust Construction work, including excavation, could disturb businesses and the work environment, although expected impacts would be substantially reduced through the use of an acoustic shed at this construction site.	Moderate negative
Supply of and access to car parking Changes to on street parking opportunities (ie potential loss of up to 125 spaces on Hickson Road) could affect local businesses. Given however that very few businesses presently operate in the central section of Hickson Road and the area is under major redevelopment, this impact is considered likely to be minor.	Slight negative
Increased trade for food and beverage The increase in workers associated with construction of the project would benefit food and beverage outlets.	Moderate positive
Martin Place Station	
Servicing and delivery access Potential impacts in this precinct relate to servicing and delivery constraints for businesses as a consequence of increased traffic and the cumulative impacts of construction work from other projects such as the CBD and South East Light Rail where they temporally and geographically overlap. It is expected that such impacts are most likely to occur between 2017 and 2023 especially during the overlap with CBD and South East Light Rail main work from 2017-2019. Delays associated with addition of construction traffic are expected to be negligible within this local business precinct.	Moderate negative
Customer access / passing trade Construction hoardings, changed access routes (including the temporary closure of Martin Place between Castlereagh and Elizabeth streets) and perceived access challenges could disrupt pedestrian access and the visibility of businesses. There would some potential loss of passing trade as a result of the closure of the existing link between Martin Place Station and the MLC Centre.	Moderate negative
Noise, vibration and dust Construction work, including excavation, could disturb businesses and the work environment, although expected impacts would be substantially reduced through the use of an acoustic shed at this construction site. These impacts would be most noticeably experienced by amenity-sensitive businesses such as outdoor cafes, bars and medical facilities in the precincts and could be exacerbated by construction work on other projects nearby.	Moderate negative

Impacts during construction	Impact
Property acquisition There would be a need to acquire an estimated eight properties (resulting in acquisition or relocation of occupying businesses, or other negotiated arrangements).	Significant negative
Changed consumer behaviour Construction could alter consumer behaviour. As the Sydney CBD layout is generally cross-form with a grid structure, this may mean businesses with access restrictions could lose trade to businesses on other streets.	Moderate negative
Increased trade for food and beverage The increase in workers associated with construction of the project would benefit food and beverage outlets. This impact would be relatively modest during the day, but demand for services may increase more noticeably during evening periods as a consequence of scheduled evening construction work.	Slight positive
Pitt Street Station	
Servicing and delivery access Potential impacts in this local business precinct relate to servicing and delivery constraints for businesses (particularly major retail businesses in locations such as Pitt, Park and Castlereagh streets) as a consequence of increased traffic and the cumulative impacts of construction work from other projects such as the CBD and South East Light Rail where they temporally and geographically overlap. Construction related traffic congestion is not expected to be a major issue for local businesses because intersection performance is expected to be maintained at all nearby intersections, except for the Bathurst Street / Day Street intersection where increased delay would be relatively minor.	Moderate negative
Customer access / passing trade: Potential impacts relate to disruptions to pedestrian access and visibility of businesses within the precincts as a result of construction hoardings, changed access routes and perceived access challenges.	Moderate negative
Noise, vibration and dust Construction work, including excavation, could disturb businesses and the work environment, although expected impacts would be substantially reduced through the use of an acoustic shed at this construction site. These impacts would be most noticeably experienced by amenity-sensitive businesses such as outdoor cafes, bars and medical facilities in the precincts and could be exacerbated by construction work on other projects nearby.	Moderate negative
Property acquisition There would be a need to acquire an estimated 12 properties (resulting in acquisition or relocation of occupying businesses, or other negotiated arrangements).	Significant negative
Changed consumer behaviour A potential impact on local businesses in this precinct is changed consumer behaviour during the construction period. As the Sydney CBD layout is generally cross form with a grid structure, this may mean businesses where there are access restrictions could lose trade to other streets.	Moderate negative
Increased trade for food and beverage The increase in workers associated with construction of the project would benefit food and beverage outlets. This impact would be relatively modest during the day, but demand for services may increase more noticeably during evening periods as a consequence of scheduled evening construction work.	Slight positive

Impacts during construction	Impact
Central Station	
Customer access / passing trade Construction hoardings, changed access routes (including the short-term closure of Devonshire Street tunnel) and perceived access challenges could disrupt pedestrian access and the visibility of businesses within and surrounding the station. This could be construction work on other projects in the station and / or station precinct (such as works on Eddy Avenue and Chalmers Street associated with the CBD and South East Light Rail). Construction is expected to result in a marginal deterioration in the performance of several intersections that are already currently experiencing congestion. This may have some impact on the convenience of customer access.	Moderate negative
Noise, vibration and dust Construction work, including excavation, could disturb businesses. These impacts would be most noticeably experienced by amenity-sensitive businesses such as outdoor cafes, bars and medical facilities in the precinct and could be exacerbated by construction work on other projects in the station and / or station precinct (such as the CBD and South East Light Rail).	Moderate negative
Property acquisition There would be a need to acquire an estimated 10 properties (resulting in acquisition or relocation of occupying businesses, or other negotiated arrangements).	Significant negative
Increased trade for food and beverage The increase in workers associated with construction of the project would benefit food and beverage outlets.	Slight positive
Waterloo Station	
Servicing and delivery access There could be servicing and delivery constraints for business located along Botany Road or on opposite sides of Raglan Street and Buckland Street. Construction related traffic congestion is not expected to be a major issue for local businesses because the majority of intersections are predicted maintain their current level of service, except for the Cleveland Street / Regent Street intersection which is already operating close to capacity.	Moderate negative
Loss of on-street car parking Up to four on street car parking spaces on Raglan Street would be removed for the duration of construction while on-street car parking spaces along Cope and Wellington streets would also be temporarily removed during demolition works. This loss of car parking could have an impact on surrounding local businesses and shoppers.	Slight negative
Customer access / passing trade Construction would result in changes to vehicle and pedestrian flows that could influence the level of trade passing businesses and subsequent customers and sales.	Moderate negative
Noise, vibration and dust Construction work, including excavation, could disturb businesses and the work environment, although expected impacts would be substantially reduced through the use of an acoustic shed at this construction site.	Moderate negative
Property acquisition There would be a need to acquire and estimated 18 properties (resulting in acquisition or relocation of occupying businesses, or other negotiated arrangements).	Significant negative
Increased trade for food and beverage The increase in workers associated with construction of the project would benefit food and beverage outlets and other retailers, particularly those located along Botany Road or Raglan and Buckland streets.	Moderate positive

Impacts during construction	Impact
Marrickville dive site (southern)	
Servicing and delivery access New and altered signals at intersections could result in constraints or restrictions to access for businesses located close to the site. Construction related traffic congestion is not expected to be a major issue for local businesses because all nearby intersections are expected to maintain their existing level of service, except for the Bedwin Road / Unwins Bridge Road / Campbell Street / May Street intersection, where increases in delay would be relatively minor.	Moderate negative
Loss of on-street parking On-street parking is a major factor in business patronage in the area. As it is relatively dense for an industrial area, the on-street parking is considered an important asset both for staff parking and for customers. The construction work would result in the estimated loss of up to four car parking spaces in the local business precinct.	Slight negative
Noise, vibration and dust Construction work, including excavation, could disturb businesses and the work environment, although expected impacts would be substantially reduced through the use of an acoustic shed at this construction site.	Moderate negative
Property acquisition There would be a need to an estimated 13 properties acquired (resulting in acquisition or relocation of occupying businesses, or other negotiated arrangements).	Significant negative
Demand for services As a mostly industrial area, businesses may benefit during the construction phase from increased demand for industrial services or construction materials.	Moderate positive
Increased trade for food and beverage The increase in workers associated with construction of the project would benefit food and beverage outlets and other retailers, particularly those on the eastern side of the rail corridor.	Moderate positive

13.4.2 Potential operation phase impacts

Table 13-4 outlines the impacts during operation for each precinct. Identified impacts at the local and regional scales would largely be positive due to the enhanced capacity and frequency of transport services, which would improve access to the Sydney CBD including Barangaroo. New stations to the north at Victoria Cross and Crows Nest, together with a new station at Waterloo would also enhance the appeal and attraction of visiting, investing, living and working in these precincts.

Negative impacts for local businesses during operation would be the potential for increased commercial rents, increased levels of competition, changes to customer access and parking, and noise.

Table 13-4 Operational impact assessment

Impacts during operation	Impact
Chatswood dive site (northern)	
Noise and vibration Noise and vibration from the project could have a potential adverse impact on business operation and the work environment.	Slight negative
Development stimulus	
The redevelopment of surplus land from construction sites (subject to separate assessment and approval processes) would stimulate development.	Significant positive

Impacts during operation	Impact
Artarmon substation	
As there are no businesses located on the site or nearby, no business impacts have been identified.	Neutral
Crows Nest Station	
Changed consumer behaviour The construction phase has the potential to affect the longer term viability of the local services and furniture retail which has been a long term use along the Pacific Highway and surrounding streets. Already these two industries have a much smaller presence at this location than they did previously. Construction related disruption, access restrictions and increased traffic congestion as a result of the construction of the project could influence consumer behaviour and, along with pre-existing factors, the need for these types of businesses to consider relocation.	Moderate negative
Competition The redevelopment of the precinct (subject to separate assessment and approval processes) would include new ground floor retail and / or commercial uses, which may increase competition with surrounding businesses and have some impact. Other businesses may benefit as a consequence of agglomeration.	Neutral
Improved commercial rent / land values The project would make the precinct a more attractive place to live and work and, therefore, invest. There is the potential for commercial rents to increase as a result of value uplift within prime locations around the new station. This may force businesses that are utilising the cheaper rent in the considerable B, C and D grade commercial office stock to move to places with more affordable rent. This may have an adverse impact on tenants but a positive impact for property owners who would also benefit from an uplift in property values.	Moderate negative Significant positive
Development stimulus The project would create a positive opportunity for the redevelopment of some under-utilised sites and locations in the precinct (subject to separate assessment and approval processes). This could result in additional housing and business opportunities with the additional population supporting demand for businesses and services.	Significant positive
Enhanced access for customers The project would create a major access point for commuters, visitors and prospective customers. Proposed improvements such as a new signalised pedestrian crossing on northern side of Pacific Highway / Oxley Street intersection, new pedestrian crossings on Clarke Street, Hume Street and Oxley Street, and provision of bike parking on Hume and Oxley Street could also benefit for businesses in this precinct and better link the precinct to surrounding areas such as Crows Nest Town Centre (which is focused along Willoughby Road). Businesses likely to benefit from this enhanced connection and accessibility include food, beverage, grocery, special uses, retail, commercial business and lifestyle uses. These improvements are also likely to result in enhanced business investment. The enhanced actual and perceived level of access is also likely to considerably increase passing trade between the new station and the streets to the west of Willoughby Road, which could expand the core entertainment precinct beyond Willoughby Road to Clarke, Oxley and Hume streets and provide opportunities for new and expanded business clusters.	Significant positive
Enhanced business connectivity The project would significantly enhance connections between the precinct and important business and employment nodes such as Macquarie Park, Norwest, Chatswood, North Sydney, Barangaroo, Sydney CBD and the Australian Technology Park. This would enhance the appeal of the precinct as a place for businesses to invest and support the State Government's objectives for employment and business growth in this precinct, and potentially reduce vacancy levels for commercial floor space. It would also enhance the dining and entertainment appeal of the precinct and its accessibility to areas to Sydney's north (that is, areas along the Sydney Metro Northwest).	Significant positive

Impacts during operation	Impact
Victoria Cross Station	
Improved commercial rent / land values The project would make the precinct a more attractive place to live and work and, therefore, invest. There is potential for commercial rents to increase as a result of increased value uplift within prime locations around the new station. This may force businesses that are utilising the cheaper rent in the considerable B, C and D grade commercial office stock to move to places with more affordable rent. As a major commercial centre, this enhanced access is likely to have a more positive impact by attracting new major commercial tenants. This may have an adverse impact on tenants but a positive impact for property owners who would also benefit from an uplift in property values.	Slight negative Significant positive
Competition The redevelopment of the precinct (subject to separate assessment and approval processes) would include new ground floor retail and / or commercial uses, which may increase competition with surrounding businesses and have some impact. Other businesses may benefit as a consequence of agglomeration impacts.	Neutral
Enhanced business connectivity The project would significantly enhance connections between the precinct and important business and employment nodes such as Chatswood, Barangaroo, Sydney CBD and the Australian Technology Park. This would enhance the appeal of the precinct as a place for businesses to invest and support the State Government's objectives for employment and business growth in this precinct, and potentially reduce vacancy levels for commercial floor space. The link with Barangaroo is considered particularly important as it would create opportunities for North Sydney to act as a more affordable business support hub for the high-value global headquarters located within Barangaroo. The link with the Sydney Metro Northwest and its associated residential areas is also considered key to opening up further job opportunities for knowledge workers in North Sydney as part of the Global Economic Corridor.	Significant positive
Staff access, recruitment and retention The project would improve connectivity to employment and residential locations across Sydney. This would enhance the appeal of this major employment precinct to potential employees and improve the prospects for retaining them. This would support business growth and productivity within the precinct.	Moderate positive
Enhanced access for customers The project would create a major access point to the precinct for commuters, visitors and customers. The new station would deliver customers to the commercial core of North Sydney and allow a transit node (with North Sydney Station) to be located on both the eastern and western sides off the Pacific Highway. These enhancements, would support North Sydney's retail sector and, in turn, night-time and weekend trade, enhancing the appeal of North Sydney overall.	Moderate positive
Development stimulus The project would create a positive opportunity for the redevelopment of some under-utilised sites and locations in the precinct.	Significant positive

Impacts during operation	Impact
Barangaroo Station	
Improved commercial rent / land values The project would enhance the appeal of the precinct to international corporations and investors, thereby improving its attraction and value as a place to live and work and, therefore, invest. There is potential for commercial rents to rise as a result of increased value within prime locations around the station.	Significant positive
Enhanced business connectivity The project would significantly enhance connections between the precinct and other parts of Sydney CBD, creating a more attractive business environment and enhancing agglomeration benefits. More broadly, the project would also enhance connections with other supporting business and employment nodes such as Macquarie Park, Chatswood, North Sydney and the Australian Technology Park.	Significant positive
Staff access, recruitment and retention The project and its improved connectivity to employment and residential locations across Sydney would enhance the appeal of this major employment precinct to potential employees, and improve the prospects for retaining them. This would support business growth and productivity within the precinct.	Moderate Positive
Enhanced access for customers The project would create a major access point to the precinct for commuters, visitors and prospective customers. The new station would deliver customers to the very heart of Barangaroo – Central Barangaroo – enhancing the appeal of the special uses and entertainment services and facilities to be located within the precinct. The close proximity of the precinct to Walsh Bay may also result in benefits to businesses in this area.	Moderate positive
Martin Place Station	
Changed consumer behaviour The project would result in the longer term behavioural change of visitors to the Sydney CBD and its associated retail and business services. Such change could occur as a result of existing Sydney CBD customers and clients using services and facilities in alternative locations to avoid the construction work and choosing not to return to Sydney CBD locations on completion of work (eg, choosing to shop in suburban locations). Additionally, the permanent closure of underground pedestrian connections including the underground connection to the MLC Centre would likely result in reduced passing trade for some retailers. However, given the high connectivity and pedestrian access aboveground around this tunnel connection coupled with the presence of an IGA supermarket acting as an anchor tenant, the impact would be slight to minimal to businesses in this location.	Slight negative
Enhanced access for customers and visitors The project would create a major access point to the precinct for a wide range of commuters, visitors and prospective customers from across Sydney. The access improvements, together with the proposed pedestrian connection improvements, would support the appeal of visiting retail, services, events and businesses in this precinct for a broader catchment of resident and tourist visitors.	Moderate positive
Improved commercial rent / land values The project would enhance the attractiveness of the precinct as a place to work and, therefore, invest. There is potential for commercial rents and land values to increase as a result of increased value within prime locations around the new station.	Significant positive

Impacts during operation	Impact
Competition The redevelopment of the precinct (subject to separate assessment and approval processes) would include new ground floor retail and / or commercial uses, which may increase competition with surrounding businesses and have some impact. Other businesses may benefit as a consequence of agglomeration impacts.	Neutral
Enhanced business connectivity The project would significantly enhance connections between the precinct and important business and employment nodes such as Macquarie Park, Chatswood, North Sydney, Barangaroo and the Australian Technology Park as well as southern sections of Sydney CBD, creating greater opportunity for the city's expansion.	Significant positive
Staff access, recruitment and retention The project would improve connectivity to employment and residential locations across Sydney. This would enhance the appeal of Sydney CBD and its tenants to prospective employees, and improve the prospects for retaining them. This would support business growth and productivity within the precinct.	Moderate positive
Development stimulus The project would create a positive opportunity for the redevelopment (subject to separate assessment and approval processes) of some under-utilised sites and locations in the precinct with the potential to provide major new commercial opportunities for tenants and investors. The demolition of buildings to facilitate the development of the station would also provide a major redevelopment opportunity.	Significant positive
Pitt Street Station	
Changed consumer behaviour The project would result in a longer term behavioural change of visitors to the Sydney CBD and its associated retail and business services. Such as change could occur as a result of existing Sydney CBD customers and clients using services and facilities in alternative locations to avoid the construction work and choosing not to return to Sydney CBD locations on completion of work (ie choosing to shop at suburban locations in preference to Pitt Street Mall).	Slight negative
Enhanced access for customers and visitors The project would create a major access point to the precinct for a wide range of commuters, visitors and prospective customers from across Sydney. The access improvements would support the appeal of visiting retail, services, events and businesses in this precinct for a broader catchment of resident and tourist visitors.	Moderate positive
Improved commercial rent/land values The project would enhance the attractiveness of the precinct as a place to work and therefore invest. There is the potential for commercial rents and land values to increase as a result of increased value uplift within prime locations around the new Pitt Street Station.	Significant positive
Competition The redevelopment of the precinct (subject to separate assessment and approval processes) to include new ground floor retail and / or commercial use may increase competition with surrounding businesses having some degree of potential impact. Other businesses may benefit as a consequence of agglomeration impacts.	Neutral
Enhanced business connectivity The project would provide significant enhanced connections between the precinct and important business and employment nodes such as Macquarie Park, Chatswood, North Sydney and Barangaroo as well as southern sections of Sydney CBD creating greater opportunity for the City's expansion. Pitt Street Station would also facilitate a major interchange between bus and rail facilities.	Significant positive

Impacts during operation	Impact
Staff access, recruitment and retention The project would improve connectivity to employment and residential locations across Sydney. This would enhance the appeal of Sydney CBD and its tenants to prospective employees and improve the prospects of retaining them. This would support business growth and productivity within the precinct.	Moderate positive
Development stimulus The project would create a positive opportunity for the redevelopment (subject to separate assessment and approval processes) of some underutilised sites and locations in the precincts with the potential to provide major new commercial opportunities for tenants and investors. The demolition of buildings to facilitate the development of the station would also provide a major redevelopment opportunity.	Significant positive
Central Station	
Increase in commercial rent The project would enhance the precinct's accessibility, which would potentially increase commercial rents in the locality, to the benefit of existing landowners. However, higher rents may have some adverse impacts on local businesses that now benefit from the precinct's stock of lower grade office space which is used by creative industries including media production, advertising and public relations. Increased rail connectivity, could mean a major increase in demand for new rental space, which could effectively price out creative industries and others in lower grade office stock, which generally operate on smaller profit margins.	Moderate negative Moderate positive
Enhanced access for customers and visitors The precinct is already served by suburban and intercity rail services. The enhanced permeability, quality and connectivity created by the project both across Sydney and within the new station environment would result in notable improvements in customer experience and access. The access improvements together with the proposed public domain and pedestrian connection improvements would support the appeal of visiting retail, services, events and businesses in this precinct for a broader catchment of residents and tourist visitors.	Moderate positive
Enhanced business connectivity The project would significantly enhance connections between the precinct and its major facilities (such as University of Technology Sydney, the University of Notre Dame and the University of Sydney) with important business and employment nodes such as Macquarie Park, Chatswood, North Sydney, Barangaroo and the Australian Technology Park as well as southern sections of Sydney CBD, which would create greater opportunity for the city's expansion. Business connectivity would also be improved via the connection of the three light rail lines in the Sydney CBD (Circular Quay to Central, CBD and South East Light Rail, and Inner West (Dulwich Hill) to Central).	Significant positive
Staff access, recruitment and retention The project would improve connectivity to employment and residential locations across Sydney, which would enhance the appeal of this southern section of Sydney CBD and its tenants to prospective employees, and improve the prospects for retaining them. This would support business growth and productivity within the precinct.	Moderate positive
Development stimulus The project would create a positive opportunity for the redevelopment of some under-utilised sites and locations in the precinct in support of major State Government programmes such as the Central to Eveleigh Transformation Urban Renewal Corridor together with improvements to Central Station. These developments would provide significant new business opportunities together with enhanced visibility and access to trade for existing businesses.	Significant Positive

Impacts during operation	Impact
Waterloo Station	
Competition The redevelopment of the precinct (subject to separate assessment and approval processes) would include new ground floor retail and / or commercial uses, which may increase competition with surrounding businesses and have some impact. Other businesses may benefit as a consequence of agglomeration impacts.	Neutral
Enhanced access for customers The project would create a major gateway for additional customers in the precinct. This would have major benefits for existing businesses in this precinct and attract investment from new businesses.	Significant positive
Enhanced business connectivity The project would significantly enhance connections between the precinct and important business and employment nodes within Sydney CBD and the Australian Technology Park. This would enhance the appeal of the precinct as a place for businesses to invest and support the continued growth of the economic, innovation and research clusters in the southern sections of Sydney.	Significant positive
Staff access, recruitment and retention The project would improve connectivity to employment and residential locations across Sydney, which would enhance the appeal of this major employer to potential employees, and improve the prospects for retaining them. It would also lead to job generation for local residents.	Significant positive
Development stimulus The project would create a positive opportunity for the redevelopment of both the precinct (the station site) and locations surrounding the precinct including the existing Redfern / Waterloo Housing Estate.	Significant positive
Land values The project would improve the capacity and reliability of public transport, which would increase the appeal of the surrounding area and likely create benefits for landowners.	Moderate positive Significant positive
Marrickville dive site (southern)	
Noise and vibration Noise and vibration from the project is not expected to exceed adopted criteria (refer to Chapter 11 – Operational noise and vibration).	Neutral
Development stimulus The project could result in the redevelopment (subject to separate assessment and approval processes) of surplus land and development capacity over the construction sites for use by businesses.	Significant positive

13.5 Mitigation measures

Mitigation measures that would be implemented to address potential business impacts are listed in Table 13-5. All measures relate to the construction phase.

Table 13-5 Mitigation measures – business impacts

Ref	Mitigation measure	Applicable location(s)[1]
BI1	Specific consultation would be carried out with businesses potentially impacted during construction. Consultation would aim to identify and develop measures to manage the specific construction impacts for individual businesses.	All
BI2	A business impact risk register would be developed to identify, rate and manage the specific construction impacts for individual businesses.	All
BI3	Appropriate signage would be provided around construction sites to provide visibility to retained businesses.	All except metro rail tunnels

1 *STW: Surface track works; CDS: Chatswood dive site; AS: Artarmon substation; CN: Crows Nest Station; VC: Victoria Cross Station; BP: Blues Point temporary site; GI: Ground improvement works; BN: Barangaroo Station; MP: Martin Place Station; PS: Pitt Street Station; CS: Central Station; WS: Waterloo Station; MDS: Marrickville dive site; Metro rail tunnels: Metro rail tunnels not related to other sites (eg TBM works); PSR: Power supply routes.*

NON-ABORIGINAL HERITAGE

CHAPTER FOURTEEN

14 Non-Aboriginal heritage

This chapter provides an assessment of the potential impact on non-Aboriginal heritage items and archaeological remains as a result of the project, and identifies mitigation measures to address these impacts. This chapter draws on information in Technical paper 4 – Non-Aboriginal heritage.

14.1 Secretary's environmental assessment requirements

The Secretary's environmental assessment requirements relating to non-Aboriginal heritage, and where these requirements are addressed in this Environmental Impact Statement, are outlined in Table 14-1.

Table 14-1 Secretary's environmental assessment requirements – non-Aboriginal heritage

Ref.	Secretary's environmental assessment requirements	Where addressed
7. Heritage		
7.1	The Proponent must identify and assess any direct and/or indirect impacts (including cumulative impacts) to the heritage significance of: **a.** environmental heritage, as defined under the *Heritage Act 1977* **b.** items listed on the National and World Heritage lists **c.** Aboriginal places and objects, as defined under the *National Parks and Wildlife Act 1974* and in accordance with the principles and methods of assessment identified in the current guidelines **d.** Aboriginal places of heritage significance, as defined in the Standard Instrument – Principal Local Environmental Plan	Environmental heritage is addressed in Section 14.5. National and World heritage is addressed in Section 14.5. Aboriginal heritage impacts are addressed in Chapter 15 (Aboriginal heritage). Cumulative impacts are addressed in Chapter 26 (Cumulative impacts).
7.2	Where impacts to State or locally significant heritage items are identified, the assessment must: **a.** include a statement of heritage impact for all heritage items (including significance assessment) **b.** consider impacts to the item of significance caused by, but not limited to, vibration, demolition, archaeological disturbance, altered historical arrangements and access, visual amenity, landscape and vistas, curtilage, subsidence and architectural noise treatment (as relevant) **c.** outline measures to avoid and minimise those impacts in accordance with the current guidelines **d.** be undertaken by a suitably qualified heritage consultant(s) (note: where archaeological excavations are proposed the relevant consultant must meet the NSW Heritage Council's Excavation Director criteria).	*Technical paper 4 – Non-Aboriginal heritage.* Non-Aboriginal heritage impacts are addressed in Section 14.5. Mitigation measures are outlined in Section 14.6.
7.3	Where archaeological investigations of Aboriginal objects are proposed these must be conducted by a suitably qualified archaeologist, in accordance with section 1.6 of the *Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW* (Department of Environment, Climate Change and Water, 2010a).	No archaeological investigations carried out.
7.4	Where impacts to Aboriginal objects and/or places are proposed, consultation must be undertaken with Aboriginal people in accordance with the current guidelines.	Aboriginal heritage impacts are addressed in Chapter 15 (Aboriginal heritage).

14.2 Assessment methodology

14.2.1 Study area

For the non-Aboriginal heritage assessment, the boundary of the study area was defined as a 25-metre buffer around the project footprint. It includes the physical footprint of the project incorporating ancillary sites, facilities and access ways to each area during construction.

The application of a buffer helps to identify heritage items that may be within the visual catchment of the project and where potential visual impacts on that item may occur. It also supports assessment of other potential indirect impacts on heritage fabric of heritage items that may be in the vicinity of the site (eg as a result of vibration). Any reference to the 'study area' in this chapter includes reference to the 25-metre buffer, unless otherwise stated.

As well as aboveground construction sites, the project footprint includes underground work associated with station construction, such as mined platforms and underground pedestrian connections. Tunnel sections between stations would generally be too deep to affect heritage items or archaeological deposits and as such the study area for assessment of potential impacts to heritage items does not extend to areas above the tunnel alignment that are outside the nominated study area buffers for each construction site (refer to Section 14.2.2 for further information).

14.2.2 Identification, significance and assessment of heritage items

Identification of heritage items

This chapter considers potential impacts of the project on:

- Heritage listed items – buildings or other structures, places, items, areas or cultural landscapes that are located aboveground
- Archaeological heritage – significant physical remains of the past, including relics and artefacts, that are located underground.

Heritage listed items within the study area have been identified through a search of various heritage registers. These listed heritage items have been previously assessed against the NSW Heritage Office guideline *Assessing Heritage Significance* (2001). Statements of heritage significance identified in this chapter are consistent with those included in relevant heritage inventory sheets and are based on the 2001 guideline.

Historic archaeological potential is defined as the potential of a site to contain historical archaeological relics, as classified under the *NSW Heritage Act 1977*. Preliminary assessment of the archaeological potential was considered based on review of several historical archaeological investigations within or close to the study area that provide evidence that helps to evaluate the potential historical archaeological resource of the study area. Portions of the study area have also previously been evaluated in various archaeological zoning and management plans, including the *Central Sydney Archaeological Zoning Plan* (City of Sydney, 1992), *The Rocks and Millers Point Archaeological Management Plan* (Higginbotham et al, 1991), *Archaeological Excavation Barangaroo South Preliminary Results* (Casey & Lowe, 2012) and the *Barangaroo Archaeological Assessment and Management Plan* (Austral Archaeology, 2010).

Significance of heritage items

Determining the significance of heritage items or a potential archaeological resource involves a system of assessment that generally follows the evaluation criteria set out in the NSW Heritage Office guideline *Assessing Heritage Significance* (2001). The level of heritage significance in relation to a place, building, work, relic, moveable object or precinct, can be considered to be at a local or State level of significance – that is, important in a local context or in a NSW State context – if it meets one or more of the following criteria:

- Criterion (a): Historic significance
- Criterion (b): Associative significance
- Criterion (c): Aesthetic significance
- Criterion (d): Social significance
- Criterion (e): Research potential
- Criterion (f): Rarity
- Criterion (g): Representativeness.

The heritage significance of all identified relics, items, areas and / or landscapes that are considered to be potentially directly or indirectly affected by the project are identified in *Technical paper 4 – Non-Aboriginal heritage*.

Assessment of heritage impact

Impacts on heritage are identified as either:

- Direct impacts, resulting in the demolition or alteration of fabric of heritage significance
- Indirect impacts, resulting in changes to the setting or curtilage of heritage items or places, historic streetscapes or views
- Potential direct impact, resulting in impacts from vibration and demolition of adjoining structures.

The vibration modelling referenced in this heritage assessment considers a 'worst case' construction vibration scenario, being excavation by rock breakers at surface level. Vibration levels have been modelled at the closest façade of buildings adjacent to this construction activity. Vibration impacts have also been considered with respect to demolition of structures adjacent to heritage items.

Specific terminology and corresponding definitions are used in this assessment to consistently identify the magnitude of the project's direct, indirect or potentially direct impacts on heritage items or archaeological remains. The terminology and definitions are based on those contained in guidelines produced by the International Council on Monuments and Sites (ICOMOS) and are shown in Table 14-2.

Table 14-2 Terminology for assessing the magnitude of heritage impact

Magnitude	Definition
Major	Actions that would have a long term and substantial impact on the significance of a heritage item. Actions that would remove key historic building elements, key historic landscape features, or significant archaeological materials, thereby resulting in a change of historic character, or altering of a historical resource. These actions cannot be fully mitigated.
Moderate	Actions involving the modification of a heritage, including altering the setting of a heritage item or landscape, partially removing archaeological remains, or the alteration of significant elements of fabric from historic structures. The impacts arising from such actions may be able to be partially mitigated.
Minor	Actions that would result in the slight alteration of heritage buildings, archaeological remains, or the setting of an historical item. The impacts arising from such actions can usually be mitigated.
Negligible	Actions that would result in very minor changes to heritage items.
Neutral	Actions that would have no heritage impact.

Vibration screening levels

A conservative vibration damage screening level of 7.5 millimetres per second peak particle velocity has been adopted for all heritage items. This screening level has been established with reference to the minor cosmetic damage criteria for unreinforced or light framed structures in *British Standard BS 7385:2 – 1993*. The vibration levels specified in this standard are designed to minimise the risk of threshold or cosmetic surface cracks, and are set well below the levels that have potential to cause damage to the main structure.

During main tunnelling works, it is anticipated that ground-borne vibration associated with the use of tunnel boring machines would be much lower than the 7.5 millimetres per second peak particle velocity screening level (refer to Chapter 10 (Construction noise and vibration)). As such the study area for assessment of potential impacts to heritage items does not extend to areas above the tunnel alignment that are outside the nominated study area buffers for each construction site.

14.3 Sydney's early European history

14.3.1 The North Shore

On the lower North Shore, land grants were made to free settlers from the late 18th century that were often never occupied given the challenges of utilising an uncleared landscape. Land sales and subdivisions were prevalent in the mid-19th century in the area around present-day North Sydney and Crows Nest. The T1 North Shore Line was formally opened in January 1890.

The majority of the lower North Shore, and land surrounding the study area, is associated with large land grants given to soldiers, convicts and free settlers in the early 19th century.

14.3.2 Sydney CBD

The European colonisation of Australia began with the establishment of a colony at Sydney Cove by Captain Arthur Phillip in January 1788 on land inhabited by the Gadigal people. The subject site and immediately surrounding area were an integral part of the pre- and post-contact history of both the Gadigal people and the Aboriginal peoples across the surrounding region.

The colony was founded around the mouth of a freshwater source provided by the Tank Stream, which flowed into the cove at the northern end of present day Pitt Street. In the months following the first landing, First Government House was established on the corner of present-day Bridge and Phillip streets, with a government wharf built on the shoreline to the north of the house.

The initial growth of the settlement was largely unplanned, with streets and laneways developing organically, shaped by the natural topography. When Governor Macquarie took office in 1810, he attempted to impose some order on the development of the city and a grid pattern was superimposed on the southern, eastern, and western sides of the expanding town. As the city grew throughout the 19th century, most of the Sydney CBD was developed with commercial buildings, while warehouses and wool stores were located on or near the waterfront, and workers' housing was located in The Rocks and Millers Point area.

South of the Sydney CBD, industrial land uses began to define the area of Chippendale and Darlington, with the Kent Brewery established on Parramatta Road in 1835, and the Eveleigh Railway Workshops and various factories established in the latter half of the 19th century.

14.4 Historical context of the project area

14.4.1 Chatswood dive site (northern)

The original focus of Chatswood was centred on the intersection of Mowbray Road and Lane Cove Road, where the Bush Mission Society had constructed a small chapel and John Bryson established a timber yard and 'school of arts' hall by the 1870s. The Great Northern Hotel was opened by Henry Russell in 1870 and in 1876 the area was sub-divided and called the Chatswood Estate. Chatswood, as it is today, was largely created after World War II and the western side of the railway was designated for commercial development. In the 1960s the first major retail stores were opened on the eastern side of the railway.

Historic plans suggest that the Chatswood dive site was occupied as early as 1836. The study area has been extensively developed over time and currently contains low-rise commercial buildings and a works depot.

14.4.2 Artarmon substation

In 1794, the first land grants were made in the area that was to become known as Artarmon. The suburb of Artarmon is believed to have been named for a 150-acre land grant made in 1810 by Governor Macquarie. A large house was built in the area in the mid-19th century and in 1922 the estate was purchased by the North Sydney Brick and Tile Company. The house was demolished in 1939.

In the mid-20th century, the study area was occupied by small-scale residential subdivisions. Some of the residences were demolished for construction of the Gore Hill Freeway, which is likely to have resulted in substantial modification to the surrounding landscape.

14.4.3 Crows Nest Station

Historic plans suggest that the earliest structures in the study area are from the late 19th century associated with the Berry's Estate subdivision.

The lower North Shore was generally held in large estates until the mid-19th century when subdivision of the area occurred more frequently. After the T1 North Shore Line was completed in 1893, suburban settlement in the area continued. However, due to difficulties crossing the harbour, this was slow.

The study area has the potential to contain archaeological remains associated with late 19th and early 20th century residential subdivision.

14.4.4 Victoria Cross Station

The area was gazetted as the township of St Leonards in the early 19th century and it is unlikely that soldiers, convicts or free settlers lived in the Victoria Cross Station study area until the mid-19th century. By the late 19th century, Miller Street was part of the commercial and civic centre of St Leonards.

Settlement in the area increased dramatically during the early to mid-20th century, and a number of public buildings, such as the former School of Arts, Post Office / Court House / Police Station complex and a Masonic Hall were all built at this time. The Sydney Harbour Bridge had dramatically changed the streetscapes in the area and redevelopment in the area was primarily associated with Art Deco architecture.

The late 1950s and early 1960s saw a dramatic change in the area with low land prices attracting large corporations that built substantial office blocks and towers, many conglomerating along the Pacific Highway, taking over land on Berry and Miller streets.

Construction of successive phases of buildings in the study area would have impacted on archaeological remains. Typically, the earlier the building was constructed, the less impact it would have had on the potential archaeological remains. There is some potential that archaeological remains dating from the mid-19th to early 20th century may be located within the study area.

14.4.5 Blues Point temporary site

The study area was originally located within land granted to William (Billy) Blue in 1817. Blue was appointed ferryman to the North Shore and began a rowing boat service between Dawes Point in the Rocks and Blues Point. The configuration of the study area in the early 19th century is unknown, although it can be assumed that it may have contained simple wharves and associated structures.

Blues Point Road was gazetted from 1839 as a thoroughfare from the ferry wharf to the St Leonards township (today known as North Sydney) and Blue's estate was subdivided from the mid-19th century, with the earliest developments occurring around its northern end. Other wharf structures were also present at Blues Point in the mid-19th century.

By the 1870s, the middle and southern portions of the peninsula had been subdivided and a vehicular ferry was established in 1900. From the late 19th century, the foreshore was known for its boat building and repair industry. Commercial and residential development was present in the study area in the early 20th century.

14.4.6 Sydney Harbour

The Heritage Division of the Office of Environment and Heritage (OEH) is the agency responsible for the management of maritime archaeology and underwater cultural heritage in NSW. The Division administers both the Commonwealth's *Historic Shipwrecks Act 1976*, and the *NSW Heritage Act 1977*. The two acts, together with the Annex to the *UNESCO Convention on the Protection of the Underwater Cultural Heritage 2001* (endorsed by the Heritage Council of NSW as best practice in 2005), provide protection to maritime archaeology and underwater cultural heritage sites in NSW and adjacent waters.

A number of vessels, including *The Three Bees* (1814), *The Sea Nymph* (1882) (probably raised soon after) and *The Birkenhead* (1913), are known to have been shipwrecked in the waters surrounding Dawes Point and Blues Point throughout the late 19th and early 20th centuries. However, no wrecks listed on the Australian National Shipwreck Database are located within the study area.

One item, a propeller, is listed on the OEH Maritime Heritage register. The propeller is located about 300 metres east of the proposed Harbour Crossing location.

14.4.7 Barangaroo Station

Development of the Barangaroo Station study area is thought to have occurred from the early 19th century. Occupation of the eastern side of what was to be named Cockle Bay (and later Darling Harbour) was confined to several key land grants to those associated with the military, including the military hospital, military bathing house and the military barracks.

From the early 19th century, the town of Sydney expanded and developed, with an organised layout of streets and construction of a wharf at the base of Market Street to allow for easy transport of produce from the farms on the Hawkesbury River. Over the following decades, numerous shipbuilding and transport wharves were constructed along the eastern shore of Darling Harbour. From 1908, the Sydney Harbour Trust carried out a number of improvements in north Darling Harbour, including the construction of Hickson Road in the mid-1920s.

The Rocks and Millers Point Archaeological Management Plan (Higginbotham et al, 1991) identifies that the study area is mostly disturbed. However, deep features, such as wells and cesspits, may be present under Hickson Road.

Archaeological investigations were also carried out for the Barangaroo development site (Austral Archaeology, 2010) that assessed the site as having potential to contain archaeological evidence of 19th and 20th century remains of wharves and associated buildings, shoreline modifications such as sea walls, and evidence of trade and industry.

A large sandstone seawall was encountered during roadwork within Hickson Road (McLeod, 2000) and subsequent archaeological investigations have found that reclamation buried, rather than demolished, this earlier evidence of land modification.

14.4.8 Martin Place Station

Soon after the arrival of Europeans at Sydney Cove in 1788, the Tank Stream was recognised as being a vital source of fresh water in the colony. The stream, today located below Pitt Street, is reflected in the layout of the streets in the vicinity of the study area. George Street (originally High Street), Pitt and Castlereagh streets (originally Camden Street) were all laid out parallel to the stream. By the early 1800s, the Martin Place Station study area began to be subdivided and developed.

By the early 1830s, many of the early landholdings and leases had been formerly granted, and plans indicate that numerous buildings were located within the Martin Place Station study area at this time. It is not known what the buildings on these early land grants were used for, but it is likely they were associated with commercial, residential and small-scale industrial uses.

Development continued through the mid-19th century and the construction of the General Post Office on the corner of George and Pitt streets between 1870 and 1880 saw the first phase of urban planning for what would become Martin Place. Sydney City Council began to promote Martin Place as the major financial and insurance centre of Sydney, resulting in many prominent banking, financial and insurance companies establishing in the area from the 1900s. In 1979, the entirety of Martin Place became a pedestrian precinct, and Martin Place Railway Station was opened.

There is potential for archaeological remains within the Sydney CBD to be substantially intact, and date from early phases of the development of the colony. An intact and early archaeological resource in the Martin Place Station study area has the potential to have significance at a State level. For example, archaeological monitoring and testing undertaken in 1997 in Angel Place (between Pitt and George streets) uncovered remains of early European settlement (circa 1810) in areas of the site that were found to have been undisturbed by later development (Godden Mackay, 1997).

Preliminary analysis suggests that archaeological remains, if they survive within the study area, would be associated with early to late 19th century residences, shopfronts and small scale industrial workshops.

14.4.9 Pitt Street Station

During the earliest years of settlement, it is likely that the study area was considered to be too far from Sydney Cove to attract substantial occupation. The presence of the burial ground, in the vicinity of present-day Sydney Town Hall, to the west of the Pitt Street Station study area, suggests that this area was considered the outer limit of the Town of Sydney. By the 1790s, the northern portion of Pitt Row, that would later become Pitt Street, had been laid out.

Sydney had greatly expanded by the 1840s, particularly due to a massive building boom in the 1830s. Land that once had been on the outer limits of the town was incorporated into the spreading commercial district. By the mid-19th century, the area was densely occupied by a number of residences and retail frontages. The majority of the buildings are likely to have been constructed of brick, and consisted of one or two storeys.

By the early 20th century, the area in the vicinity of the Pitt Street Station study area was occupied by coach factories and workshops, an auction room, numerous hotels, ironmongers, churches, a private school, food retailers, a photographer and an undertaker, among other uses.

The *Central Sydney Archaeological Zoning Plan* (City of Sydney, 1992) identifies a number of properties in Park Street (numbers 30–40) and Bathurst Street (numbers 107–109, 131–135 and 137–139) as areas of either archaeological potential or high archaeological potential due to limited physical disturbance.

The Metropolitan Fire Brigade and the Masonic Club buildings (refer Section 14.5.8) are listed as having an archaeological component to their heritage significance. The Pitt Street Station north site was 'occupied' by historic structures from an earlier period than the Pitt Street Station south site and preliminary analysis suggests that the archaeological resource, if it survives within the study area, would be associated with mid to late 19th century residences, shopfronts and small-scale industrial workshops.

14.4.10 Central Station

Central Railway Station is built on the site of the two earlier Sydney railway terminals. The Sydney Railway Company constructed the first Sydney Station in 1855. In the early 1870s, a lack of facilities identified at the original station led to the construction of a larger station which was completed 1874. Positioned in the same location as the first Sydney Station, its northern frontage faced onto Devonshire Street.

In 1892, the Chief Railway Engineer submitted proposals to the Railway Commission to build a large terminus for country trains on the site of the Benevolent Asylum and Devonshire Street Cemetery. This additional country terminus required the resumption of land occupied by a number of structures including the Devonshire Street Cemetery (1820–1867), the Benevolent Asylum, the Steam Tram Depot (established in 1879) and the Christ Church Parsonage (established in 1855).

Over time, increased congestion in the city led to a series of public infrastructure changes in Sydney. These infrastructure upgrades have become some of Sydney's most prominent transport landmarks, including the underground eastern suburbs railway, and initial planning for the Sydney Harbour Bridge. A new electric train platform on the eastern side of the existing terminal building was constructed in 1917 and involved the demolition of a carriage shed, several storage sheds and an old sewer.

The archaeological potential of the Central Station precinct was assessed in the *Central Station Conservation Management Plan* (Rappaport and Government Architect's Office, 2013). The key archaeological research value of the Central Station site is associated with the sites of the former Benevolent Asylum and government buildings.

Prince Alfred Park was part of the Government (or Cleveland) Paddocks. Continuity of use and layout of Prince Alfred Park, including the alignments of paths and planted areas have remained remarkably consistent over time and thus the layout of the park has remained unchanged since its inception. Prince Alfred Park was the site of the Royal Agricultural Society Show from 1869–1880 and an exhibition hall was constructed at the northern portion of the site in 1870. Other temporary buildings were constructed according to demand for the show. The former exhibition building was demolished in the 1950s to make way for a swimming pool.

Prince Alfred Park was listed as an archaeological item on the *Sydney Local Environmental Plan 2005*, but is not listed as having a substantial archaeological component on the *Sydney Local Environmental Plan 2012*.

14.4.11 Waterloo Station

The suburb of Waterloo is associated with a 1400-acre grant given to William Hutchinson in 1823 and it is unlikely that substantial development within the Waterloo Station study area occurred during this period. Prior to development, the area consisted of extensive swamps and although agricultural activity took place in the area in the early 19th century, the risk of flooding and marshy conditions did little to encourage settlement.

By the late 19th century, the introduction of drainage systems along areas of increased occupation and leveling of various land formations resulted in further development. Plans show that the Waterloo Station study area contained a congregational church and a bank, amongst other structures. In the early 20th century, increased industrial development in Waterloo meant warehouses and factories became prominent within the landscape and by the mid-20th century the study area was heavily developed.

14.4.12 Marrickville dive site (southern)

Most of the western half of Sydenham, including the area now occupied by Sydenham Railway Station, was previously a swamp. The swamp provided an effective boundary for early European land grants. The majority of Sydenham, including the Marrickville dive site study area, is located within the site of Douglas Farm, which was granted to Thomas Moore in 1799. The farm grew maize and wheat and also had valuable stands of timber that were logged (some were used for boat building).

Unwin's Bridge Road, located to the south and east of the study area, was originally constructed using convict labour in 1836, during a period when the area was occupied primarily by brick makers. During the Great Depression in the 1930s, a large brick-lined drainage pit (a State heritage listed item known as 'Sydenham Pit and Drainage Pumping Station 1') was constructed in Garden Street as a relief work scheme. Sydenham Railway Station, located to the southwest of the study area, was built on the duplicated line from Illawarra Junction to Hurstville and opened in 1884.

Analysis of early plans does not provide evidence of structures being present in the Marrickville dive site study area earlier than the mid-19th century. Thomas Moore owned large amounts of land in the vicinity, and it is unlikely that he had a residence in this location or used the land for more than the grazing of stock during the early 19th century. There is a possibility that the study area contains archaeology dating to the mid-19th century or later.

Industrial areas within Sydney and the inner suburbs tended to develop quickly, and were subject to rapid modification as the development of technologies required different infrastructure. Aerial photography from 1943 indicates that numerous potential clay pits were located in the area. It can be assumed, due to substantial ground disturbance, that if a late 19th or early 20th century brick-making pit is located within the study area, any archaeological remains associated with earlier phases of development are likely to have been impacted or removed.

14.5 Assessment of heritage significance and impact

This section summarises the potential impact of the project on heritage items or potential archaeological remains. Detail on all heritage listed items and potential archaeological remains in the study area is provided in *Technical paper 4 – Non-Aboriginal heritage*.

14.5.1 Chatswood dive site (northern) and northern surface works

Heritage items and conservation areas

The study area for the Chatswood dive site and northern surface works incorporates the area along the T1 North Shore Line between Chatswood Station, Chatswood and Brand Street, Artarmon. The project would impact, directly or indirectly, on a number of listed heritage items or heritage conservation areas, as identified in Table 14-3 and shown in Figure 14-1.

Table 14-3 Chatswood dive site (northern) – impacts on heritage items and conservation areas

Ref	Description	Listing [1]	Heritage significance	Heritage impact and magnitude
CDS1	Mowbray House	LEP and s.170	Local	• Direct impact: Minor (physical impact). Item would be retained and demolition of non-original outbuildings would be required. The façade of the building would not be impacted and any interior modifications would be reversible • Potential direct impact: Minor (vibration). The closest façade of this item would experience vibration above the 7.5mm/s screening level for cosmetic damage • Indirect impact: Minor (views and vistas). Visually, the surrounding buildings that would be demolished do not contribute to the heritage setting of the item.
CDS2	Garden of Remembrance	LEP	Local	• Indirect impact: Negligible (views and vistas).
CDS3	South Chatswood Conservation Area	LEP	Local	• Indirect impact: Negligible (views and vistas).
CDS4	Artarmon Conservation Area	LEP	Local	• Indirect impact: Negligible (views and vistas).
CDS5	Chatswood zone substation No.80 (Ausgrid)	LEP	Local	• Indirect impact: Negligible (views and vistas).
CDS6	Chatswood Reservoirs No.1 and No.2	SHR	State	• Indirect impact: Negligible (views and vistas).
CDS7	The Great Northern Hotel	LEP	Local	• Indirect impact: Negligible (views and vistas).
CDS8	Chatswood South Uniting Church and Cemetery	SHR, LEP	State	• Indirect impact: Negligible (views and vistas).

1 *SHR: State Heritage Register; s.170: Listing under section 170 (of the Heritage Act 1977); LEP: local environment plan*

Figure 14-1 Chatswood dive site – impacts on heritage items and conservation areas

Archaeological remains

Table 14-4 identifies the type of archaeological remains that may be present, the potential for those archaeological remains to occur within the study area, their likely heritage significance and the potential for those remains to be impacted by the project.

Table 14-4 Chatswood dive site (northern) – impacts on archaeological remains

Potential archaeological remains	Potential for occurrence	Heritage significance	Preliminary archaeological impact assessment
Evidence of mid-19th century occupation of the study area	Low	Local	Minor to moderate impact on potential archaeological resources, dependent on the location and extent of the proposed excavation works.
Evidence of mid to late 19th century residential and commercial development	Low to moderate	Local	
Evidence of 20th century residential and commercial development	Moderate	Unlikely to be of local significance	

14.5.2 Artarmon substation

Heritage items

There are no listed heritage items in the Artarmon substation study area.

Archaeological remains

Table 14-5 identifies the type of archaeological remains that may be present, the potential for those archaeological remains to occur within the study area, their likely heritage significance and the potential for those remains to be impacted by the project.

Table 14-5 Artarmon substation – impacts on archaeological remains

Potential archaeological remains	Potential for occurrence	Heritage significance	Preliminary archaeological impact assessment
Evidence of early occupation of the study area	Nil to low	Local	Minor impact on potential archaeological resources, dependent on the location and extent of the proposed excavation works.
Evidence of mid-19th century development	Nil to low	Local	
Evidence of late 19th and early 20th century residential development	Low to moderate	Unlikely to be of local significance	

14.5.3 Crows Nest Station

Heritage items

The project would indirectly impact on one listed heritage item, as identified in Table 14-6 and shown in Figure 14-2.

Table 14-6 Crows Nest Station – impacts on heritage items

Ref	Description	Listing [1]	Heritage significance	Heritage impact and magnitude
CN1	St Leonards Centre	LEP	Local	• Indirect impact: Negligible (views and vistas). Project elements would not compete visually with the heritage item • Potential direct impact: Minor (vibration). The closest façade of this item would experience vibration above the 7.5mm/s screening level for cosmetic damage.
CN2	Higgins Buildings	LEP	Local	• Indirect impact: Negligible (views and vistas).

1 *LEP: local environment plan*

KEY

Chatswood to Sydenham

LEP Heritage item

Proposed construction site area

25 m buffer

Proposed operational area at surface

Indicative only, subject to design development

0 100 m

N

Figure 14-2 Crows Nest Station – impacts on heritage items

Archaeological remains

Table 14-7 identifies the type of archaeological remains that may be present, the potential for those archaeological remains to occur within the study area, their likely heritage significance and the potential for those remains to be impacted by the project.

Table 14-7 Crows Nest Station – impacts on archaeological remains

Potential archaeological remains	Potential for occurrence	Heritage significance	Preliminary archaeological impact assessment
Evidence of early occupation of the study area	Nil to low	Local	Excavation of the cut-and-cover station would result in the complete removal of archaeological remains within the station box footprint. Therefore, works in this location would have a major impact on any potential archaeological resources.
Evidence of mid to late 19th century residential and commercial development	Low to moderate	Local	
Evidence of 20th century commercial or residential development	Moderate	Unlikely to be of local significance	

14.5.4 Victoria Cross Station

Heritage items and conservation areas

The project would impact, directly or indirectly, on a number of listed heritage items and heritage conservation areas, as identified in Table 14-8 and shown in Figure 14-3.

Table 14-8 Victoria Cross Station – impacts on heritage items and conservation areas

Ref	Description	Listing[1]	Heritage significance	Heritage impact and magnitude
VC1	Restaurant (196 Miller Street)	LEP	Local	• Indirect impact: Neutral (views and vistas) • Potential direct impact: Minor (vibration). The closest façade of this item would experience vibration above the 7.5mm/s screening level for cosmetic damage.
VC2	House (31 McLaren Street)	LEP	Local	• Indirect impact: Neutral (views and vistas) • Potential direct impact: Minor (vibration). The closest façade of this item would experience vibration above the 7.5mm/s screening level for cosmetic damage.
VC3	Fairhaven (33 McLaren Street)	LEP	Local	• Indirect impact: Neutral (views and vistas) • Potential direct impact: Minor (vibration). The closest façade of this item would experience vibration above the 7.5mm/s screening level for cosmetic damage.
VC4	O'Regan (192 Miller Street)	LEP	Local	• Indirect impact: Minor (views and vistas). Demolition of adjacent buildings would have a minor impact to the setting of the heritage item • Potential direct impact: Minor (vibration). The closest façade of this item would experience vibration above the 7.5mm/s screening level for cosmetic damage.

Ref	Description	Listing[1]	Heritage significance	Heritage impact and magnitude
VC5	Monte Sant' Angelo Group	LEP	Local	- Indirect impact: Negligible (views and vistas).
VC6	Shop at 187 Miller Street	LEP	Local	- Direct physical impact: Major (complete demolition). The item would not retain its heritage significance and would no longer provide a representative example of its type.
VC7	MLC Building (105-153 Miller Street)	LEP	Local	- Potential direct impact: Neutral (vibration). The closest façade of this item would not experience vibration above the 7.5mm/s screening level for cosmetic damage - Potential direct impact: Minor (demolition of adjacent and adjoining structure potentially resulting in impacts to fabric of heritage item).
VC8	McLaren Street Conservation Area	LEP	Local	- Indirect impact: Minor (views and vistas). Demolition of existing buildings within this site would have a minor impact as views and vistas to the south are currently compromised by a modern building that does not contribute to the setting of the heritage item.
VC9	Rag and Famish Hotel (199 Miller Street)	LEP	Local	- Indirect impact: Minor (views and vistas). Demolition of existing buildings opposite this item and construction of the proposed station entrance would have a minor impact on the streetscape of this item - Potential direct impact: Neutral (vibration). The closest façade of this item would not experience vibration above the 7.5mm/s screening level for cosmetic damage.
VC10	Commercial building (201 Miller Street)	LEP	Local	- Potential direct impact: Neutral (vibration). The closest façade of this item would not experience vibration above the 7.5mm/s screening level for cosmetic damage.
VC11	North Sydney bus shelters	LEP	Local	- Direct physical impact: Moderate (removal and re-location). Reinstatement of the item would retain its historic significance.

1 *LEP: local environment plan*

Figure 14-3 Victoria Cross Station – impacts on heritage items and conservation areas

Archaeological remains

Table 14-9 identifies the type of archaeological remains that may be present, the potential for those archaeological remains to occur within the study area, their likely heritage significance and the potential for those remains to be impacted by the project.

Table 14-9 Victoria Cross Station – impacts on archaeological remains

Potential archaeological remains	Potential for occurrence	Heritage significance	Preliminary archaeological impact assessment
Evidence of early occupation of the study area	Nil to low	Local	The extent of excavation within the Victoria Cross Station site varies from discrete areas of minor excavation through to two open shaft excavations. Therefore, works in this location are likely to have a minor to major impact on potential archaeological resources, dependent on the location and extent of excavation.
Evidence of mid-19th century residential and commercial development	Low to moderate	Local	
Evidence of late 19th century and early 20th century residential and commercial development	Moderate	May be of local significance	

14.5.5 Blues Point temporary site

Heritage items and conservation areas

The project would impact, directly or indirectly, on a number of listed heritage items and heritage conservation areas, as identified in Table 14-10 and shown in Figure 14-4.

Table 14-10 Blues Point temporary site – impacts on heritage items and conservation areas

Ref	Description	Listing [1]	Heritage significance	Heritage impact and magnitude [2]
BP1	Blues Point Waterfront Group [3]	LEP	Local	- Direct physical impact: Minor to moderate (excavation of tunnel support shaft). Direct impacts as a result of the construction site would have direct minor to moderate impacts within the reserve. These impacts would be within the existing park, which would be reinstated - Temporary indirect impact: Minor to moderate (views and vistas). The construction site would have a temporary minor to moderate visual impact on this highly regarded public reserve with important views to and from the harbour.
BP2	North Sydney bus shelters	LEP	Local	- Direct physical impact: Moderate (removal and re-location). Reinstatement of the item would retain its historic interest significance.
BP3 and BP4	House (3 Warung Street) and House (5 Warung Street)	LEP	Local	- Temporary indirect impact: Minor (views and vistas). The temporary construction site would have a minor impact on the setting of these items and their views across the harbour.

Ref	Description	Listing [1]	Heritage significance	Heritage impact and magnitude [2]
BP5	McMahons Point South Heritage Conservation Area	LEP	Local	• Direct physical impact: Minor to moderate (excavation of tunnel support shaft). Direct impacts as a result of the construction site would have direct minor to moderate impacts within the reserve. These impacts would be within the existing park, which would be reinstated • Temporary indirect impact: Minor to moderate (views and vistas). The construction site would have a temporary minor to moderate visual impact on this area. The visual impact would be removed upon finalisation of the works and reinstatement of the site.
BP6	Sydney Opera House buffer zone	WHL	Outstanding universal value	• Temporary indirect impact: Negligible (views and vistas).
BP7	Blues Point Tower	LEP	Local	• Temporary indirect impact: Minor to moderate (views and vistas). The construction site would have a minor to moderate temporary impact to aesthetic significance of this item, including its relationship with the landscape.

1 LEP: local environment plan; WHL: World Heritage List

2 Heritage impact and magnitude described is temporary in nature based on this being a temporary (construction only) site

3 The Blues Point Waterfront Group listing includes all lands south of the cliff face that forms the northern boundary of Henry Lawson Drive, from the McMahons Point Ferry Wharf to the northernmost end of the public reserve on the western side of Blues Point, but additionally includes the public steps from the corner of East Crescent Street and Warung Street down to the McMahons Point Ferry Wharf. Most of the land, excepting the Blues Point Tower, is publicly owned. The Blues Point Waterfront Group listing also includes the Foreshore shelf; Former tram turning circle and McMahons Point ferry wharf; Ferry access steps; Vehicular ferry dock remains; Former Holmes residence and slipway; Stone retaining wall; Bollards; WW2 observation post and steps; Excavation and Steps and Bollards.

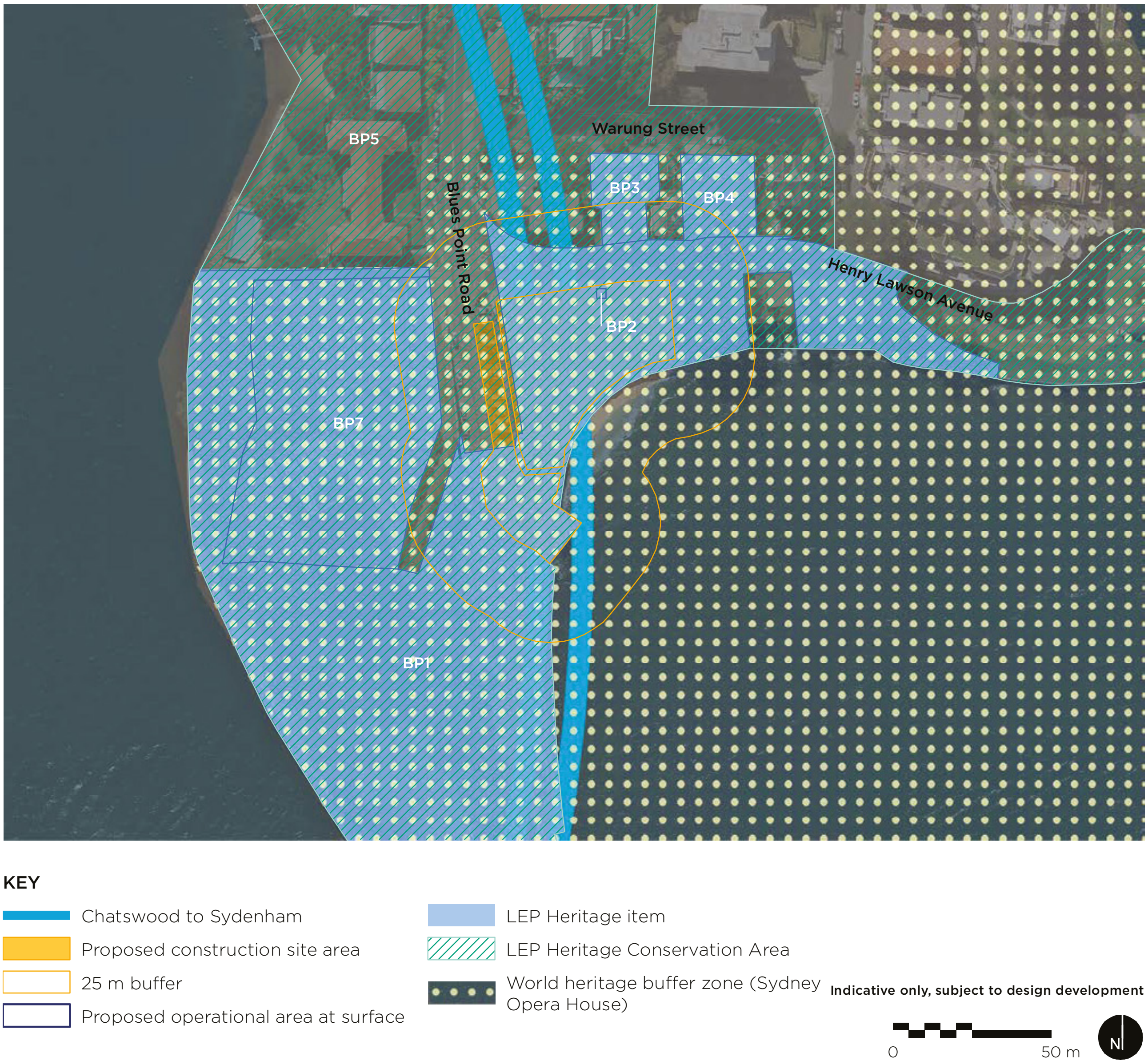


Figure 14-4 Blues Point temporary site – impacts on heritage items and conservation areas

Archaeological remains

Table 14-11 identifies the type of archaeological remains that may be present, the potential for those archaeological remains to occur within the study area, their likely heritage significance and the potential for those remains to be impacted by the project.

Table 14-11 Blues Point temporary site – impacts on archaeological remains

Potential archaeological remains	Potential for occurrence	Heritage significance	Preliminary archaeological impact assessment
Evidence of pre-1850's development of the foreshore	Low	May be of State significance	The extent of excavation at the Blues Point temporary site varies from discrete areas of minor excavation through to a substantial open shaft excavation. Therefore, works in this location are likely to have a minor impact on potential archaeological resources where discrete areas of minor excavation are proposed; and are likely to have a major impact on potential archaeological resources where more substantial shaft excavation is proposed
Evidence of mid to late 19th century boat-building industry	Moderate	Local	
Evidence of early 20th century development	Moderate	Unlikely to be of local significance	

14.5.6 Barangaroo Station

Heritage items and conservation areas

The project would impact, directly or indirectly, on a number of listed heritage items and heritage conservation areas, as identified in Table 14-12 and shown in Figure 14-5.

Table 14-12 Barangaroo Station – impacts on heritage items and conservation areas

Ref	Description	Listing[1]	Heritage significance	Heritage impact and magnitude
BN1	Warehouses and Dalgety's Bond Store Group (6-20 Munn Street)	SHR and s.170	State	• Indirect impact: Minor (views and vistas). The introduction of new station infrastructure in this location would result in a minor impact to the setting of the heritage item. The heritage significance of the item would not be impacted • Potential direct impact: Minor (vibration). The closest façade of this item would experience vibration above the 7.5mm/s screening level for cosmetic damage.
BN2	Shops and residences including interiors (1-7 Argyle Place)	SHR; s.170 and LEP	State	• Indirect impact: Negligible (views and vistas).
BN3	Terrace Duplexes (2-36 High Street)	SHR; s.170; LEP	State	• Indirect impact: Negligible (views and vistas).
BN4	Terrace Duplexes (38-72 High Street)	SHR; s.170; LEP	State	• Indirect impact: Negligible (views and vistas).
BN5	Terrace Duplexes (74-80 High Street)	SHR; s.170; LEP	State	• Indirect impact: Negligible (views and vistas).

Ref	Description	Listing[1]	Heritage significance	Heritage impact and magnitude
BN6	Millers Point and Dawes Point Village Precinct	SHR	State	• Direct impact: Minor (fabric). Excavation of the station would result in impacts to fabric within the Hickson Road corridor. These impacts to fabric would be minor in the context of the precinct as a whole. • Indirect impact: Minor to moderate (views and vistas). The station entrances and services building would be located to the west of Hickson Road, outside the precinct. However ventilation risers and skylights fronting the Hickson Road wall would be within the precinct and would have a minor impact on the setting of the precinct.
BN7	Millers Point Conservation Area	SHR; s.170; LEP; RNE	State	• Indirect impact: Negligible (views and vistas).
BN8	Shops and residences (6-8 Argyle Place)	SHR; s.170; LEP	State	• Indirect impact: Negligible (views and vistas).
BN9	Bridges over Hickson Road	LEP	Local	• Indirect impact: Minor, temporary (views and vistas). The temporary impact would not affect the historical significance of the items, being the physical evidence of major state government redevelopment of the district in the years following the 1901 bubonic plague.
BN10	Palisade fence and High Steps	LEP	Local	• Indirect impact: Negligible (views and vistas).
BN11	Terrace Duplexes (3-9 High Street)	SHR; s.170; LEP	State	• Indirect impact: Negligible (views and vistas).
BN12	Oswald Bond Store	SHR; s.170; NTR	State	• Indirect impact: Negligible (views and vistas).
BN13	Lance Kindergarten including buildings and interiors, early remnant fencing and grounds (including trees).	LEP	Local	• Indirect impact: Negligible (views and vistas).
BN14	Walsh Bay Wharves Precinct (including Terrace and MSB Bond Store No.3)	SHR	State	• Indirect impact: Neutral (views and vistas).

1 *SHR: State Heritage Register; s.170: Listing under section 170 (of the Heritage Act 1977); LEP: local environment plan; RNE: Register of the National Estate; NTR: National Trust Register*

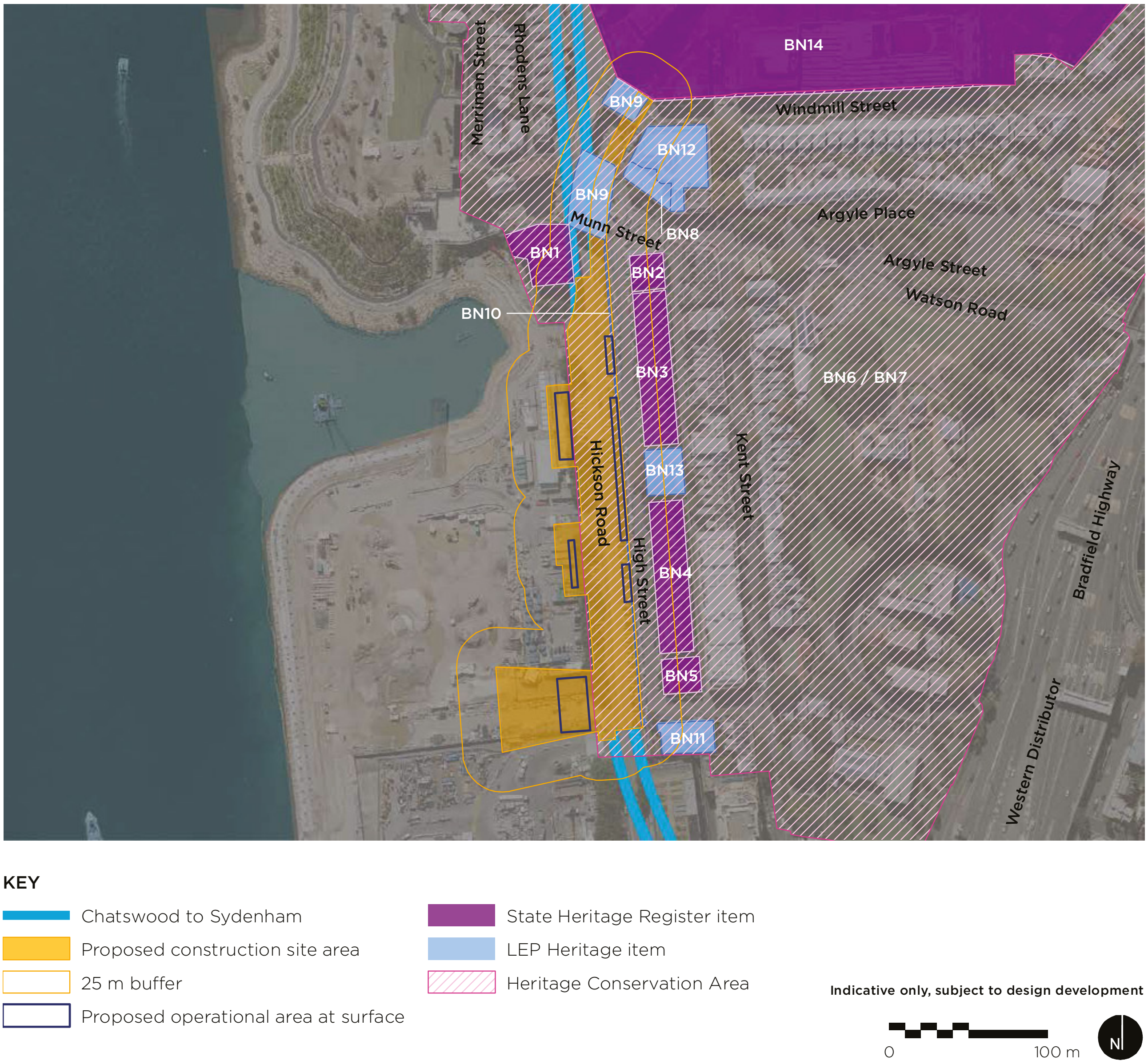


Figure 14-5 Barangaroo Station – impacts on heritage items and conservation areas

Archaeological remains

Table 14-13 identifies the type of archaeological remains that may be present, the potential for those archaeological remains to occur within the study area, their likely heritage significance and the potential for those remains to be impacted by the project.

Table 14-13 Barangaroo Station – impacts on archaeological remains

Potential archaeological remains	Potential for occurrence	Heritage significance	Preliminary archaeological impact assessment
Evidence of pre-1830s use of the foreshore	Low to moderate	State	The excavation of the cut-and-cover station would result in the complete removal of any archaeological remains within the station footprint. Therefore, works in this location would have a major impact on any archaeological resources present.
Evidence of pre-1850s resumption and development of the foreshore, wharves and / or industrial development	Moderate	Local – State	
Evidence of pre-1900 wharves and industrial development	Moderate to high	Local	
Evidence of early 20th century resumption and construction of Hickson Road	High	Local	

14.5.7 Martin Place Station

Options development and station design

As discussed in Chapter 4 (Project development and alternatives), Martin Place is intended to serve Sydney's financial district and the civic spaces and uses along Martin Place and Macquarie Street. Convenient interchange between the proposed metro station and the existing Martin Place Station is a key locational driver. Designing for Martin Place as a 'one station solution' that provides station-to-station interchange within the paid concourse areas of both stations places a geographical constraint on the station's location.

The specific location of the proposed Martin Place Station has also been influenced by a number of other key constraints. These include:

- Underground constraints such as basements and other services and infrastructure that influence the tunnel alignment and depth and therefore the location and orientation of the station itself
- Minimising impacts to heritage buildings and places, including direct and indirect impacts to the Commonwealth Bank building and the existing Martin Place Station, which are heritage items listed on the State Heritage Register
- Minimising impacts to, and optimising integration of the station with the public domain of Martin Place, a major civic spine that is a focus of the City of Sydney's *Martin Place Urban Design Study*.

The above constraints have resulted in the separation of the northbound and southbound tunnel alignments generally beneath Castlereagh and Pitt streets respectively; two station footprints (rather than one) that increase the offset distance from the Commonwealth Bank Building; and the provision of station entrances that avoid the direct use of Martin Place.

Heritage items

The project would impact, directly or indirectly, on a number of listed heritage items as identified in Table 14-14 and shown in Figure 14-6.

Table 14-14 Martin Place Station – impacts on heritage items

Ref	Description	Listing [1]	Heritage significance	Heritage impact and magnitude
MP1	Former City Mutual Life Assurance building, including interior	SHR and LEP	State	• Indirect impact: Minor (views and vistas). The heritage item has a direct visual connection with the proposed northern station entry, which would have a minor visual impact on the setting of the heritage item. The structures to be demolished within the Martin Place north construction site do not contribute to the heritage significance or setting of the item • Potential direct impact: Neutral (vibration). The closest façade of this item would not experience vibration above the 7.5mm/s screening level for cosmetic damage.
MP2	Former Qantas House, including interior	SHR and LEP	State	• Indirect impact: Minor (views and vistas). The heritage item has a direct visual connection with the proposed northern station entry, which would have a minor visual impact on the setting of the heritage item. The structures to be demolished within the Martin Place north construction site do not contribute to the heritage significance or setting of the item • Potential direct impact: Neutral (vibration). The closest façade of this item would not experience vibration above the 7.5mm/s screening level for cosmetic damage.
MP3	Richard Johnson Square, including monument and plinth	LEP	Local	• Indirect impact: Minor (views and vistas). The heritage item has a direct visual connection with the proposed northern station entry, which would have a minor visual impact on the setting of the heritage item. The structures to be demolished within the Martin Place north construction site do not contribute to the heritage significance or setting of the item. There would be no impact to the heritage significance if the item.
MP4	Chifley Square	LEP	Local	• Indirect impact: Minor (views and vistas). The heritage item has a direct visual connection with the proposed northern station entry, which would have a minor visual impact on the setting of the heritage item. There would be no impact to the heritage significance if the item.

Ref	Description	Listing [1]	Heritage significance	Heritage impact and magnitude
MP5	Flat building, including interior (7 Elizabeth Street)	LEP	Local	• Direct physical impact: Major (complete demolition). The heritage values of the item would be lost and it would not retain it's local heritage significance.
MP6	Bennelong Stormwater Channel No.29	s.170	Local	• Potential direct impact: Minor (vibration). This item would experience vibration above the 7.5mm/s screening level for cosmetic damage.
MP7	Commonwealth Bank of Australia, including interior	SHR and LEP	State	• Potential direct impact: Minor (vibration). The closest façade of this item would not experience vibration above the 7.5mm/s screening level for cosmetic damage as a result of mined construction of underground pedestrian connections, however demolition of existing adjacent and adjoining structures may result in vibration impacts above the screening level for cosmetic damage • Potential direct impact: Minor (demolition of adjacent and adjoining structure potentially resulting in impacts to fabric of heritage item) • Indirect impact: Moderate (views and vistas). The aesthetic significance of the item is primarily in relation to its design and materials. These elements of aesthetic value would not be impacted by the project. The buildings to be demolished to the north and south of the item do not contribute to the heritage significance or setting of the item. The demolition of buildings to the north and south of the item and the introduction of the southern station entry would have a moderate impact on setting of the heritage item. The social significance of the item would not be impacted as it would retain its use as a banking institution and public association with that industry. The rarity of the item would not be impacted by the project as the fabric of the item would not be impacted.

Ref	Description	Listing[1]	Heritage significance	Heritage impact and magnitude
MP8	Former MLC building, including interior	SHR and LEP	State	- Potential direct impact: Neutral (vibration). The closest façade of this item would not experience vibration above the 7.5mm/s screening level for cosmetic damage - Indirect impact: Minor (views and vistas). The heritage item has a direct visual connection with the proposed southern station entry, which would have a minor visual impact on the setting of the heritage item. The structures to be demolished within the Martin Place south construction site do not contribute to the heritage significance or setting of the item.
MP9	Martin Place	LEP	Local	- Direct physical impact: Moderate (cut and cover excavation and removal of existing station entrances within Martin Place for proposed station concourse). The project would not affect the historic significance of the item - Indirect impact: Minor to moderate (views and vistas). The heritage item has a direct visual connection with the proposed southern station entry, which would have a minor to moderate visual impact on the setting of the heritage item. This would impact its aesthetic significance.
MP10	Martin Place Railway Station	SHR; s.170 and LEP	State	- Direct physical impact: Moderate (construction of direct connection to Martin Place Station from proposed metro station concourse). The project would result in moderate impact to the heritage item's aesthetic significance through removal of original fabric (including red ceramic tiling). There are other examples of red ceramic tiling throughout the item, which would not be impacted by the project. The historical, social significance, rarity and representativeness of the item would not be adversely impacted as the project would have limited impact to fabric and it would retain its use, public association with that use and its character.

1 *SHR: State Heritage Register; s.170: Listing under section 170 (of the Heritage Act 1977); LEP: local environment plan*

Figure 14-6 Martin Place Station – impacts on heritage items

Archaeological remains

Table 14-15 identifies the type of archaeological remains that may be present; the potential for those archaeological remains to occur within the study area, their likely heritage significance and the potential for those remains to be impacted by the project.

Table 14-15 Martin Place Station – impacts on archaeological remains

Potential archaeological remains	Potential for occurrence	Heritage significance	Preliminary archaeological impact assessment
Evidence of early establishment of the colony	Nil to low	Local – State	The excavation of the shafts for access and vertical transport and cut-and-cover of Martin Place would result in the complete removal of any archaeological remains within those areas. Therefore, works in these locations would have a major impact on any archaeological resources present.
Evidence of pre-1850s residential and commercial development	Moderate	Local – State	
Evidence of late 19th century residential and commercial development	Moderate	Local	
Evidence of early to mid 20th century commercial development	Moderate to high	May be of local significance	

14.5.8 Pitt Street Station

Heritage items

The project would impact, directly or indirectly, on a number of listed heritage items, as identified in Table 14-16 and shown in Figure 14-7.

Table 14-16 Pitt Street Station – impacts on heritage items

Ref	Description	Listing [1]	Heritage significance	Heritage impact and magnitude
PS1	'National Building' incl. interior (248A–250 Pitt Street)	LEP	Local	• Indirect impact: Minor (views and vistas). The heritage item has a visual connection with the proposed northern station entry. The demolition of adjacent buildings for the Pitt Street north construction site would impact the setting of the heritage item and the introduction of a station entry adjacent to the item would have a minor visual impact. The project would not impact on the historic or aesthetic significance of the item • Potential direct impact: Minor (vibration). The closest façade of this item would experience vibration above the 7.5mm/s screening level for cosmetic damage and demolition of existing adjacent and adjoining structures may also result in vibration impacts above the screening level for cosmetic damage • Potential direct impact: Minor (demolition of adjacent and adjoining structures potentially resulting in impacts to fabric of heritage item).

Ref	Description	Listing[1]	Heritage significance	Heritage impact and magnitude
PS2	Masonic Club (169–173 Castlereagh Street)	LEP	Local	• Indirect impact: Minor to moderate (views and vistas). The demolition of adjacent buildings for the Pitt Street north construction site would impact the setting of the heritage item and the introduction of a station entry and services infrastructure adjacent to the item would have a minor to moderate visual impact. The project would not impact on the social or historic significance of the item • Potential direct impact: Minor (vibration). Demolition of existing adjacent and adjoining structures may result in vibration impacts above the screening level for cosmetic damage • Potential direct impact: Minor (demolition of adjacent and adjoining structure potentially resulting in impacts to fabric of heritage item).
PS3	Great Synagogue (166 Castlereagh Street)	SHR	State	• Indirect impact: Negligible (views and vistas) • Potential direct impact: Neutral (vibration). The closest façade of this item would not experience vibration above the 7.5mm/s screening level for cosmetic damage.
PS4	Former Australian Consolidated Press façade (189–197 Elizabeth Street)	LEP	Local	• Indirect impact: Neutral (views and vistas) • Potential direct impact: Neutral (vibration). The closest façade of this item would not experience vibration above the 7.5mm/s screening level for cosmetic damage.
PS5	Criterion Hotel	LEP	Local	• Indirect impact: Minor to moderate (views and vistas). The demolition of buildings for the Pitt Street north construction site would impact the setting of the heritage item through alteration of the existing streetscape. The introduction of a station entry opposite the item would have a minor to moderate visual impact. The project would not impact on the social or historic significance of the item • Potential direct impact: Neutral (vibration). The closest façade of this item would not experience vibration above the 7.5mm/s screening level for cosmetic damage.

Ref	Description	Listing [1]	Heritage significance	Heritage impact and magnitude
PS6	Pilgrim House including interiors (262–264 Pitt Street)	LEP	Local	• Indirect impact: Negligible (views and vistas) • Potential direct impact: Neutral (vibration). The closest façade of this item would not experience vibration above the 7.5mm/s screening level for cosmetic damage.
PS7	Former "CENEF House" including interiors (201 Castlereagh Street)	LEP	Local	• Potential direct impact: Neutral (vibration). These items would not experience vibration above the 7.5mm/s screening level for cosmetic damage.
PS8	St George's Church including interior and forecourt (201A Castlereagh Street)	LEP	Local	
PS9	"Porter House" including interior (203 Castlereagh Street)	LEP	Local	
PS10	Pitt Street Uniting Church (264 Pitt Street)	SHR	State	
PS11	Lincoln Building including interior (280–282 Pitt Street)	LEP	Local	
PS12	Former YMCA building	LEP	Local	
PS13	Former Speedwell House including interiors (284-292 Pitt Street)	LEP	Local	• Indirect impact: Minor to moderate (views and vistas). The demolition of buildings for the Pitt Street south construction site would impact the setting of the heritage item through alteration of the existing streetscape. The introduction of a station entry opposite the item would have a minor to moderate visual impact. The project would not impact on the historic significance of the item • Potential direct impact: Neutral (vibration). The closest façade of this item would not experience vibration above the 7.5mm/s screening level for cosmetic damage.

Ref	Description	Listing [1]	Heritage significance	Heritage impact and magnitude
PS14	Edinburgh Castle Hotel (294–294B Pitt Street)	LEP	Local	• Indirect impact: Minor to moderate (views and vistas). The demolition of adjacent buildings for the Pitt Street south construction site would impact the setting of the heritage item and the introduction of a station entry and services infrastructure adjacent to the item would have a minor to moderate visual impact. The project would not impact on the social or historic significance of the item • Potential direct impact: Minor (vibration). The closest façade of this item would experience vibration above the 7.5mm/s screening level for cosmetic damage and demolition of existing adjacent and adjoining structures may also result in vibration above the screening level • Potential direct impact: Minor (demolition of adjacent and adjoining structures potentially resulting in impacts to fabric of heritage item).
PS15	Metropolitan Fire Brigade building including interior (211–217 Castlereagh Street)	LEP	Local	• Potential direct impact: Minor (vibration). The closest façade of this item would experience vibration above the 7.5mm/s screening level for cosmetic damage, and demolition of existing adjacent and adjoining structures may result in vibration above the screening level • Potential direct impact: Minor (demolition of adjacent and adjoining structures potentially resulting in impacts to fabric of heritage item). There would be no impact to the historical and aesthetic significance of the item • Indirect impact: Neutral (views and vistas).
PS16	Former Sydney Water building (339–341 Pitt Street)	SHR	State	• Indirect impact: Moderate to major (views and vistas). The heritage item has a direct visual connection with buildings currently on the Pitt Street south construction site. The demolition of these buildings would considerably alter the setting of the heritage item through alteration of the existing streetscape. The introduction of a station entry opposite the item would have a minor to moderate visual impact. The historical, social significance, rarity and representativeness of the item would not be adversely impacted as the project.

Ref	Description	Listing[1]	Heritage significance	Heritage impact and magnitude
PS17	Bennelong Stormwater Channel No. 29	s.170	Local	Potential direct impact: Minor (vibration). This item would experience vibration above the 7.5mm/s screening level for cosmetic damage.

1 *SHR: State Heritage Register; s.170: Listing under section 170 (of the Heritage Act 1977); LEP: local environment plan*

Figure 14-7 Pitt Street Station – impacts on heritage items

Archaeological remains

Table 14-17 identifies the type of archaeological remains that may be present; the potential for those archaeological remains to occur within the study area, their likely heritage significance and the potential for those remains to be impacted by the project.

Table 14-17 Pitt Street Station – impacts on archaeological remains

Potential archaeological remains	Potential for occurrence	Heritage significance	Preliminary archaeological impact assessment
Evidence of early establishment of the colony	Nil to low	Local – State	The excavation of the shafts for access for platform construction, vertical transport and paid and unpaid concourse areas would result in the complete removal of any archaeological remains within those areas. Therefore, works in this location would have a major impact on any archaeological resources present.
Evidence of pre-1850s residential and commercial development	Moderate	Local – State	
Evidence of late 19th century residential and commercial development	Moderate	Local	
Evidence of early to mid 20th century commercial development	Moderate to high	May be of local significance	

14.5.9 Central Station

Options development and station design

Central Station is the busiest station in the Sydney transport network, providing key interchange for suburban and intercity rail services, light rail, bus, taxi and intercity coach services. Central Station has a large catchment comprising education, commercial and residential land uses. Having Sydney Metro services at Central Station reinforces the role of Central Station as the primary transport interchange for Sydney and also recognises the potential for the area around Central to be the civic, economic and community focus of the southern Sydney CBD.

Sydney Metro would build on the significant transport investments being made at Central, including the CBD and South East Light Rail project. The new metro platforms would support and enhance Central Station's historical role as the major interchange in the Sydney transport network and further build on the interchange functionality of the station.

Chapter 4 (Project development and alternatives) provides further discussion on a number of locations investigated for the provision of Sydney Metro platforms at Central Station. The introduction of underground metro platforms at Central Station would have material impacts to the station irrespective of the option chosen. Decision-making on the placement of the underground metro platforms seeks to balance the substantial benefits with the recognised constraints and challenges associated with its introduction.

Chapter 4 (Project development and alternatives) also discusses how specific elements of the design, such as the station services building, Sydney Yard Access Bridge and temporary pedestrian footbridge have been subject to ongoing design development to optimise the performance of the station while minimising impacts, including heritage impacts, to the existing station and adjacent heritage items. In summary:

- On balance, metro platforms below existing platforms 13 to 15 would have similar or reduced heritage impacts compared with other metro station locations considered
- The design has minimised the extent of services and other infrastructure in the northern part of the station to reduce the footprint within the existing Central Station northern concourse and below the Bradfield Building (former Lost Property Office)
- The design of the station services building has also been refined to minimise the bulk and scale of above ground infrastructure that in turn, reduces visual impacts and changes within the setting of heritage items
- A new access for Sydney Yard is required due to the removal of the existing access via Eddy Avenue. The Sydney Yard Access Bridge is the preferred solution for this new access.

The design of metro infrastructure at Central Station, including the Sydney Yard Access Bridge, is ongoing and would minimise direct impacts as well as impacts to the setting of adjoining and nearby heritage items. It would be developed in consultation with Sydney Trains and the Heritage Council of NSW and would be subject to review by the Sydney Metro Design Review Panel, including periodic independent review by an appropriately qualified and experienced heritage architect.

Heritage items

The project would impact, directly or indirectly, on a number of listed heritage items, as identified in Table 14-18 and shown in Figure 14-8.

Chapter 6 (Project description – construction) and Chapter 7 (Project description – construction) include figures that further illustrate the proposed scope of work at Central Station. Photomontages illustrating the project from key viewpoints are provided in Chapter 16 (Landscape character and visual amenity).

Table 14-18 Central Station – impacts on heritage items

Ref	Description	Listing [1]	Heritage significance	Heritage impact and magnitude
CS1	Sydney Terminal and Central Railway Stations Group	SHR; s.170 and DCP	State	• Direct physical impact: Moderate to major. The project would impact on platforms, including the removal of platforms 13 to 15. This would result in impacts to elements of heritage significance including overhead wiring structures, signalling, steel and timber furniture, awning and trusswork, goods lifts, signage, and hardwood buffers at the termination of the platforms. The station services building at the southern end of the station would extend into Sydney Yard, requiring removal of the Rolling Stock Officers Building, the Cleaners Amenities Building, and the Rolling Stock Officers Garden (these impacts would result in a total loss of significance of these elements). There would also be impacts to underground pedestrian connections (including the Devonshire Street Tunnel) that would result in the loss of original fabric and a change to the historical alignment and pedestrian flow. A temporary (up to 10 years) pedestrian bridge would span Platforms 4 to 23 and would require removal and modification of sections of heritage significant canopy on each of those platforms as well as direct impacts to each platform for construction of bridge piers. A portion of the Sydney Yard would be used as a construction site and a services ring would be constructed to house relocated utilities • Indirect impact: Moderate to major (views and vistas). Impacts include temporary and permanent visual impacts as a result of the services building, through the establishment of the Sydney Yard construction site; changed access arrangements from Eddy Avenue and the introduction of the Sydney Yard Access Bridge. The temporary pedestrian bridge would also have a temporary visual impact on the heritage item • Potential direct impact: Minor (vibration). The main central station building and the Bradfield Building (former Lost Property Office) would not experience vibration above the 7.5mm/s screening level for cosmetic damage. The closest adjacent, but not directly affected, intercity and suburban platforms would experience vibration above the 7.5mm/s screening level for cosmetic damage.

Ref	Description	Listing [1]	Heritage significance	Heritage impact and magnitude
CS2	Terrace Group including interior (99-105 Regent Street)	LEP	Local	• Indirect impact: Moderate (views and vistas). This heritage group has a direct visual connection with buildings currently on the Sydney Yard Access Bridge site. The demolition of the buildings on the Sydney Yard Access Bridge site would alter the setting of this heritage item through alteration of the existing streetscape.
CS3	Former Mortuary Railway Station including interior, ground, fence and railway platforms	SHR; s.170 and LEP	State	• Indirect impact: Moderate to major (views and vistas). The Sydney Yard Access Bridge would substantially detract from the setting of the heritage item. It would impact on views and vistas: towards Mortuary Station from Regent Street; from within Sydney Terminal (including views from passing trains); and from Mortuary Station into Sydney Yard. Although the Sydney Yard is visually cluttered with overheard wiring, signage, signalling and other infrastructure, the construction of the bridge would constitute a major intrusive element.
CS4	Co-Masonic Temple including interior (54 Regent Street)	LEP	Local	• Indirect impact: Moderate to major (views and vistas). This heritage item is adjacent to and has a direct visual connection with buildings currently on the Sydney Yard Access Bridge site. The demolition of the buildings on the Sydney Yard Access Bridge site and the introduction of the Sydney Yard Access Bridge has the potential to detract from the setting of the heritage item and would impact on views and vistas towards the Co-Masonic Temple from Regent Street • Potential direct impact: Neutral (vibration). The closest façade of this item would not experience vibration levels above the 7.5mm/s screening level for cosmetic damage.
CS5	Former Crown Hotel including interior	LEP	Local	• Indirect impact: Moderate (views and vistas). This heritage item has a direct visual connection with buildings currently on the Sydney Yard Access Bridge site. The demolition of the buildings on the Sydney Yard Access Bridge site would alter the setting of this heritage item through alteration of the existing streetscape.

Ref	Description	Listing [1]	Heritage significance	Heritage impact and magnitude
CS6	Chippendale Conservation Area	LEP	Local	Indirect impact: Moderate (views and vistas). This conservation area has a direct visual connection with buildings currently on the Sydney Yard Access Bridge site. The demolition of these buildings and the introduction of the Sydney Yard Access Bridge would alter the setting of the heritage item through alteration of the existing streetscape.

1 *SHR: State Heritage Register; s.170: Listing under section 170 (of the Heritage Act 1977); LEP: local environment plan; DCP: development control plan Railway Square/Central Station Special Character Area*

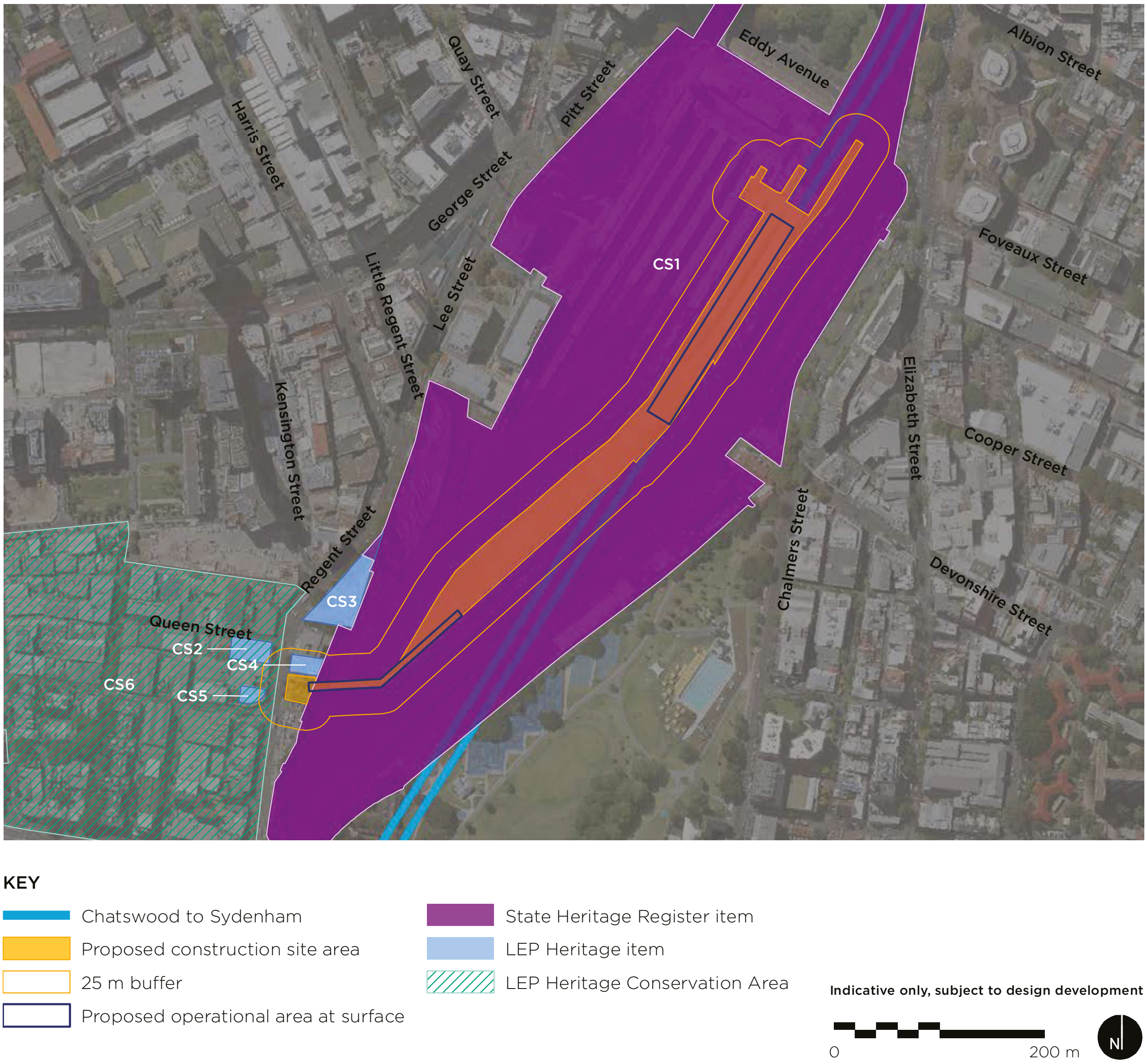


Figure 14-8 Central Station – impacts on heritage items

Archaeological remains

Table 14-19 identifies the type of archaeological remains that may be present; the potential for those archaeological remains to occur within the study area, their likely heritage significance and the potential for those remains to be impacted by the project.

Table 14-19 Central Station – impacts on archaeological remains

Potential archaeological remains	Potential for occurrence	Heritage significance	Preliminary archaeological impact assessment
Evidence of earlier phases of Central Station development within the Sydney Terminal and Central Railway Stations group area	Moderate	Local – State	Excavation works have moderate potential to encounter archaeological remains associated with earlier configurations of Central Station.
Whole or fragmentary burials related to the former cemetery	Low	Local – State	It is possible that some remains were not reinterred during removal of the cemetery. If human remains survive they would be managed appropriately in line with an Exhumation Policy developed for the project.

14.5.10 Waterloo Station

Heritage items

The project would impact, directly or indirectly, on a number of listed heritage items, as identified in Table 14-20 and shown in Figure 14-9.

Table 14-20 Waterloo Station – impacts on heritage items

Ref	Description	Listing [1]	Heritage significance	Heritage impact and magnitude
WS1	Congregational church including interior (103–105 Botany Road)	LEP	Local	- Potential direct impact: Neutral (vibration). The closest façade of this item would not experience vibration above the 7.5mm/s screening level for cosmetic damage - Indirect impact: Minor (views and vistas). Waterloo Station would be located to the rear of the item and the demolition of existing buildings and introduction of the station entry would have a minor impact on the setting of the heritage item. The architectural significance and social significance of the item would not be affected.
WS2	Former CBC Bank including interior (60 Botany Road)	LEP	Local	- Indirect impact: Minor (views and vistas). The demolition of existing buildings and introduction of the station entry would alter the streetscape and have a minor impact on the setting of the heritage item.
WS3	Cauliflower Hotel including interior (123 Botany Road)	LEP	Local	- Indirect impact: Minor (views and vistas). The demolition of existing buildings and introduction of the station entry would alter the streetscape and have a minor impact on the setting of the heritage item.

Ref	Description	Listing [1]	Heritage significance	Heritage impact and magnitude
WS4	Alignment Pin, Waterloo (South East corner of Wellington Street and Botany Road)	s.170	Local	Neutral (no impact).

1 *LEP: local environment plan; s.170: Listing under section 170 (of the Heritage Act 1977)*

Figure 14-9 Waterloo Station – impacts on heritage items

Archaeological remains

Table 14-21 identifies the type of archaeological remains that may be present; the potential for those archaeological remains to occur within the study area, their likely heritage significance and the potential for those remains to be impacted by the project.

Table 14-21 Waterloo Station – impacts on archaeological remains

Potential archaeological remains	Potential for occurrence	Heritage significance	Preliminary archaeological impact assessment
Evidence of Hutchinson's development of the study area	Nil to low	Local	The excavation of the station would result in the complete removal of any archaeological remains within those areas. Therefore, works in this location would have a major impact on any archaeological resources present.
Evidence of pre-1850s residential and commercial development	Low to moderate	Local	
Evidence of late 19th and early 20th century residential and commercial development	Moderate	May be of local significance	

14.5.11 Marrickville dive site (southern)

Heritage items

The project would impact indirectly on one listed heritage item (see Table 14-22 and Figure 14-10).

Table 14-22 Marrickville dive site (southern) – impacts on heritage items

Ref	Description	Listing [1]	Heritage significance	Heritage impact and magnitude
MDS1	Sydenham Pit and Drainage Pumping Station 1	SHR, s.170 and LEP	State	• Indirect impact: Minor (views and vistas). The establishment of the construction site in the adjacent property would result in temporary minor visual impacts to the setting of the item. The southern services facility would be about 50 metres to the north-east of the heritage item and would have negligible long term visual impacts to the setting of the item • Potential direct impact: Neutral (vibration). This item would not experience vibration above the 7.5mm/s screening level for cosmetic damage.

1 *SHR: State Heritage Register; LEP: local environment plan; s.170: Listing under section 170 (of the Heritage Act 1977)*

Figure 14-10 Marrickville dive site (southern) – impacts on heritage items

Archaeological remains

Table 14-23 identifies the type of archaeological remains that may be present; the potential for those archaeological remains to occur within the study area, their likely heritage significance and the potential for those remains to be impacted by the project.

Table 14-23 Marrickville dive site (southern) – impacts on archaeological remains

Potential archaeological remains	Potential for occurrence	Heritage significance	Preliminary archaeological impact assessment
Evidence of early development of study area (Moore's Grant)	Nil to low	Local	Works with the potential to impact archaeological resources at this site are likely to be limited to discrete locations including the dive structure itself. Works in this location are likely to have a minor impact on potential archaeological resources, dependent on the location and extent of the proposed excavation works.
Evidence of brickmaking	Low to moderate	Unlikely to be of local significance	

14.5.12 Power supply routes

The majority of the power supply routes would be constructed by trenching within the road reserve. Where major roads are crossed by the route (such as Mowbray Road for the Chatswood dive site power supply), alternative construction methods would be used such as under boring in order to avoid impacts on the road network. Alternative construction methods such as under boring may also be used to avoid other constraints such as services or areas of environmental sensitivity.

Trenches are expected to be around one metre wide and 1.5 to two metres deep. It is therefore likely any subsurface archaeological remains existing to this depth below the road treatment and pavement would be impacted. Where previous disturbance, such as utilities installation, has occurred the archaeological potential would be low.

The following review includes only those listed items that may be impacted by the power supply route work. It is assumed that the power supply routes would be located within the road corridor.

Assessments of archaeological significance provided in Table 14-24 are preliminary and are based on assessments of station sites prepared for this project and the results of other investigations. More detailed consideration of impacts would be included in the relevant archaeological research designs for the project.

Table 14-24 Power supply routes – potential impacts on heritage items and archaeological remains

Description	Listing [1]	Heritage significance	Heritage impact and magnitude
Chatswood			
Chatswood zone substation No.80 (Ausgrid)	Willoughby LEP Ausgrid s170	Local	○ Impacts to fabric and visual impacts are expected to be minor.
Archaeological resources	N/A	Potentially Local	○ Potential for locally significant archaeology in undisturbed sections of the road corridor.

Description	Listing[1]	Heritage significance	Heritage impact and magnitude
Crows Nest and North Sydney			
Archaeological resources	N/A	Potentially Local. Evidence of early occupation and development of the locality.	- Potential for locally significant archaeology in undisturbed sections of the road corridor.
Millers Point to Darling Harbour			
Millers Point and Dawes Point Village Precinct	SHR	State	- Within conservation area. Impacts to fabric and visual impacts are likely to be temporary and minor.
Millers Point Conservation Area	SHR; Dept of Housing s.170; Sydney LEP LEP; RNE	State	- Within conservation area. Impacts to fabric and visual impacts are likely to be temporary and minor.
Archaeological resources	N/A	Potentially Local to State. Potential for evidence of former gas works, reclamation, Girard's flour Mill, former wharfs and industry and 1860s residential.	- Potential for locally significant and State significant archaeology in undisturbed sections of the road corridor.
King Street Wharf to Martin Place			
Tank Stream including tanks and tunnels	SHR Sydney Water s170	State	- The power supply route would cross the Tank Stream on Margaret Street near its intersection with George Street. The Tank Stream has a curtilage of three meters from the structure. Trenching may be up to two meters deep and therefore may encroach into the curtilage of the item. The Tank Stream Conservation Management Plan states that in this area the Tank Stream is generally around three to five meters below the current ground surface. Impacts within the curtilage of the Tank Stream would be avoided.
Richard Johnson Square including monument and plinth	Sydney LEP	Local	- Impacts to fabric and visual impacts are likely to be temporary and minor.
Bennelong Stormwater Channel	Sydney Water s170	Local	- The feeder line would cross the alignment of the Bennelong Stormwater Channel at Hunter, Bligh, Elizabeth, Philip and Macquarie Streets. Impacts within the curtilage of this item would be avoided.

Description	Listing[1]	Heritage significance	Heritage impact and magnitude
Archaeological resources	N/A	Potentially Local to State. Potential evidence of early occupation and development of Sydney including drains, early road surfaces.	- Potential for locally significant and State significant archaeology in undisturbed sections of the road corridor.
Pitt Street to Surry Hills			
Archaeological resources	N/A	Potentially Local to State. Potential evidence of early occupation and development of Sydney including drains, early road surfaces.	- Potential for locally significant and State significant archaeology in undisturbed sections of the road corridor.
Pyrmont to Pitt Street			
Former Pyrmont Power Station Administrative building (42 Pyrmont Street) including interiors	City of Sydney LEP	Local	- Impacts to fabric and visual impacts are expected to be minor.
Archaeological resources	N/A	Potentially Local to State. Potential evidence of early occupation and development of Sydney including drains, early road surfaces.	- Potential for locally significant and State significant archaeology in undisturbed sections of the road corridor - Sections of the feeder route around Pyrmont are reclaimed land and would have low archaeological potential - Market Street alignment has not changed since the 1810s so there is some potential for intact early remains.

1 *SHR: State Heritage Register; RNE: Register of the National Estate; LEP: local environmental plan; s170: Listing under section 170 (of the* Heritage Act 1977*)*

14.6 Mitigation measures

Information on how the project design has been developed to avoid or minimise likely adverse impacts on heritage items is provided in Chapter 6 (Project description – operation) and Chapter 7 (Project description – construction). The following mitigation measures seek to further minimise heritage impacts.

14.6.1 Site specific mitigation measures

Mitigation measures identified in other chapters of the Environmental Impact Statement that are relevant to the management of potential heritage impacts include:

- Chapter 10 (Construction noise and vibration) with respect to management of potential vibration impacts
- Chapter 16 (Landscape character and visual amenity) with respect to management of potential visual impacts during construction and operation.

The mitigation measures that would be implemented to address potential impacts on non-Aboriginal heritage sites and areas of archaeological potential are listed in Table 14-25. Section 14.6.2 discusses, in general terms, the project approach to archaeological research design, test excavation, test and salvage excavation and archaeological monitoring.

Table 14-25 Mitigation measures – Non-Aboriginal heritage

Ref	Mitigation measure	Applicable location(s)[1]
NAH1	Archival recording and reporting of the following heritage items would be carried out in accordance with the NSW Heritage Office's *How to Prepare Archival Records of Heritage Items* (1998), and *Photographic Recording of Heritage Items Using Film or Digital Capture* (2006): • The internal heritage fabric and any non-original elements removed from within the curtilage of Mowbray House, Chatswood • The interior, exterior and setting of the shop at 187 Miller Street, North Sydney • The fabric and setting of the North Sydney bus shelters requiring removal and temporary relocation at Victoria Cross Station and Blues Point temporary site • Any component of the Blues Point Waterfront Group and the McMahons Point South heritage conservation area to be directly affected or altered, including vegetation and significant landscape features • Hickson Road wall in the vicinity of proposed ventilation risers and skylights for Barangaroo Station • The interior, exterior and setting of the 'Flat Building' at 7 Elizabeth Street, Sydney • Martin Place, between Elizabeth and Castlereagh streets, Sydney • The heritage fabric of areas of the existing Martin Place Station affected by the project • The Rolling Stock Officers Garden, Rolling Stock Officers Building and Cleaners Amenities Building in Sydney Yard and any other component of the Sydney Terminal and Central Railway Stations group to be removed or altered.	CDS, VC, BP, MP, CS
NAH2	An archaeological research designs would be prepared and implemented to identify the need for archaeological testing or monitoring. Archaeological mitigation measures recommended in the archaeological research design would be carried out in accordance with Heritage Council guidelines, and where identified in the archaeological research design, would be supervised by a suitably qualified Excavation Director with experience in managing State significant archaeology.	CDS, CN, VC, BP, BN, MP, PS, CS, WS, PSR

Ref	Mitigation measure	Applicable location(s)[1]
NAH3	An *Exhumation Policy and Guideline* would be prepared and implemented. It would be developed in accordance with the *Guidelines for Management of Human Skeletal Remains* (NSW Heritage Office, 1998b).	All except metro rail tunnels.
NAH4	The method for the demolition of existing buildings and / or structures at Chatswood dive site, Victoria Cross Station, Martin Place Station, Pitt Street Station, Central Station and Waterloo Station would be developed to minimise direct and indirect impacts to adjacent and / or adjoining heritage items.	CDS, VC, MP, PS, CS, WS
NAH5	Prior to total or partial demolition of heritage items at Victoria Cross and Martin Place stations, heritage fabric for salvage would be identified and reuse opportunities for salvaged fabric considered. This would include salvage and reuse of heritage tiles to be impacted at Martin Place Station.	VC, MP
NAH6	An appropriately qualified and experienced heritage architect would form part of the Sydney Metro Design Review Panel and would provide independent review periodically throughout detailed design.	All
NAH7	The project design would be sympathetic to heritage items and, where reasonable and feasible, minimise impacts to the setting of heritage items. The detailed design for Martin Place Station and Central Station would be developed with input from a heritage architect.	STW, CDS, CN, VC, BN, MP, PS, CS, WS, MDS
NAH8	Appropriate heritage interpretation would be incorporated into the design for the project in accordance with the *NSW Heritage Manual*, the NSW Heritage Office's *Interpreting Heritage Places and Items: Guidelines* (August 2005), and the NSW *Heritage Council's Heritage Interpretation Policy.*	CDS, CN, VC, BP, BN, MP, PS, WS
NAH9	A Central Station heritage interpretation plan would be developed and implemented. It would be consistent with the *Central Station Conservation Management Plan* (Rappoport and Government Architects Office, 2013) and in accordance with the guidelines identified in NAH8.	CS
NAH10	The design of the Sydney Yard Access Bridge would be sympathetic to surrounding heritage items and minimise impacts to sight lines, views and setting of surrounding heritage items, including to Mortuary Station and the Sydney Terminal and Central Railway Stations group. As a minimum the design would: - Incorporate materials and finishes sympathetic to the heritage context of the railway station - Minimise height and bulk of the structure.	CS
NAH11	Except for heritage significant elements affected by the project, direct impact on other heritage significant elements forming part of the following items would be avoided: - The Blues Point Waterfront Group (including the former tram turning circle, stone retaining wall, bollards and steps) - The Millers Point and Dawes Point Village Precinct - The existing Martin Place Station - Sydney Terminal and Central Railway Stations group - Sydney Yard (including the Shunters Hut and Prince Alfred Sewer).	BP, BN, MP, CS
NAH12	Power supply works would be designed and constructed to avoid impacts to the Tank Stream and Bennelong Stormwater Channel.	PSR

Ref	Mitigation measure	Applicable location(s)[1]
NAH13	The design and detailed construction planning of work at Central Station would consider the requirements of the *Central Station Conservation Management Plan* (Rappoport and Government Architects Office, 2013) and include consideration of opportunities for the retention, conservation and / or reuse of original and significant heritage fabric. Consultation would be carried out with Sydney Trains and the Heritage Council of NSW during design development.	CS

1 *STW: Surface track works; CDS: Chatswood dive site; AS: Artarmon substation; CN: Crows Nest Station; VC: Victoria Cross Station; BP: Blues Point temporary site; GI: Ground improvement works; BN: Barangaroo Station; MP: Martin Place Station; PS: Pitt Street Station; CS: Central Station; WS: Waterloo Station; MDS: Marrickville dive site; Metro rail tunnels: Metro rail tunnels related not related to other sites (eg TBM works); PSR: Power supply routes.*

14.6.2 Non-Aboriginal heritage archaeological research design

Archaeological research design

Where an archaeological research design is required, it would be prepared based on research information included in *Technical paper 4 – Non-Aboriginal heritage* and would be supplemented by additional detailed historical research of each site, with reference to the project design and proposed construction methods at each site. Based on the detailed literature review, the archaeological research designs would identify the need for, and provide a detailed methodology for undertaking:

- Archaeological test excavation or test and salvage excavation
- Archaeological monitoring.

Test excavation

Test excavation would not be carried out prior to the preparation of an archaeological research design. For this project, it is likely that the archaeological research designs would recommend test excavation:

- In areas where access for excavation activities is not restricted by buildings or other structures, and
- Where additional information regarding the nature of subsurface deposits generated through test excavation could inform the assessment of archaeological potential and / or significance at that site.

Archaeological excavation can be carried out prior to project approval as per the requirements of the Secretary's environmental assessment requirements (refer requirement 7.2(d) in Table 14-1) on the condition that archaeological relics are not removed.

Test and salvage excavation

Test and salvage excavation would not be carried out prior to the preparation of an archaeological research design. For this project, it is likely that the archaeological research designs would recommend test and excavation:

- Where detailed archival research and understanding of modern disturbance (such as basement information) needs to be supplemented with more site-specific (on-ground) information to better define the archaeological potential and / or significance of the site
- In areas where access for excavation activities is restricted by buildings or other structures.

Test and salvage excavation would generally be recommended in areas where there is a moderate to high potential for relics of local or state significance to be present. It would involve locating and recording any relics found prior to their removal by construction. Test and salvage excavation could only be carried out after project approval.

Archaeological monitoring

Archaeological monitoring involves the monitoring of construction phase excavation activities by a qualified archaeologist who would record any significant remains uncovered by excavation. Based on additional detailed historical research, the archaeological research design (see above) may identify areas where archaeological monitoring would be required. Examples of where archaeological monitoring may be required include:

- Areas where construction activities are considered low impact (such as narrow trenching)
- Areas with a low potential to contain remains of state significance.

ABORIGINAL HERITAGE

CHAPTER FIFTEEN

15 Aboriginal heritage

This chapter provides an assessment of the potential impact on Aboriginal heritage sites and areas of archaeological potential as a result of the project, and identifies mitigation measures to minimise these impacts. This chapter draws on information in Technical paper 5 – Aboriginal heritage.

15.1 Secretary's environmental assessment requirements

The Secretary's environmental assessment requirements relating to Aboriginal heritage, and where these requirements are addressed in this Environmental Impact Statement, are outlined in Table 15-1.

Table 15-1 Secretary's environmental assessment requirements – Aboriginal heritage

No.	Secretary's environmental assessment requirements	Where addressed
7. Heritage		
7.1	The Proponent must identify and assess any direct and/or indirect impacts (including cumulative impacts) to the heritage significance of: **a.** Aboriginal places and objects, as defined under the *National Parks and Wildlife Act 1974* and in accordance with the principles and methods of assessment identified in the current guidelines **b.** Aboriginal places of heritage significance, as defined in the Standard Instrument – Principal Local Environmental Plan **c.** Environmental heritage, as defined under the *Heritage Act 1977* **d.** Items listed on the National and World Heritage lists.	Aboriginal heritage impacts are addressed in Section 15.4. Cumulative impacts are addressed in Chapter 26 (Cumulative impacts).
7.3	Where archaeological investigations of Aboriginal objects are proposed these must be conducted by a suitably qualified archaeologist, in accordance with section 1.6 of the *Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW* (Department of Environment, Climate Change and Water, 2010b).	Outlined in Chapter 15 (Aboriginal heritage).
7.4	Where impacts to Aboriginal objects and / or places are proposed, consultation must be undertaken with Aboriginal people in accordance with the current guidelines.	Aboriginal heritage impacts are addressed in Section 15.4.

15.2 Assessment methodology

The purpose of the Aboriginal heritage assessment was to identify potential Aboriginal heritage impacts that could occur during construction and operation of the project, based on the locations of previously recorded Aboriginal heritage sites and the archaeological potential of the study area.

For this assessment, the Aboriginal heritage study area was defined as all land located within 25 metres of the proposed construction sites (as described in Chapter 7 (Project description – construction)). The extent of the Aboriginal heritage study area is shown in *Technical paper 5 – Aboriginal heritage*.

The scope of the Aboriginal heritage assessment comprised:

- A review of previous archaeological investigations and an extensive search of the NSW Office of Environment and Heritage's (OEH) Aboriginal Heritage Information System (AHIMS) to determine whether Aboriginal heritage sites had previously been recorded in the vicinity of the project. Information from the search was also used to determine the archaeological context of the study area
- Development of a predictive model for the study area to help determine archaeological potential
- A site inspection of the study area, in the presence of a representative from the Metropolitan Local Aboriginal Land Council
- Assessment of the project's potential to disturb Aboriginal heritage (sites, objects, remains, values, features or places) and, where this is the case:
  - Determine, in consultation with relevant stakeholders, the potential for Aboriginal heritage resources within the project area
  - Determine the extent and significance of impact on those resources as a result of construction and / or operation of the project
  - Identify any requirements for in-situ conservation of items and / or areas (as appropriate), further archaeological testing and / or detailed archaeological excavations
  - Identify appropriate measures to avoid, minimise and / or mitigate potential impacts.
- Development of environmental mitigation measures that would be implemented to minimise the risk of impacting previously unrecorded items of Aboriginal heritage significance and / or areas of Aboriginal cultural sensitivity during construction.

The following government guidelines were considered during the preparation of the Aboriginal heritage assessment:

- *Guide to investigating, assessing and reporting on Aboriginal Cultural Heritage in NSW* (Department of Environment, Climate Change and Water, 2011b)
- *Aboriginal Cultural Heritage Consultation requirements for proponents* (Department of Environment, Climate Change and Water, 2010a)
- *Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW* (Department of Environment, Climate Change and Water, 2010b)
- *NSW Skeletal Remains: Guidelines for Management of Human Remains* (Heritage Office, 1998b)
- *Criteria for the assessment of excavation directors* (NSW Heritage Council, 2011).

Further details on the Aboriginal heritage assessment methodology are provided in *Technical paper 5 – Aboriginal heritage*.

15.3 Existing environment

15.3.1 Historical background

Evidence of Aboriginal occupation in NSW dates back to around 50,000 to 60,000 years at Lake Mungo (in NSW's southwestern region, about 110 kilometres northeast of Mildura) and up to 30,000 years at Parramatta. Prior to the appropriation of their land by Europeans, Aboriginal people lived in small family or clan groups that were associated with particular territories or places. The language group spoken across Sydney was known as Darug. The Darug language group is thought to have covered the area south from Port Jackson, north from Botany Bay, and west from Parramatta (Attenbrow, 2010).

Archaeological and historical records indicate that marine and estuarine resources formed an important part of the subsistence activities of the Aboriginal people that inhabited the Port Jackson area. Shellfish not only formed an important subsistence resource, but were also used as fish-hooks, shafted onto spears, used for repairing spears, and for cutting (Attenbrow, 2010). Other locally available raw materials, including quartz, were also favoured for cutting edges (Baker, 2004).

Subsistence resources known to occur in the study area at the time of Aboriginal occupation include tidally influenced mud flats associated with the mouth of the Tank Stream (situated roughly within Circular Quay), and fresh water from the Tank Stream (which flowed through the Sydney CBD in the vicinity of Pitt Street).

15.3.2 Previously registered Aboriginal heritage sites

Extensive searches of the OEH Aboriginal Heritage Information System (AHIMS) identified one previously recorded Aboriginal heritage site within 100 metres of the project. This site comprises a sub-surface archaeological deposit associated with Angel Place. The recorded location of the site is 75 metres north of the proposed Martin Place Station. However, it is likely that the AHIMS coordinates for this site are incorrect. Rather, it is thought that the sub-surface archaeological deposit is located 200 metres west of the proposed Martin Place Station at Angel Place.

A number of previously recorded Aboriginal heritage sites were identified within the broader locality at distances greater than 100 metres from the project. The closest sites include:

- An artefact and shell midden site recorded about 560 metres west of the proposed Blues Point temporary site
- An open camp site at Moore's Wharf recorded about 300 metres north of the proposed Barangaroo Station
- A rock engraving near the site of the Maritime Services Board tower recorded about 180 metres north of the proposed Barangaroo Station
- A potential archaeological deposit (PAD) recorded about 380 metres northwest of the proposed Pitt Street Station
- A sub-surface archaeological deposit recorded about 380 metres southwest of the proposed Pitt Street Station
- An artefact site recorded about 330 metres northwest of Central Station
- An artefact and shell midden site recorded about 275 metres north of the proposed Waterloo Station
- A potential archaeological deposit recorded about 350 metres west of the proposed Marrickville dive site.

15.3.3 Aboriginal heritage sites identified during site inspections

No Aboriginal heritage sites were identified within the study area during site inspections.

15.3.4 Archaeological potential and significance

An assessment of archaeological potential and significance of the study area is provided in Table 15-2. Generally, the likelihood of Aboriginal heritage sites surviving to the present is influenced by a range of factors, including the durability of the material evidence and the subsequent impacts that have occurred at that location.

While large portions of the study area have been significantly altered by land developments (particularly within the Sydney CBD), significant archaeological resources have been identified in discrete areas that have been preserved beneath developed areas. For example, in the Sydney CBD, excavation at William Street demonstrated that the sandstone footings from the first phase of building construction protected the underlying Aboriginal archaeological deposit during subsequent demolition and deposition of fill across the site (Baker, 2004).

In contrast, an identified Aboriginal archaeological deposit at Angel Place was largely destroyed by subsequent building construction and other related activities bordering the Tank Stream, with only a very small portion of archaeological deposit found to remain intact (Godden Mackay, 1997).

Given the varying extent to which the project sites have been impacted by previous developments, archaeological potential for Aboriginal objects is likely to be present in sub-surface contexts in those parts that have not been extensively disturbed by sub-surface impacts.

As shown in Table 15-2, the following areas have a moderate or moderate to high archaeological potential:

- Blues Point temporary site – there is moderate archaeological potential associated with the presence of a possible natural landform in the northwest portion of the site
- Sydney Harbour (ground improvement work) – Sydney Harbour consists of a river valley that was inundated by sea level rise during the Pleistocene period. Preliminary geotechnical investigations have identified the potential for an intact valley floor with the associated potential for intact Aboriginal archaeological deposits
- The western portion of the Barangaroo Station footprint – there is archaeological potential in areas that are likely to contain surviving natural shoreline context(s) associated with the former shoreline of Darling Harbour
- Martin Place and Pitt Street stations – there is an area of archaeological potential where there are remaining ‘A’ horizon soil contexts beneath current structures on Elizabeth, Castlereagh and Hunter streets (‘A’ horizon soils refer to the topmost mineral soil layer, which is generally referred to as the ‘topsoil’ layer.)
- Central Station – there is potential for Aboriginal objects to occur in sub-surface contexts where there are surviving portions of ‘A’ horizon soils
- Waterloo Station – there is potential for Aboriginal objects to occur in the sub-surface archaeological deposits where there are surviving portions of ‘A’ horizon sands. The significant phases of building construction across the site and associated landform modification in the area indicate the possibility that there are no surviving natural contexts

- Marrickville dive site – there is potential for Aboriginal objects to occur in the sub-surface archaeological deposits where there are surviving portions of 'A' horizon soils. The significant phases of building construction, creek channelisation and possible extraction of natural materials for brick-making across the site suggest that there are limited remaining areas of natural 'A' horizon soils.

The research significance of any intact Aboriginal archaeological deposit identified within the Sydney CBD would be high, given the rarity of such deposits in this area. Notwithstanding, such artefacts are not considered likely to demonstrate high archaeological significance as they would be unlikely to provide accurate information or answers to relevant research questions.

Table 15-2 Archaeological potential and significance

Location	Archaeological potential	Archaeological significance
Chatswood dive site (northern)	**Low** – The site is located on a crest away from major watercourses and is likely to contain shallow soils (associated with Ashfield Shale). Construction of commercial buildings, roads and a large rail cutting is likely to have impacted or removed archaeological deposits.	**Low** – The site would have low archaeological significance as high levels of previous ground disturbance would have impacted any surface or subsurface Aboriginal sites. As the site is located on a sandstone ridge and slope landform with shallow soils, any remnant archaeological deposits that may exist are likely to be low density and are unlikely to represent areas of focus for Aboriginal occupation.
Artarmon substation	**Low** – The site has been subjected to high levels of surface disturbance, including construction and subsequent demolition of a dwelling and construction activities associated with the Gore Hill Freeway. These developments are likely to have impacted or removed archaeological deposits.	**Low** – The site would have low archaeological significance as high levels of previous ground disturbance would have impacted any surface or subsurface Aboriginal sites. As the site is located on a sandstone ridge and slope landform with shallow soils, any remnant archaeological deposits that may exist are likely to be low density and are unlikely to represent areas of focus for Aboriginal occupation.
Crows Nest Station	**Low** – The site is located on a crest away from major watercourses and is likely to contain shallow soils (associated with Ashfield Shale). Construction of commercial buildings, roads and a large rail cutting is likely to have impacted or removed archaeological deposits.	**Low** – The site would have low archaeological significance as high levels of previous ground disturbance would have impacted any surface or subsurface Aboriginal sites. As the site is located on a sandstone ridge and slope landform with shallow soils, any remnant archaeological deposits that may exist are likely to be low density and are unlikely to represent areas of focus for Aboriginal occupation.
Victoria Cross Station	**Low** – The site is located on a crest away from major watercourses and is likely to contain shallow soils (associated with Ashfield Shale and crest landscapes of Hawkesbury Sandstone). Construction of commercial buildings, roads and underground services is likely to have impacted or removed archaeological deposits.	**Low** – The site would have low archaeological significance as high levels of previous ground disturbance would have impacted any surface or subsurface Aboriginal sites. As the site is located on a sandstone ridge and slope landform with shallow soils, any remnant archaeological deposits that may exist are likely to be low density and are unlikely to represent areas of focus for Aboriginal occupation.

Location	Archaeological potential	Archaeological significance
Blues Point temporary site	**Moderate** – Although the site is likely to have been frequently used by Aboriginal people (due to its shoreline location), the development of a wharf and boat launching infrastructure is likely to have removed or significantly altered the original landform of the site. There is however some evidence of a possible natural landform in the northwest portion of the site.	**Potentially moderate to high** – Although the majority of the Blues Point temporary site is likely to have been significantly disturbed, natural profiles containing Aboriginal archaeological deposits are rare and if present would be of high research significance.
Ground improvement work	**Moderate to high** – Geotechnical investigation indicates the presence of a buried valley floor dating to the Pleistocene period.	**Potentially high** – Known intact Aboriginal deposits in Sydney Harbour are extremely rare and would be of high research significance. However, only a very small proportion of the buried valley floor underneath Sydney Harbour would be affected by the proposed ground improvement work.
Barangaroo Station	**Moderate to high** – Archaeological potential has been identified within the western portion of the Barangaroo Station footprint. This archaeological potential relates to the possible survivability of buried shell midden deposits associated with the original shoreline of Darling Harbour. The eastern portion of the Barangaroo Station footprint does not demonstrate archaeological potential due to the large-scale removal of the original sandstone context.	**Potentially high** – Intact Aboriginal archaeological deposits within the Sydney CBD are extremely rare and would be of high research significance. It is also possible that out-of-context Aboriginal artefacts may be present in the layers of fill used in the area. Any such artefacts would not likely demonstrate high archaeological significance as they would not have potential to provide accurate information or answers to relevant research questions.
Martin Place Station	**Moderate to high** – Discrete portions of surviving archaeological deposit containing Aboriginal objects may occur in very small areas. The location of Martin Place Station within the Tank Stream catchment and within 250 metres of that watercourse suggests potential for Aboriginal objects below the ground surface in areas that have not been significantly impacted or excavated (for example, during the construction of building basements and / or underground car parks).	**Potentially high** – Intact Aboriginal archaeological deposits within the Sydney CBD are extremely rare and would be of high research significance. It is also possible that out-of-context Aboriginal artefacts may be present in the layers of fill used in the area. Any such artefacts would not likely demonstrate high archaeological significance as they would not have potential to provide accurate information or answers to relevant research questions.

Location	Archaeological potential	Archaeological significance
Pitt Street Station	**Moderate to high** – The location of Pitt Street Station in a low-lying and gently sloping area around the headwaters of the Tank Stream suggests potential for Aboriginal objects below the ground surface in areas that have not been significantly impacted or excavated (for example, during the construction of building basements and / or underground car parks).	**Potentially high** – Intact Aboriginal archaeological deposits within the Sydney CBD are extremely rare and would be of high research significance. It is also possible that out-of-context Aboriginal artefacts may be present in the layers of fill used in the area. Any such artefacts would not likely demonstrate high archaeological significance as they would not have potential to provide accurate information or answers to relevant research questions.
Central Station	**Moderate to high** – There are likely to have been significant, although not necessarily comprehensive, sub-surface impacts across the site from construction of the station, including underground excavation for access tunnels, and the establishment and possible landform modifications for laying the extensive network of rail lines to the south of Central Station. The site's location on a raised, well-drained area close to estuarine resources at Cockle Bay indicates potential for Aboriginal objects to be present below the ground surface in areas that have not been significantly impacted or excavated.	**Potentially high** – Intact Aboriginal archaeological deposits within the Sydney CBD are extremely rare and would be of high research significance. It is also possible that out-of-context Aboriginal artefacts may be present in the layers of fill used in the area. Any such artefacts would not likely demonstrate high archaeological significance as they would not have potential to provide accurate information or answers to relevant research questions.
Waterloo Station	**Moderate to high** – There are likely to have been significant, although not necessarily comprehensive, sub-surface impacts across the site from 19th and 20th century construction and installation of services. Notwithstanding, discrete portions of surviving archaeological deposit containing Aboriginal objects may occur beneath buildings and deep layers of introduced fill. There is moderate to high potential for Aboriginal objects to be present in sub-surface contexts where there have not been extensive sub-surface impacts.	**Potentially high** – Intact Aboriginal archaeological deposits within the area are extremely rare and would be of high research significance. It is also possible that out-of-context Aboriginal artefacts may be present in the layers of fill used in the area. However, any such artefacts would not likely demonstrate high archaeological significance as they would not have potential to provide accurate information or answers to relevant research questions.

Location	Archaeological potential	Archaeological significance
Marrickville dive site (southern)	**Moderate to high** – The site has been significantly modified by previous developments, including channelisation of the natural watercourse through the area to Cooks River, construction of large industrial estates, and the large-scale use of the area for brick-making (including the extraction of clay soil). These activities are likely to have impacted or removed archaeological deposits. Notwithstanding, a previous archaeological excavation in the local area (Etheridge, 1905) identified Dugong bones and stone artefacts at Alexandria Canal, demonstrating the potential for Aboriginal objects to be present in sub-surface contexts where there have not been extensive sub-surface impacts.	**Potentially high** – Intact Aboriginal archaeological deposits in this area are extremely rare and would be of high research significance. It is also possible that out-of-context Aboriginal artefacts may be present in the layers of fill used in the area. However, any such artefacts would not likely demonstrate high archaeological significance as they would not have potential to provide accurate information or answers to relevant research questions.

15.4 Potential impacts

15.4.1 Construction

Impacts on Aboriginal heritage sites

Construction of the project would not directly (ie damaged as a direct result of construction) or indirectly (ie damaged due to construction vibration) impact on any previously recorded Aboriginal heritage sites. As outlined in Section 15.3.2, the closest previously recorded Aboriginal heritage site (comprising a sub-surface archaeological deposit) is located about 75 metres north of the proposed Martin Place Station. In addition, no previously unrecorded Aboriginal heritage sites were identified during the site inspection of the study area.

Impacts on areas of archaeological potential

As outlined in Section 15.3.4, there is a moderate or greater potential for previously unrecorded items of Aboriginal heritage significance to be present in sub-surface contexts at the following locations:

- The northwest corner of the Blues Point temporary site where there is evidence of natural landform
- The western portion of the Barangaroo Station footprint associated with the original shoreline of Darling Harbour
- Portions of the construction sites for Martin Place, Pitt Street, Central and Waterloo stations in situations where there are surviving portions of 'A' horizon soils
- Portions of the Marrickville dive site (southern) in situations where there are surviving portions of A' horizon soils.

The archaeological potential of these areas would vary across each site based on the locations and extent of historic sub-surface impacts (for example, the extent of excavations during the construction of existing building basements and / or car parks), with those areas containing remnant 'A' horizon soils or sand likely to have the highest potential to contain items of Aboriginal heritage significance.

Given the difficulty in performing archaeological test excavations within the study area (due to its location within the Sydney CBD and other highly developed areas), the potential for items of Aboriginal heritage significance to be present within the study area would need to be investigated further during detailed design and construction.

The overall guiding principle for cultural heritage management for the project would be to conserve Aboriginal sites in situ, where possible. In situations where the conservation of an Aboriginal heritage site is not practical, mitigation measures would be developed (in consultation with the Metropolitan Local Aboriginal Land Council) and implemented to reduce the project's Aboriginal heritage impact. These measures would include:

- Consultation with the Metropolitan Local Aboriginal Land Council in accordance with the NSW Office of Environment and Heritage's *Draft Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation 2005* (Department of Environment and Conservation, 2005a)
- Archaeological test excavation and salvage (when required).

It is currently anticipated that archaeological test excavations would be required at those portions of the construction footprints for Barangaroo Station, Martin Place Station, Pitt Street Station, Central Station, Waterloo Station and the Marrickville dive site (southern) where remnant 'A' horizon soils or sand are identified, most likely during construction.

There is potential for Aboriginal objects to occur in the sub-surface archaeological deposits associated with a buried valley floor. Only a very small proportion of the buried valley floor underneath Sydney Harbour would be affected by the proposed ground improvement work.

The buried valley floor context is essentially inaccessible to humans and therefore the ability to apply specific mitigation is difficult in these circumstances. Investigation of feasible and reasonable mitigation measures to manage potential impacts at this location would be considered in consultation with the Office of Environment and Heritage.

Works along the proposed power supply routes would involve trenching to a depth of about two metres. Preliminary Aboriginal Heritage Information Management System (AHIMS) searches indicate that no Aboriginal sites are present along the proposed power supply routes. However, in locations where there has been no previous ground disturbance, these activities could affect areas with archaeological potential.

Measures to manage potential impacts on Aboriginal heritage are provided in Section 15.5.

15.4.2 Operation

Aboriginal heritage would not be impacted during the operation of the project as widespread ground disturbance and excavation would be restricted to the construction phase.

15.5 Mitigation measures

The mitigation measures that would be implemented to address potential impacts on Aboriginal heritage sites and areas of archaeological potential are listed in Table 15-3.

Table 15-3 Mitigation measures – Aboriginal heritage

Ref	Mitigation measure	Applicable location(s)[1]
AH1	Aboriginal stakeholder consultation would be carried out in accordance with the NSW Office of Environment and Heritage's *Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010*.	All
AH2	An Aboriginal cultural heritage assessment report (ACHAR) would be prepared in accordance with the OEH *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW*. The Aboriginal cultural heritage assessment report would include: • Details of Aboriginal stakeholder consultation conducted in accordance with AH1 • An assessment of cultural significance for the project area and identification of any specific areas of cultural significance based on consultation with Aboriginal stakeholders • A methodology for archaeological test excavation and salvage (refer to AH3).	All
AH3	Archaeological test excavation (and salvage when required) would be carried out where intact natural soil profiles with the potential to contain significant archaeological deposits are encountered at the Blues Point temporary site, Barangaroo Station, Martin Place Station, Pitt Street Station, Central Station, Waterloo Station and Marrickville dive site. Excavations would be conducted in accordance with the methodology outlined in the Aboriginal cultural heritage assessment report.	BP, BN, MP, PS, CS, WS, MDS
AH4	Appropriate Aboriginal heritage interpretation would be incorporated into the design for the project in consultation with Aboriginal stakeholders.	All
AH5	Feasible and reasonable mitigation at the ground improvement locations would be identified in consultation with the Office of Environment and Heritage.	GI
AH6	The Aboriginal cultural heritage assessment report would address areas of archaeological potential associated with the power supply routes.	PSR

1 *STW: Surface track works; CDS: Chatswood dive site; AS: Artarmon substation; CN: Crows Nest Station; VC: Victoria Cross Station; BP: Blues Point temporary site; GI: Ground improvement works; BN: Barangaroo Station; MP: Martin Place Station; PS: Pitt Street Station; CS: Central Station; WS: Waterloo Station; MDS: Marrickville dive site; Metro rail tunnels: Metro rail tunnels related not related to other sites (eg TBM works); PSR: Power supply routes.*

LANDSCAPE CHARACTER AND VISUAL AMENITY

CHAPTER SIXTEEN

16 Landscape character and visual amenity

This chapter provides an assessment of the potential impact on landscape character and visual amenity as a result of the project, and identifies mitigation measures to address these impacts. This chapter draws on information in Technical paper 6 – Landscape character and visual amenity.

16.1 Secretary's environmental assessment requirements

The Secretary's environmental assessment requirements relating to landscape character and visual amenity, and where these requirements are addressed in this Environmental Impact Statement, are outlined in Table 16-1.

Table 16-1 Secretary's environmental assessment requirements – landscape character and visual amenity

Ref.	Secretary's environmental assessment requirements	Where addressed
14. Urban Design		
14.1	The Proponent must: **a.** identify the urban design and landscaping aspects of the project and its components; **b.** include consideration of urban design principles adopted by each council or within each station precinct; **c.** assess the impact of the project on the urban, rural and natural fabric; **d.** explore the use of Crime Prevention Through Environmental Design (CPTED) principles during the design development process, including natural surveillance, lighting, walkways, signage and landscape; and **e.** identify urban design strategies and opportunities to enhance healthy, cohesive and inclusive communities.	Impact on urban, rural and natural fabric is assessed in Section 16.4. Urban design, landscaping, CPTED are addressed in Section 16.2.
15. Visual Amenity		
15.1	The Proponent must assess the visual impact of the project and any ancillary infrastructure on: **a.** views and vistas; **b.** streetscapes, key sites and buildings; and **c.** the local community.	Visual impacts are addressed in Section 16.4.
15.2	The Proponent must provide artist impressions and perspective drawings of the project to illustrate how the project has responded to the visual impact through urban design and landscaping.	Photomontages showing the project from selected key viewpoints are included in Section 16.4.

16.2 Assessment methodology

Landscape character and visual amenity were assessed to identify the likely impacts during construction and operation of the project. The assessment methodology is outlined below.

16.2.1 Landscape impact assessment

Landscape in the urban context refers to the overall character and function of a place. It includes all elements within the public realm and the interrelationship between these elements and the people who use them.

A range of landscape elements may be directly or indirectly impacted by the project. To identify these impacts, the assessment identified the sensitivity of the element to change and the magnitude of change expected as a result of the project, and then made an overall assessment of the level of impact expected.

The degree of sensitivity of each landscape element to change was identified as neighbourhood, local, regional, State or national (defined in Table 16-2).

The magnitude of modification to landscape quality of each landscape element was identified as considerable reduction, noticeable reduction, no perceived change, noticeable improvement, or considerable improvement (defined in Table 16-3).

The assessed sensitivity and landscape modification were then combined for each element to identify a level of landscape impact (see Table 16-4).

Table 16-2 Landscape sensitivity levels

Landscape sensitivity	Description
National	Landscape feature protected with national or international legislation, for example the Sydney Opera House World Heritage Listed building and its surrounding public realm.
State	Landscape feature or urban place that is heavily used and is iconic to the State, for example Martin Place and Hyde Park.
Regional	Landscape feature that is heavily used and valued by residents of a major portion of a city or a non-metropolitan region, for example Blues Point Reserve and the foreshores of Barangaroo.
Local	Landscape feature valued and experienced by concentrations of residents, and / or local recreational users. Provides a considerable service to the community. For example, it provides a place for local gathering, recreation, sport, street use by cafes and / or shade and shelter in an exposed environment, for example Richard Johnson Square on Hunter Street and Willoughby Road in Crows Nest.
Neighbourhood	Landscape feature valued and appreciated primarily by a small number of local residents, for example street trees in a local street. Provides a noticeable service to the community. For example, it provides a seat or resting place, passive recreation, and / or some shade and shelter in a local street, for example Unwins Bridge Road in Marrickville and Drake Street in Chatswood.

Table 16-3 Landscape modification levels

Landscape modification	Description
Considerable reduction or improvement	Substantial portion of the landscape is changed. This may include substantial changes to parkland function, footpath continuity, building access, permeability of local streets, and / or street tree cover for example. Substantial changes to the level of comfort, vibrancy, safety and walkability, enhancement, connectivity, diversity, and enduring legacy of the public realm.
Noticeable reduction or improvement	A portion of the landscape is changed. This may include the alteration of parkland function, footpath continuity, building access, permeability of local streets, and / or street tree cover for example. Some alteration to the level of comfort, vibrancy, safety and walkability, enhancement, connectivity, diversity, and enduring legacy of the public realm.
No perceived reduction or improvement	Either the landscape quality is unchanged or if it is, it is largely mitigated by proposed public realm improvements. Does not alter or not noticeably alter the level of comfort, vibrancy, safety and walkability, enhancement, connectivity, diversity, and enduring legacy of the public realm.

Table 16-4 Landscape impact matrix

		Landscape sensitivity				
		National	**State**	**Regional**	**Local**	**Neighbourhood**
Landscape modification	**Considerable reduction**	Very high adverse	Very high adverse	High adverse	Moderate adverse	Minor adverse
	Noticeable reduction	Very high adverse	High adverse	Moderate adverse	Minor adverse	Negligible
	No perceived change	Negligible	Negligible	Negligible	Negligible	Negligible
	Noticeable improvement	Very high beneficial	High beneficial	Moderate beneficial	Minor beneficial	Negligible
	Considerable improvement	Very high beneficial	Very high beneficial	High beneficial	Moderate beneficial	Minor beneficial

16.2.2 Visual impact assessment (daytime)

The daytime visual impact assessment considered visual amenity as experienced by the users of the site and surrounds. It aimed to identify the range of views to the site that may be impacted, including views from residential areas, offices and streets. To identify these impacts, the assessment involved identifying the existing visual conditions, views that are representative of these conditions, the sensitivity of the views (as defined in Table 16-5), and the magnitude of change expected as a result of the project (as defined in Table 16-6). An overall assessment was then made of the level of impact expected (refer to Table 16-7).

Table 16-5 Visual sensitivity levels

Visual sensitivity	Description
National	Heavily experienced view to a national icon, for example view to Sydney Opera House from Circular Quay or Lady Macquarie's Chair, or a view to Parliament House Canberra along Anzac Parade.
State	Heavily experienced view to a feature or landscape that is iconic to the State, for example view along the main avenue in Hyde Park, or a view to Sydney Harbour from Observatory Hill.
Regional	Heavily experienced view to a feature or landscape that is iconic to a major portion of a city or a non-metropolitan region, or an important view from an area of regional open space, for example views to the Sydney Town Hall from George Street, a Sydney CBD skyline view from Centennial Park, or views from Blues Point Reserve to Sydney Harbour.
Local	High quality view experienced by concentrations of residents and / or local recreational users, local commercial areas, and / or large numbers of road or rail users, for example view from Chatswood Park or Chifley Square.
Neighbourhood	Views where visual amenity is not particularly valued by the wider community such as views from local streets, pocket parks and small groups of residences.

Table 16-6 Visual modification levels

Visual modification	Description
Considerable reduction or improvement	Substantial part of the view is altered. The project contrasts substantially with surrounding landscape.
Noticeable reduction or improvement	Alteration to the view is clearly visible. The project contrasts with surrounding landscape.
No perceived reduction or improvement	Either the view is unchanged or if it is, the change in the view is generally unlikely to be perceived by viewers. The project does not contrast with the surrounding landscape.

Table 16-7 Daytime visual impact matrix

		Daytime visual sensitivity				
Visual modification		National	State	Regional	Local	Neighbourhood
	Considerable reduction	Very high adverse	Very high adverse	High adverse	Moderate adverse	Minor adverse
	Noticeable reduction	Very high adverse	High adverse	Moderate adverse	Minor adverse	Negligible
	No perceived change	Negligible	Negligible	Negligible	Negligible	Negligible
	Noticeable improvement	Very high beneficial	High beneficial	Moderate beneficial	Minor beneficial	Negligible
	Considerable improvement	Very high beneficial	Very high beneficial	High beneficial	Moderate beneficial	Minor beneficial

16.2.3 Visual impact assessment (night-time)

The assessment of night-time impacts was carried out with a similar methodology to the daytime assessment.

Australian Standard *AS4282 Control of the obtrusive effects of outdoor lighting* (1997) offers some useful terminology and principles for assessing night time impacts; however, this standard excludes 'public lighting', which is defined as 'lighting for the provision of all-night safety and security on public roads, cycle paths, footpaths, and pedestrian movement areas'. For this reason, the night time assessment also drew on the *Guidance for the reduction of obtrusive light* (Institution of Lighting Engineers (UK), 2005).

The *Guidance for the reduction of obtrusive light* (Institution of Lighting Engineers (UK), 2005) identifies environmental zones, useful for the categorising of night-time landscape settings. It also defines a number of features of these environmental zones at night, including sky glow, glare and light trespass. The resulting impact levels are shown in Table 16-8.

Table 16-8 Night-time visual impact matrix

		Night-time visual sensitivity			
Visual modification		E1: Intrinsically dark landscapes	E2: Low district brightness	E3: Medium district brightness	E4: High district brightness
	Considerable reduction	Very high adverse	Very high adverse	High adverse	Moderate adverse
	Noticeable reduction	Very high adverse	High adverse	Moderate adverse	Minor adverse
	No perceived change	Negligible	Negligible	Negligible	Negligible
	Noticeable improvement	Very high beneficial	High beneficial	Moderate beneficial	Minor beneficial
	Considerable improvement	Very high beneficial	Very high beneficial	High beneficial	Moderate beneficial

16.3 Existing environment

16.3.1 Chatswood dive site (northern)

The Chatswood dive site comprises a length of railway corridor extending from around Brand Street, Artarmon to Albert Avenue, Chatswood. The high-rise skyline of Chatswood is prominent in northerly views along the corridor, framed by the steep embankments and surrounding vegetation in some parts. The corridor is mostly a residential precinct with a mix of brick detached houses and two to three storey unit blocks. A television tower sits prominently on an elevated location at Hampden Road near Mowbray Road. This tower is a local visual landmark, and is seen from surrounding residential and commercial areas.

Between Mowbray Road and Nelson Street, and west of the rail corridor towards the Pacific Highway, is an Ausgrid depot with a larger grain of built form including a mix of light industrial buildings and institutional style office buildings. The Chatswood Bowling Club is located beside the railway corridor, and a wide shared footpath, the Frank Channon Walk, runs alongside the railway corridor, connecting the Chatswood Station precinct at Albert Avenue with Nelson Road.

Chatswood Park, including Chatswood Oval, is located within the setting of multi-storey residential and high-rise buildings at the Chatswood Centre. This parkland includes a mature framework of trees and a manicured sports oval, formal gardens and a number of small recreational buildings. Chatswood Station, and the bridge over Albert Avenue, and adjacent formal parkland, create a gateway into the Chatswood CBD.

16.3.2 Artarmon substation

The Artarmon substation site is currently being used as a temporary facility for Artarmon Public School and contains a number of temporary classrooms. The site also includes grassland and scrubby vegetation around its eastern perimeter and along Butchers Lane. Residential areas are located to the north, east and south and include a mix of low residential buildings (including early 20th century single-storey brick houses) and brick unit blocks two to four storeys high. The Gore Hill Freeway forms the southwestern boundary of the site. It is about 13 lanes wide in this area and about 10 metres lower than the site.

Views of the Freeway are protected somewhat due to the level changes and noise barriers. Trees lining Butchers Lane filter views from the rear of properties on the southern side of Milner Street, which have rear gardens directly opposite the project site.

16.3.3 Crows Nest Station

The Crows Nest Station site and surrounds has a mixture of built form typologies of varying ages, heights, styles, uses and setbacks, and is influenced by a recent influx of high-rise and mid-rise office and residential tower developments. Low scale highway oriented showroom developments are located along the Pacific Highway, alongside a concentration of 19th century two storey shopfront facades to the south of Hume Street.

Oxley, Hume and Clarke streets are lined with a mixture of office and apartment buildings (up to ten storeys), as well as other uses such as an indoor sports complex, child care centre, community centre, post office and a historic substation. As Clarke Street rises to Willoughby Road, the street narrows, and is lined with double storey Victorian terraces with ground level retail.

The St Leonards Centre, located adjacent to the project site at the corner of Oxley and Clarke streets, is a local visual landmark. Mature London planetrees along the Pacific Highway, Oxley Street and Clarke Street soften views and provide a unifying element along an otherwise eclectic and architecturally disjointed urban streetscape.

Willoughby Road is a nearby retail and restaurant precinct, and the heart of the Crows Nest village. It includes over 400 metres of single and double storey, mostly Victorian, shopfronts functioning as a ‘high street’ between the Pacific Highway in the south and Albany Street in the north. The streetscape is narrow and prioritises pedestrian movement. London planetrees, podium planting and planter boxes soften the street and create a sheltered environment for alfresco dining. Views north along Willoughby Road feature the spire of St Leonards Catholic Church as a quaint local focal point.

Hume Street Park provides the only local green space in the vicinity of the project site. It is located opposite the project on Clarke Street and consists of a mounded grassy area with shade trees and paved pathways.

Several high-rise apartment buildings have been recently built and are being constructed in the vicinity, to support the growing population and emerging role of St Leonards Town Centre as a ‘Specialist Centre’. This includes the building currently under construction on the corner of Oxley and Albany streets. There is also a Development Application in place to increase the maximum allowable height to 42 metres to allow an 11 storey apartment building on the northern part of the project site, at the corner of Oxley Street and the Pacific Highway (521 Pacific Highway), which is currently vacant.

16.3.4 Victoria Cross Station

Generally, the built character of this area is of a high-rise typology in the south, stepping down to mid-rise and low-rise frontages to the north. This predominantly commercial area is interspersed with schools, tertiary education facilities, restaurants and retail. It includes several heritage buildings and conservation areas. In terms of architectural style, there is a predominance of glazed and rendered concrete office towers juxtaposed with the brick and stone facades of North Sydney’s remnant heritage buildings.

The intersection of Miller Street and the Pacific Highway forms an important focal point in the centre of North Sydney. The North Sydney Post Office and court house, sits prominently on the corner with its distinctive curved stair and clock tower, alongside a cluster of several other iconic buildings including the clock tower of the Northpoint Plaza, and the heritage listed MLC building. The public realm in this area generally consists of urban plazas, building entry spaces / courtyards and streetscapes.

Berry and Miller streets are flanked by fully paved footpaths, from building to kerb, with intermittent awnings, and are heavily used by pedestrians throughout the day. Mature London planetrees, provide a canopy over Miller Street, softening this urban environment.

To the north of the precinct, McLaren Street is located on a local ridgeline with a low to mid-rise built form typology and a mix of heritage and modern buildings. An avenue of mature London planetrees line the street, with grass verges, footpaths, and parallel parking, creating a suburban feel.

The precinct, particularly between Berry Street and the Pacific Highway, includes a number of development projects. A commercial and retail development is currently under construction at 177 Pacific Highway, to the west of the site. At 150 Pacific Highway there is approval for a high-rise apartment building to replace a six storey office building (‘Polaris’). In addition, at the corner of the Pacific Highway and Miller Street, there is a Development Application to demolish the 1990s retail podium in front of Northpoint (100 Miller Street), and replace it with a 10 storey hotel building with street level retail.

16.3.5 Blues Point temporary site

Blues Point Reserve includes sandstone embankments, mature trees, playground equipment and open lawns. The site and surrounds have important views towards Sydney Harbour, the Sydney Harbour Bridge and Sydney Opera House. Views from this location include a rare view of the Opera House framed by the Bridge. Conversely, the site is visible from the forecourt of the Sydney Opera House (which is World Heritage Listed), from the Bridge and from locations across Sydney Harbour.

Blues Point Tower sits prominently at the end of Blues Point Road and is set within Blues Point Reserve. The large expanse of roadway and surface car parking at the end of Blues Point Road detracts somewhat from the character of this parkland.

On the southern shores of the harbour, there are northerly views to the site from the Ives Stairs, under the Harbour Bridge, Hickson Road, the finger wharves and the newly opened Barangaroo Reserve.

16.3.6 Sydney Harbour ground improvement work

The site is located within a busy area of the Sydney Harbour, surrounded by Blues Point, McMahons Point, Lavender Bay, and Milsons Point in the north, the Sydney Harbour Bridge and Sydney Opera House in the east, Walsh Bay and the Barangaroo Reserve in the south, and Balmain East, Goat Island and the Balls Head in the west.

In particular, views from the Sydney Harbour Bridge and Sydney Opera House, and the site's contribution to the setting of these places are important. In addition, there are numerous other important historic and cultural buildings and landscapes located within view of this area of the harbour. These include the Blues Point Tower, Luna Park, Barangaroo Reserve, a heritage listed Victorian Mansion at Balmain East, the Goat Island National Park, Balls Head Reserve and Waverton Peninsula Reserve. There are also views from surrounding foreshore and elevated residential areas where views of the harbour are the focal point.

Although the site comprises the undeveloped, open water of the harbour, this is a busy section of the waterway. It is often frequented by a range of vessels from small boats, yachts and ferries, to tankers and large cruise ships. Visually this creates a dynamic and animated landscape.

16.3.7 Barangaroo Station

Barangaroo is currently being redeveloped, with the area divided into three precincts:

- Barangaroo Reserve is located at the northern end of Barangaroo where it meets Millers Point. It is a six hectare foreshore park opened in 2015, designed as a contemporary interpretation of the pre-1836 headland, with bush walks, grassed areas, lookouts, walking and cycle paths. A plaza has been created at North Cove, marking a southern entry to the Reserve at Hickson Road
- Central Barangaroo is currently being planned. The site for the proposed station is in Central Barangaroo. It will be the cultural heart of Barangaroo and is expected to include civic and cultural attractions with recreational, residential, retail and commercial uses. Although the actual building heights, form and massing are not yet known, the planned site development envelopes allow for medium and high density urban form
- Barangaroo South will be a major extension of the Sydney CBD with a number of high-rise buildings and stepping down to mid-rise development along the harbour foreshore. Planned as a mixed use precinct, it will have office buildings, residential apartments, an international hotel, shops, cafes and restaurants, and a waterfront promenade. Transport for NSW has planning approval for a ferry hub at Barangaroo, which is expected to open to customers in 2016.

Hickson Road forms the eastern boundary of the Barangaroo site. Hickson Road is located at the base of a distinctive cliff about four storeys high. The cliff is a local visual feature, with its exposed sandstone rock face and masonry, heritage railings and staircase cut into the stone. The cliff also creates a strong spatial 'edge' to the Barangaroo peninsular between Munn Street and the High Street stairs in the south, and a physical barrier to east–west movement.

South of the High Street stairs, there are mixture of contemporary and heritage buildings which align with the line of the wall, addressing the road with a mix of commercial, offices and service entries. In this area, there is a second staircase, providing access to the upper levels of the peninsula along Kent Street.

Hickson Road is currently two lanes with parking and an avenue of mature Fig trees on the western side, and a cluster of Livistona palms to the east, adjacent to the cliff, marking the stair entry on the eastern side of the road.

High Street runs along the top of the escarpment, offering panoramic, open views across Barangaroo, and the harbour beyond. A line of heritage listed terrace houses ('Terrace duplex group' at 2–80 High Street) line the eastern side of High Street, and are a visual feature in views towards the site, as well as in local streetscape views.

The Barangaroo South and Central precincts will provide activation to the west of Hickson Road, with a high quality public realm incorporating streets, plazas, and parks, as well as active street level frontages, which will be populated by a large number of users from the commercial, civic and residential buildings of Barangaroo. A new 30 metre footbridge over Hickson Road is proposed as a part of the Central Barangaroo precinct, and will connect Barangaroo with Central Sydney CBD, via High Street. This footbridge will require the removal of three heritage listed fig trees on Sussex Street, near the junction of Napoleon Street (Barangaroo South Public Domain Stage 1A, Aspect and Oculus, 2014).

16.3.8 Martin Place Station

The area around Martin Place Station precinct is influenced by two of central Sydney's most prominent urban plazas – Chifley Square and Martin Place. The precinct is traversed by several important civic streets, including Elizabeth, Castlereagh and Hunter streets, which are lined by office towers, with intermittent mature trees, creating important streetscape vistas.

The setting of the proposed northern station building is characterised by the unique and historic semi-circular urban form of nearby Chifley Square, including Qantas House and Chifley Tower, which follow the curved alignment of Chifley Square. These buildings create a distinct sense of enclosure for Chifley Square and this part of the Sydney CBD.

The proposed southern station building is located on the southern side of Martin Place, between Castlereagh and Elizabeth streets, opposite the historic Commonwealth Bank building. There is an office tower (of about 20 storeys) on the site with an entry-level plaza, stairs and retail space. The character of this site is influenced by the verticality of buildings flanking the southern edge of Martin Place. The built form of Martin Place is marked by iconic and identifiable buildings that both attract attention and channel views along surrounding streets.

16.3.9 Pitt Street Station

The Pitt Street Station site is located in the heart of the Sydney CBD, in one of the busiest parts of the city for vehicular and pedestrian movement. The site is a short walk, and in view of, some of Sydney's most prominent landmarks and attractions including Hyde Park, Town Hall, Pitt Street Mall, St Andrew's Cathedral and World Square.

The nearby streets are lined by a mixture of low and high-rise office, commercial and apartment buildings of varying ages and styles. They mainly include retail space, restaurants and cafés at street level. Near the corners of Pitt and Park streets, Pitt and Bathurst streets, and extending somewhat up Pitt Street, are a number of four to six-storey buildings with decorative historic facades, a number of them in stone, brick and masonry, and in Victorian and Art Deco styles.

These streets are flanked by paved footpaths, from building to kerb, with intermittent awnings, which are heavily used by pedestrians throughout the day. Several small mature trees are located on Park and Pitt streets, which provide some shade and softening to this intensely urban environment.

The Edinburgh Castle Hotel is a local visual feature on the southeastern corner of Pitt and Bathurst streets. It is a three storey hotel of Inter War Georgian Style and has been trading as a hotel since the 1860s. This building has 'aesthetic significance' due to its contribution as a landmark building.

Important views within the vicinity of the northern station site include those to the east along Park Street to and from Hyde Park, views north along Castlereagh Street to the Sydney Tower, views to the rear of The Great Synagogue, and glimpsed views west along Park Street to Town Hall.

Important views within the vicinity of the southern station site include those along Bathurst Street to Hyde Park and its Obelisk (identified as a primary vista in the Hyde Park Plan of Management, 2006), views west towards the St Andrew's Cathedral and views to the distinctive historic brick façade of the of the Edinburgh Castle Hotel on the corner of Pitt and Bathurst Streets.

A development project in this precinct which is likely to influence the existing visual setting includes the 66-storey 'Greenland Centre' apartment tower proposed at the corner of Pitt and Bathurst streets, which will be Sydney's tallest residential tower. Similarly, 'The Castlereagh' apartments are currently under construction at the corner of Castlereagh and Bathurst streets.

16.3.10 Central Station

Central Station is set within a rich and diverse townscape. It is characterised by a concentration of low to medium scale (three to seven storey) heritage buildings and streetscapes juxtaposed with modern and contemporary office and apartment towers, a series of varied interrelated and historic open spaces, and a large mix of uses and activities, including commercial, industrial, institutional, residential and hotels.

Railway Square is the major visual and functional gateway to the city from west and south. The intersection of George and Pitt streets is one of Sydney's busiest and largest intersections, and has traditionally dispersed traffic and pedestrians into and out of the city. Railway Square itself includes sandstone walls and a ramping roadway, which reaches a colonnaded station entry. Parkland occupies the main square, with a wide footpath leading to the station entry flanked by trees, framing views to the main station buildings and clock tower.

Opposite the station on a wedge of land created by Lee and George Streets is a plaza that is also called Railway Square. This plaza is the main bus interchange area for the station and is connected to the station by underground pedestrian tunnels.

The U-shaped Central Station building faces Eddy Avenue and is the location of one of the main station entrances. This includes a ramped entry leading from Eddy Avenue. The entrance is marked by a mature London planetree. Several shopfronts flank this entry, located both within the ground floor of the former Lost Property building and alongside an elevated sandstone rail bridge. This pedestrian plaza provides a transition from the vehicular dominated Eddy Avenue to the station entry and concourse.

The central rail yard is surrounded by several rail lines entering Central Station from the south and west, giving it an open, working railway character. This area of the station merges visually with the surrounding rail lines, characterised by corridors of ballast, and overhead wiring equipment.

Prince Alfred Park is an historic parkland south of Central Station, within the suburb of Surry Hills. The park is bounded by Chalmers Street, Cleveland Street and the railway. Trees and elements of the layout from the original 1870 plan of the park still exist on the site today, including Moreton Bay fig trees arranged as an informal row along the boundaries.

Regent Street is a wide, heavily trafficked five-lane road, located along the western side of Central Station, connecting Chippendale to the Pitt Street / George Street intersection. Adjacent to Central Station, Regent Street incorporates five terrace style houses, a two-storey petrol station, a Masonic Temple, a three-storey contemporary residential building and the heritage Mortuary Station.

The visual character around Central Station (including areas along Eddy Avenue and Chalmers Street) is expected to change following the introduction of the CBD and South East Light Rail, which will introduce a light rail stop on Chalmers Street, light rail tracks and associated infrastructure.

Another key development project in this precinct, which would substantially affect the existing visual setting, includes the proposed Central to Eveleigh Transformation Program. This is a 30-year project that aims to gradually transform 80 hectares of largely under-used government owned land in and around the rail corridor from Central to Macdonaldtown and Erskineville stations. It involves the development of land to provide thousands of additional homes and jobs and new open space.

16.3.11 Waterloo Station

The Waterloo Station site comprises one block bounded by Botany Road to the west, Raglan Street to the north, Cope Street to the east, and Wellington Street to the south. The site generally has a strong and consistent building line, with a dense coverage of medium grain built form, including a mix of commercial, light industrial and warehousing. The precinct is characterised by late 19th and early 20th century warehouses many of red brick construction. To the north are a row of two-storey early 20th century commercial buildings and a number of buildings with commercial ground floors and residences above.

Botany Road is a wide road lined by some small street trees and accommodating mostly large scale factory retail outlets. To the west of the road, the buildings are set back with ‘nose-in’ parking creating a vehicle-dominant streetscape. To the east, on the site of the proposed metro station, the footpath is narrower and the building line is closer to the roadway. To the south of this block, the buildings are of recent construction. To the north, buildings are mostly historic brick warehouses. Within this block is the Waterloo Congregational Church, which is a local visual landmark.

Raglan Street is characterised by three-storey brick buildings with shopfronts at street level and residences on the upper levels, creating a small shopping precinct, and stepping up to six-storey modern unit buildings beyond. A number of tall high-rise residential blocks can be seen beyond in the northeast. Leafy streets with mature Brush Box trees on the corner of Raglan and Cope streets, combined with this parkland, create a visual relief from the intensely urban environment of the area around the project site.

Cope Street has a disjointed overall character with an abrupt change in character from east to west. To the west, the project site has a strong building line, with medium grain, mostly late 19th and early 20th century warehouses. These buildings are mostly red brick or masonry with a mix of pitched, stepped, clerestory and flat roofs. A narrow road verge is fully paved, and includes numerous large garage doors and service access ways. Power lines run parallel to the road, creating a historic, industrial character.

16.3.12 Marrickville dive site (southern)

The character of this area is strongly influenced by its industrial history and transport network including the railway, busy main roads and Sydney Airport. The area includes heritage items dating back to its time as an industrial and manufacturing hub during the 19th and early 20th centuries when activities included steel works, mills, brick making and pottery. In particular, this includes a local heritage listed brick-lined drainage pit on Garden Street. Buildings in this area are mainly one and two-storey industrial buildings. There are also some three and four-storey commercial / industrial buildings.

The area comprises a mix of residential and industrial buildings reflective of its historical development. Land use is mainly light manufacturing with a mix of tertiary uses such as light industry and urban support services, retail, residential, freight and logistics, and offices. A clothing warehouse now operates on part of the Sydney Steel site in Sydney Steel Road.

To the south, land use between the railway and Unwins Bridge Road generally consists of large scale light industrial, including the Sydney Trains Sydenham Network Base, constructed in 2013. The character abruptly changes into low density residential to the south of Unwins Bridge Road, including mostly 19th and early 20th century single storey brick terraces, cottages and houses lining the narrow and dense grid street pattern, interspersed with low-rise industrial development and parkland.

Important views in the vicinity of the Marrickville dive site include those from Sydenham Station, local views from Camdenville Park, and from the Bedwin Road bridge.

16.4 Potential impacts

This section summarises the potential impact on landscape character and visual amenity as a result of the Project.

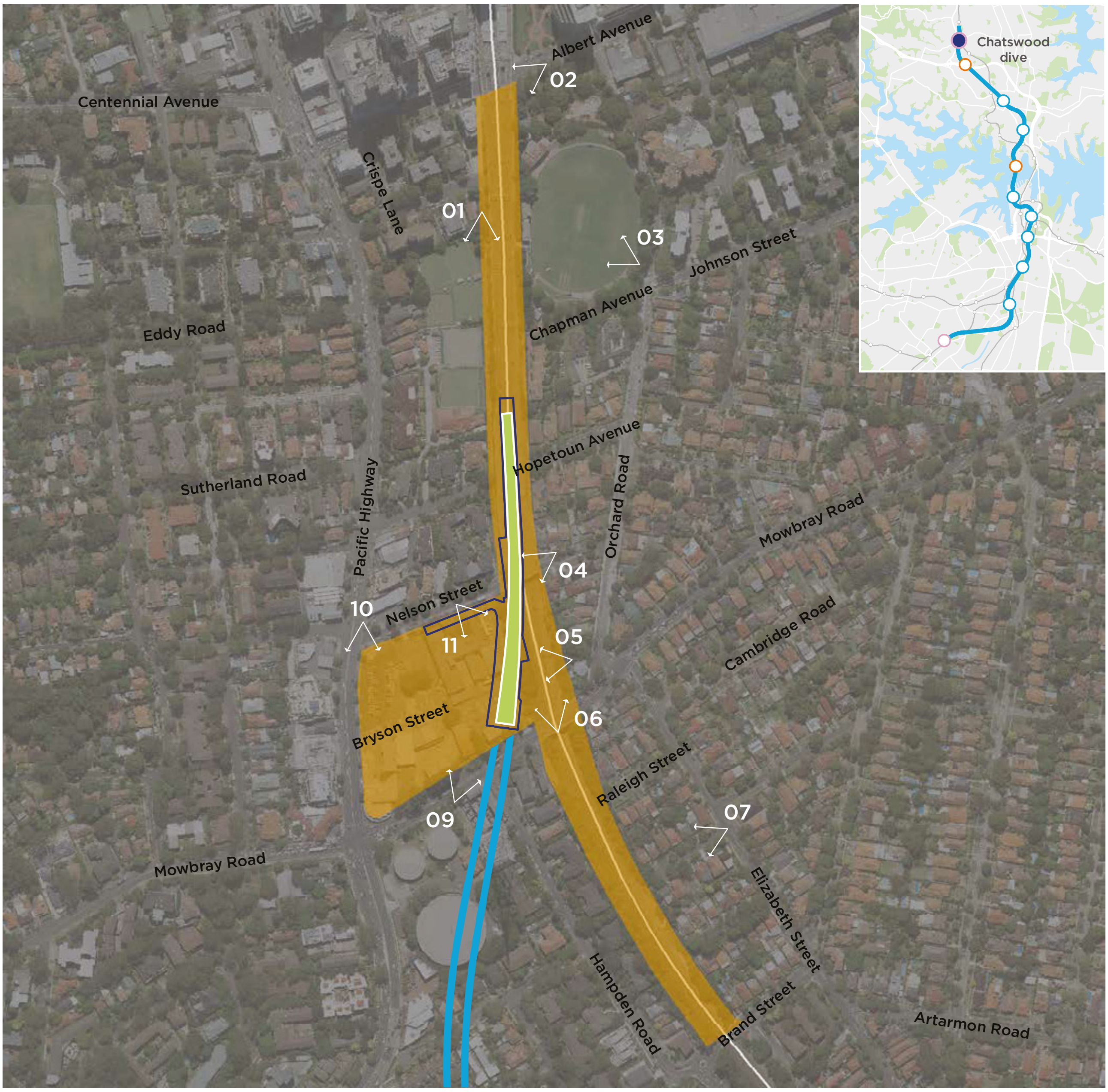
16.4.1 Chatswood dive site (northern)

Two landscape character areas and 11 representative viewpoints were selected to inform the landscape character and visual amenity assessment for the Chatswood dive site.

The landscape character areas are:

- Chatswood Park and Oval
- Frank Channon Walk.

Representative viewpoints are shown in Figure 16-1.



KEY

Chatswood to Sydenham
Proposed dive structure
Proposed operational area at surface
Proposed construction site area
Existing suburban rail
Viewpoint location

Indicative only, subject to design development

0 200 m

N

Figure 16-1 Chatswood dive site (northern) – representative viewpoints

Landscape character impacts

Landscape impacts anticipated during construction and operation are summarised in Table 16-9.

During construction, there would be:

- A moderate adverse landscape impact on the Frank Channon Walk, primarily due to direct impact on the path, including temporary short-term closures to enable construction (Frank Channon Walk would be reopened during operation of the project)
- A negligible landscape impact on Chatswood Park.

During operation, there would be:

- Minor adverse landscape impacts on the Frank Channon Walk due to the proposed removal of trees, the scale of the adjacent retaining structure and noise barriers, and associated overshadowing
- A negligible landscape impact on Chatswood Park.

Table 16-9 Chatswood dive site (northern) – landscape impacts

Location	Sensitivity rating	Construction impact		Operation impact	
		Modification rating	Impact rating	Modification rating	Impact rating
Chatswood Park	Local	No perceived change	Negligible	No perceived change	Negligible
Frank Channon Walk	Local	Considerable reduction	Moderate adverse	Noticeable reduction	Minor adverse

Daytime visual amenity impacts

The anticipated daytime visual impacts on representative viewpoints during construction and operation are summarised in Table 16-10.

During construction there would be:

- Minor and moderate adverse visual impacts on viewpoints from Nelson Street, Gilham Street, Mowbray Road and residential properties to the east of the existing rail corridor. These impacts would primarily be due to the scale and extent of the proposed work, including removal of vegetation along the rail corridor (between Nelson Street and Mowbray Road) and construction activities at the Chatswood dive site (for example, spoil removal and tunnel support works)
- Minor adverse visual impacts on viewpoints from elevated residences to the west of the Frank Channon Walk. This impact would be due to the removal of vegetation within the rail corridor, which would open up views to both existing rail infrastructure and metro infrastructure under construction.

During operation, there would be minor to moderate adverse daytime visual impacts on viewpoints from the following locations:

- Residential properties to the west of the Frank Channon Walk
- Residential properties and streets between Nelson Street and Mowbray Road
- Residential properties and streets between Mowbray Road and Hawkins Street.

These impacts would be due to the proposed removal of vegetation from within the rail corridor and scale of metro infrastructure, which would result in unfiltered views of the rail corridor, noise barriers and dive structure.

Table 16-10 Chatswood dive site (northern) – daytime visual impacts

Location	Sensitivity rating	Construction impact		Operation impact	
		Modification rating	Impact rating	Modification rating	Impact rating
Viewpoint 1: View south along Frank Channon Walk	Local	Considerable reduction	Moderate adverse	Noticeable reduction	Minor adverse
Residential areas to the west of Frank Channon Walk	Neighbourhood	Considerable reduction	Minor adverse	Considerable reduction	Minor adverse
Viewpoint 2: View southwest along Albert Avenue	Local	Noticeable reduction	Minor adverse	Noticeable reduction	Minor adverse
Viewpoint 3: View northwest across Chatswood Oval	Local	Noticeable reduction	Minor adverse	Noticeable reduction	Minor adverse
Residential areas between Chapman Avenue and Nelson Street	Neighbourhood	Noticeable reduction	Negligible	Considerable reduction	Minor adverse
Viewpoint 4: View west along Nelson Street	Neighbourhood	Considerable reduction	Minor adverse	Considerable reduction	Minor adverse
Viewpoint 5: View west from Gilham Street	Neighbourhood	Considerable reduction	Minor adverse	Considerable reduction	Minor adverse
Viewpoint 6: View north from Mowbray Road bridge	Local	Considerable reduction	Moderate adverse	Considerable reduction	Moderate adverse
Viewpoint 7: View west along Drake Street	Neighbourhood	Considerable reduction	Minor adverse	Considerable reduction	Minor adverse
Viewpoint 8: View north from Brand Street	Local	Noticeable reduction	Minor adverse	Noticeable reduction	Minor adverse
Viewpoint 9: View northeast along Mowbray Road	Local	Considerable reduction	Moderate adverse	No perceived change	Negligible
Views from residential properties on Mowbray Road	Neighbourhood	Considerable reduction	Minor adverse	No perceived change	Negligible
Viewpoint 10: View along the Pacific Highway	Local	Noticeable reduction	Minor adverse	No perceived change	Negligible
Viewpoint 11: View south from Nelson Street	Neighbourhood	Considerable reduction	Minor adverse	Noticeable reduction	Negligible
View from the rail corridor	Local	Noticeable reduction	Minor adverse	Noticeable reduction	Minor adverse

Night-time visual amenity impacts

The anticipated night-time visual impacts during construction and operation are summarised in Table 16-11.

During construction, there would be a moderate adverse visual impact on the locality due to the requirement for vehicle deliveries and haulage outside of daytime construction hours.

During operation, there would be a negligible visual impact as the project would be visually absorbed into the existing character of the rail corridor and surrounding area of E3 Medium district brightness.

Table 16-11 Chatswood dive site (northern) – night-time visual impacts

Location	Sensitivity rating	Construction impact		Operation impact	
		Modification rating	Impact rating	Modification rating	Impact rating
Chatswood dive site (northern)	E3: Medium district brightness	Noticeable reduction	Moderate adverse	No perceived change	Negligible

Chatswood dive site – existing view from viewpoint 11, Nelson Street Chatswood

Chatswood dive site – artist's impression during construction from viewpoint 11, Nelson Street Chatswood

16.4.2 Artarmon substation

One landscape character area and three representative viewpoints were selected to inform the landscape character and visual amenity assessment for the Artarmon substation.

The landscape character area is Butchers Lane and Barton Road. Representative viewpoints are shown in Figure 16-2.

KEY

Chatswood to Sydenham

Proposed operational area at surface

Proposed construction site area

Viewpoint location

Indicative only, subject to design development

0 100 m

N

Figure 16-2 Artarmon substation – representative viewpoints

Landscape character impacts

Landscape impacts anticipated during construction and operation are summarised in Table 16-12.

During construction, there would be negligible landscape impacts, as the proposed work would be contained within a relatively small site. Furthermore, there would be only a minor requirement for haulage and deliveries during construction.

During operation, there would be negligible landscape impacts, as the functioning of this precinct would be restored following the completion of construction. It is therefore expected that there would not be a perceived change in the landscape quality of this area.

Table 16-12 Artarmon substation – landscape impacts

Location	Sensitivity rating	Construction impact		Operation impact	
		Modification rating	Impact rating	Modification rating	Impact rating
Butchers Lane and Barton Road	Neighbourhood	No perceived change	Negligible	No perceived change	Negligible

Daytime visual amenity impacts

The anticipated daytime visual impacts on representative viewpoints during construction and operation are summarised in Table 16-13.

During construction and operation, there would be negligible visual impacts on surrounding viewpoints due to the change from views of temporary school buildings, to a less visually intensive activity.

Table 16-13 Artarmon substation – daytime visual impacts

Location	Sensitivity rating	Construction impact		Operation impact	
		Modification rating	Impact rating	Modification rating	Impact rating
Viewpoint 1: View southeast from Milner Road	Neighbourhood	No perceived change	Negligible	No perceived change	Negligible
Viewpoint 2: View southwest along Butchers Lane	Neighbourhood	Noticeable reduction	Negligible	No perceived change	Negligible
Views southwest from Residential units between Barton Road and Butchers Lane	Neighbourhood	Noticeable reduction	Negligible	No perceived change	Negligible
Viewpoint 3: View west from Barton Road	Neighbourhood	Noticeable reduction	Negligible	No perceived change	Negligible

Night-time visual amenity impacts

The anticipated night-time visual impacts during construction and operation are summarised in Table 16-14.

During construction, there would be negligible visual impacts due to the existing lighting levels of the area (assessed as being 'E3: Medium district brightness') and the minimal lighting required during construction, given that out of hours work would generally not be required at the site.

During operation, there would be negligible visual impacts due to the existing lighting levels of the area and the minimal lighting required to operate the facility.

Table 16-14 Artarmon substation – night-time visual impacts

Location	Sensitivity rating	Construction impact		Operation impact	
		Modification rating	Impact rating	Modification rating	Impact rating
Artarmon substation site	E3: Medium district brightness	No perceived change	Negligible	No perceived change	Negligible

16.4.3 Crows Nest Station

Four landscape character areas and five representative viewpoints were selected to inform the landscape character and visual amenity assessment for Crows Nest Station.

Landscape character areas are:

- Willoughby Road restaurant precinct
- Oxley, Hume and Clarke streets
- Pacific Highway
- Hume Street Park.

Representative viewpoints are shown in Figure 16-3.

Figure 16-3 Crows Nest Station – representative viewpoints

Landscape character impacts

Landscape impacts anticipated during construction and operation are summarised in Table 16-15.

During construction, there would be a minor adverse landscape impact on Oxley, Hume and Clarke streets and the Pacific Highway. This impact would be primarily due to proposed direct impacts on pedestrian movement and the loss of mature street trees at these locations.

During operation, there would be minor beneficial landscape impacts on these areas due to the improved accessibility of public transport and the provision of additional pedestrian crossings, which would improve overall accessibility around the entire precinct.

Table 16-15 Crows Nest Station – landscape impacts

Location	Sensitivity rating	Construction impact		Operation impact	
		Modification rating	Impact rating	Modification rating	Impact rating
Willoughby Road restaurant precinct	Local	No perceived change	Negligible	No perceived change	Negligible
Oxley, Hume and Clarke streets	Local	Noticeable reduction	Minor adverse	Noticeable improvement	Minor benefit
Pacific Highway	Local	Noticeable reduction	Minor adverse	Noticeable improvement	Minor benefit
Hume Street Park	Local	No perceived change	Negligible	Noticeable improvement	Minor benefit

Daytime visual amenity impacts

The anticipated daytime visual impacts on representative viewpoints during construction and operation are summarised in Table 16-16.

During construction, there would be minor and moderate visual impacts due to the extent of demolition and the scale of the proposed acoustic enclosures and construction sites. The range of impact levels at this location reflects the scale and proximity of the works to the viewing location. Generally, impacts would be more substantial in the vicinity of Hume Street where the construction site works would be more complex and have a larger footprint.

During operation, there would be a negligible visual impact on surrounding viewpoints. In addition, the proposed station entry and streetscape upgrades would likely improve the overall quality of views from the corner of Hume and Clarke streets.

Table 16-16 Crows Nest Station – daytime visual impacts

Location	Sensitivity rating	Construction impact		Operation impact	
		Modification rating	Impact rating	Modification rating	Impact rating
Viewpoint 1: View southeast along the Pacific Highway	Local	Noticeable reduction	Minor adverse	Noticeable improvement	Minor benefit
Viewpoint 2: View south along Oxley Street	Local	Noticeable reduction	Minor adverse	Noticeable improvement	Minor benefit
Viewpoint 3: View west along Hume Street to Clarke Street	Local	Noticeable reduction	Minor adverse	Noticeable improvement	Minor benefit
Viewpoint 4: View northwest along Clarke Lane	Local	Considerable reduction	Moderate adverse	No perceived change	Negligible
Viewpoint 5: View northeast from corner of Hume Street and Pacific Highway	Local	Considerable reduction	Moderate adverse	No perceived change	Negligible

Night-time visual amenity impacts

The anticipated night-time visual impacts during construction and operation are summarised in Table 16-17.

During construction, there would be a negligible visual impact on the locality due brightly lit visual context of the area.

During operation, there would be a negligible visual impact as the station and associated development would be visually absorbed into the surrounding area, which is brightly lit.

Table 16-17 Crows Nest Station – night-time visual impacts

Location	Sensitivity rating	Construction impact		Operation impact	
		Modification rating	Impact rating	Modification rating	Impact rating
Crows Nest Station site	E4: High district brightness	Noticeable reduction	Negligible	No perceived change	Negligible

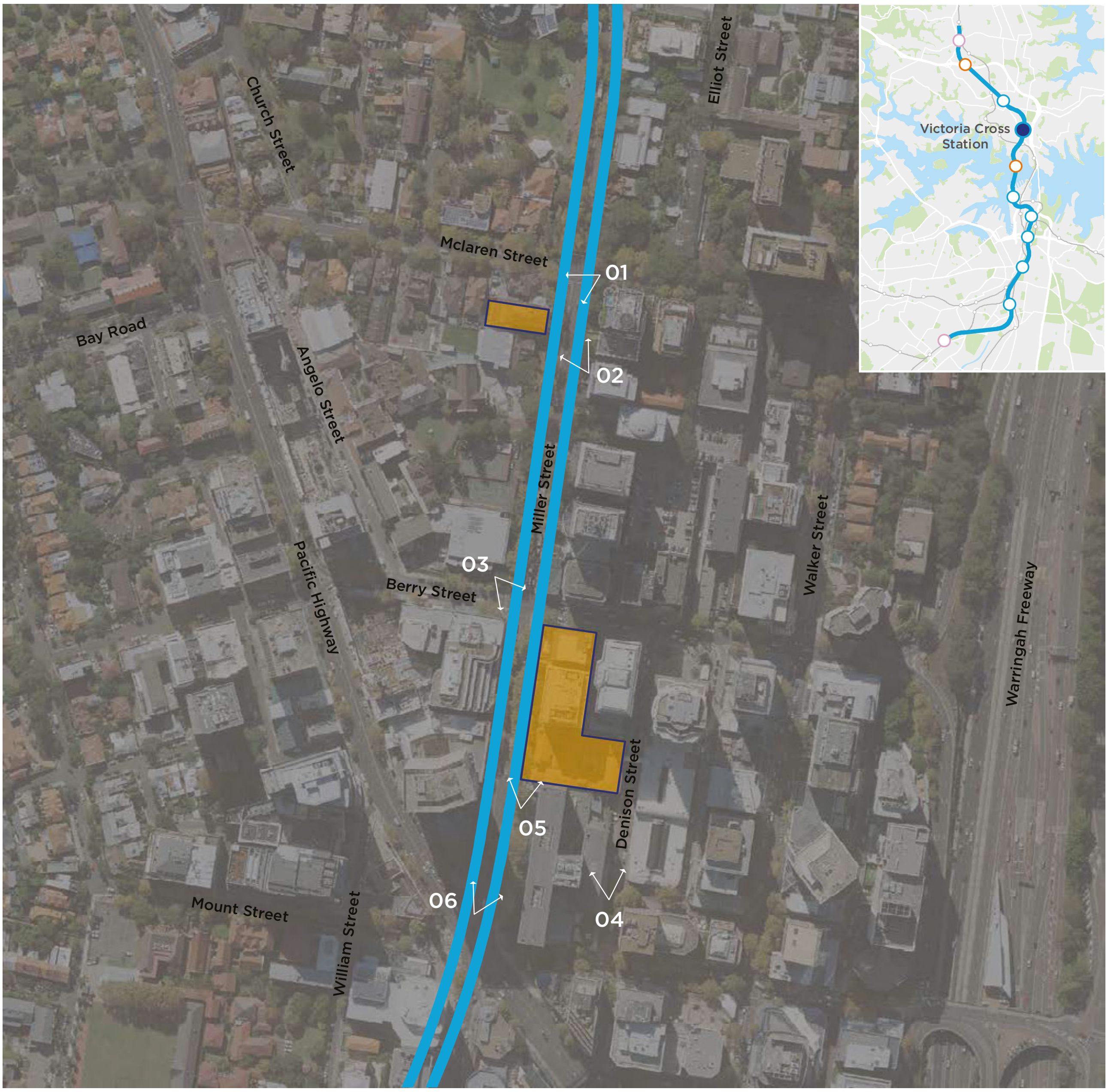
16.4.4 Victoria Cross Station

Five landscape character areas and six representative viewpoints were selected to inform the landscape character and visual amenity assessment for Victoria Cross Station.

Landscape character areas are:

- Harbour cycles sculpture
- Berry and Miller streets
- Monte Sant' Angelo Mercy College
- MLC building sculpture garden
- Brett Whiteley Place.

Representative viewpoints are shown in Figure 16-4.



KEY

Chatswood to Sydenham

Proposed operational area at surface

Proposed construction site area

Viewpoint location

Indicative only, subject to design development

0 100 m

N

Figure 16-4 Victoria Cross Station – representative viewpoints

Landscape character impacts

Landscape impacts anticipated during construction and operation are summarised in Table 16-18.

During construction, there would be a moderate adverse landscape impact on the Harbour cycles sculpture as it would be removed to make way for the construction site. There would also be a minor adverse landscape impact on Berry and Miller streets. This impact would be primarily due to direct impacts on pedestrian movement and the removal of mature street trees at these locations. There would, however, be negligible landscape impacts on the surrounding landscapes of the Monte Sant' Angelo Mercy College, MLC Building sculpture garden and Brett Whiteley Place as there would be no direct impacts on these areas.

During operation, there would be moderate beneficial landscape impacts on Berry and Miller streets. These benefits would be due to the improved accessibility of public transport, footpath widening, the proposed mid-block crossing and the creation of a plaza which would improve overall accessibility around the entire precinct. There would also be negligible landscape impacts on the Monte Sant' Angelo Mercy College, MLC Building sculpture garden and Brett Whiteley Place as the project would not result in a direct change to these areas.

Table 16-18 Victoria Cross Station – landscape impacts

Location	Sensitivity rating	Construction impact		Operation impact	
		Modification rating	Impact rating	Modification rating	Impact rating
Harbour cycles sculpture	Local	Considerable reduction	Moderate adverse	N/A	N/A
Berry and Miller streets	Local	Noticeable reduction	Minor adverse	Considerable improvement	Moderate beneficial
Monte Sant' Angelo Convent and Girls School	Local	No perceived change	Negligible	No perceived change	Negligible
MLC Building sculpture garden	Local	No perceived change	Negligible	No perceived change	Negligible
Brett Whiteley Place	Local	No perceived change	Negligible	No perceived change	Negligible

Daytime visual amenity impacts

The anticipated daytime visual impacts on representative viewpoints during construction and operation are summarised in Table 16-19.

During construction, there would be minor and moderate adverse visual impacts on viewpoints from surrounding streets. These impacts would be primarily due to demolition and the establishment of acoustic enclosures. Visual impacts experienced at surrounding viewpoints would vary depending on the sensitivity of the viewpoint and proximity to the site.

During operation, there would be a minor adverse visual impact at the northern station building site due to the introduction of a utilitarian structure and the associated loss of visual interest and reduced visual compatibility. Conversely, at the southern station building site, there would be minor beneficial impacts created by the uncluttering of views to the site, and the introduction of a broad open plaza, street trees, and a prominent, architectural station entry and plaza.

Table 16-19 Victoria Cross Station – daytime visual impacts

		Construction impact		Operation impact	
Location	**Sensitivity rating**	**Modification rating**	**Impact rating**	**Modification rating**	**Impact rating**
Northern station site					
Viewpoint 1: View west from corner of McLaren and Miller streets	Local	Noticeable reduction	Minor adverse	Noticeable reduction	Minor adverse
Viewpoint 2: View northwest along Miller Street	Local	Noticeable reduction	Minor adverse	Noticeable reduction	Minor adverse
Southern station site					
Viewpoint 3: View southeast across the intersection of Berry and Miller streets	Local	Considerable reduction	Moderate adverse	Noticeable improvement	Minor benefit
Viewpoint 4: View north along Denison Street	Local	Noticeable reduction	Minor adverse	Noticeable improvement	Minor benefit
Viewpoint 5: View north along Miller Street	Local	Considerable reduction	Moderate adverse	Noticeable improvement	Minor benefit
Viewpoint 6: View north at the intersection of the Pacific Highway and Miller Street	Local	Noticeable reduction	Minor adverse	Noticeable improvement	Minor benefit

Night-time visual amenity impacts

As indicated in Table 16-20, there would be negligible night-time visual impacts at both the northern and southern station building sites during both construction and operation. Station lighting would generally be in character with the existing lighting levels of the area (assessed as being 'E4: High district brightness').

Table 16-20 Victoria Cross Station – night-time visual impacts

Location	Sensitivity rating	Construction impact		Operation impact	
		Modification rating	Impact rating	Modification rating	Impact rating
Northern station site	E4: High district brightness	Noticeable reduction	Negligible	No perceived change	Negligible
Southern station site	E4: High district brightness	Noticeable reduction	Negligible	No perceived change	Negligible

Victoria Cross Station – existing view from viewpoint 3, corner of Berry Street and Pacific Highway North Sydney

Victoria Cross Station – artist's impression from viewpoint 3, corner of Berry Street and Pacific Highway North Sydney

16.4.5 Blues Point temporary site

One landscape character area and seven representative viewpoints were selected to inform the landscape character and visual amenity assessment for the Blues Point temporary site.

The landscape character area is Blues Point Reserve.

Representative viewpoints are shown in Figure 16-5.

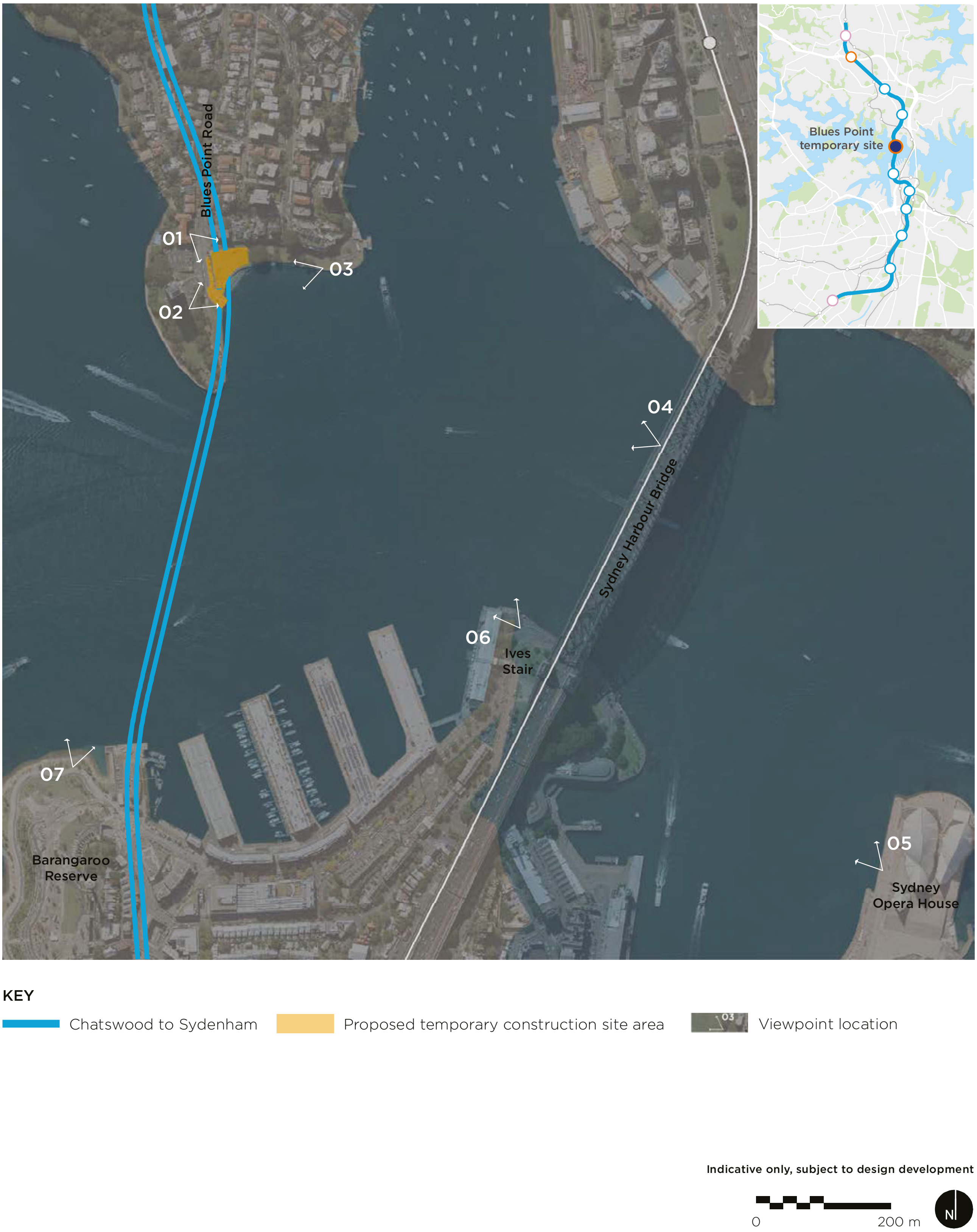


Figure 16-5 Blues Point temporary site – representative viewpoints

Landscape character impacts

Landscape impacts anticipated during construction are summarised in Table 16-21.

During construction, there would be a high adverse landscape impact on the Blues Point Reserve. This impact would be a consequence of the direct loss of harbour foreshore open space. It is noted, however, that there would be limited impacts on local vehicular movement, pedestrian access would be maintained around the foreshore edge, and existing mature trees would be retained.

During operation, there would be negligible landscape impacts as the reserve would be reinstated after construction.

Table 16-21 Blues Point temporary site – landscape impacts

Location	Sensitivity rating	Construction impact		Operation impact	
		Modification rating	Impact rating	Modification rating	Impact rating
Blues Point Reserve	Regional	Considerable reduction	High adverse	N/A	N/A

Daytime visual amenity impacts

The anticipated daytime visual impacts on representative viewpoints during construction are summarised in Table 16-22.

During construction, there would be:

- Moderate to high adverse visual impacts on viewpoints from Blues Point and McMahons Point. These impacts would be due to the obstruction of views to the open water of the harbour and the incongruent character of the construction work with these views.
- A moderate adverse visual impact on viewpoints from the Harbour Bridge and St Ives stairs due to the disruption of the green foreshore edge, which is currently visible from across the harbour
- Negligible visual impacts from the Sydney Opera House and forecourt. Although the project site would be clearly visible from these locations, the distance and ability of the surrounding urban environment to absorb visual impacts would result in no perceived change in the amenity of views. Similarly, negligible visual impacts would be experienced from Barangaroo Reserve, where distance and intervening elements would limit the visibility of the site.

The Blues Point temporary site would not be required during the operation phase of the project. Following retrieval activities, this site would be rehabilitated and reinstated as public open space in consultation with North Sydney Council. As such, operational impact ratings are not applicable.

Table 16-22 Blues Point temporary site – daytime visual impacts

Location	Sensitivity rating	Construction impact		Operation impact	
		Modification rating	Impact rating	Modification rating	Impact rating
Viewpoint 1: View southeast from the corner of Blues Point Road and Henry Lawson Avenue	Regional	Considerable reduction	High adverse	N/A	N/A
Viewpoint 2: View northeast from Blues Point	Regional	Considerable reduction	High adverse	N/A	N/A
Viewpoint 3: View west from the foreshore park on Henry Lawson Avenue	Regional	Considerable reduction	High adverse	N/A	N/A
Viewpoint 4: View west from the Harbour Bridge	Regional	Noticeable reduction	Moderate adverse	N/A	N/A
Viewpoint 5: View northwest from the Sydney Opera House forecourt plaza	National	No perceived change	Negligible	N/A	N/A
Viewpoint 6: View northwest from the Ives Stairs	Regional	Noticeable reduction	Moderate adverse	N/A	N/A
Viewpoint 7: View north from Barangaroo Reserve	Regional	No perceived change	Negligible	N/A	N/A

Night-time visual amenity impacts

The anticipated night-time visual impacts during construction are summarised in Table 16-23

During construction, there would be minor adverse visual impacts due to night-time work, particularly 24-hour tunnel boring machine retrieval activities.

As noted above, the operational phase at this site is not applicable.

Table 16-23 Blues Point temporary site – night-time visual impacts

		Construction impact		Operation impact	
Location	Sensitivity rating	Modification rating	Impact rating	Modification rating	Impact rating
Blues Point temporary site	E3: Medium district brightness	Noticeable reduction	Minor adverse	N/A	N/A

Blues Point temporary site – existing view from viewpoint 1, corner of Blues Point Road and Henry Lawson Avenue, McMahons Point

Blues Point temporary site – artist's impression from viewpoint 1, corner of Blues Point Road and Henry Lawson Avenue, McMahons Point

Blues Point temporary site – existing view (zoomed) from viewpoint 5, Sydney Opera House forecourt

Blues Point temporary site – artist's impression (zoomed) from viewpoint 5, Sydney Opera House forecourt

16.4.6 Sydney Harbour ground improvement work

One landscape character area and six representative viewpoints were selected to inform the landscape character and visual amenity assessment for the proposed Sydney Harbour ground improvement work.

The landscape character area is Sydney Harbour.

Representative viewpoints are shown in Figure 16-6.

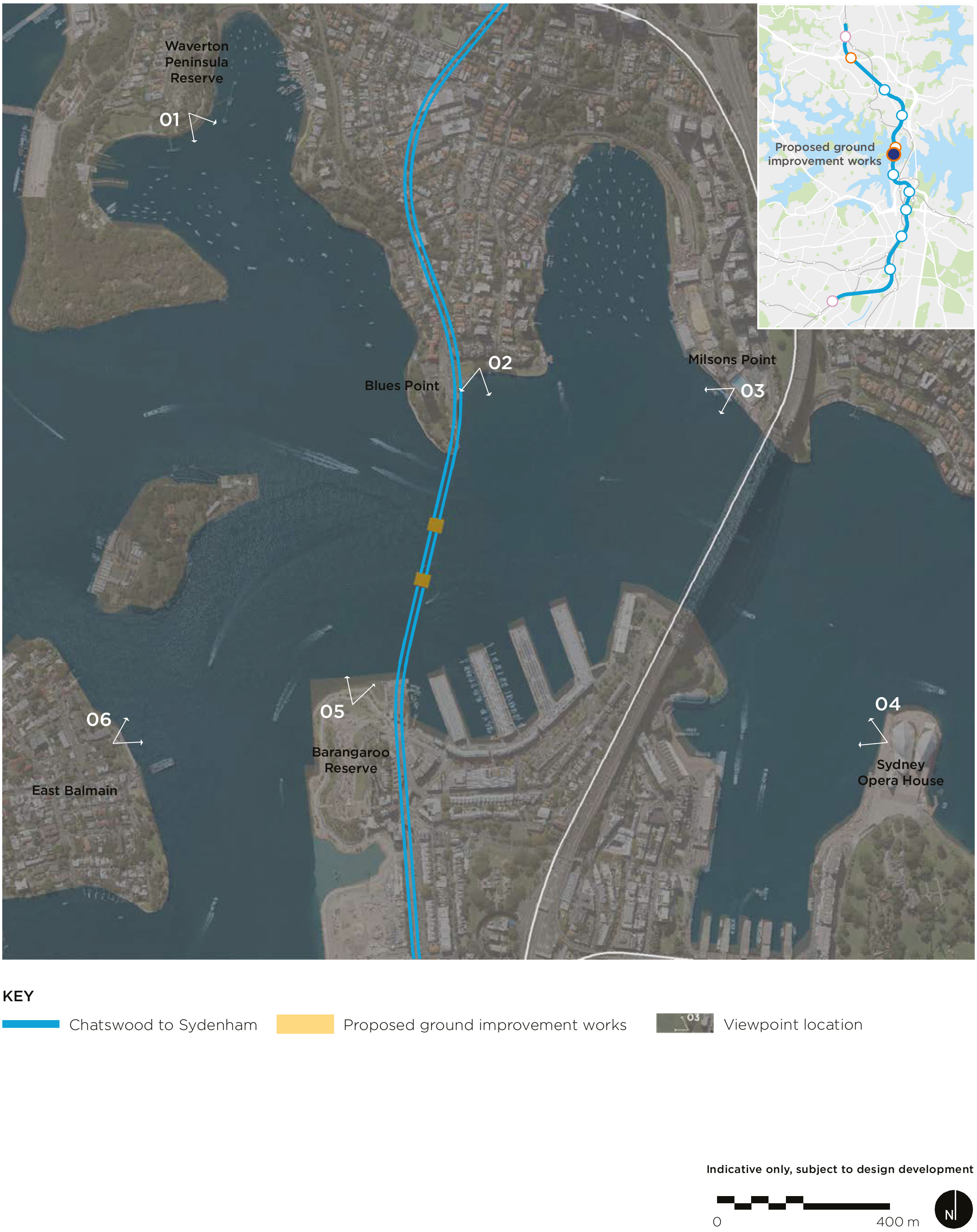


Figure 16-6 Sydney Harbour ground improvement work – representative viewpoints

Landscape character impacts

Landscape impacts anticipated during construction are summarised in Table 16-24.

During construction, the project would result in a negligible landscape impact due to the absorption capacity of the surrounding busy harbour. During operation, there would be no visible permanent infrastructure and areas affected by the harbour works would be reinstated after construction. As such operational impact ratings are not applicable.

Table 16-24 Sydney Harbour works – landscape impacts

Location	Sensitivity rating	Construction impact		Operation impact	
		Modification rating	Impact rating	Modification rating	Impact rating
Sydney Harbour	Regional	No perceived change	Negligible	N/A	N/A

Daytime visual amenity impacts

The anticipated daytime visual impacts on representative viewpoints during construction are summarised in Table 16-25.

During construction, it is expected that the project would be visually absorbed into the busy waters of this section of the harbour or screened by intervening shoreline, resulting in negligible visual impacts from the Sydney Opera House and Waverton Peninsular Reserve.

In views where the site is seen at a closer proximity, and where both sites would be seen there are minor and moderate adverse visual impacts. This includes views from Blues Point Reserve, Milsons Point Wharf, Balmain East Wharf and Barangaroo Reserve. These impacts would however be temporary, and there are no operational components of the project at this site.

Table 16-25 Sydney Harbour works – daytime visual impacts

Location	Sensitivity rating	Construction impact		Operation impact	
		Modification rating	Impact rating	Modification rating	Impact rating
Viewpoint 1: View southeast from Waverton Peninsular Reserve	Local	No perceived change	Negligible	N/A	N/A
Viewpoint 2: View southeast from Blues Point Reserve	Regional	Noticeable reduction	Moderate adverse	N/A	N/A
Viewpoint 3: View southwest from Milsons Point Wharf	Regional	Noticeable reduction	Moderate adverse	N/A	N/A
Viewpoint 4: View southwest from the Sydney Opera House forecourt plaza	National	No perceived change	Negligible	N/A	N/A
Viewpoint 5: View north from Barangaroo Reserve	Regional	Noticeable reduction	Moderate adverse	N/A	N/A
Viewpoint 6: View northeast from Balmain East Ferry Wharf	Local	Noticeable reduction	Minor adverse	N/A	N/A

Night-time visual amenity impacts

The anticipated night-time visual impacts during construction are summarised in Table 16-26.

During construction, it is expected that at night the project would create a noticeable reduction in the amenity of views in this area, including views from nearby residential properties and foreshore parkland. It is therefore expected that the project would result in a minor adverse visual impact during evening hours.

Table 16-26 Sydney Harbour works – night-time visual impacts

Location	Sensitivity rating	Construction impact		Operation impact	
		Modification rating	Impact rating	Modification rating	Impact rating
Sydney Harbour worksite	E3: Medium district brightness	Noticeable reduction	Minor adverse	N/A	N/A

Sydney Harbour ground improvement work – existing view from viewpoint 5, Barangaroo Reserve

Sydney Harbour ground improvement work – artist's impression from viewpoint 5, Barangaroo Reserve

16.4.7 Barangaroo Station

Three landscape character areas and eight representative viewpoints were selected to inform the landscape character and visual amenity assessment for Barangaroo Station. Landscape character areas are:

- Barangaroo Reserve
- Hickson Road
- Central Barangaroo.

Representative viewpoints are shown in Figure 16-7.

Figure 16-7 Barangaroo Station – representative viewpoints

Landscape character impacts

Landscape impacts anticipated during construction and operation are summarised in Table 16-27.

During construction, there would be a minor adverse landscape impact on Hickson Road due to the direct impacts on vehicular and pedestrian movement and the loss of mature street trees. However, it is expected that there would be no perceived change in the landscape quality of Barangaroo Reserve (resulting in a negligible landscape impact) due to the context of the continuing development across the Barangaroo peninsular, including works at Central Barangaroo.

During operation, there would be minor to moderate beneficial landscape impacts at Barangaroo Reserve, Hickson Road and Central Barangaroo due to improved accessibility to public transport and proposed footpath widening, which would improve overall accessibility and permeability around the entire precinct.

Table 16-27 Barangaroo Station – landscape impacts

Location	Sensitivity rating	Construction impact		Operation impact	
		Modification rating	Impact rating	Modification rating	Impact rating
Barangaroo Reserve	Regional	No perceived change	Negligible	Noticeable improvement	Moderate benefit
Hickson Road	Local	Noticeable reduction	Minor adverse	Noticeable improvement	Minor benefit
Central Barangaroo	Local	N/A	N/A	Noticeable improvement	Minor benefit

Daytime visual amenity impacts

The anticipated daytime visual impacts on representative viewpoints during construction and operation are summarised in Table 16-28.

During construction, there would be minor and moderate adverse visual impacts. Project impacts would be mitigated by other surrounding construction activity at the adjacent Central Barangaroo site, but would still be moderate due to the high sensitivity of the site. In general, greater impacts would be experienced:

- In locations of higher visual sensitivity
- In locations such as from the Munn Street Bridge where construction is seen extending into new areas, such as the Millers Point cliff wall.

During operation, there would be negligible visual impacts from the majority of assessed viewpoints due to the integration of the project into the surrounding Central Barangaroo development. A moderate adverse visual impact is expected, however, from views at the North Cove plaza, where the Metro services would be located adjacent to the Millers Point cliff wall, which would become a prominent element in streetscape views.

Table 16-28 Barangaroo Station – daytime visual impacts

Location	Sensitivity rating	Construction impact		Operation impact	
		Modification rating	Impact rating	Modification rating	Impact rating
Viewpoint 1: View west from Observatory Hill	State	No perceived change	Negligible	No perceived Change	Negligible
Viewpoint 2: View east to Barangaroo from Darling Harbour	Regional	No perceived change	Negligible	No perceived Change	Negligible
Viewpoint 3: View southeast from Barangaroo Reserve	Regional	No perceived change	Negligible	No perceived Change	Negligible
Viewpoint 4: View south from Hickson Road at Windmill Street Bridge	Local	Noticeable reduction	Minor adverse	N/A	N/A
Viewpoint 5: View south from the Munn Street Bridge	Regional	Noticeable reduction	Moderate adverse	No perceived change	Negligible
Viewpoint 6: View southeast from Northern Cove plaza	Regional	Noticeable reduction	Moderate adverse	Noticeable reduction	Moderate adverse
Viewpoint 7: View north along Hickson Road	Local	Noticeable reduction	Minor adverse	No perceived change	Negligible
Viewpoint 8: View north along High Street	Local	Noticeable reduction	Minor adverse	No perceived change	Negligible
Views to power supply route works	Local	Noticeable reduction	Minor adverse	N/A	N/A

Night-time visual amenity impacts

As indicated in Table 16-29, there would be negligible night-time visual impacts during construction and operation as due to its brightly lit Sydney CBD location and the intensity of the future Barangaroo precincts where there will 24 hour activity and lighting from surrounding buildings, urban plazas and streets creating both direct light sources and a general skyglow around the site. Additionally the Millers Point cliff wall provides a containing effect to viewing locations from the east.

Table 16-29 Barangaroo Station – night-time visual impacts

Location	Sensitivity rating	Construction impact		Operation impact	
		Modification rating	Impact rating	Modification rating	Impact rating
Barangaroo Station site	E4: High district brightness	No perceived change	Negligible	No perceived change	Negligible

Barangaroo Station – existing view from viewpoint 3, Barangaroo Reserve

Barangaroo Station – artist's impression during construction from viewpoint 3, Barangaroo Reserve

Barangaroo Station – existing view from viewpoint 5, Hickson Road

Barangaroo Station – artist's impression from viewpoint 5, Hickson Road

16.4.8 Martin Place Station

Six landscape character areas and six representative viewpoints were identified to inform the landscape character and visual amenity assessment for Martin Place Station.

Landscape character areas are:

- Richard Johnson Square
- Chifley Square
- P&O Fountain
- Castlereagh, Hunter and Elizabeth streets
- Martin Place
- Castlereagh and Elizabeth streets at Martin Place.

Representative viewpoints are shown in Figure 16-8.

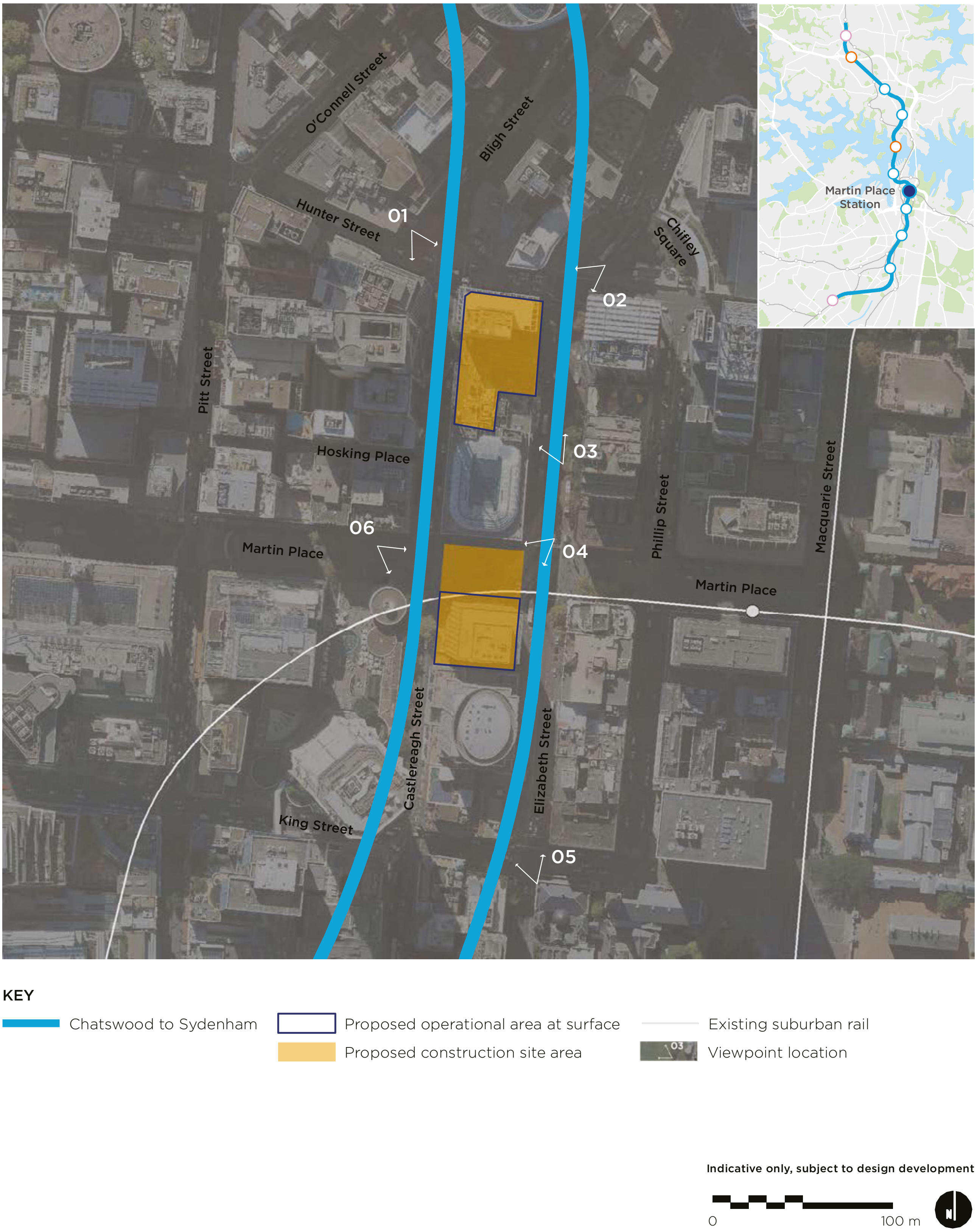


Figure 16-8 Martin Place Station – representative viewpoints

Landscape character impacts

Landscape impacts anticipated during construction and operation are summarised in Table 16-30.

During construction, there would be a minor adverse landscape impact on Hunter, Castlereagh and Elizabeth streets and a moderate adverse landscape impact on the P&O Fountain due to the removal of this item during the demolition of the 55 Hunter Street building. Construction of the project would also have a very high adverse landscape impact on Martin Place. This impact would primarily be due to the diversion of pedestrian movement on these streets and a portion of Martin Place during construction, as well as the loss of trees and plaza space for community use.

During operation, there would be a minor beneficial landscape impact on Hunter, Castlereagh and Elizabeth streets, as well as a high beneficial landscape impact on Martin Place due to the integration of the station and plaza, and improvements to legibility and accessibility.

Table 16-30 Martin Place Station – landscape impacts

Location	Sensitivity rating	Construction impact		Operation impact	
		Modification rating	Impact rating	Modification rating	Impact rating
Richard Johnson Square	Local	No perceived change	Negligible	No perceived change	Negligible
Chifley Square	Regional	No perceived change	Negligible	No perceived change	Negligible
P&O Fountain	Local	Considerable reduction	Moderate adverse	N/A	N/A
Castlereagh, Hunter and Elizabeth streets	Local	Noticeable reduction	Minor adverse	Noticeable improvement	Minor beneficial
Martin Place	State	Considerable reduction	Very high adverse	Noticeable improvement	High beneficial
Castlereagh and Elizabeth Street at Martin Place	Local	Noticeable reduction	Minor adverse	Noticeable improvement	Minor beneficial

Daytime visual amenity impacts

The anticipated daytime visual impacts on representative viewpoints during construction and operation are summarised in Table 16-31.

During construction, there would be minor adverse impacts on viewpoints from Richard Johnson Square, moderate adverse impacts on viewpoints from Chifley Square, and very high adverse impacts on viewpoints from Martin Place.

Viewpoints from Martin Place (represented as Viewpoints 4 and 6 in Table 16-31) are considered to be of state visual sensitivity. Construction works (including the demolition of buildings and establishment of acoustic enclosures) would result in a considerable reduction in visual amenity for these viewpoints. In particular, the demolition of the 20 storey office tower at 39 Martin Place, which is visually prominent from Martin Place, would be a highly visible activity from Viewpoints 4 and 6. Consequently, it is expected that there would be a very high adverse visual impact on these viewpoints during construction.

During operation, there would be high beneficial impacts on views in the vicinity of Martin Place, as the design outcome would improve views in this area.

Table 16-31 Martin Place Station – daytime visual impacts

Location	Sensitivity rating	Construction impact		Operation impact	
		Modification rating	Impact rating	Modification rating	Impact rating
Northern station site					
Viewpoint 1: View southeast from Richard Johnson Square	Local	Noticeable reduction	Minor adverse	No perceived change	Negligible
Viewpoint 2: View southwest from Chifley Square	Regional	Noticeable reduction	Moderate adverse	No perceived change	Negligible
Viewpoint 3: View north along Elizabeth Street	Local	Noticeable reduction	Minor adverse	No perceived change	Negligible
Southern station site					
Viewpoint 4: View southwest towards Martin Place from Elizabeth Street	State	Considerable reduction	Very high adverse	Noticeable improvement	High beneficial
Viewpoint 5: View northwest from corner of Elizabeth and King streets	Local	Noticeable reduction	Minor adverse	No perceived change	Negligible
Viewpoint 6: View south from Martin Place at Castlereagh Street	State	Considerable reduction	Very high adverse	Noticeable improvement	High beneficial
Views to power supply route works	Local	Noticeable reduction	Minor adverse	N/A	N/A

Night-time visual amenity impacts

The anticipated night-time visual impacts during construction and operation are summarised in Table 16-32.

There would be negligible visual impacts during construction and operation due to its brightly lit Sydney CBD location where there is 24 hour activity and lighting from buildings and streets creating both direct light sources and a general skyglow around the site. Additionally, during construction, the majority of the lighting would be contained within the acoustic enclosures.

Table 16-32 Martin Place Station – night-time visual impacts

Location	Sensitivity rating	Construction impact		Operation impact	
		Modification rating	Impact rating	Modification rating	Impact rating
Northern station site	E4: High district brightness	Noticeable reduction	Negligible	No perceived change	Negligible
Southern station site	E4: High district brightness	Noticeable reduction	Negligible	No perceived change	Negligible

Martin Place Station (northern entry) – existing view from viewpoint 2, Chifley Square

Martin Place Station (northern entry) – artist's impression from viewpoint 2, Chifley Square

Martin Place Station (southern entry) – existing view from viewpoint 6, Martin Place at Castlereagh Street

Martin Place Station (southern entry) – artist's impression from viewpoint 6, Martin Place at Castlereagh Street

16.4.9 Pitt Street Station

Two landscape character areas and nine representative viewpoints were selected to inform the landscape character and visual amenity assessment for Pitt Street Station.

Landscape character areas are:

- Pitt, Park and Castlereagh streets
- Pitt, Bathurst and Castlereagh streets.

Representative viewpoints are shown in Figure 16-9.

Figure 16-9 Pitt Street Station – representative viewpoints

Landscape character impacts

Landscape impacts anticipated during construction and operation are summarised in Table 16-33.

During construction, there would be a minor adverse landscape impact. This would primarily be due to the street-level impacts of construction on pedestrian movement. There would also be a temporary moderate adverse landscape impacts experienced during the construction of the power supply route within the public realm of Tumbalong Park, Darling Harbour.

During operation, there would be a minor beneficial impact as the highly urban environment would be improved by street activation and legible public transport access points.

Table 16-33 Pitt Street Station – landscape impacts

Location	Sensitivity rating	Construction impact		Operation impact	
		Modification rating	Impact rating	Modification rating	Impact rating
Pitt, Park and Castlereagh streets	Local	Noticeable reduction	Minor adverse	Noticeable improvement	Minor beneficial
Pitt, Bathurst and Castlereagh streets	Local	Noticeable reduction	Minor adverse	Noticeable improvement	Minor beneficial
Tumbalong Park, Darling Harbour	Regional	Noticeable reduction	Moderate adverse	N/A	N/A

Daytime visual amenity impacts

The anticipated daytime visual impacts on representative viewpoints during construction and operation are summarised in Table 16-34.

During construction, there would be a minor adverse visual impact on most views in the vicinity of the project. The impacts would primarily be due to the demolition of buildings. However, the mixed character of this precinct would readily absorb visual change. Notwithstanding, construction of the project would have a moderate adverse visual impact on views from Hyde Park, which is a more visually sensitive location. There would also be temporary moderate adverse visual impacts experienced during the construction of the power upgrade as it passes through Tumbalong Park, Darling Harbour in view of Cockle Bay.

During operation, there would be negligible visual impacts.

Table 16-34 Pitt Street Station – daytime visual impacts

Location	Sensitivity rating	Construction impact		Operation impact	
		Modification rating	Impact rating	Modification rating	Impact rating
Northern station site					
Viewpoint 1: View south along Pitt Street	Local	Noticeable reduction	Minor adverse	No perceived change	Negligible
Viewpoint 2: View south along Castlereagh Street	Local	Noticeable reduction	Minor adverse	No perceived change	Negligible
Viewpoint 3: View northwest from Hyde Park at the corner of Park and Elizabeth streets	Regional	Noticeable reduction	Moderate adverse	No perceived change	Negligible
Viewpoint 4: View northwest at the corner of Castlereagh and Park streets	Local	Noticeable reduction	Minor adverse	No perceived change	Negligible
Viewpoint 5: View northeast at the corner of Park and Pitt streets	Local	Noticeable reduction	Minor adverse	No perceived change	Negligible
Southern station site					
Viewpoint 6: View south along Pitt Street	Local	Noticeable reduction	Minor adverse	No perceived change	Negligible
Viewpoint 7: View west along Bathurst Street	Local	Noticeable reduction	Minor adverse	No perceived change	Negligible
Viewpoint 8: View west along Bathurst Street from Hyde Park	State	No perceived change	Negligible	No perceived change	Negligible
Viewpoint 9: View north along Pitt Street	Local	Noticeable reduction	Minor adverse	No perceived change	Negligible
Views to power supply route works (Surry Hills option)	Local	Noticeable reduction	Minor adverse	N/A	N/A
Views to power supply route works (Pyrmont option)	Local – regional	Noticeable reduction	Minor – moderate adverse	N/A	N/A

Night-time visual amenity impacts

The anticipated night-time visual impacts during construction and operation are summarised in Table 16-35.

There would be negligible visual impacts during construction and operation due to its brightly lit Sydney CBD location where there is 24 hour activity and lighting from buildings and streets creating both direct light sources and a general skyglow around the site. Additionally, during construction, the majority of the lighting would be contained within the acoustic enclosures.

Table 16-35 Pitt Street Station – night-time visual impacts

		Construction impact		Operation impact	
Location	Sensitivity rating	Modification rating	Impact rating	Modification rating	Impact rating
Northern station site	E4: High district brightness	Noticeable reduction	Negligible	No perceived change	Negligible
Southern station site	E4: High district brightness	Noticeable reduction	Negligible	No perceived change	Negligible

Pitt Street (northern entry) – existing view from viewpoint 3, Hyde Park at Park Street

Pitt Street (northern entry) – artist's impression from viewpoint 3, Hyde Park at Park Street

Pitt Street (southern entry) – existing view from viewpoint 6, south along Pitt Street

Pitt Street (southern entry) – artist's impression from viewpoint 6, south along Pitt Street

16.4.10 Central Station

One landscape character area and seven representative viewpoints were selected to inform the landscape character and visual amenity assessment for Central Station.

The landscape character area is northern concourse.

Representative viewpoints are shown in Figure 16-10.

KEY

Chatswood to Sydenham	Proposed operational area at surface
Existing suburban rail	Proposed construction site area
Viewpoint location	Artists impression

Indicative only, subject to design development

0 200 m

Figure 16-10 Central Station – representative viewpoints

Landscape character impacts

Landscape impacts anticipated during construction and operation are summarised in Table 16-36.

During construction the project would also have a moderate adverse landscape impact at the northern concourse due to impacts on pedestrian connectivity and activation of this plaza due to the loss of retail tenancies and construction activity.

During operation, there would be negligible landscape impacts at the northern concourse due to its reinstatement and the introduction of an improved public realm and metro station entries.

Table 16-36 Central Station – landscape impacts

Location	Sensitivity rating	Construction impact		Operation impact	
		Modification rating	Impact rating	Modification rating	Impact rating
Northern concourse	Regional	Noticeable reduction	Moderate adverse	No perceived change	Negligible

Daytime visual amenity impacts

The anticipated daytime visual impacts on representative viewpoints during construction and operation are summarised in Table 16-37.

During construction, there would be a range of adverse visual impacts including minor, moderate and high adverse visual impacts. These impacts would primarily be due to the sensitivity of views and the scale of construction activities, particularly the demolition of buildings (including heritage buildings and historic character buildings), the removal of trees, and the proposed scale of new built elements (particularly the temporary pedestrian bridge between platforms 4 and 23 and the access bridge from Regent Street).

Moderate visual impacts would be experienced in views to the Sydney Yard Access Bridge, from adjacent station platforms, and trains approaching and departing Central Station to the south.

During operation, there would be negligible visual impacts on the majority of assessed viewpoints as much of the site would be reinstated. However, moderate adverse visual impacts are anticipated to be experienced at Regent Street where the Sydney Yard Access Bridge would remain and continue to be used for access to the Yard.

Table 16-37 Central Station – daytime visual impacts

Location	Sensitivity rating	Construction impact		Operation impact	
		Modification rating	Impact rating	Modification rating	Impact rating
Viewpoint 1: View southwest from Eddy Avenue to the northern concourse	Local	Noticeable reduction	Minor adverse	No perceived change	Negligible
Viewpoint 2: View south from platform 16	Regional	Noticeable reduction	Moderate adverse	No perceived change	Negligible
Viewpoint 3: View northwest from the corner of Devonshire and Chalmers streets	Local	Noticeable reduction	Minor adverse	N/A	N/A
Viewpoint 4: View west from Chalmers Street	Local	No perceived change	Negligible	No perceived change	Negligible
Viewpoint 5: View west from Prince Alfred Park	Regional	No perceived change	Negligible	No perceived change	Negligible
Views from the rail corridor	Regional	Noticeable reduction	Moderate adverse	Noticeable reduction	Moderate adverse
Viewpoint 6: View southeast along Regent Street	Local	Considerable reduction	Moderate adverse	Considerable reduction	Moderate adverse
Viewpoint 7: View southeast from Meagher Street	Local	Considerable reduction	Moderate adverse	Considerable reduction	Moderate adverse
Viewpoint 8: View east across Regent Street to Mortuary Station	Regional	Noticeable reduction	Moderate adverse	Noticeable reduction	Moderate adverse
Views to power supply route works	Local	Noticeable reduction	Minor adverse	N/A	N/A

Night-time visual amenity impacts

As indicated in Table 16-38, there would be negligible night-time visual impacts during both construction and operation of the project.

During construction the site would be largely contained within the station and not likely to be overlooked by surrounding streets, residential properties or hotels. The construction lighting would be generally consistent with the brightly lit station area. Overall, it is expected that at night the project would not create a perceived change in the amenity of views in this area, which would result in a negligible visual impact during out of hours works.

During operation, the station function would be restored and the associated lighting would be consistent with the high district brightness environment of the existing station. Therefore, the lighting of the project would not create a perceived change in visual amenity, resulting in a negligible visual impact for this area.

Table 16-38 Central Station – night-time visual impacts

		Construction impact		Operation impact	
Location	Sensitivity rating	Modification rating	Impact rating	Modification rating	Impact rating
Central station site	E4: High district brightness	No perceived change	Negligible	No perceived change	Negligible

Central Station – existing view from suburban platforms

Central Station – artist's impression of temporary pedestrian bridge from suburban platforms


Sydney Yard Access Bridge – existing view from the rail corridor


Sydney Yard Access Bridge – artist's impression from the rail corridor

Central Station – existing view from viewpoint 8, Regent Street

Central Station – artist's impression from viewpoint 8, Regent Street (showing Sydney Yard access bridge)

16.4.11 Waterloo Station

Two landscape character areas and five representative viewpoints were selected to inform the landscape character and visual amenity assessment for Waterloo Station. Landscape character areas are:

- Botany Road and Raglan Street commercial precinct
- Cope and Wellington streets.

Representative viewpoints are shown in Figure 16-11.

KEY

Chatswood to Sydenham

Proposed operational area at surface

Proposed construction site area

Existing suburban rail

Viewpoint location

Indicative only, subject to design development

0 100 m

N

Figure 16-11 Waterloo Station – representative viewpoints

Landscape character impacts

Landscape impacts anticipated during construction and operation are summarised in Table 16-39.

During construction, there would be negligible to minor adverse landscape impacts. These impacts would primarily be a consequence of the street-level impacts of construction on pedestrian movement and the reduced shade due to removal of buildings with awnings and street trees.

During operation, there would be a minor beneficial impact. This would be due to the combined effect of footpath improvements, increased connectivity through new pedestrian crossings and introduction of a public transport access point.

Table 16-39 Waterloo Station – landscape impacts

Location	Sensitivity rating	Construction impact		Operation impact	
		Modification rating	Impact rating	Modification rating	Impact rating
Botany Road and Raglan Street commercial precinct	Local	Noticeable reduction	Minor adverse	Noticeable improvement	Minor beneficial
Cope and Wellington streets	Neighbourhood	Noticeable reduction	Negligible	Noticeable improvement	Negligible

Daytime visual amenity impacts

The anticipated daytime visual impacts on representative viewpoints during construction and operation are summarised in Table 16-40.

There would be a negligible to minor adverse visual impact on most views in the vicinity of the project during construction. These impacts are primarily derived from the demolition of existing buildings. There would also be a moderate adverse impact in views from Botany Road where the setting of the heritage listed church is altered.

During operation there would be negligible visual impacts as the precinct would readily absorb the visual change due to the existing eclectic mix of character.

Table 16-40 Waterloo Station – daytime visual impacts

Location	Sensitivity rating	Construction impact		Operation impact	
		Modification rating	Impact rating	Modification rating	Impact rating
Viewpoint 1: View east from Wellington Street towards Botany Road	Local	Noticeable reduction	Minor adverse	No perceived change	Negligible
Viewpoint 2: View northeast from Botany Road	Local	Considerable reduction	Moderate adverse	No perceived change	Negligible
Viewpoint 3: View southeast from the intersection of Botany Road and Raglan Street	Local	Noticeable reduction	Minor adverse	No perceived change	Negligible
Viewpoint 4: View southwest from the corner of Cope and Raglan streets	Neighbourhood	Noticeable reduction	Negligible	No perceived change	Negligible
Viewpoint 5: View south from Cope Street	Neighbourhood	Noticeable reduction	Negligible	No perceived change	Negligible
Views to power supply route works	Neighbourhood	Noticeable reduction	Negligible	N/A	N/A

Night-time visual amenity impacts

The anticipated night-time visual impacts during construction and operation are summarised in Table 16-41.

During construction, there would be minor adverse visual impacts due to the requirement for out-of-hours vehicle deliveries and haulage.

During operation, there would be a largely negligible visual impact due to the existing lighting levels (assessed as being 'E3: Medium district brightness') and the existing commercial development at the site. However, there would be a potential for minor adverse impacts in the vicinity of the station where it is seen from adjacent residences. This would be due to the increased lighting required to increase public safety.

Table 16-41 Waterloo Station – night-time visual impacts

Location	Sensitivity rating	Construction impact		Operation impact	
		Modification rating	Impact rating	Modification rating	Impact rating
Waterloo Station site	E3: Medium district brightness	Noticeable reduction	Minor adverse	No perceived change	Negligible

Waterloo Station – existing view from viewpoint 4, corner of Cope and Raglan Streets

Waterloo Station – artist's impression from viewpoint 4, corner of Cope and Raglan Streets

16.4.12 Marrickville dive site (southern)

Two landscape character areas and 10 representative viewpoints were selected to inform the landscape character and visual amenity assessment for the Marrickville dive site.

The landscape character areas are:

- Marrickville flood storage
- Industrial areas of Sydenham and Marrickville – street art precinct.

Representative viewpoints are shown in Figure 16-12.

Figure 16-12 Marrickville dive site – representative viewpoints

Landscape character impacts

Landscape impacts anticipated during construction and operation are summarised in Table 16-42.

During construction, there would be a minor adverse landscape impact on the Marrickville Flood Storage and street art areas due to the loss of warehousing that is located directly adjacent to the site.

During operation there are expected to be negligible landscape impacts.

Table 16-42 Marrickville dive site (southern) – landscape impacts

		Construction impact		Operation impact	
Location	Sensitivity rating	Modification rating	Impact rating	Modification rating	Impact rating
Marrickville Flood Storage	Local	Noticeable reduction	Minor adverse	N/A	N/A
Industrial areas of Sydenham and Marrickville – Street Art precinct	Local	Noticeable reduction	Minor adverse	No perceived change	Negligible

Daytime visual amenity impacts

The anticipated visual impacts on representative viewpoints during construction and operation are summarised in Table 16-43.

During construction, there would be negligible visual impact on most assessed viewpoints. This would primarily be due to the consistency in character between the existing light industrial landscape and the proposed construction site activities. There would be a minor adverse visual impact on views from the rail corridor due to the scale and increased sensitivity of these views which are seen by a large number of viewers.

During operation, there would be negligible visual impact on assessed viewpoints. This would primarily be due to the consistency in character between the existing light industrial landscape and the site features, as well as the relatively low sensitivity of surrounding viewing locations. Although the project would potentially create a slight reduction in the amenity of these views, the overall impact would not be substantial.

Table 16-43 Marrickville dive site (southern) – daytime visual impacts

Location	Sensitivity rating	Construction impact		Operation impact	
		Modification rating	Impact rating	Modification rating	Impact rating
Viewpoint 1: View southwest from Edgeware Road	Neighbourhood	Noticeable reduction	Negligible	No perceived change	Negligible
Viewpoint 2: View southwest from Bedwin Road Bridge	Neighbourhood	No perceived change	Negligible	No perceived change	Negligible
Viewpoint 3: View west from Camdenville Park	Local	No perceived change	Negligible	No perceived change	Negligible
Viewpoint 4: View northwest from Unwins Bridge Road to Sydney Trains Network System Base	Neighbourhood	No perceived change	Negligible	No perceived change	Negligible
Viewpoint 5: View northeast along Bolton Street	Neighbourhood	No perceived change	Negligible	No perceived change	Negligible
Viewpoint 6: View northeast along Railway Terrace	Neighbourhood	Noticeable reduction	Negligible	No perceived change	Negligible
Viewpoint 7: View southeast from Sydney Steel Road to footpath connection with Shirlow Street	Neighbourhood	No perceived change	Negligible	No perceived change	Negligible
Viewpoint 8: View southwest from Sydney Steel Road	Neighbourhood	No perceived change	Negligible	No perceived change	Negligible
Viewpoint 9: View southeast from the corner of Murray Street and Edinburgh Road	Neighbourhood	Noticeable reduction	Negligible	Noticeable reduction	Negligible
Viewpoint 10: Views from the rail corridor	Local	Noticeable reduction	Minor adverse	No perceived change	Negligible
Views to power supply route works	Neighbourhood	Noticeable reduction	Negligible	N/A	N/A

Night-time visual amenity impacts

As indicated in Table 16-44, there would be negligible visual impacts during both construction and operation due to the relatively low sensitivity of surrounding viewing areas and absorption of the change into the surrounding area (which was assessed as having 'E3: Medium district brightness'). Although this activity would potentially create a slight reduction in the amenity of these views, the overall impact is not expected to be substantial.

Table 16-44 Marrickville dive site (southern) – night-time visual impacts

Location	Sensitivity rating	Construction impact		Operation impact	
		Modification rating	Impact rating	Modification rating	Impact rating
Marrickville dive site	E3: Medium district brightness	No perceived change	Negligible	No perceived change	Negligible

Marrickville Dive Site – existing view from viewpoint 2, Bedwin Road bridge

Marrickville Dive Site – artist's impression during construction from viewpoint 2, Bedwin Road bridge

16.5 Mitigation measures

The mitigation measures that would be implemented to address potential landscape character and visual amenity impacts are listed in Table 16-45 and Table 16-46.

Table 16-45 Mitigation measures – landscape character and visual amenity – construction

Ref	Mitigation measure	Applicable location(s)[1]
LV1	Where feasible and reasonable, the elements within construction sites would be located to minimise visual impacts, for example materials and machinery would be stored behind fencing.	All except metro rail tunnels
LV2	Existing trees to be retained would be protected prior to the commencement of construction in accordance with Australian Standard *AS4970 the Australian Standard for Protection of Trees on Development Sites and Adjoining Properties*.	All except metro rail tunnels
LV3	Lighting of construction sites would be oriented to minimise glare and light spill impact on adjacent receivers.	All except metro rail tunnels
LV4	Visual mitigation would be implemented as soon as feasible and reasonable after the commencement of construction, and remain for the duration of the construction period.	All except metro rail tunnels
LV5	Opportunities for the retention and protection of existing street trees would be identified during detailed construction planning.	All except metro rail tunnels
LV6	The design and maintenance of construction site hoardings would aim to minimise visual amenity and landscape character impacts, including the prompt removal of graffiti. Public art opportunities would be considered.	All except metro rail tunnels
LV7	The selection of materials and colours for acoustic sheds would aim to minimise their visual prominence.	CDS, CN, VC, BN, MP,PS, WS, MDS
LV8	Tunnel boring machine retrieval works at the Blues Point temporary site would be timed to avoid key harbour viewing events.	BP
LV9	Benching would be used where feasible and reasonable at Blues Point temporary site to minimise visual amenity impacts.	BP

1 *STW: Surface track work; CDS: Chatswood dive site; AS: Artarmon substation; CN: Crows Nest Station; VC: Victoria Cross Station; BP: Blues Point temporary site; GI: Ground improvement works; BN: Barangaroo Station; MP: Martin Place Station; PS: Pitt Street Station; CS: Central Station; WS: Waterloo Station; MDS: Marrickville dive site; Metro rail tunnels: Metro rail tunnels related – not related to other sites (eg TBM works).*

Table 16-46 Mitigation measures – landscape character and visual amenity – operation

Ref	Mitigation measure	Applicable location(s)[1]
LV10	Cut off and direct light fittings (or similar technologies) would be used to minimise glare and light spill onto private property.	CDS, AS, MDS
LV11	Where feasible and reasonable, vegetation would be provided to screen and visually integrate sites with the surrounding area.	CDS, AS, MDS
LV12	Identify and implement appropriate landscape treatments for Frank Channon Walk.	STW, CDS
LV13	The architectural treatment of Artarmon substation would minimise visual amenity and landscape character impacts.	AS
LV14	The Harbour cycles sculpture at North Sydney would be reinstated at a location determined in consultation with North Sydney Council.	VC
LV15	The P&O Fountain at 55 Hunter Street would be reinstated at a location determined in consultation with City of Sydney Council.	MP
LV16	Opportunities would be investigated to provide a permanent wall for street art at Marrickville dive site in consultation with Marrickville Council.	MDS
LV17	Noise barriers would be transparent where they are augmenting existing transparent noise barriers.	STW

1 *STW: Surface track works; CDS: Chatswood dive site; AS: Artarmon substation; CN: Crows Nest Station; VC: Victoria Cross Station; BP: Blues Point temporary site; GI: Ground improvement works; BN: Barangaroo Station; MP: Martin Place Station; PS: Pitt Street Station; CS: Central Station; WS: Waterloo Station; MDS: Marrickville dive site; Metro rail tunnels: Metro rail tunnels related – not related to other sites (eg TBM works).*

GROUNDWATER AND GEOLOGY

CHAPTER SEVENTEEN

17 Groundwater and geology

This chapter provides an assessment of the potential impact on groundwater as a result of the project, and identifies mitigation measures to address these impacts. This chapter draws on information in Technical paper 7 – Groundwater.

17.1 Secretary's environmental assessment requirements

The Secretary's environmental assessment requirements relating to groundwater, and where these requirements are addressed in this Environmental Impact Statement, are outlined in Table 17-1.

Table 17-1 Secretary's environmental assessment requirements – groundwater and geology

Ref.	Secretary's environmental assessment requirements	Where addressed
17. Water- Hydrology		
17.1	The Proponent must describe (and map) the existing hydrological regime for any surface and groundwater resource (including reliance by users and for ecological purposes) likely to be impacted by the project, including stream orders, as per the Framework for Biodiversity Assessment.	The existing hydrological regime is described in Section 17.3.
17.2	The Proponent must assess (and model if appropriate) the impact of the construction and operation of the project and any ancillary facilities (both built elements and discharges) on surface and groundwater hydrology in accordance with the current guidelines, including:	Impacts associated with hydrology are addressed in Section 17.4.
17.2(a)	natural processes within rivers, wetlands, estuaries, marine waters and floodplains that affect the health of the fluvial, riparian, estuarine or marine system and landscape health (such as modified discharge volumes, durations and velocities), aquatic connectivity and access to habitat for spawning and refuge;	Water quality impacts are addressed in Chapter 18 (Soils, contamination and water quality). Aquatic ecology is addressed in Chapter 20 (Biodiversity).
17.2(b)	impacts from any permanent and temporary interruption of groundwater flow, including the extent of drawdown, barriers to flows, implications for groundwater dependent surface flows, ecosystems and species, groundwater users and the potential for settlement;	Groundwater impacts are addressed in Section 17.4. Groundwater dependent ecosystems area addressed in Chapter 20 (Biodiversity).
17.2(c)	changes to environmental water availability and flows, both regulated/licensed and unregulated/rules-based sources;	Water quality impacts are addressed in Chapter 18 (Soils, contamination and water quality).
17.2(d)	direct or indirect increases in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses;	Impacts associated with soils are addressed in Chapter 18 (Soils, contamination and water quality).
17.2(e)	minimising the effects of proposed stormwater and wastewater management during construction and operation on natural hydrological attributes (such as volumes, flow rates, management methods and re-use options) and on the conveyance capacity of existing stormwater systems where discharges are proposed through such systems; and	Hydrology is addressed in Chapter 21 (Flooding and hydrology).
17.2(f)	water take (direct or passive) from all surface and groundwater sources with estimates of annual volumes during construction and operation.	Groundwater impacts are addressed in Section 17.4. Resource use is addressed in Chapter 25 (Sustainability).

Ref.	Secretary's environmental assessment requirements	Where addressed
17.3	The Proponent must identify any requirements for baseline monitoring of hydrological attributes.	Hydrology is addressed in Chapter 21 (Flooding and hydrology).
10. Socio-economic, Land Use and Property		
10.3	Assess the likely risks of the project to public safety, paying particular attention to subsidence risks, bushfire risks and the handling and use of dangerous goods.	Subsidence and settlement risk is addressed in Section 17.4.

17.2 Assessment methodology

The assessment of potential groundwater impacts involved a consideration of the existing hydrogeological environment and the effects of the project on that environment. The assessment specifically included:

- Development of a conceptual model of the hydrogeological environment with reference to geological characteristics (including rock types, permeability and storage) and available data for groundwater levels, quality and yield; existing groundwater users and extraction rates were also considered
- Establishment of expected (or target) changes to groundwater level, flow and quality with reference to the project design, estimated groundwater inflow rates and groundwater treatment strategies during both construction and operation.

The assessment then considered the potential impacts due to the expected changes to groundwater level, flow and quality on surrounding land uses, other groundwater users, and surface water / groundwater interaction. The assessment made reference to:

- Minimal harm criteria presented in the *NSW Aquifer Interference Policy* (NSW Office of Water, 2012)
- Rules of the *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011.*

The effects of ground movement on nearby structures, either due to excavation or ground consolidation following groundwater drawdown, were also considered. This involved a screening level of assessment using accepted criteria to identify those locations where more detailed future assessment is needed.

17.3 Existing environment

17.3.1 Geological context

The project area traverses seven regional geological units identified by the *Sydney 1:100,000 Geological Sheet 9130* (Herbert, 1983). Table 17-2 presents the regional geology while Figure 17-1. shows the location of surface geological units along the project alignment. The conceptual hydrogeological model discussed later in this section includes a geological long section showing a graphical representation of the geology at different depths along the project alignment. The geological long section is provided in Appendix F.

Table 17-2 **Regional geology along the project alignment**

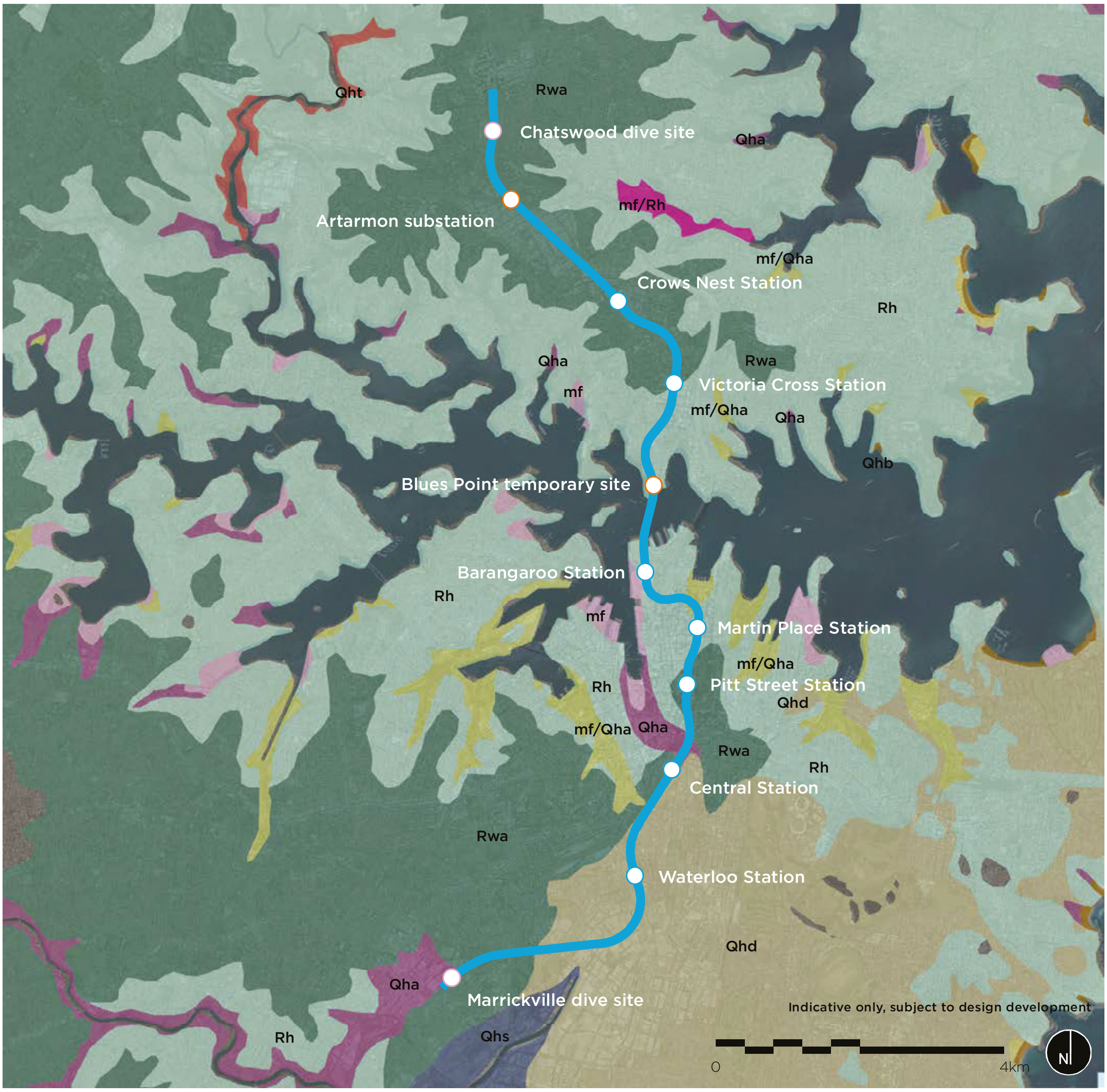
Geological unit	Description
Fill	Reclaimed areas generally adjacent to Sydney Harbour and some parklands
Holocene alluvium	Normally consolidated sediments
Pleistocene alluvium	Over-consolidated sediments (often sandy clays)
Residual soil	Derived from completely weathered siltstone and sandstone
Ashfield Shale	Black to dark-grey shale and laminite
Mittagong Formation	Interbedded shale, laminite and medium-grained quartz sandstone
Hawkesbury Sandstone	Medium to coarse-grained quartz sandstone

The proposed metro tunnels would primarily transition through Hawkesbury Sandstone with some sections of Ashfield Shale and Mittagong Formation. For a small part of the Sydney Harbour crossing, the tunnels would pass through fluvial / marine clayey-silty and clayey-sandy sediments.

The geological context for each construction site is described below (refer also to the geological long section in Appendix F):

- Chatswood dive site – residual soils and fill with underlying Ashfield Shale; Mittagong Formation and Hawkesbury Sandstone are below the level of the dive structure
- Artarmon substation – Ashfield Shale, Mittagong Formation and Hawkesbury Sandstone
- Crows Nest Station – fill, residual soils, Ashfield Shale, Mittagong Formation and then Hawkesbury Sandstone
- Victoria Cross Station – Hawkesbury Sandstone
- Blues Point temporary site – excavation through Hawkesbury Sandstone, with backfilling of the shaft following the completion of retrieval activities
- Barangaroo Station – extensive near surface fill and Hawkesbury Sandstone
- Martin Place Station – fill, residual soil and Hawkesbury Sandstone
- Pitt Street Station – fill, residual soil, Mittagong Formation and Hawkesbury Sandstone
- Central Station – fill, residual soil, Ashfield Shale, Mittagong Formation and Hawkesbury Sandstone
- Waterloo Station – fill, alluvium, residual soils, Ashfield Shale and Hawkesbury Sandstone
- Marrickville dive site (southern) – variable depths of fill, alluvium, residual soils and then Ashfield Shale.

In contrast to alluvium, the permeability of shale, siltstone and sandstone is generally low to very low, with the majority of groundwater flow transmitted through joints and fractures rather than via the porous nature of the material.



KEY

- Proposed station location
- Proposed dive locations
- Proposed ancillary infrastructure
- Chatswood to Sydenham

Geology (source: Herbert, 1983)

- Qha: Quaternary alluvium
- Qhb: Quaternary quartz sand
- Qhd: Quaternarymedium to fine grained marine sand with podsols
- Qhf: Quaternary medium to fine marine sand
- Qhs: Quaternary peat, sandy peat and mud
- Qht: Quaternary sandy mud/muddy sand
- Rh: Hawkesbury Sandstone
- Rwa: Ashfield Shale
- mf: Man-made fill
- mf/Qha: Man-made fill/Quaternary alluvium
- mf/Rh: Man-made fill/Hawkesbury Sandstone

Figure 17-1 Regional geology

17.3.2 Groundwater

Groundwater levels

The groundwater level along most of the project alignment is between 10 to 30 metres below ground level. Local shallow groundwater within residual soils is anticipated at two to five metres below ground level. A detailed review of data on groundwater levels along the project alignment is included in Technical paper 7 – Groundwater.

Groundwater quality

Groundwater that flows into existing underground structures in Sydney is generally high in iron, may contain manganese, may contain contaminants, has a relatively high salinity (as total dissolved salts) and a slightly acidic pH. Typical characteristics from existing tunnel projects in Sydney include:

- Energy Australia cable tunnel – iron 110 milligrams per litre; total dissolved solids 10,000 milligrams per litre; pH 5.9
- Sydney Harbour Tunnel – iron 40 milligrams per litre
- Epping to Chatswood Railway – iron 90 milligrams per litre; total dissolved solids 1300 milligrams per litre average to 6000 milligrams per litre; pH 5.9
- Cross City Tunnel – iron 50 milligrams per litre.

Groundwater is expected to be brackish within Ashfield Shale with neutral pH. Groundwater within Mittagong Formation and Hawkesbury Sandstone is expected to be fresh to brackish with neutral pH and slightly elevated levels of iron and manganese. The concentration of dissolved metals and nutrients in the Ashfield Shale, Mittagong Formation and Hawkesbury Sandstone, including residual soils, is expected to be naturally very low. Organic compounds are not naturally associated with Ashfield Shale, Mittagong Formation or Hawkesbury Sandstone.

Salinity of groundwater in the Ashfield Shale ranges between 269 and 493 milligrams per litre as total dissolved solids and pH ranges between 4.9 and 5.1. Groundwater quality testing conducted as part of the design process has found the Ashfield Shale to be fresher than expected, presumably reflecting leaching of salts from the formation.

Salinity of the Mittagong Formation ranges between 265 to 350 milligrams per litre as total dissolved solids and pH ranges between 4.7 and 5.6. Groundwater quality testing for the Mittagong Formation has also found it to be fresher than is expected, with pH slightly more acidic.

Salinity in the Hawkesbury Sandstone ranges between 147 and 574 milligrams per litre as total dissolved solids, while pH is near-neutral and ranges between 5.2 and 6.8. Groundwater quality testing for Hawkesbury Sandstone has found it to be fresher than is expected.

Default water quality trigger criteria for freshwater and marine ecosystems are provided in *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC/ARMCANZ, 2000a). Measured groundwater quality, with the exception of pH, meets the ANZECC 95th percentile default trigger values for marine environments, with treatment (minor) required to meet ANZECC 95th percentile default trigger values for freshwater in relation to pH.

Groundwater users and extraction

There is limited groundwater use near the project alignment due to the presence of low permeability shale, siltstone and sandstone. A search of the NSW Water Register was carried out to identify existing users and extraction rates. The search identified four sites where there is an approval as Basic Rights to extract groundwater, and therefore do not need a Water Access Licence. The expected take, as a basic right, is minor and is presumed to be less than one megalitre per year.

There are also two sites that hold Water Access Licences; both are located in the adjacent Botany Sands Groundwater Source. The remaining groundwater extraction sites do not hold a Water Supply Work Approval and therefore are assumed to be inactive and not taking groundwater. Table 17-3 summarises the NSW Water Register search results.

Table 17-3 Groundwater users and extraction

Location	ID	Approval type	Work type	Estimated extraction	Approx distance to excavation
Chatswood Oval	GW107757	Water Supply Work, Inactive	Bore	N/A	275 m
	GW029731	Water Supply Work, Inactive	Bore	N/A	215 m
St Leonards TAFE	GW072478	Basic Rights (Domestic), Inactive	–	N/A	265 m
Private Well near St Leonards Station	GW108224	Basic Rights (Domestic)	Bore	<1 ML/y	330 m
Shore School	GW107764	Basic Rights (Domestic)	Collector system	<1 ML/y	60 m
Redfern Park	GW071907	Water Supply Work	Bore	12 ML/y	440 m
Private Spear near Waterloo Station	GW106192	Basic Rights (Domestic)	Spearpoint	<1 ML/y	140 m
Industrial Water Supply, Bourke Road	GW017342 GW017684	Water Supply Work, Inactive	Bore	N/A	N/A
Erskineville Oval	GW110351	Water Supply Work	Bore	10 ML/y	445 m
Private Spear in Alexandria	GW111164	Basic Rights (Domestic)	Spearpoint	<1 ML/y	70 m

Groundwater inflows to existing tunnels

Measured inflows in existing drained tunnels in Sydney are summarised in Table 17-4 and indicate that that long term inflow into 'drained' tunnels is one litre per second per kilometre (consistent with applicable approval conditions) and typical design standards.

Table 17-4 Measured inflows in existing Sydney tunnels

Project tunnel	Length (km)	Diameter (m)	Maximum rock cover (m)	Dominant rock type	Measured inflow (L/s/km)
Northside storage	20	6	90	Hawkesbury Sandstone	0.9
Epping to Chatswood Rail Line	13	7.2 (twin)	60	Hawkesbury Sandstone	0.9
M5 East	3.9	8 (twin)	4 to 60	Hawkesbury Sandstone	0.8
Eastern Distributor	1.7	12 (double deck)	40	Hawkesbury Sandstone	1.0
MetroGrid	3.5	2	10 to 40	Narrabeen Group	0.8
Cross City Tunnel	2.1	8 (twin)	53	Hawkesbury Sandstone	<3
Lane Cove Tunnel	3.6	9 (twin)	60	Hawkesbury Sandstone	<3

Conceptual hydrogeological model

A conceptual hydrological model is a mostly qualitative and often pictorial description of a project in the context of the groundwater system, including groundwater levels, quality, inputs / outputs and a description of the soils and rocks and their properties. A conceptual model allows the effect of newly introduced changes to the hydrogeological system to be understood and assessed. It also allows consideration of whether a more detailed numerical modelling is necessary. The key elements of the conceptual hydrological model for the project are described in the preceding sections and are shown graphically in Technical paper 7 – Groundwater.

17.4 Potential impacts

17.4.1 Changes to groundwater levels

The metro tunnels would be tanked (designed to inhibit the inflow of groundwater, typically using concrete lining and waterproofing membrane), so limited to negligible change is expected to groundwater levels as a result of their construction.

Cross passages, mined station caverns, and the Artarmon substation would be tanked. There is no change expected to groundwater levels associated with these elements.

Cut-and-cover stations, with the exception of Barangaroo and Waterloo, would be drained structures and would have an ongoing inflow of groundwater.

There is also the potential for off-site impact at station excavations during construction. The target changes are presented in Table 17-5. The target changes to groundwater levels generally aim to keep the project related changes to within natural variation of groundwater level encountered in the past. They were determined as follows:

- The two metre drawdown criteria from the *NSW Aquifer Interference Policy* (NSW Office of Water, 2012) (which applies, cumulatively, at nearby water supply works) was adopted as a general guide for changes at surrounding land uses
- Recognising that the contribution of drawdown to subsidence in hard rock is minor to negligible, a four metre drawdown was allocated to project activity at depth
- Where masonry structures (rather than slab on ground structures) are located near to the station shafts, a 0.5 metre drawdown target was adopted for residual soils and a one metre target was adopted for Ashfield Shale and Mittagong Formation. For nearby commercial premises or high rise residential premises (which will have foundations to competent rock) the adopted target changes are less conservative (four metres).

Table 17-5 Target change to groundwater level at surrounding land uses

Location	Design	Target Change (metres)
Chatswood dive site (northern)	Piled retained wall, drained	<0.5 (residual soil), <2.0 (Ashfield Shale)
	Tunnels with segmental lining	<4.0 (assuming deep foundations), otherwise <2.0
Artarmon substation	Shaft (assumed drained)	<0.5 (residential in the vicinity)
Crows Nest Station	Drained station shaft	<1.0 (residual soil), <2.0 (Ashfield Shale and Mittagong Formation)
	Drained station	<2.0 (Mittagong Formation)
	Tunnels with segmental lining	<2.0 (Hawkesbury Sandstone)
Victoria Cross Station	Drained station shaft	<1.0 (residual soil), <4.0 (assuming deep foundations), otherwise <2.0
	Tanked station cavern	<1.0 (residual soil), <4.0 (assuming deep foundations), otherwise <2.0
	Tunnels with segmental lining	<1.0 (residual soil), <4.0 (assuming deep foundations), otherwise <2.0
Blues Point temporary site	Drained shaft during construction, backfilled following construction.	<0.5 (residual soil), <2.0 (Hawkesbury Sandstone)
Harbour crossing	Tunnels with segmental lining.	N/A (no change presented since, by design, groundwater inflow must be negligible)
Barangaroo Station	Tanked station shaft	<1.0 (residual soil), <2.0 (Hawkesbury Sandstone)
	Tanked station cavern	<2.0 (residential in the vicinity)
	Tunnels with segmental lining	<2.0 (residential in the vicinity)
Martin Place Station	Drained station shaft	<1.0 (residual soil), <4.0 (assuming deep foundations), otherwise <2.0
	Tanked station cavern	<4.0 (assuming deep foundations), otherwise <2.0
	Tunnels with segmental lining	<4.0 (assuming deep foundations), otherwise <2.0
Pitt Street Station	Drained station shaft	<1.0 (residual soil), <2.0 (Mittagong Formation), <4.0 (assuming deep foundations), otherwise <2.0 (Hawkesbury Sandstone)
	Tanked station cavern	<4.0 (assuming deep foundations), otherwise <2.0
	Tunnels with segmental lining	<4.0 (assuming deep foundations), otherwise <2.0
Central Station	Drained station shaft	<1.0 (residual soil), <2.0 (residential in the vicinity) (Mittagong Formation, Hawkesbury Sandstone)
	Drained station cavern	<2.0 (residential in the vicinity)
	Tunnels with segmental lining	<2.0 (residential in the vicinity)
Waterloo Station	Tanked station cavern	<0.5 (fill / Aeolian sand), <2.0 (Ashfield Shale), <2.0 (residential in the vicinity) (Hawkesbury Sandstone)
Marrickville dive site (southern)	Piled retained wall, drained	<0.5 (residual soil), <2.0 (due to stormwater channel)

Project related excavation would be located at a sufficient distance from groundwater users and, therefore, no change in groundwater level is expected at these extraction sites.

17.4.2 Ground movement

Ground movement (or settlement) refers to a localised lowering of the ground level due to construction activities. It can affect nearby buildings and other structures. Movement typically results from either the release or redistribution of stress in rock formations during tunnelling and excavation, or from ground consolidation following the drawdown of groundwater (during construction and / or operation). Movement caused by stress redistribution in rock generally occurs shortly after excavation, while consolidation settlement from groundwater drawdown can occur over a longer period of time.

For the project, a majority of the underground excavation would be within rock that has low permeability, and it is therefore expected that settlement associated with groundwater drawdown would be minimal. Some settlement could occur as a result of groundwater drawdown associated with open excavations and this would be greatest in soft superficial surface deposits, if the perched water table is lowered. The tunnels and many other project elements are designed as tanked structures (refer to Table 17-5) and, therefore, long-term settlement effects associated with groundwater drawdown are not anticipated at most locations.

The specific risk to buildings and structures due to ground movement depends on geotechnical conditions, distance from construction activities and building characteristics including condition and type of masonry. However, for the purposes of a screening assessment the risk-based criteria in Table 17-6 have been used (Construction Industry Research and Information Association, 1996). These criteria specify the maximum settlement of the building and the maximum slope of the ground below building foundations for each risk level. Buildings and structures assessed as having a risk level of two or greater would be subject to more detailed building strain and potentially a structural assessment later in the design process.

Table 17-6 Ground movement risk levels

Risk Level	Description	Maximum slope of building	Maximum settlement of building (mm)
1	Negligible – superficial damage unlikely	<1:500	<10
2	Slight – possible superficial damage which is unlikely to have structural significance	1:500 to 1:200	10 to 50
3	Moderate – expected superficial damage and possible structural damage to buildings, and possible damage to relatively rigid pipelines	1:200 to 1:50	50 to 75
4	High – expected structural damage to buildings, expected damage to rigid pipelines, and possible damage to other pipelines	>1:50	>75

The assessment of potential ground movement included consideration of the following construction activities:

- Tunnelling
- Mining (station caverns and adits, ventilation caverns and cross passages)
- Open-cut and trough excavation from the surface using conventional excavation techniques (station excavations, ventilation shafts and dive sites).

For the whole of the project alignment, three millimetre, five millimetre and ten millimetre ground movement contours were developed. The three millimetre contour defines what is considered to be the extent of the project's influence, while the ten millimetre contour defines the point at which more detailed future assessment is required as per Table 17-6. Most of the project alignment falls within the three millimetre contour and is therefore considered to have a negligible ground movement risk, with superficial damage to buildings unlikely. Small areas at station sites and dive sites are within the ten millimetre contour and may require future building strain and structural assessment to address settlement related risks.

17.4.3 Groundwater inflows

Groundwater inflows were estimated as part of the design process. The inflow rates in Table 17-7 provide indicative maximum construction related dewatering estimates (after initial works) as well as maximum operational inflows that may be expected (with drained project elements). Actual inflows would be lower with many project elements proposed to be tanked.

The annual inflow from the Sydney Basin Central Groundwater Source has been conservatively estimated (assuming drained conditions for all project elements) at 372 megalitres per year.

Table 17-7 Estimated groundwater inflows along the project alignment

Location	Predicted maximum inflow (litres/s)
Crows Nest Station	0.12
Victoria Cross Station	0.78
Barangaroo Station	2.86
Martin Place Station	1.97
Pitt Street Station	2.86
Central Station	0.03 (excluding existing seepage)
Waterloo Station	2.86
Tunnels and cross passages	0.319
Total (litres/s)	11.8 [1]

1 *To determine the capacity of the water treatment plant a maximum permissible inflow of 12.5 litres per second has been assumed consistent with Metro Northwest, with a further 2.5 litres per second allowance for additional volumes of water (for example water used fire suppression).*

17.4.4 Groundwater quality management

During construction, collected groundwater (and other tunnel water) would be treated at temporary water treatment plants at tunnel boring machine support sites (Chatswood, Barangaroo and Marrickville dive sites) and it is likely that temporary water treatment plant would be deployed at each station excavation and service facility prior to disposal of the treated groundwater to stormwater. Tunnelling using tunnel boring machines and roadheaders is unlikely to cause flows into the water table and therefore contamination of groundwater is not expected.

The quality of this discharged water during construction and operation is considered in Chapter 18 (Soils, contamination and water quality). During construction, groundwater inflows would be treated to meet the requirements of an environmental protection licence issued to the project, which are anticipated to be:

- pH – 6.5 to 8.5
- Total suspended liquids – less than 50 milligrams per litre
- Oil and grease – none visible.

During operation, groundwater collected from drained station excavations and caverns would be transferred to a centralised water treatment plant prior to disposal to stormwater. For operation, the project would be designed to achieve a maximum water discharge quality equivalent to the 90 percent protection level specified for freshwater ecosystems in accordance with ANZECC guidelines (ANZECC / ARMCANZ, 2000a). The discharge water quality level would be determined in consultation with the NSW Environment Protection Authority during detailed design, taking into consideration the current water quality of the receiving watercourse.

17.4.5 Interaction between surface water and groundwater

From the Chatswood dive site to Sydney Harbour, the alignment of the project would generally coincide with the topographic ridgeline. Aside from local shallow water tables within residual soils, the groundwater level within the Mittagong Formation and Hawkesbury Sandstone is expected to be encountered at depth. Therefore, interaction between surface water and groundwater is not expected.

For the Sydney Harbour crossing, segmental lining of the metro tunnels would prevent interaction between surface water and groundwater.

Between the harbour crossing and Central Station, the alignment would be essentially north–south and parallel to the topographic ridgeline after slewing eastward from Barangaroo Station to Martin Place. Interaction between surface water and groundwater is not expected at Barangaroo, Martin Place, Pitt Street and Central Station. All stormwater would be diverted around station excavations to prevent ingress to tunnels. Due to the proximity of Barangaroo to Sydney Harbour and the presence of remediated land, Barangaroo Station would be a tanked structure to prevent groundwater inflows. Similarly, Waterloo Station would be a tanked structure and would prevent groundwater inflows.

The Marrickville dive site is located adjacent to an existing lined stormwater channel and, accordingly, there is no anticipated interaction between surface water and groundwater at this location as surface water infiltration would be minimal.

17.4.6 Consistency with minimum harm criteria

The *Water Management Act 2000* includes the concept of ensuring 'no more than minimal harm' for both the granting of water access licences and the granting of approvals. While the project does not require a licence / approval under the *Water Management Act*, the minimal harm criteria in the *NSW Aquifer Interference Policy* (NSW Office of Water, 2012) have been used for the purposes of assessment (refer to Table 17-8).

Table 17-8 Minimal harm assessment

Minimal harm consideration	Assessment
Water table	
Less than or equal to a 10 per cent cumulative variation in the water table, allowing for typical climatic 'post-water sharing plan' variations, 40 metres from any: High priority groundwater dependent ecosystem or High priority culturally significant site listed in the schedule of the relevant water sharing plan. OR A maximum of a two metre water table decline cumulatively at any water supply work.	There are no high priority groundwater dependent ecosystems or high priority culturally significant sites in the vicinity of the project. The expected project related drawdown, cumulative, at any water supply work, is less than a two metres.
Water pressure	
A cumulative pressure head decline of not more than a two metre decline, at any water supply work.	The expected decline in groundwater elevation due to the project would be less than a two metres at any water supply work.
Water quality	
Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 metres from the activity	The project, due to groundwater inflows being captured and discharged, whether locally during construction or transmitted to centralised water treatment plant during operation, would not change groundwater quality beyond 40 metres from the activity.

17.4.7 Consistency with Water Sharing Plan rules

The *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011* provides rules for granting access licences, managing access licences, water supply works approvals and access licence dealings. While the project does not require a licence and / or approval under the *Water Management Act 2000*, these rules have been used for the purposes of assessment (refer to Table 17-9).

Table 17-9 Compliance with Water Sharing Plan rules

Rule	Assessment
Part 9 – 39: Distance restrictions to minimise interference between water supply works-	
Distance restriction from an approved water supply work nominated by another access licence is 400 metres	There are no water supply works nominated by another access licence within 400 metres of a project excavation.
Distance restriction from an approved water supply work for basic landholder rights only is 100 metres	There is a spear point adjacent Waterloo Station, however, this is more than the 100-metre distance restriction. The spear point is installed into the Botany Sands Groundwater Source and it is expected that the station excavation at Waterloo would hydraulically isolate this water source from the station excavation.
Distance restriction from the property boundary is 50 metres	The station excavations would not comply with the 50-metre distance restriction with respect to property boundaries. However, this is considered acceptable given the highly developed state of the project alignment and that there are no water supply works nearby.
Distance restriction from an approved water supply work nominated by a local water utility or major utility access licence is 1000 metres	There are no local or major water utilities near the station excavations.
Distance restriction from a Department observation bore is 200 metres	The station excavations would be more than 200 metres from a Department (NSW Office of Water) observation bore (monitoring piezometer).
Relevant rules from Part 9 – 40 to 44 of the Water Sharing Plan	
Part 9 – 40: Rules for water supply works located near contamination sources	Barangaroo Station would be adjacent to a declared remediation site under the *Contaminated Land Management 1997*. Accordingly, all elements of the station excavation and cavern would be tanked to isolate the station from the surrounding groundwater environment.
Part 9 – 41: Rules for water supply works located near sensitive environmental areas	The station excavations would not be within: • 200 metres of a high priority groundwater dependent ecosystem • 40 metres of a lagoon or any third order or higher order stream • 40 metres of a first or second order stream • 100 metres of the top of an escarpment.
Part 9 – 42: Rules for water supply works located near groundwater dependent culturally significant sites	The station excavations would not be located within 200 metres of a groundwater dependent culturally sensitive site.
Part 9 – 44: Rules for water supply works located within distance restrictions	This rule does not apply because the project would comply with distance restrictions.

17.5 Mitigation measures

The mitigation measures that would be implemented to address potential groundwater and geology impacts are listed in Table 17-10.

Table 17-10 Mitigation measures – groundwater and geology

Reference	Mitigation measure	Applicable location(s)[1]
GWG1	A detailed geotechnical model for the project would be developed and progressively updated during design and construction. The detailed geotechnical model would include: • Assessment of the potential for damage to structures, services, basements and other sub-surface elements through settlement or strain • Predicted changes to groundwater levels, including at nearby water supply works. Where building damage risk is rated as moderate or higher (as per the CIRIA 1996 risk-based criteria), a structural assessment of the affected buildings / structures would be carried out and specific measures implemented to address the risk of damage. With each progressive update of the geotechnical model the potential for exceedance of the following target changes to groundwater levels would be reviewed: • Less than 2.0 metres – general target • Less than 4.0 metres – where deep building foundations present • Less than 1.0 metre – residual soils • Less than 0.5 metre – residual soils (Blues Point) (fill / Aeolian sand). Where a significant exceedance of target changes to groundwater levels are predicted at surrounding land uses and nearby water supply works, an appropriate groundwater monitoring program would be developed and implemented. The program would aim to confirm no adverse impacts on groundwater levels or to appropriately manage any impacts. Monitoring at any specific location would be subject to the status of the water supply work and agreement with the landowner.	All
GWG2	Condition surveys of buildings and structures in the vicinity of the tunnel and excavations would be carried out prior to the commencement of excavation at each site.	All

1 STW: Surface track work; CDS: Chatswood dive site; AS: Artarmon substation; CN: Crows Nest Station; VC: Victoria Cross Station; BP: Blues Point temporary site; GI: Ground improvement works; BN: Barangaroo Station; MP: Martin Place Station; PS: Pitt Street Station; CS: Central Station; WS: Waterloo Station; MDS: Marrickville dive site; Metro rail tunnels: Metro rail tunnels related – not related to other sites (eg TBM works); PSR: Power supply route.

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SOILS, CONTAMINATION AND WATER QUALITY

CHAPTER EIGHTEEN

18 Soils, contamination and water quality

This chapter provides an assessment of the potential impact on soils, contamination and water quality as a result of the project, and identifies mitigation measures to address these impacts. In relation to contamination this chapter draws on information in Technical paper 8 – Contamination.

18.1 Secretary's environmental assessment requirements

The Secretary's environmental assessment requirements relating to soils, contamination and water quality and where these requirements are addressed in this Environmental Impact Statement, are outlined in Table 18-1.

Table 18-1 Secretary's environmental assessment requirements – soils, contamination and water quality

Ref.	Secretary's environmental assessment requirements	Where addressed
11. Soils		
11.1	The Proponent must assess the impact of the project on acid sulfate soils (including impacts of acidic runoff offsite) in accordance with the current guidelines.	Acid sulfate soils are addressed in Section 18.4.2.
11.2	The Proponent must assess whether the land is likely to be contaminated and identify if remediation of the land is required, having regard to the ecological and human health risks posed by the contamination in the context of past, existing and future land uses. Where assessment and/or remediation is required, the Proponent must document how the assessment and/or remediation would be undertaken in accordance with current guidelines.	Contamination is addressed in Sections 18.2, 18.3.3 and 18.4.2.
11.3	The Proponent must assess whether salinity is likely to be an issue and if so, determine the presence, extent and severity of soil salinity within the project area.	Salinity is addressed in Sections 18.3.2.
11.4	The Proponent must assess the impacts of the project on soil salinity and how it may affect groundwater resources and hydrology.	Salinity is addressed in Sections 18.3.2.
11.5	The Proponent must assess the impacts on soil and land resources (including erosion risk or hazard). Particular attention must be given to soil erosion and sediment transport consistent with the practices and principles in the current guidelines.	Soils are addressed in Section 18.4.2.

Ref.	Secretary's environmental assessment requirements	Where addressed
18. Water – Quality		
18.1 (a)	The Proponent must: state the ambient NSW Water Quality Objectives (NSW WQO) and environmental values for the receiving waters relevant to the project, including the indicators and associated trigger values or criteria for the identified environmental values	Water quality objectives are addressed in Section 18.4.1.
18.1(b)	identify all pollutants that may be introduced into the water cycle and describe the nature and degree of impact that any discharge(s) may have on the receiving environment, including consideration of all pollutants that pose a risk of non-trivial harm to human health and the environment	Water quality is addressed in Section 18.4.2 and 18.4.3.
18.1 (c)	identify the rainfall event that the water quality protection measures will be designed to cope with	Water quality is addressed in Section 18.4.2.
18.1 (d)	assess the significance of any identified impacts including consideration of the relevant ambient water quality outcomes	Water quality objectives are addressed in Section 18.4.1, 18.4.2 and 18.4.3.
18.1 (e)	demonstrate how construction and operation of the project will, to the extent that the project can influence, ensure that: - Where the NSW WQOs for receiving waters are currently being met they will continue to be protected; and - Where the NSW WQOs are not currently being met, activities will work toward their achievement over time	Water quality objectives are addressed in Section 18.4.1.
18.1 (f)	justify, if required, why the WQOs cannot be maintained or achieved over time;	Water quality objectives are addressed in Section 18.4.1.
18.1 (g)	demonstrate that all practical measures to avoid or minimise water pollution and protect human health and the environment from harm are investigated and implemented	Water quality is addressed in Section 18.4.2 and 18.4.3.
18.1 (h)	identify sensitive receiving environments (which may include estuarine and marine waters downstream) and develop a strategy to avoid or minimise impacts on these environments	Water quality objectives are addressed in Section 18.3.1.
18.1 (i)	identify indicative monitoring locations, monitoring frequency and indicators of surface and groundwater quality.	Water quality is addressed in Section 18.4.2.
17. Water – Hydrology		
17.2	The Proponent must assess (and model if appropriate) the impact of the construction and operation of the project and any ancillary facilities (both built elements and discharges) on surface and groundwater hydrology in accordance with the current guidelines, including: **a.** natural processes within rivers, wetlands, estuaries, marine waters and floodplains that affect the health of the fluvial, riparian, estuarine or marine system and landscape health (such as modified discharge volumes, durations and velocities), aquatic connectivity and access to habitat for spawning and refuge; **b.** changes to environmental water availability and flows, both regulated/licensed and unregulated/rules-based sources; **c.** direct or indirect increases in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses;	Hydrology impacts are addressed in Chapter 21 (Flooding and hydrology).

18.2 Assessment methodology

The assessment methodology applied for soils, contamination and water quality involved:

- A review of contamination assessments previously carried out near the project area, where available
- A review of publicly available data and web-based information searches, including:
  - Contaminated Sites Register and Record of Notices (NSW Environment Protection Authority, 2015)
  - Australian Soil Resource Information System (Commonwealth Scientific and Industrial Research Organisation (CSIRO), 2015)
  - Sydney 1:100,000 Geological Series Sheet 9130 (NSW Department of Mineral Resources, 1983)
  - Sydney 1:100,000 Soils Landscape Series Sheet 9130 (Soil Conservation of NSW, 1966)
  - Office of Water Groundwater Database (NSW Department of Primary Industries, 2015)
  - Office of Environment and Heritage NSW Soil and Land Information System (Office of Environment and Heritage, 2015a)
- A review of historical aerial photography to identify potential contamination sources located near the project based on previous land use
- A site inspection to determine potential contamination sources and verify those potential areas of environmental concern identified in the review
- Identification of potential impacts of the project on surface water quality and groundwater quality
- Identification of the potential for the project to disturb acid sulfate soils and the associated impacts
- Consideration of the potential impacts of the project associated with erosion and sedimentation
- Recommendations for additional investigations and / or management of potentially contaminated sites which may be encountered during construction
- Development of mitigation measures to address potential soils, contamination and water quality impacts.

The following guidelines were considered (where relevant):

- *Acid Sulfate Soils Assessment Guidelines* (Department of Planning, 2008)
- *Managing Land Contamination: Planning Guidelines SEPP 55 – Remediation of Land* (Department of Urban Affairs and Planning and Environment Protection Authority, 1998)
- *Managing Urban Stormwater: Soils and Construction, Volume 1* (Landcom, 2004)
- *Managing Urban Stormwater: Soils and Construction, Volume 2* (Department of Environment and Climate Change, 2008a)
- *Guidelines for Consultants Reporting on Contaminated Sites* (Office of Environment and Heritage, 2011)
- *Guidelines on the Duty to Report Contamination under the Contaminated Land Management Act 1997* (Department of Environment and Climate Change, 2009b)
- *Code of Practice for the Safe Removal of Asbestos, 2nd edition* (National Occupational Health and Safety Commission, 2005)
- *Approved Methods for the Sampling and Analysis of Water Pollutants in NSW* (Department of Environment and Climate Change, 2008b)
- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC / ARMCANZ, 2000a)
- *Using the ANZECC Guidelines and Water Quality Objectives in NSW* (Department of Environment and Conservation, 2006b).

18.3 Existing environment

18.3.1 Sensitive receiving environments

A sensitive receiving environment has a high conservation or community value or supports ecosystems or human uses of water that are particularly sensitive to pollution or degradation of water quality.

The sensitive receiving environments that would be relevant to the project are Middle Harbour, Sydney Harbour (including Darling Harbour) and groundwater users.

18.3.2 Soils

The project is located within the Sydney Basin, a large depositional geological feature that spans from Batemans Bay to the south, Newcastle to the north and Lithgow to the west. The Sydney 1:100,000 Geological Series Sheet 9130 (NSW Department of Mineral Resources, 1983) indicates that the project area is underlain by:

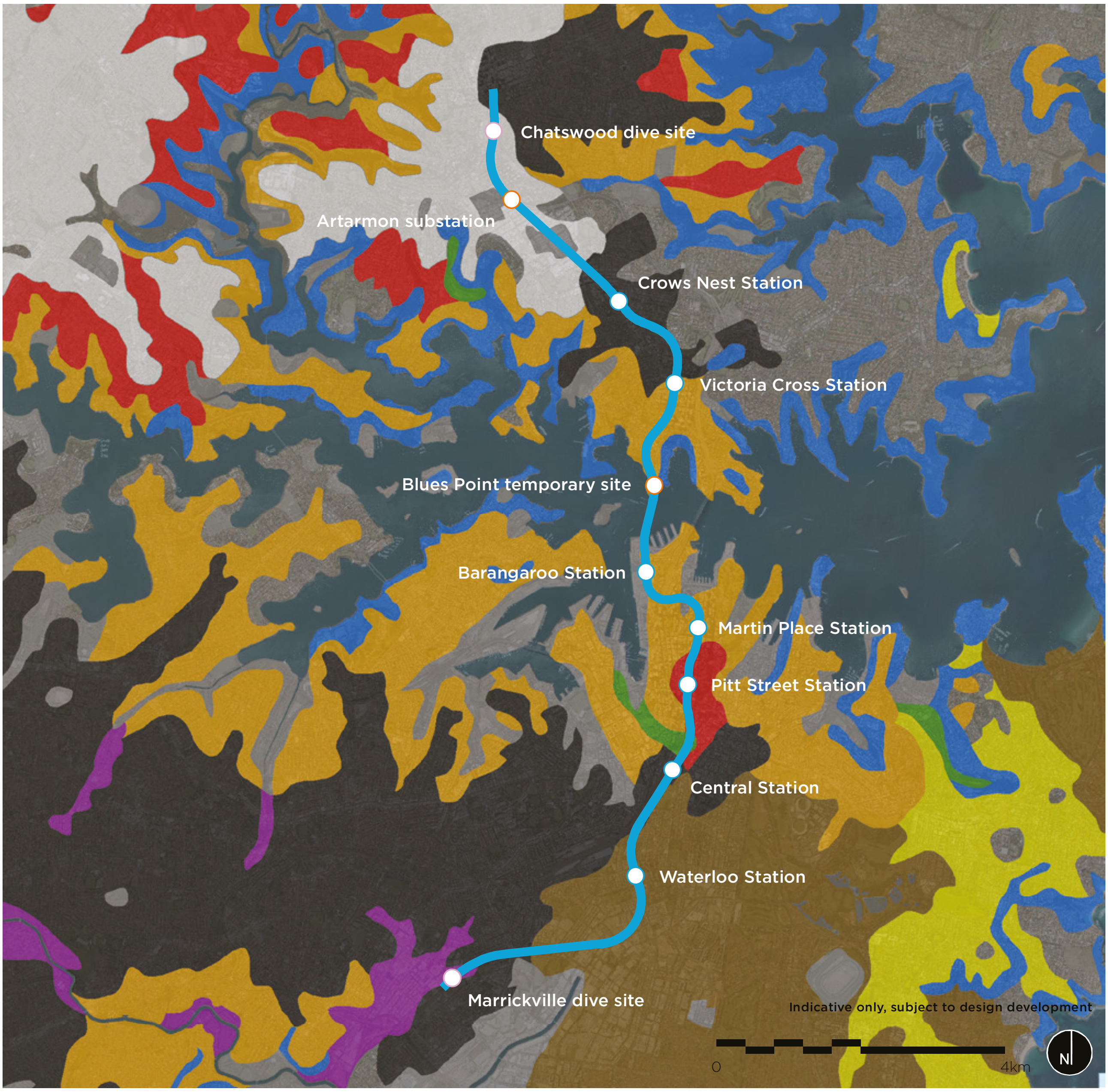
- Wianamatta Ashfield Shale – generally consisting of black to dark grey shale and laminate
- Hawkesbury Sandstone – generally consisting of medium to coarse-grained quartz sandstone, very minor shale and laminate lenses
- Mittagong Formation – comprising inter-bedded shale and fine-grained sandstone.

The Sydney 1:100,000 Soil Landscape Series Sheet 9130 (Soil Conservation of NSW, 1966) identified a number of soils underlying the project area. These include the Birrong, Blacktown, Deep Creek, Lucas Heights, Gymea, and Disturbed landscape groups to the south of the harbour crossing, and the Hawkesbury, Glenorie, Gymea, and Blacktown landscape groups to the north of the harbour crossing (see Table 18-2 and Figure 18-1).

Table 18-2 Soil units underlying the project area

Soil Unit	Location in relation to the project	Description
Birrong	Around Marrickville dive site (southern)	• Landscape – level to gently undulating alluvial floodplain draining Wianamatta Group shales. Local relief to 5 m, slopes < 3%. Extensively cleared tall open forest and woodland • Soils – deep (> 250 cm) yellow podzolic soils and yellow solodic soils on older alluvial terraces • Limitations – localised flooding, high soil erosion hazard, saline subsoils, seasonal waterlogging, and very low soil fertility.
Blacktown	Around Chatswood, Crows Nest and Central stations	• Landscape – found on gently undulating rises on Wianamatta Group shales with local reliefs of up to 30 m and slopes of < 5% • Soils – shallow to moderately deep hardsetting mottled texture contrast soils, red and brown podzolic soils on crests grading to yellow podzolic soils on lower slopes and in drainage lines • Limitations – moderately reactive, highly plastic subsoil, with low fertility and poor drainage.
Deep Creek	Around Pitt Street and Central stations	• Landscape – level to gently undulating alluvial floodplain draining the Hawkesbury Sandstone. Local reliefs of < 5 m and slopes of < 3% • Soils – deep (> 200 cm) podzols on well drained terraces, siliceous sands on current floodplain, and humus podzols in low lying areas • Limitations – flooding, extreme soil erosion hazard, sedimentation hazard, localised very low fertility and permanently high water tables.

Soil Unit	Location in relation to the project	Description
Lucas Heights	Around Martin Place and Central stations	• Landscape – gently undulating crests and ridges on plateau surfaces of the Mittagong formation. Local relief to 30 m, slopes of < 10%. Rock outcrop is absent. Extensively or completely cleared, low open forest and woodland • Soils – moderately deep (50 – 150 cm), hardsetting yellow podzolic soils on outer edges of crests • Limitations – stony soil, low soil fertility, low available water capacity.
Glenorie	Around Artarmon substation	• Landscape –undulating to rolling low hills on Wianamatta Group shales with local reliefs of 50 to 80 m and slopes of 20%. Extensively cleared tall open forest • Soils – shallow to moderately deep red podzolic soils on crests, moderately deep red/brown podzolic soils on upper slopes, deep yellow podzolic soils on lower slopes and humic gleys, yellow podzolic soils and gleyed podzolic soils along drainage lines • Limitations – high soil erosion hazard, localised impermeable highly plastic subsoil, and moderately reactive.
Gymea	Around Barangaroo, Martin Place and Victoria Cross stations, and Blues Point temporary site	• Landscape –undulating to rolling low hills on Hawkesbury Sandstone with local reliefs of 20 to 80 m and slopes of 10 to 25% and rock outcrops of < 25 % • Soils – shallow to moderately deep yellow earths and earthy sands on crests and on the inside of benches • Limitations – high soil erosion, rock outcrop, shallow highly permeable soil, and very low soil fertility.
Disturbed	Around Barangaroo Station, Artarmon substation and Chatswood	• Landscape – the topography varies from level plains to undulating terrain and has been disturbed by human activity to a depth of at least 100 cm • Soils – the original soil has been removed, greatly disturbed or buried. Most of these areas have been levelled to slopes of < 5%. Landfill includes soil, rock, building and waste material. The original vegetation has been completely cleared • Limitations – depend on the nature of fill material. Potential for subsidence resulting in a mass movement hazard, and soil impermeability leading to poor drainage and low fertility. Care must be taken when these sites are developed.
Hawkesbury	Around Blues Point temporary site	• Landscape – found on rugged, rolling to very steep hills on Hawkesbury Sandstone with local reliefs of 40 to 200 m, slopes of > 25 % and rock outcrops of > 50% • Soils – shallow (< 50 cm), discontinuous lithosols/siliceous sands associated with rock outcrops, earthy sands, yellow earths and some yellow podzolic soils on the inside of benches and along joints and fractures • Limitations – extreme soils erosion hazard, mass movement (rockfall) steep slopes, rock outcrop, shallow, stony, highly permeable soils with low fertility.



KEY

- Proposed station location
- Proposed dive locations
- Proposed ancillary infrastructure
- Chatswood to Sydenham

Soil landscapes (source: Chapman et. al., 2009)

- Birrong
- Blacktown
- Deep Creek
- Disturbed Terrain
- Glenorie
- Gymea
- Hawkesbury
- Lucas Heights
- Newport
- Tuggerah

Figure 18-1 Soils units underlying the project area

Soil salinity

Areas prone to salinity are usually at low positions in the landscape, such as floodplains, in valley floors, or at the foot of a ridge. The Office of Environment and Heritage NSW Soil and Land Information System contains data points identifying evidence of soil salinity at areas which have previously been sampled. There was no evidence within this database to suggest soil salinity at any point along the project alignment. According to the Office of Environment and Heritage, urban salinity is of concern in Western Sydney however is not considered to be an issue for areas along the project alignment. As soil salinity is unlikely to be present along the project alignment, salinity related impacts on groundwater resources and hydrology are not expected.

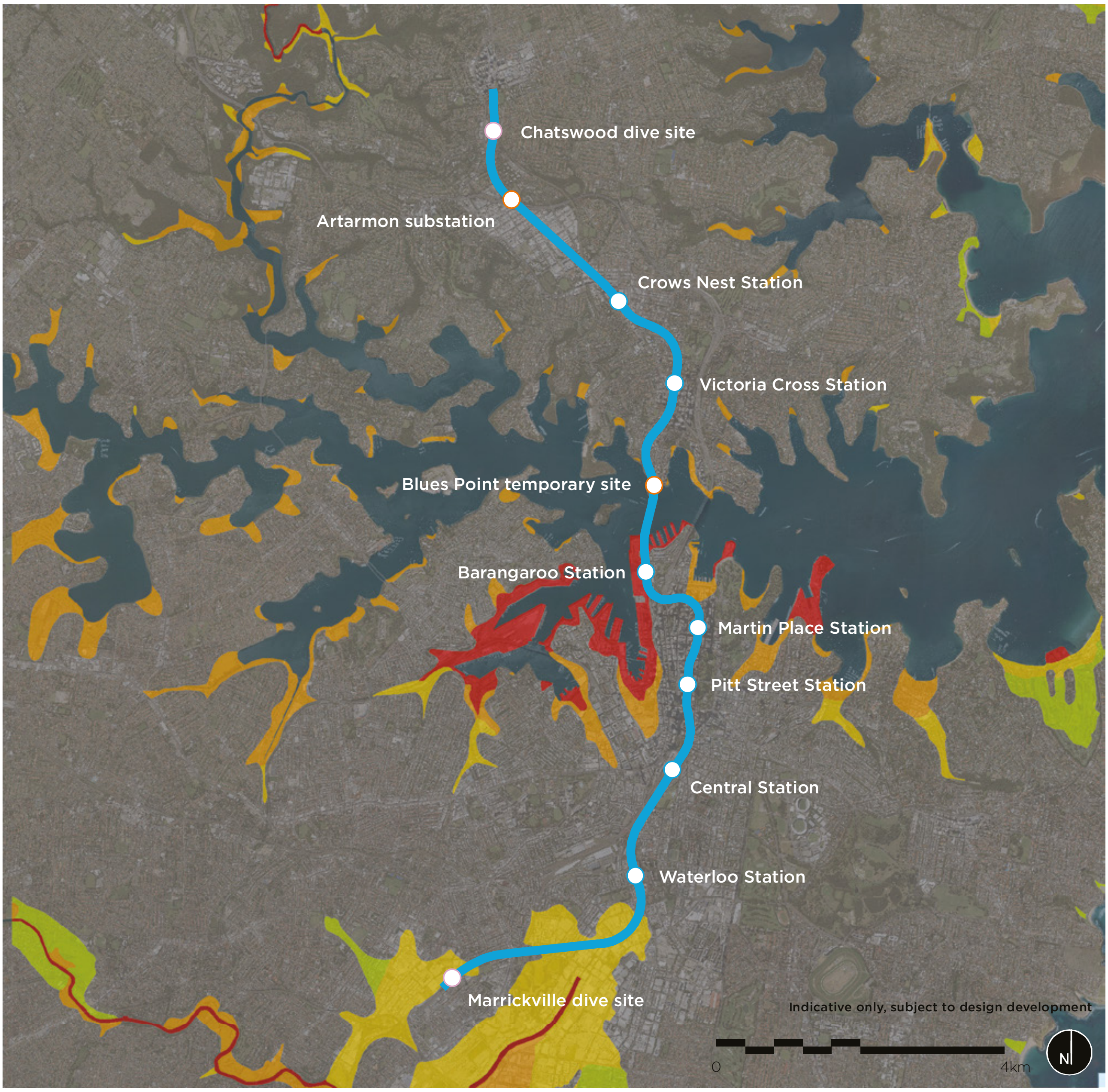
Acid sulfate soils

Acid sulfate soils are the common name given to naturally occurring sediments and soils containing iron sulfides (principally iron sulfide or iron disulfide or their precursors). Exposure of the sulfide in these soils to oxygen as a result of drainage or excavation leads to the generation of sulfuric acid. Areas of acid sulfate soils can typically be found in low-lying and flat locations that are often swampy or prone to flooding.

The Australian Soil Resource Information System (CSIRO, 2015) was searched to identify the probability for acid sulfate soils to be present within the project area. The results of the search are shown in Table 18-3 and Figure 18-2.

Table 18-3 Probability for acid sulfate soils to be present within the project area

Locations	Probability for acid sulfate soil
Chatswood to St Leonards	Low
St Leonards to North Sydney	Extremely low
Sydney Harbour to Barangaroo – only Cockle Bay, opposite Erskineville Street at Barangaroo, Lavender Bay and Darling Harbour. Acid sulfate soils are not known to be present within areas within Sydney Harbour where ground improvement works may occur for the harbour crossing.	High – in specific areas identified Low – in other areas in this location including Sydney Harbour
Barangaroo to Pitt Street	Extremely low
Pitt Street to Central Station	Low
Waterloo Station to Marrickville dive site (southern)	High



KEY

- Proposed station location
- Proposed dive locations
- Proposed ancillary infrastructure
- Chatswood to Sydenham

Acid Sulphate Soil Classification - Risk

- Class 1 - Highest Risk
- Class 2
- Class 3
- Class 4
- Class 5 - Lowest Risk (no fill)

Figure 18-2 Acid sulfate soil classification risk along project alignment

18.3.3 Contamination

The following section has been informed by the Technical paper 8 – Contamination.

Historical aerial photographs

Historical aerial photographs from the NSW Land and Property Management Authority (Land and Property Information Division) were reviewed for the years 1930, 1955, 1965, 1976, 1986, 1994, and 2004. The photographs show that:

- Since the 1930's, the Marrickville dive site, Waterloo Station, Victoria Cross Station, Crows Nest Station and Artarmon substation sites have increasingly changed from residential land use to commercial / industrial uses
- The Barangaroo Station site has seen major industrial developments since the 1950s and 1960s
- The industrial land use on and surrounding the Blues Point temporary site has changed to residential and open space
- Land use surrounding the Marrickville dive site, Barangaroo Station and Artarmon substation sites has seen major extractive or reclamation works within the past 50 years
- The Central Station, Pitt Street Station and Martin Place Station sites have remained within a commercial context since the 1930s.

NSW contaminated sites register

A search of the Contaminated Sites Register and Record of Notices under Section 58 of the *Contaminated Land Management Act 1997* (CLM Act) identified 11 registered sites within 500 metres of the project area that were either regulated or had been notified to the NSW Environment Protection Authority (EPA) (refer to Table 18-4).

Table 18-4 NSW EPA Contaminated Sites Register and Record of Notices

Suburb	Notified site address	Notified site activity	Contamination status	Location in relation to the project
Chatswood dive site (northern)				
Chatswood	607 Pacific Highway	Former Caltex Service Station	Contamination currently regulated under CLM Act	Within the Chatswood dive site footprint
Chatswood	572 Pacific Highway	Caltex Service Station	Under assessment	50m to the west of the Chatswood dive site footprint
Blues Point temporary site				
Lavender Bay	French Street	SRA Land	Regulation under CLM Act not required	About 400m north of the Blues Point temporary site
Barangaroo Station				
Millers Point	30-34 Hickson Road	Former AGL Gasworks	Regulation under CLM Act not required	Adjacent and to the south of Barangaroo Station footprint
Millers Point	36 Hickson Road	Former AGL Gasworks	Contamination currently regulated under CLM Act	Adjacent and to the south of Barangaroo Station footprint
Millers Point	38 Hickson Road	Former AGL Gasworks	Contamination currently managed via the planning process (EP&A Act)	Adjacent and to the south of Barangaroo Station footprint
Millers Point	Berths 5, 6 and 7 (already demolished) and part Hickson Road	Former AGL Gasworks	Contamination currently regulated under CLM Act	Adjacent and to the south of Barangaroo Station footprint
Millers Point	Road reserve fronting 30-38 Hickson Road	Former AGL Gasworks	Contamination currently regulated under CLM Act	Adjacent and to the south of Barangaroo Station footprint
Millers Point	4 Towns Place	Port Services (Moores) Facility	Contamination currently regulated under POEO Act	About 200m north of Barangaroo Station
Pitt Street Station				
Sydney	447 Kent Street	Interpro House (OSP 46581)	Regulation under CLM Act not required	About 320m west of Pitt Street Station
Waterloo Station				
Waterloo	2 John Street	Other industry	Regulation under CLM Act not required	About 200m south of Waterloo Station

Sydney Harbour contamination

A review of the technical report *Sydney Harbour: A systematic review of the science* (Sydney Institute of Marine Science, 2014) indicated that early investigations showed sediments in Sydney Harbour contained high concentrations of a suite of metals (most notably copper, zinc and lead). More recent studies have confirmed that sediments in large areas of Sydney Harbour are not only highly polluted by metals, but also by a wide range of non-metallic contaminants, eg organochlorine pesticides (OCs), polycyclic aromatic hydrocarbons (PAHs) and polychlorinated dibenzo-para-dioxins (dioxins) and dibenzofurans (furans). These organic contaminants have led to restrictions on the consumption of seafood from locations west of the Sydney Harbour Bridge (NSW Department of Primary Industries, 2015).

Sediment samples were collected from two locations as part of geotechnical investigations carried out for the project to a maximum depth of 0.7 metres below the surface of the sediment and analysed for a range of contaminant compounds including:

- Trace metals (Ag, Cd, Cr, Cu, Pb, Hg, Ni, Sb and Zn) and arsenic
- Polychlorinated biphenyls (PCBs)
- Organochlorine (OC) pesticide residues
- Polycyclic aromatic hydrocarbons (PAHs)
- Total petroleum hydrocarbons (TPH)
- Tri-butyltin (and mono- and di-butyltin)
- Sub-samples for polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDD/Fs).

Where available, all results were assessed against the Commonwealth of Australia (2009) *National Assessment Guidelines for Dredging* (NAGD). Concentrations of contaminants in sediment samples were below the NAGD guidelines (where available) with the exception of mercury in surface sediments at both sampling locations.

Further sediment sampling was carried out of the surface sediments (less than one metre below the bed) in the area of the two grout treatment zones. The results of this sediment sampling indicated elevated concentrations (above the applicable guidelines) of lead, mercury, tri-butyltin, polycyclic dibenzo dioxins and furans and polycyclic aromatic hydrocarbons. Contaminant concentrations in sediment at the barge locations are typical of large areas of sediment quality in Sydney Harbour.

18.3.4 Surface water

Catchments

There are two large water catchments within the project area – Sydney Harbour and Parramatta River catchment and Cooks River catchment. Within these two catchments there are five local watercourses that are located along the project alignment. These local watercourses drain into Middle Harbour, Sydney Harbour and Botany Bay. The catchments, watercourses and receiving waters for precincts along the project alignment are described in more detail below, and summarised in Table 18-5 and Table 18-6.

Sydney Harbour and Parramatta River catchment

This catchment includes the Sydney CBD and the significant commercial districts of North Sydney and Parramatta. Sydney's prime tourist attractions – the Opera House, Royal Botanic Garden, Taronga Zoo, Circular Quay, The Rocks, Darling Harbour and the Fish Markets – are all located on the harbour foreshores.

Current uses and environmental values for the Sydney Harbour and Parramatta River system include maintenance of healthy ecosystems, recreation (including swimming, boating, fishing and enjoyment of views) and commercial activities (such as commercial shipping and tourism). There is very limited extraction of fresh water, or reuse of stormwater.

Much of the catchment is urbanised, although significant areas of bushland remain, particularly within the Lane Cove, Garigal and Sydney Harbour national parks. Because of the extent of development, the waterways are affected by poor water quality and a changed flow regime. The waterways have been greatly modified, with creek systems extensively channelised or hard-edged with concrete. Wetlands have been destroyed or degraded and, where natural remnants of vegetation exist, they are often affected by weeds and rubbish.

Table 18-5 Drainage catchments – Sydney Harbour and Parramatta River

Catchment areas	Relevant project elements	Surface water catchment	Receiving waters
Sydney Harbour and Parramatta River	Chatswood dive site (northern)	Scotts Creek and Flat Rock Creek	Middle Harbour
	Artarmon substation	Flat Rock Creek	
	Crows Nest Station		
	Victoria Cross Station	Milson Park	Sydney Harbour
	Blues Point temporary site	N/A	
	Barangaroo Station	City Area (Sydney)	
	Martin Place Station	City Area (Sydney)	
	Pitt Street Station	City Area (Sydney)	
	Central Station	Darling Harbour (Sydney)	

Cooks River catchment

The Cooks River flows for about 23 kilometres from Yagoona to Botany Bay. The Cooks River catchment covers an area of about 100 square kilometres and has been identified as one of the most heavily urbanised and degraded river systems in Australia. Water quality varies across the catchment mainly due to stormwater, fertilisers, industrial discharges and sewage contamination.

The Cooks River Alliance is a partnership of eight councils – Ashfield, Bankstown, Canterbury, City of Sydney, Hurstville, Marrickville, Strathfield and Rockdale – established in 2012, who are working together with communities to carry out projects to improve the health of the Cooks River catchment.

Table 18-6 Drainage catchments – Cooks river

Catchment areas	Relevant project elements	Surface water catchment	Receiving waters
Cooks River	Waterloo Station	Alexandra Canal	Botany Bay (via the Cooks River)
	Marrickville dive site (southern)	Marrickville Valley	

Water quality

Watercourses near the project corridor are heavily urbanised, with surface water generally collected by developed stormwater networks. Surface water quality along the project alignment is largely influenced by 'point source' water pollution (for example, from stormwater drains) and diffuse water pollution (for example, from urban runoff that does not enter stormwater drains).

The NSW Office of Environment and Heritage measures the recreational water quality of Sydney's harbours and surrounding beaches through the Beachwatch program. Rainfall data is used to predict the likelihood of bacterial contamination at sample sites. Relevant samples have been taken at various locations in Middle Harbour, Sydney Harbour and Botany Bay. The closest monitoring sites to the project are Hayes Street Beach at North Sydney in Middle Harbour, Greenwich Baths in Sydney Harbour and Kyeemagh Baths at the mouth of the Cooks River in Port Botany. According to *Central Sydney State of the Beaches 2014–2015* (Office of Environment and Heritage Beachwatch, 2015), the water quality over this 12-month period was considered to be good (refer to Table 18-7).

Table 18-7 Water quality at relevant monitoring sites

Location	Site type	Beach suitability grade	Comments
Hayes Street Beach, North Sydney, Middle Harbour	Estuarine	Good – the water quality is safe for swimming most of the time, but can be susceptible to pollution from contamination.	Enterococci levels increased with increasing rainfall at this site, frequently exceeding the safe swimming limit in response to 10mm of rainfall or more.
Greenwich Baths, Greenwich, Sydney Harbour	Estuarine	Good – the microbial water quality is suitable for swimming most of the time, but can be susceptible to pollution from potential sources of faecal contamination (such as from the Lane Cove River).	Enterococci levels increased with increasing rainfall at this site, regularly exceeding the safe swimming limit in response to 10mm of rainfall or more.
Kyeemagh Baths, Cooks River, Port Botany	Estuarine	Good – the microbial water quality is suitable for swimming most of the time, but can be susceptible to pollution from potential sources of faecal contamination (such as from the Cooks River, and stormwater and sewage overflows).	Enterococci levels increased with increasing rainfall at this site, occasionally exceeding the safe swimming limit in response to light rainfall and frequently exceeding the safe swimming limit after 10mm of rainfall or more.

18.4 Potential impacts

This section provides an assessment of the project against water quality objectives, and an assessment of impacts during operation and construction of the project.

18.4.1 Water quality objectives

Water quality objectives that provide guideline levels to help manage water quality have been developed for each catchment in NSW (Department of Environment and Conservation, 2006). These objectives include community-based values, long term goals, and their associated national criteria drawn from the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000b). The objectives aim to improve poor water quality and maintain existing good water quality (Department of Environment and Conservation, 2006). Table 18-8 outlines the water quality objectives for catchments in the study area and the impacts as a result of the project during construction and operation.

Table 18-8 Priority water quality objectives for the relevant surface water

Water quality objective	Indicators	Associated trigger values or criteria	Objective a priority for catchment	Impact as a result of the project during construction and operation
Aquatic ecosystems				
Maintain or improve the ecological condition of waterbodies and their riparian zones over the long term.	Total phosphorus	• Upland rivers: 20 µg/L • Lowland rivers: 25 µg/L for rivers flowing to the coast; • Lakes & reservoirs: 10 µg/L • Estuaries: 30 µg/L	Sydney Harbour and Parramatta River Cooks River	The treatment and discharge of water during construction would comply with the requirements of an environment protection licence issued to the project and during operation would be based on ANZECC freshwater ecosystem protection levels. Therefore the discharge water quality would be higher than existing water quality of the receiving waters.
	Total nitrogen	• Upland rivers: 250 µg/L • Lowland rivers: 350 µg/L for rivers flowing to the coast; 500 µg/L for rivers in the Murray-Darling Basin • Lakes & reservoirs: 350 µg/L • Estuaries: 300 µg/L		
	Chlorophyll-a	• Upland rivers: not applicable • Lowland rivers: 5 µg/L • Lakes & reservoirs: 5 µg/L • Estuaries: 4 µg/L		
	Turbidity	• Upland rivers: 2–25 NTU • Lowland rivers: 6–50 NTU • Lakes & reservoirs: 1–20 NTU • Estuaries: 0.5–10 NTU		
	Salinity (electrical conductivity	• Upland rivers: 30–350 µS/cm • Lowland rivers: 125–2200 µS/cm		
	Dissolved oxygen	• Upland rivers: 90–110% • Lowland rivers: 85–110% • Freshwater lakes & reservoirs: 90–110% • Estuaries: 80–110%		
	pH	• Upland rivers: 6.5–8.0 • Lowland rivers: 6.5–8.5 • Freshwater lakes & reservoirs: 6.5–8.0 • Estuaries: 7.0–8.5		

Water quality objective	Indicators	Associated trigger values or criteria	Objective a priority for catchment	Impact as a result of the project during construction and operation
Visual amenity				
Maintain the aesthetic qualities of waterways.	Visual clarity and colour	Natural visual clarity should not be reduced by more than 20%. Natural hue of the water should not be changed by more than 10 points on the Munsell Scale. The natural reflectance of the water should not be changed by more than 50%.	Sydney Harbour and Parramatta River Cooks River	The treatment and discharge of water during construction would comply with the requirements of an environment protection licence issued to the project and during operation would be based on ANZECC freshwater ecosystem protection levels. Therefore the discharge water quality would be higher than existing water quality of the receiving waters. The treated discharge water quality would ensure that the aesthetic qualities of downstream waters would not be diminished.
	Surface films and debris	Oils and petrochemicals should not be noticeable as a visible film on the water, nor should they be detectable by odour. Waters should be free from floating debris and litter.		
	Nuisance organisms	Macrophytes, phytoplankton scums, filamentous algal mats, blue-green algae, sewage fungus and leeches should not be present in unsightly amounts.		

Water quality objective	Indicators	Associated trigger values or criteria	Objective a priority for catchment	Impact as a result of the project during construction and operation
Secondary contact recreation				
Maintain or improve water quality for activities such as boating and wading, where there is a low probability of water being swallowed.	Faecal coliforms	Median bacterial content in fresh and marine waters of < 1000 faecal coliforms per 100 mL, with 4 out of 5 samples < 4000/100 mL (minimum of 5 samples taken at regular intervals not exceeding one month).	Sydney Harbour and Parramatta River Cooks River	The treatment and discharge of water during construction would comply with the requirements of an environment protection licence issued to the project and during operation would be based on ANZECC freshwater ecosystem protection levels. Therefore the discharge water quality would be higher than existing water quality of the receiving waters. The treated discharge water quality would ensure that secondary contact recreation activities in downstream waters would not be affected.
	Enterococci	Median bacterial content in fresh and marine waters of < 230 enterococci per 100 mL (maximum number in any one sample: 450-700 organisms/100 mL).		
	Algae & blue-green algae	< 15 000 cells/mL		
	Chemical contaminants	Waters containing chemicals that are either toxic or irritating to the skin or mucous membranes are unsuitable for recreation.		

Water quality objective	Indicators	Associated trigger values or criteria	Objective a priority for catchment	Impact as a result of the project during construction and operation
Primary contact recreation				
Maintain or improve water quality for activities such as swimming, where there is a high probability of water being swallowed.	Turbidity	A 200 mm diameter black disc should be able to be sighted horizontally from a distance of more than 1.6 m (approximately 6 NTU).	Sydney Harbour and Parramatta River	The treatment and discharge of water during construction would comply with the requirements of an environment protection licence issued to the project and during operation would be based on ANZECC freshwater ecosystem protection levels. Therefore the discharge water quality would be higher than existing water quality of the receiving waters. The immediate receiving watercourses are not currently used for primary contact recreation activities. The discharge water quality would ensure that primary contact recreation activities in downstream waters would not be affected.
	Faecal coliforms	Beachwatch considers waters are unsuitable for swimming if: • the median faecal coliform density exceeds 150 colony forming units per 100 millilitres (cfu/100mL) for five samples taken at regular intervals not exceeding one month, or • the second highest sample contains equal to or greater than 600 cfu/100mL (faecal coliforms) for five samples taken at regular intervals not exceeding one month. ANZECC 2000 Guidelines recommend: • Median over bathing season of < 150 faecal coliforms per 100 mL, with 4 out of 5 samples < 600/100 mL (minimum of 5 samples taken at regular intervals not exceeding one month).		
	Enterococci	Beachwatch considers waters are unsuitable for swimming if: • the median enterococci density exceeds 35 cfu/100mL for five samples taken at regular intervals not exceeding one month, or • the second highest sample contains equal to or greater than 100 cfu/100mL (enterococci) for five samples taken at regular intervals not exceeding one month. ANZECC 2000 Guidelines recommend: • Median over bathing season of < 35 enterococci per 100 mL (maximum number in any one sample: 60-100 organisms/100 mL).		
	Protozoans	Pathogenic free-living protozoans should be absent from bodies of fresh water. (Note: it is not necessary to analyse water for these pathogens unless temperature is greater than 24 degrees Celsius).		

Water quality objective	Indicators	Associated trigger values or criteria	Objective a priority for catchment	Impact as a result of the project during construction and operation
	Algae & blue-green algae	< 15 000 cells/mL		
	Nuisance organisms	Use visual amenity guidelines. Large numbers of midges and aquatic worms are undesirable.		
	pH	5.0-9.0		
	Temperature	15°-35°C for prolonged exposure.		
	Chemical contaminants	Waters containing chemicals that are either toxic or irritating to the skin or mucus membranes are unsuitable for recreation.		
Aquatic foods				
Protect water quality so it is suitable for the production of aquatic foods for human consumption and aquaculture activities	Algae & blue-green algae	No guideline is directly applicable, but toxins present in blue-green algae may accumulate in other aquatic organisms.	Cooks River	The treatment and discharge of water during construction would comply with the requirements of an environment protection licence issued to the project and during operation would be based on ANZECC freshwater ecosystem protection levels. Therefore the discharge water quality would be higher than existing water quality of the receiving waters. The immediate receiving waters are not currently used for the production of aquatic foods. The discharge water quality would ensure the quality of downstream waters where aquatic food production may take place would not be affected. Sydney Harbour is currently closed to commercial fishing.
	Faecal coliforms	*Guideline in water for shellfish:* The median faecal coliform concentration should not exceed 14 MPN/100mL; with no more than 10% of the samples exceeding 43 MPN/100 mL. *Standard in edible tissue:* Fish destined for human consumption should not exceed a limit of 2.3 MPN E Coli/g of flesh with a standard plate count of 100,000 organisms/g		
	Toxicants (as applied to aquaculture activities)	Metals: • Copper: less than 5 µgm/L. • Mercury: less than 1 µgm/L. • Zinc: less than 5 µgm/L. Organochlorines: • Chlordane: less than 0.004 µgm/L (saltwater production) • PCB's: less than 2 µgm/L.		
	Physico-chemical indicators (as applied to aquaculture activities)	• Suspended solids: less than 40 micrograms per litre (freshwater) • Temperature: less than 2 degrees Celsius change over one hour		

18.4.2 Construction

The potential pollutants which could be introduced into the water cycle as a result of construction activities include sediment, hydrocarbons, acids and other dangerous goods. The project also has the potential to encounter contaminated sites which could result in existing contamination being mobilised into the water cycle. These potential impacts are considered further below.

Soils

Soil erosion

Construction of the project would temporarily expose the natural ground surface and sub-surface through the removal of vegetation, overlying structures (such as buildings and footpaths) and excavation of construction footprints for stations, structures and foundations. The temporary exposure of soil to water runoff and wind could increase soil erosion potential, particularly where construction is undertaken in soil landscapes characterised by a high and extreme erosion hazard. There is the potential that exposed soils – and other unconsolidated materials, such as spoil, sand and other aggregates – could be transported from the construction sites into surrounding waterways via stormwater runoff.

Given the relatively small areas of surface disturbance anticipated during construction and the overall topography of those parts of the project (generally slightly undulating), it is expected that soil erosion would be adequately managed by in accordance with *Managing Urban Stormwater: Soils and Construction Volume 1* (Landcom, 2004) and *Managing Urban Stormwater: Soils and Construction Volume 2* (Department of Environment and Climate Change, 2008a). Measures would be designed for the 80th percentile; 5-day rainfall event.

Acid sulfate soils

Acid sulfate soil risk varies across the project area. There is a high probability of encountering these soils opposite Erskine Street at Barangaroo and in the areas between Waterloo Station and the Marrickville dive site, if excavations in these areas are required.

The exposure of acid sulfate soils during excavation could result in the release of acid sulfates, which would damage surrounding vegetation, or cause acidic runoff offsite which would damage aquatic environments and / or drainage lines.

Further geotechnical testing of underlying sub-soil and rock stratum would be undertaken to determine the composition of rock and soil types likely to be present within excavation areas. If acid sulfate soils are encountered, they would be effectively managed in accordance with the *Acid Sulfate Soil Manual* (Acid Sulfate Soil Management Advisory Committee, 1998). The manual includes procedures for the investigation, handling, treatment and management of such soils.

Contamination

Potentially contaminated sites

Based on the review of background information as presented in Section 18.3.2, there is the potential for contamination to be encountered at a number of locations throughout the project. Contaminants that could be encountered during excavation and other ground disturbing activities include contamination associated with:

- Leaks and spills from fuel storage infrastructure (hydrocarbons and heavy metals)
- Processing of heavy end hydrocarbons, heavy metals and metalloids
- Land reclamation and other uncontrolled fill material (metals, hydrocarbons, pesticides, PCB and asbestos)
- Demolition of buildings, such as asbestos
- Former and current industrial land uses (hydrocarbons, heavy metals and metalloids, solvents, phenolics, pesticides, heavy metals and metalloids and asbestos in soil)
- Existing railways and associated activities (metals, hydrocarbons, pesticides, nutrients, phenols, carbamates, pesticides, herbicides and asbestos in soils).

A number of potential areas of environmental interest were identified during the information review and site inspection. Table 18-9 outlines the potential areas of contamination interest in the vicinity of the project area and their associated risks.

Table 18-9 Potential sites of contamination interest

Site	Location relative to site	Potential contamination source	Likely risk
Current Caltex service station, Chatswood	Adjacent to Chatswood dive site	On-site activities associated with fuel use and storage.	Low (possible contamination but no excavation activities proposed)
Ausgrid Depot, Chatswood	Within Chatswood dive site	Possible fuel storage, workshops, storage and electrical transmission	Moderate (possible contamination / major excavation activities proposed)
Former Caltex Service Station, Chatswood	Within Chatswood dive site	Former fuel storage	High (known contamination / major excavation activities proposed)
Existing T1 North Shore line between Chatswood Station and Chatswood dive site	Within railway corridor and construction footprint	On-site activities associated with railway use	Low-moderate (possible contamination / minimal excavation proposed)
Victoria Cross Station	Within footprint of Victoria Cross Station site	Demolition of existing buildings	Moderate (possible contamination / major demolition activities proposed)
Former heavy industrial land use, Blues Point	Within footprint of Blues Point temporary site	Historical industrial activities (possible shipyard)	Moderate (possible contamination / major excavation activities proposed)
Sydney Harbour	Within footprint of harbour ground improvement work	Historical industrial activities	Moderate (known contamination / minor excavation activities proposed)
Reclaimed land within Barangaroo	Adjacent to the Barangaroo Station site	Historical activities and waste / fill material	Moderate-high (known isolated contamination / major excavation activities proposed)

Site	Location relative to site	Potential contamination source	Likely risk
Former gasworks along Hickson Road, Millers Point	Adjacent to the footprint of Barangaroo Station	Historical activities as a gasworks	High (known contamination / major excavation activities proposed)
Martin Place Station	Within footprint of Martin Place Station site	Demolition of existing buildings	Moderate (possible contamination / major demolition activities proposed)
Pitt Street Station	Within footprint of Pitt Street Station site	Demolition of existing buildings	Moderate (possible contamination / major demolition activities proposed)
Former gasworks within Central railyards	Within and adjacent to the footprint of Central Station	Historical activities as a gasworks	Moderate (possible contamination / major demolition activities proposed)
Central Station	Within footprint of Central Station	On site activities associated with railway use	Low (possible contamination / minimal excavation proposed)
Regent Street service station	Adjacent to the proposed Sydney Yard Access Bridge at Central Station site	Leaks and spills from fuel storage infrastructure (hydrocarbons and heavy metals)	Moderate (possible contamination / moderate excavation activities proposed)
Former and current commercial / industrial land use, Waterloo	Within footprint of Waterloo Station	Historical and current commercial / industrial activities (including dry cleaners, automotive industry and substation)	Moderate (possible contamination / major excavation activities proposed)
Railway activities north of Sydenham Station	Within Marrickville dive site footprint	On-site activities associated with railway use	Low–moderate (possible contamination / minimal excavation proposed)

Exposure or disturbance of contaminants during construction of the project may have the following impacts:

- Mobilisation of surface and subsurface contaminants (impacting groundwater, surface water and soils)
- Migration of potential contaminants into surrounding areas (impacting groundwater, surface water and soils) via leaching, overland flow and / or subsurface flow (water and / or vapour)
- Risk of exposure to site workers, site users and site visitors
- Risk of exposure to surrounding environmental receivers (such as, flora, fauna and surrounding ecosystems including groundwater dependent ecosystems).

The sensitive receiving environments could be potentially impacted by contamination (if present) within project area. Sydney Harbour could be impacted by contamination from the Barangaroo Station construction site and Blues Point temporary site, and indirectly from the Pitt Street Station and Martin Place Station construction sites via Cockle Bay. Middle Harbour is unlikely to experience contamination from project sites. Beneficial users of groundwater downslope from the respective sites could also be affected by contamination, however this risk is considered to be negligible.

Sydney Harbour may also be impacted by disturbance of contaminants within the seabed from the ground improvement work. Disturbance of sediment by grouting activities related to the proposed harbour tunnel is likely to mobilise some shallow sediment, possibly creating increased turbidity and resuspension of contaminated sediments during the grout probe insertion and extraction works, and during the placement of anchoring blocks (if used). Considering the contamination concentrations in the sediment which would be disturbed are consistent with sediment quality throughout Sydney Harbour, the risk of spreading contamination to new areas is considered to be low. Consideration of the potential for contaminants to become bioavailable from the proposed works is provided in Chapter 20 (Biodiversity).

As shown in Table 18-9, the project has a high risk of encountering contamination at the following construction sites:

- Chatswood dive site
- Barangaroo (Hickson Road).

However, the risk of impacting on sensitive ecological environments or site workers, users or visitors would be minimised by mitigation measures, as outlined in Table 18-10.

Potentially contaminating construction activities

Construction activities have the potential to result in contamination of soils and / or groundwater due to spills and leaks of fuel, oils and other hazardous materials. These impacts would be readily manageable by implementing standard construction environment mitigation measures as outlined in Table 18-10.

The demolition of buildings and structures also has the potential to result in the disturbance of hazardous materials, including asbestos and / or materials containing lead paint. Mishandling of hazardous material waste has the potential to contaminate soils and to create health risks to construction workers and the community. To manage these potential risks, adequate hazardous material mitigation measures would be developed. These measures are outlined in Chapter 23 (Hazard and risk).

The *Marine Pollution Act 2012* includes provisions to protect the sea and waters from pollution by oil, oil residues and other noxious substances discharged from vessels. Any vessels involved in ground improvement work have the potential to contaminate the water of Sydney Harbour through leaks or spills of liquids, oils and other potentially noxious substances and therefore must comply with the requirements of the *Marine Pollution Act 2012 and the Marine Pollution Regulation 2014*.

Surface water quality

It is anticipated that 550 megalitres of water would be required for tunnelling throughout the construction period. Additional water would be required for other construction activities such as dust suppression. A large proportion of this water would require treatment before being reused or discharged.

Management

Any water discharged from construction sites has the potential to adversely affect the water quality of nearby watercourses and receiving catchments due to potential pollutants such as diesel and oil, paint, solvents, cleaners and other harmful chemicals, and construction debris and dirt. As discussed in Chapter 21 (Flooding and hydrology), potential rainfall and flood events which may affect water quality during construction would be managed through detailed construction planning, including the development of appropriate site layouts and staging of construction activities.

Potential impacts, including the redirection and capture of construction site runoff, would be adequately managed by implementing standard erosion and sediment control measures in accordance with *Managing Urban Stormwater: Soils and Construction Volume 1* (Landcom, 2004) and *Managing Urban Stormwater: Soils and Construction Volume 2* (Department of Environment and Climate Change, 2008a), as outlined in Table 18-10.

Monitoring

A monitoring program would be implemented the discharge water quality from the construction water treatment plants. Water quality mitigation controls (such as sediment fences and sediment basins) would be inspected regularly, and after significant rainfall, to detect any breach in performance.

Treatment

The excavation of the tunnels, stations and shafts is likely to intercept groundwater aquifers, resulting in the need to capture, treat and discharge water. Water treatment plants are likely to be installed at all construction sites to treat all intercepted groundwater. The groundwater would be treated to meet the requirements of an environment protection licence issued to the project, which are anticipated to be:

- pH – 6.5 to 8.5
- Total suspended liquids – less than 50 milligrams per litre
- Oil and grease – none visible.

The re-use of treated water would be maximised during construction works by recirculating it to the tunnel cutting face and using it for dust suppression aboveground. Despite this reuse, there would be a surplus of treated water, which would need to be discharged to the local stormwater system or directly to a local surface watercourse. Other options, such as Sydney Water trade waste agreements, would also be investigated during detailed design. As the intercepted groundwater would be treated prior to reuse or discharge, the impact on water quality would be negligible.

Marine water quality

Due to the expected ground conditions underneath Sydney Harbour, ground improvement would be required prior to excavation of the tunnels. Ground improvement is likely to be carried out at the rock – sediment transition zones to reduce construction risks, and allow for maintenance of the tunnel boring machine cutters before driving through the soft sediments.

There may be potential for water quality impacts due to disturbance of the seabed during the initial ground improvements works. In addition, the storage of materials (grout and spoil) would be required on barges on Sydney Harbour, which has the potential for spills or leaks. To minimise potential impacts on the water quality of Sydney Harbour during ground improvement work, mitigation measures outlined in Table 18-10 would be implemented.

In addition, a water quality monitoring program would be implemented to monitor water quality within Sydney Harbour during ground improvement work. The water quality monitoring program would be carried out to detect any potential impacts on the water quality of Sydney Harbour from the ground improvement work and inform management responses in the event any impacts are identified. The specific monitoring locations and frequencies would be determined during the development of the program in consultation with the Environment Protection Authority, however this is likely to involve a combination of water quality monitoring buoys, use of probes and grab samples from various depths within the water column.

18.4.3 Operation

The potential pollutants which could be introduced into the water cycle as a result of operation of the metro include hydrocarbons, acids and other dangerous goods. These potential impacts are considered further below.

Contamination

During operation of the project there would be a minor potential for contamination of soils and / or surface water in the vicinity of the project as a result of spills and leaks of hazardous materials from the operational wastewater treatment plant. Hazardous materials would be controlled and contained in bunded areas (see Chapter 23 (Hazard and risk)) to avoid contamination.

Water quality

The project would include some drained stations and require the ongoing capture and management of groundwater inflows into the tunnels. Groundwater inflows into the drained stations and surface water at the dive structures would be captured and pumped to the water treatment plant located at the southern services facility adjacent to the Marrickville dive structure.

Conservatively, the rate of inflow of water into the tunnel has been calculated as 12.5 litres per second. To accommodate treatment of this inflow and additional volumes of water (for example resulting the event of fire suppression) the water treatment plant design would accommodate an inflow rate of up to 15 litres per second (this equates to about 470 megalitres per year). Based on the anticipated groundwater quality, the water treatment methods would typically involve:

- pH adjustment
- Removal of suspended soils
- Removal of dissolved solids
- Dissolved iron and manganese removal by oxidising the dissolved metals which enables precipitation and physical removal.

Treated water would either be reused or discharged into the local stormwater system which in turn discharges into the Eastern Channel, a tributary which leads into Botany Bay.

The project would be designed to achieve a maximum water discharge quality equivalent to the 90 percent protection level specified for freshwater ecosystems in accordance with ANZECC guidelines (ANZECC / ARMCANZ, 2000b). The discharge water quality level would be determined in consultation with the NSW Environment Protection Authority during detailed design, taking into consideration the current water quality of the receiving watercourse. The sensitive receiving environments for the project (Middle Harbour and Sydney Harbour) would not be impacted by discharge from the water treatment plant during operation.

Runoff from aboveground project elements (such as station buildings) would be directed to existing stormwater systems (further details are provided in Chapter 21 (Flooding and hydrology)).

18.5 Mitigation measures

The mitigation measures that would be implemented to manage potential soils, contamination and water quality impacts are listed in Table 18-10 and Table 18-11.

Table 18-10 Mitigation measures – soils, contamination and water quality – construction

Reference	Mitigation measure	Applicable location(s)[1]
SCW1	Updated desktop contamination assessments would be carried out for Chatswood dive site, Blues Point temporary site, Barangaroo Station, Central Station and Waterloo Station. If sufficient information is not available to determine the remediation requirements and the impact on potential receivers, then detailed contamination assessments, including collection and analysis of soil and groundwater samples would be carried out. Detailed contamination assessment would also be carried out for the Barangaroo power supply route within Hickson Road and the Marrickville power supply route adjacent to Sydney Park and Camdenville Oval. In the event a Remediation Action Plan is required, these would be developed in accordance with *Managing Land Contamination: Planning Guidelines SEPP 55 – Remediation of Land* (Department of Urban Affairs and Planning and Environment Protection Authority, 1998) and a site auditor would be engaged.	CDS, BP, BN, CS, WS, PSR
SCW2	Prior to ground disturbance in high probability acid sulfate areas at Barangaroo Station, Waterloo Station and Marrickville dive site, testing would be carried out to determine the presence of acid sulfate soils. If acid sulfate soils are encountered, they would be managed in accordance with the *Acid Sulfate Soil Manual* (Acid Sulfate Soil Management Advisory Committee, 1998).	BN, WS, MDS
SCW3	Erosion and sediment control measures would be implemented in accordance with *Managing Urban Stormwater: Soils and Construction Volume 1* (Landcom, 2004) and *Managing Urban Stormwater: Soils and Construction Volume 2* (Department of Environment and Climate Change, 2008). Measures would be designed as a minimum for the 80th percentile; 5-day rainfall event.	All except metro rail tunnels
SCW4	Discharges from the construction water treatment plants would be monitored to ensure compliance with the discharge criteria in an environment protection licence issued to the project.	All except metro rail tunnels
SCW5	A silt curtain would be used around the Sydney Harbour ground improvement work barges.	GI
SCW6	A water quality monitoring program would be implemented to monitor water quality within Sydney Harbour during ground improvement work. The water quality monitoring program would be carried out to detect any potential impacts on the water quality of Sydney Harbour from the ground improvement work and inform management responses in the event any impactsare identified. Specific monitoring locations and frequencies would be determined during the development of the program in consultation with the Environment Protection Authority.	GI

1 *STW: Surface track work; CDS: Chatswood dive site; AS: Artarmon substation; CN: Crows Nest Station; VC: Victoria Cross Station; BP: Blues Point temporary site; GI: Ground improvement work; BN: Barangaroo Station; MP: Martin Place Station; PS: Pitt Street Station; CS: Central Station; WS: Waterloo Station; facility; MDS: Marrickville dive site; Metro rail tunnels: Metro rail tunnels not related to other sites (eg TBM works); PSR: Power supply routes.*

Table 18-11 Mitigation measures – soils, contamination and water quality – operation

Reference	Mitigation measure	Applicable location(s)[1]
SCW7	Discharges from the tunnel water treatment plant would be monitored to ensure compliance with the discharge criteria determined in consultation with the NSW Environment Protection Authority.	MDS

1 *STW: Surface track work; CDS: Chatswood dive site; AS: Artarmon substation; CN: Crows Nest Station; VC: Victoria Cross Station; BP: Blues Point temporary site; GI: Ground improvement work; BN: Barangaroo Station; MP: Martin Place Station; PS: Pitt Street Station; CS: Central Station; WS: Waterloo Station; facility; MDS: Marrickville dive site; Metro rail tunnels: Metro rail tunnels not related to other sites (eg TBM works); PSR: Power supply routes.*

SOCIAL IMPACTS AND COMMUNITY INFRASTRUCTURE

CHAPTER NINETEEN

19 Social impacts and community infrastructure

This chapter provides an assessment of the potential impact on local and regional communities and community infrastructure as a result of the project, and identifies mitigation measures to address these impacts.

19.1 Secretary's environmental assessment requirements

The Secretary's environmental assessment requirements relating to social impacts and community infrastructure, and where these requirements are addressed in this Environmental Impact Statement, are outlined in Table 19-1.

Table 19-1 Secretary's environmental assessment requirements – social impacts and community infrastructure

Ref.	Secretary's environmental assessment requirements	Where addressed
10. Socio-economic, Land Use and Property		
10.1	The Proponent must assess social and economic impacts in accordance with the current guidelines.	Business impacts are addressed in Chapter 13 (Business impacts). Economic benefits are addressed in Chapter 3 (Strategic need and justification). Social impacts addressed in this chapter.
10.2	The Proponent must assess impacts from construction and operation on potentially affected properties, approved development applications, businesses, public open space, recreational users and land and water users (for example, recreational and commercial fishers, oyster farmers), including property acquisitions/adjustments, access, amenity and relevant statutory rights.	Social impacts are addressed in this chapter. Property impacts are addressed in Chapter 12 (Land use and property). Access impacts are addressed in Chapter 8 (Construction traffic and transport). Business impacts are addressed in Chapter 13 (Business impacts). Cumulative impacts are addressed in Chapter 26 (Cumulative impacts).
10.3	Assess the likely risks of the project to public safety, paying particular attention to subsidence risks, bushfire risks and the handling and use of dangerous goods.	Public safety risks are addressed in this chapter. Traffic related public safety risks during construction are addressed in Chapter 8 (Construction traffic and transport). Traffic related public safety risks during operation are addressed in Chapter 9 (Operation traffic and transport). Risks associated with groundwater are addressed in Chapter 17 (Groundwater and geology). Bushfire risks and the handling and use of dangerous goods are addressed in Chapter 23 (Hazard and risk).

19.2 Assessment methodology

An assessment of potential social and community infrastructure impacts was carried out in accordance with reference to the *Environmental Impact Assessment Practice Note (No 5) – Socio-economic assessment* (Roads and Maritime Services, 2011).

The scope of the assessment comprised:

- Describing the existing social environment within the study area, including:
  - An analysis of population and demographic data for communities in the study area, such as information available from the Census of Population and Housing 2011 (Australian Bureau of Statistics (ABS), 2011)
  - A review of existing community infrastructure in the study area, such as education facilities, health and emergency services, recreation and transport facilities
  - Identification of existing community values relating to factors such as community cohesion, local amenity and character, and community health and safety
  - A review of the outcomes of early community consultation carried out for the project
  - Observations made during a site visit to the study area
- Evaluation of impacts on existing social conditions and community values in the study area as a result of the project, including:
  - Identification of community infrastructure that would be directly affected as a result of the project; this included consideration of the availability of alternative facilities or if the facilities can be replaced in the local area
  - Identification of where access may be affected as a result of the project
  - Consideration of the potential health impacts associated with the project
- Development of mitigation measures to address potential social and community infrastructure impacts.

The primary study area for this assessment, based on the relevant ABS Statistical Areas Level 2 (SA2) locations, is shown in Figure 19-1. It is based on those communities that have the greatest potential to experience changes to social conditions or local movement patterns due to the location of project and construction activities.

The assessment also considers impacts on communities in the Willoughby, North Sydney, City of Sydney and Marrickville local government areas (LGAs). Benefits and impacts from the project may also be experienced in other areas of the greater Sydney region, such as through improved public transport operation. These impacts have also been considered in this assessment, where relevant.

Figure 19-1 Social impact study area

19.3 Existing environment

The existing social environment is described below in terms of:

- Population and demographic characteristics of local and regional communities
- Community values, including those relating to community cohesion, local amenity and character, and community health and safety
- Community infrastructure
- Transport and access.

19.3.1 Regional context

The project extends from the Willoughby City LGA (Willoughby LGA) in the north to the Marrickville Council LGA (Marrickville LGA) in the south. In 2014, the LGAs in the study area had a combined estimated resident population of 426,878 people, of which more than 46 per cent lived in the City of Sydney LGA (Sydney LGA) and nearly 20 per cent in the Marrickville LGA. The LGAs also had a combined worker population of more than 530,000 people at the 2011 Census. About 395,000 workers, or nearly 75 per cent of the combined LGA total, worked in the Sydney LGA, while about 65,900 workers (12.4 per cent) worked in the North Sydney Council LGA (North Sydney LGA).

Willoughby City Council

The Willoughby LGA is located about six kilometres north of the Sydney CBD and covers an area of about 23 square kilometres. In June 2014, the LGA had an estimated resident population of about 74,166 people (Australian Bureau of Statistics, 2014). The Willoughby LGA is a predominantly residential area. However, it also includes commercial and industrial uses at the Chatswood and St Leonards employment hubs, and the Artarmon Industrial Area. The LGA also comprises significant parkland areas including bushland at Castle Cove, Middle Cove and along the edges of Middle Harbour (profile.id, 2015a).

The Willoughby LGA includes a range of district and regional level community services and facilities including major hospital and community health facilities at the Royal North Shore Hospital precinct, and TAFE NSW Northern Sydney Institute at St Leonards. The LGA includes a number of major retail centres within the Chatswood CBD, including Westfield Chatswood Shopping Centre, Chatswood Chase, Metro Chatswood and Chatswood Central (profile.id, 2015a). Numerous parks, reserves, golf courses, and other facilities which provide for active and passive recreational activities for both local residents and wider communities are also located in the LGA.

North Sydney Council

The North Sydney LGA is located about three kilometres north of the Sydney CBD and covers an area of about 11 square kilometres. In June 2014, the LGA had an estimated resident population of about 71,025 people. The population of the LGA grew at an average annual rate of 1.9 per cent over the five years to 2014, although the growth rate increased to 2.6 per cent between 2013 and 2014. This was higher than the rate of growth for NSW over the same periods (Australian Bureau of Statistics, 2014). The North Sydney LGA is also a popular tourist destination, attracting large numbers of holiday makers during event and festival periods (North Sydney Council, 2013e).

The North Sydney LGA includes significant residential land uses, as well as commercial land uses at North Sydney and Crows Nest, and parkland. The LGA accommodates a number of important regional level community uses, such as Luna Park, North Sydney Olympic Pool, North Sydney Oval, and TAFE NSW Northern Sydney Institute at Crows Nest (profile.id, 2015b). The LGA also includes numerous parks, reserves, golf courses, and other facilities which cater for the needs of local communities.

City of Sydney

The Sydney LGA covers an area of about 25 square kilometres and includes the Sydney CBD and inner-city suburbs. The LGA had an estimated resident population of about 198,331 people in June 2014. Over the five years to 2014, the population of the LGA grew at a higher rate than NSW as a whole. Annual average population growth was 2.3 per cent between 2009 and 2014. This grew to 3.4 per cent between 2013 and 2014 (Australian Bureau of Statistics, 2014).

The Sydney LGA comprises a mix of commercial, residential and industrial land uses. The Sydney CBD is the primary commercial and economic centre for the Sydney metropolitan area. In 2011, the LGA had a worker population of more than 395,000 people (Australian Bureau of Statistics, 2011). The Sydney CBD also attracts an estimated 480,000 visitors and students each day (City of Sydney, 2015a).

The LGA accommodates a range of regional level community services and facilities including major educational facilities (The University of Sydney, University of Technology Sydney, University of Notre Dame Australia, Curtin University Sydney, Central Queensland University (Sydney Campus), TAFE NSW Sydney Institute), major public and private hospitals (St Vincent's Hospital, Royal Prince Alfred Hospital, Sydney Hospital), and major entertainment attractions (International Convention Centre Sydney, to be opened in December 2016), The Star Casino, Sydney Cricket Ground, Sydney Football Stadium (known as Allianz Stadium), Sydney Convention and Exhibition Centre, Wild Life Sydney Zoo, Sydney Sea Life Aquarium, Sydney Observatory, The Domain and Hyde Park). Numerous iconic sites are also located within the LGA, including Sydney Harbour, Circular Quay, Sydney Harbour Bridge, Sydney Opera House, and Darling Harbour (profile.id, 2015c).

The City of Sydney hosts a number of major sporting, entertainment and cultural events that attract large numbers of visitors to the inner city from across Sydney and NSW, and from interstate and overseas. Some key events include the New Year's Eve fireworks, Chinese New Year Festival, Sydney Mardi Gras parade, ANZAC Day March, Sun-Herald City2Surf, St Patrick's Day Parade, Sydney Festival, Sydney Spring Cycle, Mother's Day Classic, Blackmores Sydney Marathon, Vivid Sydney, and Carols in the Domain.

Marrickville

The Marrickville LGA is located to the west of the Sydney CBD and covers an area of about 17 square kilometres. In 2014, Marrickville LGA had an estimated resident population of about 83,356 people. Over the five years from 2009, the LGA's population grew at a slower rate than NSW as a whole, at 1.0 per cent annually (Australian Bureau of Statistics, 2014).

The Marrickville LGA is a predominantly residential area (about 61 per cent of the LGA comprises residential uses). The LGA also comprises industrial, commercial and parkland areas. Key features within the LGA include educational facilities such as TAFE NSW Sydney Institute, Newington College, and Trinity Grammar School; the Metro Rehab Hospital and Annette Kellerman Aquatic Centre (profile.id, 2015d).

19.3.2 Community profile

This section describes the key population, demographic and housing characteristics of the study area. In particular, it provides information on these groups within the community that may be most vulnerable to changes brought about by the project due to their level of economic resources, age or need for assistance.

Population size and growth

In June 2014, the study area had an estimated resident population of about 207,421 people. Sydney-Haymarket-The Rocks SA2 had the largest resident population with 27,695 people, followed closely by the SA2s of Marrickville and Chatswood (East)-Artarmon. Sydenham-Tempe-St Peters SA2 had the smallest resident population.

Over the five years to 2014, the population of the study area grew by an average of about 1.8 per cent annually, above the rate of growth for NSW as a whole. Population growth over the 12 months to 2014 was above the five year average, at 2.5 per cent. Population growth in the study area was generally driven by relatively high growth rates in North Sydney, Redfern, Sydney City and St Leonards. The SA2s of Chatswood (East)-Artarmon, Marrickville, Newtown-Camperdown-Darlington and Surry Hills all experienced rates of growth below NSW as a whole.

Information on future population growth for the study area is available at an LGA level. The total population of the four LGAs covering the study area is expected to increase by about 150,000 people by 2031. Much of this growth is expected to be driven by population increases in the Sydney LGA. The rate of population growth in the remaining LGAs is expected to be similar to NSW as a whole.

Age profile

The study area has a relatively young population, with a lower median age, higher proportions of people aged 15-44 years, and lower proportions of people aged 65 years and over, compared to NSW. In 2011, all SA2s within the study area recorded median ages below the NSW average. The North Sydney-Lavender Bay and Marrickville SA2s recorded the highest proportion of people aged 65 years and over, although this was lower than the NSW average.

Cultural diversity

Communities in the study area are culturally diverse, with proportions of people born overseas, people who speak a language other than English at home and people who do not speak English well or at all above the NSW average.

In 2011, each of the study area SA2s recorded proportions of people born overseas above the NSW average, with Sydney-Haymarket-The Rocks and Chatswood (East)-Artarmon having proportions more than double the NSW average. About 33.2 per cent of people in the study area spoke a language other than English in 2011, with this increasing to around 50 per cent or more in the SA2s of Sydney-Haymarket-The Rocks and Chatswood (East)-Artarmon. Non-English languages commonly spoken by people in the study area include Chinese languages (ie Mandarin and Cantonese); South East Asian languages (ie Indonesian, Tagalog, and Filipino); Korean; Indo-Aryan languages; and Greek.

Overall, the study area had slightly lower levels of English proficiency compared to NSW as a whole. Levels of English proficiency varied across the study area, with the SA2s of Marrickville, Sydenham-Tempe-St Peters, Chatswood (East)-Artarmon, Sydney-Haymarket-The Rocks and Redfern-Chippendale all having proportions of people who do not speak English well or at all above the study area and NSW averages. People with lower levels of English proficiency represent a stakeholder group with particular communication needs and a group that may be more vulnerable to changes from the project.

The study area had relatively low proportions of Indigenous persons, with each of the SA2s recording proportions of Indigenous people below the NSW average. Redfern-Chippendale SA2 recorded the highest proportion of Indigenous persons within the study area, followed by Marrickville and Sydenham-Tempe-St Peters.

Households and mobility

There were about 74,685 households in the study area at the 2011 Census. Overall, the study area had lower proportions of family households, and higher proportions of lone person and group households compared to NSW. SA2s closer to the city centre generally had higher proportions of lone person and group households, while outer areas had higher proportions of family households.

The study area had relatively high levels of population mobility, with lower proportions of people who lived at the same address either 12 months or five years prior to the 2011 Census compared to NSW. This is likely to reflect the residential development that has occurred in the inner city over recent years and relatively high levels of rental accommodation, which generally experience higher levels of population turnover. Marrickville SA2 had the lowest level of population mobility, although this was still lower than NSW as a whole. This is likely to reflect some of the more established residential neighbourhoods within this area.

Housing

In 2011, there were about 82,651 dwellings in the study area, of which about 90 per cent, were occupied on Census night. Dwelling types are typical of the study area's inner city location, with very high proportions of apartments and low proportions of separate houses compared to NSW as a whole.

Apartments are the predominant dwelling type in all SA2s apart from Newtown (semi-detailed dwellings) and Sydenham (separate houses). The study area as a whole had occupancy rates similar to the NSW average, although these varied across the study area. In particular, the Sydney-Haymarket-The Rocks SA2 had relatively low occupancy rates (at 82.6 per cent), which may reflect the availability of short-term rental accommodation in inner Sydney.

The study area had relatively high proportions of dwellings that were being rented and low proportions of owner occupied dwellings, compared to that of NSW. In 2011, more than half of the occupied private dwellings in the study area were being rented. The SA2s of Sydney-Haymarket-The Rocks, Surry Hills and Redfern-Chippendale had particularly high levels of rental accommodation, at more than double the State average, which is likely to reflect the higher housing costs within inner Sydney. About 45.4 per cent of dwellings in the study area were either owned outright or owned with a mortgage. This is compared to 66.5 per cent in NSW as a whole. Sydenham-Tempe-St Peters had the highest proportion of owner occupiers, with rates similar to the NSW average, which is likely to reflect the more established, residential nature of these suburbs.

At the 2011 Census, there were 3,741 dwellings that were rented from a State housing authority, representing about 5.0 per cent of dwellings in the study area. This was marginally higher than the State average and was driven by very high proportions of State rental housing in the Redfern-Chippendale and Surry Hills SA2s.

Level of disadvantage and need for assistance

The ABS produces a range of indices that indicate relative levels of socio-economic advantage and disadvantage. The Socio-economic Indexes for Areas (SEIFA) index of relative socio-economic advantage / disadvantage is derived from Census variables such as income, educational attainment, unemployment and vehicle ownership.

At the 2011 Census, levels of relative advantage / disadvantage varied widely across the study area. Communities in the study area north of Sydney Harbour generally recorded decile scores of seven or above, indicating high levels of relative advantage and low levels of disadvantage. South of Sydney Harbour, communities displayed greater diversity in levels of relative advantage / disadvantage, with some neighbourhoods recording decile scores of three or less, placing them in the bottom 30 per cent of communities in NSW in relation to relative disadvantage, while others recorded scores of nine or 10, indicating high levels of relative advantage. A community's level of disadvantage may influence the ability of that community to cope with or respond to changes from the project. In particular, communities that display levels of relative disadvantage may be more vulnerable to the impacts of large infrastructure projects than those that display levels of relative advantage. However, improved access to employment opportunities would also provide benefits for those communities that display levels of relative disadvantage.

The study area had relatively low levels of people in need of assistance in one or more of the three core activity areas of self-help, mobility, or communication due to disability, a long-term health condition or old age. However, the level of people needing assistance varied across the study area. Marrickville SA2 had relatively high levels of people needing assistance (at 6.3 per cent), while the SA2s of Surry Hills, Sydenham-Tempe-St Peters, Redfern-Chippendale and Chatswood (East)-Artarmon all had levels of people needing assistance above the study area average. People in this group may be more vulnerable to changes from the project, such as changes in local access, including to community services and facilities, effects associated with property acquisition, including the loss of social and community networks, and changes in local amenity.

Income and employment

Households in the study area generally had relatively high levels of income compared to NSW as a whole. In 2011, the median household income in the study area was above the NSW average, with all SA2s recording median incomes above NSW.

The study area also had high levels of workforce participation compared to NSW. At the 2011 Census, there were 108,329 people in the study area aged 15 years or over either employed or actively looking for work, representing about 66.7 per cent of the study area's working age population. Unemployment in the study area was generally below the NSW average in 2011. However, unemployment levels varied across the study area with Sydney-Haymarket-The Rocks, Redfern-Chippendale and Marrickville all having unemployment rates above the State average.

Worker population

There were about 434,945 people working in the study area at the 2011 Census, of which nearly 60 per cent (251,453 people) worked within the Sydney-Haymarket-The Rocks SA2. North Sydney-Lavender Bay had the second largest worker population, followed by St Leonards-Naremburn, Surry Hills and Chatswood (East)-Artarmon. This reflects the presence of major employment centres within the study area such as the Sydney CBD, North Sydney and St Leonards employment hubs and Artarmon industrial area.

In 2011, the study area had a high proportion of full-time workers (ie worked 35 hours or more each week) and relatively low proportion of part-time workers, compared to NSW as a whole. Professional, scientific and technical services; and financial and insurance services are the main industries of employment for people working in the study area.

About 37.3 per cent of people working in the study area travelled by train for all or part of their journey to work compared to 9.4 per cent in NSW as a whole at the 2011 Census. The SA2s of Sydney-Haymarket-The Rocks and North Sydney-Lavender Bay had the highest proportion of workers who commuted by train at 44.4 per cent and 41.8 per cent respectively. Nearly 14 per cent of people working in the study area travelled to work by bus only, while a further 7.6 per cent either walked or cycled only. These were both above the averages for NSW.

19.3.3 Community values

Community values are those values held as important to residents for quality of life and well-being. They include physical elements such as parks, landscapes and pedestrian connectivity; and intangible qualities such as sense of place and community cohesion.

Community cohesion

Community cohesion refers to the connections and relationships between individuals, groups and neighbourhoods, and is encouraged by the existence of local community facilities, a sense of local identity, and opportunities for community participation.

Overall, levels of community cohesion and sense of belonging in the study area are expected to be good, with communities having access to a diverse range of local and regional level community facilities, strong support networks and a variety of meeting places such as local centres, community centres and cafes.

A number of community groups operate within the study area, which help to foster relationships and trust. These include groups associated with local communities (such as residents groups, progress associations and precinct groups), environmental areas, heritage values, transport, sporting clubs and cultural facilities. Some communities in the study area also demonstrate relatively high levels of participation in volunteering, which also contributes to community cohesion.

Communities in the study area host a variety of local events, including neighbourhood street fairs, festivals, exhibitions and markets, which provide opportunities to involve local communities and help to foster a sense of community and local identity. These events include:

- Local festivals such as Willoughby Spring Festival, North Sydney Children's Festival, Cameraygal Festival at Lane Cove, Newtown Festival, Dulwich Hill Village Fair, and Marrickville Festival
- Cultural and sporting events such as Willoughby Fun Run, Guringai Festival, Twilight Food Festival and Spring into Jazz at North Sydney, Bairro Português Food and Wine Fair at Marrickville, and Open Marrickville
- Australia Day celebrations
- Weekly and monthly farmers and arts markets, including at Chatswood Mall, Crows Nest, Kirribilli, Lane Cove, North Sydney and The Rocks.

Communities in the study area are culturally diverse, with high proportions of people born overseas, and people who speak a language other than English at home. Some communities in the study area also have relatively high levels of people needing assistance and levels of relative disadvantage. These groups are likely to be more dependent on personal and community support networks.

Local amenity and character

Community values relating to local amenity and character refer to natural and physical qualities and characteristics that contribute to a person's appreciation of their surroundings. They relate to such things as built form and landscape, environmental conditions (such as noise levels and air quality), and heritage and cultural features.

Local amenity and character in the study area is characterised by a diversity of land uses, including major commercial areas in the Sydney CBD and at North Sydney, St Leonards and Chatswood; and local centres and shopping precincts, including at Crows Nest, McMahons Point, Surry Hills and Newtown. Pockets of high density residential uses are located at centres near St Leonards, Crows Nest and North Sydney, and adjacent to Sydney Harbour at McMahons Point.

Sydney Harbour is a major contributor to the amenity and character of the study area and is highly valued by communities for its natural, ecological, scenic amenity, landscape, heritage, recreational and lifestyle values. Sydney Harbour also supports a range of transport and economic functions. The harbour is the focus of a number of major events, such as the New Year's fireworks, Australia Day celebrations and Sydney to Hobart Yacht Race, as well as a range of formal and informal recreation activities including fishing, boating, kayaking, and sailing.

The study area includes a number of open spaces, reserves and parkland areas that are valued by local and regional communities for their landscape, visual amenity, heritage and recreational values. These include Blues Point Reserve, Barangaroo Reserve, Hyde Park and Prince Alfred Park.

The character of the urban environment is important to local communities and varies throughout the study area. Residents value the village atmosphere and character of local centres within the study area, including at Artarmon, Crows Nest and McMahons Point. The protection of the character of these villages and local centres was identified as important during early community consultation for the project.

The heritage and history of the study area – including places associated with Indigenous culture and early European settlement – also contribute to the character and identity of communities. Community members identified the importance of protecting heritage values during early community consultation for the project. In particular, community members identified heritage values associated with rail stations at Artarmon and Marrickville, and the area surrounding the Crows Nest Village. Protecting the heritage values of buildings within the Sydney CBD and open space areas such as Hyde Park is also likely to be important for community members. Heritage items within the study area are discussed further in Chapter 14 (Non-Aboriginal heritage) and Chapter 15 (Aboriginal heritage).

Community health and safety

Community safety refers to the ability of people to go about their day-to-day lives without fear for their own safety or the safety of others. Maintaining a high level of community safety and ensuring people feel safe in public places is important to communities in the study area.

Previous consultation carried out by councils in the study area identified safety at public transport facilities (including train stations and interchanges), as well as at parks (such as Chatswood Park and Blues Point Reserve) as concerns for some residents (Willoughby City Council, undated; North Sydney Council, 2014).

Comments made by community members during early consultation for the project indicated support for safe, reliable and affordable public transport. Key safety issues raised by community members related to:

- Concerns about impacts on passenger safety due to overcrowding at existing stations
- The use of 'driverless' trains and concerns about safety for passengers in the event of an incident on a 'driverless' train
- The need to ensure safe access for passengers, including the elderly, by including lifts in the station design, maintaining air quality and reducing the gap between the train and the platform.

Impacts of noise and vibration during construction and operation of the project on occupants of buildings near the project were identified during early community consultation for the project. Specifically, some community members identified concerns about possible sleep disruption, impacting on children's learning and adults to function at work and causing stress for families.

19.3.4 Community infrastructure

A wide range of community services and facilities are located in or near to the study area that cater for the needs of communities within the study area and across the Greater Sydney region and NSW. These include:

- Major tertiary education facilities such as universities and Institute of TAFE at St Leonards, Crows Nest, North Sydney and within the Sydney CBD
- Major hospitals and facilities offering medical, health and emergency services, including Royal North Shore Hospital and North Shore Private Hospital at St Leonards, and Mater North Sydney Hospital at North Sydney
- Emergency services, including fire, police and ambulance stations
- Formal and informal sport, recreation, cultural and leisure facilities, including Sydney Harbour foreshore, which includes Blues Point Reserve and Barangaroo Reserve; Observatory Park; Royal Botanic Gardens; and Moore Park sporting and entertainment precinct, which includes Sydney Football Stadium and Sydney Cricket Ground.

A number of community facilities are located near to Sydney Metro surface infrastructure, construction works, haulage routes, and the tunnel alignment, which due to their proximity may experience impacts during construction and / or operation.

Chatswood dive site (northern)

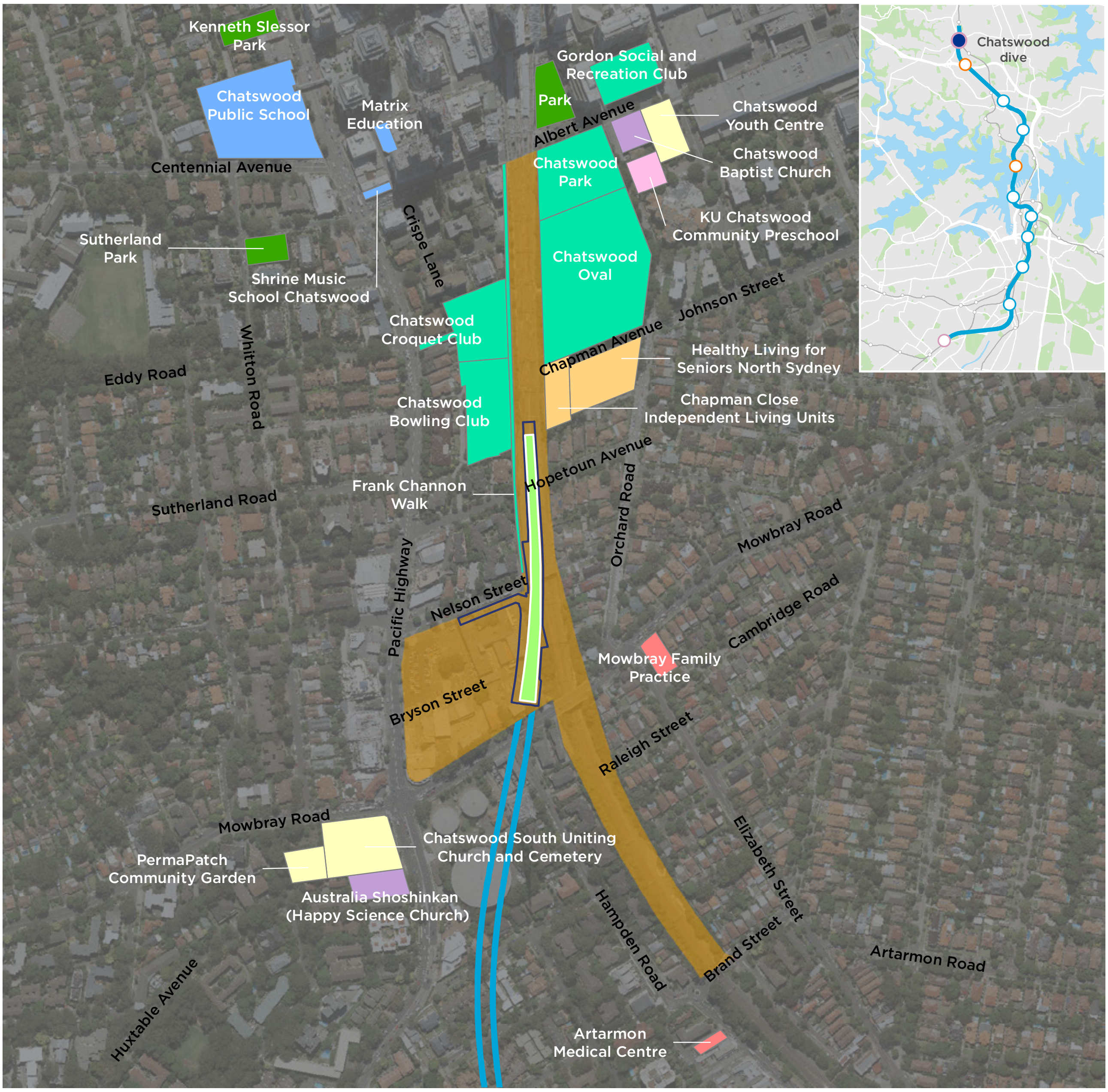
Community infrastructure around the Chatswood dive site is listed in Table 19-2 and shown on Figure 19-2. It includes:

- Chatswood Park, on Orchard Road. The oval within the park is the home ground of Gordon District Cricket Club and the Gordon Highlanders Rugby Club. The park includes picnic facilities, an exercise station, sports area, skate park, and play equipment
- Frank Channon Walk. This shared path is located on the western side of the rail corridor, between Albert Avenue and Nelson Street. It provides pedestrian and cyclist access to Chatswood Croquet Club, Chatswood Bowling Club, and Chatswood Oval via an underpass
- Australia Shoshinkan at the Pacific Highway, which is the main Australian temple of the Happy Science church. Weekly meetings are held at the temple as well as regular overnight seminars
- Chatswood Croquet Club and Chatswood Bowling Club, on the Pacific Highway
- Aged care and independent living facilities, such as the Chapman Close Independent Living Units and the Healthy Living for Seniors North Sydney, on Chapman Avenue.

Table 19-2 Chatswood dive site (northern) – community infrastructure

Facility	Location	Type
Chatswood Park	Orchard Road, Chatswood	Sport and recreation
Chatswood Oval	Albert Avenue / Orchard Road, Chatswood	Sport and recreation
Chatswood Croquet Club	Pacific Highway, Chatswood	Sport and recreation
Chatswood Bowling Club	Pacific Highway, Chatswood	Sport and recreation
Frank Channon Walk	Albert Street to Nelson Street, Chatswood	Active transport
KU Chatswood Community Preschool	Victor Street, Chatswood	Childcare
Chapman Close Independent Living Units	Chapman Avenue, Chatswood	Aged living
Healthy Living for Seniors North Sydney	Chapman Avenue, Chatswood	Aged living
Chatswood South Uniting Church and Cemetery[1]	Pacific Highway, Lane Cove	Other
Australia Shoshinkan (Happy Science Church)	Pacific Highway, Lane Cove	Place of worship
Chatswood Public School	Centennial Avenue, Chatswood	Education
PermaPatch Community Garden	Mowbray Road, Lane Cove	Other
Matrix Education	Thomas Street, Chatswood	Education
Chatswood Youth Centre	Albert Avenue, Chatswood	Other
Shrine Music School Chatswood	Pacific Highway, Chatswood	Education
Mowbray Family Practice	Mowbray Road, Artarmon	Health
Artarmon Medical Centre	Hampden Road, Artarmon	Health
Chatswood Baptist Church	Albert Avenue, Chatswood	Place of worship
Park	Albert Avenue, Artarmon	Sport and recreation
Sutherland Park	Whitton Road, Chatswood	Park
Kenneth Slessor Park	Pacific Highway / Western Way, Chatswood	Park
Gordon Social and Recreation Club	Albert Avenue, Chatswood	Sport and recreation

1 *The Chatswood South Uniting Church was closed in 2012.*



KEY

- Chatswood to Sydenham
- Proposed operational area at surface
- Proposed dive structure
- Proposed construction site area

Social infrastructure

- Aged living
- Place of worship
- Childcare
- Sport and recreation
- Health
- Park
- Education
- Other

Indicative only, subject to design development

0 200 m

N

Figure 19-2 Chatswood dive site (northern) – community infrastructure

Artarmon substation

Community infrastructure around the Artarmon substation site is listed in Table 19-3 and shown on Figure 19-3. It includes:

- Education facilities, such as Artarmon Public School, on McMillan Road. Artarmon Public School provides primary education for about 980 students from kindergarten to Year 6. The school has established a temporary extension comprising demountable classroom buildings within the Artarmon substation site. It is understood that the school will vacate the site at the end of the 2017 school year
- Sport and recreation facilities, such as Thomson Park, on Reserve Road. Thomson Park includes a soccer field, synthetic cricket pitch, basketball court and practice net.

Table 19-3 Artarmon substation – community infrastructure

Facility	Location	Type
Thomson Park	Reserve Road, Artarmon	Sport and recreation
Artarmon Public School	McMillan Road, Artarmon	Education
Artarmon District Tennis Club	Barton Road, Artarmon	Sport and recreation

Figure 19-3 Artarmon substation – community infrastructure

Crows Nest Station

Community infrastructure around the Crows Nest Station site is listed in Table 19-4 and shown on Figure 19-4. It includes:

- Cultural facilities and places of worship, such as Northside Community Church, on the corner of Oxley Street and Pole Lane
- Sport and recreation facilities, such as the North Sydney Indoor Sports Centre, on Clarke Street and Hume Street, and Crows Nest Dance Centre on the Pacific Highway
- Kelly's Place Children's Centre, on the corner of Clarke Street and Hume Street. Kelly's Place is licensed to accommodate 40 children per day
- A number of healthcare facilities on Clarke Street, such as Crows Nest Day Surgery, Crows Nest Eye Surgery, Dental on Clarke, Special Needs Dentistry Practice, Special Medical Practice, North Shore Oral and Maxillofacial Surgery, and Specialist Endo Crows Nest.

Table 19-4 Crows Nest Station – community infrastructure

Facility	Location	Type
Kelly's Place Children's Centre	Hume Street, Crows Nest	Childcare
Northside Conference Centre	Oxley Street, Crows Nest	Other
Northside Community Church	Oxley Street / Pole Lane, Crows Nest	Place of worship
Crows Nest Post Shop	Pacific Highway	Other
Centre for Independent Studies	Oxley Street, Crows Nest	Education
Crows Nest Day Surgery	Clarke Street, Crows Nest	Health
Crows Nest Eye Surgery	Clarke Street, Crows Nest	Health
Dental on Clarke	Clarke Street, Crows Nest	Health
North Shore Oral and Maxillofacial Surgery	Clarke Street, Crows Nest	Health
Specialist Endo Crows Nest	Clarke Street, Crows Nest	Health
The Special Needs Dentistry Practice	Clarke Street, Crows Nest	Health
The Specialist Medical Practice	Clarke Street, Crows Nest	Health
Awareness Institute	Clarke Street, Crows Nest	Health
Crows Nest Dance Centre	Pacific Highway, Crows Nest	Sport and recreation
North Sydney Indoor Sports Centre	Hume Street, Crows Nest	Sport and recreation
Hume Street Park	Hume Street, Crows Nest	Park
The Specialist Paediatric Dental Practice	Clarke Street, Crows Nest	Health
The Salvation Army	Pacific Highway, Crows Nest	Place of worship
Australian Institute of Fitness	Oxley Street, Wollstonecraft	Education
Sydney Design School	Oxley Street, Wollstonecraft	Education
Crows Nest Fire Station	Shirley Road, Wollstonecraft	Emergency services

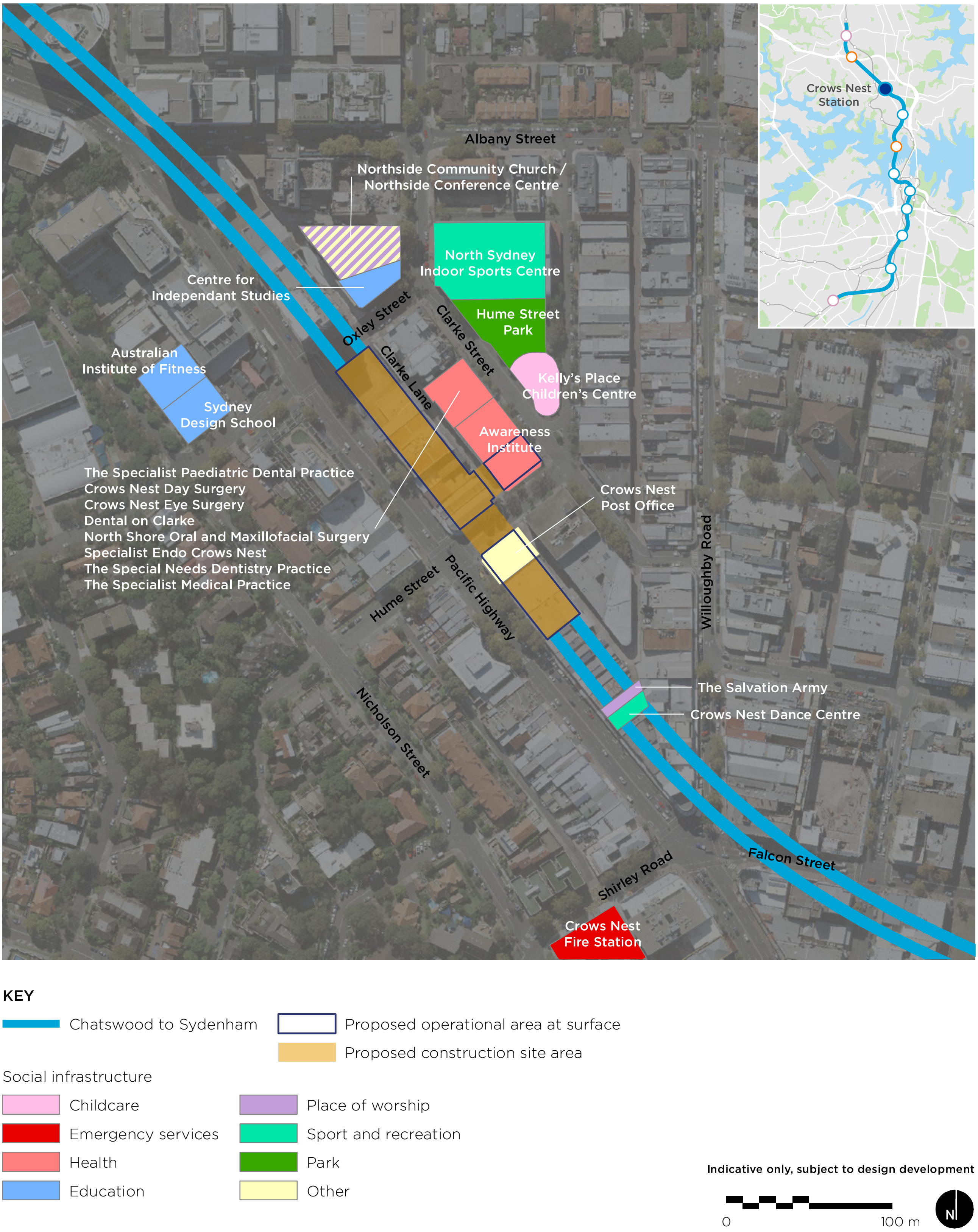


Figure 19-4 Crows Nest Station – community infrastructure

Victoria Cross Station

Community infrastructure around the Victoria Cross Station site is listed in Table 19-5 and shown on Figure 19-5. It includes:

- Education facilities such as Monte Sant' Angelo Mercy College, on Miller Street, and Wenona School, on Walker Street. Monte Sant' Angelo Mercy College offers secondary education for students in Year 7 to Year 12, and had 1164 students in 2014 (My School, 2015a). Wenona School is an independent day and boarding school offering education for students from kindergarten to Year 12. In 2014, the school had 1009 students, including 50 boarders (My School, 2015b)
- Childcare facilities. St Thomas' North Sydney Preschool is located within the grounds of St Thomas' Anglican Church on the corner of Church Street and McLaren Street. The preschool caters for 27 children per day. Goodstart Early Learning North Sydney, on the corner of Berry Street and the Pacific Highway, provides 89 places for children aged six weeks to five years. Only About Children on Berry Street provides 68 places for preschool children
- Sisters of Mercy North Sydney accommodation.

Table 19-5 Victoria Cross Station – community infrastructure

Facility	Location	Type
Only About Children	Berry Street, North Sydney	Childcare
Monte Sant Angelo Mercy College	Miller Street, North Sydney	Education
Miller Street Medical Practices	Miller Street, North Sydney	Health
Australian Catholic University School of Physiotherapy	Pacific Highway, North Sydney	Education
St Thomas Anglican Church and Memorial Hall	McLaren Street, North Sydney	Place of worship
St Thomas North Sydney Preschool	McLaren Street, North Sydney	Education
Goodstart Early Learning North Sydney	Berry Street, North Sydney	Childcare
Civic Park	Miller Street, North Sydney	Park
North Sydney Court House	Pacific Highway, North Sydney	Court house
Uniting Care Georgian House	McLaren Street, North Sydney	Aged care
Wenona High School	Walker Street, North Sydney	Education
Greenwood Medical Centre	Pacific Highway, North Sydney	Health
Quality Dental North Sydney	Elizabeth Plaza, North Sydney	Health
Wenona Primary School	Walker Street, North Sydney	Education
Mary Mackillop Place	William Street, North Sydney	Place of worship
North Sydney Stanton Library	Miller Street, North Sydney	Other
North Sydney Police Station	Pacific Highway, Crows Nest	Emergency services
North Sydney Council Chambers	Miller Street, North Sydney	Other
Sisters of Mercy (North Sydney)	McLaren Street, North Sydney	Other

Figure 19-5 Victoria Cross Station – community infrastructure

Blues Point temporary site

Community infrastructure around the Blues Point temporary site is listed in Table 19-6 and shown on Figure 19-6. It includes:

- Blues Point Reserve, which forms part of the Sydney Harbour foreshore and includes playground and picnic facilities. Blues Point Reserve is also a popular location for recreational fishing, canoeing and kayaking. The reserve is the starting point for canoe and board paddling events, such as the annual Bridge to Beach ocean paddling event
- McMahons Point Wharf, which caters for multiple Sydney Ferries routes.

Table 19-6 Blues Point temporary site – community infrastructure

Facility	Location	Type
Blues Point Reserve	Blues Point Road, McMahons Point	Park
McMahons Point Wharf	Henry Lawson Avenue, McMahons Point	Wharf

Figure 19-6 Blues Point temporary site – community infrastructure

Barangaroo Station

Community infrastructure around the Barangaroo Station site is listed in Table 19-7 and shown on Figure 19-7. It includes:

- Barangaroo Reserve, including Munn Reserve. The reserve is located on Sydney Harbour on the northern end of Barangaroo. It includes pedestrian and cycle paths, public lawn areas, and cultural spaces that can accommodate up to 5500 people. The reserve is an important location for large community events as well as smaller, private events and picnics
- Childcare facilities, such as KU Lance Preschool and Children's Centre on High Street, which is a long daycare centre catering for 39 children aged six weeks to five years.

Table 19-7 Barangaroo Station – community infrastructure

Facility	Location	Type
KU Lance Preschool and Children's Centre	High Street, Millers Point	Childcare
The Rocks Fire Station	Kent Street, Millers Point	Emergency services
Kent Street Tennis Court	Kent Street, Millers Point	Sport and recreation
Fort Street Public School	Upper Fort Street, Millers Point	Education
Sydney Observatory	Watson Road, Millers Point	Observatory
Observatory Park	Watson Road, Millers Point	Park
St Brigids School	Kent Street, Millers Point	Education
Abraham Mott Hall / Abraham Mott Youth Centre	Argyle Place, Millers Point	Other
Barangaroo Reserve	Merriman Street, Barangaroo	Park
Munn Street Reserve	Munn Street, Millers Point	Park

KEY

Chatswood to Sydenham

Proposed operational area at surface

Proposed construction site area

Social infrastructure

Childcare

Emergency services

Education

Observatory

Sport and recreation

Park

Other

Indicative only, subject to design development

0 100 m

N

Figure 19-7 Barangaroo Station – community infrastructure

Martin Place Station

Community infrastructure around Martin Place Station is listed in Table 19-8 and shown on Figure 19-8. It includes:

- Martin Place, which is a pedestrian-only public space. It comprises the Cenotaph (war memorial), sculptures, fountains and seating, and is surrounded by retail and commercial uses. Martin Place hosts a number of community events, including annual ANZAC day services
- Educational facilities, such as the University of Newcastle Sydney Campus, on Elizabeth Street
- Childcare facilities, such as the Martin Place Early Learning Centre. The Martin Place Early Learning Centre is a long day care centre, providing 76 places for children aged six weeks to five years
- Health and emergency services, such as the Sydney Hospital and Sydney Eye Hospital, on Macquarie Street, Sydney which provides surgical and medical treatment, and a 24-hour emergency service
- Entertainment facilities, such as the Theatre Royal at the MLC Centre, on King Street. The theatre is a key cultural and arts venue, hosting a large number of plays, musicals and other events. It has seating for more than 1100 people.

Table 19-8 Martin Place Station – community infrastructure

Facility	Location	Type
Martin Place	Martin Place, Sydney	Open space / active transport
Martin Place Early Learning Centre	Martin Place, Sydney	Childcare
MLC Centre (Theatre Royal)	Martin Place, Sydney	Other
University of Newcastle	Elizabeth Street, Martin Place	Education
Chifley Square	Chifley Square, Sydney	Open space
Hyde Park Barracks Museum	Macquarie Street, Sydney	Museum
St James Church	King Street, Sydney	Place of worship
High Court Of Australia; NSW Federal Court Registry; Federal Magistrates Court Of Australia NSW; Supreme Court	Queens Square, Sydney	Court house
The Mint	Macquarie Street, Sydney	Museum
Sydney Hospital and Sydney Eye Hospital	Macquarie Street, Sydney	Health
Cenotaph	Martin Place, Sydney	Monument
St Stephen's Uniting Church	Macquarie Street, Sydney	Place of worship
Museum of Sydney	Phillip Street / Bridge Street, Sydney	Museum
GPO Post Office	George Street, Sydney	Other
City Recital Hall	Angel Place, Sydney	Cultural
Parliament of NSW	Macquarie Street, Sydney	Other
State Library of NSW	Macquarie Street, Sydney	Library
Richard Johnson Square	Castlereagh Street, Sydney	Open space

KEY

Chatswood to Sydenham

Proposed operational area at surface

Proposed construction site area

Social infrastructure

Childcare
Health
Education
Museum
Cultural
Open space
Court house
Monument
Place of worship
Other

Indicative only, subject to design development

0 100 N

Figure 19-8 Martin Place Station – community infrastructure

Pitt Street Station

Community infrastructure around the Pitt Street Station site is listed in Table 19-9 and shown on Figure 19-9. It includes:

- Hyde Park at Elizabeth Street, which covers over 16 hectares and is Australia's oldest park. It includes a number of notable monuments and features including the Archibald Fountain and ANZAC Memorial and Pool of Reflection. It is also the location of major community events such as the Sydney Food and Wine Fair, NAIDOC celebrations and events for the Sydney Festival
- Great Synagogue Sydney, on Castlereagh Street. The synagogue conducts services each weekday morning and afternoon, Friday evenings and Saturdays, and hosts a number of events throughout the year and weekly public tours on Tuesdays and Thursdays
- Pitt Street Uniting Church, on Pitt Street. The church conducts weekly services on Sunday morning, as well as monthly Sunday afternoon services
- Church of Scientology, on Castlereagh Street. The church conducts Sunday morning services, weekend seminars and other weekday events
- Presbyterian Church of Eastern Australia, on Castlereagh Street. The church conducts Sunday services and Wednesday evening services.

Table 19-9 Pitt Street Station – community infrastructure

Facility	Location	Type
Wholistic Medical Centre	Park Street, Sydney	Health
Great Synagogue Sydney	Castlereagh Street, Sydney	Place of worship
Pilgrim Theatre	Pitt Street, Sydney	Other
City of Sydney Fire Station	Castlereagh Street, Sydney	Emergency services
Church Of Scientology of Sydney	Castlereagh Street, Sydney	Place of worship
Presbyterian Church of Eastern Australia	Castlereagh Street, Sydney	Place of worship
Sydney Mechanics School of Arts	Pitt Street, Sydney	Education
Kingsway Institute	Bathurst Street, Sydney	Education
Sydney Premier Medical and Health Care Centre	Pitt Street, Sydney	Health
Central Court House	Liverpool Street, Sydney	Court house
Anzac War Memorial	Hyde Park, Sydney	Monument
Wesley Mission Sydney and Conference Centre	Pitt Street, Sydney	Other
University of Sydney Business School CBD Campus	Castlereagh Street, Sydney	Education
Go Study Australia (Sydney)	Pitt Street, Sydney	Education
Town Hall Police Station	George Street, Sydney	Emergency services
Town Hall Information Kiosk Sydney	George Street, Sydney	Other
Pitt Street Uniting Church	Pitt Street, Sydney	Place of worship
Mercury Colleges	Castlereagh Street, Sydney	Education
Cubbyhouse Childcare	George Street, Sydney	Childcare
Australian International College of English	Pitt Street, Sydney	Education
Hyde Park	Elizabeth Street / Liverpool Street, Sydney	Park
The Metro Theatre	George Street, Sydney	Other

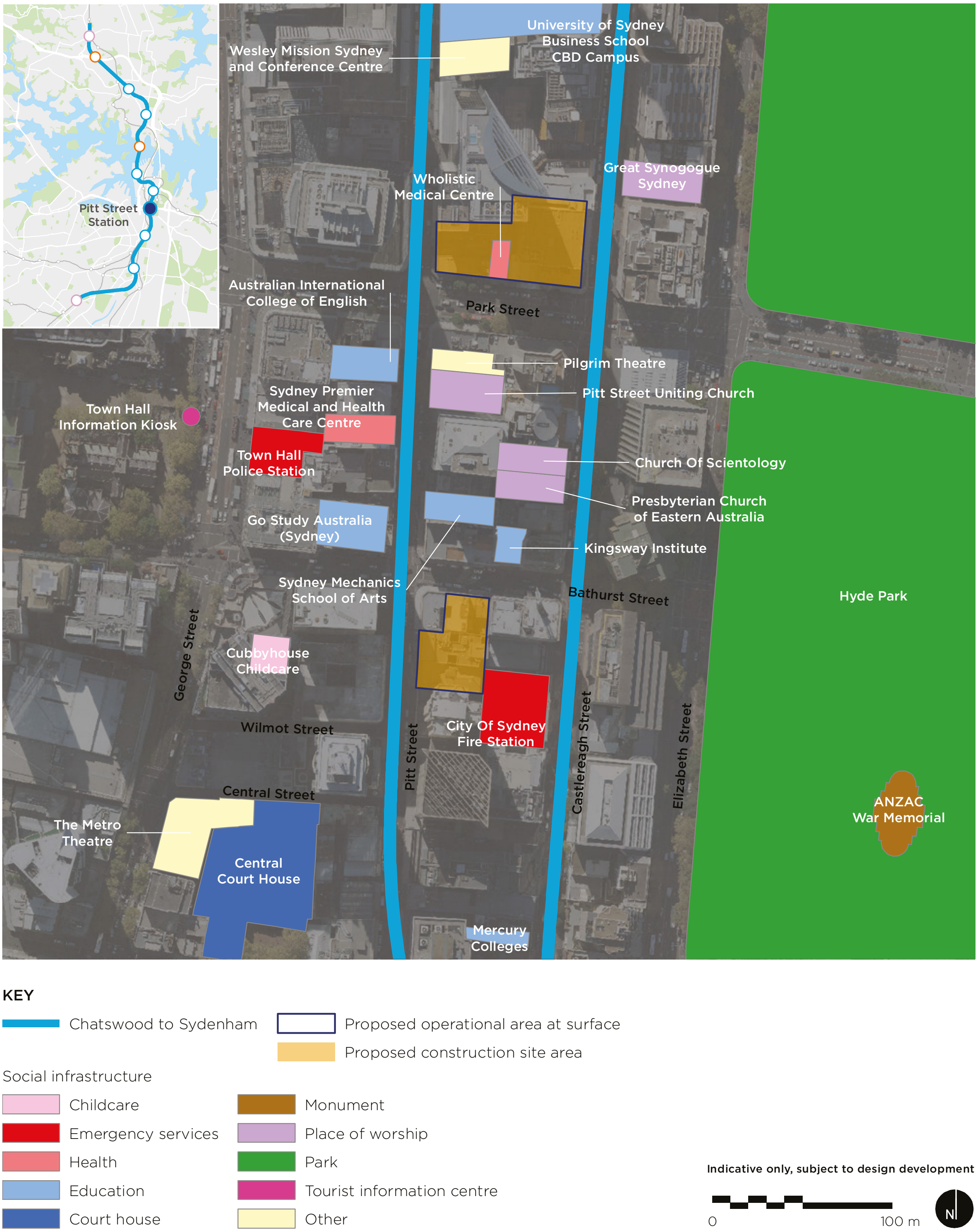


Figure 19-9 Pitt Street Station – community infrastructure

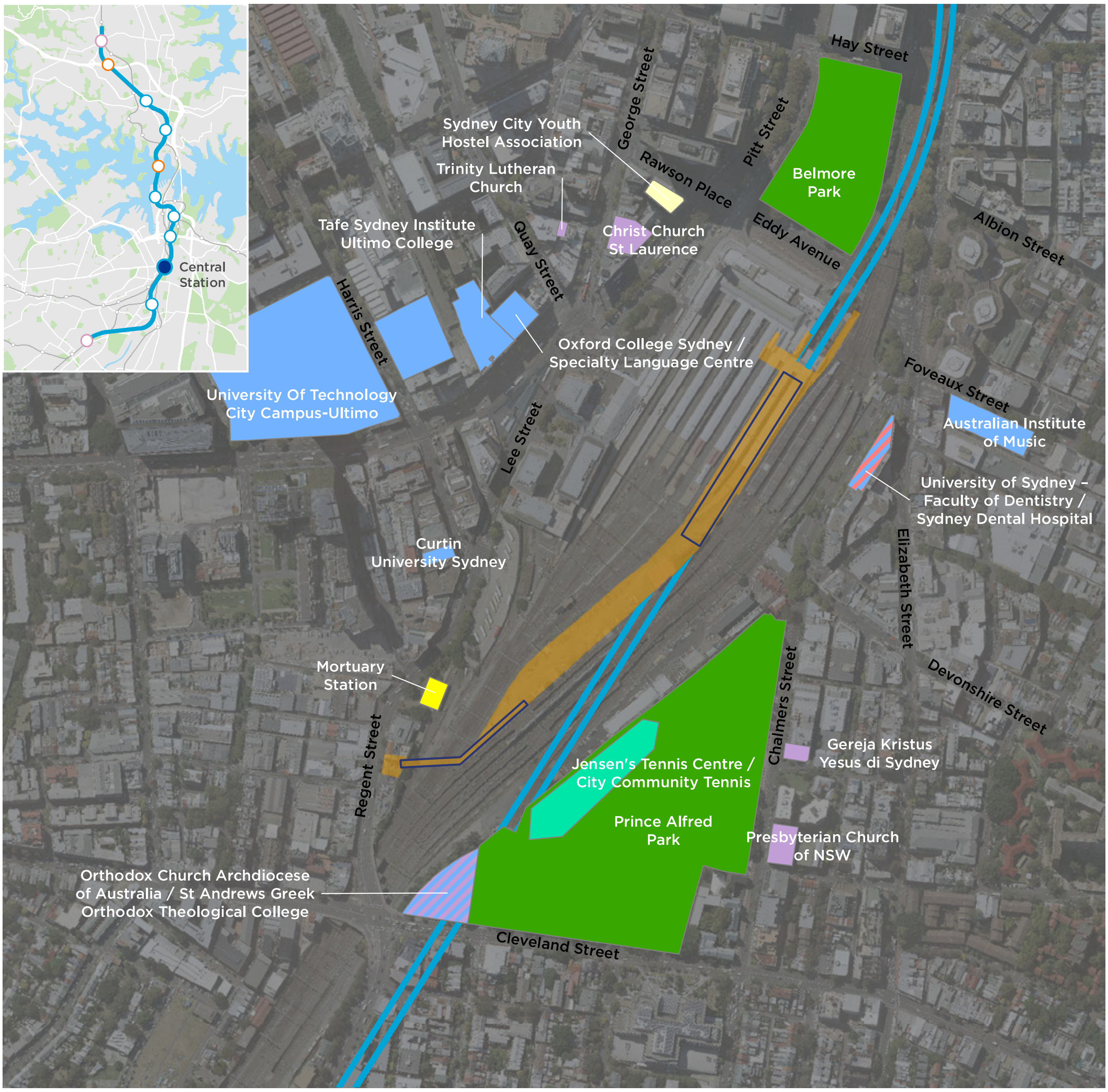
Central Station

Community infrastructure around Central Station is listed in Table 19-10 and shown on Figure 19-10. It includes:

- Prince Alfred Park, at Chalmers Street. The park has formal and informal recreation facilities, including an outdoor swimming pool; tennis centre with five tennis courts used for social tennis, private coaching and formal tennis competitions; community centre, walking paths, playgrounds and picnic areas; and dog off-leash area. The park is also popular for personal training and group training sessions during the mornings and evenings
- Tertiary education facilities, such as Curtin University Sydney and the University of Technology Sydney. Curtin University Sydney is on Regent Street, Chippendale. It has over 900 students but is due to close by early 2017 (Curtin University Sydney, 2015). The University of Technology Sydney is located on Broadway at Ultimo. It had about 34,610 students in April 2015 (University of Technology Sydney, 2015). Other education facilities near Central Station include TAFE Sydney Institute Ultimo College on George Street, Oxford College Sydney on George Street, St Andrew's Greek Orthodox Theological College on Cleveland Street, and The University of Sydney Faculty of Dentistry and Sydney Dental Hospital on Chalmers Street
- Cultural facilities and places of worship, such as Christ Church St Laurence on Pitt Street, which conducts about 25 services each week including weekly Sunday services and daily morning and evening prayer services; and Orthodox Church Archdiocese of Australia, Cathedral of the 'Annunciation of Our Lady Theotokos' on Cleveland Street.

Table 19-10 Central Station – community infrastructure

Facility	Location	Type
TAFE Sydney Institute Ultimo College	Harris Street, Ultimo	Education
Oxford College Sydney	George Street, Haymarket	Education
Christ Church St Laurence	George Street, Sydney	Place of worship
University of Sydney Faculty of Dentistry	Chalmers Street, Sydney	Education
Sydney Dental Hospital	Chalmers Street, Sydney	Health
St Andrews Greek Orthodox Theological College	Cleveland Street, Redfern	Education
Prince Alfred Park	Chambers Street, Surry Hills	Park
Orthodox Church Archdiocese of Australia	Cleveland Street, Redfern	Place of worship
Jensen's Tennis Centre	Cleveland Street, Surry Hills	Sport and recreation
Presbyterian Church of NSW	Chalmers Street, Surry Hills	Place of worship
Mortuary Station	Regent Street, Chippendale	Historic site
Curtin University Sydney	Regent Street, Sydney	Education
Specialty Language Centre	George Street, Sydney	Education
Australian Institute Of Music	Foveaux Street, Surry Hills	Education
University Of Technology City Campus-Ultimo	Broadway, Ultimo	Education
Trinity Lutheran Church	Valentine Street, Sydney	Place of worship
City Community Tennis	Cleveland Street, Surry Hills	Sport and recreation
Belmore Park	Hay Street, Haymarket	Park
Gereja Kristus Yesus di Sydney	Chalmers Street, Surry Hills	Place of worship
Sydney City Youth Hostel Association	Rawson Place, Haymarket	Other



KEY

Chatswood to Sydenham

Proposed operational area at surface

Proposed construction site area

Social infrastructure

Health

Education

Historic site

Place of worship

Sport and recreation

Park

Other

Indicative only, subject to design development

0 200 m

N

Figure 19-10 Central Station – community infrastructure

Waterloo Station

Community infrastructure around the Waterloo Station site is listed in Table 19-11 and shown on Figure 19-11. It includes:

- Waterloo Congregational Church on Botany Road, which conducts Sunday morning services as well as services at Christmas and Easter
- Waterloo Medical Centre on Raglan Street. It provides a range of general medical services for the local community
- Sport and recreation facilities, such as the IWKA martial arts school.

Table 19-11 Waterloo Station – community infrastructure

Facility	Location	Type
Waterloo Congregational Church	Botany Road, Waterloo	Place of worship
Waterloo Medical Centre	Raglan Street, Waterloo	Health
Eveleigh Ambulance Station	Garden Street, Eveleigh	Emergency services
The Salvation Army Community Centre	Phillip Street / Cope Street, Waterloo	Place of worship
Daniel Dawson Reserve	Wyndham Road, Waterloo	Park
Uniting Church Tonga Parish	Regent Street, Redfern	Place of worship
Sydney Film School	Cope Street, Waterloo	Education
IKWA Kung Fu	Botany Road, Waterloo	Sport and recreation
Park on Cope Street	Cope Street, Redfern	Park
Park on Rosehill Street	Rosehill Street, Redfern	Park
Vice Chancellors Oval	Henderson Road, Eveleigh	Sport and recreation

KEY

Chatswood to Sydenham

Proposed operational area at surface

Proposed construction site area

Social infrastructure

Emergency services

Sport and recreation

Health

Park

Education

Other

Place of worship

Indicative only, subject to design development

0 200 m

N

Figure 19-11 Waterloo Station – community infrastructure

Marrickville dive site (southern)

Community infrastructure around the Marrickville dive site is listed in Table 19-12 and shown on Figure 19-12. It includes:

- St Pius' Catholic Primary School on Edgeware Road, which provides primary education for about 188 students (My School, 2015c)
- Camdenville Public School and Preschool at Wells Street, above the proposed tunnel alignment. The school offers primary education for students in preschool to Year 6. In 2014, the school had 198 students (My School, 2015d)
- Camdenville Park on May Street, which provides a range of formal and informal sport and recreation facilities
- Sydney Park, on Sydney Park Road. The park covers an area of about 40 hectares and includes grassed areas, landscaped gardens and informal recreation and play facilities, including playground, cafes, and barbeque facilities. The Sydney Park Cycling Centre is also located in the park.

Table 19-12 Marrickville dive site (southern) – community infrastructure

Facility	Location	Type
St Pius Catholic Primary School	Edgeware Road, Enmore	Education
Camdenville Park	May Street, Sydenham	Park
Camdenville Public School	Laura Street, Newtown	Education
Sydney Trapeze School	Unwins Bridge Road, St Peters	Sport and recreation
Sydney Indoor Climbing Gym	Unwins Bridge Road, St Peters	Sport and recreation
St Pius Enmore	Edgeware Road, Enmore	Place of worship

Figure 19-12 Marrickville dive site (southern) – community infrastructure

19.3.5 Access and connectivity

The study area includes several major transport facilities, which provide a high level of access and connectivity within the study area, to the wider Sydney area and regional NSW. These include passenger and light rail services, bus and ferry services, active transport facilities, and roads. Further detail on existing and planned transport infrastructure near the project is provided in Chapter 9 (Operational traffic and transport).

Early community consultation for the project identified access and connectivity to be important to the local community.

Travel to work

Travel to work by residents in the study area generally reflects the study area's high level of access to public transport, pedestrian and cycle networks and proximity to key employment and activity centres in the Sydney CBD, North Sydney and St Leonards.

In 2011, 24.1 per cent of workers living in the study area aged 15 years or over travelled by train for all or part of their journey to work, compared to 9.3 per cent in NSW as a whole. In particular, the SA2 areas of Chatswood (East), Sydenham, Erskineville and St Leonards had very high levels of train users, reflecting the proximity of these areas to existing train stations.

About 10 per cent of people in the study area travelled to work by bus only, while about 20 per cent either walked or cycled. Overall, the study area had lower proportions of people who worked at home or did not go to work compared to NSW as a whole. However, the SA2s of North Sydney, Crows Nest, St Leonards and Chatswood (East) all had proportions of people who worked from home either at or above the State average.

19.4 Potential impacts

Potential impacts on community values and community infrastructure as a result of the project are assessed in this section.

19.4.1 Property impacts

Information on properties to be acquired for the project is provided in Chapter 12 (Land use and property). A number of businesses would be directly impacted by acquisition for the project. Further information on these impacts is provided in Chapter 13 (Business impacts).

The project would acquire a small number of residential uses at Crows Nest, Elizabeth Street near Martin Place Station, Regent Street near Central Station, and Waterloo. Residents of these properties would need to relocate prior to commencement of construction.

The relocation of households due to property acquisition may impact on community relationships and social networks for some residents, if they are required to move away from existing social and support networks. This is particularly important for longer term residents, elderly people and people with disability, who may find it more difficult to adapt to new surroundings. As indicated in Section 19.3.2, residential properties to be acquired are located in areas generally characterised by communities with younger populations, relatively high levels of population mobility and relatively low levels of people needing assistance. These impacts would be localised, but would likely be significant to the quality of life of residents who relocate and other members of their local networks, and would be managed on a case by case basis.

Uncertainty around potential property acquisitions and proposed changes has potential to cause stress and anxiety for some residents, business owners and employees, potentially affecting health and well-being for these people. This is discussed in Section 19.4.3.

19.4.2 Population and demography

Project related factors affecting population and demography generally relate to the acquisition of residential properties or in some cases, influx of construction workers.

Given the relatively small number of residential properties to be acquired for the project, there are not expected to be any impacts on population and demography relating to property acquisition.

It is expected that construction workers for the project would generally be sourced from across the broader Sydney region, or elsewhere as required. This would not result in an influx of workers at a scale that would impact on population size or demography in the study area. Indirectly, the development of new stations would support opportunities for urban renewal in areas around stations, including housing intensification. This would support population growth in these areas, consistent with State and local strategic planning priorities.

Workforce development is one of six areas of commitment in the Sydney Metro City & Southwest sustainability policy (see Chapter 25 (Sustainability)). The delivery of the project offers the potential to increase workforce capability and capacity, mitigate skills shortages and gaps that would reduce cost, improve productivity and provide local sustainable employment. Sydney Metro's skills legacy would improve the competitiveness of industry, provide individual career pathways and provide major socio-economic benefits to individuals and communities. A workforce development program would be implemented for Sydney Metro City & Southwest, building on current activity from Sydney Metro Northwest and an assessment of future needs.

19.4.3 Community values

Community cohesion

During construction, changes to amenity of public places and local centres near to construction sites may impact on people's use and enjoyment of these areas. Changes in local access near to construction activities and temporary changes to public transport facilities may also discourage some people from making some trips. These changes may temporarily impact on levels of community interaction.

Acquisition for the project of community facilities such as the Martin Place Early Learning Centre, and local businesses such as cafes and restaurants would result in the loss or relocation of these uses. This may impact on local networks associated with these uses and levels of community cohesion. Potential impacts associated with the acquisition of the Martin Place Early Learning Centre are discussed in Section 19.4.4.

Operation of the project would improve access to fast, efficient public transport for local and regional communities. New stations at Crows Nest, Victoria Cross, Barangaroo and Waterloo would improve access to communities, facilities, services and employment in these areas from across the broader Sydney region, and improve access for local communities to other destinations across the Sydney region. This would help to facilitate social interaction and economic transactions within the study area and greater Sydney region, providing benefits for community cohesion. The project would also make some trips more attractive, helping to facilitate community interaction. This would benefit residents, workers, students, visitors and public transport users.

At a local level, the project would help to improve access to local facilities, services and destinations, supporting opportunities for community interaction. As discussed in Chapter 12 (Land use and property), the project would also support urban renewal and development opportunities near the metro stations, supporting the revitalisation of local centres and creating opportunities for new facilities and local meeting places. This is expected to have positive impacts on local community cohesion.

Local amenity and character

Operation of the project would improve the amenity of those areas near the metro stations by enhancing access to public transport and improvements to the public domain surrounding stations, including awnings for shade and shelter at street level and station entries, street furniture and in some locations landscaping. Metro stations would also be designed to provide safe and efficient interchange between transport modes, including minimising conflicts between pedestrians, cyclists, buses and vehicles. This would be achieved by implementing the metro station access hierarchy (refer to Section 19.4.2).

During construction, impacts on amenity may occur for communities close to construction sites due to:

- Increased noise and vibration, dust, and traffic from construction activities (refer to Chapter 10 (Construction noise and vibration), Chapter 22 (Air quality), and Chapter 8 (Construction traffic and transport)
- Changes in visual amenity near construction sites (refer to Chapter 16 – Landscape character and visual amenity).

Changes to amenity during construction may temporarily impact on the potential use and enjoyment of some residential properties closest to construction works, particularly of outdoor areas, including balconies. Noise and lighting from night-time surface works, and ground-borne noise and vibration from tunnelling works may also impact on the night-time amenity for some residents closest to the project.

Impacts of the project on local amenity and character near community infrastructure are discussed further in Section 19.4.4.

Community health and safety

Community health – construction

If unmanaged, noise, light spill, dust and vibration from construction activities may impact on the health and wellbeing of some residents and occupants of buildings nearest to construction sites. In particular, the potential for dust from construction activities to impact on health of some sections of the community who may be more sensitive to changes in air quality (such as children or elderly people who suffer asthma or similar conditions), is likely to be of concern for some community members. This impact is most likely to occur where night-time work results in sleep disturbance over extended periods or where construction activities create extended periods of high noise or dust levels.

The majority of station fit-out and other aboveground construction activities would be carried out during standard daytime construction hours (as identified in Chapter 7 (Project description – construction)). Activities such as tunnelling, underground excavation at station and ancillary sites, and associated traffic construction, would occur 24 hours per day, up to seven days per week. Some other activities may also need to be carried out outside of standard daytime construction hours to minimise disruptions to local and regional road networks and rail services (refer to Chapter 7 (Project description – construction)).

The implementation of mitigation measures, in conjunction with ongoing consultation and communication with local communities, would help to manage potential impacts on community health (refer to Chapter 10 (Construction noise and vibration)). Uncertainty about local changes associated with the project and project impacts would have the potential to impact on health, wellbeing and / or quality of life for some people. For example, some residents, business owners and employees facing changes due to property acquisition or impacts on amenity due to increased construction noise, vibration, dust and traffic may experience stress and anxiety.

Consultation and communication with affected property owners and communities about the project's property requirements and construction activities (including timing, likely impacts and mitigation measures) would be important in reducing uncertainty and helping people make decisions about their property and / or business. Property acquisition is discussed in Chapter 12 (Land use and property).

Community health – operation

Operation of the project would improve public transport access and connectivity to employment and community infrastructure such as health services; educational, sport, recreation and leisure facilities; and community support services in the Sydney CBD and inner Sydney as well as across the wider Sydney region. This would support:

- Improved long term economic opportunities through better access to education and employment opportunities
- Opportunities for social interaction, by encouraging some people to take trips that they may have avoided due to unacceptable travel times and improved access to meeting places within the inner city and wider Sydney region
- Increased physical activity through improved access to sport, recreation and leisure facilities, such as Barangaroo Reserve, Prince Alfred Park, and Moore Park sporting and entertainment precinct
- Enhanced community health outcomes through improved access to health, medical and community support facilities within the Sydney CBD, inner Sydney and wider Sydney region.

Improved public transport access would particularly benefit those groups that currently experience transport or mobility difficulties such as elderly people, youth, people with disability, non-drivers or people without access to a private vehicle.

Improved public transport access is also likely to encourage increased walking trips, with many trips by public transport including an element of walking, for example, to or from stations. This would help to increase levels of physical activity, which would have positive community health outcomes. These impacts are likely to be ongoing with physical activity more likely to be initiated or sustained when incorporated into everyday activities, such as the commute to work (Queensland Health, 2005).

Electrical infrastructure would be required for the project, including:

- Substations within metro stations to provide power to the stations and trains
- Substations at Artarmon and the southern services facility (adjacent to the Marrickville dive site (southern))
- A network of overhead conductor bars providing power to the trains.

Possible health effects associated with electric and magnetic fields generated by electrical infrastructure may be a concern for some people. The *Draft Radiation Standard – Exposure Limits for Magnetic Fields* (Draft Radiation Standard) (Australian Radiation Protection and Nuclear Safety Agency, 2006) identifies exposure limits that are typically applied when considering electric and magnetic fields from new developments. The design of the substations has positioned these facilities as far as practical from nearby residences and other public areas (eg the Artarmon substation is positioned adjacent to the Gore Hill Freeway and as far as practical from the nearby residences). The detailed design of electrical infrastructure for the project would ensure that the exposure limits for the local community suggested by the Draft Radiation Standard would not be exceeded within public areas. This would achieved through positioning of infrastructure within the site to direct electric and magnetic fields away from residences and other public areas.

Safety – construction

The use of local roads by construction vehicles and an increase in construction traffic may impact on community perceptions of road safety. This would be particularly relevant:

- In areas that attract high numbers of pedestrians and cyclists, such as local centres (Crows Nest and North Sydney, and McMahons Point), the Sydney CBD and areas surrounding public transport facilities such as Central Station
- Near community facilities that are used by children and students (such as schools, childcare centres, and parks) or by people with mobility difficulties, such as elderly people or people with disability (for example, medical and health facilities)
- Near major facilities and community spaces such as Barangaroo Reserve and Hyde Park.

An increase in construction traffic and heavy vehicles on roads with community infrastructure may also impact on safety or community perceptions of safety for users of these facilities, including children. The implementation of mitigation measures for managing potential safety risks associated with construction traffic are discussed in Chapter 8 (Construction traffic and transport).

Pedestrian and cycle access would be maintained near construction sites, but temporary changes would be required to some footpaths to ensure the safety of pedestrians and cyclists. Changes to public spaces and footpaths may impact on peoples' perceptions of safety through reduced sight lines, opportunities for casual surveillance and levels of activity. This impact would be managed through the application of Crime Prevention through Environmental Design principles, which take into account the relationship between the physical environment and the users of that environment, promoting maximum useability and safety.

The needs of people with mobility difficulties – such as children, elderly people and people with disability – would also be considered in the design of temporary pedestrian and cycle facilities. Where possible, traffic controllers would be used to ensure safety for pedestrians and cyclists, such as at access points to construction sites. Temporary changes to pedestrian and cycle access would need to be clearly communicated and marked to ensure safety for pedestrians and cyclists.

Safety – operation

During consultation for the project, some community members raised safety concerns regarding the driverless operation of trains, including concerns about potential passenger support during train breakdowns and the potential for increase in crime. Other issues raised by community members in relation to safety included accessibility for elderly people, the inclusion of lifts at the stations, air quality maintenance and a desire for a smaller gap between the train and platform.

The project includes a number of design features to maintain safety on trains, at stations and within station precincts. These include:

- Customer service assistants and help points on trains and in stations
- Design for clear visibility
- Easy access between carriages
- Platform screen doors
- Station and train design that allows for both passive and active surveillance.

Safety within public places is also important to communities within the study area. The metro stations and station precincts would be designed according to the principles of Crime Prevention through Environmental Design to maximise safety and security for customers, staff and in areas surrounding the station. For example, metro stations and station precincts would include:

- Lighting systems, visible closed circuit television surveillance and appropriate staffing levels during operational hours, which would contribute to safe station environments
- Passive design elements that promote safety, such as clear sight lines within and around stations, use of natural daylight and wide paths to avoid blind spots.

In addition, the increased amount of pedestrian activity and the changes to urban environments and public places around stations are likely to impact positively on people's perceptions of personal safety. Activation of streets and public spaces surrounding the metro stations would also help to improve community safety.

Access and connectivity

The project would provide long-term positive impacts on public transport access for local and regional communities, by enhancing public transport access and providing more effective and efficient public transport services to and from inner Sydney, benefiting residents, workers, students, visitors and public transport users.

Metro stations would be designed to comply with the requirements of the *Disability Discrimination Act 1992*, ensuring that the stations are accessible to people with mobility difficulties. This may encourage some people, who may otherwise avoid making trips, to access public transport. This is likely to have positive impacts on the health and wellbeing of these people.

Operation of the project would require some changes to local road access and pedestrian and cycle connections near surface infrastructure and metro stations. This may impact on local access and connectivity for communities in these areas.

During construction, temporary impacts on local access and connectivity may be experienced by motorists, public transport users, pedestrians and cyclists associated with temporary road closures, increased construction traffic, changes to pedestrian and cycle paths, and temporary disruptions to some train services. As indicated in Section 19.3, train, bus, walking and cycling are important modes of transport for residents and workers in the study area and management of potential impacts on these modes of transport is important.

A detailed assessment of potential impacts of the project on access and connectivity are described in Chapter 8 (Construction traffic and transport) and Chapter 9 (Operational traffic and transport).

19.4.4 Community infrastructure

The project would have positive impacts on access to community infrastructure for communities in the study area and across the greater Sydney region, by improving public transport access to regional level community infrastructure within or near to the study area, including:

- Major tertiary education facilities, including the Northern Sydney Institute of TAFE, Australian Catholic University North Sydney Campus, University of Technology Sydney, University of Notre Dame, and Curtin University Sydney
- Secondary education facilities such as North Sydney Girls High School at Crows Nest; and Monte Sant' Angelo Mercy College and Shore Sydney Church of England Grammar School at North Sydney
- Sport, leisure and entertainment facilities such as the Moore Park sporting and entertainment precinct and adjoining Sydney Football Stadium and Sydney Cricket Ground, entertainment activities at Willoughby Road at Crows Nest and Darling Harbour
- Major open spaces, such as Barangaroo Reserve, The Domain and Royal Botanic Gardens Sydney, and Hyde Park
- Community facilities and services organisations located at Crows Nest, North Sydney and within the Sydney CBD.

Some community infrastructure located near to the project may also experience impacts during construction and operation, due to such things as property acquisition, or changes in amenity or local access. These impacts are described in the following sections.

Chatswood dive site (northern)

Community facilities near to construction activities and haulage routes for the Chatswood dive site include:

- Chatswood Park and Chatswood Oval, on Orchard Road
- Frank Channon Walk, from Albert Street to Nelson Street
- Happy Science Church, on the Pacific Highway
- Chatswood Croquet Club and Chatswood Bowling Club, on Hammond Lane
- Aged care facilities and independent living units, on Chapman Avenue and Seldon Lane.

Amenity

Temporary impacts on amenity may be experienced by users of these facilities due to increased noise and dust from surface work, excavation and spoil haulage; ground-borne noise and vibration from excavation and tunnelling; and increased construction traffic associated with spoil haulage and materials delivery.

The potential for dust to impact the health of those people who are more sensitive to changes in air quality may be a concern for some community members given the proximity of construction activities to recreation and aged care facilities.

Access

Construction of the project would require the temporary closure of the Frank Channon Walk. The closure of Frank Channon Walk would likely occur over several weekends associated with track possessions. During these periods, pedestrian and cycle access to Chatswood Station from areas to the south would be maintained via the Pacific Highway or Orchard Road. Nearby community infrastructure such as the Chatswood Croquet Club, Chatswood Bowling Club and Chatswood Oval would remain accessible for pedestrians via the local street network.

Artarmon substation

Community infrastructure is not anticipated to be impacted by the construction or operation of Artarmon substation. The site will be temporarily used as an extension to Artarmon Public School for the 2016 and 2017 school years. Construction of the Artarmon substation is not scheduled to occur until after this time.

Crows Nest Station

Community facilities that would be closest to construction activities at Crows Nest Station include:

- Northside Community Church and Northside Conference Centre, on Oxley Street
- Centre for Independent Studies, on Oxley Street
- North Sydney Indoor Sports Centre, on Clarke Street and Hume Street
- Hume Street Park, on Hume Street
- Kelly’s Place Children’s Centre, on the corner of Clarke Street and Hume Street.

Property acquisition

The project would require the full property acquisition of the Crows Nest Post Shop, on the Pacific Highway. Potential impacts associated with the acquisition of the post office are described in Chapter 13 (Business impacts). Details of property acquisition are discussed in Chapter 12 (Land use and property).

Amenity

Temporary impacts on amenity may be experienced by users of community facilities near to construction works due to increased noise and dust from excavation activities and spoil haulage, ground-borne noise and vibration from cut-and-cover excavation and tunnelling, and increased construction traffic. The implementation of environmental and traffic mitigation measures at construction sites, and early and ongoing consultation with managers of community facilities, would help to manage impacts on users of these facilities.

Increased noise and dust from construction activities may impact on amenity at Kelly’s Place Children’s Centre, particularly outdoor play areas. In addition, potential health impacts associated with increased construction dust may be a concern for some children who suffer asthma or similar conditions.

Increased construction traffic on Oxley Street and Clarke Street may also impact on amenity for some users of the Northside Community Church and associated conference centre. These impacts may also be experienced by users of the Centre for Independent Studies.

Users of the Crows Nest Dance Centre at the Pacific Highway may experience temporary changes to amenity due to ground-borne noise and vibration from underground works.

Access

If unmanaged, the use of Clarke Street and Hume Street by heavy vehicles accessing the construction site may present a safety risk for parents and children accessing Kelly's Place Children's Centre, particularly during morning drop-off and afternoon pick-up times, as well as for people using North Sydney Indoor Sports Centre. The Kelly's Place Children's Centre drop off area would not be directly affected by the project.

Victoria Cross Station

Community facilities that would be closest to construction activities at Victoria Cross Station include:

- Only About Children childcare, on Berry Street
- Monte Sant' Angelo Mercy College, on Miller Street
- Australian Catholic University School of Physiotherapy, on the Pacific Highway
- Miller Street Medical Practices.

In addition, a number of community facilities are located along potential haulage routes, including:

- St Thomas' Anglican Church, on the corner of Church Street and McLaren Street
- St Thomas' North Sydney Preschool, which is located on the grounds of the Anglican Church on Church Street and McLaren Street
- North Sydney Council offices, on the corner of McLaren Street and Miller Street
- Goodstart Early Learning North Sydney, on the corner of Berry Street and the Pacific Highway.

Amenity

Potential impacts on amenity may be experienced by users of community facilities due to noise and dust from surface work associated with excavation of the station shaft and ground-borne noise and vibration from excavation of the station cavern and tunnelling. Increased construction traffic, including heavy vehicles, removing spoil and delivering materials, may also impact on amenity at these facilities.

Potential impacts on Monte Sant' Angelo Mercy College and the Sisters of Mercy North Sydney accommodation would generally relate to noise and dust from surface work associated with the excavation of the station shafts, ground-borne noise and vibration from station excavation and use of McLaren, Miller and Berry streets for hauling spoil, materials and equipment. The Sisters of Mercy North Sydney accommodation would also experience some night time noise impacts during the construction phase. Effects would be more noticeable in outdoor teaching and recreation areas. Potential disruption to students during school examination periods from construction activities was identified as a concern during early consultation for the project. Consultation would be carried out with the College during construction to assist in managing potential impacts.

Access

Access and egress to the main construction site for Victoria Cross Station would be via Miller Street. The main vehicle entry to Monte Sant' Angelo Mercy College for student drop-off and pick-up is via Miller Street. Many students travelling to school by public transport are also likely to use bus stops at Miller Street or walk from North Sydney train station via Miller Street. As such, an increase in construction traffic, including heavy vehicles, on Miller Street and surrounding roads may present possible safety risks for students or impact on community perceptions of safety for students.

Increased construction traffic on Miller, McLaren and Berry streets may also present potential safety risks for children attending St Thomas' North Sydney Preschool and Goodstart Early Learning North Sydney, particularly during drop-off and pick-up times. Possible measures for managing safety would include limiting heavy vehicle access near schools and childcare centres during drop-off and pick-up times. Ongoing consultation and communication with the school and childcare communities, including students, parents and teachers, about haulage activities and potential safety risks would help to manage potential impacts. Measures to manage potential safety risks associated with construction traffic are discussed in Chapter 8 (Construction traffic and transport).

The project would require the temporary relocation of a bus stop at Miller Street, near McLaren Street and Monte Sant' Angelo Mercy College (refer to Chapter 8 (Construction traffic and transport)). The temporary relocation of the bus stop is not expected to require changes to local bus routes or bus services; however, depending on its temporary location, it may change pedestrian routes for some students. Early and ongoing communication with bus users about changes to bus stops would help to manage potential impacts on commuters.

Temporary changes may be required to public places and pedestrian routes near the construction sites on Miller Street. These changes may result in reduced sight lines, opportunities for casual surveillance and levels of activity in public spaces, potentially impacting people's perceptions of safety. This impact would be managed through the application of Crime Prevention through Environmental Design principles. The needs of people with mobility difficulties, including children, elderly people and people with disability would also be considered in the design of temporary pedestrian routes. This would be particularly important on Miller Street, which is a key pedestrian access to community facilities such as schools, childcare centres, churches, medical centres and council offices. Where possible, traffic controllers would be used to ensure safety for pedestrians and cyclists, such as at access points to construction sites.

Measures to manage potential safety risks associated with construction traffic are discussed in Chapter 8 (Construction traffic and transport).

Blues Point temporary site

Community facilities that would be closest to activities at the Blues Point temporary site include:

- Blues Point Reserve, at the end of Blues Point Road on Sydney Harbour
- McMahons Point Wharf.

Property acquisition

Temporary use of land would be needed over about 2,100 square metres of Blues Point Reserve.

This is primarily a grassed area adjacent to Henry Lawson Avenue that is used for recreational activities such as picnicking, fishing, and walking. The establishment of the temporary site would result in the loss of access and temporary disruption to the use of this area. The reserve is the starting point for canoe and board paddling events. Consultation with organisers of these events would be needed to manage potential impacts on these events.

Following retrieval activities, areas disturbed would be rehabilitated and reinstated as a park.

During the retrieval of tunnel boring machine equipment, a number of car parking spaces on Blues Point Road would be lost (refer to Chapter 8 (Construction traffic and transport)). This may make access to and use of the park more difficult for some users, particularly those with mobility difficulties.

Blues Point Reserve provides access to Sydney Harbour for small water craft such as canoes and kayaks. Access to Sydney Harbour for small water craft at Blues Point Reserve would be maintained by a five metre wide zone along the foreshore and along the eastern side of the site from Henry Lawson Drive to the foreshore.

Amenity

Temporary impacts on amenity may be experienced by users of Blues Point Reserve due to noise and dust from the excavations, the movement of spoil, and increased construction traffic on Blues Point Road.

Access

Pedestrian access to Blues Point Reserve and McMahons Point Wharf would be maintained during activities at this site, although temporary changes would be required to pedestrian access near to the temporary site for safety. Temporary changes to public places and pedestrian access may result in reduced sight lines and levels of activity in public spaces, potentially impacting people's perceptions of safety.

Construction vehicles would access the site via Blues Point Road. Construction traffic on this road may present potential safety risks or changes to perceptions of safety, and impact on amenity for visitors to McMahons Point village (refer to Chapter 13 (Business impacts)).

As discussed in Chapter 8 (Construction traffic and transport), there would be short periods where Blues Point Road would be closed temporarily while tunnel boring machine cutter heads are transported away from the Blues Point temporary site. Closures are likely to occur at night to minimise traffic, transport and access impacts and during these closures access to properties would be provided however delays may be experienced.

Barangaroo Station

Community facilities that would be closest to construction activities at Barangaroo Station include:

- Barangaroo Reserve, including Munn Reserve, at the northern end of Barangaroo
- KU Lance Preschool and Children's Centre, on High Street.

A number of community facilities are also located on Kent Street, including St Brigid's Church, Abraham Mott Hall and Youth Centre, The Rocks Fire Station, and Sydney Observatory and Observatory Park.

Amenity

Construction activities would not directly impact on the open space areas of Barangaroo Reserve. If unmanaged, users of some areas of Barangaroo Reserve nearest to construction activities may experience temporary changes in amenity due to increased construction noise and dust associated with excavation of station shafts and handling and removal of spoil, as well as increased construction traffic.

Increased noise and dust from construction may also impact on amenity of the KU Lance Preschool and Children's Centre on High Street, particularly outdoor play areas. In addition, potential health impacts associated with increased construction dust may be a concern for children who suffer asthma or similar conditions. The implementation of mitigation measures at construction sites and early and ongoing consultation with managers of the Preschool and Children's Centre would help to manage impacts.

Potential air quality impacts are discussed in Chapter 22 (Air quality).

Access

Use of Hickson Road for construction traffic access may present safety risks for people accessing Barangaroo Reserve.

Pedestrian and cycle access to Barangaroo Reserve would be maintained during construction, although temporary changes would be required near the construction site for safety. Changes to pedestrian access would need to consider the needs of children, elderly and people with mobility disabilities. Changes to pedestrian access and public places near construction sites may impact on peoples' perceptions of safety.

Construction phase access arrangements developed for the Barangaroo station site would be coordinated with work being carried out by Barangaroo Delivery Authority.

Martin Place Station

Community facilities that would be closest to construction activities at Martin Place Station include:

- Martin Place Early Learning Centre, at Martin Place
- The University of Newcastle Sydney campus, on Elizabeth Street (located adjacent to the proposed construction site)
- Martin Place.

Property acquisition

The project would require full property acquisition of the Martin Place Early Learning Centre.

Details of property acquisition are discussed in Chapter 12 (Land use and property). As indicated in Section 19.3.4, the centre provides long day care for up to 76 children aged six weeks to five years. There are about 12 child care centres located within about 500 metres of the Martin Place Early Learning Centre, of which about six centres showed some vacancies across all age groups at February 2016. The five childcare centres without vacancies, indicated waiting lists of between one month and four months. A further 22 centres are located within the broader Sydney CBD, of which about 21 centres showed some level of vacancies (www.careforkids.com.au).

Amenity

The University of Newcastle Sydney campus is located adjacent to the construction site for Martin Place Station. During construction there would be high daytime airborne and ground-borne noise exceedances at this location and feasible and reasonable mitigation to minimise these impacts would be implemented in accordance with the Sydney Metro Construction Noise and Vibration Strategy (see Appendix E of this Environmental Impact Statement).

The tunnels pass beneath the Theatre Royal at King Street. The theatre hosts a large number of plays, musicals and other events. Ground-borne noise and vibration from underground construction may have short-term impacts on amenity for users of the theatre. Communication with managers of the theatre would assist in managing any potential disruptions.

Access

Martin Place is a pedestrian-only public space and includes the Cenotaph (war memorial), sculptures, fountains and seating, and is surrounded by retail and commercial uses. The public space also hosts a number of community events, including annual ANZAC day services. Construction activities would restrict pedestrian and cyclist access to above and below-ground sections of Martin Place.

Alternative surface pedestrian and cyclist access would be provided to the south of Martin Place through the site of the previously demolished building. The width of this access would be sufficient to cater for the anticipated pedestrian demand.

The primary function of the underground concourse is to provide access to the existing Martin Place Station. During the period of cut and cover construction across Martin Place, suburban rail customers would be able to use the existing Martin Place Station entry points to the east of Elizabeth Street and the east of Philip Street. This would result in additional pedestrians using the pedestrian crossing facilities at Castlereagh and Elizabeth streets (where sufficient pedestrian storage is available).

Pitt Street Station

Community facilities that would be closest to construction activities at Pitt Street Station include:

- The Great Synagogue Sydney, on Castlereagh Street
- Pitt Street Uniting Church, on Pitt Street
- Church of Scientology, on Castlereagh Street
- Presbyterian Church of Eastern Australia, on Castlereagh Street
- City of Sydney Fire Station, on Castlereagh Street
- Pilgrim Theatre, on Pitt Street
- Sydney Mechanics School of Arts, on Pitt Street
- Kingsway Institute, on Bathurst Street
- Sydney Premier Medical and Health Care Centre, on Pitt Street.

A number of community facilities are also located above the tunnel alignment in this location, including:

- University of Sydney Business School CBD campus, at Castlereagh Street
- Wesley Mission Sydney and Conference Centre, at Pitt Street
- Mercury Colleges at Castlereagh Street.

Property acquisition

Details of property acquisition are discussed in Chapter 12 (Land use and property). The project would require full property acquisition of the Australia Post Shop on Castlereagh Street and the Wholistic Medical Centre on Park Street. The Wholistic Medical Centre was established in 1977, and offers patients a range of alternative and general medical services.

Potential impacts associated with the acquisition of businesses and services such as the post shop and medical centre are described in Chapter 13 (Business impacts).

Amenity

Temporary impacts on amenity may be experienced by users of these facilities due to increased construction noise (airborne noise and ground-borne noise from underground work), vibration from excavation of the station shaft and cavern, dust from surface construction activities and spoil loading and haulage, and increased construction traffic.

The station cavern would be located beneath the Pitt Street Uniting Church, Church of Scientology and Presbyterian Church of Eastern Australia. During construction, some church-goers may experience impacts from ground-borne noise and vibration from excavation of the station cavern. Underground work is proposed to be carried out 24 hours a day, seven days a week. These impacts would have the greatest effect during church services. Ongoing consultation and communication with church communities during construction would help to manage potential impacts. Consideration should be given to the timing of large church events and celebrations in planning construction activities that are likely to cause high noise impacts.

Some users of the Sydney Mechanics School of Arts, Pilgrim Theatre, the Medical and Health Care Centre and Kingsway Institute may also experience ground-borne noise and vibration impacts from excavation of the cavern beneath these buildings.

Ground-borne noise and vibration from underground construction may impact on amenity for users of facilities located above the tunnel for a short-period. Communication with managers of these facilities would assist in managing any potential disruptions.

Access

During consultation, concerns regarding station access and security were raised by the Great Synagogue Sydney. This would be managed through the application of Crime Prevention through Environmental Design principles, which take into account the relationship between the physical environment and the users of that environment, promoting maximum useability and safety.

Access for emergency vehicles near to construction sites would be maintained.

Central Station

Community facilities that would be closest to construction activities at Central Station include:

- TAFE Sydney Institute Ultimo College, on Harris Street
- Oxford College Sydney, on George Street
- Christ Church St Laurence, on Pitt Street
- The University of Sydney Faculty of Dentistry and Sydney Dental Hospital, on Chalmers Street
- Orthodox Church Archdiocese of Australia, Cathedral of the 'Annunciation of Our Lady Theotokos', on Cleveland Street
- St Andrew's Greek Orthodox Theological College, on Cleveland Street
- Prince Alfred Park, on Chalmers Street.

Property acquisition

Acquisition of residential properties would be required for the Sydney Yard Access Bridge at Central Station. Where the project requires the permanent use of Government owned land (such as within Sydney Yard at Central Station) Transport for NSW would enter into agreements with the relevant Government departments regarding the permanent use of this land – including acquisition or lease arrangements.

There would be no acquisition of community infrastructure at Central Station as a result of the project.

Amenity

Some users of facilities near to construction activities may experience temporary impacts on amenity due to increased noise, dust and construction traffic associated with construction activities, cut-and-cover construction of the underground station at Central Station, and trucks hauling spoil and materials.

Access

If unmanaged, the use of Chalmers Street by construction traffic may present a safety risk or change perceptions of safety for some users of the Prince Alfred Park, particularly children accessing park facilities such as the swimming pool, tennis courts and play areas. This area is used by a large number of pedestrians accessing community facilities and public transport facilities surrounding Central Station. Spoil haulage and additional trucks would also be required to deliver materials and equipment. Any changes to pedestrian access would need to consider the needs of children, elderly and people with mobility problems.

Waterloo Station

Community facilities that would be closest to construction activities at Waterloo Station include:

- Waterloo Congregational Church, on Botany Road
- Waterloo Medical Centre, on Raglan Street.

Property acquisition

The project would require acquisition of a number of commercial / industrial properties and one residential apartment block. There would be no acquisition of community infrastructure at Waterloo Station as a result of the project.

Amenity

Noise and dust from surface work for construction of the station cavern may impact on amenity for users of these facilities. Ground-borne noise and vibration from construction of the station cavern beneath the church may also impact on amenity for church-goers during services.

Access

Access to the site by construction vehicles would be via Botany Road and the exit would be via Raglan Street. Spoil haulage and additional trucks would be required to deliver materials and equipment.

Marrickville dive site (southern)

Community facilities that would be closest to construction activities at the Marrickville dive site include:

- St Pius' Catholic Primary School, on Edgeware Road
- Camdenville Park, on May Street.

Property acquisition

The project would require acquisition of commercial / industrial properties at the Marrickville dive site. Apart from the partial acquisition of a small area of the existing rail corridor at this location, there would be no acquisition of community infrastructure at the Marrickville dive site as a result of the project. As discussed above, Transport for NSW would enter into agreements with the relevant Government departments regarding the permanent use of this land – including acquisition or lease arrangements.

Amenity

Construction activities at this site are not expected to impact on amenity for users of these facilities.

Access

May Street would be used for hauling spoil, materials and equipment. If unmanaged, this may impact on perceptions of safety for users of Camdenville Park, particularly children.

There would be no change to current access arrangements for existing businesses or other properties as a result of construction or operation of the project at this location.

19.5 Mitigation measures

The mitigation measures that would be implemented to address potential social and community infrastructure impacts are listed in Table 19-13.

Other mitigation measures that are relevant to social and community infrastructure impacts are outlined in the following chapters:

- Chapter 8 (Construction traffic and transport) with regard to management of construction traffic and access near residential areas and community infrastructure
- Chapter 9 (Operational traffic and transport) with regard to ensuring future design development does not restrict or prohibit access to adjacent properties, including community infrastructure
- Chapter 10 (Construction noise and vibration) with regard to noise and vibration impacts associated with construction activities near residential areas and community infrastructure
- Chapter 11 (Operational noise and vibration) with regard to operational noise impacts near residential areas and community infrastructure
- Chapter 12 (Land use and property) with regard to property acquisition of residential and commercial premises, community infrastructure or other businesses used by the community
- Chapter 13 (Business impacts) with regard to property acquisition of businesses used by the community
- Chapter 16 (Landscape character and visual amenity) with regard to visual impacts associated with construction activities near residential areas and community infrastructure
- Chapter 22 (Air quality) with regard to air quality impacts, such as increased dust and exhaust emissions during construction activities, near to residential areas and community infrastructure
- Chapter 25 (Sustainability) with regard to workforce development and industry participation during construction and operation of the project.

Table 19-13 Mitigation measures – social impacts and community infrastructure

Reference	Mitigation measure	Applicable location(s)[1]
SO1	Direct impacts to public open space at the Blues Point temporary site would be minimised.	BP
SO2	Specific consultation would be carried out with sensitive community facilities (including aged care, child care centres, educational institutions and places of worship) potentially impacted during construction. Consultation would aim to identify and develop measures to manage the specific construction impacts for individual sensitive community facilities.	All except metro rail tunnels

1 STW: Surface track works; CDS: Chatswood dive site; AS: Artarmon substation; CN: Crows Nest Station; VC: Victoria Cross Station; BP: Blues Point temporary site; GI: Ground improvement works; BN: Barangaroo Station; MP: Martin Place Station; PS: Pitt Street Station; CS: Central Station; WS: Waterloo Station; MDS: Marrickville dive site; Metro rail tunnels: Metro rail tunnels not related to other sites (eg TBM works).

BIODIVERSITY

CHAPTER TWENTY

20 Biodiversity

This chapter provides an assessment of the biodiversity impacts as a result of the construction and operation of the project and identifies mitigation measures to minimise these impacts. This chapter draws on information in Technical paper 9 – Biodiversity.

20.1 Secretary's environmental assessment requirements

The Secretary's environmental assessment requirements relating to biodiversity, and where these requirements are addressed in this Environmental Impact Statement, are outlined in Table 20-1.

Table 20-1 Secretary's environmental assessment requirements – biodiversity

Ref.	Secretary's environmental assessment requirements	Where addressed
5. Biodiversity		
5.1.	The Proponent must assess biodiversity impacts in accordance with the current guidelines including the Framework for Biodiversity Assessment (FBA).	The Framework for Biodiversity Assessment is addressed in Section 20.2.5.
5.2.	The Proponent must assess any impacts on biodiversity values not covered by the FBA as specified in s2.3.	The Framework for Biodiversity Assessment is addressed in Section 20.2.5.
5.3.	The Proponent must assess impacts on the following [EECs, threatened species and/or populations] and provide the information specified in s9.2 of the FBA.	Biodiversity impacts are addressed in Section 20.4.
5.4.	The Proponent must identify whether the project as a whole, or any component of the project, would be classified as a Key Threatening Process (KTP) in accordance with the listings in the *Threatened Species Conservation Act 1997* (TSC Act), *Fisheries Management Act 1994* (FM Act) and *Environmental Protection and Biodiversity Conservation Act 2000* (EPBC Act).	Biodiversity impacts are addressed in Section 20.4.
17. Hydrology		
17.1.	The Proponent must describe (and map) the existing hydrological regime for any surface and groundwater resource (including reliance by users and for ecological purposes) likely to be impacted by the project, including stream orders, as per the FBA.	Hydrology in relation to biodiversity impacts is addressed in Section 20.3.1.
17.2. (a)	The Proponent must assess (and model if appropriate) the impact of the construction and operation of the project and any ancillary facilities (both built elements and discharges) on surface and groundwater hydrology in accordance with the current guidelines, including: natural processes within rivers, wetlands, estuaries, marine waters and floodplains that affect the health of the fluvial, riparian, estuarine or marine system and landscape health (such as modified discharge volumes, durations and velocities), aquatic connectivity and access to habitat for spawning and refuge;	Biodiversity impacts are addressed in Section 20.4.
17.2. (b)	impacts from any permanent and temporary interruption of groundwater flow, including the extent of drawdown, barriers to flows, implications for groundwater dependent surface flows, ecosystems and species, groundwater users and the potential for settlement.	Groundwater dependent ecosystems are addressed in Section 20.3.6.

20.2 Assessment methodology

The project has been assessed in relation to key biodiversity policy and legislation and policy including:

- *NSW Biodiversity Offsets Policy for Major Projects – Framework for Biodiversity Assessment 2014* (Office of Environment and Heritage, 2014b)
- *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- *Threatened Species Conservation Act 1995* (TSC Act)
- *Noxious Weeds Act 1993* (NW Act)
- *Environmental Planning and Assessment Act 1979* (EP&A Act)
- *Fisheries Management Act 1994* (FM Act).

20.2.1 Biodiversity study area

The study area for this assessment includes all areas where biodiversity values are potentially affected by the project. The project would have potential biodiversity impacts at eight sites:

- Chatswood dive site (northern)
- Artarmon substation
- Blues Point temporary site
- Sydney Harbour (ground improvement work)
- Barangaroo Station site
- Central Station
- Waterloo Station
- Marrickville dive site (southern).

20.2.2 Desktop research

Database searches

Two databases were searched to identify threatened entities listed under the TSC Act and EPBC Act (Commonwealth Matters of National Environmental Significance) known or likely to occur within ten kilometres of the project. These databases are:

- The NSW Bionet Wildlife Atlas – this is managed by the NSW Office of Environment and Heritage (OEH). A coordinate search was carried out to determine threatened species records listed under the TSC Act to within ten kilometres of the project. The search areas overlapped considerably and as such, search results were combined
- The Protected Matters Search Tool – this is managed by the Australian Government Department of the Environment (Department of the Environment). A coordinated search was carried out to determine threatened species, threatened ecological communities and migratory species listed under the EPBC Act known or likely to occur to within ten kilometres of the project.

Literature review

Reports, vegetation maps, topographic maps, aerial photography and literature were reviewed to provide an understanding of ecological values occurring or potentially occurring in the study area and wider region. This material included:

- *Soil Landscapes of the Sydney 1:100 000 Sheet* (Chapman and Murphy 1989)
- *Marrickville Biodiversity Strategy 2011–2021* (Australian Museum Business Services, 2011)
- *Urban Ecology Strategic Action Plan* (City of Sydney 2012c)
- *Urban Bushland Plan of Management Volume 1, Policy and Management Issues, 2014–2019* (Willoughby City Council, 2014)
- *The Native Vegetation of the Sydney Metropolitan Catchment Management Authority Area* (Department of Environment Climate Change and Water, 2009a).

20.2.3 Field survey

Terrestrial flora and fauna at seven sites within the study area were inspected in May and October 2015. These are listed in Table 20-2.

Table 20-2 Sites subject to biodiversity survey

Survey date	Site	Survey methods
25 May 2015	Barangaroo, part of Marrickville dive site (southern)	Diurnal site inspection
7 October 2015	Chatswood dive site (northern), Artarmon substation, Central Station, Waterloo Station	Diurnal site inspection, dusk / evening active Anabat survey (Chatswood dive site only)
8 October 2015	Waterloo Station	Dusk/evening active Anabat survey
17 February 2016	Blues Point temporary site, Marrickville dive site (southern)	Diurnal site inspection, dusk / evening active Anabat survey (Marrickville dive site only)

The site inspections involved:

- Detection and identification of native plant and animal species
- Detection and identification of environmental weeds and noxious weeds declared under the NW Act for the Willoughby, Sydney and Marrickville local government areas (LGAs)
- Assessment of fauna habitat values
- Searches for indirect evidence of fauna (such as scats, nests, burrows, hollows, tracks, scratches and digging)
- Assessment of potential habitat for threatened flora and fauna species previously recorded within the locality
- Active Anabat surveys that comprised active recording on foot at dusk for one hour, with a hand-held spotlight used to view potential roosting locations when the light was low.

20.2.4 Likelihood of occurrence

The database searches identified threatened flora and fauna species that have been recorded or that are likely to occur within ten kilometres of the study area. The probability that each threatened species occurs within the study area was determined as being either low, moderate, high or known, based on criteria outlined in *Technical paper 9 – Biodiversity*.

20.2.5 Framework for Biodiversity Assessment

The impacts of the proposal on biodiversity were assessed using the methodology in the Framework for Biodiversity Assessment (FBA) (Office of Environment and Heritage, 2014b). All applicable sections of the FBA were addressed, as outlined in Section 20.5.

Given that no Plant Community Types listed in the NSW Vegetation Information System Database are located within the study sites, it was not possible to carry out an assessment using the FBA credit calculator.

20.3 Existing environment

20.3.1 Hydrology

The project intersects the estuary of Sydney Harbour, a drowned river valley formed during sea level rise about 10,000 years ago. The estuary opens up from the entrance to form Port Jackson, and then divides into three main branches, Middle Harbour to the north and the Parramatta and Lane Cove Rivers extending south, then westward away from the heads. The estuary is about 30 kilometres long, with a total catchment of 500 square kilometres (Sydney Institute of Marine Science, 2016). The project area lies to the east of the confluence of the Parramatta and Lane Cove rivers.

The bathymetry of Sydney Harbour is complex, and comprises dredged channels for shipping and a number of deep holes of about 28 to 45 metres, separated by shoals with depths of three to five metres (Sydney Institute of Marine Science, 2016). There is a 45 metre deep hole immediately to the east of the project area.

The project lies within a highly urbanised catchment, and all natural watercourses have been historically replaced with constructed drainage systems. The only mapped watercourse within the study area is the Eastern Channel which runs through the Marrickville dive site. The Eastern Channel is a concrete canal, built in the late 1890s (Sydney Water, 2014), which drains to the Sydenham Pit to the west of the Marrickville dive site. The proposed tunnel between Marrickville dive site and Waterloo Station runs beneath Sheas Creek, another concrete canal which forms the north-eastern extent of Alexandra Canal.

20.3.2 General site characteristics

Table 20-3 outlines the general site characteristics of each of the eight sites with potential biodiversity impacts.

Table 20-3 Site characteristics

Site	Location / description
Chatswood dive site (northern)	Vegetation within the rail corridor between Albert Avenue in the north and Brand Street in the south, associated road bridges and the Ausgrid depot site immediately west of the rail corridor, between Mowbray Road and Nelson Street. The vegetation is characterised by planted native vegetation mixed with invasive exotic species. The Chatswood dive site has limited fauna habitat values due to lack of native vegetation, urban development and high levels of disturbance from road and rail traffic. Scattered trees are present within the Ausgrid depot site and around the southern boundary. A potential hollow-bearing tree was located in the middle of the depot. A nest box and a hollow-bearing tree were observed on the southern boundary of the depot. The remainder of the depot contains buildings and hardstand. Most buildings did not appear suitable for microbats. No microbats were recorded during Anabat surveys of this site. Two concrete road overbridges are present in this site. Crevices in the bridge deck could provide roosting habitat for microbats. The bridges are subject to high levels of road and rail traffic and as such, suboptimal for microbats. None were observed during targeted surveys.
Artarmon substation	Cleared block of land adjoining the northern side of the Gore Hill Freeway, south-west of residential apartment blocks on Barton Road. The vegetation of the Artarmon substation site comprised cleared grassland lined by trees and shrubs. The Artarmon substation site would provide some foraging and nesting habitat for common urban fauna. It otherwise has limited habitat value for fauna due to the disturbed nature of the site including urban development and roads.
Blues Point temporary site	Cleared grassland at southern end of Blues Point Road and south of Henry Lawson Avenue, adjoining Sydney Harbour. The site has limited fauna habitat value, though shorebirds could occur as vagrants on the shoreline or in grassland behind it.
Sydney Harbour (ground improvement work)	Ground improvement works would be undertaken in Sydney Harbour between Blues Point and Millers Point. Ground improvement work is likely to be carried out at the rock-sediment transition zones between 30 to 40 metres below the sea bed. The sediments within Sydney Harbour provide habitat for benthic infauna and epifauna. Common recreational fish species and sharks and marine mammals also known to occur in Sydney Harbour.
Barangaroo Station site	The vegetation of this site consists of planted street trees within a highly modified urban context along Hickson Road between the southern extent of High Street and the Munn Street tunnel to the north. Fauna habitats at the Barangaroo site are restricted to scattered planted street trees and a small patch of landscaped vegetation with palm trees, succulents and grasses. Street trees would provide foraging habitat and shelter for common fauna adapted to urban environments. Fig trees at this site could provide foraging habitat for the Grey-headed Flying-fox when fruiting.

Site	Location / description
Central Station	In the strip between the suburban and country railway lines, known as 'Sydney Yard', is mostly hardstand with a railway platform, a few planted / regenerating trees and buildings. The site has limited fauna habitat value due to the highly disturbed and developed nature of the site. It is possible that buildings could provide roosting habitat for microbats, though unlikely due to their location within the middle of a busy railway station.
Waterloo Station	Industrial and commercial buildings on the block bounded by Botany Road, Raglan Street, Cope Street and Buckland Street. The Waterloo site was comprised entirely of buildings and there was no vegetation observed on the site. The buildings at the Waterloo study site were inspected from the outside at street level. Based on this inspection, the buildings did not appear suitable for microbats due to the high levels of activity within, lack of suitable insulation and lack of entry / exit points.
Marrickville dive site (southern)	Industrial lands on northern and southern sides of the rail line north-east of Sydenham Station. A small strip of planted native trees (including *Casuarina* spp and *Eucalyptus* spp) adjoins the northern edge of the rail line in the centre of the northern portion of the site. Given the long history of disturbance on the site, it is likely that all vegetated areas are highly modified, with low native flora biodiversity values. The site appears to contain minimal habitat values for fauna due the disturbed nature of the site including urban development, adjacent rail line and lack of vegetation. The strip of native trees would provide limited foraging habitat and shelter for fauna species. Potential microbat roosting habitat was identified in Bedwin Road overbridge, located 30 metres to the east of the site. Warehouses and industrial buildings adjoining the rail corridor to the north did not appear to support potential microbat roosting habitat, however, microbats could possibly roost within two large warehouses on Sydney Steel Road. Microbats could gain access to these warehouses via visible gaps below the roof. Existing culverts beneath the site could offer additional microbat roosting habitat.

20.3.3 Terrestrial flora

Native vegetation

All vegetation identified within the study area is mapped as Urban – Exotic / Native in *Native Vegetation of the Sydney Metropolitan Catchment Management Authority Area* (Department of Environment, Climate Change and Water, 2009a) and field assessment has confirmed that most vegetation is planted or exotic regrowth. None of the vegetation identified in the study area falls within the description for any Plant Community Types listed in the NSW Vegetation Information System database.

No native vegetation communities were observed during site inspections, and none of the vegetation in the study area meets the criteria for any threatened ecological community listed under the EPBC Act or the TSC Act. The closest threatened ecological community mapped by the Office of Environment and Heritage (Department of Environment, Climate Change and Water, 2009a) is Blue Gum High Forest (Critically Endangered under the TSC Act and EPBC Act), which occurs in some fragmented patches about 250 metres west of the Chatswood dive site.

Terrestrial threatened flora species

No threatened flora species were recorded. Given the low native flora habitat values of the study area, there is a low likelihood of any occurring, with the exception of planted non-local native specimens.

20.3.4 Terrestrial threatened fauna species

The Protected Matters Search Tool identified 59 threatened fauna species and 78 migratory fauna species listed under the EPBC Act that are known or likely to occur within ten kilometres of the biodiversity study area. A search of the NSW Wildlife Atlas found records of 51 threatened fauna species that are known or likely to occur within ten kilometres of the biodiversity study area (refer to Technical paper 9 – Biodiversity).

The following threatened species have at least a moderate likelihood of occurrence within the biodiversity study area:

- The Grey-headed Flying-fox *(Pteropus poliocephalus)*. This is a vulnerable species under the TSC Act and EPBC Act. It is found in urban gardens and feeds on the fruit of rainforest trees and vines. Fig trees at Chatswood and in the Barangaroo road reserve would provide a foraging resource for this species. As such, it has a high likelihood of occurrence at Chatswood and in the Barangaroo road reserve. The species has a moderate likelihood of occurrence at Central Station. It is unlikely to occur at the other project sites
- The Eastern Bent-wing Bat *(Miniopterus schreibersii oceanensis)*. This is listed as Vulnerable under the TSC Act. It occurs along the east coast of Australia. The species forages in forested areas and primarily roosts in caves, but also uses a range of built structures (Churchill, 1998). There are 82 records of the Eastern Bent-wing Bat within ten kilometres of the biodiversity study area. Buildings at Sydenham, Chatswood and Waterloo, and crevices within two bridges within the rail corridor adjacent to the Chatswood dive site, may provide roosting habitat for the species outside the birthing period, though they are within a highly modified environment subject to high levels of disturbance (such as noise), and are therefore suboptimal for this species. The species has a moderate likelihood of occurrence within the Chatswood, Central, Waterloo and Marrickville dive site
- The Eastern Freetail Bat *(Mormopterus norfolkensis)*. This is listed as Vulnerable under the TSC Act. It is found east of the Great Dividing Range, from Brisbane to Sydney, where it is most commonly recorded in dry eucalypt forest and woodland, where it shows a preference for open spaces in forests. The Eastern Freetail Bat forages in openings and gaps in the forest including over larger waterways (Churchill, 1998). The species roosts mainly in tree hollows but will also roost under exfoliating bark or in built structures (Churchill, 1998). There are ten records of the Eastern Freetail Bat within ten kilometres of the biodiversity study area. Buildings at several sites and bridges at Chatswood, and hollow-bearing trees in Chatswood, may provide roosting habitat for the species, though they are within a highly modified environment subject to high levels of disturbance (such as noise), and are therefore suboptimal for this species. The species has a moderate likelihood of occurrence at Chatswood, Waterloo, Central Station and Marrickville dive sites
- The Southern Right Whale *(Eubalaena australis)*. This is listed as Endangered under the TSC Act and EPBC Act. These whales migrate between summer feeding grounds in Antarctica and winter breeding grounds around the coasts of southern Australia, New Zealand, South Africa and South America. They move inshore in winter for calving and mating. Calving females and females with young usually remain very close to the coast, particularly in the five to ten metre watermark. There are eight records of the Southern Right Whale within ten kilometres of the biodiversity study areas and the species has been recorded in Sydney Harbour near Blues Point, most likely as a vagrant. Therefore the species has a moderate likelihood of occurrence in Sydney Harbour.

20.3.5 Aquatic ecology

Aquatic flora

Expansive seagrass meadows are not known to occur between Walsh Bay and Lavender Bay within the project area, however small isolated and fragmented patches of *Zostera capricorni* have been identified on the western and northern parts of Lavender Bay and in the north-west of Berry's Bay (Department of Primary Industries, 2005). Seagrasses are unlikely to be located away from the intertidal or shallow subtidal zones in the harbour due to the deep and turbid waters which limit light available for photosynthesis. Only in the clearest waters can seagrasses grow to a depth of 12 metres (Department of Primary Industries, 2007).

Other aquatic macrophytes (saltmarsh, mangroves) are not known to occur within or near the project area. Kelp *(Ecklonia radiata)* and other algae are commonly found in the shallow subtidal areas within the Harbour, including Berrys Bay, Lavender Bay and Walsh Bay.

Lavender Bay near the southernmost tip of McMahons Point is designated as a Wetlands Protection Area in the *Sydney Harbour Regional Environmental Plan (Sydney Harbour Catchment) 2005*.

Benthic fauna

The sediments within the project area provide habitat for benthic infauna and epifauna. Benthic fauna occupying nearby areas of Berry's Bay and Barangaroo include sponges, ascidians, polychaete worms, amphipods, crustaceans, cnidarians, brittle stars, bivalves and gastropods (Worley Parsons, 2010; Marine Pollution Research, 2014).

Sediment samples of the seabed were collected in the area of the two proposed grout zones. The samples were lacking in living biota with only one living bivalve and one sea pen observed.

Threatened benthic infauna or epifauna are not known to occur in the area.

Threatened aquatic mobile fauna

The Black Rockcod is listed as a vulnerable species under the FM Act. The Black Rockcod is a reef dwelling species found along the NSW coastline. They inhabit caves, gutters, beneath bommies in near shore environments to depths of 50 metres (Department of Primary Industries, 2012). Large juveniles can be found around rocky shores in estuaries. The proposed works is not expected to directly impact suitable habitat for the Black Rockcod, however the nearshore environments could provide suitable habitat.

Sharks and marine birds and mammals are also known to occur in the area, including Bull Sharks, Little Penguins and dolphins. The Little Penguin population at North Head is listed as an Endangered Population under the TSC Act. Little penguins are often observed feeding throughout the harbour.

Pipefish and seahorses *(Syngnathids)* are protected under the FM Act and most species are listed marine species under the EPBC Act. Along coasts, *Syngnathids* are commonly found near algae, weed or seagrass habitats or around man-made structures (eg jetties). Suitable habitat is not known to occur in the biodiversity study area.

20.3.6 Groundwater dependent ecosystems

A search of the National Atlas of Groundwater Dependent Ecosystems (BOM, 2015) did not identify any Groundwater Dependent Ecosystems within the study area.

The section of the study area between Central and Sydenham (ie the Central Station, Waterloo Station and Marrickville dive site) is within land that forms part of the Botany Sands Groundwater Source, and is subject to the provisions of the *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011*. The Botany Sands Groundwater Source extends to the Botany Wetlands, which include high priority groundwater dependent ecosystem listed on Schedule 4 of the *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011*.

20.3.7 Noxious weeds and pests

Fifteen of the 51 exotic species recorded in the study area are declared noxious under the NW Act for either the Willoughby, Sydney and / or Marrickville local government areas. The NW Act imposes obligations on occupiers of land to control noxious weeds declared for their area.

The listed pest algal species, *Caulerpa taxifolia*, is not known to occur in the project area or in nearby Berrys Bay and at the Barangaroo development however marine pests could be transported from other locations. NSW Department of Primary Industries is involved in the development of the National System for the Prevention and Management of Marine Pest Incursions which aims to prevent the introduction and translocation of introduced marine species.

20.4 Assessment of potential impacts

20.4.1 Construction

Key threatening processes

The project may result in the operation of key threatening processes or the exacerbation of a key threatening process currently in operation in the study area. Key threatening processes are listed under the TSC Act and EPBC Act, and are generally defined as processes that adversely affect threatened species, populations or ecological communities, or could cause species, populations or ecological communities that are not threatened to become threatened. Table 20-4 outlines the Key Threatening Processes which have been considered with regard to the project.

Table 20-4 Key threatening processes

Act	Key Threatening Process	Applicability to project
TSC Act	Loss of hollow-bearing trees.	Up to two hollow-bearing trees would be removed for the project.
TSC Act	Invasion and establishment of exotic vines and scramblers	Numerous exotic vines were recorded in the study area, particularly in the rail corridor within the Chatswood dive site. Species recorded within this area that are listed under the key threatening process include *Anredera cordifolia* (Madeira Vine), *Asparagus aethiopicus* (Ground Asparagus), *Cardiospermum grandiflorum* (Balloon Vine), *Delairea odorata* (Cape Ivy), *Hedera helix* (English Ivy), *Ipomoea indica* (Morning Glory), *Lonicera japonica* (Honeysuckle), *Tradescantia fluminensis* (Wandering Jew) and *Vinca major* (Periwinkle). There is a potential for disturbance during works to result in further spread of these species.

Loss of native vegetation

There is minimal native vegetation in the area to be impacted. Native vegetation is limited to planted trees and shrubs and occasional scattered regeneration of common native plant species within previously disturbed areas.

Loss of fauna habitat

Clearing vegetation at the construction sites would result in the removal of fauna habitat. Planted trees and landscaped vegetation would be removed which could impact foraging habitat and shelter for fauna species. However, impacts would be to a very small amount of vegetation and would therefore be minor and generally restricted to common fauna species that inhabit urban environments. Potential removal of fig trees at Barangaroo and Chatswood could impact foraging habitat for the threatened Grey-headed Flying-fox. Up to two hollow-bearing trees could be removed at Chatswood, as well as a nest box at Chatswood, which would reduce roosting habitat / shelter.

The removal of buildings and the bridge over the rail line at Nelson Street as well as removal of buildings at Central Station, Waterloo Station and Marrickville dive site has the potential to impact roosting and nesting fauna including microbat habitat. No microbats were observed within these sites during targeted surveys, but one common microbat call was recorded in the vicinity of the Sydenham drainage pit near the Marrickville dive site. As such, there is a moderate likelihood of microbats occurring at the Chatswood dive site, Central Station site, Waterloo Station site and Marrickville dive site.

Fauna injury or death

Fauna injury or death is most likely to occur during vegetation clearing, but may also result from collisions with vehicles or construction plant, although this is highly unlikely in the highly urbanised environment of the project. The majority of fauna species recorded within the study area are highly mobile bird species. These species are likely to be able to move away from vegetation clearing activities quite readily. Any fauna inhabiting the hollows in hollow-bearing trees may be injured during tree-felling. This could potentially include hollow-dependent birds and mammals. Animals that are unable to disperse during active clearing – such as amphibians and reptiles – are also particularly susceptible to injury or death.

Impacts on threatened species

The project has the potential to impact four threatened fauna species listed under the TSC Act, two of which are also listed under the EPBC Act, as presented in Table 20-5.

Table 20-5 Impacts on threatened species

Threatened species	EPBC Act Status	TSC Act Status	Likelihood of occurrence	Impacts of proposal
Eastern Freetail Bat *(Mormopterus norfolkensis)*	N/A	Vulnerable	Moderate	Removal and / or modification of up to two hollow-bearing trees, buildings, and a bridge that could provide roosting habitat. The area to be impacted is highly disturbed and would be suboptimal due to the adjacent train lines and roads. As such, impacts would not be significant.
Eastern Bent-wing Bat *(Miniopterus schreibersii oceanensis)*	N/A	Vulnerable	Moderate	Removal and / or modification of buildings and a bridge that could provide roosting habitat. The area to be impacted is highly disturbed and would be suboptimal due to the adjacent train lines and roads. As such, impacts would not be significant.
Grey-headed Flying-fox *(Pteropus poliocephalus)*	Vulnerable	Vulnerable	High	Removal of planted fig trees that provide potential foraging habitat at Barangaroo and Chatswood. Impacts are not likely to be significant due to the small amount of potential habitat to be removed.
Southern Right Whale *(Eubalaena australis)*	Endangered	Endangered	Moderate	Impacts to Southern Right Whale could occur as a result of temporary disturbance for ground improvement work in Sydney Harbour. Impacts to this species are not likely to be significant due to the low likelihood of the species being injured or disturbed as a result of the proposed works.

Assessment of significance

No threatened species are likely to be significantly impacted by the project. The findings of the EPBC Act assessments of significance are summarised in Table 20-6.

Table 20-6 Assessment of significance – EPBC Act

Threatened species of communities	Important population[1]	Likely significant impact?
Grey-headed Flying-fox *(Pteropus poliocephalus)*	No	No
Southern Right Whale *(Eubalaena australis)*	No	No

1 *Important population as determined by the Environment Protection and Biodiversity Conservation Act 1999, is one that for a vulnerable species:*

a) is likely to be key source populations either for breeding or dispersal

b) is likely to be necessary for maintaining genetic diversity

c) is at or near the limit of the species range.

Impacts to aquatic habitats

The potential impacts to aquatic habitats in Sydney Harbour from the proposed ground improvement work include:

- Direct physical disturbance to benthic habitat. The proposed grouting of unconsolidated sediments and potential anchoring of the barges would have a direct impact to the benthic infauna and epifauna. However these are shortlived, abundant taxa which are widespread throughout Sydney Harbour. Displaced taxa can readily colonise neighbouring areas due to the abundance of similar habitat. The proposed activities would not significantly impact any species, populations or communities. No threatened benthic taxa are known to occur in the project area
- Noise and vibration disturbances to mobile aquatic fauna. Noise and vibration are expected over the duration of the works. Sydney Harbour is a busy, highly used waterway with many boating and development activities. Mobile fauna have the ability to relocate during the works. The impact from the presence of barges and construction works is likely to be negligible
- Water quality impacts, including potential spills for plant and machinery, are addressed in Chapter 18 (Soils, contamination and water quality)

  Mobilisation and release of sediment contaminants. The mobilisation of contaminants can potentially increase contaminant concentrations in filters feeders and benthic foragers. Activities resulting in sediment resuspension in contaminated environments in NSW Harbours has been shown to increase metal accumulation in the Sydney Rock Oyster *(Saccostrea glomerata)* by increasing water column contaminants (Hedge et al, 2009). The Department of Primary Industries (Fisheries) currently advises that no fish or crustaceans should be consumed if captured west of the Sydney Harbour Bridge due to elevated levels of dioxins.

  Sediment analysis carried out has identified that lead and mercury from within the footprints are readily bioavailable while mercury is less bio-available. Laboratory elutriation tests simulating resuspension of sediment in ambient seawater carried out on sediment samples within the two grout zones demonstrated that trace metals and all organic contaminants are likely to remain bound to sediment particles and would not be released into the water column
- Spread of marine pests (particularly the marine alga *Caulerpa taxifolia*) from the transportation of plant and machinery in the harbour (eg barges). C. *taxifolia* is not known to occur in the project area. A mitigation measure (see Table 20-8) would be in place to avoid transportation of marine pests from other locations, therefore no impact is expected.

Impacts to Groundwater Dependent Ecosystems

At Waterloo Station, there is around four metres of sand near ground surface. The sand layer forms part of the Botany Sands Groundwater Source. Waterloo Station would be tanked and therefore the sand layer would be hydraulically isolated (via permanent lining) from the station shaft, by design. As such, there would be no hydraulic connection between the project and the Botany Sands Groundwater Source and thereby no impact to the Botany Wetlands groundwater dependent ecosystem.

20.4.2 Operation

Mortality of fauna species

Fauna injury or death is may result from collisions with trains. However, the metro network would operate within urban areas or underground, where it is unlikely many fauna species, including threatened species, occur.

20.5 Assessment according to the Framework for Biodiversity Assessment

The NSW Biodiversity Offsets Policy for Major Projects, which clarifies, standardises and improves biodiversity offsetting for major project approvals, is underpinned by the Framework for Biodiversity Assessment (FBA). The FBA sets out the process for:

- Assessing biodiversity impacts on a proposed development site
- Determining the biodiversity offset requirements for those impacts.

An assessment of the project under the FBA has been carried out to determine whether biodiversity offsets would be required (refer to the following sections following the FBA process). It was concluded that the impacts of the project on native vegetation do not require an offset, given that the project comprises planted or highly modified native vegetation.

20.5.1 Landscape features

The FBA requires the assessment of landscape features to help describe the biodiversity values of the study area and assess the impacts of the project. Landscape features relevant to the FBA calculations summarised in Table 20-7. The project is a linear shaped development; as such, the landscape value has been assessed in accordance with the methodology in Appendix 5 of the FBA (Office of Environment and Heritage, 2014).

Table 20-7 Landscape features

Landscape feature	Study area
Interim Biogeographic Regionalisation for Australia bioregions and subregions	The study area is located within the Sydney Basin Bioregion and the Cumberland and Pittwater Subregions classified under Interim Biogeographic Regionalisation for Australia.
Mitchell landscapes	The study area intersects the Pennant Hills Ridges, Port Jackson Basin, Ashfield Plains and Sydney – Newcastle Barriers and Beaches Mitchell Landscapes.
Rivers, streams and estuaries	The study area intersects the estuary of Sydney Harbour, however the project impacts would largely be beneath the harbour bed.
Wetlands	The project site does not contain any important wetlands as defined in the FBA. Lavender Bay near the southernmost tip of McMahons Point is designated as a Wetlands Protection Area in the *Sydney Harbour Regional Environmental Plan (Sydney Harbour Catchment) 2005*.
Native vegetation extent in landscape buffer	A landscape buffer of 550 metres was applied to the centre line of the study area, in accordance with the methodology for assessing landscape value for linear shaped developments of multiple fragmentation impacts in Appendix 5 of the FBA. The landscape buffer of 550 metres results in a buffer area of about 1985 ha. The current percent native vegetation cover in the 550 metre landscape buffer is approximately 10 per cent (192.24 ha out of the 1985 ha buffer). Of this 192.24 ha, only 7.82 ha has been defined as a natural vegetation community in the Department of Environment, Climate Change and Water (2009a) mapping, with the remaining 184.42 ha mapped as "Urban Exotic / Native". This estimate of native vegetation extent includes planted and / or exotic vegetation cover and is different to the definition of native vegetation applied in offset calculations.

Landscape feature	Study area
Score for percent current extent of native vegetation cover	The score for six to 10 per cent native vegetation in the landscape buffer is 1.25.
Future native vegetation extent in the landscape buffer	The project will impact on up to 1.63 ha of mapped Urban Exotic/Native vegetation. This would result in a negligible reduction in the percent native vegetation cover in the landscape buffer, which would remain at about 10 per cent.
Score for percent current extent of native vegetation cover	The score for future native vegetation in the landscape buffer would remain at 1.25.
Connectivity value	A connecting link is identified where native vegetation on the site adjoins native vegetation surrounding the site and the native vegetation is in moderate to good condition, has a patch size >1 ha, is separated by distance of <100 metres (or <30 metres for non-woody ecosystems) and is not separated by a hostile barrier such as a large water body or dual carriageway. Based on the above definition, there are no connecting links within or adjoining the study area. The vegetation adjoining the rail corridor on the Chatswood dive site does not meet the criteria as it is planted native and exotic vegetation with an exotic dominated understorey, and is not in moderate / good condition. The definition of a state significant biodiversity link includes a riparian buffer 50 metre around an important wetland or an estuarine area. The project crosses Sydney Harbour and there would be minor impacts within the harbour and in adjacent cleared land at Blues Point. However these impacts are not within a vegetated riparian buffer and are not considered to impact on connectivity in areas adjoining the harbour.
Patch size	N/A – as discussed, there is no native vegetation in moderate / good condition to be impacted by the project.
Area to perimeter ratio	N/A – no patches of native vegetation would be impacted by the project.
Landscape value score	The landscape value score for the site is 1.25.

20.5.2 Native vegetation

All vegetation identified within the study area is mapped as Urban – Exotic / Native by Department of Environment, Climate Change and Water (2009a) and field assessment has confirmed that most vegetation is planted or exotic regrowth.

None of the vegetation identified in the study area falls within the description for any Plant Community Types listed in the NSW Vegetation Information System database. Given that no Plant Community Types listed in the NSW Vegetation Information System Database are located within the study sites, it was not possible to carry out an assessment for native vegetation using the FBA credit calculator.

20.5.3 Threatened species

Ecosystem credit species

There are no Plant Community Types within the project, as such, no vegetation zones could be entered into the credit calculator and therefore a list of candidate ecosystem species for the project could not be generated. The threatened species identified in database searches were reviewed in the Threatened Species Profile Database and the credit class applicable to each species was determined (refer to Technical paper 9 – Biodiversity).

Of the 82 threatened fauna species identified, 32 are associated with ecosystem credits and six were identified as both ecosystem and species credit species in the Threatened Species Profile Database. Species credits apply to breeding habitat and ecosystem credits apply to foraging habitat for these species.

Two species associated with ecosystem credits were considered to have a moderate or high likelihood of occurrence in some parts of the study area: Grey-headed Flying-fox *(Pteropus poliocephalus)* and Eastern Freetail-bat *(Mormopterus norfolkensis)*. These species are discussed in Section 20.3.4 and impacts from the project are considered in Section 20.4.

Species credit species

Thirty-one threatened fauna species identified in database searches are associated with species credits in the Threatened Species Profile Database. All threatened flora species are associated with species credits.

No threatened species associated with species credits, or their habitats, were identified in the study area.

The Office of Environment and Heritage identified two threatened flora species requiring further consideration and provision of the information specified in section 9.2 of the FBA:

- *Hibbertia* sp. Turramurra
- *Genoplesium baueri*.

20.5.4 Project impacts

Impacts on biodiversity that require further consideration

Section 9.2 of the FBA addresses biodiversity impacts that require further consideration. These are impacts that are considered to be complicated or severe, and require further consideration by the consent authority.

Under section 9.2.5 of the FBA, further consideration is required within the assessment of the effects of a development on a threatened species or population that is specifically nominated in the Secretary's environmental assessment requirements as a species or population that is likely to become extinct or have its viability significantly reduced in the Interim Biogeographic Regionalisation for Australia subregion if it is impacted on by the development. The Office of Environment and Heritage nominated two threatened species in the Secretary's environmental assessment requirements as requiring further consideration under section 9.2: *Hibbertia* sp. Turramurra and *Genoplesium baueri*.

***Hibbertia* sp. Turramurra (Julian's Hibbertia)**

Hibbertia sp. Turramurra (syn. *Hibbertia spanantha*) is a decumbent shrublet up to 30 centimetres high with linear leaves about six millimetres long and bright yellow flowers approximately 20 millimetres wide. *Hibbertia* sp. Turramurra is listed as critically endangered under the TSC Act. The species was discovered in 2007 and is currently known from three locations in the northern Sydney suburbs of Turramurra, North Ryde and Cheltenham. In total, there are fewer than 20 plants occurring in the three known locations (NSW Scientific Committee 2015).

Due to the sensitive nature of the species, the exact locations of known records cannot be identified. However the three suburbs named are not in the vicinity of the project area, with the closest being North Ryde, approximately 2.5 kilometres west of the Chatswood dive site. It is therefore assumed that there are no known records of the species within or adjacent to the areas to be impacted by the project.

Habitat for the species is native forest with canopy species including *Eucalyptus pilularis, E. resinifera, Corymbia gummifera* and *Angophora costata*. The understorey is open with species of Poaceae, Orchidaceae, Fabaceae and Liliaceae. The known locations of *Hibbertia* sp. Turramurra are in close proximity to urban areas (NSW Scientific Committee 2015).

The vegetation recorded in the study area is fragmented and highly modified, and consists of planted native and exotic species or mostly exotic regrowth. No areas of suitable potential habitat for *Hibbertia* sp. Turramurra were identified.

***Genoplesium baueri* (Bauer's Midge Orchid)**

Genoplesium baueri is a terrestrial orchid six to 15 centimetres high, fleshy, brittle, yellowish green or reddish, with a sparse inflorescence of one to three centimetres in length, bearing one to six flowers. *Genoplesium baueri* is listed as Endangered under the TSC Act and EPBC Act. The species generally occurs in coastal areas, and its range extends from Ulladulla to Port Stephens. There are a number of older records of the *Genopesium baueri* from Sydney suburbs including Asquith, Cowan, Gladesville, Longueville and Wahroonga; no collections have been made from these locations in recent years.

There are 11 records of *Genoplesium baueri* in the NSW Bionet Wildlife Atlas within 10 kilometres of the study area; 10 of the records are dated between 1881 and 1918. There is one record dated from 2011, located approximately 7.5 kilometres to the west of the Chatswood dive site.

Habitat for *Genoplesium baueri* is variously described as dry sclerophyll forest and moss gardens over sandstone (OEH 2016, NSW Flora Online) and heathland to shrubby woodland on sands or sandy loams or open forest, shrubby forest and heathy forest on well-drained sandy and gravelly soils (NSW Scientific Committee 2012). Plants do not regularly appear aboveground every year, and individual plants may remain dormant in the soil. Flowering is between December and April and it has been suggested that flowering is enhanced by summer fires (NSW Scientific Committee 2014).

The vegetation recorded in the study area is fragmented and highly modified, and consists of planted native and exotic species or mostly exotic regrowth. No areas of suitable potential habitat for *Genoplesium baueri* were identified.

Neither *Hibbertia* sp. Turramurra nor *Genoplesium baueri* was recorded in the study area, and no potential habitat for the species was identified during surveys. Given the poor native flora habitat values and lack of nearby records of the species nominated for further consideration, it is considered unlikely that these species or their habitat would occur in the study area or adjacent areas, and therefore they would not be impacted by the project.

Impacts not requiring assessment or offset determination

An assessor is not required to assess areas of land on a development site without native vegetation, unless the Secretary's environmental assessment requirements issued for the project specifically require it.

The project site largely contains highly modified vegetation that does not comprise native vegetation within the meaning of the FBA. These areas contain no or very little native overstorey or midstorey vegetation and are dominated by exotic ground cover. Much of this vegetation occurs on cuttings or fill associated with unnatural landforms.

The project site also includes buildings, hardstand areas and other infrastructure with occasional planted vegetation that do not comprise native vegetation within the meaning of the FBA and do not require further assessment.

20.5.5 Environmental values not assessed under the FBA

Biodiversity values not considered under the FBA include:

- Marine mammals
- Wandering sea birds
- Biodiversity that is endemic to Lord Howe Island.

There is potential for marine mammals to occur within Sydney Harbour, in the vicinity of the proposed ground improvement work.

Marine mammals recorded in Sydney Harbour include Southern Right Whale and Humpback Whale, Dwarf Minke Whale, Common Dolphin, Bottlenose Dolphin, Spotted Dolphin, New Zealand Fur-seal, Australian Fur-seal, Australian Sea-lion, Leopard Seal and Southern Elephant Seal. Of these species, only Southern Right Whale, Common Dolphin, Bottlenose Dolphin, New Zealand Fur-seal, Australian Fur-seal and Leopard Seal have been recorded in the vicinity of the proposed works; all other records are closer to the heads in the outer harbour.

The ground improvement work would be conducted from barges located to the west of Sydney Harbour Bridge. Potential impacts to marine mammals from the proposed work could include increased collision risk, stress or disturbance to navigation from noise impacts, and water quality impacts. Given the low frequency and density at which marine mammals occur in Sydney Harbour, and the existing harbour traffic, it is considered unlikely that any marine mammals would be adversely affected as a result of the proposed work.

In addition, the FBA does not assess the direct impacts of a project that are not associated with clearing of vegetation. Examples of such impacts referenced in the FBA that although highly unlikely to occur may be relevant to the current project include:

- Vehicle strike
- Downstream impacts on hydrology and environmental flows on surface vegetation and groundwater dependent ecosystems.

These types of impacts are assessed in Section 20.4 of this document.

20.6 Mitigation measures

The mitigation measures that would be implemented to address potential biodiversity impacts are listed in Table 20-8.

Table 20-8 Mitigation measures – biodiversity – construction

Ref	Mitigation measure	Applicable location(s)[1]
B1	An ecologist would be present during the removal of any hollow-bearing trees.	CDS
B2	Potential bat roosting locations at Central Station, Waterloo Station and Marrickville dive sites would be checked by a qualified ecologist or wildlife handler prior to demolition. Any bats found would be relocated.	CS, WS, MDS
B3	The local WIRES group and / or veterinarian would be contacted if any fauna are injured on site or require capture and / or relocation.	All except metro rail tunnels
B4	Procedures would be developed and implemented, in accordance with the National System for the Prevention and Management of Marine Pest Incursions, during Sydney Harbour ground improvement works to avoid transportation of marine pests from other locations, particularly the marine alga *Caulerpa taxifoli.*	GI

1 *STW: Surface track works; CDS: Chatswood dive site; AS: Artarmon substation; CN: Crows Nest Station; VC: Victoria Cross Station; BP: Blues Point temporary site; GI: Ground improvement works; BN: Barangaroo Station; MP: Martin Place Station; PS: Pitt Street Station; CS: Central Station; WS: Waterloo Station; MDS: Marrickville dive site; Metro rail tunnels: Metro rail tunnels not related to other sites (eg TBM works); PSR: Power supply routes.*

FLOODING AND HYDROLOGY

CHAPTER TWENTY-ONE

21 Flooding and hydrology

This chapter provides an assessment of the potential impact on flooding and surface water as a result of the project, and identifies mitigation measures to minimise these impacts.

21.1 Secretary's environmental assessment requirements

The Secretary's environmental assessment requirements relating to flooding and hydrology, and where these requirements are addressed in this Environmental Impact Statement, are outlined in Table 21-1.

Table 21-1 Secretary's environmental assessment requirements –flooding and hydrology

Ref.	Secretary's environmental assessment requirements	Where addressed
6. Flooding		
6.1	The Proponent must assess and model (where appropriate), taking into account any relevant Council-adopted flood model or latest flood data available from Councils, the impacts on flood behaviour during construction and operation for a full range of flood events up to the probable maximum flood (taking into account sea level rise and storm intensity due to climate change) including:	
6.1(a)	any detrimental increases in the potential flood affectation of other properties, assets and infrastructure	Flood impacts are addressed in Sections 21.4.2 and 21.5.2.
6.1(b)	consistency (or inconsistency) with applicable Council floodplain risk management plans	Flood impacts are addressed in Sections 21.4.2 and 21.5.2.
6.1(c)	compatibility with the flood hazard of the land	Flood impacts are addressed in Sections 21.4.2 and 21.5.2.
6.1(d)	compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land	Hydrology impacts are addressed in Sections 21.4.1 and 21.5.1.
6.1(e)	downstream velocity and scour potential	Hydrology impacts are addressed in Sections 21.4.1 and 21.5.1.
6.1(f)	impacts the development may have upon existing community emergency management arrangements for flooding. These matters must be discussed with the State Emergency Services and Council	Flood impacts are addressed in Sections 21.4.2 and 21.5.2. Consultation with the State Emergency Service and Council is provided in Chapter 5 (Stakeholder and community engagement).
6.1(g)	any impacts the development may have on the social and economic costs to the community as consequence of flooding.	Flood impacts are addressed in Sections 21.4.2 and 21.5.2.

Ref.	Secretary's environmental assessment requirements	Where addressed
17. Water – Hydrology		
17.1	The Proponent must describe (and map) the existing hydrological regime for any surface and groundwater resource (including reliance by users and for ecological purposes) likely to be impacted by the project, including stream orders, as per the Framework for Biodiversity Assessment (FBA).	The hydrological regime for surface water is described in Section 21.3. The hydrological regime for groundwater is described in Chapter 17 (Groundwater and geology).
17.2	The Proponent must assess (and model if appropriate) the impact of the construction and operation of the project and any ancillary facilities (both built elements and discharges) on surface and groundwater hydrology in accordance with the current guidelines, including:	
17.2(a)	natural processes within rivers, wetlands, estuaries, marine waters and floodplains that affect the health of the fluvial, riparian, estuarine or marine system and landscape health (such as modified discharge volumes, durations and velocities), aquatic connectivity and access to habitat for spawning and refuge	Hydrology impacts are addressed in Sections 21.4.1 and 21.5.1. Biodiversity impacts associated with hydrology are addressed in Chapter 20 (Biodiversity).
17.2(b)	impacts from any permanent and temporary interruption of groundwater flow, including the extent of drawdown, barriers to flows, implications for groundwater dependent surface flows, ecosystems and species, groundwater users and the potential for settlement	Groundwater impacts are addressed in Chapter 17 (Groundwater and geology).
17.2(c)	changes to environmental water availability and flows, both regulated / licensed and unregulated / rules-based sources	Chapter 18 (Soils, contamination and water quality).
17.2(d)	direct or indirect increases in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses	Hydrology impacts are addressed in Sections 21.4.1 and 21.5.1.
17.2(e)	minimising the effects of proposed stormwater and wastewater management during construction and operation on natural hydrological attributes (such as volumes, flow rates, management methods and re-use options) and on the conveyance capacity of existing stormwater systems where discharges are proposed through such systems	Hydrology impacts are addressed in Sections 21.4.1 and 21.5.1.
17.2(f)	water take (direct or passive) from all surface and groundwater sources with estimates of annual volumes during construction and operation.	Water take is addressed in Chapter 25 (Sustainability).
17.3	The Proponent must identify any requirements for baseline monitoring of hydrological attributes.	Mitigation measures are outlined in Section 21.6.

21.2 Assessment methodology

21.2.1 Surface hydrology and drainage infrastructure

The methodology for assessment of surface hydrology and drainage involved:

- Compilation and review of background information (previous studies, survey and mapping data) relevant to the project to define the existing environment within potentially affected catchments
- Identification and assessment of construction and operational activities that may impact on the surface water hydrology of receiving environments
- Identification of potential impacts as a result of changes in surface water quantity, with respect to increases or decreases in stormwater runoff and the sensitivity of the downstream waters
- Identification of mitigation measures, including type of controls and design criteria required to manage potential impacts.

The following guidelines were considered during the preparation of the surface hydrology and drainage infrastructure assessment:

- *Managing Urban Stormwater: Soils and Construction Volume 1* (Landcom 2004)
- *Managing Urban Stormwater: Soils and Construction Volume 2* (Department of Environment and Climate Change, 2008a).

21.2.2 Flooding

The methodology for assessing potential flood impacts involved:

- Compilation and review of previous flood studies relevant to the project to define existing flood behaviour within potentially affected catchments
- Identification and assessment of potential flood impacts on the project and adjacent properties
- Identification of mitigation measures, including type of controls and design criteria required to manage potential flood impacts
- Flood modelling at the Marrickville dive site to identify any potential changes to flood levels, discharges, velocities, duration of flood inundation and flood hazards (see below).

The following guidelines were considered during the preparation of the flood assessment:

- *Floodplain Development Manual* (NSW Government, 2005b)
- *Floodplain Risk Management Guideline: Practical Consideration of Climate Change* (Department of Environment and Climate Change, 2007b)
- *Floodplain Risk Management Guide: Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments* (Department of Environment, Climate Change and Water, 2010c)
- *New guideline and changes to section 117 direction and EP&A Regulation on flood prone land,* Planning Circular PS 07-003 (NSW Department of Planning, 2007).

Flood modelling at the Marrickville dive site (southern)

Two previous flood studies have been carried out for Marrickville Council within the catchment areas influenced by the Marrickville dive site:

- The *East Channel East Sub-catchment Flood Study* (Golders, 2010). The purpose of the *East Channel East Sub-catchment Flood Study* was to prepare a sub-catchment management plan, to allow Marrickville Council to apply sustainable water management to the East Channel East (ECE) sub-catchment
- The *Marrickville Valley Flood Study* (WMAwater, 2013). The purpose of the *Marrickville Valley Flood Study* was to define existing flood behaviour and provide a basis for a future Floodplain Risk Management Study and Plan (that is not yet finalised).

The *East Channel East Sub-catchment Flood Study* was used as an input into the *Marrickville Valley Flood Study*. Combined, these two flood studies cover the catchment area influenced by the Marrickville dive site.

To assess potential impacts of the project, the models for the above studies were obtained from Marrickville Council and adapted to create a new combined 1D-2D TUFLOW hydraulic flood model (the *Sydenham Flood Model*) that covers the project catchment. The *Marrickville Valley Flood Study* model was used as the basis for the *Sydenham Flood Model*; however elements of the *East Channel East Sub-catchment Flood Study* model and the *Marrickville Valley Flood Study* model have been incorporated into the *Sydenham Flood Model* as outlined in Table 21-2.

Table 21-2 Key parameters incorporated into the Sydenham Flood Model

Model parameter	Application to the Sydenham Flood Model
Hydrologic inputs	For their respective study areas, 1D network hydrology from the *Marrickville Valley Flood Study* and the *East Channel East Sub-catchment Flood Study* were applied to the *Sydenham Flood Model.*
TUFLOW version	2013-12-AE (latest version at the time of model creation).
Topographic data	As per the *Marrickville Valley Flood Study.*
Roughness values	For their respective study areas, roughness values from the *Marrickville Valley Flood Study* and the *East Channel East Sub-catchment Flood Study* were applied to the *Sydenham Flood Model* with the exception of the roughness co-efficient value for railway corridor areas, which was updated to 0.1 to ensure consistency across both models.
Building footprints	Building footprints have been applied as regions of high roughness (a roughness co-efficient of 10 has been applied) to ensure that velocities through the building footprints are reduced to be near zero. This approach produces results that are consistent with the modelling approach adopted by the *Marrickville Valley Flood Study* and the *East Channel East Sub-catchment Flood Study.*
Events simulated	Flood modelling has been carried out for the two year, five year, 10-year and 100-year average recurrence interval flood events, and the probable maximum flood event.
Critical duration storm events	Critical duration storm events have been applied as per the *Marrickville Valley Flood Study* (assumed to be two hours for the two year, five year, 10-year and 100-year average recurrence interval flood events and one hour for the probable maximum flood event.
Climate change scenario	A 30 per cent increase in rainfall combined with a 0.9 meter increase in sea level has been applied and is considered an appropriate worst case scenario.

The *Sydenham Flood Model* was run to model an ‘existing condition’ scenario (that is, existing flood conditions without the project) and checked for consistency with the outputs generated by the *Marrickville Valley Flood Study* and the *East Channel East Sub-catchment Flood Study* for the respective areas covered by those models.

Once the *Sydenham Flood Model* was verified as consistent with outputs from previous models in the ‘existing condition’ scenario, the project design was incorporated into the model to create a ‘project base-case’ (that is, modelled flood conditions inclusive of the project ‘without flood mitigation’). Based on the results of this model run it was found that flood mitigation would be required and various flood mitigation design scenarios were modelled (referred to as ‘project mitigation’ cases).

The ‘existing condition’ flood scenarios for the Marrickville dive site are discussed in Section 21.3.2, while potential construction phase flooding impacts are discussed in Section 21.4.2 and the operation phase ‘project base case’ and ‘project mitigation’ cases are discussed in Section 21.5.2.

21.3 Existing environment

21.3.1 Surface hydrology and drainage infrastructure

The project would be located within drainage catchments that ultimately drain to Middle Harbour, Sydney Harbour and Botany Bay. The catchments the project is located in, the receiving waters and associated drainage infrastructure are summarised in Table 21-3.

All drainage catchments across the project are highly urbanised, with large impervious surfaces created by roads, footpaths and buildings. These impervious surfaces are interspersed with pervious surfaces associated with parkland areas and other unsealed surfaces (such as vacant land and landscaped areas).

All natural watercourses have generally been replaced with constructed drainage systems (such as lined and unlined drainage channels, and sub-surface pit and pipe networks) that discharge into the downstream receiving environments (refer to Table 21-3).

Surface water is generally collected by developed stormwater networks, which consist of road kerb and guttering, lined and unlined drainage channels, and sub-surface pit and pipe networks. The majority of the drainage systems are owned and maintained by the local council, while a number of the larger trunk drainage systems are assets of Sydney Water. The existing drainage systems, as they would relate to project elements, are described in Table 21-3. Surface water catchments and watercourses are shown in Figure 21-1.

Table 21-3 Existing drainage catchments, receiving waters and associated drainage infrastructure

Project location	Surface water catchment	Receiving waters	Drainage infrastructure
Chatswood dive site (northern)	Near the top of Scotts Creek and Flat Rock Creek catchments	Middle Harbour	Rail corridor runoff is collected by the rail drainage system and discharged into surrounding council stormwater systems within the Flat Rock Creek Catchment. Runoff from the Chatswood dive site flows north into the Scotts Creek Catchment and is drained by a stormwater pipe that runs down Hammond Lane and crosses under the rail corridor at Chapman Avenue.
Artarmon substation	Flat Rock Creek	Middle Harbour	Runoff is collected by the drainage networks on Reserve Road and Gore Hill Freeway.
Crows Nest Station	Flat Rock Creek	Middle Harbour	Runoff is collected by road kerb and gutter systems and discharged into stormwater pits at the intersection of Oxley Street and Clarke Lane.
Victoria Cross Station	Milson Park	Sydney Harbour	Runoff is collected by road kerb and gutter systems and discharged east towards Kirribilli.
Blues Point temporary site	N/A	Sydney Harbour	Runoff drains directly into Sydney Harbour.

Project location	Surface water catchment	Receiving waters	Drainage infrastructure
Barangaroo Station	City Area (Sydney)	Sydney Harbour	Runoff is collected by a number of drainage pits and pipes on Hickson Road. The pipes discharge west directly into Sydney Harbour.
Martin Place Station	City Area (Sydney)	Sydney Harbour	Runoff is collected by the drainage system in Castlereagh Street, which discharges north toward Circular Quay and Sydney Harbour.
Pitt Street Station	City Area (Sydney)	Sydney Harbour	Runoff is collected by the road drainage systems, and drains north down Pitt Street and eventually discharges directly into Sydney Harbour.
Central Station	Darling Harbour (Sydney)	Sydney Harbour	Runoff is collected by the rail corridor drainage system and connects to larger pipe systems draining around and under the site. Rail corridor drainage in the northern half of the site connects to drainage in Eddy Avenue or a trunk drain under the site near Devonshire Street, both of which are part of the Darling Harbour catchment. Rail drainage in the southern half of the site connects to trunk mains under the site from Prince Alfred Park that are part of the Blackwattle Bay catchment.
Waterloo Station	Alexandra Canal	Botany Bay via the Cooks River	Runoff is collected by drainage systems in Botany Road and Cope Street.
Marrickville dive site (southern)	Marrickville Valley	Botany Bay via the Cooks River	Runoff is collected by the rail corridor drainage system or council stormwater system and discharged into the surrounding street and trunk drainage systems. The main drainage features comprise the Eastern Channel and the Sydenham Storage Pit located immediately north of the rail corridor. The Eastern Channel collects runoff from the areas of Enmore, Newtown and St Peters and discharges it south to the Cooks River and ultimately to Botany Bay. A number of rail culverts between Sydenham Station and the Bedwin Road overbridge drain areas south of the rail line into the Eastern Channel. The Sydenham Storage Pit is a large detention basin that collects urban runoff from areas of Marrickville that is then pumped into Eastern Channel. The Eastern Channel and Sydenham Storage Pit are both assets of Sydney Water.

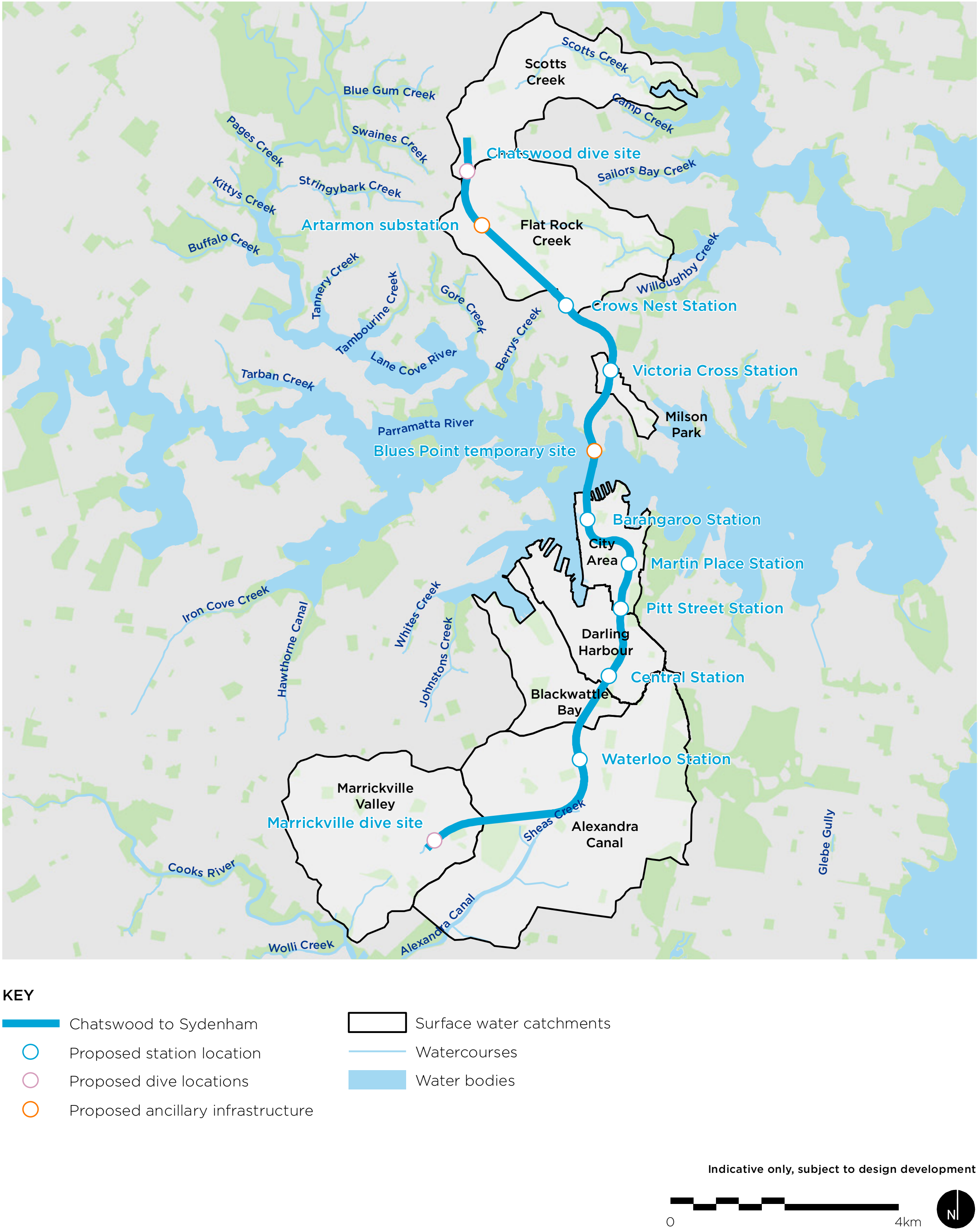


Figure 21-1 Surface water catchments and watercourses

21.3.2 Flooding

Background information

Due to the highly urbanised drainage catchments surrounding the project area, flooding behaviour is expected to be largely controlled by the capacity of stormwater drainage systems and roadways that form overland flow paths. Local councils have investigated flood behaviour to varying degrees. Relevant flood studies include:

- *Scotts Creek Flood Study* (Lyall and Associates Consulting Engineers, 2008)
- *Flat Rock Creek Flood Study* (Lyall and Associates Consulting Engineers, 2006)
- *Flat Rock Creek Updated Flood Study* (Lyall and Associates Consulting Engineers, 2011)
- *City Area Catchment Flood Study Final Report* (BMT WBM Pty Ltd, 2014a)
- *Darling Harbour Catchment Flood Study Final Report* (BMT WBM Pty Ltd, 2014b)
- *Eastern Channel East Subcatchment Management Plan Volume 1 – Management Study* (Golder Associates Pty Ltd, 2011)
- *Eastern Channel East Subcatchment Management Plan Volume 2 – Flood Study* (Golder Associates Pty Ltd, 2010)
- *Marrickville Valley Flood Study Final Report* (WMAwater, 2013)
- *Blackwattle Bay Catchment Flood Study Draft Report* (WMAwater, 2014)
- *Alexandra Canal Flood Study – Final* (Cardno Pty Ltd, 2014)
- *Cooks River Flood Study* (MWH+PB, 2009)
- *Cooks River Floodplain Risk Management Study and Plan* (WMAwater and Storm Consulting, 2015).

North Sydney Council is carrying out an overland flood study for the entire local government area. Flood modelling results from this study were not available at the time of writing.

Floodplain risk management

The *Floodplain Development Manual* (NSW Government, 2005b) identifies a floodplain risk management process that requires floodplain risk management studies and plans are developed based on relevant flood studies. As discussed in Section 21.2.2, the *Sydenham Flood Model* has been developed using the *Marrickville Valley Flood Study* model as a base, incorporating relevant elements of the *East Channel East Sub-catchment Flood Study* model. As such, the *Sydenham Flood Model* would be consistent with the flood studies informing a future floodplain risk management study and / or plan developed for the Marrickville Valley Catchment.

The *Cooks River Floodplain Risk Management Study and Plan* (2015) focusses on the Cooks River catchment and does not cover the area affected by the proposed Marrickville dive site. The Marrickville dive site (southern) is located within the Marrickville Valley Catchment and although no floodplain risk management study and / or plan is currently available for this catchment, the project is generally consistent with the *Eastern Channel East Subcatchment Management Plan* (Golder Associates Pty Ltd, 2011) and design development has considered, and does not preclude, potential future drainage improvement works proposed in this plan.

There would be ongoing consultation with Marrickville Council to review consistency of the project with any future floodplain risk management study and / or plan developed for the Marrickville Valley Catchment.

Existing flood behaviour

Based on the above studies, the existing flood behaviour around the project sites is described in Table 21-4.

Table 21-4 Description of existing flood behaviour

Location	Description of existing flood behaviour
Chatswood dive site (northern)	The Chatswood dive site is located near the top of the Scotts Creek and Flat Rock Creek drainage catchments. Localised flooding of the construction site and in the rail corridor has the potential to occur during high intensity rainfall events.
Artarmon substation	The site is located near the ridge between sub-catchments and would therefore not be affected by flooding. The main overland flow path near the site is on Reserve Road, which drains south before turning east along the northern side of the Gore Hill Freeway.
Crows Nest Station	The site is located at the top of the Flat Rock Creek catchment. During high intensity rainfall events, flows are carried away from the site by the existing road drainage infrastructure.
Victoria Cross Station	Urbanised areas of North Sydney drain towards the site. The main overland flow paths around the site are down Berry Street and Miller Street and there is a low point in Miller Street immediately north of the Pacific Highway intersection. The catchment upstream of the Miller Street low point covers about 17 hectares. Flood levels at the Miller Street low point, in the vicinity of the station site, are limited by the downstream level of the Pacific Highway.
Blues Point temporary site	This is a temporary site and would not be required for the full construction duration. It would be required to retrieve parts of the tunnel boring machines tunnelling from the Chatswood dive site and Barangaroo Station. During high intensity rainfall events, the site may be impacted by overland flows that drain into the harbour via Blues Point Road and Henry Lawson Avenue. The site may also be at risk of flooding from elevated sea levels during storm events. A Sydney Harbour water level with a 100-year average recurrence interval is about 1.4 metres above the Australian Height Datum (*Fort Denison Sea Level Rise Vulnerability Study*, Department of Environment and Climate Change, 2008c).
Barangaroo Station	The site is located along a low-lying area of Hickson Road. The catchment draining toward Hickson Road extends about 200 metres east to Observatory Hill. When the stormwater system capacity is exceeded, floodwaters flow onto Hickson Road from a low point on High Street near Lance Lane. Ponding currently occurs on Hickson Road in the Barangaroo Station site area in events as frequent as the two-year average recurrence interval. Ponding depths of between 0.5 and 0.75 metres would occur in the probable maximum flood event. There will be changes (improvements) to the existing flood environment in this location as a result of drainage infrastructure upgrade work proposed as part of the Central Barangaroo development.
Martin Place Station	The catchment falling towards the site extends about 200 metres east to Macquarie Street. The overland flow paths around the site are down Elizabeth, Castlereagh and Hunter streets. Overland flooding occurs during a five-year average recurrence interval event and flood depths of between 0.25 to 0.5 metres would occur in the probable maximum flood. High hazard flooding occurs in Hunter Street in flood events at or higher than the 20-year average recurrence interval.
Pitt Street Station	The site is located near the top of the City Area (Sydney) catchment. During high intensity rainfall events, flows would be carried by the surrounding roads and associated drainage networks and would not result in flooding in the vicinity of the Pitt Street Station site.

Location	Description of existing flood behaviour
Central Station	Urbanised areas of Surry Hills drain towards Central Station from the east. The main overland flow paths that approach Central Station are from: • Foveaux Street, where floodwaters continue west down Eddy Avenue toward George Street • Devonshire Street and Prince Alfred Park, where floodwaters enter the Central Station site and pond in low-lying sections of the rail track next to Prince Alfred Park in events as frequent as the two-year average recurrence interval.
Waterloo Station	Urban areas of Redfern drain towards the site. Cope Street and Botany Road are the main overland flow paths around the site. Flood depths of up to one metre occur near the Cope Street and Wellington Street intersection in the 100-year average recurrence interval event.
Marrickville dive site (southern)	The Marrickville dive site would be located in low-lying terrain where flooding occurs. Areas to the north and south of the existing rail lines (T2, T3 and T4 rail lines) drain towards the Marrickville dive site and Eastern Channel. The main overland flow path from the north is down Murray Street before floodwaters enter the upstream section of Eastern Channel. Catchments from south of the rail corridor drain via a number of culverts under the rail line into Eastern Channel. These culverts flow full in flood events with an average recurrence interval of two years or more, causing floodwaters to flow over the rail line near the Bedwin Road overbridge and Sydenham Station. Currently in a 10-year average recurrence interval event, overland stormwater flows mostly occur to the south of the rail corridor. From Grove and Sutherland streets, stormwater flows westward and across Unwins Bridge Road and through commercial properties before pooling mostly in low-lying areas on Bolton Street. Low-level flooding occurs within the rail corridor immediately to the north of Sydenham Station. Low to mid-level flooding also occurs on Murray Street. Currently in a 100-year average recurrence interval event, overland stormwater flows follow similar flow paths to the one in 10-year annual recurrence interval event. Low to mid-level flooding occurs in Grove and Sutherland streets and Unwins Bridge Road and high-level flooding is predicted to occur in Bolton Street. Mid-level flooding (about 0.75 metres peak depth) is predicted to occur on Murray Street in this flood event. At Sydenham Station, flooding of the rail tracks between station platforms occurs with peak depths reaching about 0.5 metres. Low-level flooding of the rail corridor occurs to the north of Sydenham Station and also in the vicinity of Murray Street (south of Bedwin Road) in the 100-year average recurrence interval flood event. Currently the modelled probable maximum flood event results in extensive flooding around the Marrickville dive site. The majority of the existing rail line between the Bedwin Road overbridge and Sydenham Station would be flooded with depths varying between 0.5 and 1.5 metres. Under current site conditions mid to high-level flooding is modelled to occur in the probable maximum flood event on Unwins Bridge Road, and high-level flooding to depths exceeding 1.5 metres is predicted to occur on Murray Street, Bolton Street and at Sydenham Station between the station platforms. Existing flood extents around the Marrickville dive site are shown in Figure 21-2.

Figure 21-2 Marrickville dive site – existing 10-year ARI, 100-year ARI and Probable Maximum Flood events

21.4 Potential impacts – construction

21.4.1 Surface hydrology and drainage infrastructure

Construction of the project has the potential to alter existing stormwater flows due to the introduction of additional areas of impervious surfaces, alterations (relocation and / or additions) to existing stormwater drainage infrastructure, dewatering activities, and the establishment of erosion and sediment control measures (to redirect stormwater runoff around the construction site and / or capture runoff in detention basins).

With the exception of widening work required in the T1 North Shore Line corridor, construction of the Artarmon substation and the Blues point temporary site all construction sites are currently impervious to infiltration and well-established drainage systems are already in place to cater for stormwater flows. At these sites construction activities would not result in any major increase in stormwater volumes or peak flow rates.

Construction activities may result in a minor redistribution of some surface water flows. However, it is unlikely that the redistribution of flows would affect the performance of downstream drainage infrastructure. For example, construction of the Marrickville dive site and southern services facility may require minor changes to existing stormwater infrastructure in Murray Street.

Construction within the T1 North Shore Line corridor, the Artarmon substation and the Blues Point temporary site may result in minor changes to existing localised surface water and / or stormwater flow regimes. At these sites it is unlikely that additional stormwater infrastructure would be required to manage any changes in flow regimes in the construction phase. Erosion and sediment controls, including the redirection and capture of construction site runoff, would be used to manage drainage on construction sites prior to discharge into existing drainage infrastructure (mitigation measures are outlined in Section 21.6).

21.4.2 Flooding

Stations and ancillary infrastructure

As identified in Table 21-4, the Barangaroo Station, Martin Place Station and Waterloo Station sites are at risk of flooding during construction. Flooding of the construction sites could result in flood water entering the tunnels and excavations or stockpiles of construction materials (such as aggregate, fuels and other hazardous materials) and spoil being washed into nearby drainage lines and waterways.

Construction of the project also has the potential to alter local flood behaviour due to the obstruction of overland flow paths, loss of floodplain storage (for example, due to stockpiling construction materials and spoil) and the alteration to stormwater drainage infrastructure. Changes in existing flood behavior may have adverse effects on nearby properties or infrastructure by increasing flood levels or the likelihood of flooding.

Work at the Blues Point temporary site and at Martin Place and Waterloo station sites is expected to have minimal impacts on flooding.

As identified in Table 21-4, Barangaroo Station construction site would be located within Hickson Road that is currently subject to flooding. There will be changes (improvements) to the existing flood environment in this location as a result of drainage infrastructure upgrade work proposed as part of the Central Barangaroo development. Detailed construction planning for the Barangaroo construction site would consider flood risk at the site inclusive of any change to the flood environment as a result of the Central Barangaroo development.

Tunnel dive structures

The Chatswood dive site would not be located in a flood prone area and because the site is not subject to inundation in flood events, any changes in levels at the site during construction of the project would not affect existing flood behaviour in the area.

As discussed in Table 21-4, the Marrickville dive site would be located within a flood-prone area and would be at risk of flooding during construction. The Marrickville dive site would cover an area bounded by Edinburgh Road, the existing rail line, Sydney Steel Road, and the Sydenham Storage Pit. Eastern Channel runs through the Marrickville dive site (southern).

Construction access within the Marrickville dive site (southern) area would require minor treatments (widening / reinforcement) to existing structures that span Eastern Channel. These treatments would not change the capacity of Eastern Channel in the construction phase.

Existing overland flow paths surrounding the Marrickville dive construction site include flows from the existing rail corridor and Edinburgh Road into Murray Street that then connect with Eastern Channel. Railway Parade and Edgeware Road also carry overland flows. Construction of the Marrickville dive site may obstruct other overland flow paths (that is, require diversion of overland flow) that may result in flooding of the construction site and / or adjacent properties.

The extent of flooding associated with the diversion of existing overland flow paths is currently unknown as detailed construction methods and sequencing have not yet been developed for this site. Potential flood impacts during construction would be managed through detailed construction planning, including the development of appropriate site layouts and staging of construction activities, to avoid or minimise obstruction of overland flow paths and limit the extent and duration of flow diversions required.

21.5 Potential impacts – operation

21.5.1 Surface hydrology and drainage infrastructure

The project has the potential to alter localised stormwater catchment flows and the operation of existing stormwater drainage networks due to:

- The introduction of additional drainage infrastructure or rerouting of existing drainage infrastructure (drainage infrastructure may need to be relocated and / or augmented to accommodate elements of the project such as station infrastructure)
- Increases to local drainage catchment areas
- Increases to impervious surface areas.

Potential impacts associated with increased local drainage catchment areas and increased runoff due to an increase in impervious surfaces may occur as a result of widening of the T1 North Shore Line corridor at Chatswood and at the Artarmon substation site. For example, widening of the T1 North Shore Line corridor to accommodate metro tracks would increase the drainage catchment within the corridor and increase the peak flow rate and volume of stormwater entering the existing drainage network.

At all other locations, the aboveground station infrastructure would be located within the footprint of existing development and would have a negligible impact on the existing surface hydrology. The runoff volume and flow rate would be similar to the existing conditions and there would be no impact to the capacity of the existing downstream stormwater infrastructure. All surface water from aboveground facilities and tunnel dive structures would also be collected by new drainage infrastructure and connected to existing stormwater systems.

Surface water from aboveground facilities and tunnel dive structures, including for the T1 North Shore Line corridor and at the Artarmon substation site, would be managed such that there would be no net increase in discharge rates from existing discharge locations into the downstream drainage system for all storm events. This management approach would not be required where it can be demonstrated that increased flow rates as a result of the project would not increase downstream flood risk.

On-site detention of stormwater would be introduced where surface water runoff rates are increased and where space for on-site detention is available. Where there is insufficient space for the provision of on-site detention, the upgrade of downstream infrastructure would be considered in the preparation of detailed design.

The southern services facility, located adjacent to the Marrickville dive site, would include a water treatment plant to treat all tunnel water prior to release into Eastern Channel. Conservatively, the rate of inflow of water into the tunnel has been estimated at about 12.5 liters per second. To accommodate treatment of this inflow and additional volumes of water (for example as a result of fire suppression) the water treatment plant design accommodates an inflow rate of up to 15 litres per second (470 megalitres per year).

The impact of this additional discharge on the performance of the stormwater channel is expected to be minimal as the additional flow would be negligible compared to the channel's existing capacity and the current volume of stormwater flows from the local catchment. There would be no potential erosion impacts as the receiving stormwater channel is fully concrete lined.

21.5.2 Flooding

Stations and ancillary infrastructure

As identified in Table 21-4 Barangaroo Station, Martin Place Station and Waterloo Station sites are at risk of flooding during operation. To avoid flooding impacts on project infrastructure, station entries aboveground rail system facilities would be located above the Probable Maximum Flood level and at least 0.5 metres above the 100-year average recurrence interval flood level, where feasible and reasonable. Where it is not feasible and reasonable to meet these design criteria, design would consider the need for sumps and pumps to manage any potential inflows into project infrastructure.

Aboveground stations and ancillary infrastructure would have a negligible impact on existing flood behaviour because the infrastructure would be located within the footprint of existing structures or located away from identified overland flow paths. The infrastructure would be compatible with the existing flood hazard and hydraulic function of the site and would have minimal impact to the community and emergency management response requirements given there would be minimal change to the existing flood behaviour.

Tunnel dive structures

To avoid inundation, the tunnel dive structures would be designed at or above the Probable Maximum Flood level for mainstream flooding. Drainage at the dive structures would be designed to manage flows for the 100-year average recurrence interval event.

No flooding impacts on, or as a result of, the project are anticipated at or surrounding the Chatswood dive site. To avoid flooding of the Marrickville dive structure, the metro tracks have been designed at a level of about 6.3 metres Australian Height Datum near the start of the dive structure, which is about 1.5 metres above the existing ground level. This design means that retaining walls for the dive structure and placement of metro tracks on new embankment material would be required within the floodplain at this location.

The flood hazard at this location in the 100-year average recurrence interval event is low, with high hazard areas being located at the Bolton Street low point (a flood storage location) and along Eastern Channel (a floodway). These flood storage and floodway areas would not be impacted by the design and hence the dive structure would not change the flood hazard at the site and would be compatible with the hydraulic function of the site.

The establishment of project infrastructure within flood-prone areas such as at the Marrickville dive structure has the potential to affect the existing flood behaviour surrounding the sites due to the loss of overland flow path capacity, loss of floodplain storage and change to local catchment boundaries (which could change the distribution of stormwater between existing drainage networks). Changes in existing flood behaviour may have adverse effects on nearby properties or infrastructure by increasing flood levels or the likelihood of flooding.

There are limitations to the design options available for the introduction of the Marrickville dive structure and associated metro tracks. The introduction of metro surface tracks on a viaduct-type structure (that allows stormwater to flow between the existing surface level and the underside of the viaduct) was considered, however this option was not viable because of the limited vertical clearance available, which is dictated by vertical clearance constraints under the station concourse and adjacent road bridge at Sydenham Station. As such, flood mitigation options considered are limited to drainage infrastructure treatments (see below).

Flood modelling at the Marrickville dive site was carried out to determine the potential impacts of the project on flood behaviour. As discussed in Section 21.3.2, the *Sydenham Flood Model* has been developed based on flood models provided by Marrickville Council and is consistent with the current available flood studies for the area. The following criteria, developed based on principles identified in the *Floodplain Development Manual* (NSW Government, 2005b), were used to assess the design:

- No additional private properties flooded, in events up to and including the 100-year average recurrence interval event
- Increases in flood levels during events up to and including the 100-year average recurrence interval are to be minimised, as far as practicable, particularly within private properties
- Any increase in flow velocity in a 100-year average recurrence interval event should not significantly increase the potential for soil erosion and scouring
- Running tunnels to be protected from inundation in the Probable Maximum Flood event.

The flood model considers the Chatswood to Sydenham project as well as elements of the Sydenham to Bankstown project located at and to the north of Sydenham Station. As such, the assessment at this location reflects the potential flooding impacts of both projects combined. The Sydenham to Bankstown Environmental Impact Statement would refine and update the flood modelling, if required, in the area between the Marrickville tunnel portal and Sydenham Station.

The design of the Marrickville dive structure was developed and incorporated into the flood model and was initially found not to comply with the above flood-related design criteria. Six flood mitigation options were developed and a preferred option selected for inclusion in the project design that best met the flood-related design criteria. Flood mitigation options considered are outlined in Table 21-5.

Table 21-5 Flood mitigation options considered

Mitigation option	Number of grated inlets provided	Inlet spacing	Connection to Eastern Channel	Assumed blockage[1]
Option 1	Five (about 3 x 1.2 metres)	About 50 metres	One culvert (about 1.2 x 0.9 metres)	25 per cent
Option 2	Six (about 3 x 1.2 metres)	About 25 metres	One culvert (about 1.2 x 0.9 metres)	25 per cent
Option 3	Six (about 3 x 1.2 metres)	About 10 metres	One culvert (about 1.2 x 0.9 metres)	25 per cent
Option 4	Six (about 3 x 1.2 metres)	About 10 metres	Two culverts (about 1.2 x 0.9 metres)	25 per cent
Option 5	10 (about 3 x 1.2 metres)	About 10 metres	Two culverts (about 1.2 x 0.9 metres)	10 per cent
Option 6	14 (about 3 x 1.2 metres)	About 10 metres	Two culverts (about 1.5 x 0.9 metres)	10 per cent

1 *'Assumed blockage' refers to an allowance made for reduced capacity performance of drainage infrastructure for modelling purposes*

As identified in Chapter 6 (Project description – operation), the preferred flood mitigation option is for the introduction of ten grated inlets (about 3 metres x 1.2 metres) at ten metre spacing on the eastern side of the proposed metro rail tracks, connected to Eastern Channel via two underground reinforced concrete box culverts (about 1.2 metres x 0.9 metres). On balance, mitigation option 5 best meets the assessment criteria and provides a realistic representation of the flood mitigation treatment that could constructed for the project in this location.

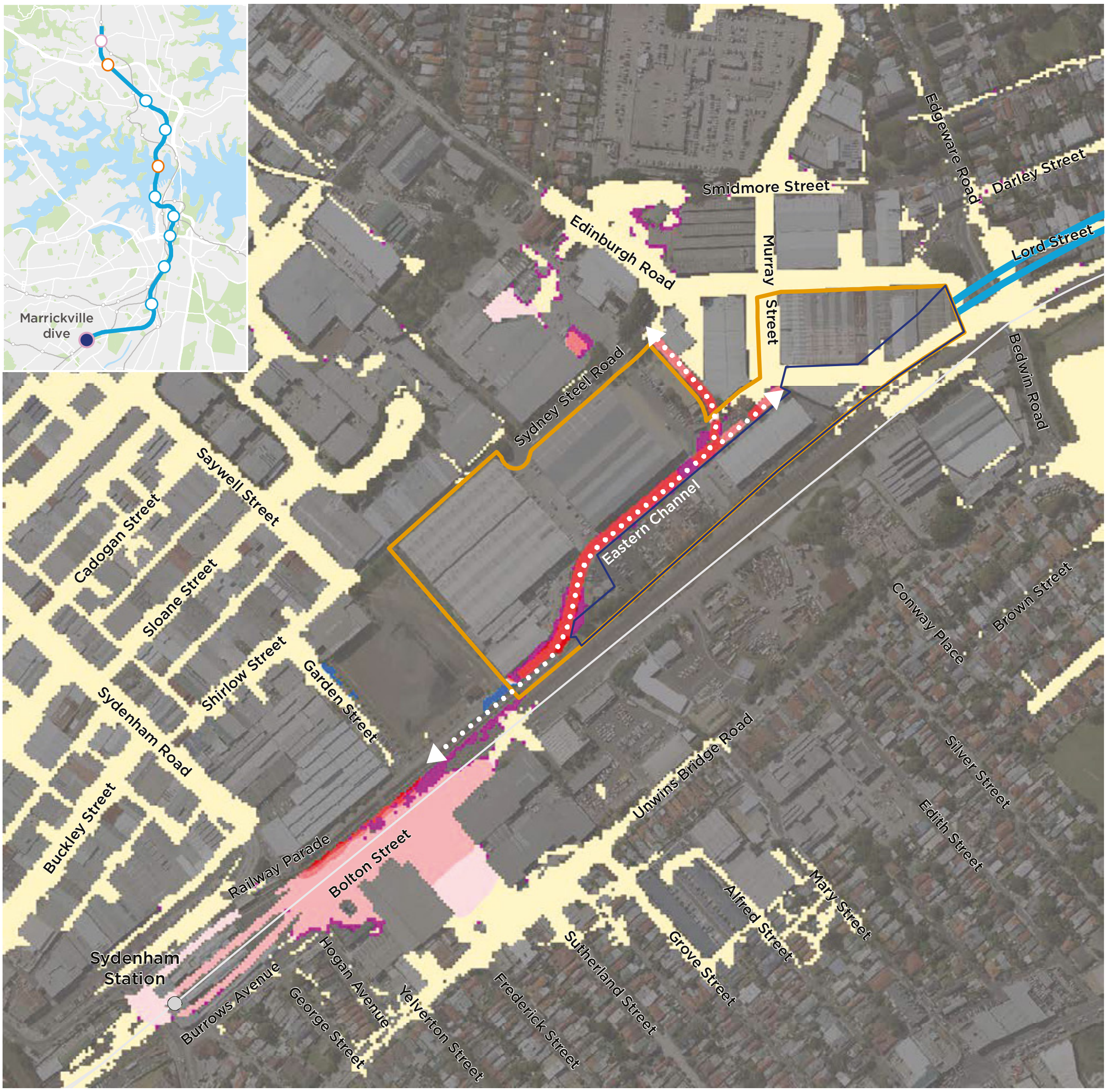
Table 21-6 identifies existing flood levels for the two year, five year, 10-year, 100-year and the probable maximum flood events at locations surrounding the Marrickville dive site and outlines the modelled changes in flood levels for those events with the project and inclusive of the preferred flood mitigation design treatment.

Table 21-6 Flood depths for modelled flood events with and without the project

Flood event		Location				
		Within private property (corner Hogan Ave and Bolton St)	Within road reserve (Bolton Street)	Within the Sydenham Station area	Generally within the rail corridor	Within rail corridor adjacent to proposed metro infrastructure
Two year ARI event	Existing flood depth	430 mm	1310 mm	420 mm	260 mm	360 mm
	Increase with project	+20 mm	+20 mm	+70 mm	+70 mm	+260 mm
Five year ARI event	Existing flood depth	510 mm	1400 mm	500 mm	340 mm	430 mm
	Increase with project	+20 mm	+30 mm	+80 mm	+80 mm	+320 mm
Ten year ARI event	Existing flood depth	550 mm	1450 mm	530 mm	390 mm	450 mm
	Increase with project	+30 mm	+30 mm	+90 mm	+90 mm	+360 mm
100 year ARI event	Existing flood depth	660 mm	1570 mm	640 mm	580 mm	570 mm
	Increase with project	+70 mm	+70 mm	+130 mm	+160 mm	+470 mm
PMF event	Existing flood depth	800 mm	1740 mm	840 mm	660 mm	740 mm
	Increase with project	+380 mm	+380 mm	+420 mm	+570 mm	+600 mm

In a 10-year average recurrence interval event, residual flood impacts have been modelled to include an increase in flood level within the rail corridor of between 90 and 360 millimetres (depending on location) and an increase of less than 30 millimetres in peak flood depth at the Bolton Street low point and at adjacent properties.

In a 100-year average recurrence interval event, there would be an increase of 70 millimetres in flood level within the Bolton Street low point and adjacent private property, and increases of 130 to 470 millimetres within the rail corridor. The changes in flood levels as a result of the project in the 100-year average recurrence interval event are shown in Figure 21-3.



KEY

- Chatswood to Sydenham
- Proposed operational area at surface
- Proposed construction site area
- Existing suburban rail
- Eastern Channel

100 year ARI event change in flood level (mm)

- > -20
- Negligible change
- 20 to 50
- 50 to 150
- 150 to 250
- 250 to 350
- 350 to 450
- 450 <
- Increase in flood extent

Indicative only, subject to design development

0 200 m

N

Figure 21-3 Marrickville dive site – change in flood level as a result of the project in the 100-year average recurrence interval event

In a probable maximum flood event, there would be increases in flood level of 150 to 250 millimetres on the southern side of the rail line on Bolton Street, Unwins Bridge Road, Sutherland Street, and Briar Lane, and increases greater than 450 millimetres on the northern side of the rail line at the intersection of Railway Parade and Sydenham Road.

The project would result in increased flood levels in areas that currently experience flooding (that is, no additional properties would be flood-affected as a result of the project in scenarios up to and including the 100-year average recurrence interval flood event). Flood levels would increase only in those parts of the road network and rail corridor that currently experience flooding (for example Bolton Street and the rail corridor from Bedwin road up to and including Sydenham Station). Bolton Street is currently not considered trafficable in the 100-year average recurrence interval event and there would be no additional sections of the rail corridor that experience 'above-rail' flooding as a result of the project.

Given that the increase in flood levels would only occur at areas already subject to flooding, the project would not require changes to existing community emergency management arrangements for flooding and there would not be increased social and / or economic costs to the community as consequence of flooding.

The frequency of disruptions to rail services in the area immediately north of Sydenham Station as a result of flooding is unknown, however given that there would be an increase in flood depth within the rail corridor there is a possibility that the frequency of flood-related disruptions to Sydney Trains operations in this area may increase. The design of this project and the Sydenham to Bankstown upgrade project would be reviewed with the intent of further reducing flood levels for events up to and including the 100-year annual recurrence interval, including at private properties, within the road reserve at Bolton Street and within the rail corridor around Sydenham Station. Consultation with Sydney Trains would be carried out during detailed design to ensure the frequency of rail service disruptions is not increased as a result of the project.

There would be no discernible change to flood velocities except within the Sydenham Station area where minor increases of up to 0.25 metres per second are predicted. There would also be no discernible change in flood duration in the area surrounding the Marrickville dive structure as a result of the project.

21.6 Mitigation measures

The mitigation measures that would be implemented to address potential impacts on hydrology and flooding are listed in Table 21-7 and Table 21-8.

Table 21-7 Mitigation measures – flooding and hydrology – construction

Ref	Mitigation measure	Applicable location(s)[1]
Flooding		
FH1	Detailed construction planning would consider flood risk at Barangaroo Station, Martin Place Station and the Waterloo Station construction sites. This would include identification of measures to avoid, where reasonable and feasible, construction phase flooding impacts on the community and on other property and infrastructure.	BN, MP, WS
FH2	The site layout and staging of construction activities at the Marrickville Dive site would avoid or minimise obstruction of overland flow paths and limit the extent of flow diversion required.	MDS
FH3	Overland flow diversions required during construction at the Marrickville dive site would meet the following criteria: - Increases in flood levels during events up to and including the 100-year average recurrence interval would be minimised, particularly within private properties - Any increase in flow velocity for events up to and including a 100-year average recurrence interval event would not increase the potential for soil erosion and scouring - Dedicated evacuation routes would not be adversely impacted in flood events up to and including the probable maximum flood. Construction planning for the Marrickville dive site would be carried out in consultation with the State Emergency Services and Marrickville Council.	MDS

1 *STW: Surface track works; CDS: Chatswood dive site; AS: Artarmon substation; CN: Crows Nest Station; VC: Victoria Cross Station; BP: Blues Point temporary site; GI: Ground improvement works; BN: Barangaroo Station; MP: Martin Place Station; PS: Pitt Street Station; CS: Central Station; WS: Waterloo Station; MDS: Marrickville dive site; Metro rail tunnels: Metro rail tunnels not related to other sites (eg TBM works); PSR: Power supply routes.*

Table 21-8 Mitigation measures – flooding and hydrology – operation

Ref	Mitigation measure	Applicable location(s)[1]
Surface hydrology and drainage infrastructure		
FH4	Where feasible and reasonable, detailed design would result in no net increase in stormwater runoff rates in all storm events unless it can be demonstrated that increased runoff rates as a result of the project would not increase downstream flood risk.	STW, AS, MDS
FH5	Where space permits, on-site detention of stormwater would be introduced where stormwater runoff rates are increased. Where there is insufficient space for the provision of on-site detention, the upgrade of downstream infrastructure would be implemented where feasible and reasonable.	STW, AS, MDS
FH6	Detailed design would occur in consultation with Marrickville Council to ensure future drainage improvement works around the Marrickville dive site would not be precluded.	MDS
FH7	Consultation would be carried out with Marrickville Council to ensure flood-related outcomes of the project are consistent with any future floodplain risk management study and / or plan developed for the Marrickville Valley Catchment.	MDS
FH8	The frequency of Sydney Trains rail service disruptions due to flooding would not be increased in the vicinity of the Marrickville dive structure.	MDS
FH9	Design of the Marrickville dive structure would be reviewed to, where reasonable and feasible, further reduce flood levels for events up to and including the 100-year annual recurrence interval, including at private properties, within the road reserve at Bolton Street and around Sydenham Station. Flood modelling to support detailed design would be carried out in accordance with the following guidelines: • *Floodplain Development Manual* (NSW Government, 2005b) • *Floodplain Risk Management Guideline: Practical Consideration of Climate Change* (Department of Environment and Climate Change, 2007b) • *Floodplain Risk Management Guide: Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments* (Department of Environment, Climate Change and Water, 2010c) • *New guideline and changes to section 117 direction and EP&A Regulation on flood prone land, Planning Circular PS 07-003* (NSW Department of Planning, 2007).	MDS

1 *STW: Surface track works; CDS: Chatswood dive site; AS: Artarmon substation; CN: Crows Nest Station; VC: Victoria Cross Station; BP: Blues Point temporary site; GI: Ground improvement works; BN: Barangaroo Station; MP: Martin Place Station; PS: Pitt Street Station; CS: Central Station; WS: Waterloo Station; MDS: Marrickville dive site; Metro rail tunnels: Metro rail tunnels not related to other sites (eg TBM works); PSR: Power supply routes.*

AIR QUALITY

CHAPTER TWENTY-TWO

22 Air quality

This chapter provides an assessment of the potential impact on air quality as a result of the project and identifies mitigation measures to address these impacts.

22.1 Secretary's environmental assessment requirements

There are no Secretary's environmental assessment requirements that relate specifically to this chapter.

22.2 Assessment methodology

A qualitative air quality impact assessment was carried out and involved:

- A desktop review of the background air quality environment based on 2013 and 2014 data sourced from NSW Office of Environment and Heritage air quality monitoring stations at Lindfield, Rozelle, Randwick and Earlwood (the closest stations to the project)
- A desktop review of long term meteorological conditions (including prevailing wind and temperature trends) based on data sourced from Bureau of Meteorology monitoring stations at Sydney Observatory Hill, Sydney Harbour Wedding Cake West, Riverview Observatory and Sydney Airport
- A desktop review of Commonwealth Department of the Environment's National Pollutant Inventory data to identify any projects or facilities that may be contributing to local air quality conditions
- The identification of air quality sensitive receivers with the potential to be adversely affected by the project
- A review of construction and operational aspects of the project with the potential to generate air pollutant emissions (including dust and exhaust emissions)
- A qualitative assessment of potential air quality impacts at surrounding sensitive receivers. This assessment was undertaken by comparing the locations of construction and operational air pollutant emission sources and nearby receivers with prevailing weather and ambient air quality conditions
- The identification of mitigation measures to address potential air quality impacts.

22.3 Existing environment

Ambient air quality throughout the Sydney Basin is influenced by a number of factors, including topography, prevailing meteorological conditions (such as wind and temperature, which vary seasonally) and local and regional air pollution sources (such as motor vehicles, industrial facilities and bushfires). Consequently, regional air quality can be highly variable and impacted by events occurring a significant distance away. Local emission sources, the existing air quality environment, and sensitive receivers are described below.

22.3.1 Local emission sources

A search of the Commonwealth Department of the Environment's National Pollutant Inventory (2015) and a desktop review of land uses surrounding the project area identified a number of air pollution sources close to the project which are likely to influence local air quality. These sources include:

- Industrial facilities at Lane Cove, Artarmon, St Leonards, North Sydney, Greenwich, Alexandria, Camperdown, Sydenham, Marrickville and Mascot that reported air emissions (under the National Pollutant Inventory reporting program) during the 2013–2014 reporting period. These facilities include:
  - basic ferrous and other fabricated metal product manufacturing (at Artarmon and Alexandria)
  - waste treatment, disposal and remediation services (at Artarmon and North Sydney)
  - hospitals (at St Leonards)
  - mineral, metal and chemical wholesaling (at Greenwich and Mascot)
  - airport operations and other air transport support services (at Mascot)
- Vehicle exhaust emissions from the road and rail networks and shipping activities in Sydney Harbour
- Commercial businesses, such as service stations and smash repairs
- Domestic activities, such as wood-fired home heaters and lawn mowing
- Other construction projects.

22.3.2 Background air quality

Air quality data sourced from monitoring stations at Lindfield, Rozelle, Randwick and Earlwood are summarised in Table 22-1. The data shows that the concentrations of air pollutants were generally below the applicable air quality criteria during the 2012, 2013 and 2014 reporting periods, with the exception of occasional days when the maximum 24-hour average concentration levels of particulate matter with an aerodynamic diameter less than 10 microns (PM_{10}) exceeded the applicable criterion of 50 micrograms per cubic metre. These occurrences are generally the result of natural events including dust storms, bushfires and sea spray arising from on-shore winds.

The NSW Office of Environment and Heritage uses a standardised measurement known as the air quality index to characterise air quality at a location and compare it in relative terms with other locations throughout NSW. The average daily air quality index values for Central and Eastern Sydney in 2012, 2013 and 2014 were 53, 60 and 52 respectively. These values correspond with an air quality index outcome of 'good', indicating that air quality around Central and Eastern Sydney is generally of an acceptable quality.

Table 22-1 Background air quality data

Pollutant	Averaging period	Criteria[1]	Lindfield			Rozelle			Randwick			Earlwood		
			2012	2013	2014	2012	2013	2014	2012	2013	2014	2012	2013	2014
PM10 (µg/m³)	Maximum 24-hour	50	35	63	38	41	59	44	44	55	46	44	63	45
	95th percentile 24-hour	50	24	26	25	29	34	30	31	34	32	34	35	30
	Annual	30	14	14	14	17	18	18	18	19	18	20	20	18
CO (µg/m³)	Maximum 1-hour	30	–	–	–	0.3 (average) 1.6 (100th %-ile)			–	–	–	–	–	–
NO_2 (µg/m³)	Maximum 1-hour	246	43.1 (100th %-ile)			57.5 (100th %-ile)			45.2 (100th %-ile)			49.3 (100th %-ile)		
	Annual	62	16.4	15.2	15.0	22.0	21.4	20.1	11.9	12.3	11.1	16.4	18.4	15.7
SO_2 (µg/m³)	Maximum 1-hour	570	11.4 (100th %-ile)			–	–	–	14.3 (100th %-ile)			–	–	–
	Annual	60	1.5	1.4	1.1	–	–	–	3.4	2.4	2.5	–	–	–

1 *Criteria sourced from the Approved Methods for Modelling and Assessment of Air Pollutants in NSW (Department of Environment and Conservation, 2005b).*

22.3.3 Sensitive receivers

The project would traverse a well-established urban environment that contains a wide range of sensitive receivers including residential properties, community facilities (such as schools, childcare centres, places of worship and medical facilities), recreational areas and commercial and retail premises. A number of these receivers are located immediately adjacent to the construction site boundaries of the proposed metro stations.

A detailed description of the existing land use patterns and sensitive receivers surrounding the project is provided in Chapter 12 (Land use and property) and Chapter 19 (Social impacts and community infrastructure) and summarised in Table 22-2.

Table 22-2 Summary of sensitive receivers

Location	Surrounding land use and sensitive receivers
Chatswood dive site (northern)	Set adjacent to the T1 North Shore Line in Chatswood, medium density residential dwellings are located to the north and south of the site, with low density housing located to the east. Commercial and industrial premises are located immediately to the south and west of the site. The nearest sensitive receivers are the residential receivers set immediately to the north along Nelson Street and the residents east of the work area, on the opposite side of the rail corridor along Orchard Road.
Artarmon substation	The site is surrounded on the northern and eastern sides by residential land uses. The Gore Hill Freeway runs along the south-west boundary of the site.
Crows Nest Station	The Crows Nest station site is to be located adjacent to the Pacific Highway within the commercial district at Crows Nest. This location is bordered to the north by a commercial district and mixed use commercial and residential premises.
Victoria Cross Station	The Victoria Cross station construction sites are located along Miller Street around the intersections with McLaren Street, and between Berry and Mounts streets. These areas are surrounded by commercial and retail land uses with some interspersed residential uses. The Monte Sant' Angelo Mercy College is located between the two construction sites, along Miller Street. The nearest single dwelling residential receivers are set along McLaren Street, immediately west of the Victoria Cross station north construction site.
Blues Point temporary site	The Blues Point temporary site would be located within the Blues Point Reserve at the end of Blues Point Road. The multi-storey residential building Blues Point Tower is set just to the west of the site with other residential premises around 50 to 150 metres away along Warung Street. One residential receiver is also present adjacent to the site to the east.
Barangaroo Station	The site would be located within the road reserve of Hickson Road and the adjacent Barangaroo development area. The nearest residential premises are located immediately to the east along High Street and High Lane, and to the north along Argyle Place.
Martin Place Station	Both sites are currently occupied by commercial and residential mixed use buildings. Both areas are surrounded by mixed use commercial and retail users, including residential. The Sydney Eye Hospital is also located around 150 metres to the east of the site.
Pitt Street Station	The Pitt Street Station construction sites would be located on the corner of Pitt, Park and Castlereagh streets; and around the corner of Pitt and Bathurst streets. Both areas are surrounded by a mixture of commercial, residential, retail and educational land uses. Several hotels and short-term accommodation premises are also located nearby.
Central Station	The Central Station construction site would be located primarily within the operational area of the station. The site is located in close proximity to commercial and residential mixed use areas. Several educational institutes are located to the east, with the University of Technology Sydney also located around 500 metres to the west. Many multi-story hotels and apartment buildings are located to the east of the site along George, Little Regent and Quay Streets.
Waterloo Station	Set at a block bounded by Raglan Street, Cope Street, Wellington Street and Botany Road, the site is surrounded in all directions by lands zoned for 'Mixed Use' and 'General Residential' uses. The nearest residential premises are located to the south along Wellington Street and the east along Cope Street.
Marrickville dive site (southern)	Located adjacent to the T3 Bankstown Line in the Marrickville industrial area, the site is mostly surrounded by industrial uses. Camdenville Park is located to the east, with the nearest residential receivers located around 150 metres away to the south east along Unwins Bridge Road and to the north on Lord and Darley streets.

22.4 Potential impacts – construction

During construction, local air quality may be temporarily affected by particulate (dust) and exhaust emissions. These impacts are described in the following sections.

22.4.1 Dust (including asbestos fibres and other hazardous materials)

The main potential air quality impacts during construction would be associated with the generation of dust, which would include pollutants such as total suspended particulates (TSP) and particulate matter with an aerodynamic diameter less than 10 microns (PM_{10}) and less than 2.5 microns ($PM_{2.5}$).

Owing to the urban setting, there is also potential for dust emissions to contain:

- Contaminants mobilised through the disturbance of contaminated soils
- Other hazardous materials, such as asbestos fibres and hazardous biological material (for example bird droppings) mobilised through the demolition of buildings and other structures. These issues are discussed in Chapter 18 (Soils, contamination and water quality).

Construction activities with the greatest potential to generate dust would include:

- Excavation, handling, stockpiling, loading and unloading, and transport of spoil
- Demolition of buildings and other structures, and the handling, stockpiling and transport of demolition material
- Transport, loading and unloading, stockpiling and handling of imported construction materials such as imported fill
- Creation of exposed surfaces through the clearing of vegetation, stripping of topsoil and other overlying structures (such as road and footpath pavements), which would increase the potential generation of dust emissions by wind erosion
- Concrete batching and pre-cast concreting activities.

Without the implementation of adequate mitigation measures, dust emissions from the above activities could result in reduced local air quality and dust deposition at the nearest potentially affected receivers due to the small distance between these receivers and the construction sites.

The volume of dust generated during a typical work day would vary depending on the types of activities occurring at each construction site and prevailing weather conditions (for example, dry windy conditions increase the potential for wind erosion) and the controls that are implemented to reduce these emissions.

Sensitive receivers with the greatest potential to be adversely affected by dust at each construction site (due to the location of sensitive receivers, magnitude of dust-generating activities and prevailing meteorological conditions) are outlined in Table 22-3.

Table 22-3 Potential construction dust impacts on nearby sensitive receivers

Site	Potential dust impacts on nearby sensitive receivers
Chatswood dive site (northern)	Nearby residential receivers located east of the site would be most susceptible to dust emissions during mornings when winds typically blow from the west. During afternoons, commercial and industrial receivers to the south of the site would have the most potential to be impacted by dust emissions. Occasional southerlies present dust emission risks for the nearest residential receivers immediately north of the site along Nelson Street.
Artarmon substation	Winds predominantly shift clockwise from the southeast to the southwest and present the greatest dust emission risks to the residential receivers immediately adjacent to the site.
Crows Nest Station	This site is surrounded in all directions by residential or mixed use residential land users. Dust emission risks would be greatest at residential receivers east of the Pacific Highway during mornings and residential receivers west of the Pacific Highway during afternoons.
Victoria Cross Station	Potential dust impacts may arise if wind-dispersible material is handled at the site when strong winds are blowing from the east and southeast, which are common during afternoons.
Blues Point temporary site	Residential receivers are located to the west, north and east of the site. The most common winds are from the east in the afternoons (which could result in dust impact to Blues Point Tower located to the west) and the west in the mornings (which could result in dust impact to the single residential receiver located to the east).
Barangaroo Station	Residential receivers located to the east of the site along High Street and High Lane are most likely to be affected during mornings when westerlies are prevalent, but also occasionally during afternoons when strong westerlies can occur (greater than 40 kilometres per hour). Receivers to the north of the site off Argyle Place may be affected during occasional southerlies. In addition, there is some potential that contaminated materials may be encountered during excavations, which would lead to potential odour impacts and require specific mitigation measures.
Martin Place Station	This site is closely bordered by commercial and retail premises. Morning winds blowing from the west present the greatest risk, considering the location of the Sydney Eye Hospital located around 150 metres to the east of the site.
Pitt Street Station	During handling and management of spoil, dust impacts could arise under any wind conditions owing to the proximity of receivers around the construction site.
Central Station	This site is surrounded by a variety of different receivers and may be sensitive to all wind conditions. Morning winds from the west may blow dust towards receivers along Chalmers Street and Elizabeth Street. The multi-story accommodation at Railway Square has the greatest risk of being affected during afternoons.
Waterloo Station	This site is surrounded by residential dwellings. As such, winds from any direction would present a risk during construction. Owing to the prevalence of westerlies in the morning and easterlies in the afternoon, the nearest receivers along Cope Street and Botany Road are expected to be most susceptible during construction.
Marrickville dive site (southern)	A range of works with a high potential to generate dust would be carried out at this site including tunnel boring machine launch and support, spoil handling, storage and removal activities, and concrete batching and pre-cast manufacture. At this site, light winds from the northwest during the morning pose the highest risk to impact on the residential receivers located to the southeast of the site along Unwins Bridge Road.

Overall, dust emissions would be comparable to other similar infrastructure projects and the risk of dust impacting on receivers would be readily manageable through standard mitigation measures, such as wetting stockpiles and exposed surfaces and minimising dust-generating works during adverse weather conditions.

The risk of mobilising hazardous materials (including contaminants, asbestos fibres and biological material) would be adequately managed through standard air quality management planning as detailed in Table 22-4.

22.4.2 Exhaust emissions

Exhaust emissions during construction would generally be restricted to minor localised emissions of carbon monoxide, oxides of nitrogen, sulfur dioxide and volatile organic compounds. These pollutants would be generated during the combustion of fuel in construction plant, machinery and equipment, as well as from the handling and / or on-site storage of fuel and other chemicals.

The tunnel boring machines used to excavate the tunnels would use electric power and therefore would not create local exhaust emissions. However, at some of the station construction sites, roadheaders may be powered by generators instead of providing a mains power connection, or for a period of time prior to the mains power supply becoming available. This would result in local exhaust emissions.

Minor emissions of carbon monoxide, oxides of nitrogen, sulfur dioxide and volatile organic compounds would not significantly affect local air quality at the nearest sensitive receivers and would be adequately managed with standard mitigation measures.

22.5 Potential impacts – operation

22.5.1 Local impacts

As the project would be powered by electricity, local emissions generated during operation are expected to be minimal and highly dispersed.

The project would include a ventilation system to circulate fresh air through the tunnels and underground stations and prevent the build-up of heat. Fresh air would be drawn into the tunnels and air would be extracted from the tunnels through the portals by the piston effect of the trains, and by mechanical ventilation at the stations. Air would be discharged from the tunnel portals and through ventilation outlets integrated into each station.

The stations would also provide separate fresh air ventilation systems to draw fresh air in and extract air from the station environment. Air discharged from the tunnels and stations would be well diluted and dispersed into the outdoor air.

Minor quantities of particulate matter (PM_{10}) emissions would be generated in the tunnels, mainly due to wear of the train brake pads, vaporisation of metals due to sparking, wear of steel due to friction between wheels and rail, and recirculation of particulates from tunnel walls. Most of these emissions would be vented through the fresh air ventilation system in very low concentrations.

Vented air is also likely to comprise minor concentrations of carbon dioxide, volatile organic compounds and oxides of nitrogen as well as ash and soot particulates generated during maintenance. The ventilation outlet air would contain small quantities of particulates at low concentrations due to the large volumes of exhaust air. Given the low concentrations of particulates, it is very unlikely that the project would have air quality impacts on the surrounding environment, including sensitive receivers.

The fresh air ventilation system would also respond to emergency conditions such as fire incidents where smoke-laden air would be discharged through the emergency ventilation system to prevent smoke entering stations or recirculating through ventilation shafts or tunnel portals. The design and location of the fresh air ventilation shafts at stations would ensure sensitive receivers were not unnecessarily affected; suitable emergency plans would be in place for these circumstances.

Although air quality may be impacted at the source of power generation, the overall impact from increased power generation to run the trains is expected to be minor. An assessment of greenhouse gas emissions anticipated to be generated during the operation of the project (due to power generation) is provided in Chapter 25 (Sustainability).

22.5.2 Regional impacts

The project is expected to benefit regional air quality by delivering an attractive alternative mode of public transport, which could result in a mode shift from road to rail. This has the potential to reduce air pollution emissions from road transport and congestion within the Global Economic Corridor (when compared to the emissions that would otherwise occur if the project were not delivered).

22.6 Mitigation measures

The mitigation measures that would be implemented to address potential air quality impacts are listed in Table 22-4.

Table 22-4 Mitigation measures – air quality

Ref	Mitigation measure	Applicable location(s)[1]
AQ1	The engines of all on-site vehicles and plant would be switched off when not in use for an extended period.	All
AQ2	Plant would be well maintained and serviced to minimise emissions. Emissions from plant would be considered as part of pre-acceptance checks.	All
AQ3	Construction site layout and placement of plant would consider air quality impacts to nearby receivers.	All except metro rail tunnels
AQ4	Hard surfaces would be installed on long term haul routes and regularly cleaned.	All except metro rail tunnels
AQ5	Unsurfaced haul routes and work area would be regularly damped down in dry and windy conditions.	All except metro rail tunnels
AQ6	All vehicles carrying loose or potentially dusty material to or from the site would be fully covered.	All except metro rail tunnels
AQ7	Stockpiles would be managed to minimise dust generation.	All except metro rail tunnels
AQ8	Demolition would be managed to minimise dust generation.	All except metro rail tunnels

1 *STW: Surface track works; CDS: Chatswood dive site; AS: Artarmon substation; CN: Crows Nest Station; VC: Victoria Cross Station; BP: Blues Point temporary site; GI: Ground improvement works; BN: Barangaroo Station; MP: Martin Place Station; PS: Pitt Street Station; CS: Central Station; WS: Waterloo Station; MDS: Marrickville dive site; Metro rail tunnels: Metro rail tunnels not related to other sites (eg TBM works).*

HAZARD AND RISK

CHAPTER TWENTY-THREE

23 Hazard and risk

This chapter provides an assessment of environmental hazards and risks that could arise during construction and operation of the project, and management strategies to address these hazards and risks.

23.1 Secretary's environmental assessment requirements

The Secretary's environmental assessment requirements relating to hazard and risk, and where these requirements are addressed in this Environmental Impact Statement, are outlined in Table 23-1.

Table 23-1 Secretary's environmental assessment requirements – hazard and risk

Ref.	Secretary's environmental assessment requirements	Where addressed
10. Socio-economic, Land Use and Property		
10.3	Assess the likely risks of the project to public safety, paying particular attention to subsidence risks, bushfire risks and the handling and use of dangerous goods.	Public safety risks are addressed in Chapter 19 (Social impacts and community infrastructure). Traffic related public safety risks during construction are addressed in Chapter 8 (Construction traffic and transport). Traffic related public safety risks during operation are addressed in Chapter 9 (Operation traffic and transport). Subsidence and settlement risks are addressed in Chapter 17 (Groundwater and geology). Bushfire risks are addressed in Sections 23.3.2 and 23.4.2. Handling and use of dangerous goods are addressed in Sections 23.3.1 and 23.4.1.

23.2 Assessment methodology

A desktop assessment was carried out to identify environmental hazards and risks that could arise during construction and operation of the project, as well as management measures to address such issues.

The assessment focused on those hazards and risks with the potential to adversely affect the quality of the surrounding environment, land uses and communities, with consideration of the following relevant guidelines:

- *Hazardous and Offensive Development Application Guidelines: Applying SEPP 33* (Department of Planning 2011)
- *International Standard (ISO / IEC 31010) Risk Management – Risk Assessment Technique*
- *Australian Code for the Transport of Dangerous Goods by Road and Rail (7th edition)* (National Transport Commission, 2007)
- *Storage and Handling of Dangerous Goods Code of Practice* (WorkCover, 2005)
- Bushfire prone land mapping developed and published by the relevant local councils.

Other work, health and safety hazards are not specifically considered in this Environmental Impact Statement. These issues would be addressed by the construction contractor and operator in accordance with relevant guidelines and legislative requirements.

23.3 Potential impacts – construction

Potential hazards and risks during construction would be associated with:

- The on-site storage, use and transport of dangerous goods and hazardous substances
- The rupture of, or interference with, underground utilities
- Risk of damage to existing building basements and ground support structures due to ground movement and geotechnical uncertainty
- Bushfire risks.

These hazards and risks are described further in the following sections.

23.3.1 On-site storage, use and transport of dangerous goods and hazardous substances

An indicative list of the types of potentially hazardous materials anticipated to be used, stored and transported during construction of the project is provided in Table 23-2, along with the relevant storage and transport thresholds established under Applying SEPP 33.

The thresholds in Applying SEPP 33 represent the maximum quantities of hazardous materials that can be stored or transported without causing a significant off-site risk.

Typically, low volumes of potentially hazardous materials would be stored on site, with the exception of the Chatswood and Marrickville dive sites where larger volumes of materials would be required to support tunnel construction. The volume required to be stored on site would largely depend on the anticipated rates of consumption, with deliveries of dangerous goods coordinated to match consumption rates. This could be about one delivery per day if needed to meet storage thresholds based on the proximity of sensitive receivers, provided that this is within transport thresholds.

Construction site planning would ensure hazardous materials are stored appropriately and at an appropriate distance from sensitive receivers, in accordance with the thresholds established under Applying SEPP 33. Should the minimum buffers be unable to be maintained, either due to space constraints, the close proximity of sensitive receivers, or a requirement to store volumes of hazardous materials in excess of storage thresholds, a risk management strategy would be developed on a case-by-case basis.

Environmental hazards and risks associated with the on-site storage, use and transport of chemicals, fuels and materials would be managed through standard mitigation measures to be developed as part of the construction environmental management documentation. These measures would include the storage and management of all hazardous substances in accordance with the *Work Health and Safety Act 2011*, the *Storage and Handling of Dangerous Goods Code of Practice* (WorkCover NSW, 2005) and Applying SEPP 33 (Department of Planning, 2011).

Table 23-2 Indicative list of hazardous materials potentially required during construction and applicable storage / transport thresholds

Material	Australian Dangerous Good Code Class	Storage locations	Storage method	Applying SEPP 33 thresholds		
				Storage volume	Minimum storage distance from sensitive receivers	Transport (weekly)
Diesel	C1[1]; 3 PG III[2]	All sites	20 litre drums / carry cans	Greater than 5 tonnes, if stored with other Class 3 flammable liquids	5 metres	Not applicable if not transported with Class 3 dangerous goods
Petrol	C1[1]; 3 PG III[2]	All sites	20 litre drums	Greater than 5 tonnes, if stored with other Class 3 flammable liquids	5 metres	Not applicable if not transported with Class 3 dangerous goods
Lubricating and hydraulic oils and greases	C2	All sites	20 litre drums	N/A	N/A	Not applicable, if not transported with Class 3 dangerous goods
Explosives	1.1	No on-site storage	Delivery of explosives would be timed to avoid the need for on-site storage	N/A	N/A	Subject to consultation with the Department of Planning and Environment
Industrial grade oxygen	2.2	All sites	Cylinders (up to 55 kilograms) in rack	N/A	N/A	Not subject to Applying SEPP 33 transport thresholds
Medical grade oxygen / breathing gas	2.2	Barangaroo Station and Blues Point	Cylinders (up to 55 kilograms) in rack	N/A	N/A	Not subject to Applying SEPP 33 transport thresholds
Acetylene	2.1	All sites	Cylinders (up to 55 kilograms) in rack	Greater than 0.1 tonnes (100kg)	15 metres	2 tonnes; 30 times per week
Cement	N/A	All sites	Bags / pallets (in container)	N/A	N/A	Not subject to Applying SEPP 33 transport thresholds

Material	Australian Dangerous Good Code Class	Storage locations	Storage method	Applying SEPP 33 thresholds		
				Storage volume	Minimum storage distance from sensitive receivers	Transport (weekly)
Premix concrete	N/A	All sites	Bags / pallets (in container)	N/A	N/A	Not subject to Applying SEPP 33 transport thresholds
Concrete curing compounds	N/A	All sites	20 litre drums	N/A	N/A	Not subject to Applying SEPP 33 transport thresholds
Concrete retardant	3 PG III	All sites	205 litre drums	Greater than 5 tonnes	5 metres	10 tonnes; 60 times per week
Shotcrete accelerator	3 PG II	All sites	1,000 litre intermediate bulk containers	Greater than 5 tonnes	5 metres	3 tonnes; 45 times per week
Epoxy glue	3 PG III	All sites	Small containers	Greater than 5 tonnes	5 metres	10 tonnes; 60 times per week
Coagulants	N/A	All sites	1,000 litre intermediate bulk containers	N/A	N/A	Not subject to Applying SEPP 33 transport thresholds
Acids	8 PG II	All sites	1,000 litre intermediate bulk containers	Greater than 25 tonnes	N/A	2 tonnes; 30 times per week
Bases	8 PG II	All sites	1,000 litre intermediate bulk containers	Greater than 25 tonnes	N/A	2 tonnes; 30 times per week
Disinfectant	8 PG III	All sites	500 litre intermediate bulk containers	Greater than 50 tonnes	N/A	2 tonnes; 30 times per week
Anti-scalent	N/A	All sites	100 litre drums	N/A	N/A	Not subject to Applying SEPP 33 transport thresholds
Membrane preservative	8 PG III	All sites	10 litre drums	Greater than 50 tonnes	N/A	2 tonnes; 30 times per week
Foam additives / surfactant	N/A	Barangaroo Station	Drums	N/A	N/A	Not applicable

Material	Australian Dangerous Good Code Class	Storage locations	Storage method	Applying SEPP 33 thresholds		
				Storage volume	Minimum storage distance from sensitive receivers	Transport (weekly)
Flocculent	N/A	Barangaroo Station	Drums	N/A	N/A	Not applicable
De-bonding agents	N/A	All sites	Drums / containers	N/A	N/A	Not applicable
Contaminated waste	Dependent on nature of material	All sites	Bunded areas or removed directly from site	Dependent on nature of material	Dependent on nature of material	Dependent on nature of material
Paint	N/A	Station sites	20 litre drums	N/A	N/A	Not subject to Applying SEPP 33 transport thresholds

1 *Classified as C1 if not stored with other Class 3 flammable liquids.*

2 *Classified as 3PGIII if stored with other Class 3 flammable liquids.*

23.3.2 Rupture of, or interference with, underground utilities

As outlined in Chapter 7 (Project description – construction), a number of utilities would need to be adjusted, relocated and / or protected to enable construction of the project. Damage, rupture and / or failure to shut down or isolate underground utilities during this work has the potential to result in the following environmental hazards and risks:

- Release of untreated sewage and / or gas from a sewer main
- Release of natural gas from a gas main
- Release of large electrical currents through the ground surface from an underground electricity cable (known as earth potential rise).

The risk associated with these hazards would be minimised by carrying out utility checks (such as dial before you dig searches and non-destructive digging), consulting with the relevant utility providers and, if required, relocating and / or protecting utilities in and around the project prior to construction. Consultation with utility providers would commence during detailed design and continue during construction to mitigate the risk of unplanned and unexpected disturbance of utilities.

23.3.3 Bushfire risks

The project would be located in a highly developed urban environment that generally lacks substantial areas of vegetation. A review of bushfire prone land mapping developed and published by the relevant local councils indicated that none of the proposed construction sites would be located on or in proximity to bushfire prone land. Therefore, bushfire risks are considered to be negligible.

23.3.4 Risk of damage to existing building basements and ground support structures due to ground movement and geological uncertainty

Ground movement (or settlement) refers to a localised lowering of the ground level due construction activities. It can affect nearby buildings and other structures. Building basements and ground support structures present potential risks in terms of direct impact and indirect ground movement impacts.

An assessment of potential ground movement associated with the project is provided in Chapter 17 (Groundwater and geology). In summary, the project is considered to have a negligible ground movement risk, with superficial damage to buildings unlikely to occur. Although, small areas at station sites and dive sites may require future building strain and structural assessment. The use of survey data would improve the understanding of risks associated with basements and ground support structures and inform the design process.

The uncertainty about ground conditions also presents risks for the construction process. For example, if rock is found to be harder or softer than assumed during the design process, this could lead to tunnelling difficulties, prompt a redesign and affect stability. This uncertainty would be addressed through further geotechnical investigation to improve understanding of ground conditions and through the development of an appropriate construction methodology.

The potential for ground settlement, and management or protection measures to address this issue, are discussed in Chapter 17 (Groundwater and geology). Chapter 10 (Construction noise and vibration) considers vibration impacts and the potential for structural damage, and includes measures to address vibration impacts.

23.4 Potential impacts – operation

Potential hazards and risks during operation would be associated with:

- The on-site storage, use and transport of dangerous goods and hazardous substances
- Bushfire risks.

These hazards and risks are described further in the following sections.

23.4.1 On-site storage, use and transport of dangerous goods and hazardous substances

The main hazards and risks likely to be encountered during the operation of the project would be the storage, use and transport of chemicals, fuels and materials. In particular, the proposed tunnel water treatment plant at the southern services facility would require the storage, use and transport of several chemicals, including sodium hydroxide, polyaluminium chloride and a polymer.

An indicative list of the types of potentially hazardous materials anticipated to be used, stored and transported during operation of the project is provided inTable 23-3, along with the relevant storage and transport thresholds established under *Hazardous and Offensive Development Application Guidelines: Applying SEPP 33* (Applying SEPP 33) (Department of Planning, 2011).

The Applying SEPP 33 thresholds represent the maximum quantities of hazardous materials that could be stored or transported without causing a significant off-site risk.

Environmental hazards and risks associated with the on-site storage, use and transport of chemicals, fuels and materials would be managed through standard mitigation measures to be developed as part of the operational environmental management system. These measures would include the storage and management of all hazardous substances in accordance with the *Work Health and Safety Act 2011*, the *Storage and Handling of Dangerous Goods Code of Practice* (WorkCover NSW, 2005) and *Applying SEPP 33* (Department of Planning, 2011).

Table 23-3 Indicative list of hazardous materials potentially required during operation and applicable storage / transport thresholds

Material	Australian Dangerous Good Code Class	Storage locations	Storage method	Applying SEPP 33 thresholds		
				Storage volume	Minimum storage distance from sensitive receivers	Transport (weekly)
Sodium hydroxide	8 PG II	Southern services facility	To be confirmed during detailed design however storage would be under the SEPP 33 thresholds	Greater than 25 tonnes	N/A	2 tonnes; 30 times per week
Polyaluminium chloride	N/A			N/A	N/A	Not subject to Applying SEPP 33 transport thresholds
Polymer	N/A			N/A	N/A	Not subject to Applying SEPP 33 transport thresholds

23.4.2 Bushfire risks

The project would be located in a highly developed urban environment that generally lacks substantial areas of vegetation. A review of bushfire prone land mapping developed and published by the relevant local councils indicated that none of the aboveground aspects of the project would be located on or in proximity to bushfire prone land. Therefore, bushfire risks are considered to be negligible.

23.5 Mitigation measures

The mitigation measures that would be implemented to address potential hazards and risks are listed in Table 23-4.

Table 23-4 Mitigation measures – hazard and risk – construction

Ref	Mitigation measure	Applicable location(s) [1]
HR1	All hazardous substances that may be required for construction and operation would be stored and managed in accordance with the *Storage and Handling of Dangerous Goods Code of Practice* (WorkCover NSW, 2005) and *Hazardous and Offensive Development Application Guidelines*: *Applying SEPP 33* (Department of Planning, 2011).	All
HR2	Dial before you dig searches and non-destructive digging would be carried out to identify the presence of underground utilities.	All
HR3	A hazardous material survey would be completed for those buildings and structures suspected of containing hazardous materials (particularly asbestos) prior to their demolition. If asbestos is encountered, it would be handled and managed in accordance with relevant legislation, codes of practice and Australian standards.	CDS, CN, VC, MP, PS, CS, WS, MDS
HR4	The method for delivery of explosives would developed prior to the commencement of blasting in consultation with the Department of Planning and Environment and be timed to avoid the need for on-site storage.	CN, VC, BN, MP, PS, WS

1 *STW: Surface track works; CDS: Chatswood dive site; AS: Artarmon substation; CN: Crows Nest Station; VC: Victoria Cross Station; BP: Blues Point temporary site; GI: Ground improvement works; BN: Barangaroo Station; MP: Martin Place Station; PS: Pitt Street Station; CS: Central Station; WS: Waterloo Station; MDS: Marrickville dive site; Metro rail tunnels: Metro rail tunnels not related to other sites (eg TBM works).*

Table 23-5 Mitigation measures – hazard and risk – operation

Ref	Mitigation measure	Applicable location(s) [1]
HR5	All hazardous substances that may be required for operation would be stored and managed in accordance with the *Storage and Handling of Dangerous Goods Code of Practice* (WorkCover NSW, 2005) and *Hazardous and Offensive Development Application Guidelines: Applying SEPP 33* (Department of Planning, 2011).	All

1 *STW: Surface track works; CDS: Chatswood dive site; AS: Artarmon substation; CN: Crows Nest Station; VC: Victoria Cross Station; BP: Blues Point temporary site; GI: Ground improvement works; BN: Barangaroo Station; MP: Martin Place Station; PS: Pitt Street Station; CS: Central Station; WS: Waterloo Station; MDS: Marrickville dive site; Metro rail tunnels: Metro rail tunnels not related to other sites (eg TBM works); PSR: Power supply routes.*

WASTE MANAGEMENT

CHAPTER TWENTY-FOUR

24 Waste management

This chapter provides an assessment of waste associated with the project and identifies mitigation measures to minimise impacts.

24.1 Secretary's environmental assessment requirements

The Secretary's environmental assessment requirements relating to waste management and where these requirements are addressed in this Environmental Impact Statement are outlined in Table 24-1.

Table 24-1 Secretary's environmental assessment requirements – waste management

Ref.	Secretary's environmental assessment requirements	Where addressed
16. Waste		
16.1	The Proponent must assess predicted waste generated from the project during construction and operation, including: **a.** Classification of the waste in accordance with the current guidelines **b.** Estimates / details of the quantity of bulk earthworks and spoil balance to be generated during the construction of the project **c.** Handling of waste including measures to facilitate segregation and prevent cross contamination **d.** Management of waste, including indicative location and volumes of spoil material **e.** Waste minimisation and re-use **f.** Lawful disposal or recycling locations for each type of waste using a hierarchy which prioritises higher value end use **g.** Contingencies for the above, including managing unexpected waste volumes.	Waste is addressed in Sections 24.6 Section 24.7.
16.2	The Proponent must assess potential environmental impacts from the excavation, handling, storage on site and transport of the waste particularly with relation to sediment / leachate control, noise and dust.	Sediment / leachate control is addressed in Chapter 18 (Soils, contamination and water quality). Noise is addressed in Chapter 10 (Construction noise and vibration). Dust is addressed in Chapter 22 (Air quality).

24.2 Regulation of waste

Waste management and recycling is regulated in NSW by the NSW Environment Protection Authority through the *Protection of the Environment Operations Act 1997* (refer to Chapter 2 (Planning and assessment process), for discussion on this Act), the *Protection of the Environment Operations (Waste) Regulation 2014* (including the requirement to track certain types of waste) and the *Waste Avoidance and Resource Recovery Act 2001*.

The *Waste Avoidance and Resource Recovery Act 2001* aims to promote waste avoidance and resource recovery through (amongst other things) the establishment of the following waste hierarchy:

1. Avoidance of waste – the first priority in waste management includes actions to reduce the amount of waste generated
2. Resource recovery – the second priority in waste management involves opportunities for re-use (without further processing), recycling (processing waste materials to make the same or different products), reprocessing and energy recovery
3. Disposal – the least desirable option in the waste management hierarchy involves the disposal of waste in an appropriate manner so as to minimise the potential adverse environmental impacts associated with its disposal.

To support the above waste hierarchy, the NSW Environment Protection Authority released the *NSW Waste Avoidance and Resource Recovery Strategy 2014–21* (Environment Protection Authority, 2014a), which provides a framework and targets for waste management and recycling in NSW to 2021–22. Targets established under this strategy comprise:

- Avoiding and reducing the amount of waste generated per person in NSW
- Increasing recycling rates to 70 per cent for municipal solid waste; 70 per cent for commercial and industrial waste; and 80 per cent for construction and demolition waste
- Increasing waste diverted from landfill to 75 per cent
- Managing problem wastes better, and establishing 86 drop-off facilities and services across NSW
- Reducing litter, with 40 per cent fewer items (compared to 2012) by 2017
- Combatting illegal dumping, with 30 per cent fewer incidents (compared to 2011) by 2017.

Transport for NSW, as a NSW Government agency, has a general responsibility to support these targets by:

- Implementing complementary policies and programs, including sustainable procurement
- Incorporating resource recovery and waste reduction objectives into its operations
- Complying with relevant regulations.

Transport for NSW's commitment to managing waste during construction and operation of the project is outlined in Section 24.3.

24.3 Sustainability strategy

Transport for NSW has developed a project-specific sustainability strategy for the Chatswood to Sydenham project. This strategy includes initiatives and targets to manage waste during construction and operation of the project. Further discussion on the initiatives and targets contained in the project-specific sustainability strategy (including how these initiatives and targets would be implemented) is provided in Chapter 25 (Sustainability).

24.4 Assessment methodology

- A desktop assessment was carried out and comprised:
- A review of spoil volumes
- A review of the likely waste streams and volumes, including wastewater and demolition materials
- Identification of the environmental impacts associated with the generation (and subsequent disposal) of waste materials, with consideration of:
  - Waste minimisation and re-use potential
  - The level of hazard associated with the types of waste generated
  - The capacity of disposal facilities to receive the volumes of waste generated by the project
- A spoil management strategy to identify how spoil would be managed during construction, including likely volumes, likely nature and classification of excavated material, opportunities for recycling, potential disposal sites, stockpile management, and method(s) and route of transportation. The spoil management strategy also considered the cumulative effects of spoil haulage and disposal activities associated with other major infrastructure projects within Sydney (cumulative impacts are assessed in Chapter 26 (Cumulative impacts))
- Targets for the beneficial re-use of solid wastes, wastewater and other construction wastes in accordance with the project's sustainability strategy (refer to Chapter 25 (Sustainability))
- Management strategies to adequately address waste during construction and operation, including:
  - Managing construction waste through the waste hierarchy established under the *Waste Avoidance and Recovery Act 2001*
  - Developing procedures for the assessment, handling, stockpiling and disposal of potentially contaminated materials and wastewater, in accordance with the NSW Office of Environment and Heritage's *Waste Classification Guidelines* (DECCW, 2009b).

24.5 Waste generation

This section outlines waste generation anticipated to be associated with construction and operation of the project. The potential impact associated with waste generation is assessed in Section 24.6 and Section 24.7.

24.5.1 Construction stage

The main construction activities anticipated to generate waste are outlined in Table 24-2 along with the likely materials produced.

Table 24-2 Indicative types of waste generated during construction

Activity	Materials produced
Tunnelling, station excavations, cuttings and general earthworks	Spoil comprising virgin excavated natural material (uncontaminated soil and crushed rock); tunnel boring machine cutter heads and associated equipment replacement (conveyer belts etc.); tunnel boring machine lubricants (bentonite slurry or similar); contaminated materials and potential acid sulfate soils; waste water including groundwater inflows to tunnels and station excavations.
Demolition of buildings and other structures	Concrete, bricks, tiles, timber (treated and untreated), metals, plasterboard, carpets, electrical and plumbing fittings and furnishings (such as doors and windows), hazardous waste (including asbestos and insulation).
Dust suppression, wash down of plant and equipment, and staff amenities at construction sites (such as toilets)	Sediment-laden and / or potentially contaminated wastewater, sewage and grey water.
Tunnel and station fit-out and general construction activities and resource use	Concrete waste, timber formwork, scrap metal, steel, plasterboard, cable and packaging material.
Maintenance of construction plant, vehicles and equipment	Adhesives, lubricants, waste fuels and oils, engine coolant, batteries, hoses and tyres.
Activities at offices and crib rooms	Putrescibles, paper, cardboard, plastics, glass and printer cartridges.
Clearing and grubbing of vegetation, landscaped and / or turfed areas	Green waste.

The types and quantities of construction waste generated by the project would be site specific and would vary throughout the stages of construction.

The largest volumes of construction waste are anticipated to be generated during the excavation of tunnels, stations, with smaller quantities of spoil also generated during the excavation of the ancillary shaft at Artarmon and the temporary retrieval shaft at Blues Point. This would predominantly comprise spoil (consisting of uncontaminated soil and crushed rock) and wastewater (from water used during excavation, and groundwater inflows).

Indicative volumes of spoil anticipated to be generated during construction of the project are outlined in Table 24-3. As discussed in Chapter 7 (Project description – construction) spoil from tunnel boring activities would be extracted from the Chatswood dive site, Marrickville dive site and Barangaroo Station (as reflected in Table 24-3), while spoil from other construction sites would generally be excavated from station sites and shafts.

Table 24-3 Indicative volumes of spoil generated during construction of the project

Activity	Materials produced (m^3)	Expected spoil composition
Chatswood dive site – dive excavation	60,000	Sandstone
Chatswood dive site – tunnelling	460,000	Sandstone
Artarmon substation	2,000	Sandstone
Crows Nest Station	150,000	Shale / sandstone
Victoria Cross Station	175,000	Sandstone
Blues Point temporary site	8,000	Sandstone
Barangaroo Station	145,000	Sandstone
Barangaroo Station – tunnelling	90,000	Sandstone / marine sediment
Martin Place Station	175,000	Sandstone
Pitt Street Station	160,000	Sandstone
Central Station	230,000	Sandstone
Waterloo Station	115,000	Shale / sandstone
Marrickville dive site – dive excavation	70,000	Shale / sandstone
Marrickville dive site – tunnelling	560,000	Shale / sandstone
Total	2,400,000	

As shown in Table 24-3, it is envisaged that the project would generate about 2.4 million cubic metres of spoil. Strategies that would be developed to address spoil management are outlined in Section 24.6.1.

The volumes of construction wastes are expected to be comparable to other similar infrastructure projects (including Sydney Metro Northwest, which is currently under construction) and have not been estimated as part of this Environmental Impact Statement (due to the early design stage of the project and the materiality of such estimates on the conclusions of the assessment). These construction wastes are expected to be manageable through the application of standard waste management strategies (addressing waste generation, storage, disposal and re-use) and the project-specific sustainability initiatives documented in Chapter 25 (Sustainability).

24.5.2 Operation stage

The main types of activities anticipated to generate waste during operation of the project are outlined in Table 24-4 along with the likely waste materials produced.

Table 24-4 Indicative types of waste generated during operation

Waste-generating activity	Waste materials produced
Disposal of general litter in station bins and cleaning activities associated with trains, stations and other infrastructure	General non-recyclable and putrescible waste (such as food waste from station rubbish bins), recyclable wastes such as plastics and aluminium cans, office waste including paper and plastics.
Infrastructure maintenance	Cable and conduit off-cuts from maintenance of electrical infrastructure, solvents, paints, adhesives, cleaning fluids, greases, acids and alkali materials, and spent spill kit absorbent materials used to clean up accidental spills during maintenance.
Capture and treatment of groundwater and stormwater ingress into tunnels and stations	Sediment-laden and / or potentially contaminated wastewater, solids, filter cake (consisting of oxides of iron and manganese) and water treatment chemicals from the water treatment plant.
Use of station customer facilities (such as toilets)	Sewage and grey water.

As discussed in Chapter 6 (Project description – operation), the capture and treatment of groundwater and stormwater ingress into the tunnels and stations would require the operation of a water treatment plant at Sydenham (located adjacent to the Marrickville dive structure). Treatment of groundwater and stormwater may generally involve the removal of dissolved iron and manganese prior to disposal to adjacent catchments (assumed to be the Alexandria Canal).

Waste materials produced from the water treatment plant would predominantly comprise wastewater (to be treated in accordance with all applicable guidelines) and solids filter cake (consisting of oxides of iron and manganese). At maximum operating capacity, the water treatment plant is estimated to produce up to 54,000 litres of wastewater per hour; however, the actual volume of wastewater produced from this facility would depend on the volume of groundwater and stormwater inflow into the tunnels and stations.

The volumes of other wastes generated during the operation of the project (as listed in Table 24-4) would be considerably lower than those generated during construction and would be typical of similar infrastructure projects, including the existing Sydney Trains network. The volumes of these wastes have not been estimated as part of this Environmental Impact Statement (due to the early design stage of the project and the materiality of such estimates on the conclusions of the assessment); however, volumes of these other wastes are expected to be manageable through the application of standard waste management strategies (outlined in Section 24.8).

24.6 Potential impacts – construction

Potential waste management issues during construction would include:

- Waste being directed to landfill due to the inadequate collection, classification and disposal of waste, which would increase the demand for landfill capacity within the Sydney region
- Contamination of soil, surface and / or groundwater from the inappropriate storage, transport and disposal of liquid and solid wastes
- An increase in vermin from the incorrect storage, handling and disposal of putrescible waste from construction sites
- Incorrect classification and / or disposal of waste, including the incorrect storage, handling and disposal of contaminated spoil and other hazardous materials (for example, asbestos from building demolition)
- Excessive amounts of materials being ordered, resulting in a large amount of left-over, unused resources
- Lack of identification of feasible options for recycling or re-use of resources.

The above issues are considered to be manageable through standard mitigation measures. These measures would be developed in accordance with the project's sustainability strategy (refer to Chapter 25 (Sustainability)) and would address the following:

- Classification of waste in accordance with the current guidelines
- Estimates / details of the quantity of bulk earthworks and spoil balance to be generated during the construction of the project
- Handling of waste including measures to facilitate segregation of waste into stockpiles of spoil, concrete, steel, timber, paper and cardboard and vegetation to make it easier to recycle components and prevent cross contamination
- Management of waste, including indicative location and volumes of spoil material
- Waste minimisation and re-use
- Lawful disposal or recycling locations for each type of waste using a hierarchy which prioritises higher value end use
- Contingencies for the above, including managing unexpected waste volumes.

Management strategies that would be developed to address construction waste are discussed further below.

24.6.1 Spoil management

Spoil generation

It is envisaged that the project would generate about 2.4 million cubic metres of spoil. The majority of spoil would be generated from the excavation of tunnels and stations. Relatively smaller quantities would be generated by site preparation activities, excavation of vertical access shafts, dive structures and cut and fill activities for the aboveground components of the project.

The majority of excavated spoil would be uncontaminated crushed sandstone and shale classified as 'virgin excavated natural material'. In general, this would consist of mixed-size crushed rock, ranging from clay and sand to lumps of rock. The volume and source of spoil generated at each construction site are outlined in Table 24-3. Strategies that would be developed to address spoil management are provided below.

Spoil management hierarchy

The strategy for spoil re-use would follow a hierarchy of options, as presented in Table 24-5.

Table 24-5 Spoil management hierarchy for the project

Priority	Re-use options	Possible re-use options
1	Within the project	• Re-use spoil in the project for fill embankments and mounds within a short haulage distance of the source • Re-use spoil to restore any pre-existing contaminated sites within the project boundary • Re-use spoil as a feed product in construction materials).
2	Environmental work	• Re-use spoil for coastal protection, such as beach nourishment and land raising • Re-use spoil in flood mitigation projects.
3	Other development projects (including other Sydney Metro projects)	• Re-use spoil for fill embankments and mounds on projects within a financially feasible transport distance of the site • Re-use spoil for land reclamation or remediation projects • Re-use sand for manufacturing concrete and shale for manufacturing bricks and tiles.
4	Land restoration	• Re use spoil to fill disused facilities (for example mines and quarries) to enable either future development or site rehabilitation.
5	Landfill management	• Re-use spoil to cap completed landfill cells • Re-use spoil in daily covering of landfill waste.

Spoil re-use opportunities

While the project would target 100 per cent of beneficial re-use of the usable spoil generated during construction, it is recognised that there would only be limited opportunities for onsite spoil re-use as the project has very limited onsite requirements for fill and construction site space is limited. The quantities and locations of such onsite re-use opportunities would be determined during the detailed design of the project.

Where spoil cannot be re-used for the project, opportunities to re-use this material on other projects (preferably within the Sydney region to reduce transport distances) would be identified.

The spoil produced by the project would have the following potential re-use opportunities:

- Clean granular fill is likely to be suitable for use as structural fill
- Excavated moist clay and clayey sand material is likely to be suitable for use as general fill following moisture conditioning
- Excavated weathered shale and sandstone could be suitable for use as structural fill following moisture conditioning to reduce reactivity
- Medium strength or better quality shale is likely to be suitable for use as non-reactive fill
- Medium to high strength sandstone may be suitable for use as structural fill
- Wet clay and wet shale spoil is unlikely to be suitable for re-use on site without substantial moisture conditioning.

The geology of the spoil material as well as its consistency and quality would determine the re-use options.

Potential spoil use for land restoration and landfill management

Spoil could be used for filling former quarries in the Sydney region. Former quarries and other sites that are potentially available for large-scale disposal of virgin excavated natural material are listed in Table 24-6. Potential spoil disposal sites would be determined during the detailed design of the project.

The disposal of spoil at these locations may require separate new or modified planning approval and an associated environmental protection licence under the Protection of the *Environment Operations Act 1997*. A waste levy would be payable for each tonne of waste directed to landfill under this Act.

Table 24-6 Possible large-scale disposal sites and quarries for virgin excavated natural material in the Sydney region

Potential disposal location	Existing estimated capacity (million m^3)	Haulage distance
CSR PGH Quarry, Schofields	1.1	Chatswood – 41km Marrickville – 47km
Austral Bricks No. 2 and No. 3 Plants, Horsley Park	0.6	Chatswood – 41km Marrickville – 49km
CSR PGH Quarry, Horsley Park	2	Chatswood – 41km Marrickville – 49km
Hornsby Quarry	1.8	Chatswood – 15km Marrickville – 36km
Gosford Quarry	2.5	Chatswood – 59km Marrickville – 83km

24.6.2 Management of other construction wastes

Demolition waste

As outlined in Chapter 7 (Project description – construction), it is anticipated that construction of the project would require the demolition of about 79 buildings. Demolition waste would be managed through the waste hierarchy established under the *Waste Avoidance and Recovery Act 2001* (refer to Section 24.2).

Demolition waste would be segregated and stockpiled on site, with materials such as bricks and tiles, timber, plastic and metals being separated where practicable and sent to a waste facility with recycling capabilities.

All demolition waste would be classified in accordance with the *Waste Classification Guidelines* (OEH, 2009) and directed to a waste management facility that is lawfully permitted to accept that type of waste.

Asbestos

There is the potential for asbestos containing materials to be present within demolished buildings / structures. The disturbance, movement and disposal of asbestos containing materials would be carried out in strict accordance with the *Work Health and Safety Regulation 2011* and applicable guidelines.

Contaminated spoil

Given that the project would predominantly be constructed within sandstone and shale, the potential for substantial volumes of contaminated spoil to be generated during tunnelling and excavation is expected to be low. Notwithstanding, there is potential to encounter contaminated soil during construction of the project during surface works and / or from tunnelling activities. This potential and associated risk is assessed in Chapter 18 (Soils, contamination and water quality).

In situ testing of soils in areas of potential contamination concern would be conducted to determine the appropriate waste classification. Contaminated spoil would need to be sampled and immobilised before being transported and disposed of at a suitably licensed offsite location.

An Unexpected Finds Protocol would be implemented in the event of encountering previously unidentified area(s) or types of contaminated material. Where this happens, all relevant work would cease in the vicinity of the discovery. Relevant works would not recommence until the need for and scope of remedial action(s), if required, is identified in accordance with the requirements of the *Contaminated Land Management Act 1997*.

Any spoil classified as being contaminated in accordance with *NSW Waste Classification Guidelines Part 1: Classifying Waste* (NSW Environment Protection Agency, 2014b) would be directed to a waste management facility that is lawfully permitted to accept that type of contaminated waste.

There are a number of solid waste landfills in Sydney that are licensed to accept contaminated soils. It is anticipated that the volumes of contaminated spoil generated by the project could be readily accommodated at these facilities.

Further discussion of contamination including asbestos and other hazardous materials is provided in Chapter 18 (Soils, contamination and water quality).

Acid sulfate soils

As discussed in Chapter 18 (Soils, contamination and water quality), there is a high probability of encountering acid sulfate soils during excavation and other ground disturbance at Barangaroo (opposite Erskine Street) and potentially between Waterloo Station and Marrickville dive site. Impacts associated with the disturbance of acid sulfate soils are described in Chapter 18 (Soils, contamination and water quality), as are measures to mitigate impacts. Acid sulfate soils would be disposed of in accordance with the *NSW Waste Classification Guidelines Part 4: Acid Sulfate Soils* (NSW Environment Protection Agency, 2014c).

Wastewater

As discussed in Chapter 17 (Groundwater and geology), the excavation of the tunnels, stations and shafts are likely to intercept groundwater aquifers resulting in the need to capture, treat and discharge water. Construction water treatment plants would be required at the three tunnelling support sites, each station site and the ancillary shaft excavation site which would treat all intercepted groundwater to meet the requirements of an environmental protection licence issued to the project. Treatment of construction water is discussed further in Chapter 18 (Soils, contamination and water quality).

The re-use of treated water would be maximised during the construction works by re-circulating water to the tunnel cutting face and for surface dust suppression; however there would be a surplus of treated water requiring discharge from the sites. It is anticipated that water would be discharged to the local stormwater system or directly to a local surface watercourse, although options such as Sydney Water trade waste agreements would be investigated during detailed design.

All wastewater requiring discharge would be managed in accordance with any relevant conditions contained in the environmental protection licence issued to the project.

Further information on wastewater management and water treatment is provided in Chapter 18 (Soils, contamination and water quality).

24.7 Potential impacts – operation

Potential waste management issues that could occur during operation would include:

- Waste from stations and maintenance activities being directed to landfill due to the inadequate collection, classification and disposal of waste, which would increase the demand for landfill capacity within the Sydney region
- Waste (such as litter) from station buildings being blown into the surrounding environment if adequate bins are not provided or emptied regularly
- Wastewater from stations (toilets and station-cleaning activities)
- Disposal of wastewater from tunnels and stations
- An increase in vermin from the incorrect storage, handling and disposal of putrescible waste at stations
- Excessive amounts of maintenance materials being ordered, resulting in a large amount of left-over, unused resources.

The above issues are considered to be manageable through standard mitigation measures. These measures would be developed in accordance with the project's sustainability strategy (refer to Chapter 25 (Sustainability)).

24.8 Mitigation measures

The mitigation measures that would be implemented to address potential waste management impacts are listed in Table 24-7 and Table 24-8.

Table 24-7 Mitigation measures – waste management– construction

Ref	Mitigation measure	Applicable location(s) [1]
WR1	All waste would be assessed, classified, managed and disposed of in accordance with the NSW Waste Classification Guidelines.	All
WR2	100 per cent of spoil that can be reused would be beneficially re-used in accordance with the project spoil re-use hierarchy.	All
WR3	A recycling target of at least 90 per cent would be adopted for the project.	All
WR4	Construction waste would be minimised by accurately calculating materials brought to the site and limiting materials packaging.	All

1 *STW: Surface track work; CDS: Chatswood dive site; AS: Artarmon substation; CN: Crows Nest Station; VC: Victoria Cross Station; BP: Blues Point temporary site; GI: Ground improvement work; BN: Barangaroo Station; MP: Martin Place Station; PS: Pitt Street Station; CS: Central Station; WS: Waterloo Station; facility; MDS: Marrickville dive site; Metro rail tunnels: Metro rail tunnels not related to other sites (eg TBM works); PSR: Power supply routes..*

Table 24-8 Mitigation measures – waste management – operation

Ref	Mitigation measure	Applicable location(s) [1]
WM5	Generation of operation phase waste would be minimised.	All

1 *STW: Surface track work; CDS: Chatswood dive site; AS: Artarmon substation; CN: Crows Nest Station; VC: Victoria Cross Station; BP: Blues Point temporary site; GI: Ground improvement work; BN: Barangaroo Station; MP: Martin Place Station; PS: Pitt Street Station; CS: Central Station; WS: Waterloo Station; facility; MDS: Marrickville dive site; Metro rail tunnels: Metro rail tunnels not related to other sites (eg TBM works); PSR: Power supply routes.*

SUSTAINABILITY

CHAPTER TWENTY-FIVE

25 Sustainability

This chapter describes the overall approach to sustainability on the project and how specific objectives and initiatives are being incorporated into its design, construction and operation. An assessment of the potential impact of climate change on the project, the resource associated with the project and the greenhouse gas emissions that would be generated during construction and operation of the project is also provided.

25.1 Secretary environmental assessment requirements

The Secretary's environmental assessment requirements relating to sustainability, and where these requirements are addressed in this Environmental Impact Statement, are outlined in Table 25-1.

Table 25-1 Secretary's environmental assessment requirements – sustainability

Ref.	Secretary's environmental assessment requirements	Where addressed
12. Sustainability		
12	The Proponent must assess the project against the current guidelines including targets and strategies to improve Government efficiency in use of water, energy and transport.	Sustainability is addressed in this chapter.

25.2 Sustainability overview

There are many definitions for sustainability or sustainable development. One of the original descriptions of sustainable development, contained in *Our Common Future* (commonly referred to as the Brundtland Report), is: 'development which meets the needs of the present without compromising the ability of future generations to meet their own needs' (World Commission on Environment and Development, 1987).

In 1992, the Commonwealth Government defined ecologically sustainable development (ESD) as 'using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future can be increased' (Commonwealth of Australia, 1992). The four principles to assist achievement of ESD are defined in the *Environmental Planning and Assessment Regulation 2000* and the *Protection of the Environment Administration Act 1999* as:

- The precautionary principle – where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for not implementing mitigation measures or strategies to avoid potential impacts
- Inter-generational equity – the present generation should ensure that the health, diversity and productivity of the environment are equal to or better for the future generations
- Conservation of biological diversity and ecological integrity – ecosystems, species and genetic diversity within species should be maintained
- Improved valuation and pricing of environmental resources – economic values for services provided by the natural environment should be determined, such as the atmosphere's ability to receive gaseous emissions; cultural values; and visual amenity.

Chapter 29 (Justification and conclusions) details how the project addresses these four principles.

25.2.1 Sustainability governance and policy

An increasing number of legislative and policy mechanisms include considerations and requirements relating to sustainability, particularly in relation to energy efficiency and resource use. The following provides a summary of these legislative and policy mechanisms:

- The Transport for NSW Corporate Plan 2012-2017 (Transport for NSW, 2012d) promotes the need to ensure that the transport system '...meets present social and economic needs without compromising the quality of life for future generations. An important part of this is minimising the impact of transport on our natural environment now and into the future.' The Plan also places a strong emphasis on energy management and the need to respond to climate change
- The NSW Government's Government Resource Efficiency Policy aims to reduce the NSW Government's operating costs and lead by example in increasing the efficiency of the resources it uses. The policy ensures NSW Government agencies meet the challenge of rising costs for energy, water, clean air and waste management and use purchasing power to drive down the cost of resource-efficient technologies and services
- The *National Greenhouse and Energy Reporting Act 2007* (NGER) is the national framework for reporting and disseminating information on greenhouse gas emissions, energy use and energy production associated with the activities of Australian corporations
- The Commonwealth Renewable Energy Target (RET) currently commits Australia to generating 33,000 GWh per year of electricity from 'low emission' sources by 2020 in order to achieve the goal of a 23.5% share of renewable energy in Australia's electricity supply by 2020. This demonstrates a substantial increase in Commonwealth Government support for renewable energy initiatives.

Regulatory and policy drivers for the inclusion of workforce development initiatives as part of the social sustainability program for the project include:

- NSW State Priorities include creating jobs and apprenticeships for the construction sector through infrastructure investment, and increasing the proportion of people completing apprenticeships and traineeships to 65 per cent
- The *Australian Jobs Act 2013* requires public and private major projects in Australia with a capital expenditure of $500 million or more to prepare and implement an Australian Industry Participation (AIP) plan. The objective is to support the development of a more diverse workforce and future growth opportunities for Australian enterprises
- The NSW Aboriginal Participation in Construction Policy aims to deliver more employment and business opportunities for Aboriginal people on selected government construction projects. The category of project defines the percentage of the project spend directed to Aboriginal related employment and education activities, procurement of goods or services from recognised Aboriginal businesses or other programs.

For Sydney Metro City & Southwest, sustainability means building public transport for current and future generations that optimises environmental, social and sustainability outcomes, transit service quality and cost effectiveness.

An environment and sustainability policy has been developed for Sydney Metro City & Southwest based on the Sydney Metro Northwest sustainability policy, and Transport for NSW sustainability commitments. The policy acknowledges that the project has the potential to maximise the potential sustainability benefits while minimising negative impacts.

Environment & Sustainability Policy

This Policy reflects a commitment in our delivery of the Sydney Metro program to:

- Align with, and support, Transport for NSW (TfNSW) Environment & Sustainability Policy.
- Optimise sustainability outcomes, transport service quality, and cost effectiveness.
- Develop effective and appropriate responses to the challenges of climate change, carbon management, resource and waste management, land use integration, customer and community expectation, and heritage and biodiversity conservation.
- Be environmentally responsible, by avoiding pollution, enhancing the natural environment and reducing the project ecological footprint, while complying with all applicable environmental laws, regulations and statutory obligations.
- Be socially responsible by delivering a workforce legacy which benefits individuals, communities, the project and industry, and is achieved through collaboration and partnerships.

To deliver on these commitments, the Sydney Metro team will:

Industry leadership

- Implement coordinated and transparent decision making, by engaging with stakeholders and suppliers, encouraging innovation and demonstrating sustainability leadership.
- Explore new benchmarks for the transport infrastructure sector by requiring high standards from our designers, contractors and suppliers, building on experience gained through development of Sydney Metro Northwest.

Community and customer

- Provide accessible, safe, pleasurable, and convenient access and transport service for all customers.
- Establish positive relationships with community and stakeholders to maximise opportunities to add value to local communities.

Land use integration and place making

- Create desirable places, promote liveability, cultural heritage, and optimise both community and economic benefit.
- Balance transit oriented development opportunities with stakeholder expectations.

Embedding environmental and social sustainability

- Establish robust sustainability objectives and targets.
- Maintain an environmental management system that is integrated into all our project activities.
- Ensure thorough and open environmental assessment processes are developed and maintained.
- Develop and maintain an environmental management framework to embed best practice pollution management and sustainable outcomes during construction.
- Apply effective assurance processes to monitor performance against the project environment and sustainability objectives and identify appropriate reward or corrective action, as required.
- Apply environment and sustainability specific processes to the procurement of delivery activities.

Accountability

- Undertake public sustainability reporting.
- Hold employees and contractors accountable for proactively meeting their environmental and social sustainability responsibilities.
- Provide appropriate training and resources necessary to meet our responsibilities.

This policy provides an overarching framework for the development of more specific sustainability objectives, developed as part of a sustainability strategy, to guide the integration of sustainability into project governance, design, construction and operation.

The delivery of the project offers the potential to increase workforce capability and capacity, mitigate skills shortages and gaps that would reduce cost, improve productivity and provide local sustainable employment. Sydney Metro's skills legacy would improve the competitiveness of industry, provide individual career pathways and provide major socio-economic benefits to individuals and communities. A workforce development program would be implemented for Sydney Metro City & Southwest, building on current activity from Sydney Metro Northwest and an assessment of future needs.

25.2.2 Sydney Metro City & Southwest sustainability strategy

An initial Sydney Metro City & Southwest sustainability strategy has been developed which incorporates the environment and sustainability policy, provides a response to relevant government regulations and policies, and sets out specific objectives and initiatives to be integrated into the project planning and design, procurement, construction and operational stages of the project.

Figure 25-1 illustrates how the Sydney Metro City & Southwest sustainability strategy integrates sustainability across the project.

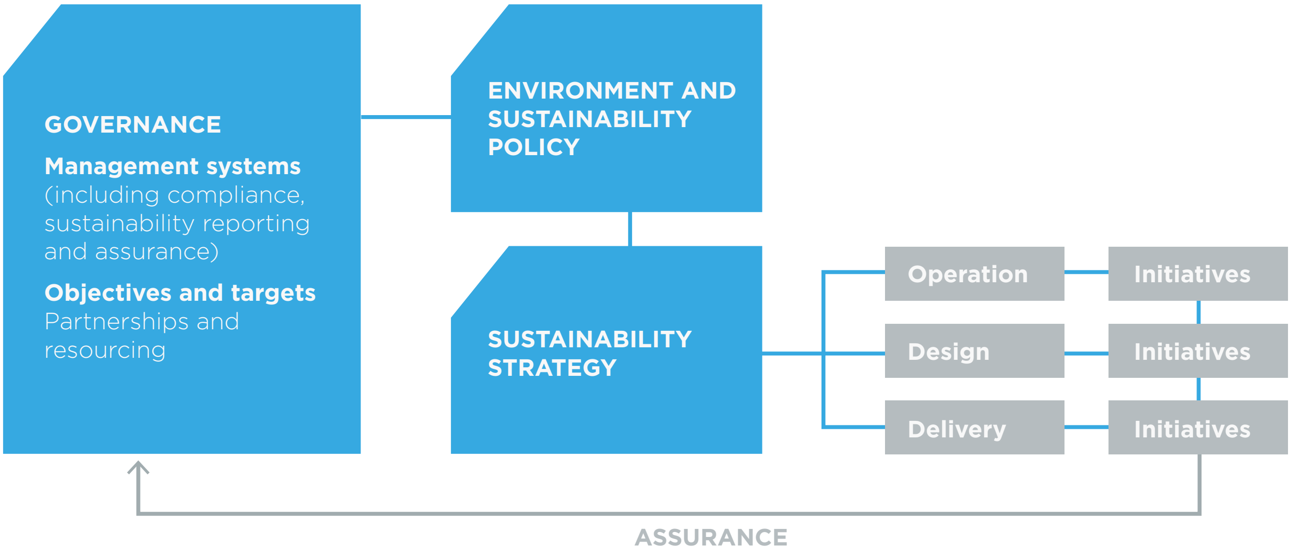


Figure 25-1 Sustainability governance structure

25.3 Sustainability objectives and initiatives

Sustainability objectives and supporting targets and initiatives which have been identified for the project are included in Table 25-3. The proposed initiatives and targets align with those outlined in the Transport for NSW Sustainable Design Guidelines for Rail (version 3) (Transport for NSW, 2013b) and other government resource efficiency policies. These initiatives and targets would be further refined as part of the design process, committed to in the Sustainability Strategy and included in the contract documents for all detailed design, construction and operations contracts. Project contractors would be required to clearly identify how they would ensure that specific sustainability objectives, initiatives and targets are met. This approach would encourage industry to develop innovative value-for-money sustainability solutions.

Table 25-3 Sydney Metro City & Southwest sustainability objectives and potential initiatives / targets

Sustainability theme	Sustainability objective	Potential sustainability initiatives / targets
Governance	Demonstrate leadership by embedding these objectives into decision making	• Ensure the project decision making framework includes sustainability criteria (environment and community).
	Demonstrate a high level of performance against objectives and appropriate benchmarks	• Develop performance targets across all sustainability themes, based on best practice benchmarking and responding to policy and regulatory context • Achieve a best practice level of performance using market leading sustainability rating tools (for example ISCA, Green Star, or equivalent) during design, construction and operation.
	Be accountable and report publicly on performance	• Use an assurance framework and reporting system to assist Sydney Metro and contractors in reliably reporting against sustainability targets • Monitor sustainability performance, and provide public sustainability reports.

Sustainability theme	Sustainability objective	Potential sustainability initiatives / targets
Carbon and energy management	Improve the shift toward lower carbon transport	• Optimise integration of the project with the most sustainable access modes including walking, cycling and bus.
	Reduce energy use and carbon emissions during construction	• Estimate carbon emissions, track performance, and reduce emissions through design refinements and construction practices • Establish energy efficiency targets for the project • Incorporate energy efficient construction equipment, methods, and practices • Local sourcing of materials where feasible. • Use biodiesel and ethanol fuel • Implement green travel plans • Offset 25 per cent of the greenhouse gas emissions associated with consumption of electricity during construction.
	Reduce energy use and carbon emissions during operations	• Establish energy efficiency and renewable energy targets for the project • Estimate and track operational carbon emissions and reduce emissions though refinements to design and operational practices • Target energy consumption at least 10 per cent lower than minimum compliance with the National Construction Code • Maximise passive design features including daylight, natural ventilation, and passive cooling • Efficient lighting and lighting control systems • Maximise reuse of energy recovered from the train braking system • Energy efficient ventilation, air conditioning, pumps, escalators, lifts and appliances • Offset 100 per cent of the greenhouse gas emissions associated with consumption of electricity during operation.
	Support innovative and cost-effective approaches to energy efficiency, low-carbon / renewable energy sources and energy procurement	• Utilise wayside energy storage, renewable energy, and district cooling systems where feasible • Offset the greenhouse gas emissions associated with electricity used during operations.

Sustainability theme	Sustainability objective	Potential sustainability initiatives / targets
Pollution control	Reduce sources of pollution and optimise control at source to avoid environmental harm	• Ensure Environmental Management Plans and Environmental Management Systems are in place prior to commencement of construction • Integrate water sensitive urban design solutions for storm water treatment • Investigate opportunities to reduce emissions from mobile non-road diesel plant and equipment at source • Include noise and air quality mitigation measures where appropriate • Design stations and temporary facilities to minimise light spill in accordance with standards • Target zero major pollution incidents.
Climate change resilience	Design infrastructure and operations to be resilient to the impacts of climate change	• Carry out a climate change risk assessment • Identify and implement adaptation measures to mitigate extreme and high level climate change risks, and address medium level climate change risks on the project • Review and update the climate change risk assessment and adaptation response through the project life cycle.
Resources water efficiency	Minimise use of potable water	• Estimate and monitor potable water usage, and implement design and construction initiatives to minimise water use • Include water-efficient features, equipment and appliances in the design of stations • Avoid use of potable water for non-potable purposes if non-potable water is available.
	Maximise opportunities for reuse of rainwater, stormwater, wastewater and groundwater	• Establish performance targets for the use of recycled water • Pending the outcome of feasibility analysis, connect to district recycled water networks where available and use non-potable water in concrete • Harvest and reuse rainwater at permanent and temporary facilities where feasible • Incorporate water sensitive urban design solutions for storm water management and reuse.

Sustainability theme	Sustainability objective	Potential sustainability initiatives / targets
Resources waste and materials	Minimise waste through the project lifecycle	• Maximise recycling of construction and demolition waste by adopting waste recycling targets (95 per cent) • Enabling recycling of waste materials from office facilities and customers • Planning for final disposal of operational assets, such as train carriages • Use modular, refabricated and precast structural and finishing materials to minimise waste during construction and maintenance.
	Reduce materials consumption	• Design optimisation to minimise volumes of excavation, concrete and steel • Dematerialisation of components and finishes • Maximise reuse of existing materials, buildings, facades, and structures.
	Consider embodied impacts in materials selection	• Minimise the embodied impacts of materials including high impact materials such as steel and concrete used in the project, through selection of low carbon alternatives, and considering durability and local sourcing • Establish targets for reducing embodied energy of high impact materials. Specify healthy surface coatings (eg low-VOC) and other materials.
	Maximise beneficial reuse of spoil	• Beneficial reuse of 100 per cent of usable spoil from excavated tunnels and station caverns, in accordance with a spoil management hierarchy.
Biodiversity conservation	Protect and create biodiversity through appropriate planning and management	• Establish and achieve targets for biodiversity conservation and enhancement • Provide biodiversity offsets as required.
Heritage conservation	Protect and promote local heritage through appropriate design, planning, and management controls	• Identify opportunities to enhance heritage values and show evidence of implementation • Develop partnerships with relevant stakeholders to utilise heritage places to promote local heritage values.

Sustainability theme	Sustainability objective	Potential sustainability initiatives / targets
Liveability	Promote improved public transport patronage by leveraging connectivity and interchange capabilities	• Ensure efficient interchange of customers accessing Sydney Metro from bus, rail and other public transport modes • Establish and achieve targets for the creation of cycle ways • Contribute to active transport link connectivity through creating improved pedestrian links • Provide secure and weather protected cycle parking spaces in station precincts.
	Provide comfortable accessible, safe and attractive stations and precincts	• Design in accordance with best practice urban design principles • Incorporate Crime Prevention Through Environmental Design principles in design to deter crime • Design to minimise urban heat island • Provide thermal comfort including consideration of local control for occupants.
Community benefit	Make a positive contribution to community health and well-being	• Establish and achieve targets for identifying and completing projects which benefit local communities and make a positive contribution to community health and well-being • Integrate station entries into public spaces and facilitate uses which benefit local communities.
	Engage and involve the community and local stakeholders in the development of the project	• Seek input from the community and stakeholders throughout the planning, design and delivery stages of the project.
	Contribute to the delivery of legacy projects to benefit local communities	• Investigate and implement feasible opportunities to use residual land to benefit local communities • Establish and achieve targets for the amount of new public open space which will be created as part of the project.
	Create opportunities for local business involvement during construction and operation	• Include involvement of local businesses in the sustainable procurement strategy for the project.
Supply chain	Influence contractors, subcontractors and materials suppliers to adopt these objectives in their works and procurement	• Develop and implement a sustainable procurement strategy, based on best practice policy and frameworks including British Standard *BS8903 Sustainable Procurement Best Practice Guidance and Code*, to apply to Principal Contractors, their subcontractors and their suppliers.

Sustainability theme	Sustainability objective	Potential sustainability initiatives / targets
Workforce development	Priority areas include: Industry participation; workforce skills development; inspiring future talent and developing capacity in the sector; and increasing workforce diversity and inclusion	- Provide employment opportunities for local people - Increase opportunities for local business, and small and medium enterprises, to access Sydney Metro supply chain - Support industry to compete in home and global markets - Resolve skills shortages locally and nationally through targeted and transferable skills development - Respond to changing job roles and increased skill requirements within industry - Embed Sydney Metro health and safety culture within all induction and training activities, promoting continuous improvement - Engage young people through education and work experience - Collaborate with higher education institutions to provide programs responding to rapid transit and other infrastructure requirements - Support vocational career development through apprenticeships and traineeships - Increase participation of indigenous workers and businesses - Increase female representation in non-traditional trades - Target long term unemployed - Develop and implement a Workforce Development and Industry Participation Strategy, establishing targets to be met during the delivery of the project.
Economic	Consider adopting a 'whole of life' costing model to maximise sustainability benefits.	- Include consideration of whole of life costs and benefits in optioneering and decision making.
	Optimise development opportunities for residual land.	- Optimise over station development.
	Capture sustainability benefits in the business case for the project.	- Ensure social and environmental benefits of improved access to transport and employment are documented in the business case - Ensure cost savings to future residents living in higher density developments as a result of the project is considered in as part of the business case for the project.

25.4 Climate change adaptation

Climate change has been recognised internationally as a significant issue with the potential to have a major impact on natural and human systems. Apart from actions to reduce greenhouse gas emissions, there is increased awareness of the need to identify potential effects of climate change and to improve planning to manage or mitigate these effects.

The Intergovernmental Panel on Climate Change, in its *Fifth Assessment Report* (2013) concluded that there is unequivocal evidence of warming of the global climate system. This conclusion is based on observed warming of the atmosphere and ocean, reductions in snow and ice cover, rising sea levels and increased concentrations of greenhouse gases in the atmosphere.

The *NSW Long Term Transport Master Plan* (Transport for NSW, 2012b) acknowledges that meeting community expectations in environmental sustainability is a statewide challenge. Initiatives to manage and minimise the environmental impacts of our transport system include:

- A co-ordinated approach to addressing environmental issues at all levels of transport planning
- Sustainable design guidelines for transport projects
- Better ways to assess the environmental benefits of projects.

Specific actions in the Master Plan to deliver environmental sustainability outcomes include 'boosting our resilience to climate change and natural disasters' and assessing 'transport climate resilience'.

The *Environment and Sustainability Policy Framework* (Transport for NSW, 2013d) is a collective and coordinated approach to deliver the NSW Government's environmental and sustainability agenda across the transport 'cluster' (Transport for NSW, Sydney Trains, NSW Trains, Roads and Maritime Services (Roads and Maritime) and State Transit Authority of NSW (STA)). The framework has been developed to implement the *Transport Environment and Sustainability Policy Statement* (Transport for NSW, 2013e).

The framework's climate change resilience theme acknowledges that some level of climate change is inevitable, and is concerned with the Transport for NSW effort to adapt and build resilience into its planning, projects and operations thereby minimising the impacts and costs of climate change on Transport for NSW customers and contributing to greater climate change resilience for NSW.

The Sustainability Strategy for the project includes an objective that the project infrastructure and operations are resilient to the impacts of climate change.

25.4.1 Climate change risk assessment methodology

The methodology for conducting the climate change risk assessment is based on the Australian Standard AS 5334-2013 *Climate change adaptation for settlements and infrastructure – A risk based approach*. The standard follows the International Standard ISO 31000:2009, *Risk management – Principles and guidelines* (adopted in Australian and New Zealand as AS/NZ ISO 31000:2009), which provides a set of internationally endorsed principles and guidance on how organisations can integrate decisions about risks and responses into their existing management and decision-making processes.

The following key steps were undertaken to complete the risk assessment:

- Determine the climate change context – carried out in accordance with AS 5334 – 2013:
    - Define the greenhouse gas emissions scenarios
    - Define future time slices
    - Define the climate variables
    - Selection of climate data
    - Determine other associated impact studies required (including flood modelling)
    - Obtain past meteorological record
- Identify the climate risks and assess the likelihood and consequence of each risk
- Identify adaptation responses.

Two risk workshops were held with multidisciplinary members of the project team throughout the design phase. The preliminary risks identified at the risk workshops were then formalised in the risk register, and thorough risk descriptions, including cause, impact / consequence and current treatment were identified.

Climate projections

Climate change issues associated with the operational phase of the project are much greater than during the construction phase, as there is much more time for those effects to be realised. Due to the expected design life of assets such as tunnels, bridges and drainage infrastructure (60 to 100 years), the time periods which were selected for the assessment were 2030, 2060 and 2090. The climate models used to project future climate conditions are not an effective tool to determine near term changes such as within the next 10 years (during the expected construction period). Construction phase climate change has therefore not been assessed.

Scientists have modelled the climate system and projected climatic changes likely to occur under various future greenhouse gas emissions scenarios. Greenhouse gas emission scenarios represent estimations of future quantities of greenhouse gas that may be released into the atmosphere. They are based on assumptions about future demographics and the implementation and efficiency of energy policies.

The Intergovernmental Panel on Climate Change produces Assessment Reports (AR) which review and synthesise the current state of scientific knowledge (at the time of them being published) on climate change.

Modelling for the Intergovernmental Panel on Climate Change's Fifth Assessment Report (AR5) used Representative Concentration Pathways (RCPs) to define different projections. The RCPs are labelled according to the radiative forcing values (relative to pre-industrial levels) which could be experienced in 2100 based on different atmospheric concentrations of greenhouse gases (with the exception of RCP2.6 which peaks at 2.6 W/m^2 and then declines by end of century). Radiative forcing refers to the difference between incoming solar energy hitting the earth's surface and that being radiated back to space, which in this context results in additional energy in the climate system resulting from elevated atmospheric greenhouse gases. A positive value results in a net earth energy gain.

There are four modelled RCPs as outlined in Table 25-4.

Table 25-4 Representative concentration pathways

RCP	Increase in radiative forcing on preindustrial levels of approximately
RCP2.6	2.6 W/m^2
RCP4.5	4.5 W/m^2
RCP6.0	6.0 W/m^2
RCP8.5	8.5 W/m^2

Projections used in this study were derived from a number of sources. However, the scenarios selected from these sources largely correlate – and represent both the worst case (and the current trajectory) for emissions and warming scenarios. These include:

- NarClim (NSW Government et al, 2015): NarClim uses a single, representative emissions scenario: the IPCC high emissions scenario similar to RCP8.5. NARCliM uses the Weather Research and Forecasting (WRF) model to develop high resolution models of meteorological variables
- NSW Climate Impact Profile: *The Impacts of Climate Change on the Biophysical Environment of New South Wales* (Department of Environment, Climate Change and Water, 2010d) has based climate change projections findings of a single, high emissions scenario. In addition, work was undertaken by the University of NSW to determine which of the models best simulated Australian climate, and only these models were used in the projections
- Climate Change in Australia (CSIRO et al, 2015): Climate Change in Australia presents the full range of RCPs as per AR5. We have presented most of the RCPs in the data used in this report, and have based the assessment on RCP8.5 representing the highest radiative forcing, and the current emissions trajectory.

The climatic variables identified as potentially generating risks for the project are annual average rainfall, extreme rainfall, extreme temperature, extreme wind, storms (cyclones, hail, dust and lightning), sea level rise and fire danger index for the Sydney region.

25.4.2 Future climate

The Australian climate is likely to experience a greater frequency and severity of extreme weather events due to climate change. As a result, it is especially important to understand the 'most likely' and 'worst case' implications of climate change on high-value infrastructure in major Australian cities such as Sydney. According to CSIRO research, the Sydney area is likely to become warmer, with more hot days and fewer cold nights. Detailed projections are presented below, and can be summarised as follows:

- **By 2030** – about 1.1 degrees Celsius increase in temperature, with increasing frequency of hot days over 35 ºC. Average rainfall may range from a 10 per cent decrease in spring to a 0.7 per cent increase in summer, with increased likelihood and intensity of extreme rainfall
- **By 2060** – up to 2.4 degrees Celsius increase in temperature, with average rainfall ranging from an 11.3 per cent decrease in winter to 0.4 per cent decrease in summer
- **By 2090** – up to 3.9 degrees Celsius increase in temperature, with increasing frequency of hot days over 35 degrees Celsius. Winter and spring rainfall patterns to vary widely, with increased likelihood and intensity of extreme rainfall.

A summary of the projections used for this assessment is presented in Table 25-5. A baseline of 1986–2005 has been presented for some variables as this relates to the period from which the changes are projected. Climate modelling does not typically model extreme storm projections directly – instead these events are inferred from other results.

Table 25-5 Summary of climate change projections – Sydney region

	Baseline (1986-2005)	2030 (RCP8.5)	2060 (RCP8.5)	2090 (RCP8.5)
Temperature				
Mean maximum temperatures (°C) – Annual	22.3	+1.2	+2.4	+3.9
Mean minimum temperatures (°C) – Annual	14.4	+1.1	+2.4	+3.9
Days over 35°C – Annual	3.5	N/A	N/A	+11
Rainfall				
Mean precipitation change (%) – Annual	1335 mm	-6.1	-6.6	-7.9
Mean precipitation change (%) – Spring	258 mm	-9.7	-10.7	-18.5
Mean precipitation change (%) – Summer	389 mm	0.0	-0.4	3.6
Mean precipitation change (%) – Autumn	387 mm	-6.8	-7.1	-7.4
Mean precipitation change (%) – Winter	301 mm	-9.9	-11.3	-15.1
Extreme rainfall				
Extreme rainfall events – Maximum 1 day rainfall	Projected to increase 2–22%			
Extreme rainfall events – 20 year return level of maximum 1 day rainfall	Projected to increase 5–42%			
Fire regimes				
Change in number of severe fire danger days per year	0.9	1.3	N/A	2.1
Severe wind				
Maximum daily wind speed	N/A	N/A	N/A	-6% to 2.5%
Sea conditions				
Sea level rise (m)	0	0.14	N/A	0.66
Sea surface temperature (°C)	N/A	1.0	N/A	3.1

25.4.3 Climate change risks

Climate change is anticipated to have direct and indirect impacts on the project. The types of impacts are relatively well understood, but their severity and extent is uncertain. As such, there is a need to identify these risks and develop strategies to treat them.

The risks identified were rated as either low, medium, high and extreme. The appropriate risk rating level was determined by:

- Determining the consequences of each risk occurring
- Determining the likelihood of each risk occurring
- Considering the existing controls expected to be applied through design and construction
- Determining the risk rating (residual risk).

In summary, the climate risk assessment process identified:

- No extreme ('unacceptable' risk) or high ('undesirable' risk) risks
- Six medium risk ratings ('tolerable' risk)
- 37 low risks ('acceptable' risk). For these risks, no risk treatment is proposed at this stage – although some of the risks would be followed up during detailed design.

The combined effect of the direct and indirect impacts of climate change falls into one of three categories:

- Accelerated infrastructure deterioration and increased maintenance requirement
- Increased frequency of rail closures / cancellations
- Infrastructure loss (total or partial loss as a result of a severe weather event).

Table 25-6 outlines the six 'medium' risks for the project. These risks are considered tolerable and the risk treatments which would be implemented may further reduce these risks to the project.

Table 25-6 Climate change risks identified as 'Medium'

Risk	Pre-mitigation risk rating	Risk treatment
Increased rainfall and extreme events affecting station access and interchange, which causes disruption to scheduled services.	Medium, tolerable	Ensure that adequate flood modelling is carried out and integrated with design.
Increased future temperatures mean that specified air-conditioning is unable to cope in the future and requires replacement and upgrade but insufficient space is available causing passenger discomfort and low levels of service satisfaction.	Medium, tolerable	Test the sensitivity of air-conditioning systems to increased temperatures, and identify potential additional capacity of air-conditioning systems that may be required within the life of the project, with a view to safeguarding space if required.
Increased frequency and severity of extreme rainfall events leading to increased flooding of creeks and waterways and potential inundation of infrastructure.	Medium, tolerable	Ensure that adequate flood modelling is undertaken and integrated with design.
Increased flooding and extreme weather events, which affect tunnel and station drainage, causing temporary closure.	Medium, tolerable	Ensure that adequate flood modelling is carried out and integrated with design.
Increased rainfall frequency and intensity results in changes to groundwater levels, and flooding in tunnels and tunnel portals.	Medium, tolerable	Ensure that adequate flood modelling is carried out and integrated with design.
Increased daily and annual temperatures, which may require larger sized tunnel ventilation equipment to maintain tunnel temperatures below design criteria than those initially specified.	Medium, tolerable	Test the sensitivity of ventilation systems to increased temperatures and provide adequate capacity.

To effectively manage climate change risks, each stage in the project should consider the most up to date climate change projections and design guidelines. The climate risks require ongoing review and response by designers and constructors. Refer to Section 25.7 for mitigation measures to manage climate change risks throughout the life of the project.

25.5 Construction resource use

Construction of the project would require the use of a wide range of resources and materials. An indicative list of construction resources and materials is provided in Table 25-7 along with the estimated quantities required. Details provided in Table 25-7 are indicative only and would be refined during the detailed design and procurement phases of the project.

As shown in Table 25-7, the largest quantities of construction resources are anticipated to comprise concrete, steel, electricity, fuel and water; with tunnel construction and spoil handling activities creating the largest demand for these resources.

Table 25-7 Indicative quantities of resources required to construct the project

Resource	Estimated quantity required	Most resource intensive activities
Electricity	45,413 MWh	Tunnel boring machines, construction site offices,
Fuel	46,172,044 L	Construction plant and equipment
Concrete	407,124 m^3	Civils and station construction works
Tunnel lining segments (pre-cast concrete)	371,886 m^3	Tunnel construction
Structural steel	23,750 tonnes	Construction of tunnels and stations
Reinforcing steel	40,033 tonnes	For use with ready mix concrete
Water	550,000 m^3	Tunnel boring machines, dust suppression

Given the scope and nature of the project, it would not be possible to avoid the need for substantial quantities of materials and resources for construction. Increased demand for construction resources may temporarily exceed existing local supplies of such materials, preventing their use by other projects and / or the community, either directly through a supply shortage of a particular resource or indirectly through an increase in the price to procure such resources (due to increased demand). However, it is considered unlikely that the project alone would result in any resource becoming scarce or in short supply.

Table 25-3 outlines the Sydney Metro City & Southwest sustainability objectives and potential initiatives / targets for reducing resource use for the project.

25.6 Greenhouse gas and energy

Greenhouse gas is a collective term for a range of gases that absorb outgoing infra-red radiation reflected from the earth which in turn generate heat. This heat warms the atmosphere. This is known as the greenhouse effect and is linked to climate change.

Human activities, including the combustion of carbon-based fuels increase the concentration of greenhouse gases in the atmosphere. This leads to greater absorption of infra-red radiation and an increase in atmospheric temperature. This is known as the enhanced greenhouse effect. The following six greenhouse gases are covered under international climate change agreements and are considered in this assessment:

- Carbon dioxide (CO_2) – this is by far the most abundant gas, and is primarily released during fuel combustion
- Methane (CH_4) – this is generated by the anaerobic decomposition of carbon-based material (including enteric fermentation and waste disposal in landfills)
- Nitrous oxide (N_2O) – this is generated by industrial activity, fertiliser use and production
- Hydrofluorocarbons (HFCs) – these are commonly used as refrigerant gases in cooling systems
- Perfluorocarbons (PFCs) – these are used in a range of applications including solvents, medical treatments and insulators
- Sulphur hexafluoride (SF_6) – these are used as a cover gas in magnesium smelting and as an insulator in heavy duty switch gear.

Each greenhouse gas behaves differently in the atmosphere with respect to its ability to trap outgoing radiation and its residence time in the atmosphere. To achieve a common unit of measurement each greenhouse gas has been compared to the warming potential of carbon dioxide over a 100 year period. This provides a global warming potential for each greenhouse gas that can be applied to the estimated emissions of the project. The resulting aggregated emissions are referred to in terms of carbon dioxide-equivalent emissions (or CO_2-e).

Identifying the likely greenhouse gas emissions associated with a project has the benefit of determining the scale of the emissions and providing a baseline from which to develop and deliver greenhouse gas reduction measures.

25.6.1 Greenhouse gas assessment methodology

Greenhouse gas emissions are reported as tonnes of carbon dioxide equivalent (tCO_2-e) and categorised into three different scopes (either scope 1, 2 or 3) in accordance with the Greenhouse Gas Protocol (WRI & WBCSD, 2004), IPCC and Australian Government greenhouse gas accounting / classification systems.

Emissions are categorised into three different scopes to help delineate between direct emissions from sources that are owned or controlled by a project and upstream indirect emissions that are a consequence of project activities but occur at sources owned or controlled by another entity. The three greenhouse gas scopes include:

- Scope 1 emissions, also called 'direct emissions' – emissions are generated directly by a project, eg emissions generated by the use of diesel fuel by construction plant / equipment
- Scope 2 emissions, also referred to as "indirect emissions" – emissions are generated outside of a project's boundaries to provide energy to the project, eg the use of purchased electricity from the grid
- Scope 3 emissions – all indirect emissions (not included in scope 2) due to upstream or downstream activities. For example indirect upstream emissions associated with the extraction, production and transport of purchased construction materials.

The objectives of the greenhouse gas assessment were to:

- Identify the sources of greenhouse gas emissions associated with construction and operation of the project
- Quantify the greenhouse gas emissions associated with each greenhouse gas source
- Present the Scope 1, 2 and 3 greenhouse gas emissions
- Identify opportunities (mitigation measures) which may be implemented to reduce the greenhouse gas emissions associated with construction and operation of the project.

To support the creation of standardised carbon footprints for construction projects, Transport for NSW has released the *Carbon Estimate and Reporting Tool* (Transport for NSW, 2015a). This tool, which is based on the Greenhouse Gas Protocol, has been developed to ensure a consistent methodology is used to complete greenhouse gas inventories for the construction stage of all projects for the Transport for NSW Infrastructure and Services projects.

Scopes 1, 2 and 3 greenhouse gas sources for construction and operation of the project are outlined in Table 25-8.

Table 25-8 Greenhouse gas sources by scope for the project

Scope	Description	Greenhouse gas sources – construction	Greenhouse gas sources – operation
Scope 1	Direct greenhouse gas emissions associated with emissions generated on site.	Removal of vegetation (loss of carbon sink) – vegetation absorbs carbon dioxide from the atmosphere (by photosynthesis). Where vegetation is removed, the ability for the vegetation to act as a carbon sink would be lost.	Maintenance equipment – most maintenance equipment would be operated by the burning of fossil fuels, typically diesel, which would create greenhouse gas emissions.
		Construction equipment – most construction equipment would be operated by the burning of fossil fuels, typically diesel, which would create greenhouse gas emissions.	
		Generator use – some small equipment and lighting for out-of-hours work would require the use of an on-site generator, typically powered by diesel, which creates greenhouse gas emissions.	

Scope	Description	Greenhouse gas sources – construction	Greenhouse gas sources – operation
Scope 2	Indirect greenhouse gas emissions associated with electricity used on-site for lighting construction sites, where actual emissions are generated elsewhere (generally at the source of the electricity generation).	Electricity – tunnel boring machines would be major users of electricity. Electricity would also be used by site offices for lighting and security.	Electricity – metro trains, station facilities, signalling and communications, tunnel ventilation and water treatment plants would be the major users of electricity.
Scope 3	Other indirect emissions, such as the extraction and production of purchased materials and fuels, transport-related activities and waste disposal.	Construction materials – different construction materials contain varying levels of embodied emissions. For example, high-strength concrete contains a greater proportion of cement (which has a high level of embodied emissions), compared to concrete for lower-strength applications that contain fly-ash (which has a lower level of embodied emissions).	Materials used for maintenance – different materials contain varying levels of embodied emissions.
		Construction waste – decomposition of cleared vegetation, disposal of contaminated soil and wood material from the demolition of acquired properties would create greenhouse gases, as the breakdown of organic matter as waste material directly releases stored carbon dioxide to the atmosphere.	Operational waste – decomposition of waste from stations would create greenhouse gases, as the breakdown of organic matter as waste material directly releases stored carbon dioxide to the atmosphere.
		Construction transport – all construction-related transport would create greenhouse gas emissions from the consumption and burning of fossil fuels.	Maintenance transport – all maintenance-related transport would create greenhouse gas emissions from the consumption and burning of fossil fuels.

This greenhouse gas assessment is based on current design information and construction staging and should be considered a preliminary estimate. The greenhouse gas emissions assessment for the project would be revised and updated as more accurate information becomes available.

25.6.2 Estimated greenhouse gas emissions construction

Greenhouse gas emissions would be generated during the construction of the project, with substantial energy-consuming activities anticipated to occur over the construction period. Greenhouse gas emissions would predominantly be generated as a result of:

- Combustion of fuel in construction plant, equipment and vehicles – these would be Scope 1 emissions (direct emissions occurring on-site)
- Electricity consumption for the tunnel boring machines – these would be Scope 2 emissions (occurring off-site at power stations)
- Electricity used at construction sites – these would be Scope 2 emissions (occurring off-site at power stations)
- Embodied emissions in key construction materials, including cement and steel – these would be Scope 3 emissions (energy and resources of construction materials consumed to produce a particular construction material).

As this project is based in an urban location, and with a large proportion of it involving tunnelling, no vegetation clearance or construction waste calculations have been included on the basis that the emissions would be low to negligible.

Greenhouse gas emissions were estimated with the level of current design detail for a range of emission sources that make up the overall construction of the project. The estimated Scope 1, 2 and 3 emissions are presented in Table 25-9.

Table 25-9 Estimated construction phase greenhouse gas emissions by scope

Scope	Source	Greenhouse gas emissions (cCO_2e) [1,2]
Scope 1	Construction plant and equipment (liquid fuel)	130,324
Scope 2	Electricity generated off-site	39,055
Scope 3	Embodied emissions of construction materials	367,347
	Construction waste transport	12,409
	Upstream fuel extraction for construction plant and equipment	9,956
	Delivery of materials to site	14,286
	Upstream fuel extraction, transmission and distribution	5,903
TOTAL		579,280

1 *tCO_2e = tonnes of CO_2 equivalent*

2 *Preliminary estimates which would be further refined during detailed design*

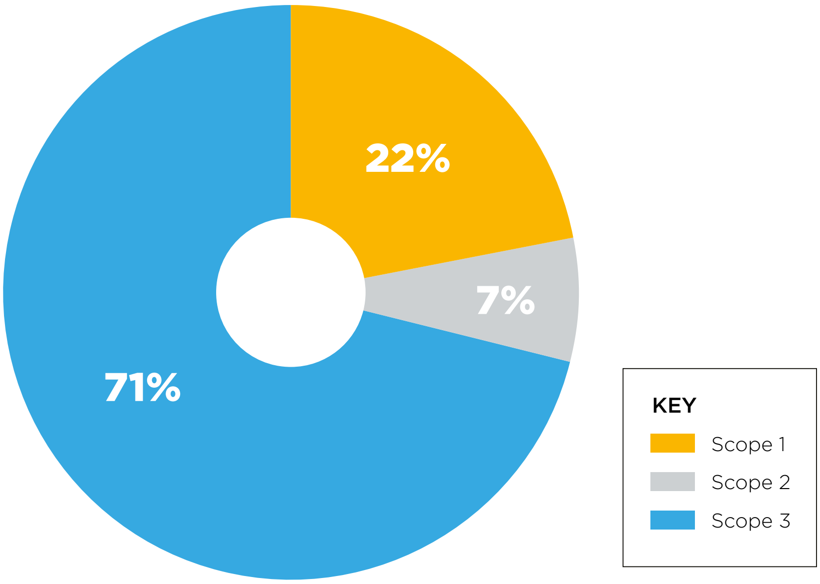


Figure 25-2 Estimated greenhouse gas emissions by scope for construction

NSW's annual greenhouse gas emissions are about 141.8 million tCO_2-e (Office of Environment and Heritage, 2015). The construction of the project is about equal to 0.4 per cent of NSW's current annual greenhouse gas emissions. Annual operation of the proposal would represent 0.05 per cent of state emissions.

Table 25-3 outlines the Sydney Metro City & Southwest sustainability objectives and potential initiatives / targets for reducing materials and energy (and therefore greenhouse gas emissions) for the project.

25.6.3 Estimated greenhouse gas emissions operation

Operational greenhouse gas emissions would predominantly be associated with electrical consumption to power the following:

- Metro trains
- Station facilities
- Signalling and communications
- Tunnel ventilation
- Water treatment plants.

An estimate of the annual electricity consumption for the operational stage of the project is 66,500 megawatt-hours per year at year of opening.

Other operational related greenhouse gas emissions related to maintenance equipment use, maintenance transport, waste generation and materials used for maintenance are considered to be low to negligible in scale when compared with electrical consumption and therefore not included in the operational greenhouse gas assessment.

The subsequent estimate of the volume of greenhouse gas emissions during the operation of the project is provided in Table 25-10. Greenhouse gas emissions are preliminary estimates and may change as the detailed design of the project progresses.

Table 25-10 Estimated greenhouse gas emissions by scope during operation of the project- annually

Scope	Source	Greenhouse gas emissions (tCO_2e)[1]
Scope 2	Electricity generated off-site	57,190
Scope 3	Upstream fuel extraction, transmission and distribution	8,645
TOTAL		65,835

1 *tCO_2e = tonnes of CO2 equivalent*

Operation and maintenance of the project would result in increased direct emissions of greenhouse gas through increased electricity use. However, the project has the potential to reduce greenhouse gas emissions overall by providing a low greenhouse gas alternative to private car travel. Notwithstanding the emissions reductions there remains a significant operational footprint.

Table 25-3 outlines the Sydney Metro City & Southwest sustainability objectives and potential initiatives / targets for reducing energy and carbon (greenhouse gas) emissions for the project.

25.7 Environmental and sustainability management

The contractors for Sydney Metro would be required to develop an environmental and sustainability management system which would link to the Sydney Metro's system.

The relationship between key documents within the Sydney Metro Environment and Sustainability Management System and the contractor's Environment and Sustainability Management System is shown in Figure 25-3. Notably:

- The Construction Environment Management Plan (CEMP) and its sub plans would capture the construction environmental management requirements emerging from the Environmental Impact Statement, subsequent planning approvals and the Sydney Metro City & Southwest Sustainability Strategy
- The Sustainability Plan and its sub plans would capture governance and design requirements as well as social sustainability initiatives required by the Sydney Metro City & Southwest Sustainability Strategy
- These plans would vary in scope across different delivery packages.

Sub-contractors engaged by the contractor would be required to work under the contractor's environmental and sustainability management system.

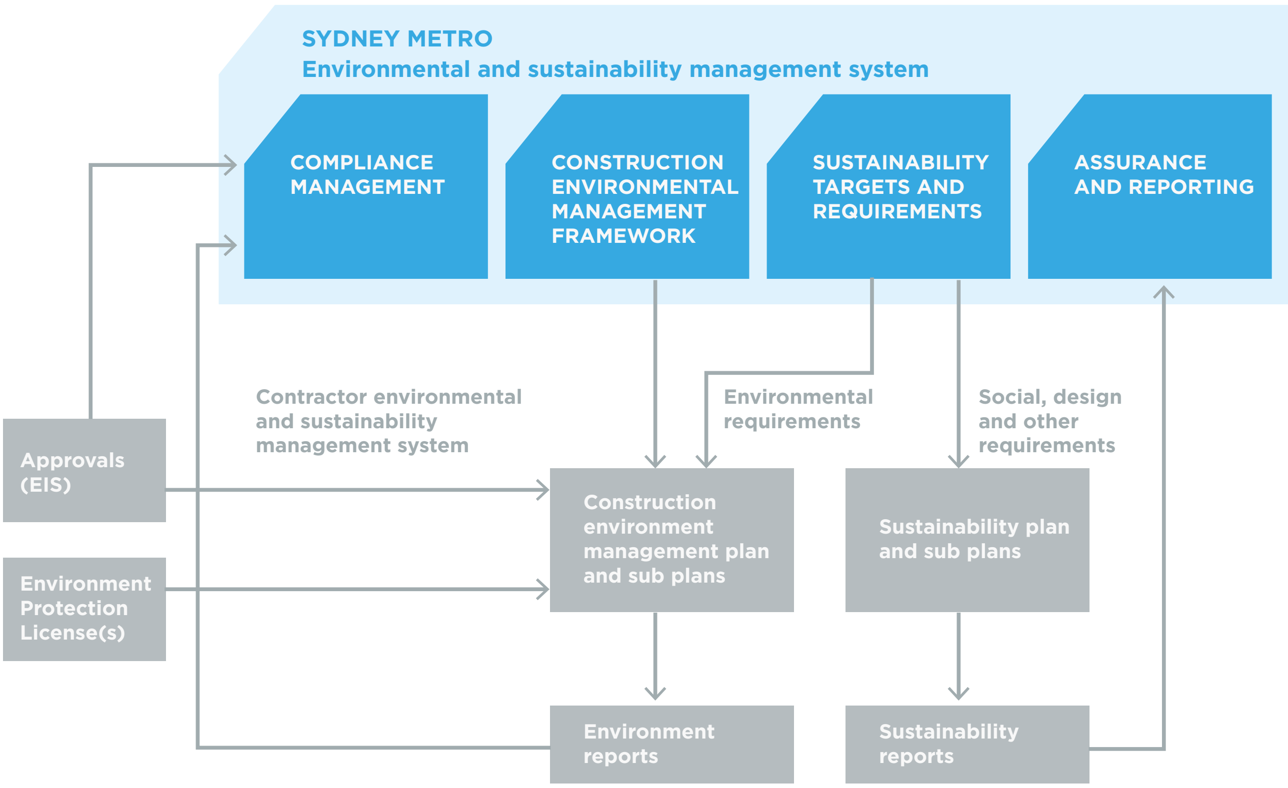


Figure 25-3 Environmental and sustainability management system

25.8 Mitigation measures

The mitigation measures that would be implemented to address project sustainability are listed in Table 25-11 and Table 25-12.

Table 25-11 Mitigation measures – sustainability – construction

Ref	Mitigation measure	Applicable location(s)[1]
SUS1	Sustainability initiatives would be incorporated into the detailed design and construction of the project to support the achievement of the project sustainability objectives.	All
SUS2	A best practice level of performance would be achieved using market leading sustainability rating tools during design and construction.	All
SUS3	A workforce development and industry participation strategy would be developed and implemented during construction.	All
SUS4	Climate change risk treatments would be incorporated into the detailed design of the project including: • Ensuring that adequate flood modelling is carried out and integrated with design • Testing the sensitivity of air-conditioning systems to increased temperatures, and identify potential additional capacity of air-conditioning systems that may be required within the life of the project, with a view to safeguarding space if required. • Testing the sensitivity of ventilation systems to increased temperatures and provide adequate capacity.	All
SUS5	An iterative process of greenhouse gas assessments and design refinements would be carried out during detailed design and construction to identify opportunities to minimise greenhouse gas emissions. Performance would be measured in terms of a percentage reduction in greenhouse gas emissions from a defined reference footprint.	All
SUS6	Opportunities to offset 25 per cent of the greenhouse gas emissions associated with consumption of electricity during construction would be offset.	All

1 *STW: Surface track work; CDS: Chatswood dive site; AS: Artarmon substation; CN: Crows Nest Station; VC: Victoria Cross Station; BP: Blues Point temporary site; GI: Ground improvement work; BN: Barangaroo Station; MP: Martin Place Station; PS: Pitt Street Station; CS: Central Station; WS: Waterloo Station; facility; MDS: Marrickville dive site; Metro rail tunnels: Metro rail tunnels not related to other sites (eg TBM works); PSR: Power supply routes.*

Table 25-12 Mitigation measures – sustainability operation

Ref	Mitigation measure	Applicable location(s)[1]
SUS7	Sustainability initiatives would be incorporated into the operation of the project to support the achievement of the project sustainability objectives.	All
SUS8	Periodic review of climate change risks would be carried out to ensure ongoing resilience to the impacts of climate change.	All
SUS9	A workforce development and industry participation strategy would be developed and implemented during the operation.	All
SUS10	100 per cent of the greenhouse gas emissions associated with consumption of electricity during operation would be offset.	All

1 *STW: Surface track work; CDS: Chatswood dive site; AS: Artarmon substation; CN: Crows Nest Station; VC: Victoria Cross Station; BP: Blues Point temporary site; GI: Ground improvement work; BN: Barangaroo Station; MP: Martin Place Station; PS: Pitt Street Station; CS: Central Station; WS: Waterloo Station; facility; MDS: Marrickville dive site; Metro rail tunnels: Metro rail tunnels not related to other sites (eg TBM works); PSR: Power supply routes.*

CUMULATIVE IMPACTS

CHAPTER TWENTY-SIX

26 Cumulative impacts

This chapter provides an assessment of the potential cumulative impacts as a result of the project, and identifies mitigation measures to minimise these impacts.

26.1 Secretary environmental assessment requirements

The Secretary's environmental assessment requirements relating to cumulative impacts, and where these requirements are addressed in this Environmental Impact Statement, are outlined in Table 26-1.

Table 26-1 Secretary's environmental assessment requirements – cumulative impacts

Ref.	Secretary's environmental assessment requirements	Where addressed
2. Environmental Impact Statement		
2.1 (m)	an assessment of the cumulative impacts of the project taking into account other projects that have been approved but where construction has not commenced, projects that have commenced construction, and projects that have recently been completed (for example WestConnex, Barangaroo, and any approved construction in the relevant precincts)	This chapter, specifically Section 26.3.
2.1 (o)	A chapter that synthesises the environmental impact assessment and provides: - the reasons justifying carrying out the project as proposed, having regard to the biophysical, economic and social considerations, including ecologically sustainable development and cumulative impacts.	Appendix G (Synthesis of the Environmental Impact Statement).
3.2(c)	For each key issue the Proponent must: identify, describe and quantify (if possible) the impacts associated with the issue, including the likelihood and consequence (including worst case scenario) of the impact (comprehensive risk assessment), and the cumulative impacts;	This chapter, specifically Section 26.3.
7.1	The Proponent must identify and assess any direct and/ or indirect impacts (including cumulative impacts) to the heritage significance	Cumulative heritage impacts are described in Section 26.3. Heritage impacts of the project are described in Chapter 14 (Non-Aboriginal heritage) and Chapter 15 (Aboriginal heritage).
10.2	The Proponent must assess impacts from construction and operation on potentially affected properties, approved development applications, businesses, public open space, recreational users and land and water users (for example, recreational and commercial fishers, oyster farmers), including property acquisitions/adjustments, access, amenity and relevant statutory rights.	Approved development applications and potential cumulative impacts are described in Sections 26.2 26.3.
13.1(g)	Details of how construction and scheduling of works are to be coordinated in regard to public events; cumulative traffic impacts resulting from concurrent work on Westconnex, Barangaroo, Sydney Light Rail and other key construction projects in the Sydney CBD;	Cumulative traffic impacts on the Sydney CBD are described in Section 26.3. Construction traffic and transport impact of the project are described in Chapter 8 (Construction traffic and transport).

26.2 Assessment methodology

26.2.1 Overview

Cumulative impacts would occur when impacts from the project interact or overlap with impacts from other projects and potentially resulting in a larger overall impact.

The selection of projects assessed as part of this cumulative impact assessment was based on the following criteria:

- **The project location** – projects in close proximity to the Sydney Metro Chatswood to Sydenham where there is potential for impacts to spatially overlap. This included potential for shared use of roads for construction access
- **The project timeframe and planning approval** – only projects likely to be built concurrently with the Sydney Metro Chatswood to Sydenham project were assessed. This includes relevant projects currently under construction and / or projects that have planning approval. Projects at a conceptual or pre-approval stage were identified for completeness but generally not assessed due to uncertainty around project scope and / or timeframe
- **The project size** – projects considered in this assessment are typically large-scale developments that would involve one or more of the following criteria:
    - Substantial temporary changes to existing traffic conditions, including traffic generation and changes to traffic flows, large truck movements and disruptions to key access routes
    - Substantial temporary changes to the existing noise environment
    - Impacts on numerous and / or significant heritage items
    - Substantial changes to the existing land use
    - Substantial changes to the existing urban landscape.

Key issues (based on the outcomes of the risk assessment in Chapter 28 (Environmental risk analysis)) and any cumulative issues explicitly identified in the Secretary's environmental assessment requirements were considered for all sites as part of the cumulative impact assessment. These key issues were identified as operational traffic and transport, construction traffic and transport, construction noise and vibration, non-Aboriginal heritage, and social impacts and community infrastructure. In addition to these key issues, other impact issues were considered where there was likely to be potential cumulative impacts given the nature of the likely interaction with adjacent projects.

The potential cumulative impact associated with land use and property; Aboriginal heritage; groundwater and geology; soils, contamination and water quality; biodiversity; flooding and hydrology; hazard and risk; waste management; and sustainability were considered to be of a minor nature. The mitigation measures identified in this Environmental Impact Statement are considered appropriate and adequate to address any potential residual cumulative impacts for these other issues.

Projects assessed as part of this cumulative impact assessment are described in Table 26-2 along with their likely timeframe and proximity to the project.

Table 26-2 Projects assessed as part of the cumulative impact assessment

Project and date	Relevant Suburb(s)	Project details and proximity to the project
Sydney Metro Northwest **2013-2019** **(Approved project)**	• Chatswood	The Sydney Metro Northwest project involves the construction of a 23 kilometre metro rail line, including 15.5 kilometre twin tunnels, eight new railway stations and associated car parking facilities between Cudgegong Road and Cherrybrook in Northwest Sydney. The project includes the conversion of the Epping to Chatswood Rail Line to metro standards, various adjustments to Chatswood Station and adjacent rail infrastructure up to the opening of Sydney Metro Northwest in 2019. It also includes a new 33kV underground transmission line between Ausgrid's Willoughby subtransmission substation and Transport for NSW's Chatswood North traction substation. The closest project construction site would be the Chatswood dive site (northern).
WestConnex Stage 2: New M5 (Beverley Hills to St Peters) **2015 – 2019** **(Project approved)**	• Tempe • Sydenham • St Peters	Stage 2 of WestConnex: the New M5 – would run from the existing M5 East corridor at Beverly Hills via a tunnel to St Peters. The New M5 would include: • Twin tunnels that would more than double capacity along the M5 East corridor and provide motorway access to north of Sydney Airport • An interchange at an industrial site at St Peters • Connections from the interchange to key roads, including Campbell Road / Street, Euston Road and across the canal to Bourke Road • Widening of Campbell Road / Street and Euston Road. Work commenced in late 2015, with the upgrading of the M5 – King Georges Road interchange. The closest project construction site would be the Marrickville dive site (southern). While not adjacent, the dive footprint would be close to the St Peters interchange.
WestConnex Stage 3: M4–M5 link **2019-2023** **(Project not yet approved)**	• Alexandria • Erskineville • St Peters	Stage 3 of WestConnex would deliver an 8.5 kilometre motorway tunnel with three lanes in each direction between the first two stages, linking the M4 and M5 corridors. The alignment would provide a western bypass of the Sydney CBD. It would generally run north of the Parramatta Road corridor from Haberfield with connections at Rozelle before heading south near Camperdown and connect to St Peters Interchange. The closest project construction sites would be Central Station and Marrickville dive site (southern).

Project and date	Relevant Suburb(s)	Project details and proximity to the project
CBD and South East Light Rail **September 2015 – 2019** **(Approved project)**	- Surry Hills - Sydney	The 12 kilometre CBD and South East Light Rail project will extend from Circular Quay along George Street to Central Station, through Surry Hills to Moore Park, then to Kensington and Kingsford via Anzac Parade and Randwick via Alison Road and High Street. The project will include: - Light rail stops - Excavation of roadways to relocate utilities - Major interchanges with ferry, heavy rail and bus services - A pedestrian zone on George Street between Bathurst and Hunter streets - Public domain improvements including possible new public spaces, paving, trees, lighting and street furniture - Substations to provide power for the light rail vehicles - A stabling facility in Randwick and a maintenance depot in Rozelle. The closest project construction sites would be Barangaroo, Martin Place, Pitt Street and Central Station.
McMahons Point Wharf Interchange upgrade **(Approved project)**	- McMahons Point - Blues Point	The McMahons Point Wharf Interchange upgrade involves the redevelopment of the wharf interchange at Henry Lawson Avenue, McMahons Point. The main elements will include: - Removal of existing McMahons Point Wharf - Construction of a new Wharf interchange comprising a covered shelter, an uncovered bride and gangway and an uncovered dual berth pontoon - Landside works including realignment of the kerb and gutter on Henry Lawson Avenue. The closest project site would be the Blues Point temporary site.
One Carrington Redevelopment **2015 – 2018** **(Approved project)**	Sydney	The One Carrington project involves upgrading the eastern entries to Wynyard Station and constructing a 27-storey commercial building above a shopping centre. The project also includes refurbishing the adjoining heritage listed buildings, 285 George Street and Shell House. About 85,000m2 of commercial and retail floor area are proposed. The closest project construction site would be Barangaroo Station.

Project and date	Relevant Suburb(s)	Project details and proximity to the project
Barangaroo **Central Barangaroo: mid 2017 – 2023 (Approved concept)** **Barangaroo South: 2012 – 2021 (Approved project)**	Sydney	The 22ha Barangaroo precinct is being redeveloped on the western edge of Sydney Harbour. Barangaroo is divided into three areas (from north to south): - Barangaroo Reserve (complete) - Central Barangaroo - Barangaroo South. The 5.2ha Central Barangaroo will be the last part of Barangaroo to be completed. The current master plan (April, 2014) provides buildings with up to 150,000m2 of gross floor area. Barangaroo South will provide a mixed-use precinct of commercial office buildings, residential apartments, an international hotel, shops, cafes, restaurants, and cultural facilities. Direct public transport connections will be provided including a major pedestrian connection through to Wynyard Station and the city. The closest project construction site would be Barangaroo Station, directly adjacent to the Central Barangaroo development site.
60 Martin Place Redevelopment **2016 – 2019** **(Approved project)**	Sydney	60 Martin Place will be a 32-storey, 40,000m2 office tower with frontages on Martin Place, Phillip Street and Macquarie Street. The project will include demolition of an existing 28-storey office tower. The closest project construction site would be Martin Place Station, with the southern construction site one block to the west of 60 Martin Place.
115 – 119 Bathurst Street Redevelopment **2015 – 2017** **(Approved project)**	Sydney	115-119 Bathurst Street will be a 54 storey mixed-use development, including retail, commercial, residential and hotel accommodation. The project will include the adaptive reuse of an existing heritage-listed Sydney Water building and the partial demolition and redevelopment of an adjacent building. The closest project construction site would be the Pitt Street construction site, which would be one block to the north of 115-119 Bathurst Street.
Sydney Metro City & Southwest Sydenham to Bankstown upgrade **2017 – 2023** **(Project not yet approved)**	- Sydenham - Marrickville	The Sydney Metro Sydenham to Bankstown upgrade would include an upgrade of 13.5 kilometres of the T3 Bankstown Line between Sydenham and Bankstown. The work between Sydenham and Bankstown would include upgrading the corridor and stations, with improvements to wayfinding and signage. The closest project construction site would be the Marrickville dive site (southern), which would adjoin with the eastern extent of the Sydenham to Bankstown upgrade.

Project and date	Relevant Suburb(s)	Project details and proximity to the project
Sydney Metro over station developments **(Project(s) not yet approved)**	• Crows Nest • North Sydney • Sydney	Sydney Metro over station developments are proposed for the following stations: • Crows Nest • Victoria Cross • Martin Place • Pitt Street • Waterloo. The nature of the over station development is not currently known. It is assumed that the construction of the over station development would be concurrent to the Sydney Metro Chatswood to Sydenham project.

Other planned projects that may result in cumulative impact but that have not yet been approved are identified in Table 26-3. A number of local strategic plans have also been considered in Table 26-3 as they influence subsequent development that has the potential to result in cumulative impacts with the Sydney Metro Chatswood to Sydenham project.

Where relevant, these projects have been identified but the potential impacts have not been considered given the uncertainty of the status and timing of these projects.

Table 26-3 Other projects and programs with potential cumulative impacts

Project	Relevant suburb(s)	Project details and proximity to the project
Mowbray Road / Pacific Highway intersection (further upgrade) **(Project not yet approved)**	• Chatswood	Roads and Maritime are currently investigating upgrades to the Mowbray Road / Pacific Highway intersection, that would be additional to those proposed as part of the Sydney Metro Chatswood to Sydenham project. The extent of any future upgrades has not yet been determined.
St Leonards Central **(Project deferred and not yet approved)**	• St Leonards • Artarmon	St Leonards Central is a proposal to consolidate four parcels of land and rail corridor by developing public space and three mixed-use towers over the rail corridor north of The Forum and east of the rail corridor, next to Christie Street. In early 2016 the State government decided not to progress the unsolicited proposal for this development. However, a revised proposal may be made in the future. If progressed, there would be potential for construction timeframes to overlap and for cumulative impacts with the construction of Crows Nest Station.
St Leonards / Crows Nest Planning Study **(Planning study – not a specific project)**	• St Leonards • Crows Nest	In October 2012, North Sydney Council formally adopted the St Leonards / Crows Nest Planning Study, which outlines the strategic objectives for the area to guide development and urban renewal. North Sydney Council resolved in September 2015 to defer planning work on Precinct 4 pending announcements by the NSW Government regarding the location and commissioning of the Metro Station in Crows Nest. Consequently, no detailed project or construction information for potential development in the vicinity of the Crows Nest Metro Station.

Project	Relevant suburb(s)	Project details and proximity to the project
North Sydney Centre Traffic and Pedestrian Study network projects **(Implementation of initiatives not yet approved)**	North Sydney	A detailed transport planning analysis of the existing transport network and travel behaviour has been undertaken in North Sydney. The study recommendations are focused on prioritising pedestrians in the North Sydney centre around the Pacific Highway and Miller Street by improving connectivity, amenity and mobility. The recommendations include a range of initiatives such as: - New mid-block pedestrian crossings - Upgrading of Miller Street - Changes in traffic operation on the Pacific Highway - Opportunities for shared zones - Footpath widening - New taxi ranks. The timing for implementation of recommendations will depend on a number of factors. These include the need for further approvals from council's Traffic Committee or State authority approval, and the possible incorporation of recommendations into existing or planned projects. There is potential for projects associated with this initiative to overlap and have cumulative impacts associated with the construction of Victoria Cross Station.
Brett Whiteley Place development **(Project not yet approved)**	North Sydney	The upgrade of Brett Whiteley Place at the corner of Pacific Highway and Mount Street at North Sydney involves an expanded pedestrian space that includes the existing Brett Whiteley Place and Elizabeth Plaza, as well as portions of the Denison Street and Mount Street shared zones. There is also potential to expand the plaza for retail, creative and public use. The concept plan has been exhibited and is currently being finalised. Indicative dates for this work are not currently available. There is potential for future construction timeframes associated with Stage Two and beyond to overlap and for cumulative impacts associated with the construction of Victoria Cross Station.
AMP Circular Quay redevelopment **(Project partially approved)**	Sydney	The AMP redevelopment at Circular Quay comprises a 1.1ha site that includes 33 Alfred Street, 50 Bridge Street and a number of properties at Young and Loftus streets Stage 1 development approval for the building envelopes and design parameters of the precinct was granted in June 2014. Stage 2 development applications have been lodged for all sites, with the exception of 33 Alfred Street and 12-14 Loftus Street. Stage 2 approvals have been granted for redevelopment of the main AMP tower at 50 Bridge Street. Stage 2. Deferred commencement has been granted on the Stage 2 development application for 2-10 Loftus Street, 16-20 Loftus Street, 9-13 Young Street and 15-17 Young Street. Construction timing is yet to be confirmed, although it is anticipated that construction would start in 2017 and be completed in 2019 or 2020. There is potential for construction timeframes to overlap and cumulative impacts associated with the construction of Martin Place Station.

Project	Relevant suburb(s)	Project details and proximity to the project
Sandstone buildings – Bridge Street, Sydney **(Project not yet approved)**	Sydney	The NSW Government is selling a long term lease of two historic sandstone buildings on Bridge Street that are currently used as government offices. The purchaser of the lease proposes to redevelop the site as a luxury hotel. There is potential for an additional three storeys to be added to the buildings. The project is in the planning phase, with construction timing to be confirmed, although it is anticipated that construction would commence in 2018 and be completed by 2021. There is potential for construction timeframes to overlap and cumulative impacts associated with the construction of Martin Place Station.
410 Pitt Street Redevelopment **(Project not yet approved)**	Sydney	Demolition of an existing building and the construction of a 33 storey hotel is proposed for 410 Pitt Street by a private developer. The proposal is currently in a state of deemed refusal with an appeal to the Land and Environment Court lodged. If the appeal is successful, there is potential for construction timeframes to overlap, with cumulative impacts associated with the construction of Pitt Street Station.
505-523 George Street Redevelopment **(Project not yet approved)**	Sydney	Development of a 70 storey residential and retail tower is proposed for 505-523 George Street by a private developer. The proposal is in the planning phase, with amendments to existing planning controls endorsed by The Central Sydney Planning Committee to enable the development of the proposal. There is potential for construction timeframes to overlap, with cumulative impacts associated with the construction of Pitt Street Station.
116 Bathurst Street Redevelopment **(Project has deferred commencement consent)**	Sydney	A 36 storey mixed-use development is proposed for 116 Bathurst Street by a private developer. The proposal includes the restoration of an existing heritage building on the site and demolition of other existing structures. The proposal has deferred commencement consent. If commencement requirements are met, there is potential for construction timeframes to overlap, with cumulative impacts associated with the construction of Pitt Street Station.
Town Hall Square Precinct Urban Design Strategy **(Strategy – not a specific project)**	Sydney	The City of Sydney Council has investigated the creation of a new civic square opposite Town Hall. This would involve the demolition of several buildings and the creation of a new public domain. The strategy is currently in the planning phase, with construction timing to be confirmed. There is potential for construction timeframes to overlap and cumulative impacts associated with the construction of Pitt Street Station.

Project	Relevant suburb(s)	Project details and proximity to the project
University of Technology Sydney (UTS) Central project **(Concept approved, project not yet approved)**	Ultimo	The UTS Central project involves the extension of the UTS Tower on Broadway to include new private and public space. Construction is anticipated to commence in late 2016 and be complete in 2019. The modification to the approved concept plan (relating to gross floor area, building height and building envelope) was approved in March 2016. There is potential for construction timeframes to overlap and cumulative impacts associated with the construction of the metro platforms at Central Station.
Central Park (future stages) **(Project not yet approved)**	Chippendale	Central Park is a multi-stage $2 billion mixed-use development on the former Carlton and United brewery site. Construction began in 2010 and is due to be finish in 2020. Projects that may be constructed between 2017 and 2020 include Kensington Street and Abercrombie Street student accommodation, and residential apartments on Wellington Street and O'Connor Street. The specific construction timeline for future stages of Central Park is yet to be confirmed. There is potential for construction timeframes to overlap and cumulative impacts associated with the construction of the metro platforms at Central Station.
Central to Eveleigh Urban Transformation and Transport Program **(Projects within program not yet approved)**	- Sydney - Redfern	The Central to Eveleigh Transformation Program is a 30-year project to develop 80ha of largely under-used State Government land in and around the rail corridor between Central, Macdonaldtown and Erskineville stations. The project extends for three kilometres and includes Central and Redfern stations, Australia Technology Park, Eveleigh Rail Yards and the airspace above the railway lines. The program is at the strategic planning stage and the initial construction timeline is yet to be confirmed. There is potential for construction timeframes to overlap and for cumulative impacts associated with the construction of the metro platforms at Central Station and the new station at Waterloo.
Waterloo transformation project **(Project not yet approved)**	Waterloo	The NSW Government plans to transform the area around Waterloo to encourage the introduction of new homes, jobs, parks and community facilities to meet the needs of a growing Sydney. The project is in the initial stages of strategic planning and any construction timeline is yet to be confirmed. There is potential for construction timeframes to overlap and for cumulative impacts associated with the construction of the metro station at Waterloo.

26.3 Potential impacts

This section describes the cumulative impacts based on likely interactions with the projects described in Table 26-2 and Table 26-3.

The cumulative impacts listed would likely arise if these projects were constructed during the same time period as the project. Impacts outlined in each table are unmitigated potential cumulative impacts. Mitigation measures are included in Section 26.4.

26.3.1 Chatswood dive site (northern)

The construction of the Chatswood dive site would have potential cumulative impacts associated with the Sydney Metro Northwest project. Key activities associated with this project that may result in cumulative impacts include:

- Construction activities in the vicinity of Chatswood Station
- Additional buses in the vicinity of Chatswood during the conversion of the Epping to Chatswood Rail Line
- Construction activities associated with the 33 kV feeder from the Willoughby subtransmission substation to the Chatswood North Traction Substation around Artarmon and Chatswood.

These cumulative impacts are identified in Table 26-4.

Table 26-4 Chatswood dive site (northern) – potential cumulative impacts

Environmental impact	Potential cumulative environmental impacts without mitigation
Sydney Metro Northwest	
Operational traffic and transport	- The Chatswood to Sydenham project is an extension of Sydney Metro Northwest. As such, the operation of the two projects would provide cumulative transport related benefits. Further details of the benefits are provided in Chapter 3 (Strategic need and justification).
Construction traffic and transport	- Shared use of key roads by light and heavy construction vehicles including Pacific Highway, Railway Street, Brown Street, Victoria Avenue, Thomas Street, Albert Avenue and Brand Street - Additional delays for general traffic on the Pacific Highway due to construction vehicle movements to and from the construction sites and additional bus movements associated with the Epping to Chatswood Rail Line conversion - Additional traffic delays due to road occupation, eg at Brand Street, Artarmon for the 33 kV works - Potential for additional track possessions, and impacts to rail customers, to carry out works within the rail corridor.
Construction noise and vibration	- Additional temporary increase in noise and vibration around Chatswood Station and Artarmon.
Non-Aboriginal heritage	- No cumulative impacts greater than a minor nature are expected.
Social impacts and community infrastructure	- No cumulative impacts greater than a minor nature are expected.

If approved, the following proposed project (described in Table 26-3) may result in cumulative impacts with the Chatswood dive site:

- Mowbray Road / Pacific Highway Intersection (further upgrade).

26.3.2 Artarmon substation

There would be no interactions that are expected to result in cumulative impacts between construction of the Artarmon substation and the projects described in Table 26-2 or Table 26-3.

26.3.3 Crows Nest Station

The key cumulative impacts associated with the proposed Crows Nest Station would largely relate to the impacts associated with the proposed over station development. As discussed in Chapter 6 (Project description – operation), impacts of over station development would be assessed under a separate approval process and would also be required to take into account the impacts of this project. Expected cumulative impacts are identified in Table 26-5.

Table 26-5 Crows Nest Station – potential cumulative impacts

Environmental impact	Potential cumulative environmental impacts without mitigation
Sydney Metro Chatswood to Sydenham over station development	
Operational traffic and transport	• No cumulative impacts greater than a minor nature are expected.
Construction traffic and transport	• Shared use of key roads by light and heavy construction vehicles including Pacific Highway, Hume Street, Clarke Street and Oxley Street • Additional delays for general traffic on the Pacific Highway due to construction vehicle movements to and from the construction sites • Additional vehicles turning right onto Oxley Street from the Pacific Highway • Additional temporary road closures on Hume Street.
Construction noise and vibration	• Additional temporary increase in noise and vibration around the Crows Nest Station site.
Non-Aboriginal heritage	• No cumulative impacts greater than a minor nature are expected.
Social impacts and community infrastructure	• No cumulative impacts greater than a minor nature are expected.
Landscape character and visual impacts	• Additional temporary landscape and visual impacts due to construction occurring at both ground level and above the station • Additional night-time light spill.
Air quality	• Additional temporary reduction in air quality around the Crows Nest Station site.

If approved, the following proposed projects and strategic plans (described in Table 26-3) may result in cumulative impacts with the Crows Nest Station site:

- Projects associated with the St Leonards / Crows Nest Planning Study
- St Leonards Central development.

26.3.4 Victoria Cross Station

The key cumulative impacts associated with the proposed Victoria Cross Station would largely relate to the impacts associated with the proposed over station development. As discussed in Chapter 6 (Project description – operation), impacts of over station development would be assessed under a separate approval process and would also be required to take into account the impacts of this project. Expected cumulative impacts are identified in Table 26-6.

Table 26-6 Victoria Cross Station – potential cumulative impacts

Environmental impact	Projects and potential cumulative environmental impacts without mitigation
Sydney Metro Chatswood to Sydenham over station development	
Operational traffic and transport	• No cumulative impacts greater than a minor nature are expected.
Construction traffic and transport	• Shared use of, and additional delays on, key roads by light and heavy construction vehicles, including the Pacific Highway, and McLaren, Miller and Berry streets • Additional temporary road closures around the Victoria Cross Station site.
Construction noise and vibration	• Additional temporary increase in noise and vibration around the Victoria Cross Station site.
Non-Aboriginal heritage	• No cumulative impacts greater than a minor nature are expected.
Social impacts and community infrastructure	• No cumulative impacts greater than a minor nature are expected.
Landscape character and visual impacts	• Additional temporary landscape and visual impacts due to construction occurring at both ground level and above the station • Additional night-time light spill.
Air quality	• Additional temporary reduction in air quality around the Victoria Cross Station site.

If approved, the following proposed projects (described in Table 26-3) may result in cumulative impacts with the Victoria Cross Station site:

- Projects associated with the North Sydney Centre Traffic and Pedestrian Study Brett Whiteley Place redevelopment.

26.3.5 Blues Point temporary site

The use the Blues Point temporary site may have potential cumulative impacts associated with the proposed McMahons Point Wharf Interchange upgrade. At this stage, the McMahons Point Wharf Interchange upgrade is proposed to commence in 2016 and take around six months to complete, and the Sydney Metro activities at Blues Point are not anticipated to start until early 2019. As such, there is not anticipated to be any overlap of construction timeframes. Additionally, the Blues Point temporary site would not involve any operational infrastructure. Based on the above cumulative impacts are not expected to occur during construction or operation.

26.3.6 Sydney CBD – overview of potential cumulative impacts

The Sydney CBD is experiencing and will continue to experience an unprecedented level of development in the coming years. This includes:

- Changes associated with the implementation of the Sydney City Centre Access Strategy (Transport for NSW, 2013a) including major transport projects such as the CBD and South East Light Rail, the pedestrianisation of George Street between Hunter Street and Bathurst Street, the new CBD Bus Strategy and the cycleway program
- Continuation of the Barangaroo development
- A number of property redevelopments.

The impact assessments carried out for this project have to a large extent already taken into account these other projects where relevant. For example, the construction traffic and transport assessment is based on the closure of George Street to vehicular traffic and other road network changes associated with the CBD and South East Light Rail.

The construction of the project would involve the use of six construction sites through the Sydney CBD, being:

- Barangaroo Station
- Martin Place Station north
- Marin Place Station south
- Pitt Street Station north
- Pitt Street Station south
- Central Station.

With respect to cumulative impacts the main issue for the Sydney CBD is expected to be construction traffic. At this stage, the following potential key conflict points have been identified:

- Hickson Road, Sussex Street and the Western Distributor – as a construction haul route for Barangaroo, CBD and South East Light Rail and the Sydney Metro Barangaroo Station site
- Druitt and Bathurst streets – to access the Sydney Metro Pitt Street Station sites, and the potential interface with CBD and South East Light Rail works on George Street in these locations
- Chalmers Street and Eddy Avenue – to access the Sydney Metro Central Station site, and the interface with the construction of CBD and South East Light Rail on these roads
- Cleveland Street – as a construction haul route for CBD and South East Light Rail and the Sydney Metro Central Station site.

The CBD Coordination Office has been established to coordinate all traffic and transport in the Sydney CBD including decisions, directions and approvals affecting all road and traffic arrangements in the Sydney CBD. The CBD Coordination Office has developed a 'spatial tool' to help manage the potential cumulative impacts of construction with the Sydney CBD. The spatial tool is a GIS based system which takes inputs such as construction programs, construction locations, haul routes and identifies key conflict points between different construction projects.

Sydney Metro has been providing inputs to the CBD Coordination Office including a high level construction program to assist with forward planning for potential conflicts.

Sydney Metro would continue to liaise closely with the CBD Coordination Office during detailed construction planning and throughout construction phase to minimise the potential construction traffic impacts within the Sydney CBD, including potential cumulative impacts with other projects or special events. This would include:

- Provision of regular updates to the detailed construction program, construction sites and haul routes
- Identification of key potential conflict points with other construction projects
- Developing mitigation strategies in order to manage conflicts. Depending on the nature of the conflict, this could involve:
  - Adjustments to the Sydney Metro construction program, work activities or haul routes; or adjustments to the program, activities or haul routes of other construction projects
  - Co-ordination of traffic management arrangements between projects.

Further details on other potential cumulative impacts within the Sydney CBD, with respect to each construction site, are provided in the following sections.

26.3.7 Barangaroo Station

The construction of Barangaroo Station would have potential cumulative impacts associated with the following projects and activities:

- Central Barangaroo and Barangaroo South:
  - Construction activities around Barangaroo, especially Central Barangaroo
  - Access and egress using Hickson Road Hickson Road, Sussex Street and the Western Distributor. Barangaroo would also carry out works within Hickson Road

  At the proposed time of the Sydney Metro Barangaroo construction, it is anticipated that multiple elements of Barangaroo Central would also be under construction. It is anticipated that much of the Barangaroo South construction would be complete by 2021 and the precinct largely operational.
- One Carrington:
  - Potential construction access and egress via Hickson Road, Sussex Street and the Western Distributor.
- CBD and South East Light Rail:
  - Access and egress to and from the Circular Quay works may be via Hickson Road, Sussex Street and the Western Distributor.

These potential cumulative impacts are identified in Table 26-7.

Table 26-7 Barangaroo Station – potential cumulative impacts

Environmental impact	Potential cumulative environmental impacts without mitigation		
	Central Barangaroo, Barangaroo South	One Carrington	CBD and South East Light Rail
Operational traffic and transport	No cumulative impacts greater than a minor nature are expected.	No cumulative impacts greater than a minor nature are expected.	No cumulative impacts greater than a minor nature are expected.
Construction traffic and transport	Shared use of, and additional traffic delays on, key roads by light and heavy construction vehicles, primarily Hickson Road, Sussex Street and the Western Distributor Additional temporary road closures on Hickson Road Additional alteration of pedestrian and cyclist movements and associated impacts on safety and amenity, around Barangaroo including Hickson Road and the approaches to Barangaroo Reserve Additional loss of parking spaces and loading zones on Hickson Road.	Shared use of, and additional traffic delays on, key arterial and local roads by light and heavy construction vehicles, primarily Hickson Road, Sussex Street and the Western Distributor.	Shared use of, and additional traffic delays on, key roads by light and heavy construction vehicles, primarily Hickson Road, Sussex Street and the Western Distributor.
Construction noise and vibration	Additional temporary increase in noise and vibration around Barangaroo.	No cumulative impacts greater than a minor nature are expected.	No cumulative impacts greater than a minor nature are expected.
Non-Aboriginal heritage	Potential additional impacts to non-Aboriginal archaeology.	No cumulative impacts greater than a minor nature are expected.	No cumulative impacts greater than a minor nature are expected.

Environmental impact	Potential cumulative environmental impacts without mitigation		
	Central Barangaroo, Barangaroo South	One Carrington	CBD and South East Light Rail
Social impacts and community infrastructure	No cumulative impacts greater than a minor nature are expected.	No cumulative impacts greater than a minor nature are expected.	No cumulative impacts greater than a minor nature are expected.
Business impacts	Altered access, visibility and amenity of businesses around Barangaroo, including along Hickson Road and on the Central Barangaroo and Barangaroo South sites.	No cumulative impacts greater than a minor nature are expected.	No cumulative impacts greater than a minor nature are expected.
Landscape character and visual impacts	Additional temporary visual impacts due to the presence of multiple construction sites and out-of-hours light spill around Barangaroo.	No cumulative impacts greater than a minor nature are expected.	No cumulative impacts greater than a minor nature are expected.
Air quality	Additional temporary reduction in air quality around Barangaroo.	No cumulative impacts greater than a minor nature are expected.	No cumulative impacts greater than a minor nature are expected.

None of the unapproved projects in Table 26-3 have the potential to have cumulative impacts at the Barangaroo site.

26.3.8 Martin Place Station

The construction of Martin Place Station would have potential cumulative impacts associated with the proposed over station development and the following projects and activities:

- CBD and South East Light Rail:
  - Potential construction access and egress via Hunter, Castlereagh, Elizabeth and Macquarie streets.
- 60 Martin Place:
  - Construction activities around Martin Place and Elizabeth Street
  - Restrictions to access in and around Martin Place Station
  - Potential construction access and egress via Hunter and Macquarie streets.

These cumulative impacts are identified in Table 26-8.

Table 26-8 Martin Place Station – potential cumulative impacts

Environmental impact	Potential cumulative environmental impacts without mitigation		
	Sydney Metro Chatswood to Sydenham over station development	CBD and South East Light Rail	60 Martin Place
Operational traffic and transport	• No cumulative impacts greater than a minor nature are expected.	• No cumulative impacts greater than a minor nature are expected.	• No cumulative impacts greater than a minor nature are expected.
Construction traffic and transport	• Shared use of, and additional traffic delays on, key roads by light and heavy construction vehicles, possibly including Castlereagh, Hunter, Macquarie and Elizabeth streets • Additional temporary road closures around Martin Place Station construction sites.	• Shared use of, and additional traffic delays on, key roads by light and heavy construction vehicles, possibly including Castlereagh, Macquarie, Hunter and Elizabeth streets • Additional temporary road closures around Martin Place Station construction sites • Additional bus service delays and changes on Castlereagh Street and Elizabeth Street.	• Shared use of, and additional traffic delays on, key roads by light and heavy construction vehicles, possibly including Macquarie and Hunter streets • Additional temporary road closures around Martin Place Station construction sites • Additional alteration of pedestrian and cyclist movements and associated impacts on safety and amenity, in and around Martin Place Station • Additional closure of an entry and exit point to Martin Place Station • Additional minor bus service delays and changes on Castlereagh Street and Elizabeth Street.
Construction noise and vibration	• Additional temporary increase in noise and vibration around Martin Place Station.	• Additional temporary increase in noise between Martin Place and George Street.	• Additional temporary increase in noise and vibration around Martin Place.
Non-Aboriginal heritage	• No cumulative impacts greater than a minor nature are expected.	• No cumulative impacts greater than a minor nature are expected.	• No cumulative impacts greater than a minor nature are expected.

Environmental impact	Potential cumulative environmental impacts without mitigation		
	Sydney Metro Chatswood to Sydenham over station development	CBD and South East Light Rail	60 Martin Place
Social impacts and community infrastructure	No cumulative impacts greater than a minor nature are expected.	No cumulative impacts greater than a minor nature are expected.	No cumulative impacts greater than a minor nature are expected.
Business impacts	No cumulative impacts greater than a minor nature are expected.	No cumulative impacts greater than a minor nature are expected.	Additional altered access, visibility and amenity of businesses around Martin Place Station.
Landscape character and visual impacts	Additional temporary landscape and visual impacts due to construction occurring at both ground level and above the station.	Additional temporary visual impacts due to the presence of multiple construction sites and out-of-hours light spill between Martin Place and George Street.	Additional temporary visual impacts due to the presence of multiple construction sites and out-of-hours light spill around Martin Place Station.
Air quality	Additional temporary reduction in air quality around Martin Place Station.	Additional temporary reduction in air quality between Martin Place and George Street.	Additional temporary reduction in air quality around Martin Place.

If approved, the following proposed projects (described in Table 26-3) may result in cumulative impacts with the Martin Place Station site:

- AMP Circular Quay re-development
- Sandstone buildings on Bridge Street, Sydney.

26.3.9 Pitt Street Station

The construction of Pitt Street Station would have potential cumulative impacts associated with the proposed over station development, and the following projects and activities:

- CBD and South East Light Rail:
  - Construction activities on George Street around the intersections of Druitt and Bathurst streets
  - Potential construction access and egress via Druitt and Bathurst streets
- 115-119 Bathurst Street Redevelopment:
  - Construction activities around Bathurst Street
  - Potential construction access and egress via Bathurst and Pitt streets.

These cumulative impacts are identified in Table 26-9.

Table 26-9 Pitt Street Station – potential cumulative impacts

Environmental impact	Potential cumulative environmental impacts without mitigation		
	Sydney Metro Chatswood to Sydenham over station development	CBD and South East Light Rail	115-119 Bathurst Street Redevelopment
Operational traffic and transport	• No cumulative impacts greater than a minor nature are expected.	• No cumulative impacts greater than a minor nature are expected.	• No cumulative impacts greater than a minor nature are expected.
Construction traffic and transport	• Shared use of, and additional traffic delays on, key arterial and local roads by light and heavy construction vehicles, possibly including Castlereagh, Bathurst, Pitt and Druitt streets • Additional temporary road closures around the Pitt Street Station construction sites.	• Shared use of, and additional traffic delays on, key arterial and local roads by light and heavy construction vehicles, possibly including Bathurst and Druitt streets • Temporary road closures at George Street / Druitt Street and George Street / Bathurst Street intersections interfacing with the Sydney Metro haul routes • Additional temporary road closures around the Pitt Street Station construction sites • Additional alteration of pedestrian and cyclist movements and associated impacts on safety and amenity, around the Pitt Street Station construction sites.	• Shared use of, and additional traffic delays on, key arterial and local roads by light and heavy construction vehicles, possibly including Bathurst and Pitt streets • Additional temporary road closures around the Pitt Street Station construction sites • Additional alteration of pedestrian and cyclist movements and associated impacts on safety and amenity, around the Pitt Street Station construction sites.
Construction noise and vibration	• Additional temporary increase in noise and vibration around the Pitt Street Station site.	• Additional temporary increase in noise and vibration around the Pitt Street Station site.	• Additional temporary increase in noise and vibration around Bathurst Street.
Non-Aboriginal heritage	• No cumulative impacts greater than a minor nature are expected.	• No cumulative impacts greater than a minor nature are expected.	• No cumulative impacts greater than a minor nature are expected.

Environmental impact	Potential cumulative environmental impacts without mitigation		
	Sydney Metro Chatswood to Sydenham over station development	CBD and South East Light Rail	115-119 Bathurst Street Redevelopment
Social impacts and community infrastructure	• No cumulative impacts greater than a minor nature are expected.	• No cumulative impacts greater than a minor nature are expected.	• No cumulative impacts greater than a minor nature are expected.
Business impacts	• No cumulative impacts greater than a minor nature are expected.	• Additional alterations to access, visibility and amenity of businesses between Pitt Street and George Street.	• No cumulative impacts greater than a minor nature are expected.
Landscape character and visual impacts	• Additional temporary landscape and visual impacts due to construction occurring at both ground level and above the station.	• Additional temporary visual impacts due to the presence of multiple construction sites and out-of-hours light spill around the Pitt Street Station construction sites and on nearby George Street.	• Additional temporary visual impacts due to the presence of multiple construction sites and out-of-hours light spill around Bathurst Street.
Air quality	• Additional temporary reduction in air quality around the Pitt Street Station construction sites.	• Additional temporary reduction in air quality around the Pitt Street Station site and on nearby George Street.	• Additional temporary reduction in air quality around Bathurst Street.

If approved, the following proposed projects (described in Table 26-3) may result in cumulative impacts with the Pitt Street Station site:

- 410 Pitt Street Redevelopment
- 505-523 George Street Redevelopment
- 116 Bathurst Street Redevelopment
- Town Hall Square Precinct Urban Design Strategy.

26.3.10 Central Station

The construction of the metro platforms at Central Station would have potential cumulative impacts associated with the following projects and activities:

- CBD and South East Light Rail:
  - Construction activities on Eddy Avenue and Chalmers Street
  - Access and egress via Cleveland Street, Chalmers Street and Eddy Avenue.

These cumulative impacts are identified in Table 26-10.

Table 26-10 Central Station – potential cumulative impacts

Environmental impact	Potential cumulative environmental impacts without mitigation
	CBD and South East Light Rail
Operational traffic and transport	- Potential cumulative benefits associated with enhanced modal transport interchange.
Construction traffic and transport	- Shared use of, and additional traffic delays on, key arterial and local roads by light and heavy construction vehicles, including Eddy Avenue, Chalmers Street and Cleveland Street - Temporary road closures on Chalmers Street and Eddy Avenue interfacing with the Sydney Metro haul routes - Additional temporary road closures around Central Station - Additional alteration of pedestrian and cyclist movements and associated impacts on safety and amenity, around Central Station.
Construction noise and vibration	- Additional temporary increase in noise and vibration around Central Station.
Non-Aboriginal heritage	- Additional impacts to the Sydney Terminal and Central Railway Station Group (State heritage listed). CBD and South East Light Rail would impact the setting of Eddy Avenue, the setting of Chalmers Street and directly impact the Elizabeth Street Garden. - Works associated with this project would result in direct impacts to other individual items (removal and reinstatement of platforms 13 to 15, partial removal of canopies on platforms 4 to 23, removal of the Rolling Stock Officers building and garden, minor physical work to the Lost Property Office, and adjustments to overhead wiring structures) within the Sydney Terminal and Central Railway Station Group, indirect visual impacts to Mortuary Station and may also result in impacts to the setting of Eddy Avenue.
Social impacts and community infrastructure	- No cumulative impacts greater than a minor nature are expected.
Business impacts	- Additional alteration to access, visibility and amenity of businesses around Central Station.
Landscape character and visual impacts	- Additional temporary visual impacts due to the presence of multiple construction sites and out-of-hours light spill around Central Station.
Air quality	- Additional temporary reduction in air quality around Central Station.

If approved, the following proposed projects (described in Table 26-3) may also result in cumulative impacts with the Central Station site:

- University of Technology Sydney Tower Extension
- Central Park development (future stages)
- Central to Eveleigh Urban Transformation and Transport Program.

26.3.11 Waterloo

The key cumulative impacts associated with the proposed Waterloo Station would largely relate to the impacts associated with the proposed over station development. As discussed in Chapter 6 (Project description – operation), impacts of over station development would be assessed under a separate approvals process and would also be required to take into account the impacts associated with this project. Expected cumulative impacts are identified in Table 26-11.

Table 26-11 Waterloo Station – potential cumulative impacts

Environmental impact	Potential cumulative environmental impacts without mitigation
	Sydney Metro Chatswood to Sydenham over station development
Operational traffic and transport	• No cumulative impacts greater than a minor nature are expected.
Construction traffic and transport	• Shared use of, and additional delays on, key arterial and local roads by light and heavy construction vehicles, including the Botany Road, and Wellington, Cope and Raglan streets • Additional temporary road closures around the Waterloo Station site.
Construction noise and vibration	• Additional temporary increase in noise and vibration around the Waterloo Station site.
Non-Aboriginal heritage	• No cumulative impacts greater than a minor nature are expected.
Social impacts and community infrastructure	• No cumulative impacts greater than a minor nature are expected.
Landscape character and visual impacts	• Additional temporary landscape and visual impacts due to construction occurring at both ground level and above the station • Additional night-time light spill.
Air quality	• Additional temporary reduction in air quality around the Waterloo Station site.

Waterloo transformation project

The Sydney Metro Chatswood to Sydenham project would provide a major opportunity for the Waterloo transformation project, which is anticipated to introduce a significant number of new homes, jobs, parks and community facilities to the Waterloo area. The Waterloo transformation project is in the initial stages of strategic planning and the scope and timeframe for delivery are still under development and would require a full environmental assessment (including operational stage impacts, particularly with respect to traffic and social and community impacts) as part of its own planning approvals process.

However it is expected that the outcome of the Sydney Metro Chatswood to Sydenham project would be highly beneficial with respect to social and community aspects (compared with no metro station and / or transport improvement alternatives to a metro station such as the upgrading of local roads).

If approved, the following proposed projects (described in Table 26-3) may result in cumulative impacts with the Waterloo Station site:

- Central to Eveleigh Urban Transformation and Transport Program
- Waterloo transformation project.

26.3.12 Marrickville dive site (southern)

The construction of the Marrickville dive site would have potential cumulative impacts associated with the following projects and activities:

- Sydney Metro City & Southwest Sydenham to Bankstown upgrade:
  - Construction activities around Sydenham Station and Marrickville industrial area
  - Potential construction access and egress via Princes Highway, May Street and Bedwin Road.

  Additional information relating to Sydenham to Bankstown upgrade is provided in Section 26.3.13
- WestConnex Stage 2: New M5 (Beverley Hills to St Peters):
  - Construction activities to upgrade Campbell Street and in the vicinity of St Peters
  - Access and egress to the construction works around St Peters Interchange via Princes Highway
- WestConnex Stage 3: M4–M5 link:
  - Construction activities in the vicinity of St Peters
  - Potential construction access and egress via Princes Highway.

These cumulative impacts are identified in Table 26-12.

Table 26-12 Marrickville dive site (southern) – potential cumulative impacts

Environmental impact	Potential cumulative environmental impacts without mitigation		
	Sydney Metro City & Southwest Sydenham to Bankstown Upgrade	WestConnex Stage 2: New M5 (Beverley Hills to St Peters)	WestConnex Stage 3: M4-M5 link
Operational traffic and transport	As the two projects form part of the Sydney Metro network the operation of the two projects would provide cumulative transport related benefits. Further details of the benefits are provided in Chapter 3 (Strategic need and justification).	No cumulative impacts greater than a minor nature are expected.	No cumulative impacts greater than a minor nature are expected.

Environmental impact	Potential cumulative environmental impacts without mitigation		
	Sydney Metro City & Southwest Sydenham to Bankstown Upgrade	WestConnex Stage 2: New M5 (Beverley Hills to St Peters)	WestConnex Stage 3: M4-M5 link
Construction traffic and transport	• Shared use of, and additional traffic delays on, key arterial and local roads by light and heavy construction vehicles, including Bedwin Road, May Street and the Princes Highway • Additional temporary road closures around Sydenham • Additional alteration of pedestrian and cyclist movements around Sydenham.	• Shared use of, and additional traffic delays on, key arterial and local roads by light and heavy construction vehicles, including the Princes Highway • Temporary road closures on Campbell Street, potentially interfacing with Sydney Metro haul routes • Additional temporary road closures around Sydenham and St Peters (St Peters Interchange) • Additional alteration of pedestrian and cyclist movements around Sydenham and St Peters (St Peters Interchange).	• Shared use of, and additional traffic delays on, key arterial and local roads by light and heavy construction vehicles, including the Princes Highway • Additional temporary road closures around Sydenham and St Peters (St Peters Interchange) • Additional alteration of pedestrian and cyclist movements around Sydenham and St Peters (St Peters Interchange).
Construction noise and vibration	• Additional temporary increase in noise and vibration around Sydenham.	• Additional temporary increase in noise and vibration around Sydenham and St Peters (St Peters Interchange).	• Additional temporary increase in noise and vibration around Sydenham and St Peters (St Peters Interchange).
Non-Aboriginal heritage	• No cumulative impacts greater than a minor nature are expected.	• No cumulative impacts greater than a minor nature are expected.	• No cumulative impacts greater than a minor nature are expected.
Social impacts and community infrastructure	• No cumulative impacts greater than a minor nature are expected.	• No cumulative impacts greater than a minor nature are expected.	• No cumulative impacts greater than a minor nature are expected.
Business impacts	• Altered access, visibility and amenity of businesses around Sydenham.	• Altered access, visibility and amenity of businesses around Sydenham and St Peters (St Peters Interchange).	• Altered access, visibility and amenity of businesses around Sydenham and St Peters (St Peters Interchange).
Landscape character and visual impacts	• Additional temporary visual impacts due to the presence of multiple construction sites and out-of-hours light spill around Sydenham Station.	• Additional temporary visual impacts due to the presence of multiple construction sites and out-of-hours light spill around Sydenham and St Peters (St Peters Interchange).	• Additional temporary visual impacts due to the presence of multiple construction sites and out-of-hours light spill around Sydenham and St Peters (St Peters Interchange).

Environmental impact	Potential cumulative environmental impacts without mitigation		
	Sydney Metro City & Southwest Sydenham to Bankstown Upgrade	WestConnex Stage 2: New M5 (Beverley Hills to St Peters)	WestConnex Stage 3: M4-M5 link
Flooding and hydrology	• The flooding assessment provided in Chapter 21 (Flooding and hydrology) specifically considers the Chatswood to Sydenham project as well as elements of the Sydenham to Bankstown upgrade project located at and to the north of Sydenham Station. As such, the impact assessment reflects the potential flooding impacts of both projects combined.	• No cumulative impacts greater than a minor nature are expected.	• No cumulative impacts greater than a minor nature are expected.
Air quality	• Additional temporary reduction in air quality around Sydenham.	• Additional temporary reduction in air quality around Sydenham and St Peters (St Peters Interchange).	• Additional temporary reduction in air quality around Sydenham and St Peters (St Peters Interchange).

None of the unapproved projects in Table 26-3 have the potential to have cumulative impacts at the Marrickville dive site (southern).

26.3.13 Sydney Metro Sydenham to Bankstown

As identified in Chapter 1 (Introduction), Sydney Metro City & Southwest is comprised of two projects being:

- Chatswood to Sydenham – the subject of this Environmental Impact Statement
- Sydenham to Bankstown upgrade – upgrading the 13.5 kilometre rail line and existing stations from Sydenham to Bankstown which is subject to a separate environmental assessment process.

These two projects would involve a direct interface to the north of Sydenham Station around the Marrickville dive site. At this stage, it is proposed that these projects would be constructed concurrently and would commence operations at the same time.

Sydney Metro are currently progressing the design and Environmental Impact Statement for the Sydenham to Bankstown upgrade as a separate project. As the design and assessment of this project is still being developed, the cumulative impact assessment of the two projects would be documented in detail in the Sydenham to Bankstown upgrade Environmental Impact Statement – it being a later document and being able to take into account greater detail about the impacts of both projects. Relevant cumulative impact issues that would be considered in the Sydenham to Bankstown upgrade Environmental Impact Statement are identified in Table 26-13.

Table 26-13 Sydenham to Bankstown upgrade Environmental Impact Statement scope

Aspect	Sydenham to Bankstown upgrade Environmental Impact Statement scope in relation to cumulative impacts with Chatswood to Sydenham
Strategic need and justification	- A description of the need and justification for Sydney Metro City & Southwest - The strategic benefits of Sydney Metro City & Southwest.
Construction traffic and transport	- Impacts to commuters around Sydenham and the need for rail replacement buses during the conversion of the T3 Bankstown Line - Potential cumulative traffic, pedestrian and cyclists impacts around the Marrickville dive site.
Operational traffic and transport	- An assessment of the strategic impacts and benefits to the traffic and transport network from the operation of Sydney Metro City & Southwest. Implications of this transfer on other transport interchanges including Central Station and Redfern Stations - A description and assessment of the interchange arrangements at the upgraded Sydenham Station.
Construction noise and vibration	- Assessment of the potential cumulative noise and vibration impacts around the Marrickville dive site with the Chatswood to Sydenham project.
Operational noise and vibration	- An assessment of the potential airborne rail noise in the vicinity of the Marrickville dive structure, including consideration the airborne rail noise from train operations associated with the Chatswood to Sydenham project (ie, metro trains operating in the dive structure and tunnel breakout noise).
Land use and property	- Identification and assessment of potential cumulative impacts of any additional land required in the vicinity of the Marrickville dive site and the potential cumulative impacts to the Marrickville industrial area.
Business impacts	- Assessment of any potential cumulative impacts to businesses in the Marrickville industrial area and around Sydenham Station.
Non-Aboriginal heritage	- Assessment of any potential cumulative impacts, particularly to the Sydenham Pit and Drainage Pumping Station 1.
Aboriginal heritage	- Identification and assessment of any potential cumulative impacts to any Aboriginal heritage items, including potential archaeology.
Landscape character and visual amenity	- Assessment of any potential cumulative visual and landscape character impacts in the vicinity of Marrickville dive site.
Groundwater and geology	- Cumulative groundwater and geology impacts are not anticipated to occur. The Sydenham to Bankstown component would be aboveground and would have negligible impacts to groundwater and geology.
Soils, contamination and water quality	- Assessment of any potential cumulative contamination impacts around Marrickville dive site (from the rail corridor).
Social impacts and community infrastructure	- Assessment of any potential cumulative social related impacts (mainly amenity) around the Marrickville dive site.
	- Cumulative impacts to community infrastructure are not anticipated to occur. The Chatswood to Sydenham project would not directly impact any community infrastructure around Marrickville.
Biodiversity	- Assessment of any potential cumulative impacts to microbat roosting habitat around the Marrickville dive site and Sydenham Station.

Aspect	Sydenham to Bankstown upgrade Environmental Impact Statement scope in relation to cumulative impacts with Chatswood to Sydenham
Flooding and hydrology	As indicated above, the flood modelling carried out as part of this Environmental Impact Statement has included part of the Sydenham to Bankstown project. The Sydenham to Bankstown Environmental Impact Statement would refine and update the flood modelling, if required, in the area between the Marrickville tunnel portal and Sydenham Station.
Air quality	Assessment of potential cumulative air quality impacts during construction from concurrent construction works around Marrickville dive site and Sydenham Station.
Hazard and risk	Cumulative hazard and risk impacts are not anticipated to occur. Any additional storage of dangerous goods and hazardous substances for the Sydenham to Bankstown component would remain below the applicable SEPP33 thresholds.
Waste management	Cumulative waste management impacts are not anticipated to occur. The Sydenham to Bankstown component is not anticipated to generate large volumes of spoil. Other construction wastes would be minor and manageable through standard mitigation measures.
Sustainability	Cumulative sustainability impacts are not anticipated to occur. The sustainability strategy would be adopted across all components of Sydney Metro City & Southwest.

Potential interim operation

As identified in Chapter 6 (Project description – operation) there may be a situation where this project is constructed and operated in advance of the Sydenham to Bankstown upgrade project. In this situation, a rail track-turnback would be constructed between the Marrickville dive structure and Sydenham Station with Waterloo Station effectively becoming a terminus for all rail passengers in the short term.

In this event, construction impacts would be essentially the same for all construction sites associated with this project with the exception of the Marrickville dive site where impacts would be the same or less.

When operational, the environmental impacts would also be essentially the same if this project opens in advance of the Sydenham to Bankstown upgrade project, with the exception of potential changes to rail airborne noise associated with the turnback facility. The differences in airborne noise levels between a train turnback and a train continuing through to Sydenham Station are expected to be minor. Furthermore, land use in the immediate vicinity of the potential turnback is predominately industrial, with the closest residential areas being across the existing rail tracks, some 150 metres away on Unwins Bridge Road. Accordingly, it is expected that the applicable criteria from the *Rail Infrastructure Noise Guidelines* (EPA, 2013) would be achievable without additional mitigation measures as currently identified.

It is also noted that the approved Sydney Metro Trains Facility in Rouse Hill was for an expanded network and is proposed to be used for this project. There would be no impact on stabling requirements in the event this project operates for a period without the Sydenham to Bankstown upgrade project.

As indicated in Chapter 6 (Project description – operation), should the Chatswood to Sydenham project be opened in advance of the Sydenham to Bankstown project and it is necessary to construct and operate the turnback, a supplementary environmental review / assessment would be carried out and if necessary the appropriate approvals obtained.

26.4 Mitigation measures

Mitigation measures that would be implemented to address potential cumulative impacts are listed in Table 26-14.

Table 26-14 Mitigation measures – cumulative impacts

Ref	Mitigation measure	Applicable location(s)[1]

CU1	Transport for NSW would manage and co-ordinate the interface with projects under construction at the same time. Co-ordination and consultation with the following stakeholders would occur, where required:
	- CBD Coordination Office
	- Department of Planning and Environment
	- Roads and Maritime Services
	- Sydney Trains
	- NSW Trains
	- Sydney Buses
	- Sydney Water
	- Port Authority of NSW
	- Willoughby Council
	- North Sydney Council
	- City of Sydney Council
	- Marrickville Council
	- Sydney Motorways Corporation
	- Barangaroo Delivery Authority
	- Emergency service providers
	- Utility providers
	- Construction contractors.
	Co-ordination and consultation with these stakeholders would include:
	- Provision of regular updates to the detailed construction program, construction sites and haul routes
	- Identification of key potential conflict points with other construction projects
	- Developing mitigation strategies in order to manage conflicts. Depending on the nature of the conflict, this could involve:
	  - Adjustments to the Sydney Metro construction program, work activities or haul routes; or adjustments to the program, activities or haul routes of other construction projects
	  - Co-ordination of traffic management arrangements between projects.
		All

1 *STW: Surface track works; CDS: Chatswood dive site; AS: Artarmon substation; CN: Crows Nest Station; VC: Victoria Cross Station; BP: Blues Point temporary site; GI: Ground improvement works; BN: Barangaroo Station; MP: Martin Place Station; PS: Pitt Street Station; CS: Central Station; WS: Waterloo Station; MDS: Marrickville dive site; Metro rail tunnels: Metro rail tunnels not related to other sites (eg TBM works); PSR: Power supply routes.*

CONSOLIDATED ENVIRONMENTAL MITIGATION MEASURES

CHAPTER TWENTY-SEVEN

27 Consolidated environmental mitigation measures

This chapter collates the environmental mitigation measures for the project that were identified through the impact assessment process in Chapters 8 to 26. It also identifies the environmental performance outcomes for the project.

27.1 Approach to environmental mitigation and management

The project approach to environmental mitigation and management is shown on Figure 27-1. This includes:

- Project design – measures which are inherent in the design of the project to avoid and minimise impacts. Further detail on these aspects of the project are provided in Chapter 6 (Project description – operation) and Chapter 7 (Project description – construction)
- Mitigation measures – additional to the project design which are identified through the environment impact assessment in Chapters 8 to 26. These measures are consolidated in Table 27-1
- Construction environmental management framework – details the management processes and documentation for the project. Further details are provided in section 27.1.1
- Construction noise and vibration strategy – identifies how Sydney Metro proposes to manage construction noise and vibration. Further details are provided in section 27.1.2
- Design guidelines – provides an assurance of end-state design quality. Further details are provided in section 27.1.3
- Environmental performance outcomes – which establish the intended outcomes which would be achieved by the project. The performance outcomes are identified in section 27.3.

The construction environmental management framework, construction noise and vibration strategy and design guidelines would be reviewed and updated periodically throughout delivery of the project.

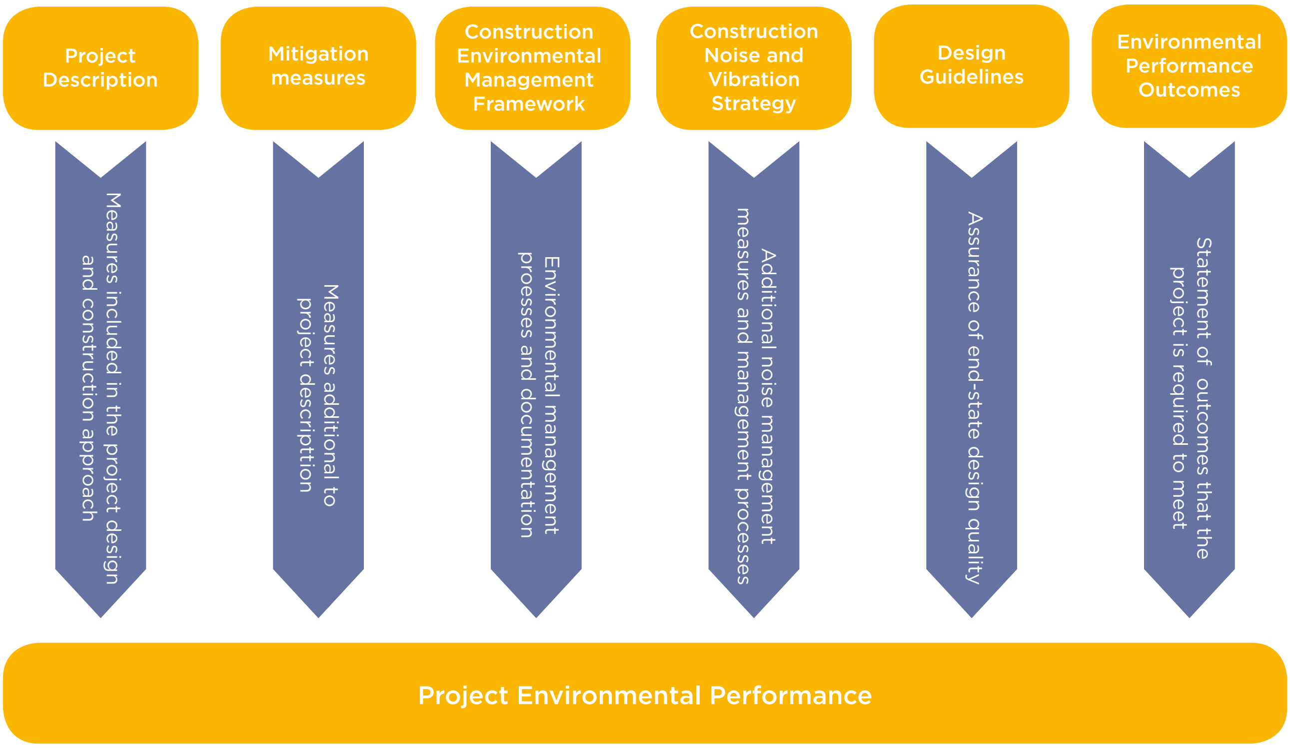


Figure 27-1 Project approach to environmental mitigation and management

27.1.1 Construction environmental management framework

A construction environmental management framework (CEMF) was developed and successfully implemented as part of the Sydney Metro Northwest project. This document has been reviewed and amended for application on this project and is provided in Appendix D.

The practical application of the CEMF is as a linking document between planning approval documentation and construction environmental management documentation, which would be developed by the construction contractors.

The CEMF details the environmental, stakeholder and community management systems and processes for the construction of the project. Specifically, it details the requirements in relation to the Construction Environmental Management Plan, sub-plans and other supporting documentation for each specific environmental aspect.

27.1.2 Construction noise and vibration strategy

The *Construction Noise and Vibration Strategy* (CNVS) (Appendix E) has been developed to identify how Sydney Metro proposes to manage construction noise and vibration for the City & Southwest project. It is anticipated that construction of City & Southwest would be developed under a number of separate construction contracts. The CNVS defines the strategies by which construction noise and vibration impacts are to be minimised on Sydney Metro projects and aims to provide a consistent approach to management and mitigation across the Sydney Metro projects.

Specifically the CNVS identifies:

- The requirements and methodology to develop Construction Noise Impact Statements. These are prepared prior to specific construction activities and are based on a more detailed understanding of the construction methods, including the size and type of construction equipment. Construction Noise Impact Statement would include:
  - A more detailed understanding of surrounding receivers including particularly sensitive receivers such as education and child care, and vibration sensitive medical, imaging and scientific equipment
  - Application of appropriate noise and vibration criteria for each receiver type
  - An assessment of the potential noise and vibration impacts as a result of the construction activities

  Two different types of Construction Noise Impact Statements may be developed:
  - General – for construction activities that are consistently the same and progressively move along the alignment, eg tunnelling
  - Location specific – for activities that are specific to a location. This also includes out of hours works and to support applications for variations to the project Environment Protection Licence
- The minimum requirements in relation to standard noise and vibration mitigation measures
- Noise and vibration auditing and monitoring requirements
- Additional mitigation measures to be implemented when exceedances to the noise management levels (NMLs) are likely to occur. These measures are primarily aimed at pro-active engagement with potentially affected receivers, and the provision of respite periods and alternative accommodation for defined exceedance levels.

27.1.3 Design guidelines

Sydney Metro has developed design guidelines in order to guide the design development process, and establish the aesthetic standards for the project. These guide the design of:

The interface between stations and their surrounding locality including:

- Station entries
  - Development over stations
  - Transport interchange facilities (bicycle facilities, bus stops, kiss-and-ride, taxi ranks and connections to existing rail, ferry and light rail transport)
  - Landscaping and other public domain elements
- Rail corridor works including the tunnel dive structures, rail cuttings and embankments
- Station and service buildings, including underground stations.

Five Design Objectives have been developed for the project to guide decision making and the design process for the project. These are:

1. Ensuring an easy customer experience
2. Being part of a fully integrated transport system
3. Being a catalyst for positive change
4. Being responsive to distinct contexts and communities
5. Delivering an enduring and sustainable legacy for Sydney.

The Chatswood to Sydenham Design Guidelines are provided in Appendix B.

27.2 Consolidated environmental mitigation measures

The site specific mitigation measures identified through the impact assessment process are consolidated in Table 27-1. The location(s) applicable to each mitigation measure are identified by using a unique identifier as follows:

- STW – Surface track works
- CDS – Chatswood dive site
- AS – Artarmon substation
- CN – Crows Nest Station
- VC – Victoria Cross Station
- BP – Blues Point temporary site
- GI – Ground improvement works
- BN – Barangaroo Station
- MP – Martin Place Station
- PS – Pitt Street Station
- CS – Central Station
- WS – Waterloo Station
- MDS – Marrickville dive site
- Metro rail tunnels – Metro rail tunnels not related to other sites (eg TBM works)
- PSR – Power supply routes.

Table 27-1 **Consolidated environmental mitigation measures**

ID	Mitigation measure	Applicable location (s)[1]
Construction traffic and transport		
T1	Ongoing consultation would be carried out with (as relevant to the location) the CBD Coordination Office, Roads and Maritime Services, Sydney Trains, NSW Trains, local councils, emergency services and bus operators in order to minimise traffic and transport impacts during construction.	All except metro rail tunnels
T2	Road Safety Audits would be carried out at each construction site. Audits would address vehicular access and egress, and pedestrian, cyclist and public transport safety.	All except metro rail tunnels
T3	Directional signage and line marking would be used to direct and guide drivers and pedestrians past construction sites and on the surrounding network. This would be supplemented by Variable Message Signs to advise drivers of potential delays, traffic diversions, speed restrictions, or alternate routes.	All except metro rail tunnels
T4	In the event of a traffic related incident, co-ordination would be carried out with the CBD Coordination Office and / or the Transport Management Centre's Operations Manager.	All except metro rail tunnels
T5	The community would be notified in advance of proposed road and pedestrian network changes through media channels and other appropriate forms of community liaison.	All except metro rail tunnels
T6	Vehicle access to and from construction sites would be managed to ensure pedestrian, cyclist and motorist safety. Depending on the location, this may require manual supervision, physical barriers, temporary traffic signals and modifications to existing signals or, on occasions, police presence.	All except metro rail tunnels
T7	Additional enhancements for pedestrian, cyclist and motorist safety in the vicinity of the construction sites would be implemented during construction. This would include measures such as: - Use of speed awareness signs in conjunction with variable message signs near construction sites to provide alerts to drivers - Shared experience educational events that allow pedestrians, cyclists or motorists to sit in trucks and understand the visibility restrictions of truck drivers, and for truck drivers to understand the visibility from a bicycle - Specific construction driver training to understand route constraints, expectations, safety issues and to limit the use of compression braking - Safety devices on construction vehicles that warn drivers of the presence of a vulnerable road user located in the vehicles' blind spots and warn the vulnerable road user that a vehicle is about to turn.	All except metro rail tunnels
T8	Access to existing properties and buildings would be maintained in consultation with property owners.	All except metro rail tunnels
T9	All trucks would enter and exit construction sites in a forward gear, where feasible and reasonable.	All except metro rail tunnels
T10	Any relocation of bus stops would be carried out by Transport for NSW in consultation with Roads and Maritime Services, the CBD Coordination Office (for relevant locations), the relevant local council and bus operators. Wayfinding and customer information would be provided to notify customers of relocated bus stops.	All except metro rail tunnels

ID	Mitigation measure	Applicable location (s)[1]
T11	For special events that require specific traffic measures, those measures would be developed in consultation the CBD Coordination Office (for relevant locations), Roads and Maritime Services, and the organisers of the event.	BN, MP, PS, CS
T12	Construction sites would be managed to minimise construction staff parking on surrounding streets. The following measures would be implemented: • Encouraging staff to use public or active transport • Encouraging ride sharing • Provision of alternative parking locations and shuttle bus transfers where feasible and reasonable.	All except metro rail tunnels
T13	Construction site traffic would be managed to minimise movements in the AM and PM peak periods.	All except metro rail tunnels
T14	Construction site traffic immediately around construction sites would be managed to minimise movements through school zones during pick up and drop off times.	All except metro rail tunnels
T15	Pedestrian and cyclist access would be maintained at Crows Nest during the temporary closure of Hume Street, and at Martin Place during the temporary partial closure of Martin Place. Wayfinding and customer information would be provided to guide pedestrians and cyclists to alternative routes.	CN, MP
T16	Timing for the temporary closure of the Devonshire Street tunnel would avoid periods of peak pedestrian demand. Wayfinding and customer information would be provided to guide pedestrians to alternative routes.	CS
T17	Consultation would occur with the Harbour Master, Roads and Maritime Services and Sydney Ferries' to ensure shipping channels are maintained during the Sydney Harbour ground improvement works.	GI
T18	During the closure of existing entrances to Martin Place Station, marshalls would be provided during the AM and PM peak periods to direct customers to available access and egress points.	MP
T19	Where existing parking is removed to facilitate construction activities, alternative parking facilities would be provided where feasible and reasonable.	All except metro rail tunnels
T20	Alternative pedestrian routes and property access would be provided where these are affected during the construction of the power supply routes.	PSR
Operational traffic and transport		
OpT1	Enhancement of pedestrian infrastructure in the vicinity of Victoria Cross and Martin Place stations would be investigated further in consultation with (as relevant to the location) the CBD Coordination Office, Roads and Maritime Services and the relevant local council.	VC, MP
OpT2	Access would be maintained to neighbouring properties.	All except metro rail tunnels

ID	Mitigation measure	Applicable location (s)[1]
Construction noise and vibration		
NV1	The Construction Noise and Vibration Strategy would be implemented with the aim of achieving the noise management levels where feasible and reasonable. This would include the following example standard mitigation measures where feasible and reasonable: • Provision of noise barriers around each construction site • Provision of acoustic sheds at Chatswood dive site, Crows Nest, Victoria Cross, Barangaroo, Martin Place, Pitt Street, Waterloo and Marrickville dive site • The coincidence of noisy plant working simultaneously close together would be avoided • Offset distances between noisy plant and sensitive receivers would be increased • Residential grade mufflers would be fitted to all mobile plant • Dampened rock hammers would be used • Non-tonal reversing alarms would be fitted to all permanent mobile plant • High noise generating activities would be scheduled for less sensitive period considering the nearby receivers • The layout of construction sites would consider opportunities to shield receivers from noise.	All
NV2	Unless compliance with the relevant traffic noise criteria can be achieved, night time heavy vehicle movements at the Chatswood dive site, Crows Nest Station and Victoria Cross Station sites would be restricted to: • The Pacific Highway and Mowbray Road at the Chatswood dive site • The Pacific Highway, Hume Street and Oxley Street at the Crows Nest Station construction site • McLaren Street, Miller Street and Berry Street at the Victoria Cross station construction site.	CDS, CN, VC
NV3	Where vibration levels are predicted to exceed the screening criteria, a more detailed assessment of the structure and attended vibration monitoring would be carried out to ensure vibration levels remain below appropriate limits for that structure. For heritage items, the more detailed assessment would specifically consider the heritage values of the structure in consultation with a heritage specialist to ensure sensitive heritage fabric is adequately monitored and managed.	All except metro rail tunnels
NV4	Feasible and reasonable measures would be implemented to minimise ground-borne noise where exceedences are predicted.	All
NV5	Feasible and reasonable mitigation measures would be implemented where power supply works would result in elevated noise levels at receivers. This would include: • Carrying out works during the daytime period when in the vicinity of residential receivers • Where out of hours works are required, scheduling the noisiest activities to occur in the evening period (up to 10 pm) • Use of portable noise barriers around particularly noisy equipment such as concrete saws.	PSR

ID	Mitigation measure	Applicable location (s)[1]
Operational noise and vibration		
OpNV1	The height and extent of noise barriers adjacent to the northern surface track works would be confirmed during detailed design with the aim of not exceeding trigger levels from the *Rail Infrastructure Noise Guidelines* (Environment Protection Authority, 2013). At property treatments would be offered where there are residual exceedances of the trigger levels.	STW
OpNV2	Track form would be confirmed during the detailed design process in order to meet the relevant ground-borne noise and vibration criteria from the *Rail Infrastructure Noise Guidelines* (EPA, 2013) and the *Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects* (DECC, 2007a).	Metro rail tunnels
OpNV3	Stations and ancillary facilities including train breakout noise from draught relief shafts would be designed to meet the applicable noise criteria derived from the *Industrial Noise Policy* (EPA, 2000).	All except metro rail tunnels
Business impacts		
BI1	Specific consultation would be carried out with businesses potentially impacted during construction. Consultation would aim to identify and develop measures to manage the specific construction impacts for individual businesses.	All
BI2	A business impact risk register would be developed to identify, rate and manage the specific construction impacts for individual businesses.	All
BI3	Appropriate signage would be provided around construction sites to provide visibility to retained businesses.	All except metro rail tunnels
Non-Aboriginal heritage		
NAH1	Archival recording and reporting of the following heritage items would be carried out in accordance with the NSW Heritage Office's *How to Prepare Archival Records of Heritage Items* (1998a), and *Photographic Recording of Heritage Items Using Film or Digital Capture* (2006): • The internal heritage fabric and any non-original elements removed from within the curtilage of Mowbray House, Chatswood • The interior, exterior and setting of the shop at 187 Miller Street, North Sydney • The fabric and setting of the North Sydney bus shelters requiring removal and temporary relocation at Victoria Cross Station and Blues Point temporary site • Any component of the Blues Point Waterfront Group and the McMahons Point South heritage conservation area to be directly affected or altered, including vegetation and significant landscape features • Hickson Road wall in the vicinity of proposed ventilation risers and skylights for Barangaroo Station • The interior, exterior and setting of the 'Flat Building' at 7 Elizabeth Street, Sydney • Martin Place, between Elizabeth and Castlereagh streets, Sydney • The heritage fabric of areas of the existing Martin Place Station affected by the project • The Rolling Stock Officers Garden, Rolling Stock Officers Building and Cleaners Amenities Building in Sydney Yard and any other component of the Sydney Terminal and Central Railway Stations group to be removed or altered.	CDS, VC, BP, MP, CS

ID	Mitigation measure	Applicable location (s)[1]
NAH2	An archaeological research designs would be prepared and implemented to identify the need for archaeological testing or monitoring. Archaeological mitigation measures recommended in the archaeological research design would be carried out in accordance with Heritage Council guidelines, and where identified in the archaeological research design, would be supervised by a suitably qualified Excavation Director with experience in managing State significant archaeology.	CDS, CN, VC, BP, BN, MP, PS, CS, WS, PSR
NAH3	An *Exhumation Policy and Guideline* would be prepared and implemented. It would be developed in accordance with the *Guidelines for Management of Human Skeletal Remains* (NSW Heritage Office, 1998b).	All except metro rail tunnels
NAH4	The method for the demolition of existing buildings and / or structures at Chatswood dive site, Victoria Cross Station, Martin Place Station, Pitt Street Station, Central Station and Waterloo Station would be developed to minimise direct and indirect impacts to adjacent and / or adjoining heritage items.	CDS, VC, MP, PS, CS, WS
NAH5	Prior to total or partial demolition of heritage items at Victoria Cross and Martin Place stations, heritage fabric for salvage would be identified and reuse opportunities for salvaged fabric considered. This would include salvage and reuse of heritage tiles to be impacted at Martin Place Station.	VC, MP
NAH6	An appropriately qualified and experienced heritage architect would form part of the Sydney Metro Design Review Panel and would provide independent review periodically throughout detailed design.	All
NAH7	The project design would be sympathetic to heritage items and, where reasonable and feasible, minimise impacts to the setting of heritage items. The detailed design for Martin Place Station and Central Station would be developed with input from a heritage architect.	STW, CDS, CN, VC, BN, MP, PS, CS, WS, MDS
NAH8	Appropriate heritage interpretation would be incorporated into the design for the project in accordance with the *NSW Heritage Manual*, the NSW Heritage Office's *Interpreting Heritage Places and Items: Guidelines* (August 2005), and the NSW Heritage Council's *Heritage Interpretation Policy*.	CDS, CN, VC, BP, BN, MP, PS, WS
NAH9	A Central Station heritage interpretation plan would be developed and implemented. It would be consistent with the *Central Station Conservation Management Plan* (Rappoport and Government Architects Office, 2013) and in accordance with the guidelines identified in NAH8.	CS
NAH10	The design of the Sydney Yard Access Bridge would be sympathetic to surrounding heritage items and minimise impacts to sight lines, views and setting of surrounding heritage items, including to Mortuary Station and the Sydney Terminal and Central Railway Stations group. As a minimum the design would: • Incorporate materials and finishes sympathetic to the heritage context of the railway station • Minimise height and bulk of the structure.	CS

ID	Mitigation measure	Applicable location (s)[1]
NAH11	Except for heritage significant elements affected by the project, direct impact on other heritage significant elements forming part of the following items would be avoided: • The Blues Point Waterfront Group (including the former tram turning circle, stone retaining wall, bollards and steps) • The Millers Point and Dawes Point Village Precinct • The existing Martin Place Station • Sydney Terminal and Central Railway Stations group • Sydney Yard (including the Shunters Hut and Prince Alfred Sewer).	BP, BN, MP, CS
NAH12	Power supply works would be designed and constructed to avoid impacts to the Tank Stream and Bennelong Stormwater Channel.	PSR
NAH13	The design and detailed construction planning of work at Central Station would consider the requirements of the *Central Station Conservation Management Plan* (Rappoport and Government Architects Office, 2013) and include consideration of opportunities for the retention, conservation and / or reuse of original and significant heritage fabric. Consultation would be carried out with Sydney Trains and the Heritage Council of NSW during design development.	CS
Aboriginal heritage		
AH1	Aboriginal stakeholder consultation would be carried out in accordance with the NSW Office of Environment and Heritage's *Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010*.	All
AH2	An Aboriginal cultural heritage assessment report would be prepared in accordance with the OEH *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW*. The Aboriginal cultural heritage assessment report would include: • Details of Aboriginal stakeholder consultation conducted in accordance with AH1 • An assessment of cultural significance for the project area and identification of any specific areas of cultural significance based on consultation with Aboriginal stakeholders • A methodology for archaeological management including test excavation and salvage (refer to AH3).	All
AH3	Archaeological test excavation (and salvage when required) would be carried out where intact natural soil profiles with the potential to contain significant archaeological deposits are encountered at the Blues Point temporary site, Barangaroo Station, Martin Place Station, Pitt Street Station, Central Station, Waterloo Station and Marrickville dive site. Excavations would be conducted in accordance with the methodology outlined in the Aboriginal cultural heritage assessment report	BP, BN, MP, PS, CS, WS, MDS
AH4	Appropriate Aboriginal heritage interpretation would be incorporated into the design for the project in consultation with Aboriginal stakeholders.	All
AH5	Feasible and reasonable mitigation at the ground improvement locations would be identified in consultation with the Office of Environment and Heritage.	GI
AH6	The Aboriginal cultural heritage assessment report would address areas of archaeological potential associated with the power supply routes.	PSR

ID	Mitigation measure	Applicable location (s)[1]
Landscape character and visual amenity		
Construction		
LV1	Where feasible and reasonable, the elements within construction sites would be located to minimise visual impacts, for example materials and machinery would be stored behind fencing.	All except metro rail tunnels
LV2	Existing trees to be retained would be protected prior to the commencement of construction in accordance with Australian Standard *AS4970 the Australian Standard for Protection of Trees on Development Sites and Adjoining Properties*.	All except metro rail tunnels
LV3	Lighting of construction sites would be oriented to minimise glare and light spill impact on adjacent receivers.	All except metro rail tunnels
LV4	Visual mitigation would be implemented as soon as feasible and reasonable after the commencement of construction, and remain for the duration of the construction period.	All except metro rail tunnels
LV5	Opportunities for the retention and protection of existing street trees would be identified during detailed construction planning.	All except metro rail tunnels
LV6	The design and maintenance of construction site hoardings would aim to minimise visual amenity and landscape character impacts, including the prompt removal of graffiti. Public art opportunities would be considered.	All except metro rail tunnels
LV7	The selection of materials and colours for acoustic sheds would aim to minimise their visual prominence.	CDS, CN, VC, BN, MP, PS, WS, MDS
LV8	Tunnel boring machine retrieval works at the Blues Point temporary site would be timed to avoid key harbour viewing events.	BP
LV9	Benching would be used where feasible and reasonable at Blues Point temporary site to minimise visual amenity impacts.	BP
Operation		
LV10	Cut off and direct light fittings (or similar technologies) would be used to minimise glare and light spill onto private property.	CDS, AS, MDS
LV11	Where feasible and reasonable, vegetation would be provided to screen and visually integrate sites with the surrounding area.	CDS, AS, MDS
LV12	Identify and implement appropriate landscape treatments for Frank Channon Walk.	STW, CDS
LV13	The architectural treatment of Artarmon substation would minimise visual amenity and landscape character impacts.	AS
LV14	The Harbour cycles sculpture at North Sydney would be reinstated at a location determined in consultation with North Sydney Council.	VC
LV15	The P&O Fountain at 55 Hunter Street would be reinstated at a location determined in consultation with City of Sydney Council.	MP
LV16	Opportunities would be investigated to provide a permanent wall for street art at Marrickville dive site in consultation with Marrickville Council.	MDS
LV17	Noise barriers would be transparent where they are augmenting existing transparent noise barriers.	STW

ID	Mitigation measure	Applicable location (s) [1]
Groundwater and geology		
GWG1	A detailed geotechnical model for the project would be developed and progressively updated during design and construction. The detailed geotechnical model would include: • Assessment of the potential for damage to structures, services, basements and other sub-surface elements through settlement or strain • Predicted changes to groundwater levels, including at nearby water supply works. Where building damage risk is rated as moderate or higher (as per the CIRIA 1996 risk-based criteria), a structural assessment of the affected buildings / structures would be carried out and specific measures implemented to address the risk of damage. With each progressive update of the geotechnical model the potential for exceedance of the following target changes to groundwater levels would be reviewed: • Less than 2.0 metres – general target • Less than 4.0 metres – where deep building foundations present • Less than 1.0 metre – residual soils • Less than 0.5 metre – residual soils (Blues Point) (fill / Aeolian sand). Where a significant exceedance of target changes to groundwater levels are predicted at surrounding land uses and nearby water supply works, an appropriate groundwater monitoring program would be developed and implemented. The program would aim to confirm no adverse impacts on groundwater levels or to appropriately manage any impacts. Monitoring at any specific location would be subject to the status of the water supply work and agreement with the landowner.	All
GWG2	Condition surveys of buildings and structures in the vicinity of the tunnel and excavations would be carried out prior to the commencement of excavation at each site.	All
Soil, contamination, water quality		
Construction		
SCW1	Updated desktop contamination assessments would be carried out for Chatswood dive site, Blues Point temporary site, Barangaroo Station, Central Station and Waterloo Station. If sufficient information is not available to determine the remediation requirements and the impact on potential receivers, then detailed contamination assessments, including collection and analysis of soil and groundwater samples would be carried out. Detailed contamination assessment would also be carried out for the Barangaroo power supply route within Hickson Road and the Marrickville power supply route adjacent to Sydney Park and Camdenville Oval. In the event a Remediation Action Plan is required, these would be developed in accordance with Managing *Land Contamination: Planning Guidelines SEPP 55 – Remediation of Land* (Department of Urban Affairs and Planning and Environment Protection Authority, 1998) and a site auditor would be engaged.	CDS, BP, BN, CS, WS, PSR
SCW2	Prior to ground disturbance in high probability acid sulfate areas at Barangaroo Station, Waterloo Station and Marrickville dive site, testing would be carried out to determine the presence of acid sulfate soils. If acid sulfate soils are encountered, they would be managed in accordance with the *Acid Sulfate Soil Manual* (Acid Sulfate Soil Management Advisory Committee, 1998).	BN, WS, MDS

ID	Mitigation measure	Applicable location (s)[1]
SCW3	Erosion and sediment control measures would be implemented in accordance with *Managing Urban Stormwater: Soils and Construction Volume 1* (Landcom, 2004) and *Managing Urban Stormwater: Soils and Construction Volume 2* (Department of Environment and Climate Change, 2008a). Measures would be designed as a minimum for the 80th percentile; 5-day rainfall event.	All except metro rail tunnels
SCW4	Discharges from the construction water treatment plants would be monitored to ensure compliance with the discharge criteria in an environment protection licence issued to the project.	All except metro rail tunnels
SCW5	A silt curtain would be used around the Sydney Harbour ground improvement work barges.	GI
SCW6	A water quality monitoring program would be implemented to monitor water quality within Sydney Harbour during ground improvement work. The water quality monitoring program would be carried out to detect any potential impacts on the water quality of Sydney Harbour from the ground improvement work and inform management responses in the event any impacts are identified. Specific monitoring locations and frequencies would be determined during the development of the program in consultation with the Environment Protection Authority.	GI
Operation		
SCW7	Discharges from the tunnel water treatment plant would be monitored to ensure compliance with the discharge criteria determined in consultation with the NSW Environment Protection Authority.	MDS
Social impacts and community infrastructure		
SO1	Direct impacts to public open space at the Blues Point temporary site would be minimised.	BP
SO2	Specific consultation would be carried out with sensitive community facilities (including aged care, child care centres, educational institutions and places of worship) potentially impacted during construction. Consultation would aim to identify and develop measures to manage the specific construction impacts for individual sensitive community facilities.	All except metro rail tunnels
Biodiversity		
B1	An ecologist would be present during the removal of any hollow-bearing trees.	CDS
B2	Potential bat roosting locations at Central Station, Waterloo Station and Marrickville dive sites would be checked by a qualified ecologist or wildlife handler prior to demolition. Any bats found would be relocated.	CS, WS, MDS
B3	The local WIRES group and / or veterinarian would be contacted if any fauna are injured on site or require capture and / or relocation.	All except metro rail tunnels
B4	Procedures would be developed and implemented, in accordance with the National System for the Prevention and Management of Marine Pest Incursions, during Sydney Harbour ground improvement works to avoid transportation of marine pests from other locations, particularly the marine alga *Caulerpa taxifoli*.	GI

ID	Mitigation measure	Applicable location (s)[1]
Flooding and hydrology		
Construction		
FH1	Detailed construction planning would consider flood risk at Barangaroo Station, Martin Place Station and the Waterloo Station construction sites. This would include identification of measures to avoid, where feasible and reasonable, construction phase flooding impacts on the community and on other property and infrastructure.	BN, MP, WS
FH2	The site layout and staging of construction activities at Marrickville dive site would avoid or minimise obstruction of overland flow paths and limit the extent of flow diversion required.	MDS
FH3	Overland flow diversions during construction at the Marrickville dive site would meet the following criteria: • Increases in flood levels during events up to and including the 100-year average recurrence interval would be minimised particularly within private properties • Any increase in flow velocity for events up to and including a 100-year average recurrence interval event would not increase the potential for soil erosion and scouring • Dedicated evacuation routes would not be adversely impacted in flood events up to and including the probable maximum flood. Construction planning for the Marrickville dive site would be carried out in consultation with the State Emergency Services and Marrickville Council.	MDS
Operation		
FH4	Where feasible and reasonable, detailed design would result in no net increase in stormwater runoff rates in all storm events unless it can be demonstrated that increased runoff rates as a result of the project would not increase downstream flood risk.	STW, AS, MDS
FH5	Where space permits, on-site detention of stormwater would be introduced where stormwater runoff rates are increased. Where there is insufficient space for the provision of on-site detention, the upgrade of downstream infrastructure would be implemented where feasible and reasonable.	STW, AS, MDS
FH6	Detailed design would occur in consultation with Marrickville Council to ensure future drainage improvement works around the Marrickville dive site would not be precluded.	MDS
FH7	Consultation would be carried out with Marrickville Council to ensure flood-related outcomes of the project are consistent with any future floodplain risk management study and / or plan developed for the Marrickville Valley Catchment.	MDS
FH8	The frequency of Sydney Trains rail service disruptions due to flooding would not be increased in the vicinity of the Marrickville dive structure.	MDS

ID	Mitigation measure	Applicable location (s)[1]
HF9	Design of the Marrickville dive structure would be reviewed to, where feasible and reasonable, further reduce flood levels for events up to and including the 100-year annual recurrence interval, including at private properties, within the road reserve at Bolton Street and around Sydenham Station. Flood modelling to support detailed design would be carried out in accordance with the following guidelines: • *Floodplain Development Manual* (NSW Government, 2005b) • *Floodplain Risk Management Guideline: Practical Consideration of Climate Change* (DECC, 2007b) • *Floodplain Risk Management Guide: Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments* (DECCW, 2010c) • *New guideline and changes to section 117 direction and EP&A Regulation on flood prone land, Planning Circular PS 07-003* (NSW Department of Planning, 2007).	MDS
Air Quality		
AQ1	The engines of all on-site vehicles and plant would be switched off when not in use for an extended period.	All
AQ2	Plant would be well maintained and serviced to minimise emissions. Emissions from plant would be considered as part of pre-acceptance checks.	All
AQ3	Construction site layout and placement of plant would consider air quality impacts to nearby receivers.	All except metro rail tunnels
AQ4	Hard surfaces would be installed on long term haul routes and regularly cleaned.	All except metro rail tunnels
AQ5	Unsurfaced haul routes and work area would be regularly damped down in dry and windy conditions.	All except metro rail tunnels
AQ6	All vehicles carrying loose or potentially dusty material to or from the site would be fully covered.	All except metro rail tunnels
AQ7	Stockpiles would be managed to minimise dust generation.	All except metro rail tunnels
AQ8	Demolition would be managed to minimise dust generation.	All except metro rail tunnels
AQ9	Ventilation from acoustic sheds would be filtered.	CDS, CN, VC, BN, MP, PS, WS, MDS

ID	Mitigation measure	Applicable location (s) [1]
Hazard and risk		
Construction		
HR1	All hazardous substances that may be required for construction would be stored and managed in accordance with the *Storage and Handling of Dangerous Goods Code of Practice* (WorkCover NSW, 2005) and *Hazardous and Offensive Development Application Guidelines: Applying SEPP 33* (Department of Planning, 2011).	All
HR2	Dial before you dig searches and non-destructive digging would be carried out to identify the presence of underground utilities.	All
HR3	A hazardous material survey would be completed for those buildings and structures suspected of containing hazardous materials (particularly asbestos) prior to their demolition. If asbestos is encountered, it would be handled and managed in accordance with relevant legislation, codes of practice and Australian standards.	CDS, CN, VC, MP, PS, CS, WS, MDS
HR4	The method for delivery of explosives would developed prior to the commencement of blasting in consultation with the Department of Planning and Environment and be timed to avoid the need for on-site storage.	CN, VC, BN, MP, PS, WS
Operation		
HR5	All hazardous substances that may be required for operation would be stored and managed in accordance with the *Storage and Handling of Dangerous Goods Code of Practice* (WorkCover NSW, 2005) and *Hazardous and Offensive Development Application Guidelines:* Applying SEPP 33 (Department of Planning, 2011).	All
Waste management		
Construction		
WM1	All waste would be assessed, classified, managed and disposed of in accordance with the *NSW Waste Classification Guidelines*.	All
WM2	100 per cent of spoil that can be reused would be beneficially reused in accordance with the project spoil reuse hierarchy.	All
WM3	A recycling target of at least 90 per cent would be adopted for the project.	All
WM4	Construction waste would be minimised by accurately calculating materials brought to the site and limiting materials packaging.	All
Operation		
WM5	Generation of operation phase waste would be minimised.	All

ID	Mitigation measure	Applicable location (s)[1]
Sustainability		
Construction		
SUS1	Sustainability initiatives would be incorporated into the detailed design and construction of the project to support the achievement of the project sustainability objectives.	All
SUS2	A best practice level of performance would be achieved using market leading sustainability rating tools during design and construction.	All
SUS3	A workforce development and industry participation strategy would be developed and implemented during construction.	All
SUS4	Climate change risk treatments would be incorporated into the detailed design of the project including: - Ensuring that adequate flood modelling is carried out and integrated with design - Testing the sensitivity of air-conditioning systems to increased temperatures, and identify potential additional capacity of air-conditioning systems that may be required within the life of the project, with a view to safeguarding space if required - Testing the sensitivity of ventilation systems to increased temperatures and provide adequate capacity.	All
SUS5	An iterative process of greenhouse gas assessments and design refinements would be carried out during detailed design and construction to identify opportunities to minimise greenhouse gas emissions. Performance would be measured in terms of a percentage reduction in greenhouse gas emissions from a defined reference footprint.	All
SUS6	25 per cent of the greenhouse gas emissions associated with consumption of electricity during construction would be offset.	All
Operation		
SUS7	Sustainability initiatives would be incorporated into the operation of the project to support the achievement of the project sustainability objectives.	All
SUS8	Periodic review of climate change risks would be carried out to ensure ongoing resilience to the impacts of climate change.	All
SUS9	A workforce development and industry participation strategy would be developed and implemented during operation.	All
SUS10	100 per cent of the greenhouse gas emissions associated with consumption of electricity during operation would be offset.	All

<table>
<tr><th>ID</th><th>Mitigation measure</th><th>Applicable location (s) [1]</th></tr>
<tr><td colspan="3">Cumulative impacts</td></tr>
<tr><td>CU1</td><td>Transport for NSW would manage and co-ordinate the interface with projects under construction at the same time. Co-ordination and consultation with the following stakeholders would occur, where required:
• CBD Coordination Office
• Department of Planning and Environment
• Roads and Maritime Services
• Sydney Trains
• NSW Trains
• Sydney Buses
• Sydney Water
• Port Authority of NSW
• Willoughby Council
• North Sydney Council
• City of Sydney Council
• Marrickville Council
• Sydney Motorways Corporation
• Barangaroo Delivery Authority
• Emergency service providers
• Utility providers
• Construction contractors.
Co-ordination and consultation with these stakeholders would include:
• Provision of regular updates to the detailed construction program, construction sites and haul routes
• Identification of key potential conflict points with other construction projects
• Developing mitigation strategies in order to manage conflicts. Depending on the nature of the conflict, this could involve:
  ♦ Adjustments to the Sydney Metro construction program, work activities or haul routes; or adjustments to the program, activities or haul routes of other construction projects
  ♦ Co-ordination of traffic management arrangements between projects.</td><td>All</td></tr>
</table>

1 *STW: Surface track works; CDS: Chatswood dive site; AS: Artarmon substation; CN: Crows Nest Station; VC: Victoria Cross Station; BP: Blues Point temporary site; GI: Ground improvement works; BN: Barangaroo Station; MP: Martin Place Station; PS: Pitt Street Station; CS: Central Station; WS: Waterloo Station; MDS: Marrickville dive site; Metro rail tunnels: Metro rail tunnels not related to other sites (eg TBM works); PSR: Power supply routes.*

27.3 Environmental performance outcomes

The Secretary's environmental assessment requirements identify a number of desired performance outcomes. These desired performance outcomes outline the broader objectives to be achieved by the proponent in the design, construction and operation of the project.

Table 27-2 identifies the environmental performance outcomes based on the outcomes of the assessment and the implementation of the mitigation measures identified in Table 27-1. Future design development and any design changes would be considered against these environmental performance outcomes.

Table 27-2 Environmental performance outcomes

Relevant Secretary's environmental assessment requirements desired performance outcomes	Environmental performance outcome
Construction traffic and transport	
Transport and traffic Network connectivity, safety and efficiency of the transport system in the vicinity of the project are managed to minimise impacts. The safety of transport system customers is maintained. Impacts on network capacity and the level of service are effectively managed. Works are compatible with existing infrastructure and future transport corridors.	• The project would minimise impacts to the road network • Pedestrian and cyclist safety would be maintained • Effective coordination would be carried out to minimise cumulative network impacts • Access to properties would be maintained.
Operational traffic and transport	
Transport and traffic Network connectivity, safety and efficiency of the transport system in the vicinity of the project are managed to minimise impacts. The safety of transport system customers is maintained. Impacts on network capacity and the level of service are effectively managed. Works are compatible with existing infrastructure and future transport corridors.	• The project would appropriately integrate with existing and planned future transport infrastructure including active transport • Access to properties would be maintained • Metro customers would be provided with a safe and secure service • The project would reduce station crowding, increase rail network reach and use, improve network resilience, and improve travel times within the global economic corridor.
Construction noise and vibration	
Noise and vibration – amenity Construction noise and vibration (including airborne noise, ground-borne noise and blasting) are effectively managed to minimize adverse impacts on acoustic amenity. **Noise and vibration – structural** Construction noise and vibration (including airborne noise, ground-borne noise and blasting) are effectively managed to minimize adverse impacts on the structural integrity of buildings and items including Aboriginal places and environmental heritage.	• Noise levels would be minimised with the aim of achieving the noise management levels where feasible and reasonable • The project would avoid any damage to buildings from vibration.

Relevant Secretary's environmental assessment requirements desired performance outcomes	Environmental performance outcome
Operational noise and vibration	
Noise and vibration – amenity Increases in noise emissions and vibration affecting nearby properties and other sensitive receivers during operation of the project are effectively managed to protect the amenity and well-being of the community. **Noise and vibration – structural** Increases in noise emissions and vibration affecting environmental heritage as defined in the *Heritage Act 1977* during operation of the project are effectively managed.	• Noise levels would comply with the *Rail Infrastructure Noise Guidelines* (Environment Protection Authority, 2013). • The project would avoid any damage to buildings from vibration.
Landuse and property	
Socio-economic, land use and property The project minimises impacts to property and business and achieves appropriate integration with adjoining land uses, including maintenance of appropriate access to properties and community facilities, and minimisation of displacement of existing land use activities, dwellings and infrastructure.	• The project would be appropriately integrated into local landuse planning strategies • The surface footprint of the project would be minimised • The project would provide substantial future development opportunities.
Business impacts	
Socio-economic, land use and property The project minimises adverse social and economic impacts and capitalises on opportunities potentially available to affected communities. The project minimises impacts to property and business and achieves appropriate integration with adjoining land uses, including maintenance of appropriate access to properties and community facilities, and minimisation of displacement of existing land use activities, dwellings and infrastructure.	• The project would minimise impacts on businesses during construction • During operation, the project would improve access to businesses for employees and customers, and connectivity between businesses within the global economic corridor.
Non-Aboriginal heritage	
Heritage The design, construction and operation of the project facilitates, to the greatest extent possible, the long term protection, conservation and management of the heritage significance of items of environmental heritage and Aboriginal objects and places. The design, construction and operation of the project avoids or minimises impacts, to the greatest extent possible, on the heritage significance of environmental heritage and Aboriginal objects and places.	• The project would be sympathetic to heritage items and, where feasible and reasonable, avoid and minimise impacts to non-Aboriginal heritage items and archaeology • The design of the project would reflect the input of an independent heritage architect, relevant stakeholders and the design review panel.

Relevant Secretary's environmental assessment requirements desired performance outcomes	Environmental performance outcome
Aboriginal heritage	
Heritage The design, construction and operation of the project facilitates, to the greatest extent possible, the long term protection, conservation and management of the heritage significance of items of environmental heritage and Aboriginal objects and places. The design, construction and operation of the project avoids or minimises impacts, to the greatest extent possible, on the heritage significance of environmental heritage and Aboriginal objects and places.	• The project would be sympathetic to heritage items and, where feasible and reasonable, avoid and minimise impacts to Aboriginal heritage items and archaeology • The design of the project would reflect the input of an independent heritage architect, relevant stakeholders and the design review panel.
Landscape character and visual amenity	
Urban design The project design complements the visual amenity, character and quality of the surrounding environment. The project contributes to the accessibility and connectivity of communities. **Visual amenity** The project minimises adverse impacts on the visual amenity of the built and natural environment (including public open space) and capitalises on opportunities to improve visual amenity.	• During operation, the project would make a positive contribution to the quality of the urban environment at each station site • During operation, the project would minimise change to landscape character in the vicinity of the dive structures and Artarmon substation • The project would be visually integrated with its surroundings.
Groundwater and geology	
Water – hydrology Long term impacts on surface water and groundwater hydrology (including drawdown, flow rates and volumes) are minimised. The environmental values of nearby, connected and affected water sources, groundwater and dependent ecological systems including estuarine and marine water (if applicable) are maintained (where values are achieved) or improved and maintained (where values are not achieved). Sustainable use of water resources.	• The project would make good any impacts on groundwater users • The project would avoid any damage to buildings from settlement.

Relevant Secretary's environmental assessment requirements desired performance outcomes	Environmental performance outcome
Soils, contamination and water quality	
Soils The environmental values of land, including soils, subsoils and landforms, are protected. Risks arising from the disturbance and excavation of land and disposal of soil are minimised, including disturbance to acid sulfate soils and site contamination. **Water – quality** The project is designed, constructed and operated to protect the NSW Water Quality Objectives where they are currently being achieved, and contribute towards achievement of the Water Quality Objectives over time where they are currently not being achieved, including downstream of the project to the extent of the project impact including estuarine and marine waters (if applicable).	- Erosion and sediment controls during construction would be implemented in accordance with *Managing Urban Stormwater: Soils and Construction Volume 1* (Landcom, 2004) and *Managing Urban Stormwater: Soils and Construction Volume 2* (Department of Environment and Climate Change, 2008a) - There would be no impacts on aquatic environments associated with the disturbance of acid sulfate soils during construction - Any contamination on project sites would be remediated to suit future land use - The project would protect or contribute to achieving the Water Quality Objectives, during construction and operation - Construction water quality discharge would comply with the requirements of an environment protection licence issued to the project - Operation water quality discharge would comply with a discharge criteria determined in consultation with the NSW Environment Protection Authority.
Social impacts and community facilities	
Socio-economic, land use and property The project minimises adverse social and economic impacts and capitalises on opportunities potentially available to affected communities. The project minimises impacts to property and business and achieves appropriate integration with adjoining land uses, including maintenance of appropriate access to properties and community facilities, and minimisation of displacement of existing land use activities, dwellings and infrastructure.	- The project would avoid long term impacts (during operation) on the availability and quality of public open space and community facilities - The project, during operation, would help to improve access to local facilities, services and destinations, supporting opportunities for community interaction.
Biodiversity	
Biodiversity The project design considers all feasible measures to avoid and minimise impacts on terrestrial and aquatic biodiversity. Offsets and/or supplementary measures are assured which are equivalent to any remaining impacts of project construction and operation.	- The biodiversity outcome would be consistent with the Framework for Biodiversity Assessment - The project would minimise impacts to biodiversity.

Relevant Secretary's environmental assessment requirements desired performance outcomes	Environmental performance outcome
Flooding and hydrology	

Flooding
The project minimises adverse impacts on existing flooding characteristics. Construction and operation of the project avoids or minimises the risk of, and adverse impacts from, infrastructure flooding, flooding hazards, or dam failure.
Water – hydrology
Long term impacts on surface water and groundwater hydrology (including drawdown, flow rates and volumes) are minimised. The environmental values of nearby, connected and affected water sources, groundwater and dependent ecological systems including estuarine and marine water (if applicable) are maintained (where values are achieved) or improved and maintained (where values are not achieved).
Sustainable use of water resources.
	• Changes to overland flow diversions during construction would meet the following criteria:
	  ♦ Increases in flood levels during events up to and including the 100-year average recurrence interval would be minimised particularly within private properties
	  ♦ Any increase in flow velocity for events up to and including a 100-year average recurrence interval event would not increase the potential for soil erosion and scouring
	  ♦ Dedicated evacuation routes would not be adversely impacted in flood events up to and including the probable maximum flood
	• There would be no additional private properties affected by flooding up to and including the 100-year average recurrence interval event during operation
	• Flood levels would be increased by a maximum of 470 mm during the 100-year average recurrence interval event in the vicinity of the Marrickville dive structure during operation
	• The performance of the downstream drainage network would be maintained during operation.

Air quality	
There are no Secretary's environmental assessment requirements relevant to air quality.	• Dust and exhaust emissions during construction would be minimised.
Hazard and risk	
There are no Secretary's environmental assessment requirements relevant to hazard and risk.	• The storage, use and transport of dangerous goods and hazardous substances would comply with *Hazardous and Offensive Development Application Guidelines: Applying SEPP 33* (Department of Planning, 2011) • There would be no unplanned or unexpected disturbance of utilities.
Waste Management	
Waste All wastes generated during the construction and operation of the project are effectively stored, handled, treated, reused, recycled and/or disposed of lawfully and in a manner that protects environmental values.	• All waste would be assessed, classified, managed and disposed of in accordance with the NSW Waste Classification Guidelines • 100 per cent of spoil that can be reused would be beneficially reused in accordance with the project spoil reuse hierarchy • A recycling target of at least 90 per cent would be adopted for the construction of the project.

Relevant Secretary's environmental assessment requirements desired performance outcomes	Environmental performance outcome
Sustainability	
Sustainability The project reduces the NSW Government's operating costs and ensures the effective and efficient use of resources. Conservation of natural resources is maximised.	• The project would be carried out in accordance with the Sydney Metro City & Southwest Environment and Sustainability Policy • 25 per cent of the greenhouse gas emissions associated with consumption of electricity during construction would be offset • 100 per cent of the greenhouse gas emissions associated with consumption of electricity during operation would be offset.

ENVIRONMENTAL RISK ANALYSIS

CHAPTER TWENTY-EIGHT

28 Environmental risk analysis

This chapter provides an environmental risk analysis for the project.

28.1 Secretary's environmental assessment requirements

The Secretary's environmental assessment requirements relating to environmental risk analysis, and where these requirements are addressed in this Environmental Impact Statement, are outlined in Table 28-1.

Table 28-1 Secretary's environmental assessment requirements – environmental risk analysis

Ref.	Secretary's environmental assessment requirements	Where addressed
3. Assessment of Key Issues		
3.2(c)	Identify, describe and quantify (if possible) the impacts associated with the issue, including the likelihood and consequence (including worst case scenario) of the impact (comprehensive risk assessment), and the cumulative impacts.	A risk assessment is provided in Section 28.5.

28.2 Purpose of environmental risk analysis

The purpose of this environmental risk analysis is to:

- Identify the potential environmental and community risks and issues to be considered as part of this Environmental Impact Statement
- Identify any issues not included in the Secretary's environmental assessment requirements to enable appropriate assessment
- Consider environmental impacts based on additional detailed investigations and greater project definition
- Identify the residual environmental impacts after the implementation of the mitigation measures described in this Environmental Impact Statement. This provides early identification of high residual impacts to allow a focus on these areas during the refinement of the design and the development of construction methodologies.

This environmental risk analysis is intended to identify broad environmental risks associated with the project. Activity and site-specific risks are detailed within each individual chapter.

28.3 Key issues identified

Various environmental risk identification and analyses have been undertaken throughout the development of the project (refer to Chapter 4 (Project development and alternatives) for a summary of the planning history of the project). Of most relevance to this environmental risk analysis is the risk analysis carried out as part of the *Chatswood to Sydenham State Significant Infrastructure Application Report* (Transport for NSW, 2015b).

This document, along with the assessments carried out as part of this Environmental Impact Statement identified the environmental issues associated with the project as:

- Construction traffic and transport
- Operational traffic and transport
- Construction noise and vibration
- Operational noise and vibration
- Land use and property
- Business impacts
- Non-Aboriginal heritage
- Aboriginal heritage
- Landscape character and visual amenity
- Groundwater and geology
- Soils, Contamination and water quality
- Social impacts and community infrastructure
- Biodiversity
- Flooding and hydrology
- Air quality
- Hazard and risk
- Waste management
- Sustainability
- Cumulative impacts.

28.4 Environmental risk analysis methodology

The environmental risk analysis was undertaken in accordance with the principles of the Australian and New Zealand standard *AS / NZS ISO 31000:2009 Risk Management – Principles and Guidelines*. This involved:

- Ranking the risk of each identified potential impact by identifying the consequences of the impact and the likelihood of each impact occurring
- Considering the probable effectiveness of the proposed mitigation measures to determine the likely residual risk of each impact.

The first step in the risk analysis involved the identification of the consequence, should an impact occur. The definitions of the consequences used are provided in Table 28-2 and the definitions of likelihood are provided in Table 28-3. The risk rating was then determined by combining the consequence and likelihood to identify the level of risk as shown in the matrix in Table 28-4.

Table 28-2 Risk analysis consequence definitions

Consequence level	Definition
Catastrophic	• Long-term (greater than 12 months) and irreversible large-scale environmental, social or economic impacts • Extended substantial disruptions and impacts to stakeholder(s) or customers.
Severe	• Long-term (6 to 12 months) and potentially irreversible impacts • Extensive remediation required • Severe disruptions or long-term impacts to stakeholder(s) or customers.
Major	• Medium-term (between 3 and 6 months) and potentially irreversible impacts • Considerable remediation required • Major impacts or disruptions to stakeholder(s) or customers.
Moderate	• Medium-term (between 1 and 3 months), reversible and / or well-contained impacts • Minor remedial actions required • Moderate impacts or disruptions to stakeholder(s) or customers.
Minor	• Short-term (less than 1 month), reversible or minor impacts that are within environmental regulatory limits and within site boundaries • Minor or short-term impacts to stakeholder(s) or customers.
Insignificant	• No appreciable or noticeable changes to the environment • Negligible impact to environment, stakeholder(s) or customers.

Table 28-3 Risk analysis likelihood definitions

Likelihood	Definition	Probability
Almost certain	Expected to occur frequently during time of activity or project (10 or more times per year)	>90%
Likely	Expected to occur occasionally during time of activity or project (1 to 10 times per year)	75% to 90%
Possible	More likely to occur than not occur during time of activity or project (once per year)	50% to 75%
Unlikely	More likely not to occur than occur during time of activity or project (once every 1 to 10 years)	25% to 50%
Rare	Not expected to occur during the time of activity or project (once every 10 to 100 years)	10% to 25%
Almost unprecedented	Not expected to ever occur during time of activity or project (less than once every 100 years)	<10%

Table 28-4 Risk matrix

Likelihood	Consequence					
	Insignificant	Minor	Moderate	Major	Severe	Catastrophic
Almost unprecedented	Low	Low	Low	Low	Medium	Medium
Rare	Low	Low	Low	Medium	Medium	High
Unlikely	Low	Low	Medium	Medium	High	High
Possible	Low	Medium	Medium	High	High	Very high
Likely	Medium	Medium	High	High	Very high	Very high
Almost certain	Medium	High	High	Very high	Very high	Very high

28.5 Environmental risk analysis

Using the framework described above, an environmental risk analysis for the project is presented in Table 28-5. The risk analysis identifies an initial risk rating for each of the environmental issues and provides a description of how the risk ratings were derived. The risk analysis also identifies the residual risk rating is arrived at after the application of mitigation measures developed and recommended by this Environmental Impact Statement.

Table 28-5 Environmental risk analysis

Potential impact	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk rating	Proposed mitigation	Residual consequence	Residual likelihood	Residual risk rating
Construction traffic and transport							
Pedestrians and cyclists							
• Diversions of pedestrian and cyclist facilities • Reduced pedestrian and cyclist access or flows due to construction • Pedestrian and cyclist safety	Major	Likely	High	Refer to mitigation in Chapter 8 (Construction traffic and transport)	Minor	Likely	Medium
Public transport							
• Relocation of bus stops • Impacts on reliability of public transport services (Sydney Trains and buses) • Increased travel times for customers during rail possessions	Moderate	Likely	High	Refer to mitigation in Chapter 8 (Construction traffic and transport)	Minor	Likely	Medium
Road network							
• Deterioration of traffic performance on surrounding road network due to construction vehicles • Deterioration of traffic performance due to road or lane closures • Loss of parking spaces or loading zones • Impacts on access to private property • Traffic safety and impacts on marine traffic	Major	Likely	High	Refer to mitigation in Chapter 8 (Construction traffic and transport)	Moderate	Likely	High

Potential impact	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk rating	Proposed mitigation	Residual consequence	Residual likelihood	Residual risk rating
Operational traffic and transport							
Pedestrians and cyclists							
• Additional pedestrian load on existing infrastructure resulting in less efficient pedestrian movements at Victoria Cross and Martin Place • Provision of facilities to provide for cyclist interchange at or around stations	Major	Likely	High	Refer to mitigation in Chapter 9 (Operational traffic and transport)	Moderate	Likely	High
Public transport							
• Improved public transport system capacity and efficiency • Provision of facilities to provide for public transport interchange at or around stations	Positive						
Motorists							
• Deterioration in intersection performance at Pacific Highway / Mowbray Road • No material change in intersection performance at all other locations • Provision of kiss-and-ride facilities to provide for motor vehicle interchange at or around stations • Wider road network benefits including reduced road congestion	Minor	Likely	Medium	None beyond project design	Minor	Likely	Medium

Potential impact	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk rating	Proposed mitigation	Residual consequence	Residual likelihood	Residual risk rating
Construction noise and vibration							
Ground-borne noise							
• Ground-borne noise from tunneling exceed the criteria	Moderate	Likely	High	Refer to mitigation in Chapter 10 (Construction noise and vibration)	Minor	Likely	Medium
Air borne noise							
• Unacceptable airborne noise impacts from surface construction sites during standard construction hours • Unacceptable airborne noise impacts from surface construction sites outside standard construction hours • Construction traffic results in an increase in traffic noise greater than 2 dB	Major	Likely	High	Refer to mitigation in Chapter 10 (Construction noise and vibration)	Moderate	Likely	High
Vibration							
• Vibration from tunneling works exceed human comfort or damage levels • Vibration from surface works exceed human comfort or damage levels	Major	Likely	High	Refer to mitigation in Chapter 10 (Construction noise and vibration)	Minor	Likely	Medium

Potential impact	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk rating	Proposed mitigation	Residual consequence	Residual likelihood	Residual risk rating
Operational noise and vibration							
Ground-borne noise							
• Unacceptable ground-borne noise impacts	Major	Possible	High	Refer to mitigation in Chapter 11 (Operational noise and vibration)	Minor	Unlikely	Low
Air borne noise							
• Unacceptable airborne noise impacts due to the number of trains and proximity to receivers • Unacceptable airborne noise impacts at stations or other at-surface ancillary infrastructure from fresh air ventilation, mechanical and electrical equipment, substations, public address systems, etc	Major	Possible	High	Refer to mitigation in Chapter 11 (Operational noise and vibration)	Major	Unlikely	Low
Vibration							
• Unacceptable vibration impacts resulting in exceedance of human comfort levels • Unacceptable vibration impacts resulting in exceedance of building or structure damage levels	Major	Possible	High	Refer to mitigation in Chapter 11 (Operational noise and vibration)	Minor	Unlikely	Low

Potential impact	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk rating	Proposed mitigation	Residual consequence	Residual likelihood	Residual risk rating
Property and land use							
Onsite (direct)							
• Residual land use and ability for appropriate reuse or development • Property acquisition • Direct impacts on other infrastructure during construction including utilities and Sydney Trains property	Major	Likely	High	Refer to mitigation in Chapter 12 (Land use and property)	Minor	Likely	Medium
Surrounding (indirect)							
• Potential restrictions on future development within defined corridor due to subsurface tunnels	Major	Likely	High	Refer to mitigation in Chapter 12 (Land use and property)	Minor	Likely	Medium
Surrounding (indirect)							
• Uplift potential • Potential change in land use and zoning provisions surrounding new station sites	Positive. The project would likely be a catalyst for uplift which is consistent with the strategic planning documents such as *A Plan for Growing Sydney*.						

Potential impact	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk rating	Proposed mitigation	Residual consequence	Residual likelihood	Residual risk rating
Business impacts							
Businesses directly impacted (removed)							
• Permanent loss of business due to acquisition	Major	Likely	High	Refer to mitigation in Chapter 13 (Business impacts)	Minor	Likely	Medium
Business amenity during construction							
Altered access and visibility to businesses (deliveries, patrons, employees) during construction Impacts on businesses during construction (due to loss of amenity)	Major	Likely	High	Refer to mitigation in Chapter 13 (Business impacts)	Moderate	Possible	Medium
Increased trade for food and beverage during construction	Positive						
Business amenity during operation							
• Altered access and visibility to businesses (deliveries, patrons, employees) during operation • Impacts on businesses during operation (due to changes in amenity)	Minor	Likely	Medium	Refer to mitigation in Chapter 13 (Business impacts)	Minor	Unlikely	Low
• Increased commercial rents during operation	Moderate	Unlikely	Medium	N/A	Moderate	Unlikely	Medium
Indirect outcomes for businesses during operation							
• Enhanced business connectivity during operation • Staff access, recruitment and retention during operation • Enhanced access for customers during operation • Development stimulus during operation	Positive						

Potential impact	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk rating	Proposed mitigation	Residual consequence	Residual likelihood	Residual risk rating
Non-Aboriginal heritage							
Direct impacts to non-Aboriginal heritage items							
• Direct impacts on world heritage and / or Commonwealth or National heritage items • Direct impacts on State, section 170 (of the Heritage Act, 1979) or locally listed heritage items • Change to the values of a heritage conservation area.	Major	Almost certain	Very high	Refer to mitigation in Chapter 14 (Non-Aboriginal heritage)	Moderate	Likely	High
Potential direct impacts to non-Aboriginal heritage items							
• Change to the values of a heritage conservation area during operation • Damage to heritage items from vibration during construction or operation	Major	Almost certain	Very high	Refer to mitigation in Chapter 14 (Non-Aboriginal heritage)	Moderate	Possible	Medium
Indirect impacts to non-Aboriginal heritage items							
• Unsympathetic design that detracts from the heritage significance of a nearby item • Project elements that impact the landscape character or heritage context of heritage items	Moderate	Likely	High	Refer to mitigation in Chapter 14 (Non-Aboriginal heritage)	Minor	Possible	Medium
Potential impacts to archaeology							
• Impacts on unknown heritage items (eg archaeological items) during construction.	Major	Possible	High	Refer to mitigation in Chapter 14 (Non-Aboriginal heritage)	Moderate	Unlikely	Medium

Potential impact	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk rating	Proposed mitigation	Residual consequence	Residual likelihood	Residual risk rating
Aboriginal heritage							
• Impacts on known Aboriginal heritage items	Major	Almost unprecedented	Low	Refer to mitigation in Chapter 15 (Aboriginal heritage)	Moderate	Rare	Low
• Impacts on areas of known Aboriginal cultural sensitivity	Major	Possible	High	Refer to mitigation in Chapter 15 (Aboriginal heritage)	Major	Rare	Medium
• Impacts on unidentified Aboriginal heritage items	Major	Possible	High	Refer to mitigation in Chapter 15 (Aboriginal heritage)	Major	Rare	Medium
Landscape character and visual amenity							
Construction							
• Adverse visual impacts due to the presence of construction activities and compounds • Adverse impacts on landscape character during construction • Light spill from out-of-hours works during construction	Moderate	Likely	High	Refer to mitigation in Chapter 16 (Landscape character and visual amenity)	Moderate	Possible	Medium
Operation							
• Adverse visual impacts associated with the introduction of new stations • Adverse visual impacts associated with the introduction of other surface infrastructure (tunnel portals, fresh air tunnel ventilation facilities, etc) • Adverse impacts on landscape character during operation • Light spill from stations at night	Minor	Likely	Medium	Refer to mitigation in Chapter 16 (Landscape character and visual amenity)	Minor	Possible	Medium

Potential impact	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk rating	Proposed mitigation	Residual consequence	Residual likelihood	Residual risk rating
Groundwater and geology							
Groundwater levels							
• Impacts on groundwater flows and levels during tunnel construction and station excavation • Ongoing operational changes to ground-water flows and levels from underground stations and other drained structures	Minor	Likely	Medium	Refer to mitigation in Chapter 17 (Groundwater and geology)	Minor	Unlikely	Low
Settlement							
• Ground movement / settlement due to tunnelling and other excavations	Moderate	Likely	High	Refer to mitigation in Chapter 17 (Groundwater and geology)	Insignificant	Likely	Medium
Soils, Contamination and water quality							
Soils							
• Erosion of soils resulting in offsite sedimentation during construction • Exposure of acid sulfate soils during construction • Exposure of soil salinity / saline soils during construction	Major	Likely	High	Refer to mitigation in Chapter 18 (Soils, contamination and water quality)	Moderate	Possible	Medium
Contamination							
• Contamination of groundwater due to spills and leaks during construction and operation • Contamination of land due to spills and leaks during construction and operation • Disturbance of contaminated land during construction	Major	Likely	High	Refer to mitigation in Chapter 18 (Soils, contamination and water quality)	Moderate	Possible	Medium

Potential impact	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk rating	Proposed mitigation	Residual consequence	Residual likelihood	Residual risk rating
Water quality							
• Water quality impacts due to spills and erosion from the project site during operation • Water quality impacts due to discharge of captured groundwater during construction and operation • Water quality impacts on nearby watercourses due to runoff from the project site resulting in sedimentation to waterways during construction • Water quality impacts on nearby watercourses due to Contamination / spills from the project site during construction • Water quality impacts associated with the Sydney Harbour ground improvement works	Major	Likely	High	Refer to mitigation in Chapter 18 (Soils, contamination and water quality)	Moderate	Possible	Medium

Potential impact	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk rating	Proposed mitigation	Residual consequence	Residual likelihood	Residual risk rating
Social impacts and community infrastructure							
Social infrastructure							
• Loss of community facilities / open space for construction purposes • Impacts on community facilities due to changes to access during construction	Moderate	Likely	High	Refer to mitigation in Chapter 19 (Social impacts and community infrastructure)	Moderate	Likely	High
Broader social impacts							
• Improved public transport to regional community infrastructure during operation	Positive						
• Impacts on access to areas / community facilities of regional significance during construction	Moderate	Likely	High	Refer to mitigation in Chapter 19 (Social impacts and community infrastructure)	Moderate	Possible	Medium
Health							
• Electromagnetic fields from operational substations • Potential impacts associated with long term construction noise	Moderate	Likely	High	Refer to mitigation in Chapter 19 (Social impacts and community infrastructure)	Minor	Likely	Medium
• Health benefits associated with public transport	Positive						

Potential impact	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk rating	Proposed mitigation	Residual consequence	Residual likelihood	Residual risk rating
Biodiversity							
Flora							
• Impacts on threatened ecological communities within the construction footprint • Impacts on threatened ecological communities outside of the construction footprint • Impact on native vegetation (non-threatened ecological communities) outside of the construction footprint • Significant impacts on threatened flora species • Impacts on previously unidentified threatened flora species	Moderate	Rare	Low	Refer to mitigation in Chapter 20 (Biodiversity)	Minor	Rare	Low
Fauna							
• Impacts on groundwater dependent ecosystems • Significant impacts on threatened fauna species and endangered populations • Impacts to aquatic ecology associated with Sydney Harbour crossing works	Moderate	Rare	Low	Refer to mitigation in Chapter 20 (Biodiversity)	Minor	Rare	Low
Hydrology and flooding							
Impacts of flooding on the project							
• Flooding of the tunnels during construction and operation • Impacts on construction activities due to flooding	Moderate	Possible	Medium	Primarily incorporated into project design. Also refer to mitigation in Chapter 21 (Flooding and hydrology)	Moderate	Rare	Low
Impacts on flooding due to the project							

Potential impact	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk rating	Proposed mitigation	Residual consequence	Residual likelihood	Residual risk rating
Impacts on flood-prone areas (eg increase flooding outside the project site) during construction and operation	Moderate	Likely	High	Primarily incorporated into project design. Also refer to mitigation in Chapter 21 (Flooding and hydrology)	Minor	Possible	Medium
Air quality							
Construction							
Impacts on local air quality due to construction plant and equipment and increase in vehicle movements Impacts on local air quality due to dust generation from exposed surfaces, spoil stockpiles or spoil haulage	Minor	Likely	Medium	Refer to mitigation in Chapter 22 (Air quality)	Minor	Unlikely	Low
Operation							
Impacts on local air quality during operation	Minor	Possible	Medium	Refer to mitigation in Chapter 22 (Air quality)	Minor	Rare	Low
Hazard and risk							
Construction							
Transport and storage of hazardous substances and dangerous goods during construction Potential for tunnel collapse during construction	Major	Unlikely	Medium	Refer to mitigation in Chapter 23 (Hazard and risk)	Major	Almost unprecedented	Low
Operation							
Transport and storage of hazardous substances and dangerous goods during operation	Major	Rare	Medium	Refer to mitigation in Chapter 23 (Hazard and risk)	Moderate	Rare	Low

Potential impact	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk rating	Proposed mitigation	Residual consequence	Residual likelihood	Residual risk rating
Waste management							
Construction							
• Impacts associated with the management of waste during construction • Impacts associated with the management and disposal of excess spoil from tunnel construction	Moderate	Likely	High	Refer to mitigation in Chapter 24 (Waste management)	Moderate	Unlikely	Medium
Operation							
• Impacts associated with the management of waste during operation	Minor	Likely	Medium	Refer to mitigation in Chapter 24 (Waste management)	Minor	Unlikely	Low
Sustainability							
Greenhouse gas							
• Emissions of greenhouse gases from operational energy use and embodied energy in materials • Emissions of greenhouse gases from construction activities including energy use for tunnel boring machines	Minor	Possible	Medium	Refer to mitigation in Chapter 25 (Sustainability)	Insignificant	Possible	Low
Climate change adaptation							
• Impact of climate change on rail operations and infrastructure • Impact of climate change on customer and staff comfort	Major	Unlikely	Medium	Refer to mitigation in Chapter 25 (Sustainability)	Moderate	Unlikely	Medium

Potential impact	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk rating	Proposed mitigation	Residual consequence	Residual likelihood	Residual risk rating
Resource use							
• Increased electricity use during operation • Increased demand on electricity and water supply during construction • Increased demand on local and regional resources including sand and aggregate during construction • Increased diesel use during construction	Minor	Possible	Medium	Refer to mitigation in Chapter 25 (Sustainability)	Insignificant	Possible	Low
Cumulative impacts							
• Construction noise and traffic associated with CBD and South East Light Rail • Construction noise and traffic associated with WestConnex • Spoil management and disposal from multiple tunnelling projects in Sydney (ie WestConnex and NorthConnex) • Other stages of Sydney Metro such as Sydney Metro Northwest and Sydenham to Bankstown upgrade • Construction noise and traffic associated with other developments in proximity to the construction sites	Major	Likely	High	Refer to mitigation in Chapter 26 (Cumulative impacts)	Moderate	Likely	High

28.6 Conclusion and next steps

The environmental risk analysis has identified that the following issues would have a high residual risk after the incorporation of the mitigation measures proposed in this Environmental Impact Statement:

- Construction traffic and transport, specifically potential impacts to the road network
- Operational traffic and transport, specifically pedestrian movement impacts
- Construction noise and vibration, specifically potential airborne noise impacts
- Non-Aboriginal heritage, specifically direct impacts to heritage items
- Social impacts and community infrastructure, specifically the loss of open space during construction
- Cumulative impacts, especially construction noise and traffic within the Sydney CBD.

This suggests that an increased focus would be required on these aspects throughout the construction of the project to meet an acceptable risk level.

Other issues that would have a moderate residual risk include:

- Land use and property and land use
- Business impacts
- Aboriginal heritage
- Landscape character and visual amenity
- Groundwater and geology
- Soils, Contamination and water quality
- Flooding and hydrology
- Hazard and risk
- Waste management
- Sustainability.

The level of assessment carried out for these issues has determined the likely extent of impacts and recommended appropriate mitigation required to ensure that the risk would be abated.

Operational noise and vibration, biodiversity and air quality have a low residual risk. It is expected that these issues can be adequately managed through detailed design and construction, and by the implementation of standard management measures aimed at ensuring that all necessary environmental criteria and guidelines would be achieved.

JUSTIFICATION AND CONCLUSIONS

CHAPTER TWENTY-NINE

29 Justification and conclusions

This chapter outlines the justification and conclusions for the project. Justification is based on the strategic need for the project and, in particular, how it would fulfil the project objectives. The project justification also takes into account the alternatives to the project, public interest, project benefits and the principles of ecologically sustainable development. The conclusion is based on an overall consideration of the assessment including the key benefi^pts and adverse impacts.

29.1 Secretary's environmental assessment requirements

The Secretary's environmental assessment requirements identify a general reference to Schedule 3 of the *Environmental Planning & Assessment Regulation 2000*. Clause 7(1)(f) of Schedule 3, requires an Environmental Impact Statement to include *the reasons justifying the carrying out of the development, activity or infrastructure in the manner proposed, having regard to biophysical, economic and social considerations, including the principles of ecologically sustainable development.*

29.2 Need for the project

The strategic need for the project is discussed in detail in Chapter 3 (Strategic need and justification).

At a broader network level, Sydney Metro (of which the project would be a key component) is considered essential to maintain Sydney as Australia's economic capital by:

- Enabling the growth and development of the Global Economic Corridor as Sydney's prime employment district through the provision of a high quality transit system
- Providing transport infrastructure to connect housing increases to key employment areas in order to maintain liveability and provide support for continued growth
- Improving reliability across the rail network by addressing current and emerging constraints such as train crowding, platform and station crowding, and network complexity.

Rail is, and will continue to be, the dominant mode of public transportation for commuters traveling to and from the Sydney CBD. It is forecast that travel by rail will experience the highest growth in demand when compared to buses and car use. Sydney Metro, together with signalling and infrastructure upgrades across the existing network, would increase the capacity of the rail network from about 120 per hour during peak periods today, to up to 200 services per hour beyond 2024, including capacity for up to 60 metro trains per hour during peak periods (or 30 trains per hour in each direction). This would equate to an increase of up to 60 per cent capacity across the network. Sydney Metro would also result in travel time improvements and a reduction in congestion on trains and platforms.

Alternative transport modes would have limited capacity to absorb Sydney's forecast long-term travel demand growth. For example while extra buses can carry more people, these services would not be necessarily faster or more reliable. Without measures to improve journey times, adding more buses would add to congestion and each bus becomes less effective in meeting customer needs.

The full realisation of the benefits is dependent on the delivery of all stages of Sydney Metro, however this project would be fundamental to achieving the benefits of additional rail capacity across Sydney Harbour and additional Sydney CBD station rail infrastructure. In particular it would provide two additional tracks from Chatswood to the Sydney CBD which would more than double the number of train paths available from the north.

The project would be integral for increased economic clustering around the Sydney CBD (including Barangaroo) and the Global Economic Corridor by:

- Providing the opportunity for development and increasing the rail catchment areas to service the strategic locations of Crows Nest, Victoria Cross, Barangaroo and Waterloo
- Relieving congestion and increase service accessibility and rail capacity across the Sydney CBD, particularly at Wynyard and Town Hall stations, through the provision of new stations at Barangaroo, Martin Place and Pitt Street, and through the provision of extra connectivity and interchange capacity at Central Station and Martin Place
- Reducing pressure on the road and bus networks through the provision of a high quality metro system, particularly for the Sydney CBD and connections across Sydney Harbour
- Improving network resilience through the Sydney CBD and across Sydney Harbour by providing an additional route during planned and unplanned events affecting other Sydney CBD and harbour links.

29.3 Achieving the project objectives

Table 29-1 provides an assessment of the project against the project objectives, as detailed in Chapter 3 (Strategic need and justification).

Table 29-1 Assessment against project objectives

Project objectives	Assessment
Improve the quality of the transport experience for customers	• New Sydney CBD stations and platforms provided at Barangaroo, Martin Place, Pitt Street and Central would spread station loading and decrease crowding at Wynyard and Town Hall stations • The project is being developed with an emphasis on supporting the needs of customers for 'door-to-door' journeys from origin to destination. It would deliver a new tier for Sydney's rail network, supporting high demand with a high-capacity, turn-up-and-go service. 'Turn up and go' frequencies means there is no need for a timetable • Customer service assistants at every station and moving through the network during the day and night • Australian-first platform screen doors which keep people and objects away from the edge, improving customer safety and allowing trains to get in and out of stations much faster. These doors run the full length of all metro platforms and only open at the same time as the train doors • Operational performance requirements that include 98 per cent on time running and clean platforms and trains • Wheelchair spaces, separate priority seating and emergency intercoms inside trains • Safety benefits including security cameras on trains and the ability for customers to see inside the train from one end to the other • Video help points at platforms, connecting directly with train controllers – an Australian first • Level access between the platform and train and three double doors per side per carriage for faster loading and unloading • On-board real time travel information and live electronic route maps.
Provide a transport system that is able to satisfy long-term demand	• Provides the largest increase in capacity to the Sydney rail network for 80 years • Travel by rail will experience the highest growth in demand when compared to buses and car use. Total capacity across the rail network would be increased by about 60 per cent as a result of Sydney Metro City & Southwest • The metro rail network would be capable of carrying more people, more quickly, than any other form of public transport ever seen in Sydney • At ultimate capacity, the Sydney Metro network would be able to run up to 30 trains per hour in each direction through Sydney's CBD, providing the foundation for a 60 per cent increase in the number of trains that could operate in the peak periods and catering for an extra 100,000 customers per hour. At ultimate capacity, the Chatswood to Sydenham component would provide additional capacity for more than 40,000 passengers per hour through the Sydney CBD in each direction • Sydney Metro would improve reliability across the rail network by addressing current and emerging constraints such as train crowding, platform and station crowding, and network complexity • Alternative transport modes would have limited capacity to absorb Sydney's forecast long-term travel demand growth.
Grow public transport patronage and mode share	• The railway network across greater Sydney would have room for an extra 100,000 train customers per hour in the am peak in 2036.

Project objectives	Assessment
Support the productivity of the Global Economic Corridor	• Provides faster and more reliable access and by fostering clusters of activities that support more economic growth. In particular this would include improvement to links to the strategic centres of Chatswood, Macquarie Park, Castle Hill, Norwest and Rouse Hill • Facilitates higher productivity by enabling businesses to become effectively closer together through reduced travel times between major economic centres, and between economic centres and potential employees • Delivers wider economic benefits by facilitating land development and business logistics improvements, particularly for knowledge based businesses.
Serve and stimulate urban development	• Provides opportunities for a higher intensity of land use around new and converted stations, including potential higher density residential areas which could offer more affordable housing options with better access to services and employment, and support more liveable, vibrant communities • More specifically provides the opportunity for urban development at Crows Nest, Victoria Cross, Barangaroo and Waterloo.
Improve the resilience of the transport network	• Provides an additional public transport link across Sydney Harbour • Provides an additional route during planned and unplanned events affecting other Sydney CBD and harbour links.
Improve the efficiency and cost effectiveness of the public transport system	• Relieves congestion at major city rail stations – particularly at Wynyard and Town Hall • Increases service accessibility and rail capacity across the Sydney CBD, particularly at Wynyard and Town Hall stations, through the provision of new stations at Barangaroo, Martin Place and Pitt Street • Provides extra connectivity and interchange capacity at Central Station and Martin Place • Freeing of bus services by bus customers transferring to rail, enabling the opportunity to redeploy bus services from the north and north west • Less demand for Sydney Harbour Bridge bus services, freeing capacity over the Harbour Bridge • Reduced road congestion by road users transferring to rail • Less congestion on key road corridors including Sydney Harbour Bridge, Sydney Harbour Tunnel and Eastern Distributor.
Implement a feasible solution recognising impacts, constraints and delivery risk	• The project has been developed in consideration of feasible alternatives including regulatory, governance and better-use reforms, mode, corridor, alignment and station options. Details are provided in Chapter 4 (Project development and alternatives) • Impacts have been reduced through a comprehensive assessment process including close iteration and interactions between the design and environment specialists. Previous, current and ongoing stakeholder and community consultation would also help to improve project outcomes and reduce impacts • Ongoing and detailed design of the project would further reduce impacts, constraints and delivery risks.

29.4 Objects of the Environmental Planning and Assessment Act 1979

The objects of the *Environmental Planning and Assessment Act 1979* (EP&A Act) provide a policy framework within which the justification of the project can be considered. Table 29-2 outlines those objects and provides comment on their relevance to the project.

Table 29-2 Relevance of the EP&A Act 1979 objects to the project

Environmental Planning and Assessment Act 1979 Objects	Comments
Encourage the proper management, development and conservation of natural and artificial resources, including agricultural land, natural areas, forests, minerals, water, cities, towns and villages for the purpose of promoting the social and economic welfare of the community and a better environment	This Environmental Impact Statement identifies impacts and with a focus on managing impacts, proposes mitigation and management measures. The project has been developed with a focus on sustainable development and is supported by a project specific Environmental and Sustainability Policy and Sustainability Strategy.
Encourage the promotion and coordination of the orderly and economic use and development of land	The project has been designed to minimise impacts to the surrounding natural and built environments, and to minimise disruption to existing development patterns. Provision of a mostly underground metro system is an orderly and economic approach to delivery of the project in the context of existing development along the project alignment.
Encourage the protection, provision and coordination of communication and utility services	The project has been designed to minimise impacts on communications and utility services.
Encourage the provision of land for public purposes	The project would create or improve a number of areas of public land, including station complexes. New pedestrian links would be created as part of the overall project and there is potential to incorporate community facilities within the station precincts.
Encourage the provision and coordination of community services and facilities	The project has been designed and located to avoid direct impacts to community facilities. The predicted improvements in travel times as a result of the project would improve the local access to community services and community facilities.
Encourage the protection of the environment, including the protection and conservation of native animals and plants, including threatened species, populations and ecological communities, and their habitats	The project impacts on terrestrial and aquatic ecology have been assessed in detail and measures to avoid, mitigate and offset potential impacts on native animals and plants have been developed.
Encourage ESD	Sustainability has been a key driver for the project. A Sustainability Strategy has been developed as well as an Environment and Sustainability Policy (refer to Chapter 25 (Sustainability)). Section 29.5 below provides details of how the project addresses the principles of ESD.
Encourage the provision and maintenance of affordable housing	The project provides public transport accessibility to future growth areas and an affordable transport option for future residents. In particular the proposed station at Waterloo would provide significant benefit to proposed affordable housing development.

Environmental Planning and Assessment Act 1979 Objects	Comments
Promote the sharing of the responsibility for environmental planning between the different levels of government in the state	The responsibility for environmental planning and approval in relation to the project rests primarily with the NSW Government. Consultation has, however, occurred across all levels of government including councils for the four local government authorities through which the project passes – Willoughby Council, North Sydney Council, City of Sydney Council and Marrickville Council.
Provide increased opportunity for public involvement and participation in environmental planning and assessment	The project development process has involved extensive consultation with the community and stakeholders. An objective of the project is to deliver a transport service that has been informed by engagement with communities and stakeholders.

29.5 Principles of ecologically sustainable development

Sustainability has been a key driver for the project. A Sustainability Strategy has been developed as well as an Environment and Sustainability Policy (refer to Chapter 25 (Sustainability)). This section provides details of how the project has and would address the principles of ecologically sustainable development.

Ecologically sustainable development is development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends. The principles of ecologically sustainable development have been an integral consideration throughout the development of the project and a series of sustainability targets have been developed for the project. *The Environmental Planning and Assessment Act 1979* recognises that ecologically sustainable development requires the effective integration of economic and environmental considerations into decision making processes.

There are four main principles supporting the achievement of ecologically sustainable development:

- Precautionary principle
- Intergenerational equity
- Conservation of biological diversity and ecological integrity
- Improved valuation and pricing of environmental resources.

These are discussed in the following sections.

29.5.1 Precautionary principle

The precautionary principle: If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, public and private decisions should be guided by:

- Careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment
- An assessment of the risk-weighted consequence of various options.

Application to the project

The environmental risk analysis documented in Chapter 28 (Environmental risk analysis) addresses the potential impacts of the project. That analysis, together with the detail assessment carried out in preparing this Environmental Impact Statement indicates that there would be no threat of serious or irreversible damage to the environment.

In addition the lack of full scientific certainty has not been used as a reason for postponing measures to prevent environmental degradation. As detailed in each impact assessment chapter, mitigation measures have been proposed to manage identified risks / threats of environmental damage. For example targeted threatened species which were not found during the field surveys have, in line with the precautionary principle, been assumed to be present in the study area.

This Environmental Impact Statement documents the careful evaluation of environmental impacts associated with the project and has been carried out using the best available technical information and adoption of best practice environmental standards, goals and measures to minimise environmental risks. The impact assessments have been carried out in collaboration with key stakeholders and relevant statutory and agency requirements.

29.5.2 Intergenerational equity

Inter-generational equity: The present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations.

Application to the project

The objectives of the project are essentially around ensuring an efficient and reliable public transport network. This would benefit current and future generations. Once operational, the project would leave a positive legacy for future generations. It would provide long term benefits by strengthening connections and access across Sydney, providing improved connectivity on the rail network and improving the capacity, reliability and efficiency of the existing transport system. The project would address emerging issues with respect to capacity and congestion which otherwise would be more difficult to address at a future stage. The project would improve the quality of the transport experience for customers.

In addition to the broader Sydney transport operational benefits, the 'door-to-door' experience provided by Sydney Metro would also result in long-term health benefits with the creation of safer and more appealing conditions for pedestrians, cyclists and other transit users. These benefits would also flow through to future generations.

The project would result in a greater demand on electricity. Significant changes to carbon and energy policy (and legislation) are currently occurring in Australia which aim to shift electricity generation from coal fired to renewable sources. As more electricity is generated from renewable sources, the climate change benefits of using electric rail would be improved. A range of measures to mitigate greenhouse gas emissions have been developed and would be implemented (refer to Chapter 25 (Sustainability) for further details).

29.5.3 Conservation of biological diversity and ecological integrity

Conservation of biological diversity and ecological integrity: Conservation of biological diversity and ecological integrity should be a fundamental consideration.

Application to the project

Conservation of biological diversity and ecological integrity has been considered throughout the project planning and design stages (refer Chapter 25 (Sustainability)). The project construction footprint has been developed to avoid or minimise impact to areas of high ecological value. Detailed assessments have been carried out to identify flora and fauna impacts and a range of mitigation measures identified for implementation. Impacts on biological diversity and ecological integrity have been assessed as minor.

29.5.4 Improved valuation and pricing of environmental resources

Improved valuation and pricing of environmental resources: Environmental factors should be included in the valuation of assets and services. Such as:

- Polluter pays (ie those who generate pollution and waste should bear the cost of containment, avoidance, or abatement)
- The users of goods and services should pay prices based on the full life cycle of costs of providing the goods
- Environmental goals, having been established, should be pursued in the most cost effective ways.

Application to the project

Economic appraisal of the project draws on a number of established methodologies which provide for the valuation of externalities, including environmental externalities, and their inclusion in the appraisal process. Environmental parameters which can be valued include air pollution, greenhouse gas emissions, noise pollution, water run-off, nature and landscape and urban separation. Valuations typically adopt broad average values.

The value placed on the environment was inherent in the development of the project design (refer Chapter 25 (Sustainability)). In addition the costs associated with the planning and design of measures to avoid / minimise adverse environmental impacts and the costs to implement them have been built into the overall project costs. Ongoing and detailed design of the project together with specific issue-based management plans would represent further commitment to the recognition of the value of protecting environmental resources.

29.6 Alternatives and consequences of not proceeding with the project (do nothing)

A detailed discussion on alternatives and consequences of not proceeding with the project are provided in Chapter 4 (Project development and alternatives).

29.6.1 Alternatives

A comprehensive assessment of alternatives has been carried out for the project. This has included consideration of:

- Regulatory, governance and better-use reforms
- Investment in road, bus and light rail
- Rail network options
- Station location options
- Tunnel alignment options
- Specific project options such as the method for crossing of Sydney Harbour, dive structures and tunnel portal options.

The project would best meet the objectives when compared to all other alternatives considered.

29.6.2 Consequences of not proceeding (do nothing)

The key consequences of not proceeding with the project would include:

Loss of potential economic benefits

- Lost economic benefits: $2.0 billion per year on average over 30 years
- Lost economic value-add in the corridor by 2036: including $5.2 billion in the Sydney CBD
- Jobs lost: 44,000 in the Global Economic Corridor by 2036 (3500 per year)
- Reduced population growth in key areas. By 2036: 1950 less people in the Sydney CBD
- Reduced competitiveness between Sydney and other Australian cities such as Melbourne and Brisbane.

Reduced transport efficiency

- Additional public transport travel time: 12.7 million passenger hours per year (weighted)
- Additional road users: 20,000 driver and passenger trips (2036 AM peak)
- Cost of road congestion: 5.9 million vehicle hours per year (weighted)
- Increased rail demand to the Sydney CBD impacting existing Central, Town Hall, Martin Place and Wynyard stations: 6733 per year (2026 AM peak)
- Increased train services required: six per year
- Increased train crowding: 3.3 million passenger hours (weighted) in 2026, increasing in severity each year thereafter
- Increased station crowding: 8.4 million hours by 2026 (weighted)
- Reduced reliability: 5.1 million hours per year by 2026 (weighted)
- Insufficient transport capacity will prevent Sydney from reaching its economic potential, leading to worse economic outcomes for the State and nation
- Sydney's transport network will not provide the minimum standard of service expected by rail customers and there will be major impacts on the operational efficiency, reliability and capacity of the suburban rail network in the medium to long term.

29.7 Conclusion

The NSW Government is committed to delivering a step-change in the capacity and customer experience of Sydney's rail network. The project would deliver a brand new tier for Sydney's rail network, supporting high demand with a high capacity – turn-up-and-go service.

Other key benefits of the project include:

- Doubling the number of train paths available from the north (from 20 train paths per direction per hour to 50 train paths per direction per hour)
- Strengthening connections and access across Sydney, particularly within the Global Economic Corridor
- Providing new connections to the rail network – including connections to the T4 Eastern Suburbs Line, and connecting the Sydney CBD with the Northwest
- Improving the capacity, reliability and efficiency of the existing transport system, by relieving the pressure on existing rail lines, Sydney CBD train stations, Sydney CBD, North Sydney and Sydney South bus routes, and the Sydney CBD road network
- Providing improved connectivity across the rail network, particularly direct connection between the Sydney CBD and the Northwest
- Providing the opportunity for urban development particularly around the new stations at Crows Nest, Victoria Cross, Barangaroo and Waterloo
- Improving network resilience through the Sydney CBD and across Sydney Harbour by providing an additional route during planned and unplanned events affecting other Sydney CBD and harbour links.

The project is considered to best meet the objectives when compared to all other alternatives considered. The consequences of not proceeding (do nothing) would result in unacceptable impacts.

This Environmental Impact Statement has been prepared in accordance with the provisions of Part 5.1 of the *Environmental Planning and Assessment Act 1979*. In particular it addresses the requirements of the Secretary of the Department of Planning and Environment. It also includes consideration of the issues raised by the community and stakeholders during the development of the project.

It is inevitable that a project of this scale and location in a heavily urbanised environment would have some adverse impacts, particularly during construction. These impacts need to be considered within the context of the overall objectives of the project and the significant transportation and other benefits it would provide over the medium to longer term and particularly for future generations.

Key environmental issues have been examined throughout the design development process. Consultation has been carried out with affected stakeholders during the assessment to ensure that key potential impacts have been identified at an early stage, and where possible, avoided or appropriate mitigation measures developed. This has resulted in a number of changes that have mitigated many of the potential significant impacts.

Despite these efforts a number of adverse impacts would remain. These impacts would be largely temporary and confined to the construction period. The main potential adverse construction stage impacts would include:

- Traffic and pedestrian impacts with respect to temporary road closures and diversions
- Noise and vibration related impacts
- Demolition of buildings and impacts on business operators
- Temporary use of public land for construction work
- Impacts on community infrastructure
- Visual impacts of construction activities, particularly on construction work sites
- Water quality, particularly during ground improvement work on Sydney Harbour.

These impacts would be mitigated through further consideration during the detailed design stage including the decision on appropriate construction methodologies, and the implementation of the environmental management practices. These residual impacts would be considered as acceptable in the context of the scale and environment of the project.

The cumulative impacts during construction have been a particularly important consideration given the potential overlap with a considerable number of large infrastructure projects in the Sydney CBD. These cumulative impacts would be managed and minimised through a comprehensive coordination and consultation process involving a range of State and local government agencies.

When operational the key residual adverse impacts would be:

- Impacts to pedestrian movement in the vicinity of some metro stations
- Increase in electricity consumption and associated greenhouse gases
- Permanent impact on State heritage associated with the works at Central Station
- Increase in flood levels at existing flood affected properties near the Marrickville dive structure – primarily in the rail corridor and adjacent road reserve.

Further investigations would be carried out prior to the commencement of construction. The results of these investigations would assist in further reducing adverse construction and operational impacts. Any residual long-term adverse impacts would be more than offset by the many and significant benefits of the project.

29.8 The next steps

Transport for NSW is seeking approval from the Minister for Planning for the construction and operation of Sydney Metro Chatswood to Sydenham. Subsequent steps in the process are as follows:

- Exhibition of the Environmental Impact Statement for a minimum of 30 days and invitation for the community and stakeholders to make submissions
- Consideration of submissions. Submissions received by the Secretary would be provided to Transport for NSW and any relevant public authorities. Transport for NSW may then be required to prepare and submit:
  - A submissions report, responding to issues raised in the submissions
  - A preferred infrastructure report, outlining any proposed changes to the project to minimise its environmental impacts or to deal with any other issues raised
- Determination of the Environmental Impact Statement. The Secretary of the Department of Planning and Environment, who would then make a decision on the project and, if approved, set Conditions of Approval.

Consultation with the community and stakeholders would continue throughout the detailed design and construction phases.

Any person wishing to make a submission should use the online form if possible. To find the online form go to the web-page for the proposal via www.majorprojects.planning.nsw.gov.au/page/on-exhibition.

Your submission must reach the Department of Planning & Environment by close of business on Monday 27 June 2016. Before making your submission, please read the Privacy Statement at www.planning.nsw.gov.au/privacy or for a copy, telephone the number below. The Department of Planning & Environment will publish your submission in accordance with the Privacy Statement.

If you cannot lodge online, you can write to the address below. If you want The Department of Planning & Environment to delete your personal information before publication, please make this clear at the top of your letter. You need to include:

1. Your name and address (at the top of the letter only);
2. The name of the application and the application number (SSI 7400);
3. A statement on whether you support or object to the proposal;
4. The reasons why you support or object to the proposal;
5. A declaration of any reportable political donations made in the previous two years. To find out what is reportable, and for a disclosure form, go to www.planning.nsw.gov.au/donations or phone 1300 305 695 for a copy.

Address:
Department of Planning and Environment
GPO Box 39, SYDNEY, NSW 2001.

Your submission should be marked Attention: Director, Transport Assessments.

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GLOSSARY

Glossary

Acronym	Definition
100-year flood	A 100-year flood is the flood that will occur or be exceeded on average once every 100 years. It has a 1% probability of occurring in any given year. The same principle applies to other flooding events, such as 10-year, 20-year and 50-year flood.
ABS	Australian Bureau of Statistics
ACHAR	Aboriginal Cultural Heritage Assessment Report
AHD	Australian Height Datum
AIP	Australian Industry Participation
Alluvium	Unconsolidated deposit of gravel, sand or mud formed by water flowing in identifiable channels. Commonly well sorted and stratified.
ANZECC	Australian and New Zealand Environment and Conservation Council
ANZSIC	Australian and New Zealand Standard Industrial Classification
AR	Assessment Reports
ARMCANZ	Agriculture and Resources Management Council of Australia and New Zealand
ASS	Acid sulfate soils
Average recurrence interval	The long-term average number of years between the occurrence of a flood larger than the selected event.
CBD	Central business district
CEMF	Construction Environmental Management Framework
CEMP	Construction Environmental Management Plan
CFU	Colony Forming Units
CH4	Methane
CIRIA	Construction Industry Research and Information Association
CNVS	Construction Noise and Vibration Strategy
CO	Carbon monoxide
CO_2	Carbon dioxide
CO2-e	Carbon dioxide-equivalent emissions
CLM Act	*Contaminated Land Management Act 1997*
CPTED	Crime Prevention Through Environmental Design
CSRIO	Commonwealth Scientific and Industrial Research Organisation
dB	Decibel
dBA	A-weighted decibels
DCP	Development Control Plan
Dioxins	Polychlorinated dibenzo-para-dioxins
DoS	Degree of Saturation
Drained structures	Underground structures designed to allow the inflow of groundwater, which is then captured, treated and discharged.
Drawdown	The localised lowering of groundwater levels as a result of water extraction

Acronym	Definition
ECRL	Epping to Chatswood Rail Line
ECTM	Enhanced Train Crowding Model
EEC	Endangered Ecological Community
EPA	NSW Environment Protection Authority
EP&A Act	*Environmental Planning and Assessment Act 1979*
EP&A Regulation	*Environmental Planning and Assessment Regulation 2000*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPL	Environment protection licence
FBA	Framework for Biodiversity Assessment
Financial core	A precinct of the Sydney CBD that occupies approximately 50 hectares of the most prestigious real-estate in Sydney. Situated within the valley that runs north between the ridges of Macquarie Street and York Street, the precinct enjoys unrivalled views north and east across the Botanic Gardens and Sydney Harbour. The financial core is located south of the station location, between Alfred Street and Circular Quay to the north, Macquarie Street to the east, King Street to the south and George Street to the west.
FM Act	*Fisheries Management Act 1994*
Furans	Dibenzofurans
GEC	Global Economic Corridor
Groundwater	All waters occurring below the land surface. The upper surface of the soils saturated by groundwater in any particular area is called the water table.
GWh	Gigawatts
HFCs	Hydrofluorocarbons
Hz	Hertz
IBRA	Interim Biogeographic Regionalisation for Australia
ICNG	Interim Construction Noise Guideline
ICOMOS	International Council on Monuments and Sites
INP	Industrial Noise Policy
IPCC	Intergovernmental Panel on Climate Change
KTP	Key Threatening Process
kV	Kilovolts
L/s	Litres per second
LEP	Local Environmental Plan
LGA	Local government area
LoS	Level of Service
mm/s	Millimetres per second
N_2O	Nitrous oxide
NAGD	National Assessment Guidelines for Dredging
NGER Act	*National Greenhouse and Energy Reporting Act 2007*

Acronym	Definition
NML	Noise management level
NO_2	Nitrogen dioxide
NR	Noise rating
NSW	New South Wales
NSW WQO	NSW Water Quality Objectives
NTU	Nephelometric Turbidity Units
NW Act	*NSW Noxious Weeds Act 1993*
OCs	Organochlorine pesticides
OEH	NSW Office of Environment and Heritage
PAD	Potential archaeological deposit
PAHs	Polycyclic aromatic hydrocarbons
PCBs	Polychlorinated biphenyls
PCDD/Fs	Polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans
PCTs	Plant Community Types
PFCs	Perfluorocarbons
pH	A measure of the degree of acidity or alkalinity expressed on a logarithmic scale of 1-14, on which 1 is most acid, 7 is neutral and 14 is most basic (alkaline).
POEO Act	*NSW Protection of the Environment Operations Act 1997*
PM	Particulate matter
PPV	Peak Particle Velocity
Probable maximum flood event	The largest flood that could conceivably occur (a worst-case flood event). It is typically estimated from probable maximum precipitation coupled with the worst flood-producing catchment conditions. The PMF extent defines the floodplain and incorporates all flood-prone land. The PMF is a very rare and improbable flood.
PTMP	Public Transport Project Model
RBL	Rating background level
RCP	Representative Concentration Pathways
RET	Renewable Energy Target
RING	Rail Infrastructure Noise Guidelines
RNP	NSW Road Noise Policy
RPC	Representative Concentration Pathways
SA	Statistical Area
SEIFA	Socio-economic Indexes for Areas
SEPP	State Environmental Planning Policy
SF_6	Sulphur hexafluoride
STA	State Transit Authority

Acronym	Definition
Tanked structures	Underground structures designed to inhibit the inflow of groundwater, typically using concrete lining and waterproofing membrane.
TBM	Tunnel boring machine
tCO_2e	Tonnes of CO_2 equivalent
TPH	Total petroleum hydrocarbons
TSC Act	*Threatened Species Conservation Act 1997*
TSP	Total suspended particulates
$\mu g/m^3$	Microgram per cubic metre
UK	United Kingdom
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UTS	University of Technology Sydney
v/c	Volumes and capacity
VOC	Volatile Organic Compounds

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SECRETARY'S ENVIRONMENTAL ASSESSMENT REQUIREMENTS

APPENDIX A

Desired Performance Outcome	Requirement	Where addressed in EIS
1. Environmental Impact Assessment Process **The process for assessment of the proposal is transparent, balanced, well focussed and legal.**	1. The Environmental Impact Statement must be prepared in accordance with Part 3 of Schedule 2 of the *Environmental Planning and Assessment Regulation 2000* (the Regulation).	Certification page
	2. It is the Proponent's responsibility to determine whether the project needs to be referred to the Commonwealth Department of the Environment for an approval under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Proponent must contact the Commonwealth Department of the Environment immediately if it is determined that an approval is required under the EPBC Act, as supplementary environmental assessment requirements may need to be issued to ensure a streamlined assessment under the Bilateral agreement can be achieved.	Chapter 2 (Planning and assessment process)
	3. Where the project requires approval under the EPBC Act and is being assessed under the Bilateral Agreement the EIS should address:	
	(a) Consideration of any Protected Matters that may be impacted by the development where the Commonwealth Minister has determined that the proposal is a Controlled Action.	
	(b) Identification and assessment of those Protected Matters that are likely to be significantly impacted.	
	(c) Details of how significant impacts to Protected Matters have been avoided, mitigated and, if necessary, offset.	
	(d) Consideration of, and reference to, any relevant conservation advices, recovery plans and threat abatement plans.	
	4. The onus is on the Proponent to ensure legislative requirements relevant to the project are met.	
2. Environmental Impact Statement **The project is described in sufficient detail to enable clear understanding that the project has been developed through an iterative process of impact identification and assessment and project refinement to avoid, minimise or offset impacts so that the project, on balance, has the least adverse environmental, social and economic impact, including its cumulative impacts.**	1. The EIS must include, but not necessarily be limited to, the following:	
	(a) executive summary;	Executive Summary
	(b) a description of the project, including all components and activities (including ancillary components and activities) required to construct and operate it;	Chapter 6 (Project description – operation) Chapter 7 (Project description – construction)
	(c) a statement of the objective(s) of the project;	Chapter 3 (Strategic need and justification)
	(d) a summary of the strategic need for the project with regard to its critical State significance and relevant State Government policy;	Chapter 3 (Strategic need and justification)

Desired Performance Outcome	Requirement	Where addressed in EIS
	(e) an analysis of any feasible alternatives to the project;	Chapter 4 (Project development and alternatives)
	(f) a description of feasible options within the project;	Chapter 4 (Project development and alternatives)
	(g) a description of how alternatives to and options within the project were analysed to inform the selection of the preferred alternative / option. The description must contain sufficient detail to enable an understanding of why the preferred alternative to and options(s) within the project were selected;	Chapter 4 (Project development and alternatives)
	(h) potential opportunities for further network expansion and consideration of relationship to other Government public transport initiatives; a concise description of the general biophysical and socioeconomic environment that is likely to be impacted by the project (including offsite impacts). Elements of the environment that are not likely to be affected by the project do not need to be described;	Chapter 4 (Project development and alternatives) Chapters 8 to 26 of the EIS
	(i) a demonstration of how the project design has been developed to avoid or minimise likely adverse impacts;	Chapter 6 (Project description – operation) Chapter 7 (Project description – construction)
	(j) the identification and assessment of key issues as provided in the 'Assessment of Key Issues' performance outcome;	Chapter 28 (Environmental risk analysis) Chapters 8 to 26 of the EIS
	(k) a statement of the outcome(s) the proponent will achieve for each key issue;	Chapters 8 to 26 of the EIS
	(l) measures to avoid, minimise or offset impacts must be linked to the impact(s) they treat, so it is clear which measures will be applied to each impact;	Chapter 27 (Consolidated environmental mitigation measures and performance outcomes)
	(m) an assessment of the cumulative impacts of the project taking into account other projects that have been approved but where construction has not commenced, projects that have commenced construction, and projects that have recently been completed (for example WestConnex, Barangaroo, any approved construction in the relevant precincts);	Chapter 26 (Cumulative impacts)
	(n) statutory context of the project as a whole, including: • how the project meets the provisions of the EP&A Act and EP&A Regulation; • a list of any approvals that must be obtained under any other Act or law before the project may lawfully be carried out;	Chapter 2 (Planning and assessment process)

Desired Performance Outcome	Requirement	Where addressed in EIS
	(o) a chapter that synthesises the environmental impact assessment and provides: • a succinct but full description of the project for which approval is sought; • a description of any uncertainties that still exist around design, construction methodologies and/or operational methodologies and how these will be resolved in the next stages of the project; • a compilation of the impacts of the project that have not been avoided; • a compilation of the proposed measures associated with each impact to avoid or minimise (through design refinements or ongoing management during construction and operation) or offset these impacts; • a compilation of the outcome(s) the proponent will achieve; and • the reasons justifying carrying out the project as proposed, having regard to the biophysical, economic and social considerations, including ecologically sustainable development and cumulative impacts.	Appendix G (Synthesis of the Environmental Impact Statement)
	(p) relevant project plans, drawings, diagrams in an electronic format that enables integration with mapping and other technical software.	
	2. The EIS must only include data and analysis that is reasonably needed to make a decision on the proposal. Relevant information must be succinctly summarised in the EIS and included in full in appendices. Irrelevant, conflicting or duplicated information must be avoided.	Throughout the EIS
3. Assessment of Key Issues* **Key issue impacts are assessed objectively and thoroughly to provide confidence that the project will be constructed and operated within acceptable levels of impact.** ** Key issues are nominated by the Proponent in the CSSI project application and by the Department in the SEARs. Key issues need to be reviewed throughout the preparation of the EIS to ensure any new key issues that emerge are captured. The key issues identified in this document are not exhaustive but are key issues common to most CSSI projects.*	1. The level of assessment of likely impacts must be proportionate to the significance of, or degree of impact on, the issue, within the context of the proposal location and the surrounding environment. The level of assessment must be commensurate to the degree of impact and sufficient to ensure that the Department and other government agencies are able to understand and assess impacts.	Chapters 8 to 26 of the EIS

Desired Performance Outcome	Requirement	Where addressed in EIS
	2. For each key issue the Proponent must:	Chapters 8 to 26 of the EIS
	(a) describe the biophysical and socio-economic environment, as far as it is relevant to that issue;	
	(b) describe the legislative and policy context, as far as it is relevant to the issue;	
	(c) identify, describe and quantify (if possible) the impacts associated with the issue, including the likelihood and consequence (including worst case scenario) of the impact (comprehensive risk assessment), and the cumulative impacts;	
	(d) demonstrate how potential impacts have been avoided (through design, or construction or operation methodologies);	
	(e) detail how likely impacts that have not been avoided through design will be minimised, and the predicted effectiveness of these measures (against performance criteria where relevant).	
	3. Where multiple reasonable and feasible options to avoid or minimise impacts are available, they must be identified and considered and the proposed measure justified taking into account the public interest.	Chapter 4 (Project development and alternatives) Chapter 6 (Project description – operation)
4. Consultation **The project is developed with meaningful and effective engagement during project design and delivery.**	1. The project must be informed by consultation, including with relevant government agencies, infrastructure and service providers, special interest groups, affected landowners, businesses and the community. The consultation process must be undertaken in accordance with the current guidelines.	Chapter 5 (Stakeholder and community engagement)
	2. The Proponent must document the consultation process, and demonstrate how the project has responded to the inputs received.	
	3. The Proponent must describe the timing and type of community consultation proposed during the design and delivery of the project, the mechanisms for community feedback, the mechanisms for keeping the community informed, and procedures for complaints handling and resolution.	
5. Biodiversity **The project design considers all feasible measures to avoid and minimise impacts on terrestrial and aquatic biodiversity.** **Offsets and/or supplementary measures are assured which are equivalent to any remaining impacts of project construction and operation.**	1. The Proponent must assess biodiversity impacts in accordance with the current guidelines including the Framework for Biodiversity Assessment (FBA).	Chapter 20 (Biodiversity)

Desired Performance Outcome	Requirement	Where addressed in EIS
	2. The Proponent must assess any impacts on biodiversity values not covered by the FBA as specified in s2.3.	
	3. The Proponent must assess impacts on the following [EECs, threatened species and/ or populations] and provide the information specified in s9.2 of the FBA.	
	4. The Proponent must identify whether the project as a whole, or any component of the project, would be classified as a Key Threatening Process (KTP) in accordance with the listings in the *Threatened Species Conservation Act 1997* (TSC Act), *Fisheries Management Act 1994* (FM Act) and *Environmental Protection and Biodiversity Conservation Act 2000* (EPBC Act).	
6. Flooding **The project minimises adverse impacts on existing flooding characteristics.** **Construction and operation of the project avoids or minimises the risk of, and adverse impacts from, infrastructure flooding, flooding hazards, or dam failure.**	1. The Proponent must assess and model (where required), taking into account any relevant Council-adopted flood model or latest flood data available from Councils, the impacts on flood behaviour during construction and operation for a full range of flood events up to the probable maximum flood (taking into account sea level rise and storm intensity due to climate change) including:	Chapter 21 (Flooding and hydrology)
	(a) any detrimental increases in the potential flood affectation of other properties, assets and infrastructure;	
	(b) consistency (or inconsistency) with applicable Council floodplain risk management plans;	
	(c) compatibility with the flood hazard of the land;	
	(d) compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land;	
	(e) downstream velocity and scour potential;	
	(f) impacts the development may have upon existing community emergency management arrangements for flooding. These matters must be discussed with the State Emergency Services and Council; and	
	(g) any impacts the development may have on the social and economic costs to the community as consequence of flooding.	

Desired Performance Outcome	Requirement	Where addressed in EIS
7. Heritage **The design, construction and operation of the project facilitates, to the greatest extent possible, the long term protection, conservation and management of the heritage significance of items of environmental heritage and Aboriginal objects and places.** **The design, construction and operation of the project avoids or minimises impacts, to the greatest extent possible, on the heritage significance of environmental heritage and Aboriginal objects and places.**	1. The Proponent must identify and assess any direct and/or indirect impacts (including cumulative impacts) to the heritage significance of:	Chapter 14 (Non-Aboriginal heritage) Chapter 15 (Aboriginal heritage) Chapter 26 (Cumulative impacts)
	(a)Aboriginal places and objects, as defined under the *National Parks and Wildlife Act 1974* and in accordance with the principles and methods of assessment identified in the current guidelines;	Chapter 15 (Aboriginal heritage)
	(b) Aboriginal places of heritage significance, as defined in the Standard Instrument – Principal Local Environmental Plan;	Chapter 15 (Aboriginal heritage)
	(c) environmental heritage, as defined under the *Heritage Act 1977*; and	Chapter 14 (Non-Aboriginal heritage)
	(d) items listed on the National and World Heritage lists.	
	2. Where impacts to State or locally significant heritage items are identified, the assessment must:	
	(a) include a statement of heritage impact for all heritage items (including significance assessment);	
	(b) consider impacts to the item of significance caused by, but not limited to, vibration, demolition, archaeological disturbance, altered historical arrangements and access, visual amenity, landscape and vistas, curtilage, subsidence and architectural noise treatment (as relevant);	
	(c) outline measures to avoid and minimise those impacts in accordance with the current guidelines; and	Chapter 14 (Non-Aboriginal heritage) Chapter 15 (Aboriginal heritage)
	(d) be undertaken by a suitably qualified heritage consultant(s) (note: where archaeological excavations are proposed the relevant consultant must meet the NSW Heritage Council's Excavation Director criteria).	Chapter 14 (Non-Aboriginal heritage) Chapter 15 (Aboriginal heritage)
	3. Where archaeological investigations of Aboriginal objects are proposed these must be conducted by a suitably qualified archaeologist, in accordance with section 1.6 of the *Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW* (DECCW 2010).	Chapter 15 (Aboriginal heritage)
	4. Where impacts to Aboriginal objects and/ or places are proposed, consultation must be undertaken with Aboriginal people in accordance with the current guidelines.	Chapter 15 (Aboriginal heritage)

Desired Performance Outcome	Requirement	Where addressed in EIS
8. Noise and Vibration – Amenity **Construction noise and vibration (including airborne noise, ground-borne noise and blasting) are effectively managed to minimise adverse impacts on acoustic amenity.** **Increases in noise emissions and vibration affecting nearby properties and other sensitive receivers during operation of the project are effectively managed to protect the amenity and well-being of the community.**	1. The Proponent must assess construction and operational noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. The assessment must include consideration of impacts to sensitive receivers including commercial premises, and include consideration of sleep disturbance and, as relevant, the characteristics of noise and vibration (for example, low frequency noise).	Chapter 10 (Construction noise and vibration) Chapter 11 (Operational noise and vibration)
	2. If blasting is required, the relevant requirements of *Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration* (ANZEC 1990) are to be assessed.	Chapter 10 (Construction noise and vibration)
9. Noise and Vibration – Structural **Construction noise and vibration (including airborne noise, ground-borne noise and blasting) are effectively managed to minimise adverse impacts on the structural integrity of buildings and items including Aboriginal places and environmental heritage.** **Increases in noise emissions and vibration affecting environmental heritage as defined in the *Heritage Act 1977* during operation of the project are effectively managed.**	1. The Proponent must assess construction and operation noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. The assessment must include consideration of impacts to the structural integrity and heritage significance of items (including Aboriginal places and items of environmental heritage).	Chapter 10 (Construction noise and vibration) Chapter 11 (Operational noise and vibration) Chapter 14 (Non-Aboriginal heritage) Chapter 15 (Aboriginal heritage)
	2. The Proponent must demonstrate that blast impacts are capable of complying with the current guidelines, if blasting is required.	Chapter 10 (Construction noise and vibration)
10. Socio-economic, Land Use and Property **The project minimises adverse social and economic impacts and capitalises on opportunities potentially available to affected communities.** **The project minimises impacts to property and business and achieves appropriate integration with adjoining land uses, including maintenance of appropriate access to properties and community facilities, and minimisation of displacement of existing land use activities, dwellings and infrastructure.**	1. The Proponent must assess social and economic impacts in accordance with the current guidelines.	Chapter 13 (Business impacts) Chapter 19 (Social impacts and community infrastructure) Chapter 3 (Strategic need and justification)
	2. The Proponent must assess impacts from construction and operation on potentially affected properties, approved development applications, businesses, public open space, recreational users and land and water users (for example, recreational and commercial fishers, oyster farmers), including property acquisitions/ adjustments, access, amenity and relevant statutory rights.	Chapter 12 (Land use and property) Chapter 13 (Business impacts) Chapter 19 (Social impacts and community infrastructure) Chapter 8 (Construction traffic and transport) Chapter 26 (Cumulative impacts)

Desired Performance Outcome	Requirement	Where addressed in EIS
	3. Assess the likely risks of the project to public safety, paying particular attention to subsidence risks, bushfire risks and the handling and use of dangerous goods.	Chapter 23 (Hazard and risk) Chapter 8 (Construction traffic and transport) Chapter 9 (Operational traffic and transport) Chapter 17 (Groundwater and geology) Chapter 19 (Social impacts and community infrastructure)
11. Soils **The environmental values of land, including soils, subsoils and landforms, are protected.** **Risks arising from the disturbance and excavation of land and disposal of soil are minimised, including disturbance to acid sulfate soils and site contamination.**	1. The Proponent must verify the risk of acid sulfate soils (Class 1, 2, 3 or 4 on the Acid Sulfate Soil Risk Map) within, and in the area likely to be impacted by, the project.	Chapter 18 (Soils, contamination and water quality)
	2. The Proponent must assess the impact of the project on acid sulfate soils (including impacts of acidic runoff offsite) in accordance with the current guidelines.	
	3. The Proponent must assess whether the land is likely to be contaminated and identify if remediation of the land is required, having regard to the ecological and human health risks posed by the contamination in the context of past, existing and future land uses. Where assessment and/or remediation is required, the Proponent must document how the assessment and/or remediation would be undertaken in accordance with current guidelines.	
	4. The Proponent must assess whether salinity is likely to be an issue and if so, determine the presence, extent and severity of soil salinity within the project area.	
	5. The Proponent must assess the impacts of the project on soil salinity and how it may affect groundwater resources and hydrology.	
	6. The Proponent must assess the impacts on soil and land resources (including erosion risk or hazard). Particular attention must be given to soil erosion and sediment transport consistent with the practices and principles in the current guidelines.	
12. Sustainability **The project reduces the NSW Government's operating costs and ensures the effective and efficient use of resources.** **Conservation of natural resources is maximised.**	1. The Proponent must assess the project against the current guidelines including targets and strategies to improve Government efficiency in use of water, energy and transport.	Chapter 25 (Sustainability)

Desired Performance Outcome	Requirement	Where addressed in EIS
13. Transport and Traffic **Network connectivity, safety and efficiency of the transport system in the vicinity of the project are managed to minimise impacts.** **The safety of transport system customers is maintained.** **Impacts on network capacity and the level of service are effectively managed.** **Works are compatible with existing infrastructure and future transport corridors.**	1.The Proponent must assess construction transport and traffic (vehicle, pedestrian and cyclists) impacts, including, but not necessarily limited to:	Chapter 8 (Construction traffic and transport)
	(a) a considered approach to route identification and scheduling of transport movements;	
	(b) the number, frequency and size of construction related vehicles (passenger, commercial and heavy vehicles, including spoil management movements);	
	(c) the capacity of or need to upgrade roads proposed as construction vehicle routes including Bedwin Road;	
	(d) changes to existing local and regional road networks including access to and around the proposed Chatswood tunnelling site;	
	(e) construction worker parking;	
	(f) the nature of existing traffic (types and number of movements) on construction access routes (including consideration of peak traffic times and sensitive road users and parking arrangements), including access to the Overseas Passenger Terminal for deliveries and passenger coaches;	
	(g) details of how construction and scheduling of works are to be coordinated in regard to public events; cumulative traffic impacts resulting from concurrent work on Westconnex, Barangaroo, Sydney Light Rail and other key construction projects in the Sydney CBD;	Chapter 26 (Cumulative impacts)
	(h) alternatives to road transport of construction spoil;	
	(i) access constraints and impacts on public transport, pedestrian access and cyclists;	
	(j) the need to close, divert or otherwise reconfigure elements of the road and cycle network associated with construction of the project;	
	(k) assess the likely risks of the project to public safety, paying particular attention to pedestrian safety and users of Sydney Harbour; and	
	(l) impacts to water based traffic and shipping channels on users of Sydney Harbour with particular reference to the channel between Blues Point and Millers Point for passage to and from White Bay, Glebe Island and Gore Cove.	

Desired Performance Outcome	Requirement	Where addressed in EIS
	2. The Proponent must assess the operational transport impacts of the project, including: (m) forecast travel demand and traffic volumes for the project and the surrounding road, cycle and public transport network; (n) travel time analysis; (o) performance of interchanges and intersections by undertaking a coordinated level of service analysis at locations affected by stations; (p) wider transport interactions (local and regional roads, permanent loss of parking, the need for kiss and ride facilities, cycling, public and freight transport); (q) induced traffic and operational implications for public transport (particularly with respect to strategic bus corridors and bus routes) and consideration of opportunities to improve public transport; (r) impacts to pedestrian access in and around stations and connecting streets, capacity of streets at peak pedestrian times, including phasing of traffic lights, intersection crossing times and connectivity between stations (s) assess the benefits to each station and the general vicinity of walking and cycling catchments and the provision of infrastructure to support sustainable transport options. (t) impacts on cyclists and pedestrian access and safety; and (u) opportunities to integrate cycling and pedestrian elements with surrounding networks and in the project.	Chapter 9 (Operational traffic and transport)
14.Urban design **The project design complements the visual amenity, character and quality of the surrounding environment.** **The project contributes to the accessibility and connectivity of communities.**	1. The Proponent must: (a) identify the urban design and landscaping aspects of the project and its components; (b) include consideration of urban design principles adopted by each council or within each station precinct; (c) assess the impact of the project on the urban, rural and natural fabric; (d) explore the use of Crime Prevention Through Environmental Design (CPTED) principles during the design development process, including natural surveillance, lighting, walkways, signage and landscape; and (e) identify urban design strategies and opportunities to enhance healthy, cohesive and inclusive communities.	Chapter 6 (Project description – operation) Chapter 16 (Landscape character and visual amenity)

Desired Performance Outcome	Requirement	Where addressed in EIS
15. Visual Amenity **The project minimises adverse impacts on the visual amenity of the built and natural environment (including public open space) and capitalises on opportunities to improve visual amenity.**	1.The Proponent must assess the visual impact of the project and any ancillary infrastructure on:	Chapter 16 (Landscape character and visual amenity)
	(a) views and vistas;	
	(b) streetscapes, key sites and buildings;	
	(c) the local community.	
	2. The Proponent must provide artist impressions and perspective drawings of the project to illustrate how the project has responded to the visual impact through urban design and landscaping.	
16. Waste **All wastes generated during the construction and operation of the project are effectively stored, handled, treated, reused, recycled and/or disposed of lawfully and in a manner that protects environmental values.**	1. The Proponent must assess predicted waste generated from the project during construction and operation, including:	Chapter 24 (Waste management)
	a) classification of the waste in accordance with the current guidelines;	
	b) estimates / details of the quantity of bulk earthworks and spoil balance to be generated during construction of the project;	
	c) handling of waste including measures to facilitate segregation and prevent cross contamination;	
	d) management of waste including indicative location and volume of stockpiles;	
	e) waste minimisation and reuse;	
	f) lawful disposal or recycling locations for each type of waste using a hierarchy which prioritises higher value end use; and	
	g) contingencies for the above, including managing unexpected waste volumes.	
	2. The Proponent must assess potential environmental impacts from the excavation, handling, storage on site and transport of the waste particularly with relation to sediment/leachate control, noise and dust.	

Desired Performance Outcome	Requirement	Where addressed in EIS
17. Water – Hydrology **Long term impacts on surface water and groundwater hydrology (including drawdown, flow rates and volumes) are minimised.** **The environmental values of nearby, connected and affected water sources, groundwater and dependent ecological systems including estuarine and marine water (if applicable) are maintained (where values are achieved) or improved and maintained (where values are not achieved).** **Sustainable use of water resources.**	1. The Proponent must describe (and map) the existing hydrological regime for any surface and groundwater resource (including reliance by users and for ecological purposes) likely to be impacted by the project, including stream orders, as per the FBA.	Chapter 17 (Groundwater and geology)
	2. The Proponent must assess (and model if appropriate) the impact of the construction and operation of the project and any ancillary facilities (both built elements and discharges) on surface and groundwater hydrology in accordance with the current guidelines, including:	Chapter 17 (Groundwater and geology)
	(a) natural processes within rivers, wetlands, estuaries, marine waters and floodplains that affect the health of the fluvial, riparian, estuarine or marine system and landscape health (such as modified discharge volumes, durations and velocities), aquatic connectivity and access to habitat for spawning and refuge;	Chapter 20 (Biodiversity) Chapter 18 (Soils, contamination and water quality)
	(b) impacts from any permanent and temporary interruption of groundwater flow, including the extent of drawdown, barriers to flows, implications for groundwater dependent surface flows, ecosystems and species, groundwater users and the potential for settlement;	Chapter 20 (Biodiversity) Chapter 17 (Groundwater and geology)
	(c) changes to environmental water availability and flows, both regulated/licensed and unregulated/rules-based sources;	Chapter 18 (Soils, contamination and water quality)
	(d) direct or indirect increases in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses;	Chapter 21 (Flooding and hydrology) Chapter 18 (Soils, contamination and water quality)
	(e) minimising the effects of proposed stormwater and wastewater management during construction and operation on natural hydrological attributes (such as volumes, flow rates, management methods and re-use options) and on the conveyance capacity of existing stormwater systems where discharges are proposed through such systems; and	Chapter 21 (Flooding and hydrology)
	(f) water take (direct or passive) from all surface and groundwater sources with estimates of annual volumes during construction and operation.	Chapter 17 (Groundwater and geology) Chapter 25 (Sustainability)
	3. The Proponent must identify any requirements for baseline monitoring of hydrological attributes.	Chapter 21 (Flooding and hydrology)

Desired Performance Outcome	Requirement	Where addressed in EIS
18. Water – Quality **The project is designed, constructed and operated to protect the NSW Water Quality Objectives where they are currently being achieved, and contribute towards achievement of the Water Quality Objectives over time where they are currently not being achieved, including downstream of the project to the extent of the project impact including estuarine and marine waters (if applicable).**	1. The Proponent must:	Chapter 18 (Soils, contamination and water quality)
	(a) state the ambient NSW Water Quality Objectives (NSW WQO) and environmental values for the receiving waters relevant to the project, including the indicators and associated trigger values or criteria for the identified environmental values;	
	(b) identify all pollutants that may be introduced into the water cycle and describe the nature and degree of impact that any discharge(s) may have on the receiving environment, including consideration of all pollutants that pose a risk of non-trivial harm to human health and the environment;	
	(c) identify the rainfall event that the water quality protection measures will be designed to cope with;	
	(d) assess the significance of any identified impacts including consideration of the relevant ambient water quality outcomes;	
	(e) demonstrate how construction and operation of the project will, to the extent that the project can influence, ensure that: • where the NSW WQOs for receiving waters are currently being met they will continue to be protected; and • where the NSW WQOs are not currently being met, activities will work toward their achievement over time;	
	(f) justify, if required, why the WQOs cannot be maintained or achieved over time;	
	(g) demonstrate that all practical measures to avoid or minimise water pollution and protect human health and the environment from harm are investigated and implemented;	
	(h) identify sensitive receiving environments (which may include estuarine and marine waters downstream) and develop a strategy to avoid or minimise impacts on these environments; and	
	(i) identify proposed monitoring locations, monitoring frequency and indicators of surface and groundwater quality.	
19. Utilities **The project is designed, construction and operated to minimise impacts to utilities and provision of such to the public.**	1. The Proponent must consider:	Chapter 7 (Project description – construction)
	(a) the impact of the project on the integrity of trunk assets and the need to augment or relocate;	
	(b) opportunities to support initiatives adopted by Councils and utilities providers; and	
	(c) how access to assets will be maintained during construction.	

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SYDNEY METRO CHATSWOOD TO SYDENHAM DESIGN GUIDELINES

APPENDIX B

NSW GOVERNMENT | Transport for NSW

Sydney Metro City & Southwest

Chatswood to Sydenham Design Guidelines

March 2016

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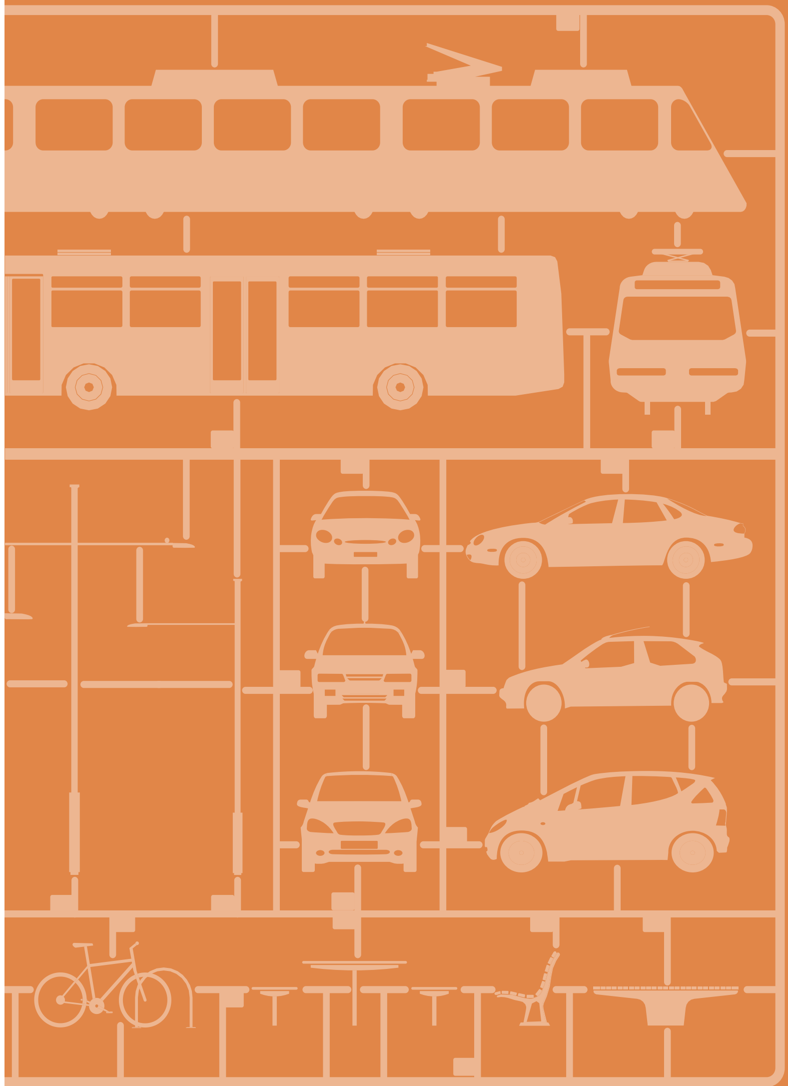

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Introduction

1.1 Purpose of these Guidelines

The Guidelines will support the development of healthy, cohesive and inclusive communities.

The Guidelines establish the design standards for the Sydney Metro Chatswood to Sydenham project (the project) by guiding the design of:

- The interface between stations and their surrounding locality including
  - Station entries
  - Transport interchange facilities (bicycle facilities, bus stops, kiss and ride, taxi ranks and connections to existing rail, ferry and light rail transport)
  - Landscaping and other public domain elements.
- Rail corridor works including the tunnel dive structures, rail cuttings and embankments.
- Station and service buildings, including underground stations

Any development above Metro stations would be subject to a separate planning approval.

The Guidelines have been developed to respond to the strategic directions and urban design strategies of the local Councils. The Guidelines will be used by Transport for NSW (TfNSW) to guide the design development process for the project.

Grand Concourse, Central Station, Sydney. Accommodating Sydney's growing population in a manner that protects Sydney's status as a global city.
Source: TfNSW.

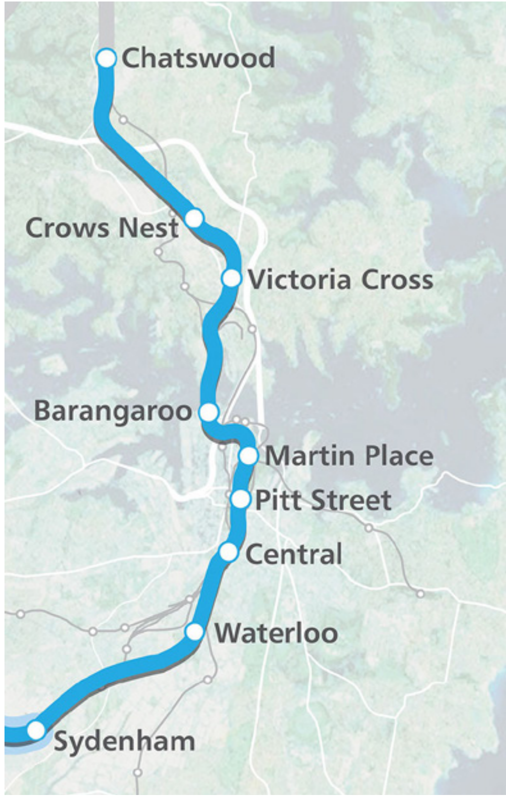
1.2 Project Scope

The Chatswood to Sydenham component of the Project includes the construction and operation of a new metro rail line from Chatswood under Sydney Harbour through Sydney's CBD to Sydenham. The project will deliver seven new metro stations at;

- Crows Nest
- Victoria Cross (North Sydney)
- Barangaroo
- Martin Place
- Pitt Street
- Central Station (new underground platforms)
- Waterloo.

Key Project features include:

- 16km of new metro line between Chatswood and Sydenham.
- 15km of new twin rail tunnels.
- Convenient interchanges with other forms of transport including Sydney Trains, NSW Trains, light rail, buses and ferries.
- All stations will meet the needs of pedestrians, cyclists, customers catching or getting off buses and taxis, and people being dropped off and picked up in cars.
- There will be platform screen doors and all stations will be fully accessible.
- New stations designed for passenger comfort including environmentally friendly features like natural ventilation and natural lighting.



Chatswood to Sydenham alignment map

1.3 Project Vision

Transport for NSW's vision for Sydney Metro is:

"Transforming Sydney with a new world class metro".

The Sydney Metro Delivery Office's mission is to deliver a world class, connected metro, which will provide more choice to customers and opportunities for our communities now and in the future.

Sydney Metro is also a unique opportunity to demonstrate an exemplary approach to integrated transport and land use planning. Quality architecture, good urban design and a user friendly and inter-connected transport system are critical to ensuring that the Sydney Metro project meets customer needs and expectations and maximises its city shaping potential and broader urban benefits.

Sydney Metro alignment map

1.4 Design Objectives

To help meet the transformational vision and world class aspirations of the project, five **Design Objectives** for the project have been agreed to guide decision making and the design process for the City & Southwest project.

A **Design Principle** is prescribed under each design objective, describing the intention of the objective for the design of stations, station precincts and the wider Metro corridor:

Objective 1: Ensuring an easy customer experience.

Principle
Sydney Metro places the customer first. Stations are welcoming and intuitive with simple, uncluttered spaces that ensure a comfortable, enjoyable and safe experience for a diverse range of customers.

Objective 2: Being part of a fully integrated transport system.

Principle
Sydney Metro is a transit-oriented project that prioritises clear and legible connections with other public and active transport modes within the wider metropolitan travel network that intersect with this new spine.

Objective 3: Being a catalyst for positive change.

Principle
Sydney Metro is a landmark opportunity to regenerate and invigorate the city with new stations and associated development that engage with their precincts, raise the urban quality and enhance the overall experience of the city.

Objective 4: Being responsive to distinct contexts and communities.

Principle
Sydney Metro's identity is stronger for the unique conditions of centres and communities through which it passes. This local character is to be embraced through distinctive station architecture and public domain that is well integrated with the inherited urban fabric of existing places.

Objective 5: Delivering an enduring and sustainable legacy for Sydney.

Principle
Sydney Metro is a positive legacy for future generations. A high standard of design across the corridor, stations and station precincts, that sets a new benchmark, is vital to ensuring the longevity of the Metro system, its enduring contribution to civic life and an ability to adapt to a changing city over time.

Kings Cross Station, London UK. World class transport hub.
Architect: John McAslan + Partners
Source: Wikipedia

1.5 Understanding Customer Needs

"The Customer is at the centre of everything we do."

Who are our customers?
To provide customer centred design we first need to identify who are Sydney Metro's customers are and what their needs are.

Sydney Metro customers are those who derive a direct benefit from using the system and the services offered.

Sydney Metro's customers will be as diverse as they are numerous and will have different transport needs and patterns of use. Examples of customer segments include work commuters, school students, tertiary students, personal or recreational users, tourist & visitors. Within these groups there is a mix of demographics, lifestyle, travel needs and patterns of use.

An important consideration in designing for all customers is providing a fully accessible service. Whilst approximately 8% of our customers have some form of disability the potential market for accessible transport is much larger when people with prams, injuries and less mobile and older customers are considered.

Customers travel at all times of the day and week and Sydney Metro will deliver a service to meet the needs of these customers.

What customers want?
A quality 'door to door' transport offering is critical to attract and retain customers. Sydney Metro will be applying customer centric design to deliver the Sydney Metro product. This will ensure the Sydney Metro product will be developed in response the customer's door-to-door journey and the customer experience drivers.

TfNSW's customer research has showed that there are nine key themes or aspects of public transport service delivery that meet customer needs and drive customer satisfaction: Timeliness, Convenience, Safety and Security, Comfort, Accessibility, Information, Ticketing, Cleanliness and Customer Service.

Each experience driver represents a group of individual, related service attributes, and together the nine drivers provide a high-level, holistic view of the key things that contribute to a great public transport experience.

In general public transport customers want convenient, easy-to-use environments and expect them to offer good levels of personal safety and security, comfort and cleanliness, information and accessibility.

Public Transport Customer Experience Drivers

Timeliness
Frequent and reliable services that keep to schedule, arrive on time, and offer a reasonable journey time given the distance travelled.

Convenience
Conveniently located station, stop or wharf, ease of interchange and connection between modes, plus ease of parking and drop-off.

Safety and security
Feeling safe and secure on all parts of the system as a result of physical design features, the way the service is operated and the behaviour of other people.

Comfort
Comfort throughout the journey including adequate personal space, availability and comfort of seats, a smooth journey, appropriate temperature, and other amenities where needed.

Accessibility
Ease and convenience of physical access and navigation through the system.

Information
Clear, effective, relevant communication of service information and timetables, including real-time updates on service changes and clear, easy-to-understand announcements.

Ticketing
Ease and convenience of getting and using tickets without having to queue, and confidence that the right price has been charged.

Cleanliness
A clean, well-maintained environment with clean seats, toilets and operating equipment, an absence of graffiti and litter, and availability of rubbish bins.

Customer service
Polite, knowledgeable, helpful staff who respond promptly and effectively to service requests, issues and feedback.

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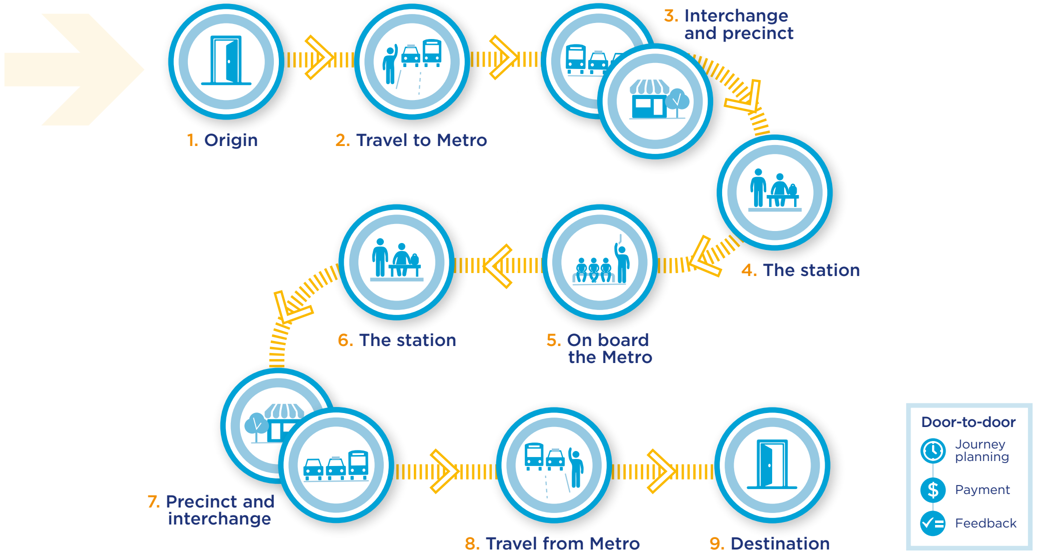
How is Sydney Metro customer-focused?
Our customers' experience of public transport is a door-to-door experience. It begins with finding out information and deciding which service to use and doesn't end until after the customer has reached their final destination (see Section 3.1.1).

Sydney Metro has applied this door-to-door design philosophy and applied journey mapping to ensure that we look at public transport from our customers' point of view; taking the time to put ourselves in their shoes and think about who they are, the transport tasks they need to achieve and the steps they go through as they use our services.

Sydney Metro is focused on making the journey experience easy for all customers. This means all customers can make their journey without any great effort and with few difficulties.



Customer environment on their door-to-door journey.
Source: TfNSW

1.6 A Commitment to Safety

Transport for NSW is committed to ensuring Sydney Metro is designed, constructed and operated in a manner that facilitates safe working and customer passage. The project will provide facilities for customers, staff and contractors that meet or exceed any required safety standards. Sydney Metro will also comply with all relevant statutory and regulatory requirements in respect of safe system design, delivery and operation.

Safety will be considered at all stages of design across all aspects of corridor and station planning, construction, operation and maintenance. In particular, the design of Metro infrastructure in the city must provide safe interfaces between stations and the existing urban environment. The safe movement of customers, staff and contractors through station areas needs to be facilitated through many aspects of physical design, including provision of adequate platform capacity and circulation space, clear routes, adequate lighting and slip resistant flooring, as well as by minimising obstructions and eliminating crush zones.

Station and station realm design will identify and reflect current architectural and engineering best practice with respect to safety. Guidelines and protocols, such as CPTED, will also be important benchmarks in minimising the risks of personal harm, operational disruption and conflict.

Construction and operational safety will be managed through a rigorous safety in design process which will identify, develop and implement safety controls, and enhance the construction, operational and maintenance outcomes.

Maintenance and asset management strategies will be adopted that reduce risk through safety auditing and reporting. Sydney Metro will have a comprehensive framework to avoid or minimise risk, and to enhance safety, without unreasonably reducing amenity and functionality.

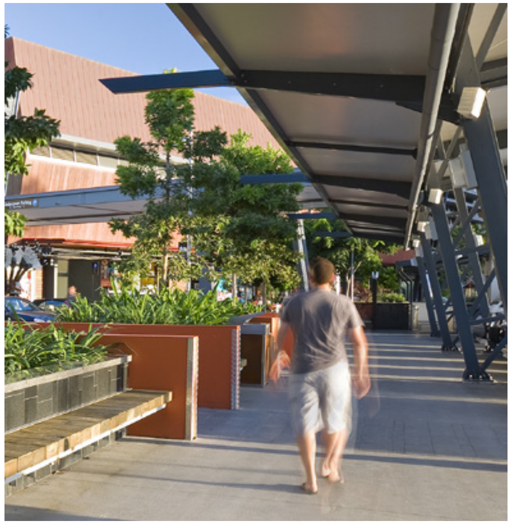
Construction of Sydney Metro Northwest.
Source: TfNSW

Sydney Metro | Chatswood to Sydenham EIS

1.7 A Commitment to Sustainability

Transport for NSW has a clear vision for Sydney Metro to achieve new benchmarks in sustainable infrastructure delivery. This means demonstrating that Sydney Metro is at the forefront of best practice, delivering environmental, social and economic improvements throughout the delivery and operational phases of the project.

This commitment is articulated through a strategic Sydney Metro objective to deliver a sustainable metro product which contributes to environmental, social and economic sustainability and the project Environment and Sustainability Policy which contains specific sustainability objectives. Sustainability objectives relevant to these design guidelines are presented in the table below.



Microclimate and customer comfort can be improved through the use of landscaping and appropriate shading.
Source: AECOM.

Governance	Demonstrate leadership by embedding sustainability objectives into decision making
	Demonstrate a high level of performance against objectives and appropriate benchmarks
Carbon & Energy Management	Improve the shift toward lower carbon transport
	Reduce energy use and carbon emissions during operations
	Support innovative and cost effective approaches to energy efficiency, low-carbon / renewable energy sources and energy procurement
Pollution Control	Reduce sources of pollution and optimise control at source to avoid environmental harm
Climate Change Resilience	Infrastructure and operations will be resilient to the impacts of climate change
Resources - Water Efficiency	Minimise use of potable water
	Maximise opportunities for reuse of rainwater, stormwater, wastewater and groundwater
Resources - Waste & Materials	Minimise waste through the project lifecycle
	Reduce materials consumption
	Consider embodied impacts in materials selection
	Maximise beneficial reuse of spoil
Biodiversity Conservation	Protect and create biodiversity through appropriate planning, management
Heritage Conservation	Protect and promote heritage through appropriate design, planning, and management controls
Liveability	Promote improved public transport patronage by maximising connectivity and interchange capabilities
	Provide well designed stations and precincts that are comfortable, accessible, safe and attractive.
Community Benefit	Make a positive contribution to community health and well-being
	Ensure community and local stakeholder engagement and involvement in the development of the project
	Contribute to the delivery of legacy projects to benefit local communities
	Optimise community benefit of residual land development

Appendix B

1.8 Structure of the Guidelines

The Design Guidelines are structured into four sections:

1. Introduction (this part)

Provides an overview of the Sydney Metro City & Southwest, the project objectives, design principles, an understanding of our customers' needs and the importance of design in meeting those needs.

2. Stations

Outlines the key contextual factors and design drivers that impact the design of the station and surrounding environment.

3. Function & Experience

Outlines the principles and design guidelines to be applied to the design strategies for stations and their interface with adjoining areas.

4. Elements

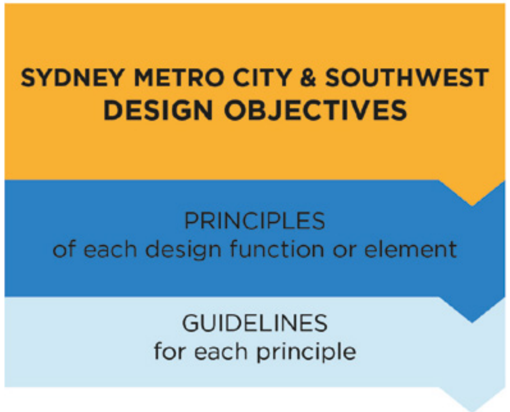
Outlines the principles and design guidelines to be applied to the elements of the new stations and their interface with adjoining areas.

Document Structure
Sections 3 and 4 are structured to include:

Relevant Design Objectives - how each design guideline relates to the project Design Objectives.

Principle - of each design guideline.

Guidelines - describes best practice design responses that address the objective.



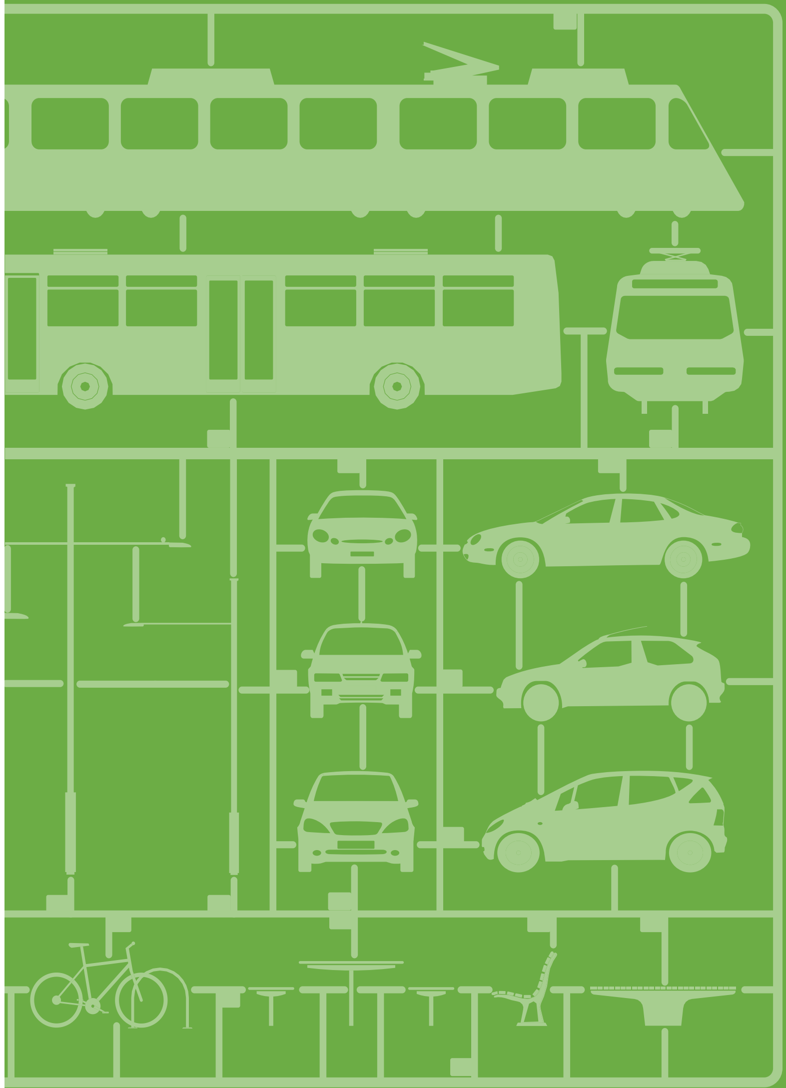
1.9 Application of the Guidelines

Review of Design
The design of Sydney Metro is subject to ongoing internal review processes to ensure the designs are developed to respond to these Guidelines. This will ensure design quality meets the needs and expectations of Sydney Metro customers and the people of NSW. These Guidelines will be kept under review through subsequent detailed design and procurement stages to ensure that they remain up to date and relevant.

The design of Sydney Metro including these Guidelines is also subject to external review by the Sydney Metro Design Review Panel. The Design Review Panel is a group of industry recognised design experts from the fields of architecture, urban design, landscape architecture, heritage and sustainability, who have been commissioned to provide independent design review periodically throughout the development of the design. They will maintain an ongoing review role in the design process for the project, ensuring that as the design of individual components develops, it delivers on the principles contained within this document.

Updating the Guidelines
These guidelines will be reviewed and updated following exhibition of the Chatswood to Sydenham EIS. The Guidelines may be augmented for the delivery stage, including application of the Guidelines in relevant contracts. The objectives and principles of this document would continue to apply in subsequent versions.

Artists rendering of Waterloo station.
Source: TfNSW



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Stations

About this Section

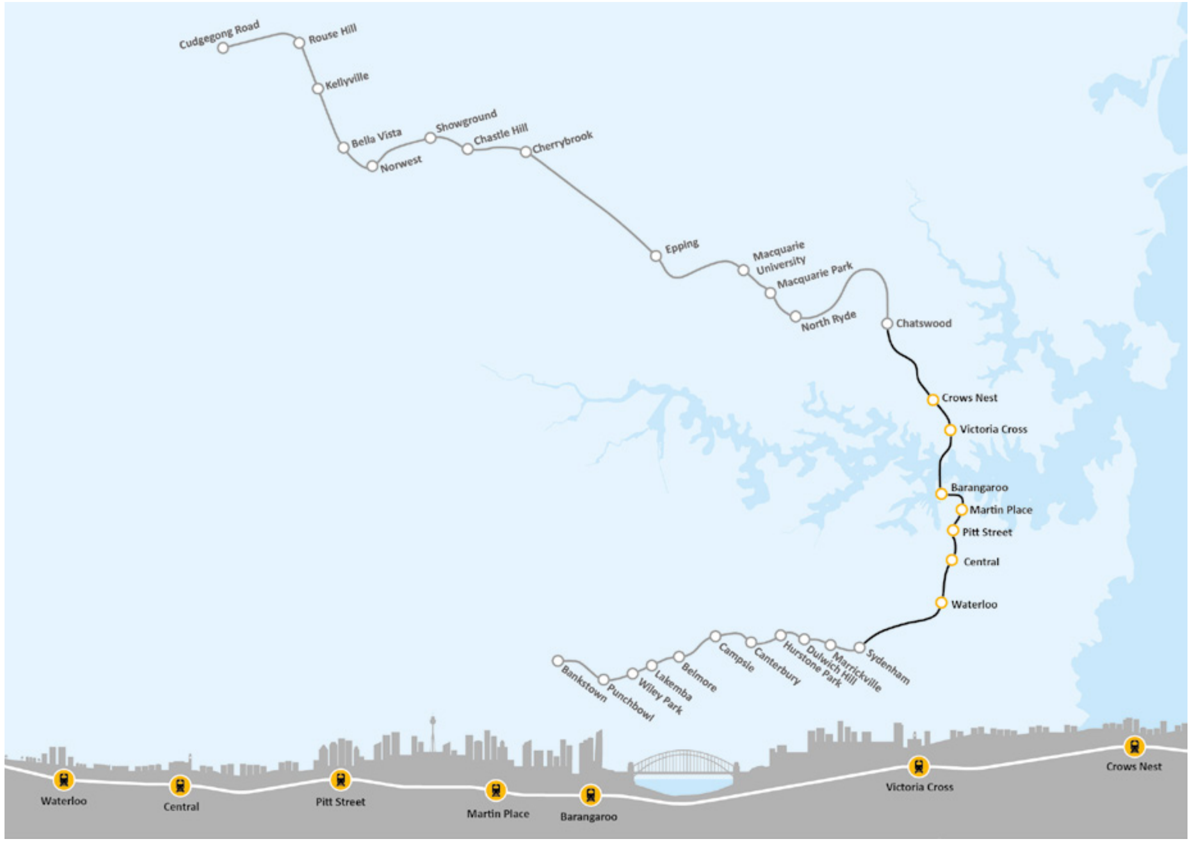
This section describes the context and functional character of the Metro stations. It acknowledges the existing conditions and urban interfaces of each station in order to inform the delivery of contextually responsive and integrated environmental outcomes.

The urban and public domain design must be developed with reference to the existing urban context and infrastructure (including built form and public domain conditions, landscape elements and existing and proposed services) as well as planned initiatives in the locality.

New metro stations are proposed at:

- Crows Nest
- Victoria Cross (North Sydney)
- Barangaroo
- Martin Place
- Pitt St
- Central Station (new underground platforms)
- Waterloo.

Key descriptors for each station are noted in this section including; centre type, primary function (e.g. origin/destination), catchment type, and Local Government Area. An outline of the transport role and function and geographical catchment of each station, including the key design drivers for the station precinct, are also set out in the following pages.



Sydney Metro alignment map

2.1 Crows Nest

Centre type: Strategic centre

Primary Function: Origin and Destination

Catchment: Commercial, residential, leisure

Local Government Area: North Sydney

Context
Crows Nest Station would be located on the western fringe of the Crows Nest village. Access to the station would be from the corner of Clarke and Hume Streets and from the corner of Oxley Street and Pacific Highway.

Crows Nest Station would support the St Leonards strategic centre as a southern gateway to commercial and mixed use activities. The station would also improve access to the restaurants and specialist shops in the Crows Nest village.

Convenient and legible links to employment and mixed use developments around Atchison and Chandos Streets are important aspects of the station context. Oxley Street is important in the urban structure as a north-south link that is relatively level and has good sight lines.

The station would provide access to a new transport mode for the surrounding residential areas. This includes the lower scale Holtermann Estate to the east and medium density and multi-unit developments on the western side of the Pacific Highway.

A service building would be located above the station box on the Pacific Highway. The station design would enable development to be built above the station with frontage to the Pacific Highway.

Key design drivers:
- Create a new transport focus on the southern side of the St Leonards strategic centre.
- Maximise legibility and connectivity with the local urban structure.
- Integrate the station with local improvement plans and make a positive contribution to the sense of place.


Clarke/Hume Streets, Crows Nest.
Source: Cox Richardson


Clarke Street, Crows Nest
Source: Cox Richardson


Willoughby Road, Crows Nest
Source: Cox Richardson


Crows Nest Community Centre
Source: Cox Richardson

Crows Nest Station Design Drivers

2.2 Victoria Cross

Centre type: Global Sydney (North Sydney CBD)

Primary Function: Destination

Catchment: Commercial, residential, education

Local Government Area: North Sydney

Context
Victoria Cross Station would be located in the northern section of the North Sydney CBD. Access to the station would be from the east side of Miller Street between Berry and Mount Streets.

The Victoria Cross Metro station would support the continued growth of the North Sydney CBD as an integral part of Global Sydney. The new station would improve customer experience at the existing North Sydney Station by relieving demand in peak times.

The North Sydney CBD is characterised by multi-storey commercial developments. A number of educational facilities including high schools and an Australian Catholic University campus are located on the north and western edges of the North Sydney CBD. The area north of Berry Street includes residential and mixed use developments.

The station design would enable development to be built above the station. The future development would have frontage to Miller and Berry Streets.

Key design drivers:
- Create a new transport focus in the North Sydney CBD.
- Contribute to the attractiveness of the North Sydney CBD by adding to and integrating with the public domain.
- Improve the permeability of the immediate station context.

Miller Street, North Sydney
Source: Cox Richardson

Miller Street, North Sydney
Source: Cox Richardson

Entrance to North Sydney station at Brett Whiteley Place
Source: Cox Richardson

Artist rendering of planned Brett Whitely Place
Source: North Sydney Times

LEGEND

- Metro station entry
- Station development site boundary
- 1 Planned - Brett Whitely Place Stage 1 and Elizabeth Plaza
- 2 Planned - Brett Whitely Place Stage 2
- 3 Under Construction - Walker Street upgrade
- 4 Planned - Denison Street upgrade
- 5 Planned - Berry Street pedestrian crossing

Victoria Cross Station Design Drivers

2.3 Barangaroo

Centre type: Global Sydney (Sydney CBD)

Primary Function: Destination

Catchment: Commercial, visitor (recreation)

Planning Authority: Minister for Planning

Context

Barangaroo Station would be located on the western side of the Sydney CBD within the Barangaroo Central precinct. Access to the station would be from within the Barangaroo Central development and Barangaroo Reserve.

The Barangaroo station would improve accessibility to Barangaroo and to the Walsh Bay Arts and Culture precinct.

The Barangaroo precinct includes office, retail, residential uses and a new casino, hotel and apartment complex. Barangaroo Central will combine civic and cultural attractions with recreational, retail and commercial uses. At the north end Barangaroo Reserve includes Headland Park, a major new waterfront public open space and new cultural centre hosting events. Barangaroo South will be home to three significant new employment towers.

Key design drivers:

- Maximise connectivity and legibility to the primary uses within and near the Barangaroo precinct including the Walsh Bay Arts and Culture precinct.
- Ensure legible and direct access to Barangaroo Reserve and surrounding development.
- Integrate with the development plans for Barangaroo.

Barangaroo Master Plan
Source: Barangaroo South

Barangaroo South under construction & Headland Park
Source: Cox Richardson

Walsh Bay Arts & Culture Precinct
Source: Timeout Sydney

Barangaroo Station Design Drivers

2.4 Martin Place

Centre type: Global Sydney (Sydney CBD)

Primary Function: Destination and interchange (rail)

Catchment: Commercial, retail, civic

Local Government Area: City of Sydney

Context
Martin Place Station would be located between Elizabeth Street, Hunter Street, Castlereagh Street and Martin Place. Access to the station would be from Hunter, Castlereagh and Elizabeth Streets and from Martin Place.

The station would serve Sydney's high-end commercial and financial district, the Macquarie Street civic precinct and the Pitt Street retail zone. A key function of the Metro station would be to facilitate interchange with the existing Eastern Suburbs and Illawarra line platforms at Martin Place station.

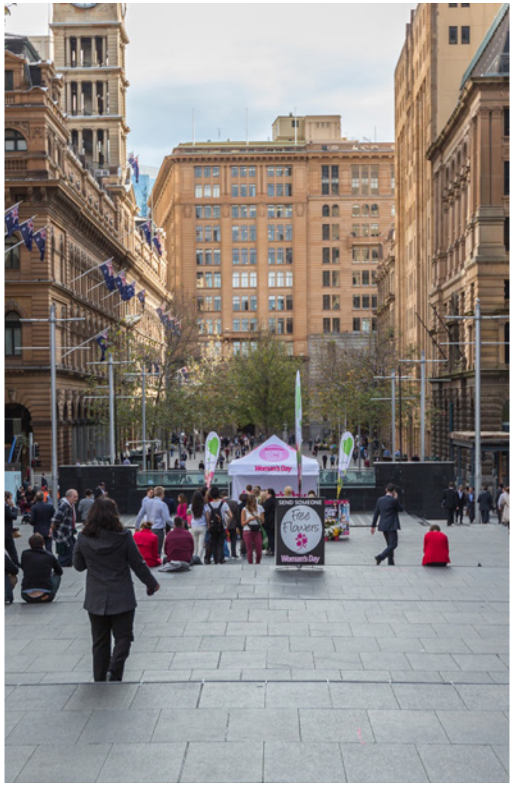
Connection to Martin Place is an important aspect of the station's context. Martin Place is one of Sydney's most recognisable civic and public spaces and a primary east-west pedestrian corridor in the city centre.

The design would enable development to be built above the station at Hunter Street and on the south side of Martin Place.

Key design drivers:
- Reflect the significance of Martin Place and status of the station by designing clear, legible, iconic, integrated entries.
- Provide generous space for customers in a busy pedestrian environment by extending the public domain into the station entries.
- Efficient interchange in the centre of the Sydney CBD through convenient, direct connections to the existing Eastern Suburbs and Illawarra line train platforms.
- Integrate with public domain and transport access improvements.

Hunter Street
Source: Cox Richardson

9 Castlereagh St, Sydney. The public domain is extended within the building's site.
Source: Cox Richardson



Martin Place
Source: TfNSW

Martin Place Station Design Drivers

2.5 Pitt Street

Centre type: Global Sydney (Sydney CBD)

Primary Function: Destination

Catchment: Commercial, retail, residential, civic

Local Government Area: City of Sydney

Context
Pitt Street Station is located in the centre of Sydney CBD within the Town Hall civic precinct. Two entries are proposed - a northern entry on the north side of Park Street to the east of Pitt Street and a southern entry on the south side of Bathurst Street to the east of Pitt Street.

Pitt Street Station would serve the retail centre of the Sydney CBD on George and Pitt Streets north and west of the station, the civic and entertainment uses on George Street south and west and the emerging southern CBD residential developments between Park Street and Belmore Park.

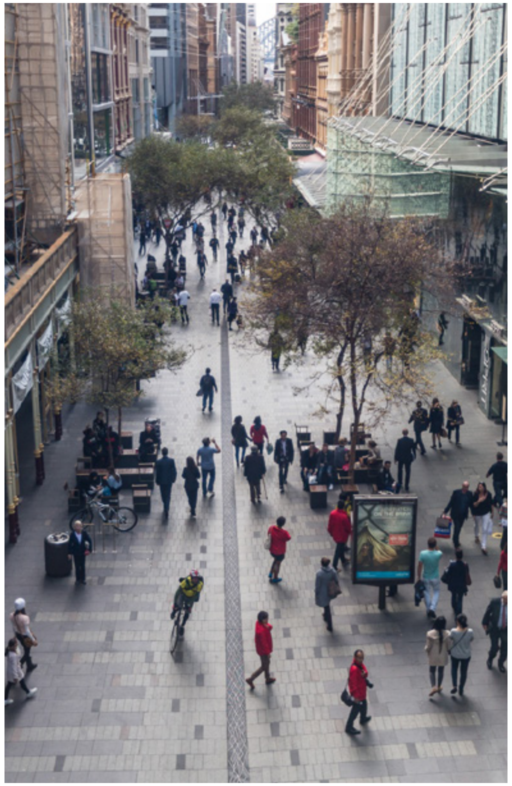
The station would facilitate interchange with Light Rail on George Street and buses on the key corridors along Park, Elizabeth and Castlereagh Streets.

The station design would enable development to be built above the station entries.

Key design drivers:
- Provide space for customers in a busy pedestrian environment by extending the public domain into the station entries.
- Integrate with the Sydney City Centre Access Strategy and other CBD planning.
- Anticipate connections to a future Town Hall Square and other nearby developments
- Extend the transport focus along Park Street, near Pitt Street.

Sydney Light Rail, George Street.
Source: TfNSW

Park Street
Source: TfNSW



Pitt Street Mall
Source: TfNSW

Pitt Street Station Design Drivers

2.6 Central

Centre type: Global Sydney (Sydney CBD)

Primary Function: Destination and interchange (intercity and suburban rail/bus/light rail/coach services/taxis)

Catchment: Commercial, education

Local Government Area: City of Sydney

Context
The proposed Central Metro Station would be located within the existing Central Station precinct. Access would be from upgraded entries at Eddy Avenue, Chalmers Street and the western forecourt.

The station would have a major interchange role with suburban and intercity trains, light rail, buses and coaches.

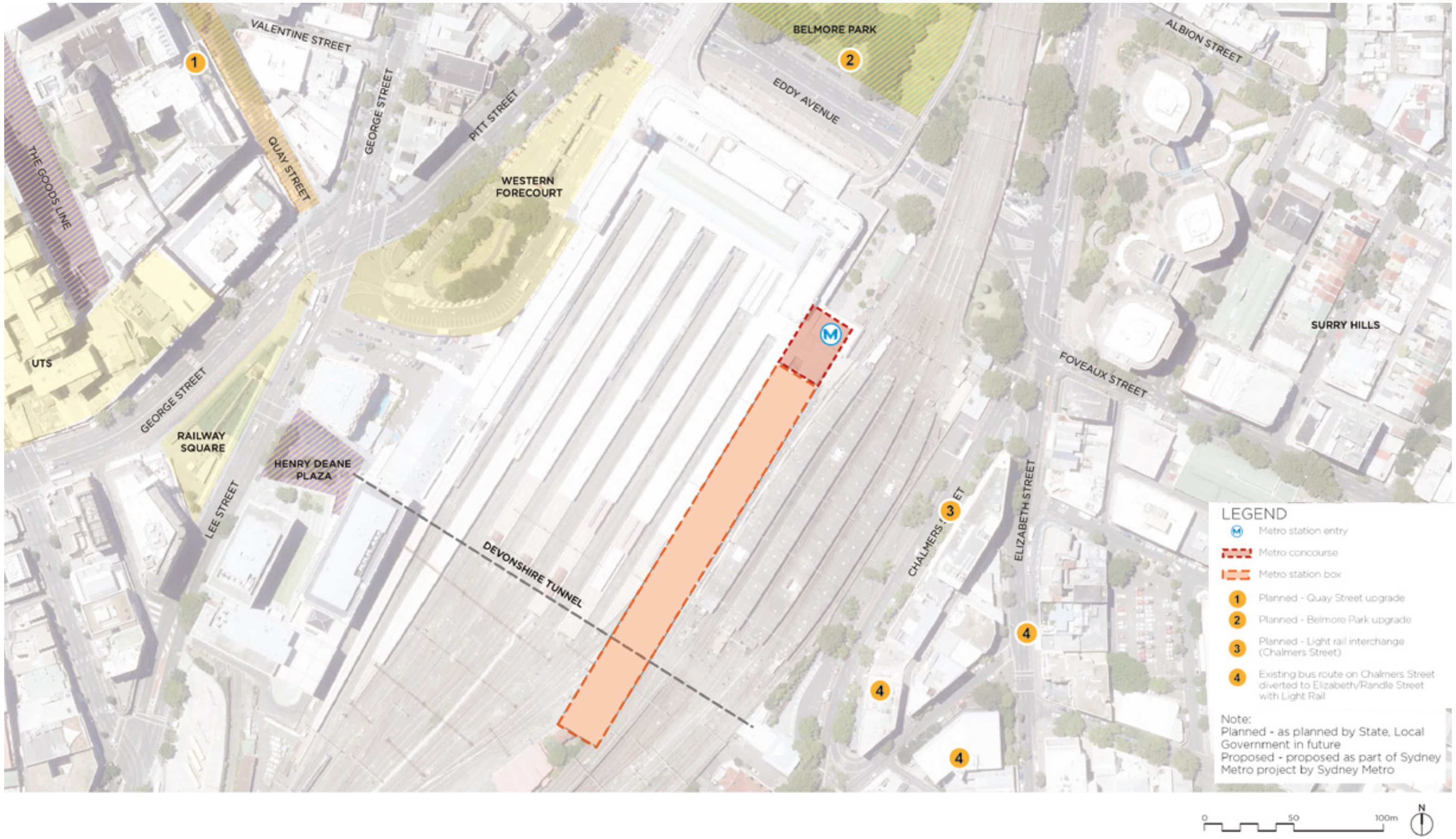
Central Station would provide access to retail and mixed use precincts in the locality including Haymarket, Chinatown, Central Park and Surry Hills and to educational facilities including the University of Technology Sydney, the University of Notre Dame, Australia and Sydney Institute of Technology.

Key design drivers:
- Provide an efficient and high quality interchange for customers to connect to other public transport services.
- Respect the heritage significance of the Central Station precinct.
- Integrate with the Sydney City Centre Sydney Access Strategy and Central Station Precinct Plan.
- Support connectivity with major land uses and developments in the locality.

Central Station, view over suburban/city platforms
Source: TfNSW

Railway Square. Central Station is a major interchange place
Source: Cox Richardson

Central Station precinct. View over Railway Square looking south.
Source: TfNSW



Central Station Design Drivers

2.7 Waterloo

Centre type: Global Sydney (Sydney CBD)

Primary Function: Origin

Catchment: Residential

Local Government Area: City of Sydney

Context

The proposed Waterloo Station would be located between Botany Road and the Land and Housing Corporation landholdings in Waterloo.

A Waterloo Station would provide the opportunity to catalyse the development and urban renewal of the Land and Housing Corporation landholdings, connect the Australian Technology Park and the residents in the Waterloo/Redfern area with Sydney Metro.

The station design would enable development to be built above the station.

Key design drivers:

- Contribute to the sense of place and public domain.
- Create a new transport focus in Waterloo.
- Integrate the station with local improvement plans and make a positive contribution to the regeneration of this new urban community.

Botany Road, Waterloo
Source: Cox Richardson

Land and Housing Corporation site with Sydney CBD beyond.
Source: Cox Richardson

Raglan Street, Waterloo
Source: TfNSW

Artists Impression of Raglan Street, Waterloo
Source: UrbanGrowth NSW

Waterloo Station Design Drivers

3

Function & Experience

About this Section

This section provides guidelines for the spatial and functional design of the urban and public domain in each station precinct, as well as the urban form of associated project development. The guidelines are articulated according to a number of core design strategies that guide the planning and design of Metro stations and their precincts. The strategies are grouped under the following family headings:

- Designing for Customers
- Identity
- Connectivity
- Development Opportunities

More detailed design guidelines and key requirements for each of these strategies will be included in the scope and performance documents during the procurement stage.

Chatswood Transport Interchange. Interchange places should be active public spaces that support a range of amenities for all users.
Architect: CoxDesignInc.
Source: COX Richardson, Photographer: John Gollings

3.1 An Easy Customer Experience

An easy customer experience is central to all aspects of the Sydney Metro design. A high quality customer transport product across the whole 'door-to-door' customer journey is critical to the customer experience. Sydney Metro will be a fast, safe, reliable, easy service for all customers.

Sydney Metro will cater to all customers including daily commuters, people with disabilities, families, visitors to Sydney and infrequent users.

The key public transport customer service design principles which underpin customer focused design are provided below.

Public transport customer service design principles

Balanced: Functional performance is balanced with customer service to achieve high levels of customer satisfaction.

Efficient, assisted service: A self-service system that is designed for easy, intuitive use. Where assistance may be required, support is available and easy to get.

Universally accessible: Meet the needs of all members of the community, accommodate the distinct needs of key customer segments.

Flexible: Able to adapt to a range of typical usage patterns and services while delivering a consistent level of service outcomes.

Legible and consistent: Reflect a service style and tone that is easily understood and consistent with the experience of an integrated transport system.

Responsive: A service system open to feedback from customers, that adjusts over time as needs and preferences change, and continuously improves.

This part of the document provides guidelines for the following areas of the customer experience:

- Door-to-Door Journey
- Customer Circulation
- Wayfinding and Legibility
- Customer Safety
- Comfort and Amenity
- Accessibility

Provide an easy experience for a diverse range of customers.
Source: TfNSW

3.1.1 Door-to-Door Journey

Relevant Design Objectives	
1	Ensuring an easy customer experience

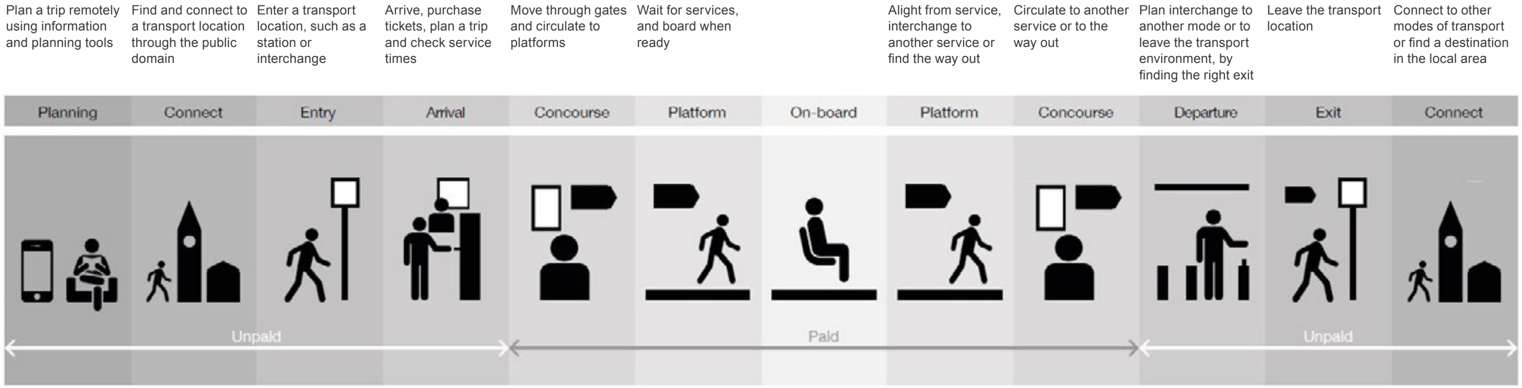
Principle

Ensure the customer experience is central to all aspects of Sydney Metro design by:

- ***Responding to customer experience drivers***
- ***Ensuring adequate space to meet peak and longer-term demands***
- ***Providing a comfortable and safe environment.***

Guidelines

- Station designs should be developed in direct response to customer segments and user requirements. Customer journeys should be understood to appreciate their various requirements for their door-to-door journey.
- All aspects of design are to address the nine Public Transport Customer Experience Drivers; Timeliness, Convenience, Safety and Security, Comfort, Accessibility, Information, Ticketing, Cleanliness and Customer Service. All aspects of design should ensure an easy customer experience.
- The design of all elements of Sydney Metro is to cater for the diversity in customers including daily commuters, users with reduced mobility, families and infrequent users.
- Facilities within stations and precincts are to be grouped and integrated to minimise clutter, promote quality design and provide a consistent and easy customer experience.
- The design should provide calm, simple and uncluttered platforms and concourses to emphasise a safe, welcoming customer environment.
- A high level of connectivity to the public domain, passive surveillance and activation to station entries should be provided.
- Minimising decisions required and level changes should be considered to design an easy customer experience.



Customer Journey Stages
Source: TfNSW

3.1.2 Customer Circulation

Relevant Design Objectives

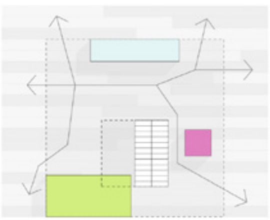
1	Ensuring an easy customer experience

Principle

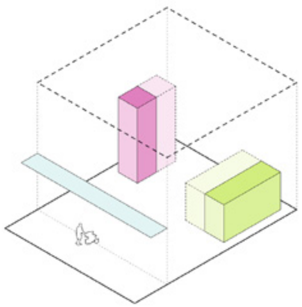
Provide adequate space to meet customer demands, including during peak periods and long-term patronage demands.

Guidelines

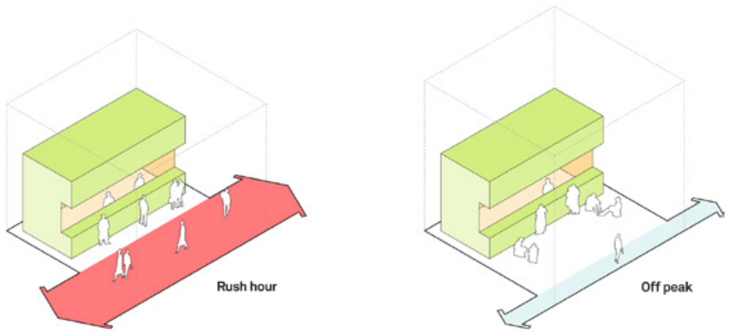
- Each part supports a different range of functions that must be addressed on station opening and in future scenarios.
- The movement capacity, configuration and spatial sequences of each of the Sydney Metro stations is to respond to patronage requirements as defined by a Level of Service (LOS) appropriate to the location and context.
- Pedestrian paths, crossings and spaces adjacent to Sydney Metro stations are to have sufficient capacity to meet potential demand with particular consideration of key decision points (gatelines, entrances, exits, customer queue zones) and information points. Where constrained, this may be met by extending the public domain into the station forecourt.
- The customer circulation paths within the station are to optimise timeliness for customers moving between concourse, platform, and station entries.
- Circulation paths are to be designed for convenience of connections into the station and from surrounding areas and other transport modes. These should reflect pedestrian desire lines as much as possible to enhance the convenience of circulation routes.
- Ancillary development and activities (retail, commercial or residential development, services areas and advertising structures) within Sydney Metro station sites are not to compromise efficient transport operations.
- All areas are to provide sufficient space for emergency access and movements in accordance with relevant design standards and legislation.



Station elements located to optimise permeability.



The effective space around each element can vary with the changing customer circulation requirements throughout the day.



Station design and capacity is to respond to primary customer flows and circulation during peak and off peak times.

3.1.3 Wayfinding and Legibility

Relevant Design Objectives	
1	Ensuring an easy customer experience
2	Being part of a fully integrated transport system

Principle

Provide intuitive, clear and consistent information and signage as well as legible, intuitive spaces to enhance customer journeys through efficient navigation and interchange. Wayfinding is to create a seamless and intuitive customer journey from origin to final destination to support an easy customer experience.

Guidelines

- Planning for wayfinding and legibility will support all customers to travel independently and easily on Sydney Metro. This is done by:
  - Anticipating the needs of customers
  - Providing the accurate information at the right time
  - Planning and creating predictable and intuitive environments
  - Applying consistent system of signs and information.
- Spaces are to be visually simple and intuitive to negotiate, to contribute to an easy customer experience. This is done by:
  - Providing visibility between station levels where possible
  - Using intuitive design to minimise wayfinding choices and the need for signage
  - Providing safe, legible, efficient, convenient, obstruction free, level, direct and attractive routes for customer access
- Wayfinding signage and information is to be provided in accordance with the TfNSW guidelines. Ensure consistency with TfNSW signage.
- Customers are to be provided with wayfinding and information when they are:
  - Interchanging between services or modes.
  - Connecting to and from public transport by walking, cycling, catching a taxi, being dropped off or picked up in private vehicle or parking in their car.

Town Hall Station. Wayfinding signage enables easy navigation and interchange.
Source: TfNSW

Macquarie Park Station design provides a high level of visibility between concourse and platform level to aid wayfinding and legibility.
Architect: Hassell
Source: TfNSW

3.1.4 Comfort and Amenity

Relevant Design Objectives

1	Ensuring an easy customer experience

Principle

Provide a comfortable customer environment that provides sufficient personal space and amenity and is well lit with effective and appropriate microclimate amenity for all users.

Guidelines

- Station entry orientation and design are to minimise adverse micro climate effects including wind tunnel impacts.
- Customer weather protection outside Sydney Metro stations is to be provided to ensure good levels of customer comfort are maintained and to provide useable spaces at ground level.
- A range of customer facilities and amenities is to be provided to grow patronage by making public transport a more attractive choice.
- A high level of amenity and security in customer waiting areas is to be provided to positively influence patronage and perceptions of the public transport system.
- Waiting areas, pedestrian walkways and cycle ways are to have adequate shade and day and night time lighting, while minimising energy consumption, providing an appropriate balance between sun access in winter and shade in summer.
- Minimise urban heat island effect through light coloured finishes, roofs and pavements, green walls, roofs, plantings and shade trees.

Chatswood Transport Interchange. Waiting and circulation areas outside the station entry are weather protected and have a high level of amenity and customer facilities.
Architect: CoxDesignInc.
Source: Cox Richardson, Photographer: John Gollings

9 Castlereagh Street, Sydney. Landscaped spaces provide shade in waiting areas.
Architect: Harry Seidler & Associates.
Source: Cox Richardson

3.1.5 Customer Safety

Relevant Design Objectives

1	Ensuring an easy customer experience

Principle

Ensure stations and precincts provide a safe and secure environment for customers and also contribute to the overall public safety of urban places throughout the day and night.

Guidelines

General

- Safety issues are to be embedded in the design development process and optimised through the application of relevant Crime Prevention through Environmental Design (CPTED) principles and guidelines.
- Operators are to be consulted to advise on issues such as lighting, lines of sight and CCTV, based on their network experience.
- Integrated CCTV systems must be provided at entry and exits, stairways, ramps, bridges, tunnels, lifts, ticket office and vending machines, emergency help points, public telephones, waiting and seating areas in accordance with Australian Standards and Sydney Metro requirements.
- Vandal-resistant fittings and fixtures are to be used throughout.

Public Domain

- An initial CPTED review of station precincts is to assess activity generators, edge effects, movement predictors, conflicting user groups, crime hotspots, the 'displacement phenomenon' and building elements
- All public domain areas are to be planned with guidance from CPTED experts, adopt a risk prevention design approach and eliminate entrapment and concealed space opportunities.
- A Crime Risk Assessment audit must be applied to the precinct design to ensure that all precinct areas comply with CPTED guidelines.

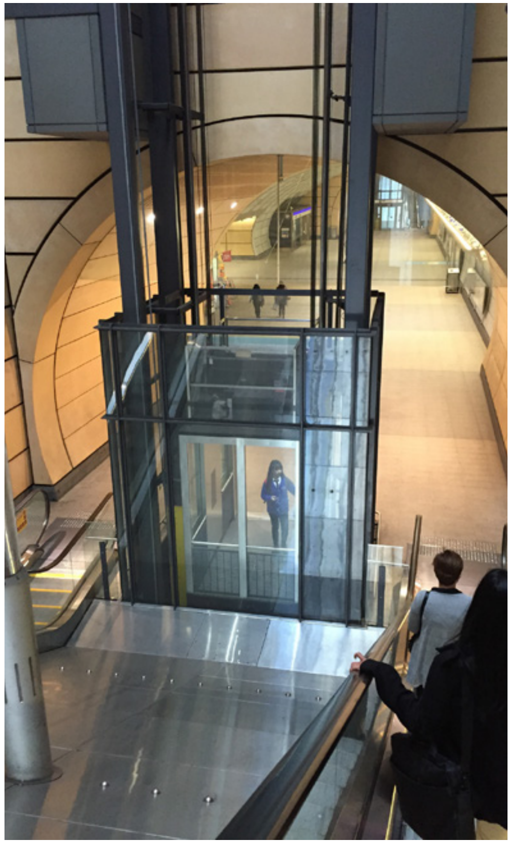
Chatswood Transport Interchange, NSW. Design of the public domain enables passive surveillance with clear sight lines through the station areas. Architect: CoxDesignInc.
Source: Cox Richardson

Stations

- The station design is to incorporate CPTED strategies:
  - Eliminating hidden spaces, recesses or voids that could provide a person with the ability to conceal themself or others from general view.
  - Secured stations out of operating hours and during emergencies.
  - Ticket Vending Machines (TVMs) positioned to allow surveillance.
  - Minimising inadvertent or intentional access to hazardous or unauthorised areas of the station.
  - Physical barriers to minimise the risk of trespass or self-harm by station users.
  - Protective screening to elevated walkways and concourse areas particularly where persons traverse above or immediately adjacent to the rail corridor.
  - Glazed lift car and lift shaft enclosures to maximise visibility and safety.
- Station designs are to support visible staff presence as close as possible to customer movement and decision making zones to enhance customer safety.
- The stations are to be designed to minimise obstructions and projections, providing clear routes for customers.
- Station designs are to eliminate crush zones and provide equipment at safe and accessible locations.

Help Points

- Help points should be easily identifiable, accessible components integrated into station cladding systems
- Help point enclosures should be integrated with the surrounding wall or equipment cabinet.



Macquarie Park Station, NSW. Glass sided lifts enable passive surveillance and sight lines through to the concourse.
Architect: Hassell
Source: Cox Richardson

3.1.6 Accessibility

Relevant Design Objectives

1	Ensuring an easy customer experience
2	Being part of a fully integrated transport system

Principle

Ensure the stations and associated spaces are safe, efficient, universally accessible, legible and easy for customers and pedestrians.

Guidelines

- Stations and precincts are to be easy, safe and accessible for all to use including the elderly, customers with disabilities, young children and those with prams and luggage.
- As far as possible, pedestrian pathways are to be obstacle and step free to maximise access for all customers. Where the use of stairs cannot be avoided, then they must be easy and safe to use.
- Where obstacles to universal access are unavoidable, clearly legible alternative routes must be provided as close as possible to the main travel path.
- Where the use of stairs is unavoidable, clearly legible, alternative accessible circulation routes are to be provided. These alternatives are to be as close as possible and not isolated from the primary circulation route.
- Where lifts and escalators are provided as an alternative to stair access they are not to result in a longer journey than the primary circulation route or compromise the safety of customers who need to use them.
- Ramps may provide opportunities for universal access; however, where possible, seek alternative means of effecting level changes, for example, by altering the path of travel.
- All facilities, furniture and fixings must be designed to be accessible to all customers. Accessible and ambulant toilets must be provided.
- Priority seats and adequate space should be provided in waiting areas and groups of seating to accommodate the elderly and customers with disabilities and prams.
- Information must be provided throughout the customer journey that considers user impairment, culture and language.
- Equivalent service and safety information must be provided for customers with disabilities in their preferred accessible format.
- Public transport information should be provided across a range of multimedia technologies including mobile phones, audio and visual and tactile signage, assisted listening for the hearing impaired and near field technologies to optimise accessibility for all users.
- The use of international icon protocols, colour coding and other graphic devices should also be considered to minimise the use of text-based signage and language difficulties.
- Comply with Disability Standards for Accessible Public Transport.
- All Metro service elements must comply with the Disability Discrimination Act 1992 and associated Public Transport and Premise Standards.

Universal access must be provided to all stations and precinct facilities.
Source: San Francisco Municipal Transportation Agency

Universal access must cater to customers with a wide range of disabilities.
Source: TfNSW

3.2 Identity

For a project of this importance it is imperative that the design delivers not just on the project objectives but provides an architectural and urban design experience that connects with the city and its diverse communities so that they embrace and identify with the project, the rail line and the opportunities it unlocks.

All of the public transport infrastructure is public space, so internal and external spaces of the stations are public realm. Having a consistent theme binds the internal and external areas integrating paid and unpaid areas and helps the station to integrate within its local context. The station entrances need to engage with their local context to create welcoming landmarks in the urban environment.

A major design objective is the achievement of a 'whole-of-corridor' identity for Sydney Metro. In this respect the design strategies in this section all contribute to the character, appearance, accessibility and function of the stations and their surrounding precincts. A unified approach can be fostered through adherence to common strategies for buildings and structures, finishes, accessibility and legibility that respond to local contexts while forming part of a 'whole-of-corridor' identity.

This part of the document provides guidelines for the following areas of creating a Sydney Metro identity:

- Network and Station Legibility
- Place Making
- Heritage & Archaeology
- Environment & Sustainability
- Art
- Lighting

Southwark Station, London. Station spaces are designed as distinctive, high quality public domain.
Architect: MPJ Architects
Source: MPJ Architects

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3.2.1 Network and Station Legibility

Relevant Design Objectives

1	Ensuring an easy customer experience
2	Being part of a fully integrated transport system
4	Being responsive to distinct contexts and communities

Principle

Create a line-wide identity for the Chatswood to Sydenham project that is recognisably part of the Sydney Metro network while enabling elements of station design to respond to context, character and environment to create locally distinctive sustainable outcomes.

Guidelines

- A line-wide identity is to be established through the architectural language and layout of the station types (cut and cover, single cavern, binocular cavern).
- The architectural language and elements of the transport infrastructure and stations are to form a line-wide design that reinforces the Sydney Metro identity within the broader transport network.
- The stations are to maintain a coherent identity with consideration of:
  - Network identity
  - Line-wide identity
  - Station-specific local identity.
- Station buildings, service facilities, public domain elements and component elements are all to form part of the identity and project an image which evokes a modern, contemporary and efficient transport system providing an attractive, comfortable, safe and inspiring customer environment, while also responding to the local context and environment.

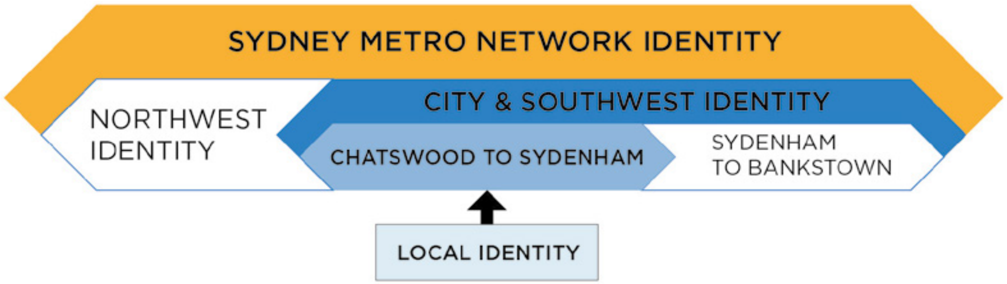

Diagram highlighting the various layers of identity that should be considered in the design.

Kings Cross Station, London. Clear signage contributes to network and station legibility. The architectural quality of the space creates an attractive place for customers with a local identity.
Architect: John McAslan + Partners
Source: Cox Richardson

3.2.2 Place-making

Relevant Design Objectives	
1	Ensuring an easy customer experience
3	Being a catalyst for positive change

Principle

Create welcoming, secure and well maintained public domain spaces and station buildings with an attractive 'sense of place'.

Guidelines

- Stations and associated spaces are to promote a welcoming image or identity that reinforces a positive sense of place.
- Station plazas are to be designed as an extension of the internal station environment providing shelter, comfort, safety and security for customers, and contributing positively to customer journey experiences. These spaces are to reflect the local public realm context and character.
- The enhancement of station spaces can be achieved by introducing a range of uses, services and facilities such as retail, food and beverage, shade trees, landscaping and public art.
- Create public spaces which allow for spontaneous uses and activities by their occupants.
- Use opportunities to facilitate active uses and informal recreation.
- Consider opportunities for temporary event, pop ups, retail spaces and the night time economy.
- Station public spaces are to be designed with a consistent hierarchy of landscape treatments. The treatment of these spaces is to reflect local character and context, integrate within their settings, and provide attractive space and streetscapes.
- Fixtures, including furniture and lighting, are to enrich site context and sense of place and contribute to wayfinding.
- A coordinated lighting approach is to create aesthetic consistency across Sydney Metro by defining station address, public domain areas and attracting customer into station forecourts and plazas.
- A positive precinct image is to be developed around the particular heritage values of a place or by the qualities of the existing urban context.

'Solar Tree' St John's Square, London
Artist: Ross Lovegrove
Source: Ross Lovegrove

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3.2.3 Heritage and Archaeology

Relevant Design Objectives

4	Being responsive to distinct contexts and communities
5	Delivering an enduring and sustainable legacy for Sydney

Principle

Ensure elements and items of heritage significance are appropriately managed and respected. Identify opportunities for heritage conservation to contribute to the celebration of local identity in station design.

Guidelines

- Sydney Metro is to be fully integrated within, and sensitive to, its heritage context. This includes built and natural heritage, European and Indigenous archaeology and may include places, buildings, works, relics, moveable objects or precincts.
- Where Sydney Metro intervenes in or interfaces with heritage places (such as Central Station or Martin Place), design excellence is to be sought to support inventive, interpretive and contemporary responses to the heritage values of that place.
- Where appropriate, the design of the rail corridor and station precincts are to integrate and conserve existing heritage items and mitigate any negative impacts.
- New work is to be based on an understanding of the heritage significance of heritage items, heritage conservation areas and places and is also to take into consideration:
  - Siting - including urban grain, streetscape rhythm, setbacks, orientation and address of buildings, location of boundary walls, key views, significant natural features and archaeological remains,
  - Scale - including wall and floor to floor heights, modulation and façade rhythms, massing, density, proportions, relationship to ground plane, wall modulation including openings and roof planes,
  - Form – including proportion and number of openings, solid to void ratios, roof form, skyline and relationship between internal and external spaces,
  - Materials and colour – giving consideration to characteristic materials, textures, colours, light and shadow,
  - Details – creating complementary relationships between new and old elements to provide visual interest.
- Consideration is to be given to integrating heritage interpretation with Public Art.
- Retaining or interpreting heritage fabric is to be viewed as a means of defining local identity.
- For new underground stations, archaeological material, features and deposits may need to be considered.

Newtown Station, Sydney. Heritage interpretation.
Architect: NSW Government Architects Office/Caldis Cook Group.
Source: TfNSW

St Pancras Station, London. Heritage building has been enhanced to accommodate new rail requirements.
Architect: Alistair Lansley
Source: Visit London

3.2.4 Environment and Sustainability

Relevant Design Objectives

5	Delivering an enduring and sustainable legacy for Sydney

Principle

Ensure best practice sustainable design solutions are adopted for the public domain, stations and buildings, to minimise environmental impacts and benefit customers and local communities.

Guidelines

- Achieve a high level of performance using sustainable design rating systems.
- Adopt energy efficient and low carbon design solutions that minimise the carbon intensity of the project.
- Incorporate passive design solutions to optimise solar access, introduce daylight, and maximise natural ventilation.
- Harness both direct and indirect daylight to minimise energy consumption in lighting, while creating a light and airy ambience in stations and surface buildings.
- Utilise energy efficient lighting and lighting control systems.
- Ensure resilience to climate change, by incorporating climate change adaptation measures which respond to weather extremes, including flood risk, and temperature increases.
- Provide a positive journey experience in station precincts by protecting users from the potential negative impacts of extreme weather.
- Ensure designs respond to the local microclimate and incorporate opportunities to reduce heat island effects, including (as appropriate) light coloured finishes, roofs and pavements, green walls or roofs, plantings, and shade trees.
- Include integration of renewable energy sources at stations and in the public domain where feasible.
- Consider water efficiency in design, utilising water from recycled sources where appropriate.
- Opportunities for collection, treatment, storage and reuse of rainwater from station roofs, canopies and other surfaces are to be considered where practicable within the urban environment.
- Water Sensitive Urban Design (WSUD) initiatives are to include an integrated and site-responsive range of design solutions, influenced by urban design considerations and be adaptable into the future.
- Minimise materials consumption, and reduce embodied energy and impacts in materials selection.
- Prioritise reuse of materials, use of recycled materials, and selection of materials from sustainable sources.
- Use durable, climate resilient, long life, healthy, low maintenance materials.
- Minimise materials consumption, and reduce embodied energy and impacts in materials selection.
- Maximise opportunities for beneficial reuse of spoil in landscape features and other uses.
- Provide noise control measures to ensure appropriate and comfortable acoustic conditions for users.
- Minimise waste through efficient design and material selections.

Central Park, Sydney. Landscaped facade treatment helps cool the microclimate.
Architect: Jean Nouvel
Source: Cox Richardson

3.2.5 Art

Relevant Design Objectives	
1	Ensuring an easy customer experience
4	Being responsive to distinct contexts and communities

Principle

Ensure public art is integrated within the design of stations and other corridor structures to aid place-making and to enhance local amenity and celebrate local character.

Guidelines

- Public art is to be a key feature of the customer experience, bringing joy to customers and adding value to the operation and success of Sydney Metro by contributing to station identity, beauty, amenity, wayfinding, safety, security, community values and the public domain.
- Public art is to be integrated into the station and building designs to enliven and enrich the public realm and contribute to a sense of place.
- Public art is to be integrated but separate from the architecture, budgeted and managed from the architectural scope.
- The design and location of art works is to be coordinated within the broader urban context of city stations and be reflective of the distinctive character of each place.
- Artworks are to contribute to the cultural identity of precincts and neighbourhoods and are to be developed in consultation with the local community and stakeholders.
- Maximise community involvement/representation/ownership in public art.
- Art works must be located to support the safe intermodal function of precincts around Metro stations.
- In station concourse and precinct areas, appropriate integration is required of permanent artworks with station wayfinding, information and other customer amenities.

Artwork may also be incorporated into the public realm as part of a building element.
Artist: Bronwyn Bancroft.
Source: TfNSW

Georg-Brauchle-Ring Station, Munich U-Bahn, Germany. Artwork on the trackside walls gives the station a distinctive identity and facilitates wayfinding.
Artist: Franz Ackermann
Source: Wikipedia

3.2.6 Lighting

Relevant Design Objectives

1	Ensuring an easy customer experience
4	Being responsive to distinct contexts and communities

Principle

Ensure a coordinated approach to lighting that responds to the local context, addresses CPTED and operational requirements and provides feature lighting representative of the Sydney Metro image. Use light to enhance station built form and corridor landscape, whilst delivering functional lighting and creating a safe and high quality experience for all users.

Guidelines

General

- Lighting is to integrate with access, wayfinding and public art strategies.
- Lighting is to reinforce the visibility of station entries as safe and welcoming elements within the local context at night.
- Illumination levels are to be appropriate to the task, be it wayfinding, reading tasks and facial recognition, while creating visual interest within the stations.
- Glare and visual discomfort is to be eliminated through appropriate specification and positioning of luminaires.
- The number of luminaires is to be minimised to aid maintenance and sustainable aspirations.
- A coordinated lighting approach is to provide aesthetic consistency across Sydney Metro by defining station address, public domain areas and attracting customers into station precincts.
- Provide market leading energy efficient lighting and lighting control systems.

Public Domain

- Lighting at station precincts and facilities must provide a safe, secure, legible and comfortable environment for all operators and users.
- Provide public space lighting to facilitate diverse uses including night time use of public spaces.
- Station precincts are to be defined by the application of an iconic, consistent, multi-functional pole and luminaire system, as for example at Epping to Chatswood Rail Line stations in Sydney.
- To eliminate unnecessary clutter, lighting must be coordinated with all other public domain elements.
- Lighting within station precincts is to celebrate the station address and pedestrian links with lighting systems that are of an appropriate scale, different to that which defines the precinct streets and street frontages.

Stations

- Lighting is to complement the architectural design and seek to provide an appropriate balance of artificial and daylight.
- Natural light is to be maximised and artificial lighting is to support natural light levels.
- Protection from intense sun penetration is to be provided.

Britomart Transport Centre, Auckland. Lighting is designed to provide a safe, legible and comfortable environment for customers and users.
Architects: Mario Madayag & Jasmax
Source: Opus

Westfriedhof Station, Munich. Coloured light in station platform
Lighting Designer: Ingo Maurer
Source: Unframed World

3.3 Connectivity

Safe and convenient connections to and from Sydney Metro stations are an important part of an easy customer experience. Connectivity between different transport modes including walking, cycling, rail, light rail, buses, taxis and kiss and ride, must be legible and easy, acknowledging that Sydney Metro is part of an integrated transport system.

A modal hierarchy that prioritises pedestrian connections has been established to guide the Sydney Metro design and ensure the safety and wellbeing of customers and users of the station environs.

The design of the Sydney Metro stations and station precincts must facilitate safe, welcoming intuitive and accessible connections between transport modes. This part provides guidelines for the following:

- Interchange
- Pedestrian Movement
- Bicycle Movement
- Vehicular Interface

Signage supports connectivity between different modes, and provides customer information to assist trip planning.
Source: TfNSW

3.3.1 Interchange

Relevant Design Objectives	
1	Ensuring an easy customer experience
2	Being part of a fully integrated transport system

Principle

Provide an efficient, safe transport service that is part of a fully integrated and accessible transport system.

Guidelines

- Station planning and design is to acknowledge Sydney Metro forms part of an integrated transport network that includes a hierarchy of movement modes:
  - Priority 1: Pedestrian, wheelchair and pram movement and access
  - Priority 2: Bicycle movement and access
  - Priority 3: Other primary Public Transport services (including Light Rail and Bus movement and access)
  - Priority 4: Taxi movement and access
  - Priority 5: Kiss and ride movement and access
- Station Precinct planning is to support good access to and between public transport modes for all customers, with connections designed to support efficient and timely interchange for customers.
- Integration of station precincts with the surrounding urban structure is to facilitate cross and through movements, enhancing precinct permeability and access to the transport interchange functions of the locality.
- The stations are to provide a safe, welcoming, intuitive and accessible environment for customers transferring between transport modes.
- Station design is to minimise movement conflicts for customers between key transport modes.
- Station forecourt areas to accommodate adequate customer access and waiting spaces (as relevant), while ensuring that customer confidence, sense of safety and wellbeing are not compromised.
- The varying spatial requirements of different transport modes, including third party operators, are to be accommodated to avoid user conflicts.
- Provide point of decision wayfinding signage to facilitate walking and cycling choices.
- Consider the Sydney City Centre Access Strategy when planning for transport and interchange functions around stations.

Station modal access hierarchy
Source: TfNSW

3.3.2 Pedestrian Movement

Relevant Design Objectives	
1	Ensuring an easy customer experience
2	Being part of a fully integrated transport system

Principles

Provide pedestrian connectivity between transport modes that is safe, efficient, accessible, legible and enjoyable.

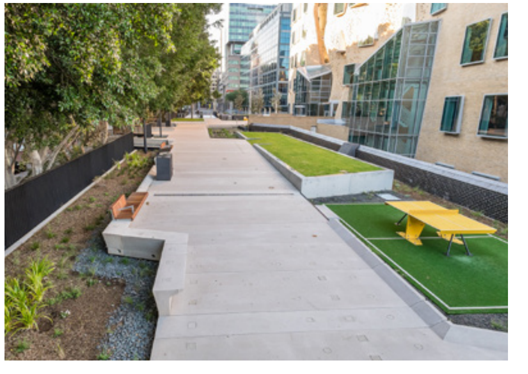
Provide pedestrian movement systems that clearly connect the stations with their surrounding locality.

Ensure the vertical journey is a core element of the station architecture and provides step free access between the street and the platforms as it is integral to the station's design and has a major influence on the function and visual impact of the station environment.

Guidelines

- The station forecourt and associated areas are to adopt a clear hierarchy of movement functions that favour pedestrians ahead of vehicular circulation, thereby promoting opportunities for public transport patronage, walking and cycling.
- Station precincts are to provide pedestrian routes that connect people with places they want to go and provide clear sightlines through open, uncluttered spaces along pedestrian desire lines between key destinations.
- Pedestrian movements are to accommodate an appropriate level of service in all areas of the station. Precinct designs are to optimise the variety of movement functions in order to minimise potential conflicts.
- Circulation systems are to respond to context and reinforce the character of precincts so they are easy and efficient to navigate.
- Design decisions affecting movement planning are to consider varying customer usage patterns including commuters, customers with disabilities, station employees, tourist customers and non-travelling visitors.

Wide, clear footpaths enable people to stop and wait without obstructing pedestrian movement flow.
Source: TfNSW



The Goods Line, Sydney. Design walkable attractive places with high visual amenity. Circulation systems that respond to context and reinforce the character of precincts should be easier to navigate and therefore more efficient.
Architect & Landscape Architect: CHROFI & Aspect Studios
Source: TfNSW

3.3.3 Bicycle Movement

Relevant Design Objectives

2	Being part of a fully integrated transport system

Principle

Prioritise bicycle movement consistent with the modal access hierarchy by providing optimum connectivity and convenient, secure and accessible bicycle parking at stations to accommodate current and future demands.

Guidelines

- Bicycle paths to/from stations are to be connected with regional and local government bicycle networks, existing and future.
- Bicycle infrastructure is to be responsive to the specific characteristics of each station precinct, address the bicycle network and storage requirements, and integrate them into the broader precinct movement networks.
- The design of bicycle paths and routes connecting directly to/from stations is to be legible, with a distinct and identifiable character and be safe for cyclists and other users.
- Access to bicycle networks is to be easy, enabling the comfortable flow of bicycle traffic.
- Conflicts between pedestrians and cyclists at stations are to be designed out, particularly at high activity zones such as station entries and retail areas.
- Provide convenient, safe, secure bicycle storage facilities, with good natural surveillance and weather protection, connected to existing cycle ways.
- Sheltered and secure bicycle parking at stations is to be placed directly adjacent to movement paths to provide clear and legible access, without compromising safe, accessible paths of travel for customers with mobility and vision impairment.
- Design for bicycle facilities is to give priority to bicycle safety at road interfaces.
- Integrate with the directions established in Sydney's Cycling Future.

Attractive, secure, weather protected bicycle storage.
Source: Sydney Cycleways.

Provide for people with bicycles throughout the intermodal connections.
Source: TfNSW. Copyright: Glenn Duffus Photography

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3.3.4 Vehicular Interface

Relevant Design Objectives	
2	Being part of a fully integrated transport system

Principle

Establish a legible hierarchy of safe vehicular streets that respond to the varying customer and operational requirements for vehicular, bicycle and pedestrian movements in accordance with the modal hierarchy.

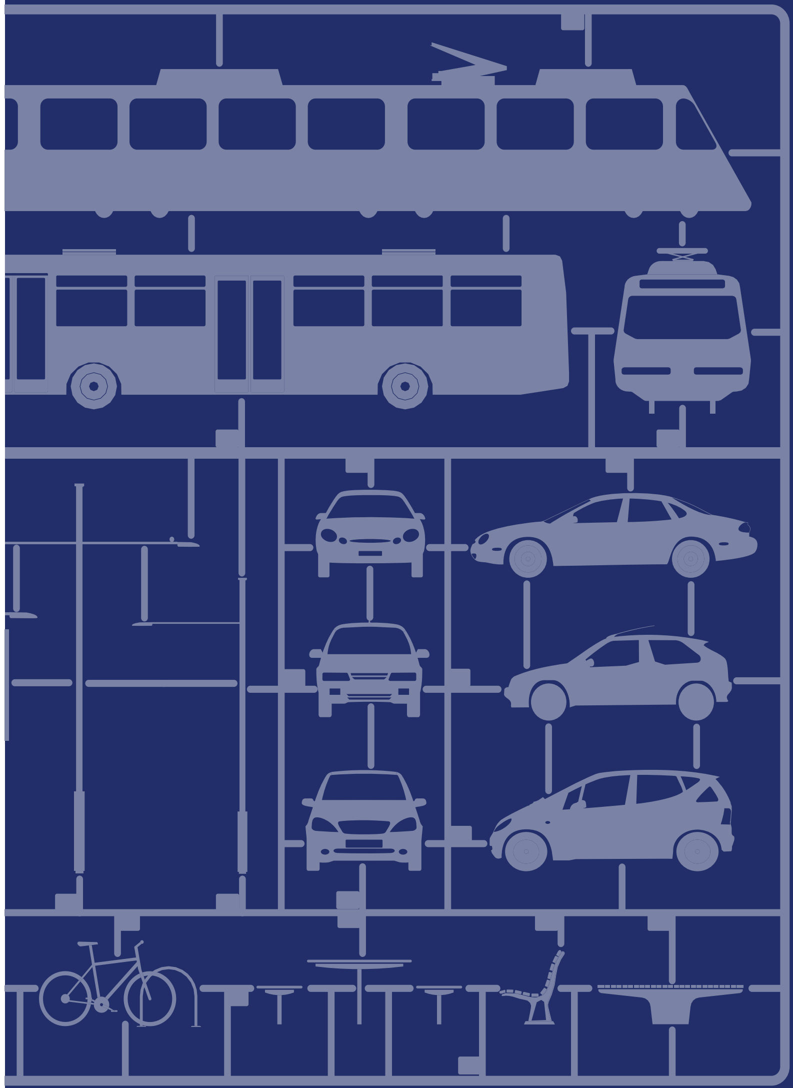
Guidelines

- The design of stations and associated urban realm is to respond to the character of established streets and variations in carriageway width, on-street parking, existing and planned future cycle ways, street tree planting and pedestrian amenity.
- Modifications to existing roads are to consider:
  - Agreed adjustment of existing roads with relevant authority
  - Number of traffic lanes
  - Length and type of slip lanes
  - Intersection types and configurations Signalling requirements
  - Speed environments, traffic calming measures
  - Kerbside zones
  - Cycling
  - Footpaths
  - Crossings
- Changes to streets, footpaths and bicycle paths are to contribute to the quality and character of the urban area, and will heavily influence customer experience.
- Vehicular traffic planning is to be integrated with the built form and spatial planning of precincts.
- Consider the Sydney City Centre Access Strategy in planning for vehicular movement around stations.
- Provide for bus stops close to the station in accordance with the modal hierarchy, bus movements where buses operate on streets adjacent to station entries and safe and accessible paths to bus stops.
- Consider the need for secure electric bike/scooter and motorbike parking spaces. Consider locker provision at stations to cater for storage of electric scooters, electric bicycles, and batteries, and charging of personal electric transport.
- Taxi and kiss and ride spaces are to be located in accordance with the modal hierarchy.
- Service vehicle access for all precinct functions is to be addressed as part of the broader station precinct movement strategies.

Note - further guidelines on Service Vehicle Access are set out in Section 4.3.7

Sydney. Dedicated bicycle and bus lanes.
Source: TfNSW

Sydney City. Designated taxi pick up zones.
Source: AECOM.



4

Elements

About this Section

This section provides guidelines for developing the detailed elements of the urban and public domain around and within stations including connecting customer areas through station entries.

The guidelines for the design elements in this part of the document are arranged according to the following three topics:

- Stations
- Urban Realm
- Operational and Services

More detailed design guidelines and key requirements for each of these elements will be included in the scope and performance documents during the procurement stage.

Sculptural plant extraction vents at One Shelley Street, Sydney.
Artist: Anton James
Source: TfNSW

4.1 Stations

The Sydney Metro stations are part of a wider system requiring consistency between station planning, operations and architecture. Each station will take on a unique identity that relates to its locality, expressed through the station design. The interface between the station and surrounding context is critical in providing an integrated and legible transport system that is easy for the customer to use.

The design of each station must be framed around the benefits to or impacts upon the customer experience. Station entries, platforms and circulation elements must be designed to meet operational requirements while ensuring an easy customer experience. Stations are public buildings and all circulation elements, finishes and fittings must be of a robustness and quality associated with outdoor public spaces as well as suitability for the rail environment.

This part provides guidelines for the following station elements:

- Station Typology
- Station Entries
- Platforms
- Circulation Elements
- Flooring
- Internal Walls and Ceilings

Macquarie Park Station. Clear sightlines and uncluttered spaces provide a safe and welcoming customer environment.
Source: TfNSW

4.1.1 Station Typology

Relevant Design Objectives

1	Ensuring an easy customer experience
2	Being part of a fully integrated transport system
5	Delivering an enduring and sustainable legacy for Sydney

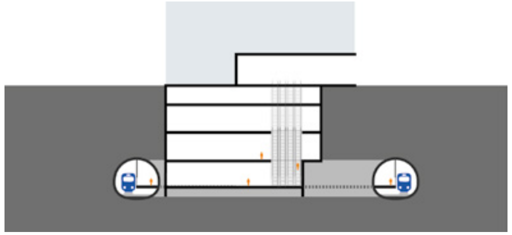
Principle

The designs are to provide consistency between station planning, operations and architecture across the differing station typologies that will be adopted between Chatswood and Sydenham. There will be three principal typologies that relate to their construction type:

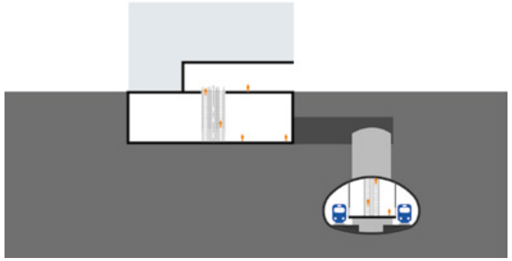
- ***Cut and cover***
- ***Single cavern***
- ***Binocular cavern***

Guidelines

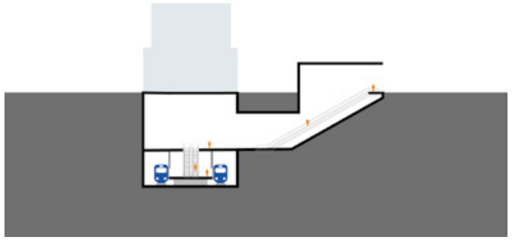
- The stations are to be integrated with the urban design of the adjoining precinct to provide direct and safe accessibility to the station entry.
- The station design is to enable integration with existing and future local development opportunities within adjacent sites as relevant.
- Designs are to provide a legible station entry integrated with public domain.
- Station designs are to provide a seamless transition between transport modes.
- The Sydney Metro stations should maximise consistency in the key functional elements of the architecture.
- Where there is sufficient space and where appropriate, station entries and gatelines are to be located at ground level to provide a line of security at street level.
- Integration of operational and customer facilities is to be consistent across the three typologies providing a high quality and consistent experience for all users.
- Design to minimise level changes between the street and station entries
- Maximise access to natural light and ventilation
- All entries and concourses are to be open and transparent, generous and inviting.
- Design for efficient customer circulation and intuitive wayfinding to and from station entries and platforms.
- Allow for affordable and flexible business premises including pop ups, start-ups, micro and small businesses.
- Consider role of station retail elements in supporting a night time economy, including retail areas, lighting, and use of public spaces by the community.



BINOCULAR CAVERN STATIONS
MARTIN PLACE
PITT STREET



SINGLE CAVERN STATIONS
VICTORIA CROSS



CUT AND COVER STATIONS
CROWS NEST
BARANGAROO
CENTRAL
WATERLOO

4.1.2 Station Entries

Relevant Design Objectives

1	Ensuring an easy customer experience
4	Being responsive to distinct contexts and communities
5	Delivering an enduring and sustainable legacy for Sydney

Principle

Station entries including canopies and concourses are to create a strong and consistent line-wide visual identity to the station environments and be designed as intuitive interchange spaces for customers.

Guidelines

General

- Entrances to stations including canopies and concourses are to provide a consistent line-wide identity for Sydney Metro and are to be clearly visible from the immediate area.
- Canopies and entrances are to respond to the scale and character of the surrounding context
- Station entries are to incorporate canopies/awnings as appropriate to provide weather protection for customers, community information, amenities, and ticketing equipment, gateline and appropriate queuing zones.
- Entry concourses should be clutter-free with clear and simple directional signage, simple volumes and flush continuous materials with components that support wayfinding.
- Entry spaces are to be well lit, bright and welcoming to enhance customer experience providing a safe, open environment that has good permeability and clear sight lines from inside and outside the station.
- Where possible, natural light areas should be provided over Vertical Transport (VT) and concourse areas to reinforce intuitive wayfinding.
- Adequate space should be provided to meet patronage demand and to provide clear zones for queuing at Ticket Vending Machines (TVMs) and gatelines, including during special events, separate to paths of travel.
- Columns are to be minimised and carefully positioned not to obstruct key sightlines or pedestrian movement, particularly for the mobility or visually impaired.
- Lighting, communication, wayfinding and information and security systems are to be well integrated with equipment and recessed where possible.
- Unobtrusive maintenance access is to be provided.
- The materials palette is to be of high quality and is to integrate with surrounding high quality public realm context.
- Permanent public art should be integrated within the station architecture. Art should act as a visual cue to enhance wayfinding.

Canopies and Awnings

- Canopy or awning features are to consider the adjacent character of buildings and should sit comfortably within their context.
- The entry canopy/awning design is to create a recognisable identity for stations along the Sydney Metro line but may not necessarily be common across all types of stations due to the diversity of the built form.
- Entry canopies should be clearly visible in the locality.
- The entry canopies should promote a sense of arrival and offer a weather protected threshold for customers.
- The entry canopy design should contribute positively to the built environment by enhancing the immediate public domain.
- Weather protection to station entry and concourse should be provided as a single integrated element.
- Roof lights should be integrated within the entry canopy and located directly over the customer's path of travel towards the vertical circulation zone to aid intuitive wayfinding.

Canary Wharf Station, London. Natural light over entries and VT enhances wayfinding and creates a welcoming station environment.
Architect: Foster + Partners
Source: Cox Richardson

4.1.3 Platforms

Relevant Design Objectives

1	Ensuring an easy customer experience

Principle

Platform designs are to maximise efficiency and provide a high level of service and an easy customer experience.

Guidelines

- Platforms are to provide efficient and safe access to the Metro service through good sightlines, generous circulation and open and spacious planning.
- Vertical transport (VT) distribution and position on the platform is to be coordinated with the demand and movement patterns of customers.
- Platforms are to be free of recesses and indentations which could offer hiding places and litter traps, disrupt continuous paths of travel for the visually impaired and hinder CCTV coverage.
- Emergency egress must be provided.
- Platforms should establish a strong relationship with the vertical circulation zone through lighting and material palette selection.
- Platforms should minimise structures and columns to maximise sightlines and customer waiting and circulation space.

Note - design guidelines for platform screen doors are set out in Section 4.1.6.

Canary Wharf Station, London. Example of central columns and fixtures
Architect: Foster + Partners
Source: Cox Richardson

Macquarie Park Station. Example of transparent vertical circulation within an open platform that maximises sight lines.
Architect: Hassell
Source: Cox Richardson

4.1.4 Circulation Elements

Relevant Design Objectives

1	Ensuring an easy customer experience
2	Being part of a fully integrated transport system

Principle

Enable step free access between the street and the platform via lifts and escalators that are integrated with station design.

Guidelines

- All Sydney Metro platforms are to be served by escalators and lifts. Lifts and escalators are to provide direct access from entry concourse to platform level.
- All circulation elements are to provide a means of safe movement of people in and around the stations.
- Stairs are to be avoided in stations as far as possible as they reduce opportunities for universal access. Where the use of stairs cannot be avoided or provide a secondary means of access, they must be easy and safe to use.
- Where ramps, lifts and escalators are provided as an alternative to stair access they must not result in a longer journey than the primary circulation route.
- Escalators are to enable a safe, fast and efficient method for vertical transportation for customers to and from station entrance level and platform levels.
- Where feasible, provide stairs adjacent to escalators to facilitate increased levels of activity and for when escalators are closed for maintenance.
- Lifts are to integrate into each different station design and be strong architectural elements in their own right to promote the inclusion of customers using step free circulation elements.
- All circulation elements are to incorporate high quality materials that contribute to the Sydney Metro identity.

Note - further design guidelines on accessible pathways are set out in Section 4.2.2.

Chatswood Transport Interchange, NSW. Good example of a glazed lift and shaft
Architect: CoxDesignInc.
Source: Cox Richardson

4.1.5 Flooring

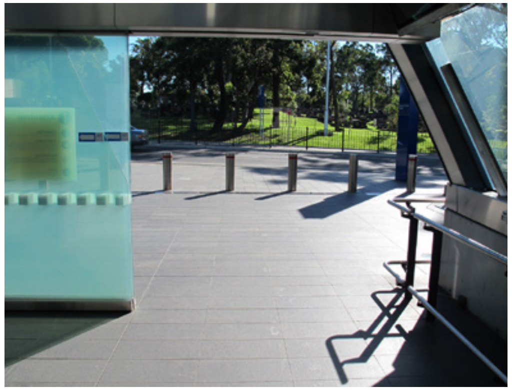
Relevant Design Objectives	
1	Ensuring an easy customer experience
4	Being responsive to distinct contexts and communities
5	Delivering an enduring and sustainable legacy for Sydney

Principle

Ensure the safe, efficient movement of pedestrians, including people with disabilities, through high quality and robust flooring design suitable for the station environment.

Guidelines

- Flooring is to provide a safe and robust solution, suitable for the station environments. Types of flooring include those appropriate to public areas and others to areas of the station where special flooring is required.
- Flooring is to form a part of the Sydney Metro line-wide identity and maximise operational efficiencies.
- Flooring selection is to consider long term wear and tear, maintenance, sustainability objectives including dematerialisation and embodied energy, and future replacement as an important consideration in the design process.
- Flooring is to consider the urban realm context of the station, creating a seamless transition between the external and internal station environs.
- Flooring is to provide a clean, attractive and uniform appearance throughout the stations and is to be integrated with the broader internal materials palette to aid wayfinding.
- Flooring pattern and design is to accentuate movement.



Coordinate interior and exterior public domain pavements.
Source: AECOM.

North Sydney Station, NSW. Example of an open clutter free concourse with directional flooring.
Architect: Cox Richardson
Source: Cox Richardson

4.1.6 Internal Walls and Ceilings

Relevant Design Objectives	
1	Ensuring an easy customer experience
4	Being responsive to distinct contexts and communities
5	Delivering an enduring and sustainable legacy for Sydney

Principle

The vision for the design of wall and ceiling elements is the development of a system with inherent flexibility to adapt to the characteristics of individual stations while contributing to the Sydney Metro line-wide identity.

Guidelines

General

- The appearance and function of the walls is to be suitable for a rail environment and reinforce the Sydney Metro identity.
- Wall systems and details are to respond to their location, function and acoustic environment.
- Ease of access, maintenance and replacement of walls sections is to be considered.
- Robust cladding materials and finishes are to be selected in response to the local environment and conditions.
- Feature walls are to be an identifiable station element used in vertical circulation zones to accentuate the customer pathways and establish a strong architectural language.
- Walls and ceilings over tracks are to be calm and simple and contribute to the high quality station environment and customer experience.
- The materials palette should balance a calm and neutral quality with vibrant materials to aid wayfinding and accentuate movement.
- Use of colour/texture should assist in legibility and wayfinding.
- Wall and ceiling detailing should take into consideration the integration of station assets such as signage, fixtures and machines.

Platform Screen Doors

- Platform Screen Doors (PSDs) are to be minimal and elegant, seamlessly integrating customer information and supporting the station servicing requirements.
- Stations are to integrate the following PSD design considerations:
  - Be full height
  - Run full platform length
  - Integration of the end walls is to be well-considered.
  - Extent of glazing for customer experience is to be well-considered.
  - Security requirements
  - Modularity of units - constructability, repair and replacement.
  - Interface with other wall, floor and ceiling junctions

Copenhagen Metro, Denmark. Good example of full height PSD
Architect: KHRAS Architects
Source: Cox Richardson

4.2 Urban Realm

The public domain is a significant component of the door-to-door journey for Sydney Metro customers. The design quality of station precincts, forecourts and streetscapes outside station entries will therefore be of paramount importance to the overall public experience and perception of the new system. This has implications for the detailed design stages of the project with a range of architectural and engineering structures, landscaping elements and operational equipment that will need to be coordinated to ensure that coherent and distinctive station environs are delivered.

Each station will take on a unique identity that responds to its locality, expressed through the station design in both precinct urban realm and buildings. The interface between the station and surrounding streetscape needs to be well integrated and functional as part of the provision of robust and legible interchange precincts around Sydney Metro stations.

Key elements of the public realm around Metro stations and the alignment that are considered in this part of the document include:

- Landscaping
- Accessible pathways
- Furniture
- Walls and Fences
- Earthworks and Engineered Structures

The Goods Line, Sydney.
Architect & Landscape Architect: CHROFI & Aspect Studios
Source: TfNSW

4.2.1 Landscaping

Relevant Design Objectives	
1	Ensuring an easy customer experience
4	Being responsive to distinct contexts and communities
5	Delivering an enduring and sustainable legacy for Sydney

Principle

Provide hard and soft landscapes that establish a civic quality to the Sydney Metro project and an attractive customer public realm at stations located within the central city. Reflect the existing urban character along the corridor that is appropriate to local conditions.

Guidelines

General

- The landscape design is an important component of a positive, high quality and appealing urban realm identity for Metro stations and structures.
- Hard and soft landscaping design, species selection and material palettes are to relate and reflect the existing urban fabric of the city.
- Landscape treatments are to be appropriate to a functional station and related transport operations and address safety-in-design issues relevant to a transport customer environment and adjacent road and public realm networks.
- Landscape treatments are to be designed to provide appropriate scale and comfort to users throughout the seasons, with planting and materials palettes suited to the local microclimate and any surrounding development considerations.
- Integrate water sensitive urban design including permeable pavement.
- Consider reuse of materials from demolition e.g. in public space landscaping.
- Materials are to minimise slips, trips and falls.

Hard Landscaping

- The external materials palette is to be durable and establish a strong Sydney Metro identity, consistent with a CBD and inner-urban station environment.
- Materials and finishes are to be high quality, robust, durable and meet all functional requirements such as customer interface, component and services integration.
- A hierarchy of paving types should be provided that are appropriate to function and location.
- Use of colour/texture is to assist in legibility and wayfinding, within the context of the immediate station public realm.
- To optimise the legibility of precinct spaces, paving should consist of simple, linear patterns that relate to the main direction of travel.
- The paving palette is to be developed with reference to relevant local council public domain requirements and materials guidelines.
- Materials are to maximise economies of scale and be designed to ensure safe installation, low maintenance and long term durability to minimise the need for replacement.
- Paving is to be the same on each side of the station gateline and be of the highest quality consistent with the Sydney Metro image.
- As well as satisfying the relevant standards and design codes for visual and tactile contrast, products should be selected in order to complement the design of associated pavement materials.

Soft Planting

- Plant species are to be appropriate to local conditions and relate to the character of the urban context - both current and/or planned future context.
- The general planting arrangements and species are to suit the spatial scale of each public domain setting, without compromising pedestrian capacity and circulation outside stations.
- Where appropriate street trees are to provide strong, legible structure planting where appropriate at stations, either to reinforce spatial movement, connectivity with adjacent areas, civic quality, visual continuity or identity and character.
- Depending on orientation and urban enclosure, selected tree species are to provide shade during summer months and good solar access in winter months. Proposed species are to respond to existing council policies and guidelines and character drivers.
- Proposed plants are to be low maintenance and based on minimal water requirements beyond the establishment phase.
- Trees, shrubs and groundcover are to help reduce potential heat island effects and to provide valuable amenity for customers and the broader urban community.
- Screen planting is to be employed to help mitigate the visual impact of retaining structures, noise walls and service facilities as required.
- All planting must maintain clear setbacks and sight lines at road intersections and be offset from other transport infrastructure elements at suitable distances for the selected species.

4.2.2 Accessible Pathways

Relevant Design Objectives	
1	Ensuring an easy customer experience
2	Being part of a fully integrated transport system

Principle

Provide pathways to and from station entries and facilities that are accessible, safe and comfortable for all users.

Guidelines

- A system of appropriate pathway surfaces, widths and gradients is to provide safe and equitable pedestrian access throughout the public domain and to link transport modes.
- Station precincts must be easy and safe for all to use regardless of physical mobility; able bodied customers, wheelchair users, carers with strollers, the visually and cognitively impaired should all be provided with equal access.
- Stairs are to be avoided as far as possible as they reduce opportunities for universal access. Where the use of stairs cannot be avoided, then they must be short in length, easy and safe to use.
- Where the use of stairs is unavoidable, clearly legible alternative circulation routes should be provided. These alternatives should be as close as possible and not isolated from the primary circulation route.
- Ramps may provide opportunities for universal access; however, where possible, seek alternative means of effecting level changes, for example, by altering the path of travel.
- All alternative means of effecting level changes should be considered, for example by altering the path of travel.
- Selective use of colour, texture, lighting, finishes and customer information to further define paths of travel, circulation spaces and the location of key facilities.
- Tactile Ground Surface Indicators (TGSIs) should be used on paths of travel to warn customers with vision impairment of hazards and assist wayfinding where required.
- Where possible, provide a consistent, clear path of travel for customers with vision and mobility impairments by keeping one side of paths of travel clear of fittings and fixtures.

Design paths and ramps for access for all. All modal connections must be located in convenient, safe, well-lit areas with good natural surveillance. *Source: AECOM.*

Martin Place, Sydney. Carefully locate all street furniture to minimise potential obstructions and maximise use of circulation spaces. *Source: AECOM.*

4.2.3 Furniture

Relevant Design Objectives

1	Ensuring an easy customer experience
2	Being part of a fully integrated transport system

Principle

Furniture and fixtures are to provide respite, safety, comfort, services and functionality to public spaces, as well as punctuating the station domain with items of interest.

Guidelines

General

- Furniture and fixings are to be robust, high quality and attractive, respond appropriately to context and be representative of the Sydney Metro identity.
- In addition to their functional and amenity value, furniture and fixings are to be used to delineate function zones and restrict or manage pedestrian access.
- Elements in common locations (bins/seating/drinking fountains/bollards) are to adopt a rational layout in order to minimise visual clutter within the public domain and maximise safe and accessible paths of travel.
- All components should be accessible and fully integrated with the station design.
- Modularity of components should retain ability for future enhancement or replacement.
- Robust materials should ensure durability within a rail environment.
- Street furniture should be selected with consideration to facilitating active uses and informal recreation.

Seating

- Seating placement should not impede customer flows and be located to provide resting points for the customer journey.
- Seating is to be located along main paths of travel adjacent to entrances, transit shelters, major crossover areas and no more than 60m apart.
- The location and grouping of seating and other elements is also an opportunity to help create meeting places and a sense of place.

Handrails and Balustrades

- Handrails and balustrades should guide safe customer movement and be consistent in material and quality line wide.

Waste Bins

- Bins should be consistent line-wide, including consideration of the locality and considerations below.
- The station design and management should ensure that, through the placement and maintenance of bins, cleanliness is maintained during operating hours.
- Bins are to be located to minimise the recurrence of litter, whilst considering the ambience and attractiveness of the station precinct.
- Facilitate waste separation and recycling.

Barangaroo, Sydney. The furniture and fixing colour palette should be coordinated with architectural elements, surface finishes and pavements.
Architect: Tzannes Associates
Source: TfNSW

Chatswood Station, Sydney, NSW. Example of handrail and stanchion
Architect: CoxDesignInc.
Source: Cox Richardson

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4.2.4 Walls and Fences

Relevant Design Objectives	
1	Ensuring an easy customer experience
4	Being responsive to distinct contexts and communities
5	Delivering an enduring and sustainable legacy for Sydney

Principle

The vision for the design of wall and fencing elements is the development of a system which can be applied across the corridor and station sites with a high quality, robust and durable form that is representative of the Sydney Metro image and each station's context.

Guidelines

- The appearance and function of external walls and fencing is to be suitable for a rail environment and reinforce the Sydney Metro identity.
- Location, scale and articulation of external walls and fences are important elements of the public realm. Their design is to be an integral part of the urban design of station areas and corridor sites to minimise excessively long unarticulated lengths, inactive, bland and unappealing frontages.
- Wall and fencing systems and details are to respond to their location, function and acoustic environment.
- Ease of access, maintenance and replacement of walls and fencing sections is to be considered.
- Robust cladding materials and finishes are to be selected in response to the local environment and conditions, and sustainability objectives including dematerialisation and embodied energy.
- Feature walls are to be used to accentuate customer pathways and establish a strong architectural language at stations, employing artworks at appropriate sites.
- The materials palette should balance a calm and neutral quality with vibrant materials to aid wayfinding and accentuate movement.
- Use of colour/texture should assist in legibility and wayfinding.

Terracotta louvred facade provides a vibrant wall surface.
Source: AECOM.

Glazed facades enable transparency and legibility.
Architect: The Buchan Group
Source: Apple

4.2.5 Earthworks and Engineered Structures

Relevant Design Objectives

1	Ensuring an easy customer experience
4	Being responsive to distinct contexts and communities

Principle

Ensure earthworks and engineered structures such as noise walls, retaining walls and portals are visually integrated into their urban or landscape setting as much as possible, keeping engineered structures to a minimum.

Guidelines

Earthworks

- Dive structures at Marrickville and Chatswood may require cut embankments as a combination of engineered slopes and low retaining walls, to create an integrated, 'sculpted' landform, suited to the rail corridor setting.
- All earthworks are to sit lightly in their context, exhibiting a 'natural fit' within their landscape setting wherever possible.

Retaining Walls and Portals

- Retaining walls and related elements are to be designed as a unified composition and be integrated with the adjoining landscape (as appropriate) and other components such as fencing, guard rails, steps and other walls.
- The precautionary principle is to be adopted throughout so that retaining walls are only constructed where there is no other alternative.

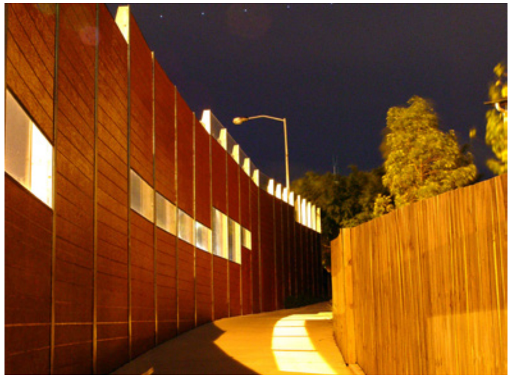
Noise Walls

- Noise walls and retaining walls (where required) are to form a coordinated design system.
- Noise wall panels are to be comprised of robust, vandal-resistant materials and be resilient to damage by adjacent planting. Material and system selection to consider sustainability objectives including dematerialisation and embodied energy.
- Any noise walls are to be designed as part of a hierarchy of walls that includes retaining walls, abutments and parapet walls, such that each element appears to be visually coordinated.
- The apparent scale and visual impact of noise walls is to be reduced with careful planting, even when space is limited.

Bridges

- Design in accordance with the Bridge Aesthetics Design Guideline prepared by Roads and Maritime Services.

Gore Hill Freeway, Sydney. Provide retaining walls that are topped out by a consistent concrete capping beam.
Source: AECOM.



When designing noise walls consider their visual impacts from both inside and outside of the rail corridor.
Source: AECOM.

4.3 Operation and Services

The design of project infrastructure must be tailored to meet operational requirements and the transport function and integrity of the Metro system over the longer term. Design should also respond to the management and maintenance obligations that will be a critical part of the success of the Metro over successive generations as the greater Sydney region grows and demands on the transit services increase.

Stations, buildings, external areas and related corridor structures must be suitable for a high capacity passenger rail environment traversing a dense urban setting and a complexity of interfaces. The stations needs to have a consistent, reliable and bespoke series of facilities that assist both staff, servicing and security operations and meet the needs of the customers who will utilise the system on a daily or more infrequent basis.

This part of the guidelines relates to the following elements:

- Wayfinding and Signage
- Ticketing equipment and Fixtures
- Engineering and Services Integration
- Management and Maintenance
- Security
- Emergency Requirements
- Service Vehicle Access

Grand Concourse, Central Station. Transport Information with Passenger Information Display.
Source: TfNSW

4.3.1 Wayfinding and Signage

Relevant Design Objectives

1	Ensuring an easy customer experience
2	Being part of a fully integrated transport system
4	Being responsive to distinct contexts and communities

Principle

Provide intuitive, clear and consistent information and signage to enhance customer journeys through efficient navigation and interchange, creating a seamless and intuitive customer journey from origin to final destination.

Guidelines

- All customer wayfinding and information signage must enable customers to navigate each station and precinct as part of a cohesive door-to-door journey.
- Information is to include, but not be limited to, information in trip planning; finding the right platform; making connections to another form of transport; destinations in the local precinct; 'real time' information for all public transport modes; wayfinding; facilities and amenities.
- A modern public address system is provided that is capable of projecting clear and audible information throughout the station.
- Advertising should not compromise wayfinding. The design and placement of customer information is prioritised as follows:
  - Wayfinding and customer information
  - Customer campaigns
  - Advertising

Circular Quay, Sydney. Signage and wayfinding enables clear sightlines of the interchange precinct.
Source: TfNSW

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4.3.2 Ticketing Equipment

Relevant Design Objectives

1	Ensuring an easy customer experience
2	Being part of a fully integrated transport system

Principle

Provide ticketing equipment and fixtures that are integrated standard products across the Sydney Metro and Sydney Trains network and that contribute to quality and efficient service for customers.

Guidelines

General

- Common ticketing equipment and fixtures include:
  - Ticket Gates
  - Ticket Vending Machines (TVMs) and Opal Top-up Machines
- Equipment and fixtures are to be high quality, consistent throughout the Sydney Metro network and fully integrated with the station design.
- All components are to be robust and durable, suitable for the rail environment.
- Equipment and fixtures are to be located where they are visible and accessible to customers and station staff for wayfinding, security and maintenance
- Materials and installation must enable ease of access for maintenance and future repairs or replacement

Ticket Gates

- Ticket gates should be standard products used line-wide that contribute to quality and efficient service for customers.
- Opal ticket gates are to be used. Provision should be made for accessible gates and glazed manual wide aisle gates to allow for large equipment and prams.
- The number of ticket gates provided is to be sufficient for peak periods
- Ticket gates are to be located to enable sufficient space for comfortable and safe queuing without interfering with circulation routes.
- Wide aisle gates are to be clearly visible and located on accessible paths of travel.

Ticket Vending and Opal Top-up Machines

- TVMs and Opal Top-up Machines are to be clustered together to provide a legible ticket sales zone within the station entrance, and designed to integrate with interior components, materials and information systems.
- TVMs and Opal Top-up Machines must be publicly accessible and close to the station entrance without interfering with circulation routes.
- TVM and Opal Top-up Machine arrangement are to provide adequate space for queuing and manoeuvring by customers using mobility aids.
- TVMs and Opal Top-up Machines should be proprietary standard items and be DDA compliant.

Sydney Trains Opal Only Gates
Source: TfNSW

4.3.3 Engineering and Services Integration

Relevant Design Objectives

1	Ensuring an easy customer experience
2	Being part of a fully integrated transport system
4	Being responsive to distinct contexts and communities

Principle

The rail engineering and service elements for the stations and service facilities should be integrated into the design holistically, whilst being able to be easily maintained.

Guidelines

General

- The station structures and engineering elements are to be designed holistically, fusing architecture and engineering as one cohesive and compelling product.
- The station and station surrounds are to integrate all structural, civil, mechanical, electrical and rail systems to ensure efficient designs.
- Design integrity must be addressed through careful positioning of equipment.
- Minimise the visual impact of engineering components in public areas by concealing all services.
- Station and services design must allow for personnel access and regular maintenance of all engineering elements.
- Dedicated services zones should be integrated into the station designs allowing sufficient space proofing for future requirements.
- Expression of primary structural elements is to be considered.

Service Buildings

- Services buildings and facilities should form an integrated solution with the station architecture and precinct taking into account the scale, context and purpose of the structure.
- Similar materials and components as used in the station should be selected where appropriate to support the Sydney Metro identity.
- Opportunities to provide for active uses and frontages should take priority over service related structures.
- Elements in major urban settings need to consider impacts including visual, environmental and acoustic on the streetscape.
- Elements located in public areas of the station and surrounds are to be integrated with other functions such as public facilities, ticketing and information, fire stairs, community facilities or retail to minimise the impact of the services on the station precinct.
- Access for maintenance and replacement of plant and equipment should be considered including personnel access for regular maintenance tasks. Designs should allow for safe access and egress to all areas of services buildings.

King's Cross Square, London. Good example of a well designed vent structure integrated with other functions within an urban setting
Architect: Stanton Williams
Source: Getty

Macquarie Park Station. Services are concealed and integrated within the cavern structure, enabling the clean expression of the cavern form.
Architect: Hassell
Source: Cox Richardson

4.3.4 Management and Maintenance

Relevant Design Objectives	
2	Being part of a fully integrated transport system

Principle

Ensure the selection of cost effective, adaptable materials and assets that are durable and easily maintained and fit-for purpose for high traffic rail environments and customer interface.

Guidelines

- Adopt a consistent and coordinated palette of materials, furniture and fixtures within stations and their precincts to promote cost effectiveness and assist in the development of an efficient management and maintenance plan for Sydney Metro.
- Proposed hard and soft landscaping elements within the external urban realm of stations are to comply with the standards of each local council area to facilitate consistent future management and maintenance regimes.
- Public domain elements external to stations, such as pavement materials, wall types, furniture and fixtures are to be consistent with the existing urban context for ease of maintenance.
- Hard landscaped surfaces and structures in some locations may have to be more durable to withstand the larger loads of and vibrations from specialist installation or maintenance vehicles, notwithstanding vibrations from above or below ground trains.
- All signage, street furniture and operational equipment (e.g. Passenger Information Displays (PIDs) and CCTVs systems) in the public domain are to be designed to minimise vandalism and simplify cleaning.
- Placement and detailing of furniture, fixtures and equipment should consider impacts by birds, insects and mammals on operational assets and the customer environment.
- All assets, including paving, lighting, signage and street furniture, are to be of a standardised modular design as far as practical that is readily available and have readily replaceable components.
- Materials, furniture, fittings and fixtures should be selected and sized in a manner that allows easy installation and repair. All components should meet the required life cycle objectives of Sydney Metro and consider sustainability objectives including dematerialisation and embodied energy.
- The design for each station is to accommodate future maintenance access to all elements, including components that may require the use of heavy or large machinery or structures to be erected for installation of structures and equipment, regular cleaning or repair.
- Stations and station precincts should be designed to facilitate access in a safe environment for operational staff and

Temporary or ancillary equipment, vending machines or any other structures (i.e. temporary signage) are not be placed in the primary pedestrian paths.
Source: Grimshaw.

4.3.5 Security

Relevant Design Objectives	
2	Being part of a fully integrated transport system

Principle

Ensure adequate security for the rail corridor infrastructure, station assets and their users. Visually integrate security elements such fencing, security screens CCTV and lighting into the rail corridor, precinct or station design as part of a coordinated whole-of-corridor design.

Guidelines

- Risks to the rail corridor and stations must be regularly assessed during the design phase to ensure adequate control measures can be put in place.
- A public address system is to be provided at emergency egress and risk points, controllable from Station Control Rooms and Operational Control Rooms.
- CCTV must be provided throughout the station.
- CCTV must be provided at all egress points and risk-sensitive areas.

Fencing and Gates

- Security fencing must be provided along the sections of the rail corridor not in tunnel and include permanent gated access at controlled locations. Fencing and gate locations are to be coordinated with strategic emergency access and egress points.
- The selection and detailing of fencing should be fully coordinated throughout the corridor and consist of modular components.
- Corridor fencing must not only respond to security considerations, but also respond to corridor context, including, for example, the provision for high quality fencing at station precincts.
- Security fencing types must be consistent throughout Sydney Metro and respond to the contextual environmental of the rail corridor, including provision for high quality fencing at station precincts where users experience the fencing close at hand and high security, more robust and utilitarian fencing at rail infrastructure/ facility locations.
- Fencing types must be robust, suitable to the rail environment and consider maintenance and future replacement.
- Fencing throughout the station precincts and public domain areas must avoid creating dead ends or sightline conflicts.

Lighting

- Lighting is to consider:
  - Natural daylight.
  - Emergency and exit lighting.
  - Interfaces with wall cladding, soffit systems and other visible services.
  - Consistency in design across all stations and precincts.
  - Ongoing access and maintenance - minimising the number of luminaire and lamp types and considering replacement processes.
  - Sustainability targets and energy usage.
  - Lighting levels sufficient for adequate operation of CCTV.

Homebush, Sydney. Rail corridor security fences should be robust, easily maintained, modular systems that are readily integrated with other urban design elements such as retaining walls.
Source: AECOM.

4.3.6 Emergency Requirements

Relevant Design Objectives

2	Being part of a fully integrated transport system

Principle

Ensure that station precincts, facilities and rail corridors are provided with clearly identified zones for emergency access and egress, eliminating the potential for movement conflicts during emergencies.

Guidelines

- The precincts and rail corridor should provide access for emergency service vehicles and appropriate measures to safeguard all users.
- All station precincts and public domain areas must comply with statutory requirements and emergency procedures and relevant guidelines for fire and safety.
- Emergency requirements are to consider;
  - Effective and clearly signposted station emergency evacuation routes and assembly areas.
  - Adequate zoning and space at emergency assembly points to ensure they are free of clutter and remain accessible at all times.
  - Fire safe refuge areas with CCTV and accessible communication system in underground stations for people who are unable to self-evacuate.
  - Full integration within the relevant station and facilities evacuation plan.
  - Emergency lighting to the immediate station curtilage.
  - The appropriate location of firefighting equipment such as hydrants; all clearly identified and readily accessible.
  - The provision of emergency/security electronic help points.

Hydrant Enclosures

- Hydrant enclosures should be easily identifiable, easily accessed modular components integrated into station cladding systems.
- Hydrant enclosures should be integrated with the surrounding wall system to minimise their visual impact.

All station precincts must accommodate station evacuation and emergency procedures.
Source: AECOM.

4.3.7 Service Vehicle Access

Relevant Design Objectives

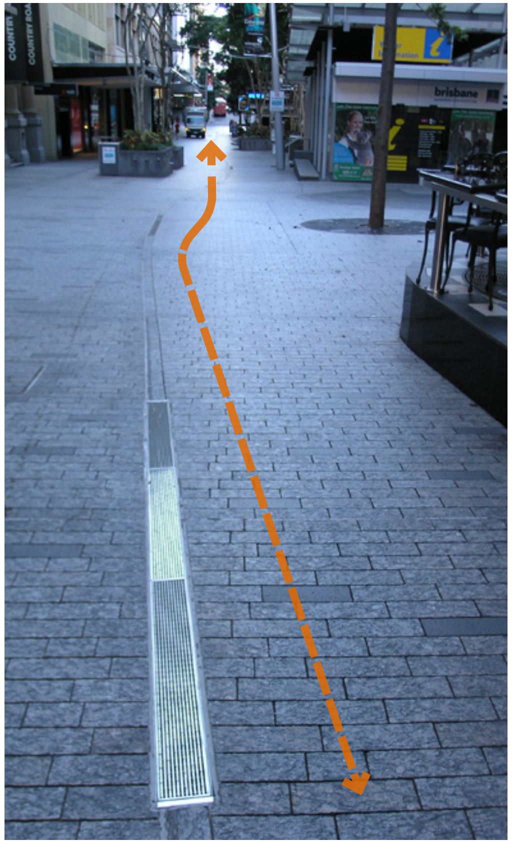
2	Being part of a fully integrated transport system
4	Being responsive to distinct contexts and communities

Principle

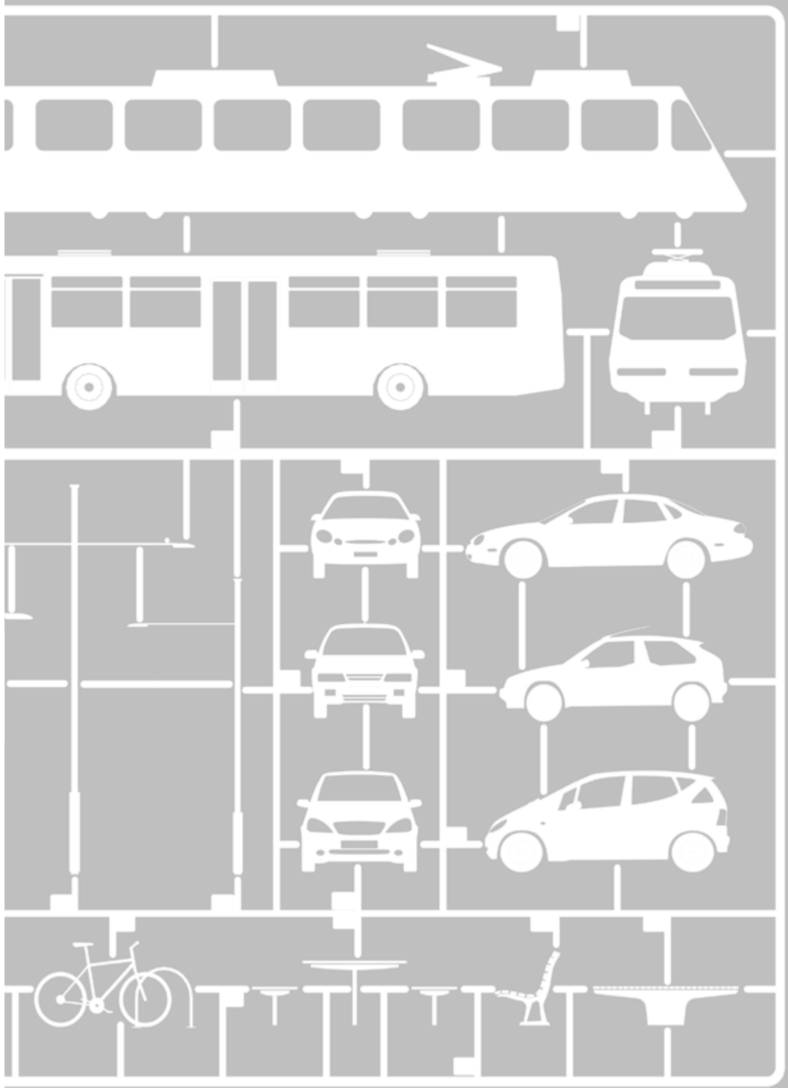
Ensure well defined and efficient coordination of service vehicle movements within precincts.

Guidelines

- The station design is to enable access for service vehicles. Service vehicle access is not to compromise the public domain areas of the station forecourt or interchange and connectivity functions.
- Service vehicle access for all precinct functions must be addressed as part of the broader station precinct movement strategies. These strategies must address both the project works requirements and increased movements over the life of the station precincts.
- The operational function and frequency of service vehicles should be considered to determine dedicated zones for daily or frequent access, or shared zones for occasional access within station precincts. Multi-use conflicts in shared zones should be eliminated.



Queen St Mall, Brisbane. Emergency vehicle and service vehicle access through the mall has been provided.
Source: AECOM.



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STAKEHOLDER AND COMMUNITY ENGAGEMENT

APPENDIX C

Contents

1 Introduction

1.1 Purpose

The purpose of this report is to support the stakeholder and community engagement process detailed in Chapter 5 of the Environmental Impact Statement. It outlines the engagement activities carried out in the lead up to exhibition of the Environmental Impact Statement to ensure all stakeholders are aware of the project and have the opportunity to input into the planning and environmental assessment stages.

1.2 Communication objectives

Transport for NSW has been and continues to be interested in community and stakeholder feedback on the project. The Sydney Metro communication objectives include to:

- Communicate the rationale for the project and the broader network benefits it would deliver, including how it fits into the NSW Government's plans to increase Sydney's rail capacity
- Communicate the Sydney Metro concept and timing
- Build community and key stakeholder relationships and maintain goodwill
- Provide information about the planning approvals process and encourage community participation
- Clearly communicate the corridor protection and property acquisition process.

The project team has developed a comprehensive community and stakeholder engagement program to proactively engage with local communities, key stakeholders and government agencies.

2 Engagement milestones

Feedback from stakeholder and community engagement for Sydney Metro City & Southwest has formed an integral part of informing and scoping investigations for the Chatswood to Sydenham Environmental Impact Statement.

Key stakeholders for the project include (but are not necessarily limited to):

- State agencies (eg Department of Planning & Environment, Roads and Maritime Services, Environmental Protection Authority, NSW Office of Water, Port Authority of NSW, Sydney Water and Office of Environment and Heritage)
- Local government (eg Willoughby, Lane Cove, North Sydney, City of Sydney and Marrickville councils)
- Public utilities, business and industry groups near the project
- Directly impacted communities
- The broader community.

The following outlines the engagement milestones achieved during the development of the project and Chatswood to Sydenham Environmental Impact Statement.

2.1 Stakeholder consultation

On 11 June 2014, the Premier of NSW announced the proposed Sydney Rapid Transit project would extend the North West Rail Link under Sydney Harbour, through the Sydney CBD and on to Bankstown.

Early engagement during this period included briefings with key stakeholders. Information about the project was available at the North West Rail Link community information centre, on the Transport for NSW and North West Rail Link websites and via fact sheets and media releases.

2.2 Project scope consultation and engagement

On 4 June 2015, the Premier of NSW announced a name change from Sydney Rapid Transit to Sydney Metro City & Southwest and that funding had been secured to progress planning on the project. The announcement also initiated a round of consultation and engagement (4 June and 17 July) to collect stakeholder and community feedback on the project and to help inform the development of the Environmental Impact Statement.

Engagement during this period was carried out along the entire Sydney Metro City & Southwest corridor between Chatswood and Bankstown and included stakeholder briefings, community information sessions and interactive online forums. Information about the project was also available at the Sydney Metro Northwest and Transport for NSW community information centres, on the Transport for NSW and Sydney Metro City & Southwest websites and via a newsletter, project overview booklet, advertisements and media releases.

In June, industry engagement started and included a presentation at the Australian Financial Review Infrastructure Summit and an industry briefing.

2.3 Project update announcement

On 16 November 2015, the Premier of NSW announced the Projects' State Significant Infrastructure Application Report was ready to be lodged with the Department of Planning & Environment. The announcement confirmed station and tunnelling locations and investigations would continue into a station at The University of Sydney or Waterloo.

Engagement during this period included doorknocks with directly affected (by property acquisition) and adjacent property owners and occupiers around station and dive site locations between Chatswood and Sydenham and key stakeholder briefings. Information about the project was also available at the Sydney Metro Northwest and Transport for NSW community information centres, on the Transport for NSW and Sydney Metro City & Southwest websites and via fact sheets, project update booklet, advertisements and media releases.

2.4 Waterloo Station announcement

On 11 February 2016, the Minister for Transport and Infrastructure announced the location of Waterloo Station.

Stakeholders directly affected by property acquisition were individually notified by the project team.

Engagement during this period was completed around the Waterloo Station site with directly affected (by property acquisition) and adjacent property owners and occupiers, and key stakeholders.

Information about the project was also available at the Sydney Metro Northwest and Transport for NSW community information centres, on the Transport for NSW and Sydney Metro City & Southwest websites and via fact sheets, project update booklet, advertisements and media releases.

2.5 Blues Point temporary site engagement

On 22 and 23 February 2016, the project team Place Managers visited residential and business properties adjacent to the Blues Point temporary site.

Information about the Blues Point temporary site was also available at the Sydney Metro Northwest and Transport for NSW community information centres, on the Sydney Metro City & Southwest website and a fact sheet.

2.6 Marrickville dive site pre-cast facility

On 21 April 2016, the project team Place Managers visited commercial properties adjacent to the Marrickville dive site pre-cast facility.

2.7 Environmental Impact Statement exhibition

Consultation and engagement activities during the public exhibition of the Environmental Impact Statement will be consistent with those carried out for the project scope consultation and engagement period and are outlined in section 14 of this report.

3 Engagement timeline

Table 1 outlines the engagement timeline for key milestones throughout the planning and environmental assessment stages of the project. Further detail on these activities is described later in this report.

Table 1 Engagement timeline

Activity	Content	Date
Stakeholder consultation		2014
Media release	*'Getting down to business: Early work begins on Sydney Metro'*	8 April
Media announcement	**The *Sydney Rapid Transit* project would extend the *North West Rail Link* under Sydney Harbour, through the CBD and on to Bankstown**	**11 June**
Media release	*'Sydney Metro: More trains, less crowding'*	11 June
Website update	The *North West Rail Link* and Transport for NSW websites provided an overview of Sydney's new rapid transit system with links to fact sheets and media releases	11 June
Fact sheet	*'More trains, faster services right across Sydney'*	11 June
Community information centre	The *North West Rail Link* community information centre at Castle Hill provided general information on the entire metro product	11 June
Stakeholder briefings	Key stakeholders were briefed via meetings, presentations and phone calls	11 June – ongoing
Media release	'Budget delivers on NSW Government promise to build major infrastructure and improve services'	17 June
Fact sheet	*'Transforming Sydney'*	November
Project scope consultation and engagement		2015
Place Managers	Place Managers employed to ensure members of the community have a single, direct and identifiable link to the project team	April
Advertisements	Invitations to industry briefing in metropolitan and international newspapers	2-4 June

Activity	Content	Date
Media announcement	***Sydney Metro City & Southwest* (formerly *Sydney Rapid Transit*) project scope consultation and engagement to help inform the development of the Environmental Impact Statement**	**4 June**
Media release	*'Funding secured: Sydney Metro to be a reality'*	4 June
Booklet	*'Transforming Sydney, Sydney Metro City & Southwest – Project overview'*	4 June
Newsletter	*'Sydney Metro City & Southwest – Have your say, more choice, more opportunity with metro rail'*	4 June
Community contact points	Established to direct callers directly to the City & Southwest team, including: • Community Information Line (toll free) • Community email address • Postal address.	4 June
Community information centre	Updated information available at Community Information Centres: • Sydney CBD (Transport for NSW) • Castle Hill (Sydney Metro Northwest).	4 June
Website launch	The *Sydney Metro City & Southwest* website launched to provide a central point of up to date information for the community and stakeholders with document links to the latest project overview and industry briefing documents	4 June
Email alert	Sent to 6,000 community members registered in the Sydney Metro City & Southwest and Northwest databases	4 June
Consultation period	Project scope consultation and engagement period to receive community and stakeholder input into the project scope	4 June – 17 July
Stakeholder briefings	Key stakeholders were briefed via meetings, presentations and phone calls	4 June 2014 – ongoing
Online forum	Sought feedback on Sydney Metro and particularly the proposed station options	4 June – 17 July
Advertisements	Invitations to community information sessions in metropolitan, local and ethic newspapers	4-26 June
Presentation	Australian Financial Review Infrastructure Summit	12 June
Community Info sessions	Eight sessions held across the project alignment, attended by over 800 people	13-27 June
Media release	*'World comes to get on board Sydney Metro'*	16 June
Industry briefing	Held at the Roslyn Packer Theatre, Walsh Bay and attended by just under 500 industry representatives from Australian and international firms	16 June
Booklet	*'Sydney Metro – Delivering Sydney Metro, Industry Briefing'*	16 June
Media release	*'New underground railway station at Barangaroo as part of Sydney Metro'*	23 June
Media release	*'Budget delivers $9 billion for public transport services and infrastructure'*	23 June
Media release	*'NSW Budget in the fast lane – $590 million boost for infrastructure projects'*	23 June
Media release	*'Biggest congestion busting budget in NSW history – More than $16 billion for transport upgrades'*	23 June

Activity	Content	Date
Email alert	*'Last day to have your say on Sydney Metro City and Southwest'* Sent to 6,000 community members registered in the Sydney Metro City and Southwest and Northwest databases	16 July
Online forum	Sought feedback on the planning process and how the community would like to see the project delivered and impacts managed	August
Email alert	*'New online forums – have your say on Sydney Metro City & Southwest'* Sent to 6,000 community members registered in the Sydney Metro City and Southwest and Northwest databases	11 August
Media release	*'Sydney Metro to get video help points for customers'*	18 September
Media release	*'Hello, Sydney! First look inside our new metro train'*	5 November
Advertisements	Invitations to industry briefing in metropolitan and international newspapers	12 November
Project update announcement		**2015**
Media announcement	**State Significant Infrastructure Application lodged confirming the metro route and station locations. Investigations will begin into potentially extending metro rail from Bankstown to Liverpool**	**16 November**
Media release	*'Sydney Metro accelerates through CBD: Stations confirmed and first borer to arrive in 2018'*	16 November
Place Managers	Briefings and doorknocks initiated with affected and adjacent property owners and occupiers around station and dive site locations	16-20 November
Stakeholder briefings	Key stakeholders were briefed via meetings, presentations and phone calls	16 November – ongoing
Fact sheet	*'Sydney Metro City & Southwest – Property Acquisition'*	16 November
Fact sheet	*'Sydney Metro City & Southwest – Property Acquisition – Commercial Tenants'*	16 November
Website update	Sydney Metro web content updated with document links to the latest project overview booklet, Chatswood to Sydenham State Significant Infrastructure Application Report and Early community consultation, and Submissions Report and an updated animation	16 November
Community information centre	Updated information available at Community Information Centres: • Sydney CBD (Transport for NSW) • Castle Hill (Sydney Metro Northwest).	16 November
Fridge magnet	A 'Project Information' flyer and fridge magnet delivered to 37,000 properties within 60metres of the project alignment	16 November
Email alert	Sent to 6,000 community members registered in the Sydney Metro City & Southwest and Northwest databases	16 November
Booklet	*'Sydney Metro City & Southwest – Project update'*	16 November
Report	*'Sydney Metro City & Southwest – Early community consultation, Submissions Report'*	16 November
Report	*'Sydney Metro City & Southwest – Chatswood to Sydenham State Significant Infrastructure Application Report'*	30 November
Advertisements	Notification of the application for project approval lodged in metropolitan, local and ethic newspapers	1-10 December

Activity	Content	Date
Industry briefing	Held at the Civic Pavilion in The Concourse, Chatswood and attended by more than 460 industry representatives from Australian and international firms	4 December
Booklet	*'Sydney Metro, City & Southwest – industry briefing, December 2015'*	4 December
Waterloo / The University of Sydney options		**2015**
Media announcement	**Waterloo announced as the preferred station location**	**16 December**
Media release	*'Sydney Metro to rejuvenate Waterloo'*	16 December
Waterloo Station announcement		**2016**
Media announcement	**Waterloo Station location announced**	**11 February**
Media release	*'Location locked in for Waterloo Metro Station'*	11 February
Booklet	*'Sydney Metro City & Southwest – Project update'*	11 February
Website update	Sydney Metro web content updated with document links to the latest project overview booklet	11 February
Place Managers	Briefings and doorknocks initiated with affected and adjacent property owners and occupiers around the Waterloo station site	11 February
Stakeholder briefings	Key stakeholders were briefed via meetings, presentations and phone calls	11 February
Community information centre	Updated information available at Community Information Centres: • Sydney CBD (Transport for NSW) • Castle Hill (Sydney Metro Northwest).	11 February
Email alert	Sent to 6,000 community members registered in the Sydney Metro City & Southwest and Northwest databases	11 February
Blues Point temporary site engagement		**2016**
Place Managers	Briefings and doorknocks initiated with adjacent property occupiers around the Blues Point temporary site and businesses along Blues Point Road between the site and Union Street	22 and 23 February
Stakeholder briefings	Key stakeholders were briefed via meetings, presentations and phone calls	22 and 23 February
Website update	Sydney Metro web content updated with the factsheet	22 February
Fact sheet	*'Blues Point Temporary Retrieval Site'* (February 2016), delivered to all properties along Blues Point Road between the site and Union Street	22 February
Community information centre	Updated information available at Community Information Centres: • Sydney CBD (Transport for NSW) • Castle Hill (Sydney Metro Northwest).	22 February
Industry briefing		**2016**
Advertisements	Invitations to industry briefing in metropolitan newspapers	31 March
Media release	'All systems go for new Metro tunnels under Sydney Harbour and CBD'	13 April
Industry briefing	Held at the Civic Pavilion in the Concourse, Chatswood and attended by more than 460 industry representatives from Australian and international firms	16 April

Activity	Content	Date
Booklet	*'Sydney Metro, City & Southwest – Industry Briefing, April 2016'*	16 April
Marrickville dive site pre-cast facility engagement		**2016**
Place Managers	Doorknocks initiated with adjacent property occupiers around the site	21 April
Stakeholder briefings	Key stakeholders were briefed via meetings, presentations and phone calls	21 April

4 Community engagement

4.1 Community contact and information points

Table 2 outlines the community contact and information points for the community and stakeholders.

Table 2 Community contact and information points

Activity	Establishment date	Detail
Community Information Line (toll free)	4 June 2015	1800 171 386
Community email address	4 June 2015	sydneymetro@transport.nsw.gov.au
Postal address	4 June 2015	Sydney Metro City & Southwest PO Box K659, Haymarket, NSW 1240

4.2 Place Managers

Place Managers were successfully implemented on the Sydney Metro Northwest ensuring members of the community have a single, direct and identifiable link to the project team. Place Managers build relationships and act as a feedback mechanism to help ensure community and stakeholder aspirations are consistently considered in the planning process.

Three Place Managers have been employed on the project since April 2015 to cover the following areas:

- Chatswood to Sydney Harbour
- Sydney CBD to Marrickville
- Sydenham to Bankstown.

4.3 Contact statistics

Table 3 outlines community engagement statistics between 11 June 2014 and 30 April 2016.

Table 3 Contact statistics

Activity	Number of contacts
Calls to 1800 171 386	247
Emails to sydneymetro@transport.nsw.gov.au	870
Doorknocks	911
Meetings	528

5 Community information centres

5.1 Sydney Metro Northwest community information centre

The Sydney Metro Northwest community information centre has operated in Castle Hill since 2011 providing information on the North West Rail Link, now known as Sydney Metro Northwest. After the announcement in June 2014, the centre provided general information on the project. The centre is located at Shop 490, Castle Towers Shopping Centre, Castle Hill.

5.2 Transport for NSW community information centre

The Transport for NSW community information centre has operated in the Sydney CBD since November 2013 providing information on a range of transport projects including the North West Rail Link (now Sydney Metro Northwest) and now Sydney Metro City & Southwest. The centre is located at 388 George Street, Sydney.

6 Electronic information

6.1 Sydney Metro Northwest website

From February 2014, the Sydney Metro Northwest (formerly North West Rail Link) website provided an overview of Sydney's new metro system (http://nwrail.transport.nsw.gov.au/The-Project/Rapid-Transit-System).

Themes included:

- Delivering Sydney's new metro trains
- Why build a new metro network
- What the independent experts say on metro system
- Fast, safe and reliable – a new generation of rail for Sydney
- More reliable trains
- Sydney Metro means more trains
- Modern tunnel sizes
- Right here, right now
- Deciding on the right network for the future.

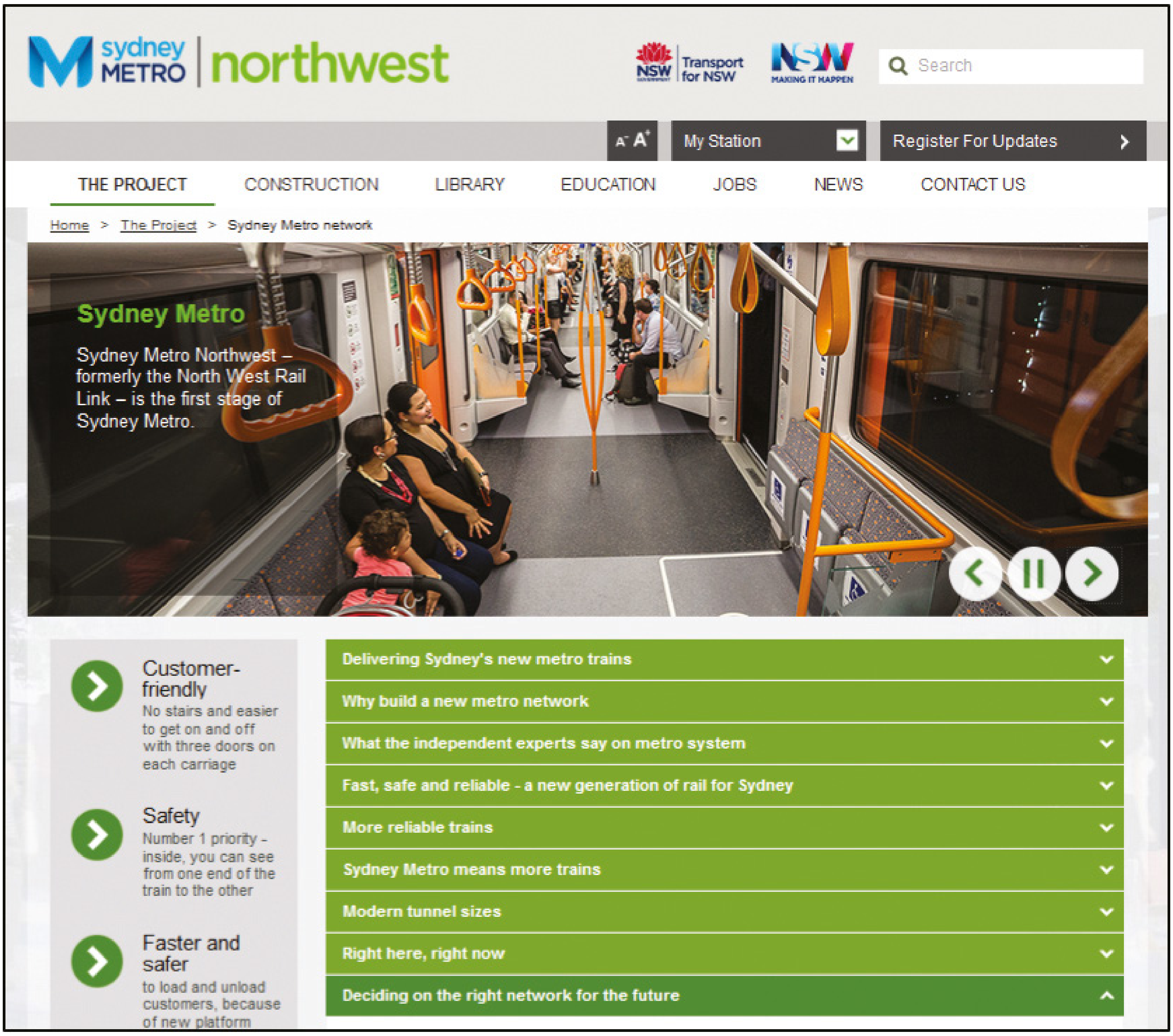

Plate 1 **The Sydney Metro Northwest website with Sydney Metro content (November 2015)**

6.2 Transport for NSW website

Since June 2014, the Transport for NSW website has contained information about the project, including:

- The fact sheet *'More trains, faster services right across Sydney'* (June 2014)
- The fact sheet – *'Transforming Sydney'* (November 2014)
- Media Releases (ongoing).

6.3 Sydney Metro City & Southwest website

The Sydney Metro City & Southwest website was launched on 4 June 2015 to provide information on the project. The website is a central point of up to date information for the community and stakeholders.

Information on the website includes:

- Project overview:
  - Customer Experience
  - Benefits (economic, employment and sustainability)
  - Strategic context
  - Sydney Metro Northwest
- Chatswood to Sydenham:
  - Project features
  - Station and dive sites
- Sydenham to Bankstown
- Resources:
  - Sydney Metro Project Overview (November 2015)
  - Chatswood to Sydenham State Significant Infrastructure Application Report (November 2015)
  - Sydney Metro Community Consultation Submissions Report (November 2015)
  - Sydney Metro City & Southwest Project Overview (June 2015)
  - Sydney Metro City & Southwest Newsletter (June 2015)
  - Sydney Metro City & Southwest Industry Briefing Presentation (June 2015)
  - Industry Briefing document (June 2015)
- Video and animation
- Online forums
- Online submission function (June/July 2015)
- Contact information.

Plate 2 The Sydney Metro website (November 2015)

6.4 Contact statistics

Table 4 outlines website activity statistics between 11 June 2015 and 30 April 2016.

Table 4 Website statistics

Website activity	Number of visits
Sydney Metro Northwest	
Registrations for project updates	2,970
Unique visitors	376,938
Total hits	1,777,542
Document views	30,497
Sydney Metro City & Southwest	
Registrations for project updates	2,405
Unique visitors	127,211
Total hits	171,000
Document views	36,333

7 Interactive online forums

During the project scope engagement period and finalisation of the Environmental Impact Statement, the Sydney Metro City & Southwest website included an online forum for public feedback about the proposal.

One of the objectives of the forum is to collect feedback from the local community on the planning process and how they would like to see the project delivered and impacts managed. The forums covered proposed station locations, station options, and management of construction impacts such as noise and vibration, and traffic. The responses to questions received have been considered in the preparation of the Environmental Impact Statement and will continue to be considered in ongoing project development.

Stakeholders were encouraged to visit the web forum via posts on the Sydney Metro Northwest Facebook page (there are currently over 7,000 followers) and via direct email to the project's email subscription list (there are currently almost 6,000 recipients).

7.1 Project scope

During the project scope consultation and engagement period, the forum sought feedback on Sydney Metro and particularly the proposed station options around Barangaroo, Waterloo or The University of Sydney, St Leonards or Crows Nest and the Artarmon Industrial Area.

Table 5 outlines interactive online forum statistics between 4 June to 17 July 2015.

Table 5 Project scope forums statistics

Forum statistics	Number		
Visitors	8,699		
Total comments made	243		
Forum topic	Visitors	Contributors*	Comments
What do you think will be the benefits of a station at Barangaroo?	255	7	3
What are your first impressions of the Sydney Metro City & Southwest?	1,310	33	23
Have your say on the University of Sydney or Waterloo Station option	3,888	134	109
Have your say on the St Leonards or Crows Nest Station option	1,735	76	61
Have your say on the Barangaroo Station option	760	30	26
Have your say on the Artarmon Industrial Area Station option	751	25	21

* *A contributor is a participant who submits a comment or replies to a comment.*

7.2 Planning process

During the second half of 2015, Transport for NSW sought further feedback from stakeholders via the online forums. The objective of the forum was to collect feedback from the local community on the planning process and how they would like to see the project delivered and impacts managed.

A number of questions were posted on the forum in a staged approached to ensure regular engagement via the project website.

Table 6 outlines interactive online forum statistics in August 2015.

Table 6 Planning process forums statistics

Forum statistics	Number		
Visitors	2,140		
Total comments made	99		
Forum topic	**Visitors**	**Contributors***	**Comments**
What is the best way to engage with you and your local community?	213	9	8
To plan how the project can best assist local businesses we'd like your feedback on how to minimise delivery impacts.	75	1	2
Have you experienced traffic changes in your local area due to construction, if so what worked well and what could be improved?	134	4	4
How should access be prioritised around the stations?	270	11	10
Project development – environmental studies	901	24	59
What positive experiences have you had with other infrastructure projects?	319	9	11
Have you ever been affected by construction noise and if so how was it managed?	228	4	5

**A contributor is a participant who submits a comment or replies to a comment.*

8 Public material

Public material has been developed on an as-needed basis throughout the planning process and would continue to be released throughout the development of the project.

Table 7 outlines public material produced between 11 June 2014 and 30 April 2016.

Table 7 Printed collateral regarding Sydney Metro City & Southwest

Title	Date	Distribution
Stakeholder consultation		
Fact sheet – *'More trains, less crowding'*	June 2014	• Transport for NSW website • Limited print run for stakeholder engagement meetings • Available at TfNSW Community Information Centres
Fact sheet – *'Transforming Sydney'*	June 2014	• Transport for NSW website • Limited print run for stakeholder engagement meetings • Available at TfNSW Community Information Centres
Project scope consultation and engagement		
Brochure – *'Transforming Sydney, Sydney Metro City & Southwest – Project overview'*	June 2015	• Sydney Metro City & Southwest website • Community information sessions • TfNSW and Sydney Metro Northwest community information centres • Provided to participants at stakeholder meetings • Displayed at Council offices (Bankstown, City of Canterbury, City of Sydney, Marrickville, North Sydney and Willoughby) • Provided to local MP offices

Title	Date	Distribution
Newsletter – ***'Have your say, more choice, more opportunity with metro rail'***	June 2015	• Sydney Metro City & Southwest website • Community information sessions • TfNSW and Sydney Metro Northwest community information centres • 220,000 newsletters delivered to properties within about one kilometre of the proposed alignment and station locations • 3,500 newsletters handed out at Sydney Trains rail stations (Martin Place, St Leonards, Town Hall, Chatswood, North Sydney) • Provided to participants at stakeholder meetings • Displayed at Council offices (Bankstown, City of Canterbury, City of Sydney, Marrickville, North Sydney and Willoughby) • Provided to local MP offices
Brochure – ***'Delivering Sydney Metro, Industry Briefing'***	June 2015	• Sydney Metro City & Southwest website • Available at the industry briefing on 16 June 2015
Project update announcement		
Booklet – ***'Sydney Metro City & Southwest – Project update'***	November 2015	• Sydney Metro City & Southwest website • TfNSW and Sydney Metro Northwest community information centres • Provided to local MP offices
Report – ***'Sydney Metro City & Southwest – Early community consultation, Submissions Report'***	November 2015	• Sydney Metro City & Southwest website • TfNSW and Sydney Metro Northwest community information centres
Report – ***'Sydney Metro City & Southwest – Chatswood to Sydenham State Significant Infrastructure Application Report'***	November 2015	• Sydney Metro City & Southwest website • Department of Planning & Environment, major projects website
Fact sheet – ***'Sydney Metro City & Southwest – Property Acquisition'***	November 2015	• Provided to property owners subject to acquisition
Fact sheet – ***'Sydney Metro City & Southwest – Property Acquisition – Commercial Tenants'***	November 2015	• Provided to commercial tenants subject to acquisition
Waterloo Station announcement		
Booklet – ***'Sydney Metro City & Southwest – Project update'***	February 2016	• Sydney Metro City & Southwest website • TfNSW and Sydney Metro Northwest community information centres • Provided to local MP offices
Fact sheet – ***'Sydney Metro City & Southwest – Property Acquisition'***	November 2015	• Provided to property owners subject to acquisition
Fact sheet – ***'Sydney Metro City & Southwest – Property Acquisition – Commercial Tenants'***	November 2015	• Provided to commercial tenants subject to acquisition

Title	Date	Distribution
Blues Point temporary site engagement		
Fact sheet – *'Blues Point Temporary Retrieval Site'*	February 2016	• Sydney Metro City & Southwest website • TfNSW and Sydney Metro Northwest community information centres • Provided to local MP offices • Delivered to all properties along Blues Point Road between the site and Union Street

9 Community information sessions

Community information sessions were hosted by TfNSW during the project scope consultation and engagement phase (4 June – 17 July 2015) to receive community input into the project scope.

9.1 Locations

Table 8 provides an overview of the community information sessions, about 800 people attended.

Table 8 Community information sessions

Date	Time	Location
13 June 2015	10am–2pm	Dougherty Community Centre (Auditorium), 7 Victor Street, Chatswood
17 June 2015	4pm–8pm	North Sydney Harbour View Hotel, 17 Blue Street, North Sydney
18 June 2015	4pm–8pm	Marrickville Metro, 34 Victoria Road, Marrickville
18 June 2015	4pm–8pm	TfNSW Information Centre, Ground floor, 388 George Street, Sydney
20 June 2015	9am–1pm	Crows Nest Markets, Ernest Place, Crows Nest
20 June 2015	10am–2pm	Redfern Oval Community Room, 51 Redfern Street, Redfern
23 June 2015	4pm–8pm	Canterbury-Hurlstone Park RSL, 20–26 Canterbury Road, Hurlstone Park
27 June 2015	10am–2pm	Bankstown Sports Club, 8 Greenfield Parade, Bankstown

9.2 Invitations

Invitations to attend the sessions were included in:

- The newsletter – 'Have your say, more choice, more opportunity with metro rail'
- On the Sydney Metro CBD & Southwest website
- Advertisements in local newspapers (see below).

9.3 Display materials

Display boards were designed around the following themes:

- The proposal at a glance:
  - Northern corridor works
  - Sydney Harbour Metro Crossing (Chatswood to Sydenham)
  - South west extension to Bankstown (Sydenham to Bankstown upgrade)
- Tunnelling under the harbour
- Project benefits
- Metro trains
- Fast, frequent metro
- Saving time
- Train features
- Connectivity
- Proposed timeline
- New Sydney Metro stations:
  - Central
  - Pitt Street
  - Martin Place
  - Victoria Cross
  - Either St Leonards or Crows Nest
- Strategic options – additional stations
- Optional stations:
  - Waterloo
  - The University of Sydney
  - Barangaroo
  - Artarmon Industrial Area
- How to have your say.

10 Newspaper advertising

Table 9 outlines the advertisements placed in local newspapers to promote the engagement period, community information sessions and the application for project approval.

Table 9 Newspaper advertising

Newspaper	Advertisement date
Have your say	
Daily Telegraph	13 and 15 June 2015
Sydney Morning Herald	13 and 15 June 2015
Inner West Courier	9 June 2015
Mosman Daily	4 June 2015
North Shore Times	10 and 12 June 2015
Southern Courier	16 June 2015
Canterbury Bankstown Express	16 and 23 June 2015
Australian Chinese Daily	6 June 2015
New trains for Sydney	
Penrith Press	12, 19 and 26 June 2015
Mt Druitt St Marys Standard	10, 17 and 24 June 2015
Blacktown Advocate	10, 17 and 24 June 2015
Parramatta Advertiser	10, 17 and 24 June 2015
Auburn Review	9, 16 and 23 June 2015
Inner West Courier	9, 16 and 23 June 2015
Central Courier	9, 16 and 23 June 2015
MX Sydney	9, 16 and 23 June 2015
Australian Chinese Daily	9, 16 and 23 June 2015
Hills Shire Times	9, 16 and 23 June 2015
Rouse Hill Times	10, 17 and 24 June 2015
Northern Districts Times	11, 18 and 25 June 2015
Hills News	9, 16 and 23 June 2015
Application for project approval	
North Shore Times	2 and 9 December 2015
Mosman Daily	3 and 10 December 2015
Inner West Courier	1 and 8 December 2015
Sydney Central Courier	2 and 9 December 2015
The Australian	2 and 5 December 2015
Daily Telegraph	2 and 5 December 2015
SMH	2 and 5 December 2015

Newspaper	Advertisement date
Australian Chinese Daily	2 December 2015
El Telegraph	2 December 2015
Chieu Dong	2 December 2015

Plate 3 Example advertisements

11 Stakeholder engagement

Transport for NSW's stakeholder consultation team has ensured all stakeholders are proactively engaged and informed about the project. Regular briefings via meetings, presentations and phone calls were held to keep stakeholders informed and to ensure key issues raised are addressed in the Environmental Impact Statement.

Table 10 outlines stakeholders who have been briefed on the project between 11 June 2014 and 30 April 2016.

Table 10 Stakeholder engagement

Stakeholder engagement	
Federal Government	
Australian Rail Track Corporation	
State Government	
Barangaroo Delivery Authority	Port Authority of NSW
CBD Coordination Office	Roads and Maritime Services
Department of Planning & Environment	State Emergency Service
Environmental Protection Authority	Sydney Harbour Foreshore Authority
Harbour Trust	Sydney Light Rail
Health NSW	Sydney Trains
Heritage Council of NSW	Transport Management Centre
NSW Health – Sydney Local Health District	UrbanGrowth NSW
NSW Trains	
Local Government	
Bankstown Council	Liverpool City Council
City of Canterbury	Marrickville Council
City of Sydney	North Sydney Council
Hills Shire Council	Willoughby City Council
Lane Cove Council	
Regional Organisation of Councils	
Northern Sydney Regional Organisation of Councils ♦ Hornsby, Hunters Hill, Ku-ring-gai, Lane Cove, North Sydney, Ryde and Willoughby Councils Southern Sydney Regional Organisation of Councils ♦ Ashfield, Bankstown, Botany, Burwood, Canada Bay, Sydney, Hurstville, Kogarah, Leichhardt, Marrickville, Randwick, Rockdale, Sutherland, Waverley and Woollahra Councils Western Sydney Regional Organisation of Councils ♦ Auburn, Fairfield, Blacktown, Blue Mountains, Bankstown, Hawkesbury, Holroyd, Liverpool, Parramatta and Penrith Councils	

Stakeholder engagement	
Federal Members of Parliament	
• Member for Bradfield	• Member for North Sydney
State Members of Parliament	
• Member for Canterbury	• Member for North Shore
• Member for Holsworthy	• Member for Summer Hill
• Member for Ku-ring-gai	• Member for Sydney
• Member for Lane Cove	• Member for Willoughby
Member of the Legislative Council	
• The Hon. Shayne Mallard	
Peak bodies	
• 10,000 Friends of Greater Sydney	• NRMA
• Action for Public Transport	• NSW Business Chamber
• Australian Institute of Architects	• NSW Commuter Council
• Australasian Railway Association	• Planning Institute of Australia
• BusNSW	• Property Council
• Committee for Economic Development of Australia	• Sydney Business Chamber
• Committee for Sydney	• Tourism and Transport Forum
• Consult Australia	• Urban Taskforce
• Housing Industry Association	• Warren Centre for Advanced Engineering
• Infrastructure Partnerships Australia	• Western Sydney Business Chamber
• Metropolitan Local Aboriginal Land Council	
Educational Institutions	
• Church of England Grammar School (SHORE)	• University of Wollongong
• Monte Sant' Angelo Mercy College	• Western Sydney University
• The University of Sydney	
Transport specialists	
Dr Gary Glazebrook	Mr Ron Christie

Stakeholder engagement	
Community and interest groups	
Artarmon Bushcare Group	RedWatch
Artarmon Progress Association	Stanton Precinct Committee
Chatswood West Ward Progress Association	Willoughby District Historical Society
Friends of Sydney Harbour	Wollstonecraft Precinct Committee
Holtermann Precinct Committee	Millers Point Community Working Party
Ian Kiernan	Millers Point, Dawes Point & The Rocks Public Housing Tenants
Lavender Bay Precinct Committee	Waverton Precinct Committee (Berry's Bay)
Naremburn Progress Association	WestConnex Action Group
North Shore Historical Society	
North Sydney Sunrise Rotary Club	
Utilities	
AARNet	Optus / Uecomm
AMCOM / Vocus	Sydney Water
Ausgrid	Telstra
iPrimus	TPG (AAPT / Powertel / PipeNetworks)
Jemena	TransGrid
NBN Co	Verizon / Worldcom
Nextgen / Visionstream	Viva Energy

12 Industry engagement

The industry briefings detailed plans for Sydney Metro City & Southwest, the scope of works and the process for industry to contribute to the project and take part in its delivery.

Industry representatives came from Australia and overseas including the United Kingdom, USA, Singapore, Hong Kong, Spain, South Korea, Japan, Italy, Germany, China, Austria and France.

During the first round of industry engagement in mid 2015, the project team met with more than 40 local and international companies and received more than 60 written submissions. This feedback has been used to inform the ongoing development of the project, including plans for the procurement of major construction contracts.

In addition to industry briefings and meetings, the Project Director presented at the Australian Financial Review Infrastructure Summit on 12 June 2015.

Table 11 outlines the industry briefings held.

Table 11 Sydney Metro City & Southwest industry briefings

Date	Location	Booklet	Attendees
16 June 2015	Roslyn Packer Theatre, Walsh Bay	*'Delivering Sydney Metro, Industry Briefing'*	Just under 500
4 December 2015	Civic Pavilion in The Concourse, Chatswood	*'Sydney Metro, City & Southwest Industry Briefing'*	Just over 460
16 April 2016	Civic Pavilion in The Concourse, Chatswood	*'Sydney Metro, City & Southwest Industry Briefing'*	Just over 450

12.1 Invitations

Invitations to attend the briefings were included in:

- The Sydney Metro City & Southwest website
- Advertisements in Australian and international newspapers
- Direct invitations.

12.2 Newspaper advertising

Table 12 outlines the advertisements that were placed in local and international newspapers to advertise the briefing and invite industry to register to attend.

Table 12 Newspaper advertising

Newspaper	Advertisement date
16 June briefing	
Australian Financial Review	Thursday 4 June 2015
Sydney Morning Herald	Thursday 4 June 2015
The Australian	Thursday 4 June 2015
Paris – Le Monde	Tuesday 2 June 2015
Hong Kong – South China Morning Post	Tuesday 2 June 2015
London – Daily Telegraph	Tuesday 2 June 2015
New York Times	Tuesday 2 June 2015
4 December briefing	
Australian Financial Review	Thursday 12 November 2015
Sydney Morning Herald	Thursday 12 November 2015
The Daily Telegraph	Thursday 12 November 2015
The Australian	Thursday 12 November 2015
Paris – Le Monde	Thursday 12 November 2015
Hong Kong – South China Morning Post	Thursday 12 November 2015
London – Daily Telegraph	Thursday 12 November 2015
16 April briefing	
Australian Financial Review	Thursday 31 March 2016
Sydney Morning Herald	Thursday 31 March 2016

Newspaper	Advertisement date
The Daily Telegraph	Thursday 31 March 2016
The Australian	Thursday 31 March 2016

Plate 4 Example advertisements

13 Compiling the Environmental Impact Statement

In addition to the consultation and engagement outlined above, consultation was carried out in the form of surveys as part of environmental impact assessment studies to assess:

- Social impacts
- Business impacts
- Non-Aboriginal and Aboriginal heritage.

Full details on these surveys and stakeholders involved can be found in the relevant specialist reports in the Environmental Impact Statement.

14 Environmental Impact Statement consultation

14.1 Public exhibition of Environmental Impact Statement

Public exhibition of the Environmental Impact Statement will be for a minimum of 30 days. Advertisements will be placed in newspapers to advise of the public exhibition and where the Environmental Impact Statement can be viewed, including details on proposed community consultation activities and information sessions.

Consultation and engagement activities during the public exhibition of the Environmental Impact Statement will be consistent with those carried out for the project scope exhibition and may include:

- Awareness and marketing campaigns
- Community event stalls
- Community information centres
- Community information sessions
- Displays at Council offices
- Doorknocks
- Email updates
- Enquiries and complaints hotline
- Environmental Impact Statement summary document
- Fact sheets
- Government stakeholder engagement
- Local business engagement
- Media releases
- Newsletter
- Newspaper advertising
- Place Managers
- Project briefings and presentations
- Social media updates
- Stakeholder meetings
- Website, animations and online forums.

14.2 Submissions

During the exhibition period, all stakeholders will be invited to make written submissions to the Department of Planning & Environment in response to the environmental assessment.

Once the exhibition period closes, a submission report will be prepared to address the issues raised in the submissions received. The report will be submitted to the Department of Planning & Environment and will be made publicly available.

Stakeholders who make public submissions will formally be advised of receipt of their submission and provided with a submission number.

CONSTRUCTION ENVIRONMENTAL MANAGEMENT FRAMEWORK

APPENDIX D

Contents

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1. Introduction

1.1 Purpose and Scope

This Construction Environmental Management Framework (CEMF) is a Sydney Metro project framework which sets out the environmental, stakeholder and community management requirements for construction. It provides a linking document between the planning approval documentation and the construction environmental management documentation to be developed by the Principal Contractors relevant to their scope of works.

Sydney Metro Principal Contractors will be required to implement and adhere to the requirements of this CEMF. The requirements of this CEMF will be included as a contract document in all design and construction contracts.

1.2 Status

This is a controlled document, please refer to the version register below which is updated as required.

Version	Description	Date
1.0	For EIS 1	4 April 2012
1.1	For EIS 1 Submissions Report	26 July 2012
1.2	For EIS 2 and the Rapid Transit Rail Facility (RTRF)	31 October 2012
1.3	Updated to incorporate all planning approvals, including ECRL conversion Part 5 approvals	11 July 2014
3.0	Updated to encompass the scope of Sydney Metro – Chatswood to Sydenham EIS	16 February 2016

Previous versions of the CEMF (shown above) still apply to their respective works packages and form part of the contract requirements for the relevant Principal Contractors. The CEMF will continue to be updated and form part of future contract requirements for Sydney Metro works packages.

1.3 Environment and Sustainability Policy

Transport for NSW (TfNSW) has developed an Environment and Sustainability Policy (Appendix A) for Sydney Metro. Principal Contractors will be required to undertake their works in accordance with this policy. The policy reflects a commitment in the delivery of the project to:

- Align with, and support, Transport for NSW (TfNSW) Environment & Sustainability Policy.
- Optimise sustainability outcomes, transport service quality, and cost effectiveness.
- Develop effective and appropriate responses to the challenges of climate change, carbon management, resource and waste management, land use integration, customer and community expectation, and heritage and biodiversity conservation.
- Be environmentally responsible, by avoiding pollution, enhancing the natural environment and reducing the project ecological footprint, while complying with all applicable environmental laws, regulations and statutory obligations.
- Be socially responsible by delivering a workforce legacy which benefits individuals, communities, the project and industry, and is achieved through collaboration and partnerships.

1.4 Project Description

The New South Wales (NSW) Government is implementing Sydney's Rail Future, a plan to transform and modernise Sydney's rail network so that it can grow with the city's population and meet the needs of customers in the future.

Sydney Metro is a new standalone rail network identified in Sydney's Rail Future. The Sydney Metro network consists of Sydney Metro Northwest (previously known as the North West Rail Link) and Sydney Metro City & Southwest. The proposed Sydney Metro network is shown in Figure 1-1.

The proposed Sydney Metro City & Southwest (SM C&SW) comprises two core components:

- The Chatswood to Sydenham project (the project), which is the subject of this Environmental Impact Statement. The project would involve construction and operation of an underground rail line, about 15.5 kilometres long, and new stations between Chatswood and Sydenham
- The second core component would involve upgrading the 13.5 kilometre rail line and existing stations from Sydenham to Bankstown which will be subject to a separate environmental assessment process.

Investigations have started on the possible extension of Sydney Metro from Bankstown to Liverpool. The potential extension would support growth in Sydney's south west by connecting communities, businesses, jobs and services as well as improving access between the south west and Sydney's CBD. It would also reduce growth pressure on road infrastructure and the rail network, including the potential to relieve crowding on the T1 Western Line, T2 South Line and T2 Airport Line.

The Sydney Metro Delivery Office has been established as part of Transport for NSW to manage the planning, procurement and delivery of the Sydney Metro network.

Figure 1.1 The Sydney Metro network

2. Legislative and Other Requirements

The key environmental obligations to be addressed are contained within:

- Legislative requirements.
- Project approval documentation.
- Conditions of Approval.
- Environment Protection Licences.
- Other permits, approval and licences.
- Standards and guidelines.

2.1 Key Legislative Requirements

Table 1.1 below identifies key NSW environmental legislative requirements and their application to SM C&SW construction works, current as at the date of this document. TfNSW and its Contractors should regularly review their legislative requirements.

Table 1.1 NSW Legislative Requirements

Legislation and Administering Authority	Requirements	Application to Sydney Metro
Contaminated Land Management Act 1997 **NSW Environment Protection Authority (EPA)**	The Act provides a process for the investigation and remediation of land where contamination presents a significant risk of harm to human health or some other aspect of the environment.	Sydney Metro must follow the process where contaminated land is identified.
Dangerous Goods (Road and Rail Transport) Act 2008 **EPA / Workcover**	A licence is required for the storage (Workcover) and /or transport (EPA) of prescribed quantities of dangerous goods.	Sydney Metro Principal Contractors must obtain a licence where storage of dangerous goods would exceed licensable quantities.
Environmental Planning and Assessment Act 1979 **Department of Planning and Environment (DP&E)**	Encourages proper environmental impact assessment and management of development areas for the purpose of promoting the social and economic welfare of the community and a better environment.	Sydney Metro must adhere to mitigation measures and conditions within the planning approval documentation. The proponent and their contractors must endeavor to deliver in a consistent manner within the assessed scope of works.
Fisheries Management Act 1994 **Department of Primary Industries (Fisheries)**	The relevant objectives of the Act are to conserve threatened species, populations and ecological communities and promote ecologically sustainable development, including the conservation of biological diversity.	Sydney Metro projects assessed under Part 5.1 of the Environmental Planning and Assessment Act 1979 (EP&A Act) are exempt from permits required under sections 201, 205 or 219.
Heritage Act 1977 **NSW Office of Environment and Heritage (OEH)**	The Act aims to encourage the conservation of the State's heritage and provides for the identification and registration of items of State heritage significance.	Sydney Metro projects assessed under Part 5.1 of the Environmental Planning and Assessment Act 1979 (EP&A Act) are exempt from approvals required under Part 4 and permits required under section 139.

Legislation and Administering Authority	Requirements	Application to Sydney Metro
National Parks and Wildlife Act 1974 OEH	The objectives of the Act are for the conservation of nature and the conservation of objects, places or features (including biological diversity) of cultural value within the landscape.	Sydney Metro projects assessed under Part 5.1 of the Environmental Planning and Assessment Act 1979 (EP&A Act) are exempt from obtaining an Aboriginal Heritage Impact Permit required under section 90.
Native Vegetation Act 2003 OEH	The objective of the Act is to protect and improve the value of native vegetation.	Sydney Metro projects assessed under Part 5.1 of the Environmental Planning and Assessment Act 1979 (EP&A Act) are exempt from section 12 authorisation to clear native vegetation.
Noxious Weeds Act 1993 Department of Primary Industries	The Act aims to prevent the introduction of new weeds and restrict the spread of existing weeds.	Sydney Metro Principal Contractors must control weeds as required on land under the management of the Contractor.
Protection of the Environment Operations Act 1997 EPA	The relevant objective of the Act is to prevent environmental pollution.	Where Sydney Metro projects are scheduled activities under Schedule 1 of the Act an Environment Protection Licence (EPL) must be obtained. Further details on the requirements to obtain an EPL are provided in Section 2.3.
Roads Act 1993 Roads and Maritime Service	The relevant objective of the Act is to regulate the carrying out of various activities on public roads.	Sydney Metro Principal Contractors must obtain consent under section 138 for carrying out work in, on or over a public road, or digging up or disturbance of the surface of the road.
Waste Avoidance and Resource Recovery Act 2001 EPA	The objectives of the Act are to reduce environmental harm and provide for the reduction in waste generation.	Sydney Metro Principal Contractors must implement strategies to reduce waste volumes and report on waste generated.

Legislation and Administering Authority	Requirements	Application to Sydney Metro
Water Management Act 2000 NSW Office of Water	The relevant objective of the Act is to protect, enhance and restore water sources, their associated ecosystems, ecological processes and biological diversity and their water quality.	Sydney Metro projects assessed under Part 5.1 of the Environmental Planning and Assessment Act 1979 (EP&A Act) are exempt from obtaining water use approval under section 89, a water management work approval under section 90 or an activity approval (other than an aquifer interference approval) under section 91.

Table 1.2 identifies key Commonwealth environmental legislative requirements and their application to SM C&SW construction works, current as at the date of this document. TfNSW and its Contractors should regularly review their legislative requirements.

Table 1.2 Commonwealth Legislative Requirements

Legislation and Administering Authority	Requirements	Application to Sydney Metro
Environment Protection and Biodiversity Conservation Act 1999 Department of the Environment	The relevant objective of the Act is to provide for the protection of the environment, especially those aspects of the environment that are matters of national environmental significance.	A project may be defined as a controlled action under the Act due to impacts on matters of national environmental significance.
National Greenhouse and Energy Reporting Act 2007 Department of Climate Change and Energy Efficiency	The Act established a framework for reporting of greenhouse gas emissions, abatement actions, energy consumption and production data.	Sydney Metro Principal Contractors must report on greenhouse gas and energy usage data as required by the Act.

2.2 Environmental Approvals

Sydney Metro Northwest is classified as Critical State Significant Infrastructure and was approved under the following in accordance with Section 115W of the Environmental Protection and Assessment Act 1997:

- Staged State Infrastructure Approval (1 October 2011, modified on 25 September 2012)
- Stage 1 – Major Civil Construction Works (25 September 2012, modified on 18 April 2013)
- Stage 2 – Stations, Rail Infrastructure and Systems (8 May 2013, modified on 20 May 2014).

Some components of Sydney Metro Northwest (such as the conversion of the Epping to Chatswood component of the project) have also been approved under Part 5 of the Environmental Protection and Assessment Act. in which case TfNSW is the consent authority.

Sydney Metro City and Southwest is also classified as Critical State Significant Infrastructure and requires approval from a consent authority under the requirements of the Environmental Protection and Assessment Act 1997 (Section 115W). Two separate approvals will be sought:

- Sydney Metro City and Southwest – Chatswood to Sydenham
- Sydney Metro City and Southwest - Sydenham to Bankstown

The requirements of the approval are required to be complied with by TfNSW. Responsibility for implementing mitigation measures and conditions of approval will be allocated between TfNSW and Principal Contractors as appropriate. Typically TfNSW will produce a Staging Report which sets out the applicability and allocation of approval requirements within the project's program of works.

2.3 Environment Protection Licence Requirements

Sydney Metro projects often meet the definition of a number of scheduled activities under Schedule 1 of the *Protection of the Environmental Operation Act 1997* (POEO Act) and as such our contractors may be required to obtain an Environment Protection Licence (EPL).

Where required Sydney Metro Principal Contractors will:

a. Apply for and be granted an EPL from the EPA.

b. Hold an EPL which covers their scope of works as necessary under the POEO Act.

c. Undertake their scope of works in accordance with the conditions of the applicable EPLs as issued by the EPA.

2.4 Standards and Guidelines

Numerous environmental publications, standards, codes of practice and guidelines are relevant to Sydney Metro construction and are referenced throughout this Construction Environmental Management Framework. A summary of these applicable standards and guidelines is provided in Table 1.3.

Table 1.3 Environmental Standards and Guidelines

Standard / Guideline	Relevant Authority	CEMF Reference
ISO14001 Environmental Management System – Requirements with Guidelines for Use	DP&E	Section 3.1
Interim Construction Noise Guidelines (Department of Environment and Climate Change, 2009)	EPA	Section 9.2
Managing Urban Stormwater: Soil and Construction (Landcom, 2008)	EPA	Section 15.2
AS4282:1997 Control of the Obtrusive Effect of Outdoor Lighting	OEH	Section 12.3
Waste Classification Guidelines (Department of Environment, Climate Change and Water, 2008)	EPA	Section 17.3

3. Environmental Management Requirements

3.1 Environmental and Sustainability Management System

a. Principal Contractors are required to have a corporate Environmental Management System certified under AS/NZS ISO 14001:2004.

b. Principal Contractors are required to develop a project based Environment and Sustainability Management System (E&SMS). The E&SMS will:

- be consistent with the Principal Contractors corporate Environmental Management System and the principles of AS/NZS ISO 14001:2004: Environmental Management Systems – Requirements with Guidelines for Use;
- be supported by a process for identifying and responding to changing legislative or other requirements;
- include processes for assessing design or construction methodology changes for consistency against the planning approvals;
- include processes for tracking and reporting performance against sustainability targets;
- include a procedure for the identification and management of project specific environmental risks and appropriate control measures.
- be consistent with the SM C&SW Sustainability Strategy and Sydney Metro Environment and Sustainability Policy;

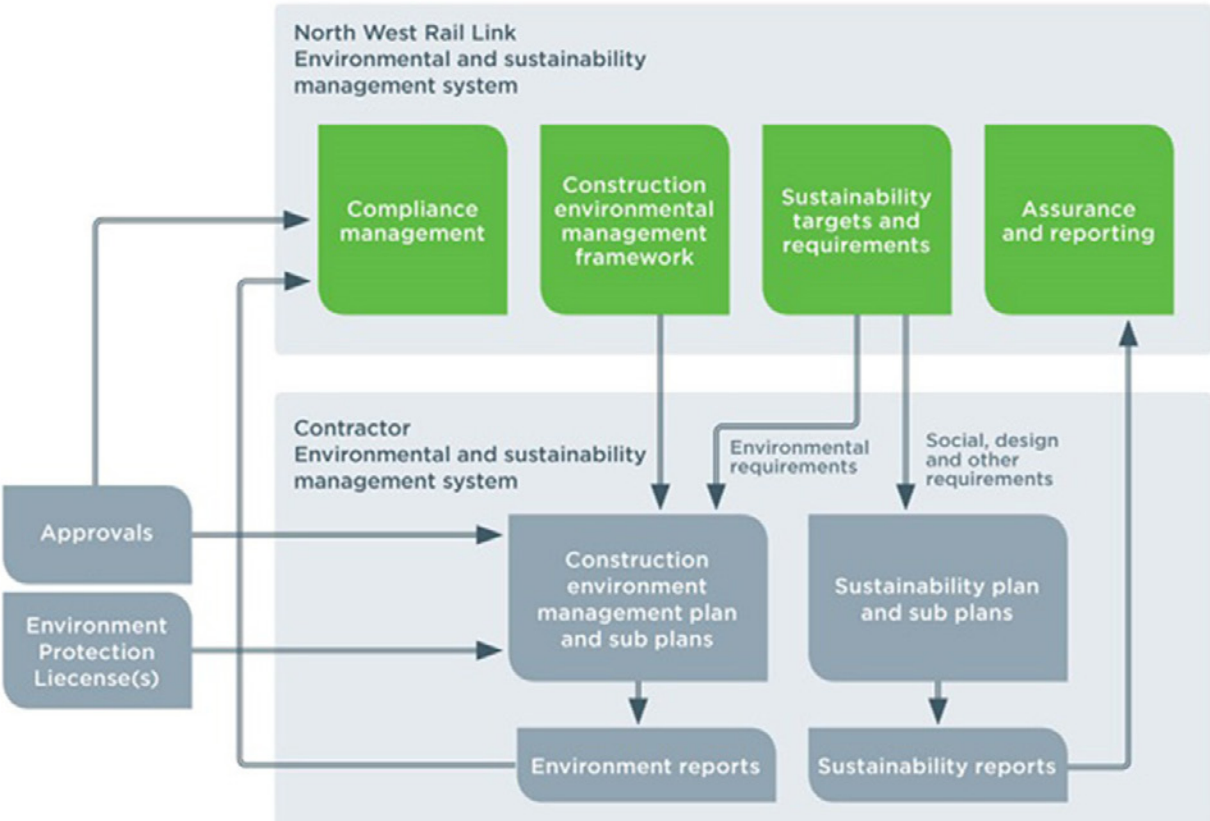
c. All sub-contractors engaged by the Principal Contractor will be required to work under the Principal Contractor's E&SMS.

d. the relationship between key documents within the Sydney Metro Environment and Sustainability Management System and the Principal Contractor's Environment and Sustainability Management System is shown in Figure 2.

e. the Principal Contractors Sustainability Plan and its sub plans will capture governance and design requirements as well as social sustainability initiatives as required by the Sydney Metro Sustainability Strategies.

f. These plans vary in scope across different delivery packages.

Figure 2 - Environmental Management and Sustainability Structure



3.2 Construction Sustainability Management Plan

a. Principal Contractors are required to prepare and implement a Sustainability Management Plan (SMP) relevant to the scale and nature of their scope of works. The SMP shall comprise of a main SMP document and issue-specific sub-plans.

b. Depending on the scope and scale of the works, TfNSW may decide to streamline the SMP and sub-plan requirements. As a minimum the SMP will address and detail:

- The requirements of the relevant planning approval documentation, any relevant conditions of all other permits and licences, the Contractor's corporate EMS, the sustainability provisions of the contract documentation and this Construction Environmental Management Framework.
- The sustainability management team structure, including key personnel authority and roles of key personnel, lines of responsibility and communication, minimum skill levels of each role and interfaces with the overall project organisation structure;
- A sustainability policy statement and strategies for adaptation to climate change, resource management (including energy, water and waste), workforce development, procurement and biodiversity enhancement;
- Sustainability initiatives to be implemented during the project.
- How sustainability initiatives will be identified and implemented;
- The processes and methodologies for assurance, monitoring, auditing, corrective action, continuous improvement and reporting on sustainability performance;

- The processes and methodologies which will be used to achieve the required scores under rating systems identified in contract documents;
- The processes and procedures for undertaking climate change risk assessments;
- The processes and procedures for the identification and implementation of climate change adaption measures;
- The approach to sustainable procurement including:
    - The processes and procedures that will be used to provide environmental and social improvement;
    - The processes and environmental and social criteria that will be used for the selection of Subcontractors;
    - The processes that will be used to ensure ethical sourcing of labour and materials
    - Where equipment, materials or labour are procured from locations outside Australia, the processes that will be used to ensure human rights impacts and risks are identified and mitigated.
    - Interfaces with other Project Plans.

c. Depending on the scope of the works, the SMP will also include, as a separate sub-plans:

- A Construction Workforce Development Plan
- A Construction Carbon and Energy Management Plan
- A Waste Management & Recycling Plan

d. The Workforce Development Plan will address and detail:

- The proposed response to workforce-related regulatory, planning approval, and contract requirements which will be addressed for the project
- The workforce development team structure, including key personnel authority and roles of key personnel, lines of responsibility and communication, minimum skill levels of each role and interfaces with the overall project organisation structure;
- A description of the workforce development initiatives which will be implemented, and the implementation methodology, including for:
    - Assessing current and future workforce skill needs and workforce profiles including a skills and workforce gap plan.
    - Increasing local employment, local business opportunities and involvement of local SMEs.
    - Provision of relevant Nationally Recognised Accredited Training.
    - Increasing workforce diversity and inclusion, targeting indigenous workers and businesses, female representation in non-traditional trades and long-term unemployed.
    - Participation in work placement and education programs for young people.
    - Increasing participation of apprentices and trainees.
- The processes and methodologies for assurance, monitoring, auditing, corrective action, continuous improvement and reporting on workforce development performance.

3.3 Construction Environmental Management Plans

a. Principal Contractors are required to prepare and implement a Construction Environmental Management Plan (CEMP) relevant to the scale and nature of their scope of works.

b. The CEMP shall comprise of a main CEMP document, issue specific sub-plans, activity specific procedures and site based control maps. The CEMP framework shall show the relationship between the contractors corporate EMS, other relevant project based documentation, and the CEMP.

c. Depending on the scope and scale of the works, TfNSW may decide to streamline the CEMP and sub-plan requirements. For example, depending on the risk associated with particular environmental issues it may be appropriate to remove the need for a sub plan and replace with a procedure as part of the CEMP.

d. The CEMP will cover the requirements of the relevant planning approval documentation, the conditions of all other permits and licences, the Principal Contractor's corporate EMS, the environmental provisions of the contract documentation and this Construction Environmental Management Framework.

e. As a minimum the CEMP will:

- Include description of activities to be undertaken during construction
- Include a contract specific environmental policy
- For each plan under the CEMP include a matrix of the relevant Conditions of Approval or Consent showing where each requirement is addressed.
- For each plan under the CEMP, set objectives and targets, and identify measurable key performance indicators in relation to these.
- Identify a clear organisational structure for the project including the roles responsible for environmental management activities, accompanied by a description of those roles and responsibilities.
- Assign the responsibility for the implementation of the CEMP to the Environment Manager, who will have appropriate experience. The Principal Contractor's Project Director will be accountable for the implementation of the CEMP.
- Identify communication requirements, including liaison with stakeholders and the community.
- Include induction and training requirements.
- Include procedures for monitoring and evaluating environmental performance.
- Include reporting requirements.
- Include procedures for emergency and incident management, non-compliance management, and corrective and preventative actions.
- Include procedures for audit and review.
- Include procedures for the control of environmental records.
- Provide a clear description of the relationship to other plans required by the contract, in particular those that relate to design management.

f. The CEMP and associated sub-plans will be reviewed by TfNSW and/or an independent environmental representative (see Section3.11) prior to any construction works commencing. Depending on the conditions of approval, the CEMP and certain sub-plans may also require the approval of the Department of Planning and Environment (DP&E), and other government agencies.

g. Where a corresponding systems document exists within the Sydney Metro Integrated Management System, the Principal Contractor's procedures will be required to be consistent.

3.4 Construction Environmental Management Sub-Plans

a. Subject to Section 3.3(c) and Section 3.2(c) the Principal Contractor will prepare issue-specific environmental sub-plans to the CEMP and SMP which address each of the relevant environmental impacts at a particular site or stage of the project. Issue specific sub-plans will include:

- Spoil management.
- Groundwater management.
- Soil and water management.
- Traffic and transport management.
- Noise and vibration management.
- Heritage management.
- Flora and fauna management.
- Visual amenity management.
- Carbon and energy management.
- Air quality management.
- Waste management.

b. Additional detail on the minimum requirements for these sub plans is provided in Sections 6-17 of this CEMF.

3.5 Environmental Procedures and Control Maps

a. The Principal Contractor will prepare and implement activity specific environmental procedures. These procedures should supplement environmental management sub-plans, but may substitute for sub-plans in agreement with Sydney Metro if a reasonable risk based justification can be made and the sub plan is not a requirement of approval.

b. The procedures will include:

- A breakdown of the work tasks relevant to the specific activity and indicate responsibility for each task.
- Potential impacts associated with each task.
- A risk rating for each of the identified potential impacts.
- Mitigation measures relevant to each of the work tasks.
- Responsibility to ensure the implementation of the mitigation measures.

c. The Principal Contractor will prepare and implement site based progressive Environmental Control Maps (ECM's) which as a minimum:

- Is a progressive document depicting a current representation of the site.
- Indicates which environmental procedures, environmental approvals, or licences are applicable.
- Illustrates the site showing significant structures, work areas and boundaries.
- Illustrates environmental control measures and environmentally sensitive receivers.
- Is endorsed by the Principal Contractors Environmental Manager or delegate.
- Relevant workers will be trained in the requirements of and will sign off the procedures prior to commencing works on the specific site and / or activity.

3.6 Additional Environmental Assessments

a. Where the requirement for an additional environmental assessment is identified, this will be undertaken prior to undertaking any physical works. The environmental assessment will include:

- A description of the existing surrounding environment.
- Details of the ancillary works and construction activities required to be carried out including the hours of works.
- An assessment of the environmental impacts of the works, including, but not necessarily limited to, traffic, noise and vibration, air quality, soil and water, ecology and heritage.
- Details of mitigation measures and monitoring specific to the works that would be implemented to minimise environmental impacts.
- Identification of the timing for completion of the construction works, and how the sites would be reinstated (including any necessary rehabilitation).

3.7 Condition Surveys

a. Prior to the commencement of construction the Principal Contractors will offer Pre-construction Building Condition Surveys, in writing, to the owners of buildings where there is a potential for construction activities to cause cosmetic or structural damage. If accepted, the Principal Contractor will produce a comprehensive written and photographic condition report produced by an appropriate professional prior to relevant works commencing.

b. Prior to the commencement of construction the Principal Contractor will prepare a Road Dilapidation Report for all local public roads proposed to be used by heavy vehicles.

3.8 Register of Hold Points

a. Principal Contractors will identify hold points, beyond which approval is required to proceed with a certain activity. Example activities include vegetation removal and water discharge. Hold points will be documented in relevant CEMPs.

b. Table 1.4 provides the structure for the register of hold points as well as a preliminary list of hold points which will be implemented.

Table 1.4 Preliminary Register of Hold Points

Hold Point	Release of Hold Point	By Who
Prior to Vegetation Clearing / Ground Disturbance	Pre-clearing inspection Erosion and sediment control plan	Qualified Ecologist Contractor's Environmental Manager or delegate
Discharge of water	Water tested to verify compliance and approval to discharge	Contractor's Environment Manager or delegate
Out of hours works	Noise Assessment	Contractor's Environment Manager
Use of local roads by heavy vehicles	Road Dilapidation Report	Appropriate Professional nominated by Principal Contractor
Construction identified as affecting buildings	Building Condition Survey	Appropriate Professional nominated by Principal Contractor

3.9 Training, Awareness and Competence

a. Principal Contractors will be responsible for determining the training needs of their personnel. As a minimum this will include site induction, regular toolbox talks and topic specific environmental training as follows:

- The site induction will be provided to all site personnel and will include, as a minimum:
    - Training purpose, objectives and key issues.
    - Contractor's environmental policy and key performance indicators.
    - Due diligence, duty of care and responsibilities.
    - Relevant conditions of any environmental licence and/or the relevant conditions of approval.
    - Site specific issues and controls including those described in the environmental procedures.
    - Reporting procedure for environmental hazards and incidents.
    - Communication protocols.

b. Toolbox talks will be held on a regular basis in order to provide a project or site wide update, including any key or recurring environmental issues.

c. Topic specific environmental training, eg erosion and sediment control training will be undertaken for relevant site personnel as determined by the Principal Contractor.

d. Principal Contractors will conduct a Training Needs Analysis which:

a. Identifies the competency requirements of staff that hold environmental roles and responsibilities documented within the Construction Environmental Management Plan and sub-plans.

b. Identifies appropriate training events and the frequency of training to achieve and/or maintain these competency requirements.

c. Implements a documented training schedule which plans attendance at training events, provides mechanisms to notify staff of their training requirements, and identifies staff that fail to attend scheduled training events or who have overdue training requirements.

d. Identifies that all staff are to receive an environmental induction and undertake environmental incident management training.

3.10 Emergency and Incident Response

a. Principal Contractors will develop and implement a Pollution Incident Response Management Plan, in accordance with the requirements of the POEO Act. Contractors' emergency and incident response procedures will also be consistent with any relevant TfNSW procedures and will include:

- Categories for environmental emergencies and incidents.
- Notification protocols for each category of environmental emergency or incident, including notification of TfNSW and notification to owners / occupiers in the vicinity of the incident. This is to include relevant contact details.
- Identification of personnel who have the authority to take immediate action to shut down any activity, or to affect any environmental control measure (including as directed by an authorised officer of the EPA).
- A process for undertaking appropriate levels of investigation for all incidents and the identification, implementation and assessment of corrective and preventative actions;
- Depending on the nature of the incident the EPA, DP&E or OEH will be notified by the Principal Contractor or TfNSW as appropriate.

b. The Contractor will make all personnel aware of the plan and their responsibilities.

3.11 Independent Environmental Representatives

a. TfNSW will engage Independent Environmental Representatives (ERs) to undertake the following, along with any additional roles as required:

- Review, provide comment on and endorse (where required) any relevant environmental documentation to verify it is prepared in accordance with relevant environmental legislation, planning approval conditions, relevant standards and this CEMF.
- Monitor and report on the implementation and performance of the above mentioned documentation and other relevant documentation.
- Provide independent guidance and advice to TfNSW and the Contractors in relation to environmental compliance issues and the interpretation of planning approval conditions.
- Be the principal point of advice for the DP&E in relation to all questions and complaints concerning the environmental performance of the project.
- Ensure that environmental auditing is undertaken in accordance with all relevant project requirements.
- Recommend reasonable steps, including 'stop works', to be taken to avoid or minimise adverse environmental impacts.

3.12 Roles and Responsibilities

a. In relation to Roles and Responsibilities the CEMP will:

- describe the relationship between the Principal Contractor, TfNSW, key regulatory stakeholders, the independent environmental representative and the independent certifier.
- Describe the Principal Contractors environment, sustainability, and approvals team structure,
- For each role that has environmental accountabilities or responsibilities provide a tabulated description of the role, accountabilities, responsibilities, lines of communication, minimum skill level requirements and their interface with the overall project organisation structure.
- Provide details of each specialist environment, sustainability or planning consultant who is employed by the Principal Contractor including the scope of their work.
- Provide an overview of the role and responsibilities of the Independent Environmental Representative, the Independent Certifier and other regulatory stakeholders.

b. All sub-contractors engaged by the Principal Contractor will be required to operate within the EMS documentation of that Principal Contractor.

3.13 Environmental Monitoring, Inspections and Auditing

a. Issue specific environmental monitoring will be undertaken as required or as additionally required by approval, permit or licence conditions.

b. The results of any monitoring undertaken as a requirement of the EPL will be published on the Principal Contractor's, or a project specific, website within 14 days of obtaining the results.

c. Environmental inspections will include:

- Surveillance of environmental mitigation measures by the Site Foreman.
- Periodic inspections by the Principal Contractor's Environmental Manager (or delegate) to verify the adequacy of all environmental mitigation measures. This will be documented in a formal inspection record.

d. Regular site inspections by the ERs and TfNSW representatives at a frequency to be agreed with the Principal Contractor.

e. Principal Contractors will be required to undertake internal environmental audits. Internal audits will include:

- Compliance with approval, permit and licence conditions.
- Compliance with the E&SMS, CEMP, SMP, sub-plans and procedures.
- Community consultation and complaint response.
- Environmental training records.
- Environmental monitoring and inspection results.

f. TfNSW (or an independent environmental auditor) will also undertake periodic audits of the Principal Contractor's E&SMS and compliance with the environmental aspects of contract documentation, including this Construction Environmental Management Framework.

3.14 Environmental Non-compliances

a. Principal Contractors will document and detail any non-compliances arising out of the above monitoring, inspections and audits. TfNSW will be made aware of all non-compliances in a timely manner.

b. Principal Contractors will develop and implement corrective actions to rectify the non-compliances and preventative actions in order to prevent the re-occurrence of the non-compliance. Contractors will also maintain a register non compliances, corrective actions and preventative actions.

c. TfNSW or the Environmental Representative may raise non-compliances against environmental requirements.

3.15 Environmental Records and Compliance Reporting

a. Principal Contractors will maintain appropriate records of the following:

- Site inspections, audits, monitoring, reviews or remedial actions.
- Documentation as required by performance conditions, approvals, licences and legislation.
- Modifications to site environmental documentation (eg CEMP, sub-plans and procedures).
- Other records as required by this Construction Environmental Management Framework.

b. Records will be retained onsite for the duration of works.

c. Additionally records will be retained by the Principal Contractor for a period of no less than 7 years in total. Records will be made available in a timely manner to TfNSW (or their representative) upon request.

d. Compliance reports detailing the outcome of any environmental surveillance activity including internal and external audits (refer to Section 3.13) will be produced by the Principal Contractors Environmental Manager or delegate. These reports will be submitted to TfNSW at an agreed frequency.

3.16 Review and Improvement of the E&SMS

a. Principal Contractors will ensure the continual review and improvement of the E&SMS. This will generally occur in response to:

- Issues raised during environmental monitoring, inspections and audits.
- Significant environmental incidents.
- Environmental non-conformances.

b. A formal review of the E&SMS by the Principal Contractor's Senior Management Team will also occur on an annual basis, as a minimum. This review will generate actions for the continual improvement of the E&SMS and supporting management plans.

4. Stakeholder and Community Involvement

4.1 Overview

a. Throughout construction, Sydney Metro and the Principal Contractors will work closely with stakeholders and the community to ensure they are well informed regarding the construction works.

b. Stakeholders and the community will be informed of significant events or changes that affect or may affect individual properties, residences and businesses. These will include:

- Significant milestones.
- Design changes.
- Changes to traffic conditions and access arrangements for road users and the affected public.
- Construction operations which will have a direct impact on stakeholders and the community including noisy works, interruptions to utility services or construction work outside of normal work hours.

4.2 Communication and Consultation Strategy

a. This communication and consultation strategy will form the basis of a Stakeholder and Community Involvement Plan which will be developed by the Sydney Metro Principal Contractors.

b. Key elements of the communication and consultation strategy which will be implemented at appropriate times in the construction process will include:

- Notification (including targeted letterbox drops, email and SMS) of any works that may disturb local residents and businesses (such as noisy activities and night works) at least seven days prior to those works commencing.
- Notification (including targeted letterbox drops) of works that may affect transport (such as road closures, changes to pedestrian routes and changes to bus stops).
- Traffic alerts (via email) to all key traffic and transport stakeholders advising of any changes to access and local traffic arrangements (at least seven days prior to significant events).
- Print and radio advertisements regarding major traffic changes.
- 24-hour toll-free community project information phone line.
- Complaints management process.
- Regular community information sessions.
- Regular updates to the Sydney Metro website (sydneymetro.info), including uploading of all relevant documents, and contact details for the stakeholder and community involvement team.
- Public displays, local events and open days.
- Assistance to any Sydney Metro Community Information Centers in provision of regular community newsletters, information brochures and fact sheets and ongoing use of interactive web-based activities.
- Clear signage at the construction sites and construction updates on the hoardings at construction sites.
- Media releases and regular newspaper advertisements in local and metropolitan papers.
- Regular inter-agency group meetings.
- Community, business and stakeholder satisfaction surveys and feedback forms.
- Translator and interpreter services.
- The Principal Contractor's Community Relations Team will liaise with the TfNSW Place Managers as the point of contact for the community.

4.3 Complaint Handling

a. Community liaison and complaints handling will be undertaken in accordance with the Construction Stakeholder and Community Involvement Plan and will include:

- Principal Contractors will deal with complaints in a responsive manner so that stakeholders' concerns are managed effectively and promptly.
- A verbal response will be provided to the complainant as soon as possible and within a maximum of two hours from the time of the complaint (unless the complainant requests otherwise). A detailed written response will then be provided, if required, to the complainant within one week.

4.4 Urban Design of Temporary Works

a. Principal Contractors will develop and implement a Landscape and Temporary Works Management Plan for their scope of works. The Landscape and Temporary Works Management Plan will ensure as a minimum:

- Temporary construction works including site hoardings and acoustic sheds consider urban design and visual impacts, including:
- Artwork, graphics and images to enhance the visual appearance of temporary works in high visibility locations.
- Project information to raise awareness on benefits, explain the proposed works at each site and provide updates on construction progress.
- Community information, including contact numbers for enquiries / complaints.
- Signage and information to mitigate impacts on local businesses which may be obscured by the construction site.
- Sydney Metro advertising / public awareness campaigns.
- Logos / branding, including Sydney Metro, NSW Government, and Contractor branding.

b. The design of all temporary works will require TfNSW approval in relation to urban design and visual impacts.

c. Construction hoardings, scaffolding and acoustic sheds will be regularly inspected and kept clean and free of dust build up. Graffiti on construction hoardings, scaffolding or acoustic sheds will be removed or painted over promptly.

d. The principles of Crime Prevention Through Environmental Design will be applied to all works, including temporary works, that have a public interface.

4.5 Business and Property Impacts

a. Principal Contractors will proactively work with potentially affected stakeholders to identify the likely impacts and put in place measures to minimise impacts.

b. Construction works will be undertaken to meet the following objectives:

- Minimise the potential impact of the project to businesses affected by construction works.
- Ensure businesses are kept informed of the project and consulted in advance of major works or factors that are likely to have a direct impact.
- Consult with all business directly affected by changes to access arrangements regarding specific requirements at least two weeks prior to those changes coming into effect.
- Ensure that business stakeholder enquiries and complaints regarding the project are managed and resolved effectively.

c. Principal Contractors will document in the Stakeholder and Community Involvement Plan (Section 4.2) key issues relating to business impacts by locality with a particular focus on proactive consultation with affected businesses. Including:

- Identification of specific businesses which are sensitive to construction activity disturbances.
- Summary of the commercial character of the locality, its general trading profile (daily and annually) and information gained from the business profiling such as:
  - Operating hours;
  - Main delivery times;
  - Reliance on foot traffic;
  - Any signage or advertising that may be impacted;
  - Customer origin; and
  - Other information specific to the business that will need to be considered in construction planning.
- Define the roles and responsibilities in relation to the control and monitoring of business disturbances.
- Identification of locality specific standard business mitigation measures which would be implemented.
- Maps and diagrams to illustrate the information for easy identification of measures which would be implemented.
- Description of the monitoring, auditing and reporting procedures.
- Procedure for reviewing performance and implementing corrective actions.
- Description of the complaints handling process.
- Procedure of community consultation and liaison.

5. General Site Works

Figure 3 - Aerial View of the Sydney Metro Norwest Station Site

5.1 Working Hours

a. Standard working hours are between 7am – 6pm on weekdays and 8am – 1pm on Saturdays.

b. Works which can be undertaken outside of standard construction hours without any further approval include:

- Those which have been described in respective environmental assessments as being required to take place 24/7. For example, tunneling and underground excavations and supporting activities will be required 24/7.
- Works which are determined to comply with the relevant Noise Management Level at sensitive receivers.
- The delivery of materials outside of approved hours as required by the Police or other authorities (including RMS) for safety reasons.
- Where it is required to avoid the loss of lives, property and / or to prevent environmental harm in an emergency.
- Where written agreement is reached with all affected receivers.

c. Principal Contractors may apply for EPA approval to undertake works outside of normal working hours under their respective Environment Protection Licences.

5.2 Site Layout

a. Principal Contractors will consider the following in the layout of construction sites:

- The location of noise intensive works and 24 hour activities in relation to noise
- sensitive receivers.
- The location of site access and egress points in relation to noise and light sensitive receivers, especially for sites proposed to be utilised 24 hours per day.
- The use of site buildings to shield noisy activities from receivers.
- The use of noise barriers and / or acoustic sheds where feasible and reasonable for sites proposed to be regularly used outside of daytime hours.
- Aim to minimise the requirement for reversing, especially of heavy vehicles.

5.3 Reinstatement

a. Mitigation measures for reinstatement will be produced in consultation with TfNSW, the community and stakeholders.

b. Mitigation measures required for reinstatement will be incorporated into the CEMP and will include as a minimum:

- Principal Contractors will clear and clean all working areas and accesses at project completion.
- At the completion of construction all plant, temporary buildings or vehicles not required for the subsequent stage of construction will be removed from the site.
- All land, including roadways, footpaths, loading facilities or other land having been occupied temporarily will be returned to their pre-existing condition or better.
- Reinstatement of community spaces, infrastructure and services will occur as soon as possible after completion of construction.

6. Spoil Management

Figure 4 - Spoil and Excavation Works at the Showground Station Site

6.1 Spoil Management Objectives

a. The following spoil management objectives will apply to the construction of the project:

- Minimise spoil generation where possible
- The project will mandate 100% reuse or recycling (on or off-site) of usable spoil.
- Spoil will be managed with consideration to minimising adverse traffic and transport related issues.
- Spoil will be managed to avoid contamination of land or water.
- Spoil will be managed with consideration of the impacts on residents and other sensitive receivers.
- Site contamination will be effectively managed to limit the potential risk to human health and the environment.

6.2 Spoil Management Implementation

a. Principal Contractors will develop and implement a Spoil Management Plan for their scope of works. The Spoil Management Plan will include as a minimum:

- The spoil mitigation measures as detailed in the environmental approval documentation.
- A link or reference to where traffic movements in relation to spoil are described.
- A register of spoil receipt sites that includes the site or project name, location, capacity, site owner and which tier the site is classified as under the spoil reuse hierarchy.
- The responsibilities of key project personnel with respect to the implementation of the plan.
- How spoil generation is minimised through the design development process.
- Procedures for the testing, classification, handling and reuse of spoil.
- Spoil management monitoring requirements.
- Compliance record generation and management.

b. Spoil management measures will be included in regular inspections undertaken by the Contractor, and compliance records will be retained. These will include:

- Records detailing the beneficial re-use of spoil either within the project or at off-site locations.
- Waste dockets for any spoil disposed of to landfill sites.

6.3 Spoil Mitigation

a. Examples of spoil mitigation measures include:

- Implementing the spoil re-use hierarchy.
- Handling spoil to minimise potential for air or water pollution.
- Minimise traffic impacts associated with spoil removal.

7. Groundwater Management

7.1 Groundwater Management Objectives

a. The following groundwater management objectives will apply to construction:

- Reduce the potential for drawdown of surrounding groundwater resources.
- Prevent the pollution of groundwater through appropriate controls.
- Reduce the potential impacts of groundwater dependent ecosystems.

7.2 Groundwater Management Implementation

a. The following content may be provided within other sub-plans such as the Soil and Water Management Plan and Flora and Fauna Management Plan.

b. Principal Contractors will develop and implement a Groundwater Management Plan for their scope of works. The Groundwater Management Plan will include as a minimum:

- The groundwater mitigation measures as detailed in the environmental approval documentation.
- The requirements of any applicable licence conditions.
- details of proposed extraction, use and disposal of groundwater, and measures to mitigate potential impacts to groundwater sources, incorporating monitoring, impact trigger definition and response actions for all groundwater sources potentially impacted by the SSI.
- Evidence of consultation with the NSW Office of Water.
- The responsibilities of key project personnel with respect to the implementation of the plan.
- Procedures for the treatment, testing and discharge of groundwater from the site.
- Compliance record generation and management.
- Details of groundwater monitoring if required.

7.3 Groundwater Mitigation

a. Examples of groundwater mitigation measures include:

- Implementing all feasible and reasonable measures to limit groundwater inflows to stations and crossovers.
- Undertaking groundwater monitoring during construction (levels and quality) in areas identified as ‘likely’ and ‘potential’ groundwater dependent ecosystems.

8. Construction Traffic Management

Figure 5 – Castle Hill Station Site at the Intersection of Old Northern Rd and McMullen Ave

8.1 Construction Traffic Management Objectives

a. The following traffic management objectives will apply to the construction of the project:

- Minimise disruption to traffic operation, road users, pedestrians, cyclists and access to adjoining properties (private and public)
- Maximise the safety for the workers, by isolating work areas from traffic flows, applying low exposure work methods, education and the installation of appropriate traffic control
- Limit obstructions and restrictions, and when required, provide alternatives to maintain access for local community, transport operators (buses) including over-dimension load movements and commercial developments
- Encourage sustainable transport options by site workers.

8.2 Construction Traffic Management Implementation

a. Principal Contractors will develop and implement a Construction Traffic Management Plan for their scope of works. The Construction Traffic Management Plan will as a minimum:

- Implement the traffic and transport mitigation measures as detailed in the environmental approval documentation.
- be developed in consultation with the relevant road authority, Central Business District Co-ordination Group (CBDCG) and / or transport operator.
- set out the overall traffic management resources, processes and procedures for the management of traffic and transport during construction of the Project Works and Temporary Works.
- include Construction Traffic Control Plans setting out the specific traffic and transport management arrangements to be implemented at specific locations during the construction of the Project Works and Temporary Works.
- includes a Traffic Route Management Plan that identifies:
  - traffic generation from other major infrastructure developments, impacts from construction traffic and haulage routes,
  - types and volumes of construction vehicles and associated route and time restrictions,
  - potential traffic disruptions and temporary and permanent detours, and
  - management, mitigation and restoration measures.
- Includes a Parking Management Plan that identifies:
  - parking requirements and on and offsite parking arrangements and associated impacts,
  - remote parking arrangements and associated access between sites and public transport nodes,
  - alternate parking arrangements for displaced parking, and
  - communication and parking management measures.
- Includes Site Specific Traffic Access and Management Plans which detail:
  - Site access and associated route and turning movements and the design and signalisation of intersections,
  - Potential activities that could result in the disruption to traffic and transport networks, including pedestrian, cyclist and public transport networks and during special events.
  - The timing to limit disruptions to the road and transport networks,
  - The maintenance of access to and safety of transport networks, parking and property.
  - Service facilities and station sites, and other locations identified by the relevant road authority or transport regulator.
  - details responses to the management of an event that directly involves or impacts on traffic and transport networks.

b. TfNSW and its Contractors will undertake liaison with agencies and the community regarding traffic management. This may involve:

- Establishment of a Traffic and Transport Liaison Group which could consist of representatives from Sydney Metro Contractors, TfNSW, CBDCG, Westconnex, RMS, NSW Police, relevant councils, emergency services, and bus operators the group would review:
    - Road Occupancy Licence (ROL) applications to monitor potential cumulative impacts from multiple ROLs operating concurrently in one area.
    - be consulted on the preparation of the Construction Traffic Management Plan.
- Consultation with the CBDCG in relation to the approval of Construction Traffic Management Plans, supporting plans, or related licences for works in the CBD..

8.3 Construction Traffic Mitigation

a. Examples of traffic mitigation measures include:

- Minimising heavy vehicle movements during peak traffic times.
- Avoidance of local road for heavy vehicle routes, where feasible.
- Providing safe pedestrian and cyclist movements around the worksites.

9. Construction Noise and Vibration Management

Figure 6 - Hebel Wall Noise Barrier at the Cheltenham Services Facility Site

9.1 Construction Noise and Vibration Management Objectives

a. The following noise and vibration management objectives will apply to construction:

- Minimise unreasonable noise and vibration impacts on residents and businesses.
- Avoid structural damage to buildings or heritage items as a result of construction vibration.
- Undertake active community consultation.
- Maintain positive, cooperative relationships with schools, childcare centres, local residents and building owners.

9.2 Construction Noise and Vibration Management Implementation

a. Principal Contractors will develop and implement a Construction Noise and Vibration Management Plan for their scope of works consistent with the Interim Construction Noise Guidelines (Department of Environment and Climate Change, 2009). The Construction Noise and Vibration Management Plan will include as a minimum:

- Identification of work areas, site compounds and access points,
- Identification of sensitive receivers and relevant construction noise and vibration goals,
- Be consistent with and include the requirements of the noise and vibration mitigation measures as detailed in the environmental approval documentation and the Sydney Metro Construction Noise and Vibration Strategy (CNVS).
- Details of construction activities and an indicative schedule for construction works, including the identification of key noise and/or vibration generating construction activities (based on representative construction scenarios) that have the potential to generate noise or vibration impacts on surrounding sensitive receivers, in particular residential areas.
- Identification of feasible and reasonable procedures and mitigation measures to ensure relevant vibrations and blasting criteria are achieved, including a suitable blast program.
- Community notification provisions specifically in relation to blasting.
- The requirements of any applicable EPL conditions.
- Additional requirements in relation to activities undertaken 24 hours of the day, 7 days per week.
- Pre-construction compliance requirements and hold points.
- The responsibilities of key project personnel with respect to the implementation of the plan.
- Noise monitoring requirements.
- Compliance record generation and management.
- Community consultation requirements.
- An Out of Hours Works Protocol applicable to all construction methods and sites.

b. Detailed Construction Noise and Vibration Impact Statements will be prepared for noise-intensive construction sites and or activities, to ensure the adequacy of the noise and vibration mitigation measures. Specifically, Construction Noise and Vibration Impact Statements will be prepared for EPL variation applications and works proposed to be undertaken outside of standard construction hours.

c. Noise and vibration monitoring would be undertaken for construction as specified in the CNVS and the EPL.

d. The following compliance records would be kept by Principal Contractors:

- Records of noise and vibration monitoring results against appropriate NMLs and vibration criteria.
- Records of community enquiries and complaints, and the Contractor's response.

9.3 Construction Noise and Vibration Mitigation

a. All feasible and reasonable mitigation measures would be implemented in accordance with the CNVS. Examples of noise and vibration mitigation measures include:

- Construction hours will be in accordance with the working hours specified in Section 5.1.
- Hoarding and enclosures will be implemented where required to minimise airborne noise impacts.
- The layout of construction sites will aim to minimise airborne noise impacts to surrounding receivers.

10. Heritage Management

Figure 7 –White Hart Inn Excavation Site

10.1 Heritage Management Objectives

a. The following heritage management objectives will apply to construction:

- Embed significant heritage values through any architectural design, education or physical interpretation.
- Minimise impacts on items or places of heritage value.
- Avoid accidental impacts on heritage items.
- Maximise worker's awareness of indigenous and non-indigenous heritage.

10.2 Heritage Management Implementation

a. Principal Contractors will develop and implement a Heritage Management Plan which will include as a minimum:

- Will be developed in consultation with Registered Aboriginal Parties (Indigenous Heritage only) and the NSW Heritage Council.
- The heritage mitigation measures as detailed in the environmental approval documentation.
- The responsibilities of key project personnel with respect to the implementation of the plan.
- Procedures for interpretation of heritage values uncovered through salvage or excavation during detailed design.
- Procedures for undertaking salvage or excavation of heritage relics or sites (where relevant) and any recordings of heritage relics prior to works commencing that would affect them.
- Details of management measures to be implemented to prevent and minimise impacts on heritage items (including further heritage investigations, archival recordings and/ or measures to protect unaffected sites during construction works in the vicinity);
- Procedures for unexpected heritage finds, including procedures for dealing with human remains.
- Heritage monitoring requirements.
- Compliance record generation and management.

b. The Contractor's regular inspection will include checking of heritage mitigation measures.

c. Compliance records will be retained by the Contractor. These will include:

- Inspections undertaken in relation to heritage management measures.
- Archival recordings undertaken of any heritage item.
- Unexpected finds and stop work orders.
- Records of any impacts avoided or minimised through design or construction methods.

10.3 Heritage Mitigation

a. Examples of heritage mitigation measures include:

- Any heritage item not affected by the works will be retained and protected throughout construction.
- Prior to the commencement of construction undertake professional archaeological excavation, investigation and reporting of any historical Indigenous heritage sites of state significance which will be affected.
- Undertake archival recordings of all non-Indigenous heritage items affected by the works prior to commencement of works.
- Implement unexpected heritage find procedures for Indigenous and non-Indigenous heritage items.

11. Flora and Fauna Management

Figure 8 - Demarcation of Retained Flora

11.1 Flora and Fauna Management Objectives

a. The following flora and fauna management objectives will apply to construction:

- Minimise impacts on flora and fauna.
- Design waterway modifications and crossings to incorporate best practice principles.
- Retain and enhance existing flora and fauna habitat wherever possible.
- Appropriately manage the spread of weeds and plant pathogens.

11.2 Flora and Fauna Management Implementation

a. Principal Contractors will develop and implement a Flora and Fauna Management Plan which will include as a minimum:

- The ecological mitigation measures as detailed in the environmental approval documentation.
- The responsibilities of key project personnel with respect to the implementation of the plan.
- Procedures for the clearing of vegetation and the relocation of flora and fauna.
- Details on the locations, monitoring program and use of nest boxes by fauna;
- Procedures for the demarcation and protection of retained vegetation, including all vegetation outside and adjacent to the construction footprint.
- Plans for impacted and adjoining areas showing vegetation communities; important flora and fauna habitat areas; locations where threatened species, populations or ecological communities have been recorded.
- Vegetation management plan(s) for sites where native vegetation is proposed to be retained.
- Identification of measures to reduce disturbance to sensitive fauna.
- Rehabilitation details, including identification of flora species and sources, and measures for the management and maintenance of rehabilitated areas (including duration of the implementation of such measures).
- Weed management measures focusing on early identification of invasive weeds and effective management controls.
- A procedure for dealing with unexpected EEC threatened species identified during construction, including cessation of work and notification of the Department, determination of appropriate mitigation measures in consultation with the OEH (including relevant re-location measures) and updating of ecological monitoring or off-set requirements.
- Details on the methodology for vegetation mapping and survey.
- Ecological monitoring requirements.
- Compliance record generation and management.

b. Principal Contractors would undertake the following ecological monitoring as a minimum:

- A pre-clearing inspection will be undertaken prior to any native vegetation clearing by a suitable qualified ecologist and the Contractor's Environmental Manager (or delegate). The pre-clearing inspection will include, as a minimum:
  - Identification of hollow bearing trees or other habitat features.
  - Identification of any threatened flora and fauna.
  - A check on the physical demarcation of the limit of clearing.
  - An approved erosion and sediment control plan for the worksite.
  - The completion of any other pre-clearing requirements required by any project approvals, permits or licences.
- The completion of the pre-clearing inspection will form a HOLD POINT requiring sign-off from the Contractor's Environmental Manager (or delegate) and a qualified ecologist.
- A post clearance report will be produced that validates the type and area of vegetation cleared including confirmation of the number of hollows impacted and the corresponding nest box requirements to offset these impacts.

c. The Principal Contractor's regular inspections will include a check on the ecological mitigation measures and project boundary fencing.

d. The following compliance records would be kept by the Principal Contractor:

- Records of pre-clearing inspections undertaken.
- Records of the release of the pre-clearing hold point.
- Records of ecological inspections undertaken.

11.3 Flora and Fauna Mitigation

a. Examples of flora and fauna mitigation measures include:

- Areas to be retained and adjacent habitat areas will be fenced off prior to works to prevent damage or accidental over clearing.
- Clearing will follow a two-stage process as follows:
  - Non-habitat trees will be cleared first after sign-off of the pre-clearing inspection.
  - Habitat trees will be cleared no sooner than 48 hours after non-habitat trees have been cleared. A suitably qualified ecologist will be present on site during the clearing of habitat trees. Felled habitat trees will be left on the ground for 24 hours or inspected by the ecologist prior to further processing.
- Weed management is to be undertaken in areas affected by construction prior to any clearing works in accordance with the Noxious Weeds Act 1993.

12. Visual Amenity Management

12.1 Visual Amenity Management Objectives

a. The following visual and landscape management objectives will apply to the construction of the project:

- Minimise impacts on existing landscape features as far as feasible and reasonable.
- Ensure the successful implementation of the Landscape Design.
- Reduce visual impact of construction to surrounding community.

12.2 Visual Amenity Management Implementation

a. Principal Contractors will develop and implement a Visual Amenity Management Plan for temporary works which will include as a minimum:

- The visual mitigation measures as detailed in the environmental approval documentation for construction.
- Input from an experienced Landscape or Urban Designer.
- The maintenance of outward facing elements of site hoarding or noise barriers, including the removal of graffiti and weeds.
- Apply the principles of Australian Standard 4282-1997 Control of the obtrusive effects of outdoor lighting and relevant safety design requirements and detail mitigation measures to minimise lighting impacts on sensitive receivers for all permanent, temporary and mobile light sources.
- Apply the principals of the NSW Government Crime Prevention through Environmental Design guidelines.
- Monitoring requirements.
- Compliance record generation and management.

b. Visual and landscape measures will be incorporated into the Principal Contractor's regular inspections including checking the health of retained vegetation around site boundaries, checking the condition of any site hoarding and acoustic sheds, and checking the position and direction of any sight lighting.

c. The Contractor will retain compliance records of any inspections undertaken in relation to visual and landscape measures.

12.3 Visual Amenity Mitigation

a. Examples of visual amenity mitigation measures include:

- Wherever feasible and reasonable, vegetation around the perimeter of the construction sites will be maintained.
- Temporary construction works will be designed with consideration of urban design and visual amenity as per Section 4.4.
- Temporary site lighting, for security purposes or night works will be installed and operated in accordance with AS4282:1997 Control of the Obtrusive Effect of Outdoor Lighting.

13. Carbon and Energy Management

13.1 Carbon and Energy Management Objectives

a. The following carbon and energy management objectives will apply to construction:

- Reduce energy use and carbon emissions during construction.
- Support innovative and cost effective approaches to energy efficiency, low carbon / renewable energy sources and energy procurement.
- Design to reduce energy use and carbon emissions during operations.

13.2 Carbon and Energy Management Implementation

a. Principal Contractors will develop and implement a Carbon and Energy Management Plan that will include, as a minimum:

- The carbon and energy mitigation measures as detailed in the environmental approval documentation.
- The relevant requirements of the Sydney Metro Environment and Sustainability Policy and the Sydney Metro Sustainability Strategy.
- The responsibilities of key project personnel with respect to the implementation of the plan.
- The low carbon strategies and initiatives that will be implemented to minimise the carbon emissions associated with construction.
- The energy efficiency strategies and initiatives that will be implemented to minimise energy use associated with construction.
- Carbon emission estimates determined using a carbon footprint assessment undertaken in accordance with ISO 14064-1, ISO14064-2 and ISO14064-3 that incorporates direct and indirect emissions associated with construction.
- Compliance record generation and management.

b. Reporting of carbon and energy will be undertaken throughout the construction works in accordance with the National Greenhouse and Energy Reporting Act 2007.

c. The Contractors would be required to retain appropriate records and prepare carbon footprint assessments (inclusive of Scope 1, 2 and 3 emissions) at various stages of construction.

13.3 Carbon and Energy Mitigation

a. Examples of carbon and energy mitigation measures include:

- Equipment and material selection will have consideration of energy efficiencies.
- Construction workers will be encouraged to use sustainable transport options and green travel plans will be developed.
- Inclusion of renewable energy sources to power temporary facilities and equipment where feasible.
- Designing and operating Site offices for energy efficiency.
- Offsetting a portion of construction greenhouse gas emissions.
- Efficient operation of vehicles and equipment.

14. Materials Management

Figure 9 - Sydney Monorail Beams being re-used at the Norwest Station Site

14.1 Materials Management Objectives

a. The following materials management objectives would apply to the construction of the project:

- Reduce material use throughout the project life-cycle.
- Consider embodied impacts in materials selection.
- Use recycled materials.
- Recycle and reuse materials onsite.
- Influence subcontractors and materials suppliers to adopt sustainability objectives in their works and procurement.

14.2 Materials Management Implementation

a. Principal Contractors will be required to develop and implement a Sustainable Procurement Policy that will include as a minimum:

- The materials mitigation measures as detailed in the environmental approval documentation.
- The relevant requirements of the City & Southwest Environment and Sustainability Policy and the City & Southwest Sustainability Strategy.
- The responsibilities of key project personnel with respect to the implementation of the policy.
- Compliance record generation and management.
- Ethical sourcing of materials.
- Local sourcing.

b. The Contractors will be required to retain records detailing the consideration of sustainability in the procurement of all materials.

14.3 Materials Mitigation

a. Examples of materials mitigation measures include:

- Consideration of quality and durability in the procurement of materials.
- Using recycled materials.
- Using materials with a lower embodied impact.
- Using recycled steel in concrete reinforcement.
- Developing deconstruction plans to enable recycling and reuse at end-of-life.
- Using low-VOC, low emission materials.
- Using sustainably sourced timber and wood products.
- Low-carbon concrete.
- Consideration of whole-of-life costs during procurement.

15. Soil and Water Management

Figure 10 - Erosion and Sediment Controls at the Cudgegong Rd Site

15.1 Soil and Water Management Objectives

a. The following soil and water management objectives will apply to construction:

- Minimise pollution of surface water through appropriate erosion and sediment control.
- Maintain existing water quality of surrounding surface watercourses.
- Source construction water from non-potable sources, where feasible and reasonable.

15.2 Soil and Water Implementation

a. Principal Contractors will develop and implement a Soil and Water Management Plan for their scope of works. The Soil and Water Management Plan will include as a minimum:

- The surface water and flooding mitigation measures as detailed in the environmental approval documentation.
- details of construction activities and their locations, which have the potential to impact on water courses, storage facilities, stormwater flows, and groundwater;
- surface water and ground water impact assessment criteria consistent with the principles of the Australian and New Zealand Environment Conservation Council (ANZECC) guidelines;
- management measures to be used to minimise surface and groundwater impacts, including identification of water treatment measures and discharge points, details of how spoil and fill material required by the SSI will be sourced, handled, stockpiled, reused and managed; erosion and sediment control measures; salinity control measures and the consideration of flood events;
- a contingency plan, consistent with the Acid Sulfate Soils Manual (EPA 1998), to deal with the unexpected discovery of actual or potential acid sulfate soils, including procedures for the investigation, handling, treatment and management of such soils and water seepage;
- management measures for contaminated material (soils, water and building materials) and a contingency plan to be implemented in the case of unanticipated discovery of contaminated material, including asbestos, during construction;
- a description of how the effectiveness of these actions and measures would be monitored during the proposed works, clearly indicating how often this monitoring would be undertaken, the locations where monitoring would take place, how the results of the monitoring would be recorded and reported, and, if any exceedance of the criteria is detected how any non-compliance can be rectified;
- The requirements of any applicable EPL conditions.
- The responsibilities of key project personnel with respect to the implementation of the plan.
- Procedures for the development and implementation of progressive erosion and sediment control plans.
- Identification of locations where site specific Stormwater and Flooding Management Plans are required.
- Compliance record generation and management.

b. Principal Contractors will develop and implement progressive erosion and sediment control plans (ESCPs) for all active worksites in accordance with Managing Urban Stormwater: Soils & Construction Volume 1 (Landcom, 2004) (known as the "Blue Book"). The ESCPs will be approved by the Contractor's Environmental Manager (or delegate) prior to any works commencing (including vegetation clearing) on a particular site. Copies of the approved ESCP will be held by the relevant Contractor personnel including the Engineer and the Site Foreman.

c. ESCPs will detail all required erosion and sediment control measures for the particular site at the particular point in time and be progressively updated to reflect the current site conditions. Any amendments to the ESCP will be approved by the Contractor's Environmental Manager (or delegate).

d. Principal Contractors will develop and implement Stormwater and Flooding Management Plans for the relevant construction sites. These plans will identify the appropriate design standard for flood mitigation based on the duration of construction, proposed activities and flood risks. The plan will develop procedures to ensure that threats to human safety and damage to infrastructure are not exacerbated during the construction period.

e. Principal Contractors will undertake the following soil and water monitoring as a minimum:

- Weekly inspections of the erosion and sediment control measures. Issues identified would be rectified as soon as practicable.
- Additional inspections will be undertaken following significant rainfall events (greater than 20 mm in 24 hours).
- All water will be tested (and treated if required) prior to discharge from the site in order to determine compliance with the parameters of the EPL. No water will be discharged from the site without written approval of the Contractor's Environmental Manager (or delegate). This is to form a HOLD POINT.

f. The following compliance records will be kept by the Principal Contractors:

- Copies of current ESCPs for all active construction sites.
- Records of soil and water inspections undertaken.
- Records of testing of any water prior to discharge.
- Records of the release of the hold point to discharge water from the construction site to the receiving environment.

15.3 Soil and Water Mitigation

a. Examples of surface water and flooding mitigation measures include:

- Clean water will be diverted around disturbed site areas, stockpiles and contaminated areas.
- Control measures will be installed downstream of works, stockpiles and other disturbed areas.
- Exposed surfaces will be minimised, and stabilised / revegetated as soon feasible and reasonable upon completion of construction.
- Dangerous good and hazardous materials storage will be within bunded areas with a capacity of 110 per cent of the maximum single stored volume.
- Spill kits will be provided at the batch plants, storage areas and main work sites.

15.4 Water Resources Management

a. The following water resources management objectives will apply to the construction of the project:

- Minimise demand for, and use of potable water.
- Maximise opportunities for water re-use from captured stormwater, wastewater and groundwater.
- Examples of measures to minimise potable water consumption include:
- Water efficient controls, fixtures and fittings in temporary facilities.
- Collecting, treating and reusing water generated in tunnelling operations, concrete batching and casting facility processes.
- Using recycled water or treated water from onsite sources in the formulation of concrete.
- Harvesting and reusing rainwater from roofs of temporary facilities.
- Using water from recycled water networks.
- Collecting, treating and reusing groundwater and stormwater.
- Using water efficient construction methods and equipment.
- Providing designated sealed areas for equipment wash down.

16. Air Quality

Figure 11 - Dust Mitigation at Norwest Station Site

16.1 Air Quality Management Objectives

a. The following air quality management objectives will apply to construction:

- Minimise gaseous and particulate pollutant emissions from construction activities as far as feasible and reasonable.
- Identify and control potential dust and air pollutant sources.

16.2 Air Quality Management Implementation

a. Principal Contractors will develop and implement an Air Quality Management Plan which will include, as a minimum:

- The air quality mitigation measures as detailed in the environmental approval documentation.
- The requirements of any applicable EPL conditions.
- Site plans or maps indicating locations of sensitive receivers and key air quality / dust controls.
- The responsibilities of key project personnel with respect to the implementation of the plan.
- Air quality and dust monitoring requirements.
- Compliance record generation and management.

b. Air quality and dust monitoring will involve the following as a minimum:

- Meteorological conditions will be monitored and appropriate responses will be organised and undertaken periodically by the Principal Contractor.
- Regular visual monitoring of dust generation from work zones.
- Monitoring emissions from plant and construction vehicles to ensure they have appropriate emission controls and are being maintained correctly.

c. The following compliance records will be kept by the Principal Contractor:

- Records of any meteorological condition monitoring.
- Records of any management measures implemented as a result of adverse, windy weather conditions.
- Records of air quality and dust inspections undertaken.

16.3 Air Quality Mitigation

a. Examples of air quality mitigation measures include:

- Plant and equipment will be serviced and maintained in good working order to reduce unnecessary emissions from exhaust fumes.
- Water suppression will be used for active earthwork areas, stockpiles, unsurfaced haul roads and loads of soil being transported to reduce wind-blown dust emissions.
- Wheel-wash facilities or rumble grids will be provided and used near the site exit points, as appropriate.
- Dust extraction and filtration systems will be installed for tunnel excavation works and deep excavation with limited surface exposure.

17. Waste Management

17.1 Waste Objectives

a. The following waste objectives will apply to construction:

- Minimise waste throughout the project life-cycle.
- Waste management strategies will be implemented in accordance with the *Waste Avoidance and Resource Recovery Act 2001* management hierarchy as follows:
- Avoidance of unnecessary resource consumption.
- Resource recovery (including reuse, reprocessing, recycling and energy recovery).
- Disposal.

b. Targets for the recovery, recycling or reuse of construction waste, and beneficial reuse of spoil will be provided by the Principal Contractor.

17.2 Waste Implementation

a. Principal Contractors will develop and implement a Waste Management and Recycling Plan which will include as a minimum:

- The waste management and recycling mitigation measures as detailed in the environmental approval documentation.
- The responsibilities of key project personnel with respect to the implementation of the plan.
- Waste management and recycling monitoring requirements.
- A procedure for the assessment, classification, management and disposal of waste in accordance with the Waste Classification Guidelines (DECC, 2008).
- Compliance record generation and management.

b. Principal Contractors will undertake the following waste monitoring as a minimum:

- Weekly inspections will include checking on the waste storage facilities on site.
- All waste removed from the site will be appropriately tracked from 'cradle to grave' using waste tracking dockets.

c. Principal Contractors will report all necessary waste and purchasing information to TfNSW as required for TfNSW to fulfil their WRAPP reporting requirements.

d. Compliance records will be retained by the Principal Contractors in relation to waste management including records of inspections and waste dockets for all waste removed from the site.

17.3 Waste Mitigation

a. Examples of waste management and recycling mitigation measures include:

- All waste materials removed from the sites will be directed to an appropriately licensed waste management facility.
- The use of raw materials (noise hoarding, site fencing, etc...) will be reused or shared, between sites and between construction contractors where feasible and reasonable.
- Recyclable wastes, including paper at site offices, will be stored separately from other wastes.

18. Acronyms

Acronym	
CEMP	Construction Environmental Management Plan
CNVS	Construction Noise and Vibration Strategy
DP&E	Department of Planning and Environment (Formerly Department of Planning and Infrastructure)
EIS	Environmental Impact Statement
EMF	Environmental Management Framework
EMS	Environmental Management System
EPA	Environment Protection Authority
EP&A Act	Environmental Planning and Assessment Act 1979
EPL	Environment Protection Licence (issued by EPA under the POEO Act)
ER	Environmental Representative
ESCP	Erosion and Sediment Control Plan
NOHSC	National Occupational Health and Safety Commission
OEH	Office of Environment and Heritage (Formerly DECCW)
POEO Act	Protection of the Environment Operation Act 1997
RMS	Roads and Maritime Service (Formerly RTA)
TBM	Tunnel Boring Machine
TfNSW	Transport for NSW

Appendix A – Environment and Sustainability Policy

Environment & Sustainability Policy

This Policy reflects a commitment in our delivery of the Sydney Metro program to:

- Align with, and support, Transport for NSW (TfNSW) Environment & Sustainability Policy.
- Optimise sustainability outcomes, transport service quality, and cost effectiveness.
- Develop effective and appropriate responses to the challenges of climate change, carbon management, resource and waste management, land use integration, customer and community expectation, and heritage and biodiversity conservation.
- Be environmentally responsible, by avoiding pollution, enhancing the natural environment and reducing the project ecological footprint, while complying with all applicable environmental laws, regulations and statutory obligations.
- Be socially responsible by delivering a workforce legacy which benefits individuals, communities, the project and industry, and is achieved through collaboration and partnerships.

To deliver on these commitments, the Sydney Metro team will:

Industry leadership

- Implement coordinated and transparent decision making, by engaging with stakeholders and suppliers, encouraging innovation and demonstrating sustainability leadership.
- Explore new benchmarks for the transport infrastructure sector by requiring high standards from our designers, contractors and suppliers, building on experience gained through development of Sydney Metro Northwest.

Community and customer

- Provide accessible, safe, pleasurable, and convenient access and transport service for all customers.
- Establish positive relationships with community and stakeholders to maximise opportunities to add value to local communities.

Land use integration and place making

- Create desirable places, promote liveability, cultural heritage, and optimise both community and economic benefit.
- Balance transit oriented development opportunities with stakeholder expectations.

Embedding environmental and social sustainability

- Establish robust sustainability objectives and targets.
- Maintain an environmental management system that is integrated into all our project activities.
- Ensure thorough and open environmental assessment processes are developed and maintained.
- Develop and maintain an environmental management framework to embed best practice pollution management and sustainable outcomes during construction.
- Apply effective assurance processes to monitor performance against the project environment and sustainability objectives and identify appropriate reward or corrective action, as required.
- Apply environment and sustainability specific processes to the procurement of delivery activities.

Accountability

- Undertake public sustainability reporting.
- Hold employees and contractors accountable for proactively meeting their environmental and social sustainability responsibilities.
- Provide appropriate training and resources necessary to meet our responsibilities.

Rodd Staples - Program Director, Sydney Metro

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CONSTRUCTION NOISE AND VIBRATION STRATEGY

APPENDIX E

Integrated Management System

Sydney Metro City & Southwest Construction Noise and Vibration Strategy

Report No 610.14213-R3

Sydney Metro Integrated Management System (IMS)

Applicable to:	Sydney Metro Northwest/City & Southwest
Author:	Tom Cockings, Principal Consultant SLR Consulting Australia Pty Ltd
System owner:	Transport for NSW
Status:	Final
Version:	0.3
Date of issue:	1 April 2016
Review date:	31 March 2017
Security classification:	Open Access
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1. FOREWORD

The Department of Environment, Climate Change and Water NSW (now the Environmental Protection Authourity EPA) issued the Interim Construction Noise Guideline (ICNG) in July 2009.

The main objectives of the ICNG are stated in Section 1.3, a portion of which is presented below:

> *"The main objectives of the Guideline are to:*
>
> - *promote a clear understanding of ways to identify and minimise noise from construction works*
> - *focus on applying all 'feasible' and 'reasonable' work practices to minimise construction noise impacts*
> - *encourage construction to be undertaken only during the recommended standard hours unless approval is given for works that cannot be undertaken during these hours*
> - *streamline the assessment and approval stages and reduce time spent dealing with complaints at the project implementation stage*
> - *provide flexibility in selecting site-specific feasible and reasonable work practices in order to minimise noise impacts."*

The ICNG guideline (in Section 7.3) also encourages organisations involved with construction, maintenance or upgrading works (such as Sydney Metro) to develop their own best-practice techniques for managing construction noise.

In line with this recommendation the purpose of this 'Construction Noise and Vibration Strategy' is to document how Sydney Metro proposes to manage construction noise and vibration for the Sydney Metro and SouthWest project including any potential extensions.

2. PURPOSE AND SCOPE

2.1. Background

People are usually more tolerant to noise and vibration during the construction phase of proposals than during normal operation. This response results from recognition that the construction emissions are of a temporary nature – especially if the most noise-intensive construction impacts occur during the less sensitive daytime period. For these reasons, acceptable noise and vibration levels are normally higher during construction than during operations.

Construction often requires the use of heavy machinery which can generate high noise and vibration levels at nearby buildings and receivers. For some equipment, there is limited opportunity to mitigate the noise and vibration levels in a cost-effective manner and hence the potential impacts would be minimised by using feasible and reasonable management techniques.

At any particular location, the potential impacts can vary greatly depending on factors such as the relative proximity of sensitive receivers, the overall duration of the construction works, the intensity of the noise and vibration levels, the time at which the construction works are undertaken and the character of the noise or vibration emissions.

The construction noise and vibration emissions associated with a large infrastructure project such as Sydney Metro will cause disturbance to adjacent communities. This is of particular relevance in urban areas, such as in the Sydney CBD, where many sensitive receivers (not just residential) are present.

Due to the nature of this large infrastructure project a significant number of activities will be required outside normal construction hours as work during daytime periods would be highly disruptive to road traffic for commuters. In addition, noise and vibration impacts for this project are generally expected to have a duration of several years. It is therefore important that reasonable and feasible mitigation measures (as defined in the ICNG) are identified and implemented to ensure that construction noise and vibration impacts are reduced to a minimum.

2.2. Strategy Objectives

Generally the strategy is intended to provide a single interface for the large number of policies, guidelines, standards and regulations that apply to a large infrastructure project such as Sydney Metro. Where possible the strategy consolidates these information sources eg vibration criteria from numerous sources are collated into one section of this strategy for ease of reference. Further, the strategy aims to provide interpretation of the reference documents which are specific to the Metro project. Where the reference documents are found to have insufficient detail the strategy provides additional assessment criteria and methodologies.

The specific objectives of this Construction Noise and Vibration Strategy are as follows:

- Applying the strategy during the different construction phases of the project
- Environmental Protection Licence (EPL) conditions
- Construction noise and vibration guidelines to apply to the project (additional guidance to complement the ICNG)
- Construction noise and vibration assessment methodology
- Standard noise and vibration mitigation measures for the project
- Additional noise and vibration mitigation measures for the project
- Out of hours (OOH) Work
- Monitoring, auditing and reporting
- Construction noise and vibration documentation requirements

2.3. Distribution and Use

This document may be used in the development of, or referred to in:

- Environmental impact assessment documents
- Design and construction environmental management documents
- Contract documents
- Approvals and licences (subject to the agreement of the relevant regulatory authority)

2.4. Strategy Review

The strategy will be reviewed, as a minimum, annually to ensure that it meets the needs of the community, Sydney Metro and the contractors engaged on Sydney Metro projects. This document does not take precedence over approval or licence conditions and will be reviewed as required in response to the release of relevant approvals, licences, guidelines, standards and policies dealing with construction noise and vibration.

3. APPLYING THE STRATEGY

The planning procedure for all infrastructure projects requires that a detailed Environmental Assessment of the construction phases of the proposal be completed. As construction contractors are not typically appointed until much later in a project's timeline, the exact construction methodology they will use for a particular project may not be known during the environmental assessment stage.

It is expected that conservative assumptions would be incorporated at early stages of the project approval process and these must not unduly restrict innovation (eg construction methods or mitigation) at later design stages. This reflects the refinement of construction methodologies with subsequent stages of the project.

This document therefore defines the strategies by which construction noise and vibration impacts are to be minimised on Sydney Metro projects throughout the construction of a project by recognising the changing assessment requirements for each construction phase.

Table 1 outlines the level of detail expected from the assessment process (refer to Section 7) at the following stages of the project:

- Environmental Impact Statement / Environmental Assessment
- In delivery / pre-construction impact statements

Table 1: Summary of Assessment Detail Required During the Various Stages of the Project

Assessment Input	Environmental Impact Statement / Environmental Assessment	In Delivery / Pre-construction Impact Statements
Construction Scenarios / Equipment List	Construction scenarios defined by project team, based on potential construction methodologies known at the time	Construction scenarios defined by construction team. These are expected to include finalised equipment lists, itemising the realistic worst-case plant proposed to be used at any one time, and in any one location
Modelled works location	Works location by scenario (or group of scenarios) ie different locations for different works	Works location by works scenario ie specific locations for each works
Background noise monitoring	Background noise monitoring required to determine RBL at locations representative of worst-affected receiver areas adjacent to the works areas	Supplementary noise monitoring required to determine RBL at locations representative of worst-affected receiver areas adjacent to the works areas where noise survey data is not current (ie more than 5 years old)
Study Area	The study area must, as a minimum, include receivers subjected to predicted $L_{Aeq(15minute)} \geq$ RBL+5dB for the applicable time period. Vibration level predictions up to 100 m	Predict noise and vibration levels to the sensitive receivers within the area surrounding the works, to include all receivers where the $L_{Aeq(15minute)} \geq$ RBL +5dB and the vibration screening criteria are exceeded during the applicable time periods.

Assessment Input	Environmental Impact Statement / Environmental Assessment	In Delivery / Pre-construction Impact Statements
Reporting	n/a	Predictions would be undertaken for the proposed time period of the works
Assessment of mitigation	Demonstration that assessment of this stage includes reasonable and feasible mitigation measures	Based on these predictions the Construction Noise Management Plan (CNMP) shall identify all reasonable and feasible mitigation measures to minimise noise and vibration from construction. Sections 7 and 8 identify the standard and additional mitigation measures to be included where applicable in the CNMP. Eg. Detailed vibration assessments to include dilapidation surveys, continuous vibration monitoring and accurate vibration transfer measurements (site law measurements) for all buildings with the potential to exceed the screening criteria for vibration.
Documentation	n/a	Implementation of the EPL conditions, or as modified by subsequent CNVIS (eg for OOHW)

4. ENVIRONMENTAL PROTECTION LICENCES (EPL)

Environmental Protection Licences are a fundamental noise control requirement for large infrastructure projects. These licences often provide detailed construction noise and vibration criteria and management measures that are tailored to the specifics of individual projects. To use this strategy effectively the time-line of assessments, approvals and licences would be understood and the necessary interaction of this strategy, the CNIS reports it generates and the EPL issued for the project.

4.1. Time-line of Assessments, Approvals and the EPL

The general time-line for this process with respect to noise and vibration from construction activities is outlined below:

1. Project concept. Preliminary high-level CNIS and CNMP reports.
2. Department of Planning Issues the Conditions of Approval for the project.
3. Environmental Impact Statement (EIS). Preliminary but more detailed CNIS and CNMP reports based on a complete concept design.
4. Project Approval from the Department of Planning.
5. Contactor Tender and Award.
6. Contractor Detailed Design. Mature CNIS and CNMP reports based on the detailed design.
7. Contractor application for Environmental Protection License for the project.
8. Licence award by the Environmental Protection Agency EPL.
9. Construction commences.
10. Ongoing of review of construction methodology and project noise and vibration issues.
11. Re-assess CNIS and CNMP based on new inputs (if necessary).
12. Consistency Assessment
13. Contractor application for amendments to the EPL.
14. Approval of the amendments to the EPL.

As can been seen from the above time-line this Strategy is used through the planning, approval and construction stages. Steps 10 through to 14 can be repeated to review and add to the EPL conditions, if necessary, during the construction stage.

5. NOISE AND VIBRATION GUIDELINES

5.1. Construction Noise Metrics

The three primary noise metrics used to describe construction noise emissions in the modelling and assessments are:

$L_{A1(1minute)}$ The typical ‘maximum noise level for an event’, used in the assessment of potential sleep disturbance during night-time periods. Alternatively, assessment may be conducted using the L_{Amax} or maximum noise level

$L_{Aeq(15minute)}$ The ‘energy average noise level’ evaluated over a 15-minute period. This parameter is used to assess the potential construction noise impacts.

L_{A90} The 'background noise level' in the absence of construction activities. This parameter represents the average minimum noise level during the daytime, evening and night-time periods respectively. The $L_{Aeq(15minute)}$ construction noise management levels are based on the L_{A90} background noise levels.

The subscript 'A' indicates that the noise levels are filtered to match normal hearing characteristics (A weighted).

5.2. Construction Hours

Where possible, works will be completed during the standard day time construction hours of Monday to Friday 7.00 am to 6.00 pm and Saturdays 8.00 am to 1.00 pm. However, the nature of the project means evening and night work are required throughout the construction program. Many of the construction scenarios for this project will require 24/7 operation. These scenarios include:

- Excavation of station shafts
- Excavation of the station caverns
- Operation of the tunnel boring machines
- Spoil removal and transport from site

Out of Hours Works (OOHWs) are to be included in the assessment for all proposed works at all locations in order to inform the scheduling of construction activity and management of noise during the detailed design phase. It is anticipated that the finalised requirements for OOHWs would be determined at a later design stage. It is understood that any OOHWs would be subject to a separate approval on a case-by-case basis and would likely require approval under the project's Environmental Protection Licence (EPL).

5.3. Construction Noise Management Levels (NML)

Construction Noise Management Levels (NML) for all Sydney Metro projects will be determined in accordance with the procedures nominated in the DECCW's "Interim Construction Noise Guideline" dated July 2009 (ICNG, 2009). The following information is intended to supplement the ICNG with respect to the unique requirements of the Metro project.

5.3.1. Residences and Other Sensitive Land Uses

Table 2 sets out the noise management levels and how they are to be applied. This approach intends to provide respite for residents exposed to excessive construction noise outside the recommended standard hours whilst allowing construction during the recommended standard hours without undue constraints.

Table 2 the rating background level (RBL) is used when determining the management level. The RBL is the overall single-figure background noise level measured in each relevant assessment period (as defined in the EPA "Industrial Noise Policy" dated January 2000).

Table 2: Noise at Residences Using Quantitative[1]

Time of Day	Management Level $L_{Aeq(15minute)}$[2]	How to Apply
Recommended standard hours: Monday to Friday 7.00 am to 6.00 pm Saturday 8.00 am to 1.00 pm	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq(15minute)}$ is greater than the noise affected level, the proponent would apply all feasible and reasonable work practices to minimise noise. The proponent would also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
No work on Sundays or public holidays	Highly noise affected 75 dB	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the proponent would consider very carefully if there is any other feasible and reasonable way to reduce noise to below this level. If no quieter work method is feasible and reasonable, and the works proceed, the proponent would communicate with the impacted residents by clearly explaining the duration and noise level of the works, and by describing any respite periods that will be provided.
Outside recommended standard hours	Noise affected RBL + 5 dB	A strong justification would typically be required for works outside the recommended standard hours. The proponent would apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5 dBA above the noise affected level, the proponent would negotiate with the community. For guidance on negotiating agreements see Section 7.2.2 of the ICNG.

Note 1: Adopted from the ICNG.

Note 2: Noise levels apply at the property boundary that is most exposed to construction noise. If the property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence.

Table 3 presents management levels for noise at other sensitive land uses based on the principle that the characteristic activities for each of these land uses would not be unduly disturbed. The noise management levels apply only to when the property is being used, for example classrooms during school hours. Internal noise levels are to be assessed at the centre of the occupied room. External noise levels are to be assessed at the most-affected point within 50 m of the area boundary.

Table 3: Noise at Other Sensitive Land Uses Using Quantitative Assessment[1]

Land Use	Management Level, LAeq(15minute) (Applies When Land Use is being Utilised)
Classrooms at schools and other educational institutions	Internal noise level 45 dB
Hospital wards and operating theatres	Internal noise level 45 dB
Places of worship	Internal noise level 45 dB
Active recreation areas (such as parks and sports grounds or playgrounds)	External noise level 65 dB
Passive recreation areas (such as outdoor grounds used for teaching, outdoor cafes or restaurants)	External noise level 60 dB

Note 1: Adopted from the ICNG.

Other noise-sensitive businesses require separate specific noise goals and it is suggested in the ICNG that the internal construction noise levels at these premises are to be referenced to the 'maximum' internal levels presented in AS 2107. Recommended 'maximum' internal noise levels from AS 2107 are reproduced in **Table 4** for other sensitive receiver types.

However, the ICNG and AS 2107 do not provide specific criteria for childcare centres. Childcare centres generally have internal play areas and sleep areas. The Association of Australian Acoustical Consultants (AAAC) Technical Guideline on Child Care Centre Noise Assessments provides criteria for these land uses. Based on this guideline an LAeq (1hour) of 55 dBA for external play areas and LAeq (1hour) of 40 dBA for indoor play areas and sleeping areas would be adopted.

Table 4 AS 2107 Recommended Maximum Internal Noise Levels

Land Use	Time Period	AS 2107 Classification	Recommended "Maximum" Internal LAeq (dBA)
Hotel	Daytime & Evening	Bars and Lounges	50
	Night-time	Sleeping Areas: - Hotels near major roads	40
Café	When in use	Coffee bar	50
Bar/Restaurant	When in use	Bars and Lounges / Restaurant	50
Library	When in use	Reading Areas	45
Recording Studio	When in use	Music Recording Studios	25
Theatre / Auditorium	When in use	Drama Theatres	30

5.3.2. Commercial and Industrial Premises

Due to the broad range of sensitivities that commercial or industrial land can have to noise from construction, the process of defining management levels is separated into three categories. The external noise levels would be assessed at the most-affected occupied point of the premises:

- Industrial premises (external): 75 dB $L_{Aeq(15minute)}$
- Offices, retail outlets (external): 70 dB $L_{Aeq(15minute)}$
- Other businesses that may be very sensitive to noise, where the noise level is project specific as discussed below

Examples of other noise-sensitive businesses are theatres, studios and child care centres. The proponent would undertake a special investigation to determine suitable noise levels on a project-by-project basis; the recommended internal noise levels presented in Table 1 of AS 2107 "*Acoustics - Recommended design sound levels and reverberation times for building interiors"* (Standards Australia 2000) may assist in determining relevant noise levels; however, an acoustical consultant would be engaged in order to determine corresponding external noise levels based on the published internal noise levels. The proponent would assess construction noise levels for the project, and consult with occupants of commercial and industrial premises prior to lodging an application where required. During construction, the proponent would regularly update the occupants of the commercial and industrial premises regarding noise levels and hours of work.

5.4. Ground-Borne Vibration

The effects of vibration in buildings can be divided into three main categories; those in which the occupants or users of the building are inconvenienced or possibly disturbed, those where the building contents may be affected and those in which the integrity of the building or the structure itself may be prejudiced.

5.4.1. Human Comfort Vibration

The DECCW's "Assessing Vibration: a technical guideline" dated February 2006 (DEC, 2006) recommends the use of BS 6472-1992 for the purpose of assessing vibration in relation to human comfort.

British Standard 6472-1992 "*Guide to evaluation of human exposure to vibration in building*" nominates guideline values for various categories of disturbance, the most stringent of which are the levels of building vibration associated with a "low probability of adverse comment" from occupants.

BS 6472-1992 provides guideline values for continuous, transient and intermittent events that are based on a Vibration Dose Value (VDV), rather than a continuous vibration level. The vibration dose value is dependant upon the level and duration of the short term vibration event, as well as the number of events occurring during the daytime or night-time period.

The vibration dose values recommended in BS 6472-1992 for which various levels of adverse comment from occupants may be expected are presented in **Table 5**.

Table 5: Vibration Dose Value Ranges which Might Result in Various Probabilities of Adverse Comment within Residential Buildings

Place and Time	Low Probability of Adverse Comment ($m/s^{1.75}$)	Adverse Comment Possible ($m/s^{1.75}$)	Adverse Comment Probable ($m/s^{1.75}$)
Residential buildings 16 hr day	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings 8 hr night	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8

Note: For offices and workshops, multiplying factors of 2 and 4 respectively would be applied to the above vibration dose value ranges for a 16 hr day.

5.4.2. Structural Damage Vibration

Most commonly specified 'safe' structural vibration limits are designed to minimise the risk of threshold or cosmetic surface cracks, and are set well below the levels that have potential to cause damage to the main structure.

In terms of the most recent relevant vibration damage goals, Australian Standard AS 2187: Part 2-2006 'Explosives - Storage and Use - Part 2: Use of Explosives' recommends the frequency dependent guideline values and assessment methods given in BS 7385 Part 2-1993 'Evaluation and measurement for vibration in buildings Part 2' as they "are applicable to Australian conditions".

The Standard sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

Sources of vibration that are considered in the standard include demolition, blasting (carried out during mineral extraction or construction excavation), piling, ground treatments (eg compaction), construction equipment, tunnelling, road and rail traffic and industrial machinery.

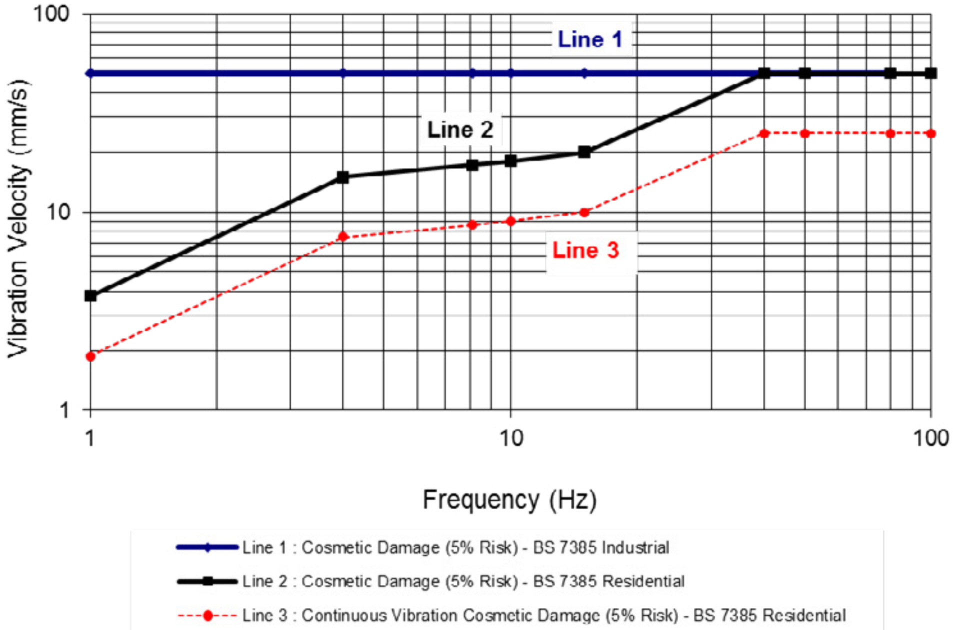
5.4.3. Cosmetic Damage Vibration

The recommended limits (guide values) for transient vibration to ensure minimal risk of cosmetic damage to residential and industrial buildings are presented numerically in **Table 6** and graphically in **Figure 1**.

Table 6: Transient Vibration Guide Values - Minimal Risk of Cosmetic Damage

Line	Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
		4 Hz to 15 Hz	15 Hz and Above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

Figure 1: Graph of Transient Vibration Guide Values for Cosmetic Damage



The Standard goes on to state that minor damage is possible at vibration magnitudes which are greater than twice those given in **Table 6**, and major damage to a building structure may occur at values greater than four times the tabulated values.

Fatigue considerations are also addressed in the Standard and it is concluded that unless calculation indicates that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the guide values in **Table 6** would not be reduced for fatigue considerations.

In order to assess the likelihood of cosmetic damage due to vibration, AS2187 specifies that vibration measured would be undertaken at the base of the building and the highest of the orthogonal vibration components (transverse, longitudinal and vertical directions) would be compared with the guidance curves presented in **Figure 1**.

It is noteworthy that extra to the guide values nominated in **Table 6**, the standard states that:

> *"Some data suggests that the probability of damage tends towards zero at 12.5 mm/s peak component particle velocity. This is not inconsistent with an extensive review of the case history information available in the UK."*

Also that:

> *"A building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive."*

5.5. General Vibration Screening Criterion

The Standard states that the guide values in **Table 6** relate predominantly to transient vibration which does not give rise to resonant responses in structures and low-rise buildings.

Where the dynamic loading caused by continuous vibration may give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in **Table 6** may need to be reduced by up to 50%.

Note: rockbreaking/hammering and sheet piling activities are considered to have the potential to cause dynamic loading in some structures (eg residences) and it may therefore be appropriate to reduce the transient values by 50%.

Therefore for most construction activities involving intermittent vibration sources such as rockbreakers, piling rigs, vibratory rollers, excavators and the like, the predominant vibration energy occurs at frequencies greater than 4 Hz (and usually in the 10 Hz to 100 Hz range). On this basis, a conservative vibration damage screening level per receiver type is given below:

- Reinforced or framed structures: 25.0 mm/s
- Unreinforced or light framed structures: 7.5 mm/s

At locations where the predicted and/or measured vibration levels are greater than shown above (peak component particle velocity), a more detailed analysis of the building structure, vibration source, dominant frequencies and dynamic characteristics of the structure would be required to determine the applicable safe vibration level.

5.6. Guidelines for Vibration Sensitive and Special Structures

5.6.1. Heritage

Heritage buildings and structures would be assessed as per the screening criteria in **Section 5.5** as they should not be assumed to be more sensitive to vibration unless they are found to be structurally unsound. If a heritage building or structure is found to be structurally unsound (following inspection) a more conservative cosmetic damage criteria of 2.5 mm/s peak component particle velocity (from DIN 4150) would be considered.

5.6.2. Sensitive Scientific and Medical Equipment

Some scientific equipment (eg electron microscopes and microelectronics manufacturing equipment) can require more stringent objectives than those applicable to human comfort.

Where it has been identified that vibration sensitive scientific and/or medical instruments are likely to be in use inside the premises of an identified vibration sensitive receiver, objectives for the satisfactory operation of the instrument would be sourced from manufacturer's data. Where manufacturer's data is not available, generic vibration criterion (VC) curves as published by the Society of Photo-Optical Instrumentation Engineers (Colin G. Gordon - 28 September 1999) may be adopted as vibration goals. These generic VC curves are presented below in **Table 7** and **Figure 2**.

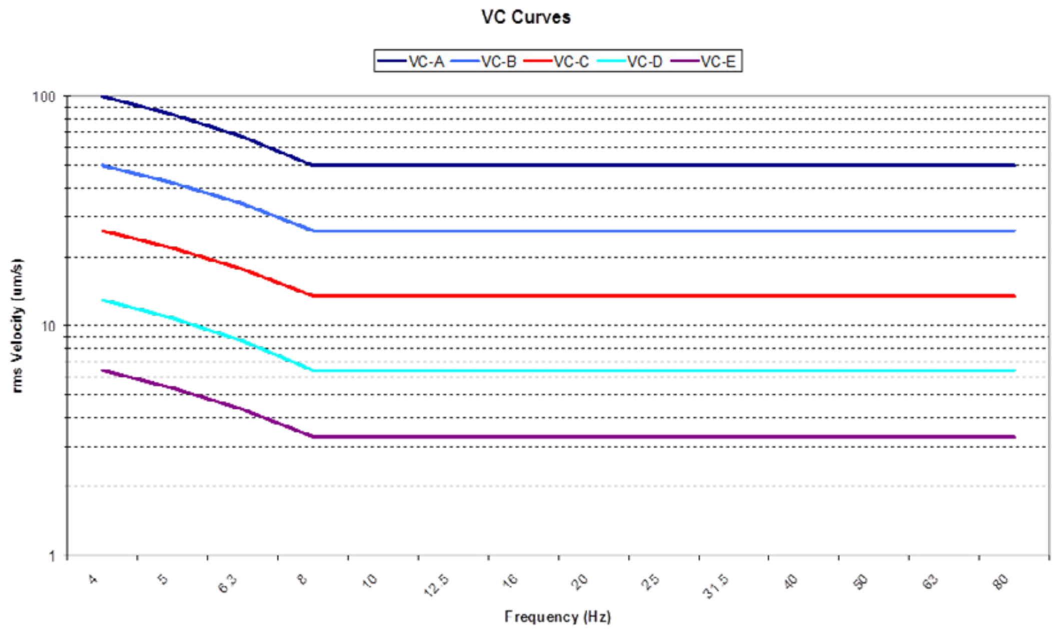
Table 7: Application and Interpretation of the Generic Vibration Criterion (VC) Curves (as shown in Figure 2)

Criterion Curve	Max Level (µm/sec, rms)[1]	Detail Size (microns)[2]	Description of Use
VC-A	50	8	Adequate in most instances for optical microscopes to 400X, microbalances, optical balances, proximity and projection aligners, etc.
VC-B	25	3	An appropriate standard for optical microscopes to 1000X, inspection and lithography equipment (including steppers) to 3 micron line widths.
VC-C	12.5	1	A good standard for most lithography and inspection equipment to 1 micron detail size.
VC-D	6	0.3	Suitable in most instances for the most demanding equipment including electron microscopes (TEMs and SEMs) and E-Beam systems, operating to the limits of their capability.
VC-E	3	0.1	A difficult criterion to achieve in most instances. Assumed to be adequate for the most demanding of sensitive systems including long path, laser-based, small target systems and other systems requiring extraordinary dynamic stability.

Note 1: As measured in one-third octave bands of frequency over the frequency range 8 to 100 Hz.

Note 2: The detail size refers to the line widths for microelectronics fabrication, the particle (cell) size for medical and pharmaceutical research, etc. The values given take into account the observation requirements of many items depend upon the detail size of the process.

Figure 2: Vibration Criterion (VC) Curves



5.6.3. Other Vibration Sensitive Structures and Utilities

Where structures and utilities are encountered which may be considered to be particularly sensitive to vibration, a vibration goal which is more stringent than structural damage goals presented in Section 5.4 may need to be adopted. Examples of such structures and utilities include:

- Tunnels
- Gas pipelines
- Fibre optic cables

Specific vibration goals would be determined on a case-by-case basis. An acoustic consultant would be engaged by the construction contractor and would liaise with the structure or utility's owner in order to determine acceptable vibration levels.

5.7. Vibration and Overpressure from Blasting

The DECCW's ICNG recommends that vibration and overpressure from blasting be assessed against the levels presented in the Australian and New Zealand Environment Council's (ANZECC) Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration (ANZECC, 1990).

The criteria set by this standard are targeted at operations that occur for long periods of time such as those at mining sites and hence are targeted at protecting human comfort vibration levels. As a result the vibration levels are conservative and can introduce unnecessary constraints when applied to construction projects which typically occur for much shorter time periods. Recent NSW infrastructure project approvals have recognised the restrictive nature of these blasting criteria when applied to construction projects and have therefore allowed the following vibration and overpressure limits:

- Vibration (PPV): 25 mm/s
- Overpressure: 125 dBL

These upper limits are deemed acceptable where the proponent has a written agreement with the relevant landowner to exceed the criteria and the Secretary has approved the terms of the written agreement. These upper limits to vibration and overpressure are intended to target the protection of building structures from cosmetic damage rather than human comfort criteria as construction works are considered short-term.

5.8. Ground-Borne (Regenerated) Noise

Ground-borne (regenerated) noise is noise generated by vibration transmitted through the ground into a structure. Ground-borne noise caused, for example by underground works such as tunnelling, can be more noticeable than airborne noise. The following ground-borne noise levels for residences are nominated in the ICNG and indicate when management actions would be implemented. These levels recognise the temporary nature of construction and are only applicable when ground-borne noise levels are higher than airborne noise levels.

The ground-borne noise management levels are given below:

- Day (7.00 am to 6.00pm)
  Internal Residential: 45 dB $L_{Aeq(15minute)}$
  Internal Commercial: 50 dB $L_{Aeq(15minute)}$

- Evening (6.00 pm to 10.00 pm)
  Internal Residential: 40 dB $L_{Aeq(15minute)}$
- Night-time (10.00 pm to 7.00 am)
  Internal Residential: 35 dB $L_{Aeq(15minute)}$

The daytime criteria are applicable to both residential and commercial receivers, whereas the evening and night-time criteria are only applicable to residential receivers.

The internal noise levels are to be assessed at the centre of the most-affected habitable room. For a limited number of discrete, ongoing ground-borne noise events, such as drilling or rock-hammering, The L_{Amax} noise descriptor using a slow response on the sound level meter may be better than the L_{Aeq} noise descriptor (15 min) in describing the noise impacts. The level of mitigation of ground-borne noise would depend on the extent of impacts and also on the scale and duration of works. Any restriction on the days when construction work is allowed would take into account whether the community:

- Has identified times of day when they are more sensitive to noise (for example Sundays or public holidays).
- Is prepared to accept a longer construction duration in exchange for days of respite.

5.9. Traffic Noise Assessment Goals

When trucks and other vehicles are operating within the boundaries of the various construction sites, road vehicle noise contributions are included in the overall predicted $L_{Aeq(15minute)}$ construction site noise emissions. When construction related traffic moves onto the public road network a different noise assessment methodology is appropriate, as vehicle movements would be regarded as 'additional road traffic' rather than as part of the construction site.

The ICNG does not provide specific guidance in relation to acceptable noise levels associated with construction traffic. For assessment purposes, guidance is taken from the RNP.

One of the objectives of the RNP is to apply relevant permissible noise increase criteria to protect sensitive receivers against excessive decreases in amenity as the result of a proposal. In assessing feasible and reasonable mitigation measures, an increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person.

On this basis, construction traffic NMLs set at 2 dB above the existing road traffic noise levels during the daytime and night-time periods are considered appropriate to identify the onset of potential noise impacts. Where the road traffic noise levels are predicted to increase by more than 2 dB as a result of construction traffic, consideration would be given to applying feasible and reasonable noise mitigation measures to reduce the potential noise impacts and preserve acoustic amenity.

In considering feasible and reasonable mitigation measures where the relevant noise increase is greater than 2 dB, consideration would also be given to the actual noise levels associated with construction traffic and whether or not these levels comply with the following road traffic noise criteria in the RNP:

- 60 dB $L_{Aeq(15hour)}$ day and 55 dB $L_{Aeq(9hour)}$ night for existing freeway/ arterial/ sub-arterial roads.
- 55 dB $L_{Aeq(1hour)}$ day and 50 dB $L_{Aeq(1hour)}$ night for existing local roads.

5.9.1. Sleep Disturbance and Maximum Noise Events

In addition to the current legislative guidance on potential sleep disturbance outlined in Section 5.10 the RNP refers to Practice Note 3 of the ENMM for specific impacts from road traffic. The ENMM recommends an evaluation of the number and distribution of night-time passby events where the L_{AFmax} - $L_{Aeq(1hour)}$ difference is greater than 15 dB, and the maximum noise level of that event is greater than 65 dB L_{Amax}.

On the basis of the current guidance:

- External sleep disturbance screening criterion of RBL + 15 dB
- External sleep disturbance criterion of 65 dB L_{Amax} (assuming open windows).

5.10. Sleep Disturbance and Maximum Noise Level Events

The DECCW's ECRTN and the Road and Traffic Authority's (RTA's) *'Environmental Noise Management Manual'* (ENMM) provide guidance as to the likelihood of sleep disturbance resulting from maximum noise level events (mainly associated with heavy vehicle movements). The ECRTN points out the following:

"There are no universally accepted criteria governing the likelihood of sleep disturbance. In other words, at the current level of understanding, it is not possible to establish absolute noise levels that correlate to levels of sleep disturbance (for all or even a majority of people)."

Notwithstanding the ECRTN/ENMM suggests that:

- Maximum internal noise levels below 50 dB to 55 dB L_{Amax} are unlikely to cause awakening reactions.
- One or two events per night, with maximum internal noise levels of 65 dB to 70 dB L_{Amax}, are not likely to affect health and wellbeing significantly.
- At locations where road traffic is continuous rather than intermittent, the $L_{Aeq(9hour)}$ target noise level should sufficiently account for sleep disturbance impacts.
- Where the emergence of L_{Amax} noise levels over the ambient L_{Aeq} noise level is greater than 15 dB, the L_{Aeq} criterion may not sufficiently account for sleep disturbance impacts.

A maximum noise event can be defined as any passby for which the difference in the L_{Amax} and $L_{Aeq(1Hour)}$ noise levels is greater than 15 dB. Furthermore, the ECRTN recommends that the assessment of sleep disturbance should include a consideration of the maximum noise level exceedances occurring during the night-time period and the emergence of these exceedances above the ambient noise level.

6. CONSTRUCTION NOISE & VIBRATION ASSESSMENT METHODOLOGY

6.1. Overview

Program and site constraints require that 24 hour working would most likely be required at all metro construction sites for a significant proportion of the total construction period. In particular, noisy activities such as:

- Excavation of tunnel and station caverns by Tunnel Boring Machines (TBMs) and roadheaders would be required over a 24 hour day, 6 days a week. Note that TBMs typically require routine maintenance of equipment on the 7th day.

- Bulk excavation of station entry and ventilation shafts by rockbreaker / blasting (or equivalent methodology), raise boring, line drilling and milling head would be required 24 hours a day for 7 days a week.
- Truck movements would be required 24 hours a day for 7 days a week.

6.2. Expected Construction Activities

Table 8 presents the construction activities which are likely to be undertaken during the construction of all Sydney Metro projects, together with typical plant and equipment required to execute each activity.

Table 8: Construction Activities and Typical Plant and Equipment

Activity	Significant Noise and Vibration Generating Plant and Equipment
Demolition	Excavator Dump Trucks Rockbreaker Jackhammer
General Earthworks and site establishment	Excavator Dumps Trucks Delivery Trucks
Spoil Removal	Excavator Dump Trucks
Shaft Excavation	Rockbreakers Penetrating Cone Fracture (PCF) Blasting Jackhammer
Station Cavern Excavation	Roadheaders
Tunnelling	Tunnel Boring Machine (TBM) Roadheaders
Cross passages	Rock breakers Roadheaders
Building/Facility Construction	Standard Construction Techniques Including: - Cranes - Delivery Trucks - Hand Tools/Hand Held Power Tools
Demolition	Excavator Dump Trucks Rockbreaker Jackhammer
General Earthworks and site establishment	Excavator Dumps Trucks Delivery Trucks
Spoil Removal	Excavator Dump Trucks
Shaft Excavation	Rockbreakers Penetrating Cone Fracture (PCF) Blasting Jackhammer

6.3. Noise and Vibration Sensitive Receivers

The sensitivity of occupants to noise and vibration varies according to the nature of the occupancy and the activities performed within the affected premises. For example, recording studios are more sensitive to vibration and ground borne noise than residential premises, which in turn are more sensitive than typical commercial premises.

Specific noise and vibration sensitive receivers relevant to individual construction sites would be identified and addressed in the Environmental Assessment of each Sydney Metro project. Each receiver would be identified as falling into one of the following categories:

- Commercial
- Educational
- Industrial
- Mixed residential/commercial
- Residential
- Residential occupied by shift workers
- Place of Worship
- Medical facilities
- Other sensitive receivers

6.4. General Assessment Procedure

All assessments must be quantitative as per the procedure given in the ICNG. If the assessment is being carried out for the environmental impact assessment documentation (eg EIS) it will be based on a concept design and construction scenarios for the project (usually prepared by a technical advisor and/or planning consultant). If the assessment is being undertaken prior to construction (eg CNIS) it will be based on a more detailed design and actual construction scenario (usually prepared by the design and/or construction contractors).

Constructions Noise Impact Statements (CNIS) are to be developed to assess the potential impact of noise at NSRs as a result of a Sydney Metro project's construction activities prior to the commencement of construction components.

In order to develop accurate and comprehensive CNIS reports for work components associated with the project, specific detail of the construction methodology, including the size and type of equipment is required. Detailed design, construction and engineering solutions are progressively developed and applied throughout the life-span of the project. Consequently, CNIS reports that cover the key construction activities/components are to be developed to reflect the progressive nature of design and construction of the project. There are to be two (2) different types of CNIS report to be developed throughout the project:

- General Construction Activity CNIS for construction scenarios that are consistently the same and progressively move along the project alignment eg tunnelling, retaining walls.
- Location Specific CNIS for construction scenarios that are specific to a location. Where works are required to be undertaken outside of standard construction hours, Out of Hours Work (OOHW) assessments will be included in CNIS or a new CNIS

developed in support of all applicable variations to the project Environment Protection Licence (EPL).

For all CNIS reports the noise impacts are to be assessed based on construction scenarios. A construction scenario relating to noise impact is essentially a construction activity with is made up of the required plant and equipment. A number of construction scenarios will make up any one CNIS report. In undertaking an assessment of the noise impact from a construction scenario(s) including the development of CNIS report, the following steps are to be taken:

- Identify all noise and/or vibration sensitive receivers (NSRs) which may be affected by the project.
- Conduct background noise monitoring at representative NSRs to determine the rating background noise levels (RBLs) in accordance with the procedures presented in the NSW Industrial Noise Policy, where RBLs have not been established in previous project stages.
- Determine the appropriate noise and vibration management levels of each NSR.
- Determine the source noise levels (Sound Power Levels) of each noise generating plant and equipment item required to undertake the construction scenario. Note: Sound Power Levels for each plant and equipment would be less than the maximum allowable levels found in Table 11 and Table 12.
- Clearly indicate which mitigation measures identified in Section 7 have been/are to be incorporated into the noise assessment. Noise mitigation measures to be implemented will vary for reasons such as safety and space constraints, these are to be identified and the calculations adjusted accordingly.
- For Location Specific construction scenarios and where applicable for Generic scenarios, include the effects of noise shielding provided by site offices, residential fences, noise barriers or natural topographic features.
- Where applicable include the effects of noise reflections and ground attenuation.
- On the basis of the duration of each activity (over a typical "worst case" 15-minute period), determine whether any correction between the L_{Amax} and the L_{Aeq} is required.
- Calculate the L_{Aeq} noise or range of levels from construction scenarios at sensitive receiver groups, with the use of noise contour maps where appropriate and/or at 10 m, 25 m, 50 m, 75 m,100 m and 200 m for more general construction activities.
- Compare these against the goals identified for each NSR and identify predicted exceedances.
- For night-time activities, calculate the $L_{A1(60second)}$ noise levels and compare with the DECCW's RBL + 15 dB sleep disturbance screening criterion. On the basis of the ambient noise environment during the night-time period, the predicted L_{A1} noise levels and the number of expected L_{A1} noise events would be assessed. From this assessment determine the likelihood of potential sleep disturbance. Note: the L_{Amax} noise level can be used to estimate the L_{A1} noise level.
- On completion of all CNIS reports for the subjective classification of the noise impact is to be evaluated and documented as:
    - Lower Impact
    - Moderate Impact

   - High Impact

The classifications are to be determined on a case-by-case basis with consideration of the following points. These are guidelines for classifications only and subjective due to the number of variances within any construction scenario. An objective evaluation is to be applied to all construction scenarios.

- The location of the works in relation to NSRs with consideration of noise attenuation features such as noise barriers including topographical features (earth-mounds), buildings, dividing fences etc (distance of works from sensitive receiver(s)).
- The type and sensitivity of the NSRs:
   - Lower Impact: eg Commercial buildings/ Scattered Residential (low density)
   - Moderate Impact: eg Standard residential (typical density)
   - High Impact: eg Residential home for the elderly/high density unit blocks/persistent complainers/residents deemed to have "construction noise fatigue".
- The extent of noise exceedance above Noise Management Level.
- The likelihood for potential sleep disturbance RBL + 15 dB.
- The type of and intensity of noise emitted from works (ie tonal or impulsive):
   - Lower Impact: No high noise and/or vibration intensive activities
   - Moderate Impact: Short/intermittent high noise and/or vibration intensive activities
   - High Impact: Prolonged high noise and/or vibration intensive activities.
- The duration of any OOHW required.
- The time frames for any OOHW:
   - Lower Impact: 6.00 pm till 10.00 pm weekdays 1.00 pm till 10.00pm Saturdays

     8.00 am till 6.00 pm Sundays or Public Holidays
   - Moderate Impact: 10.00 pm to 7.00 am Weekday Nights 10.00 pm to 8.00 am Saturdays
   - High Impact: 6.00 pm to 7.00 am Sundays and Public Holidays.
- As a result of noise classification and/or the noise level exceedances at sensitive receivers provided by the CNIS reports, appropriate reasonable and feasible noise mitigation is to be adopted and implemented. For sites where works are predicted to significantly exceed noise goals and impact on receivers for a significant period of time, additional reasonable and feasible noise mitigation measures such as those outlined in Section 7 would be considered if practical to reduce the noise levels and impact on sensitive receivers.

6.5. Ground-Borne (Regenerated) Noise

Ground-borne noise as a result of construction activities is usually associated with tunnelling projects where equipment such as tunnel boring machines, road headers, rock hammers and drilling rigs are operated underground. It is therefore anticipated that ground-borne noise may be an issue during the construction of Sydney Metro projects.

If ground-borne noise is anticipated as a result of construction activities, a CNIS report, specifically in relation to the assessment of ground-borne construction noise would be undertaken.

In undertaking a CNIS report for ground-borne construction noise the following steps are to be taken:

- Determine the location of each plant and equipment item in relation to each receiver.
- On the basis of ground-borne noise versus distance prediction algorithms for each plant item, determine the level of ground-borne noise at each building location. For highly sensitive building occupancies, such as recording studios, the assessment may need to incorporate the acoustic properties of the building space and the structural response of the building. This is to be determined by a qualified acoustic consultant, should ground-borne noise be a potential issue.
- Include the effect of all relevant standard mitigation measures as part of the construction scenario.
- Calculate the $L_{Aeq(15minute)}$ noise levels from the proposed construction actives at each receiver and compare these to the ground-borne noise management levels.

6.6. Ground-Borne Vibration

Vibration as a result of construction activities is usually associated with tunnelling projects where equipment such as tunnel boring machines, road headers, rock hammers and drilling rigs are operated underground. It is therefore anticipated that ground-borne vibration may be an issue during the construction of Sydney Metro projects.

If vibration impacts are anticipated as a result of construction activities, a CNIS report, specifically in relation to the assessment of construction vibration would be undertaken.

In undertaking a CNIS report for ground-borne construction vibration the following steps are to be taken:

- Determine the location of each plant and equipment item in relation to each receiver.
- On the basis of ground-borne vibration versus distance prediction algorithms for each plant item, determine the level of ground-borne vibration at each building location. For highly sensitive building occupancies, such as recording studios, the assessment may need to incorporate the vibration properties of the building space and the structural response of the building. This is to be determined by a qualified acoustic consultant, should ground-borne vibration be a potential issue.
- Include the effect of all relevant standard mitigation measures as part of the construction scenario.

Calculate the vibration levels from the proposed construction actives at each receiver and compare these to the ground-borne vibration criteria.

6.7. Vibration and Overpressure from Blasting

Vibration and overpressure as a result of construction activities is usually associated with tunnelling projects where blasting is required. If this construction is implemented then vibration and overpressure may be an issue during the construction of Sydney Metro projects.

If vibration and overpressure impacts are anticipated as a result of construction blasting, a CNIS report, specifically in relation to the assessment of construction blasting would be undertaken.

In undertaking a CNIS report for blasting vibration and overpressure the following steps are to be taken:

- Determine the location of blast charge in relation to each receiver.
- On the basis of vibration / overpressure versus distance prediction algorithms for blasting determine the level of vibration / overpressure at each receiver (building) location.
- Include the effect of all relevant standard mitigation measures as part of the construction scenario.

Calculate the vibration and overpressure levels from the proposed blasting actives at each receiver and compare these to the blasting criteria.

7. STANDARD NOISE AND VIBRATION MITIGATION MEASURES

7.1. Minimum Requirements

This section sets out the standard construction noise and vibration mitigation measures to be implemented on all Sydney Metro projects and delivered via relevant procedures, systems, environmental assessment, construction environmental management and all relevant contract documentation.

For all Sydney Metro construction projects, the standard mitigation measures in **Table 9** shall be applied by default in order to minimise the potential noise and vibration impacts at the surrounding Noise Sensitive Receivers. Additional information in relation to specific mitigation measures, the assessment process and relevant objectives are provided in **Section 8**.

During the preparation of the environmental assessment documentation, a construction noise and vibration assessment would be undertaken. This includes monitoring requirements in order to validate the modelling assumptions and confirm that noise levels from individual plant and equipment items are not excessive. This section provides guidance in relation to standard monitoring and survey requirements that are expected for Sydney Metro construction projects.

7.1.1. Management Strategies during Construction

- Construction hours would be in accordance with the ICNG, project approvals and the EPL, except where otherwise specified in an approved noise management plan.
- When working adjacent to schools, medical facilities and childcare centres, particularly noisy activities would be scheduled outside normal working hours, where feasible and reasonable.
- When working adjacent to churches and places of worship particularly noisy activities would be scheduled outside services, where feasible and reasonable.
- Avoiding the coincidence of noisy plant working simultaneously close together and adjacent to sensitive receivers will result in reduced noise emissions.

- Where feasible and reasonable, the offset distance between noisy plant items and nearby noise sensitive receivers would be as great as possible.
- Regular compliance checks on the noise emissions of all plant and machinery used for the project would indicate whether noise emissions from plant items were higher than predicted. This also identifies defective silencing equipment on the items of plant.
- Ongoing noise monitoring during construction at sensitive receivers during critical periods (ie times when noise emissions are expected to be at their highest - eg piling and hammering) to identify and assist in managing high risk noise events.
- Where feasible and reasonable heavy vehicle movements would be limited to daytime hours.
- The implementation of procedures to maximise the night-time onsite spoil storage capacity where spoil is produced between the hours of 10.00 pm and 7.00 am.

7.1.2. Site Induction for all Employees, Contractors and Subcontractors

The site induction would include the following as a minimum:

- All relevant project specific and standard noise and vibration mitigation measures
- Relevant licence and approval conditions
- Permissible hours of work
- Any limitations on high noise generating activities
- Location of nearest sensitive receivers
- Construction employee parking areas
- Designated loading/unloading areas and procedures
- Site opening/closing times (including deliveries)
- Environmental incident reporting and management procedures

7.1.3. Source Noise Control Strategies

- Engines and exhausts are typically the dominant noise sources on mobile plant such as cranes, graders, excavators, heavy vehicles, etc. In order to minimise noise emissions, residential grade mufflers would be fitted on all mobile plant utilised on Sydney Metro construction projects.
- The use of damped hammers is recommended such as the ‘City’ model Rammer hammers. These reduce the ‘ringing’ of the rockpick, cylinder and excavator arm that is commonly associated with rockbreaking works. Approximately 10 dB attenuation can be achieved compared to undamped hammers of the same size.
- Regular maintenance of all plant and machinery used for the project will assist in minimising noise emissions, including the reporting of the results.
- Acoustic enclosure of plant items, if required, as identified during compliance monitoring.
- Air brake silencers would be correctly installed and fully operational for any heavy vehicle that approaches and uses any Sydney Metro construction site.
- Non-tonal reversing alarms would be used for all permanent mobile plant operating on Sydney Metro construction projects. Whilst the use of non-tonal reversing

alarms is suggested to ensure noise impacts are minimised, it is noted that OH&S requirements must also be fully satisfied.

7.1.4. Noise Barrier Control Strategies

Temporary noise barriers are recommended between the noise sources and nearby potentially affected noise sensitive receivers, wherever feasible. Typically, 5 dB to 15 dB attenuation can be achieved with a well-constructed barrier.

7.1.5. Acoustic Enclosures

Where significant noise impacts are predicted and/or long periods of construction works are planned, acoustic enclosures can be used as an effective mitigation method. Acoustic enclosures act to contain the sources of noise, whilst also providing the benefit of screening the construction site from view. An enclosure with no openings would be expected to provide attenuation the order of 20 dB.

7.1.6. Vibration Control Strategies

Attended vibration measurements are required at the commencement of vibration generating activities to confirm that vibration levels satisfy the criteria for that vibration generating activity. Where there is potential for exceedances of the criteria further vibration site law investigations would be undertaken to determine the site-specific safe working distances for that vibration generating activity. Continuous vibration monitoring with audible and visible alarms would be conducted at the nearest sensitive receivers whenever vibration generating activities need to take place inside the calculated safe-working distances.

7.1.7. Community Consultation

Active community consultation and the maintenance of positive, cooperative relationships with schools, local residents and building owners and occupiers assists in managing impacts from noisier operations and in alleviating concerns and thereby minimising disturbance and complaint. This includes, for example:

- Periodic notification or work activities and progress (eg regular letterbox drops, e-consult)
- Specific notification (letter-box drop) prior to especially noisy activities
- Comprehensive website information
- Project information and construction response telephone line
- Email distribution list

7.2. Summary of the Standard Mitigation Measures

The actions set out in **Table 9** must be implemented on all Sydney Metro construction projects.

Table 9: Standard Mitigation Measures to Reduce Construction Noise and Vibration

Action required	Applies to	Details
Management Measures		
Implementation of any project specific mitigation measures required	Airborne noise Ground-borne noise and vibration	In addition to the measures set out in this table, any *project specific* mitigation measures identified in the environmental assessment documentation (eg EA, REF, submissions or representations report) or approval or licence conditions must be implemented.
Implement community consultation measures	Airborne noise Ground-borne noise and vibration	Periodic Notification (monthly letterbox drop)[1] Website Project information and construction response telephone line Email distribution list Place Managers
Register of Noise Sensitive Receivers	Airborne noise Ground-borne noise and vibration	A register of all noise and vibration sensitive receivers (NSRs) would be kept on site. The register would include the following details for each NSR: • Address of receiver • Category of receiver (eg Residential, Commercial etc.) • Contact name and phone number
Site inductions	Airborne noise Ground-borne noise and vibration	All employees, contractors and subcontractors are to receive an environmental induction. The induction must at least include: • All relevant project specific and standard noise and vibration mitigation measures • Relevant licence and approval conditions • Permissible hours of work • Any limitations on high noise generating activities • Location of nearest sensitive receivers • Construction employee parking areas • Designated loading/unloading areas and procedures • Site opening/closing times (including deliveries) • Environmental incident procedures
Behavioural practices	Airborne noise	No swearing or unnecessary shouting or loud stereos/radios; on site. No dropping of materials from height; throwing of metal items; and slamming of doors. No excessive revving of plant and vehicle engines Controlled release of compressed air.
Monitoring	Airborne noise Ground-borne noise and vibration	A noise monitoring program is to be carried out for the duration of the works in accordance with the Construction Noise and Vibration Management Plan and any approval and licence conditions.

[1] Detailing all upcoming construction activities at least 14 days prior to commencement of relevant works

Action required	Applies to	Details
Attended vibration measurements	Ground-borne vibration	Attended vibration measurements are required at the commencement of vibration generating activities to confirm that vibration levels satisfy the criteria for that vibration generating activity. Where there is potential for exceedances of the criteria further vibration site law investigations would be undertaken to determine the site-specific safe working distances for that vibration generating activity. Continuous vibration monitoring with audible and visible alarms would be conducted at the nearest sensitive receivers whenever vibration generating activities need to take place inside the applicable safe-working distances.
Source Controls		
Construction hours and scheduling	Airborne noise Ground-borne noise and vibration	Where feasible and reasonable, construction would be carried out during the standard daytime working hours. Work generating high noise and/or vibration levels would be scheduled during less sensitive time periods.
Construction respite period	Ground-borne noise and vibration Airborne noise	High noise and vibration generating activities[2] may only be carried out in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block[3].
Equipment selection	Airborne noise Ground-borne noise and vibration	Use quieter and less vibration emitting construction methods where feasible and reasonable. For example, when piling is required, bored piles rather than impact-driven piles will minimise noise and vibration impacts. Similarly, diaphragm wall construction techniques, in lieu of sheet piling, will have significant noise and vibration benefits.
Maximum noise levels	Airborne-noise	The noise levels of plant and equipment must have operating Sound Power Levels compliant with the criteria in **Table 11**.
Rental plant and equipment	Airborne-noise	The noise levels of plant and equipment items are to be considered in rental decisions and in any case cannot be used on site unless compliant with the criteria in **Table 11**.
Plan worksites and activities to minimise noise and vibration	Airborne noise Ground-borne vibration	Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site.
Non-tonal reversing alarms	Airborne noise	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work.

[2] Includes jack and rock hammering, sheet and pile driving, rock breaking and vibratory rolling.

[3] "Continuous" includes any period during which there is less than a 60 minutes respite between ceasing and recommencing any of the work.

Action required	Applies to	Details
Minimise disturbance arising from delivery of goods to construction sites	Airborne noise	Loading and unloading of materials/deliveries is to occur as far as possible from NSRs Select site access points and roads as far as possible away from NSRs Dedicated loading/unloading areas to be shielded if close to NSRs Delivery vehicles to be fitted with straps rather than chains for unloading, wherever feasible and reasonable
Path Controls		
Shield stationary noise sources such as pumps, compressors, fans etc	Airborne noise	Stationary noise sources would be enclosed or shielded whilst ensuring that the occupational health and safety of workers is maintained. Appendix F of AS 2436: 1981 lists materials suitable for shielding.
Shield sensitive receivers from noisy activities	Airborne noise	Use structures to shield residential receivers from noise such as site shed placement; earth bunds; fencing; erection of operational stage noise barriers (where practicable) and consideration of site topography when situating plant.

Table 10: Minimum Requirements for Construction Methods

Method	Minimum Requirements
Excavator	Ensure that the Sound Power Levels given in **Table 11** have been met.
Truck	Ensure that the Sound Power Levels given in **Table 11** have been met.
Rockbreakers and jackhammers	Ensure that the Sound Power Levels given in Error! Reference source not found. have been met. Noise and vibration monitoring would be conducted at the nearest identified NSR where exceedances of the criteria have been predicted.
PCF	Where it has been predicted that vibration / regenerated noise is likely to be in excess of the nominated goals, specific notification would be given to all NSRs a minimum of 2 weeks prior to a shot being fired. Vibration and overpressure monitoring would be conducted at the nearest identified NSR.
Blasting	Where it has been predicted that vibration / overpressure is likely to be in excess of the nominated goals, specific notification would be given to all NSRs a minimum of 2 weeks prior to a shot being fired. Vibration and overpressure monitoring would be conducted at the nearest identified NSR.
TBM	Noise and vibration monitoring would be conducted at the nearest identified NSR where levels are expected to exceed the relevant noise and vibration goals.
Roadheaders	Noise and vibration monitoring would be conducted at the nearest identified NSR where levels are expected to exceed the relevant noise and vibration goals.

7.3. Maximum Allowable Plant Sound Power Levels

Plant or equipment operating on Sydney Metro project construction sites shall have an operating sound power level (SWL) which is no higher than the corresponding SWL presented in **Table 11**. The SWLs presented in **Table 11** have been compiled from a selection of field measurements conducted between 2004 and 2008 of plant and equipment operating on large construction projects throughout NSW and are therefore considered to representative of plant and equipment SWLs which are readily achieved by current plant and equipment normally used in the construction industry.

Plant and equipment with SWLs higher than those presented in **Table 11** would be deemed to be emitting an excessive level of noise and would not be permitted to operate Sydney Metro project construction sites.

Table 11: Maximum Allowable Sound Power Levels for Construction Equipment

Equipment	Maximum Allowable Sound Power Level (dB) LAmax	Maximum Allowable Sound Pressure Level (dB) LAmax at 7 m
Excavator Hammer	118	93
Excavator (approx. 3 tonne)	90	65
Excavator (approx. 6 tonne)	95	70
Excavator (approx. 10 tonne)	100	75
Excavator (approx. 20 tonne)	105	80
Excavator (approx. 30 tonne)	110	85
Excavator (approx. 40 tonne)	115	90
Skidsteer Loaders (approx. 1/2 tonne)	107	82
Skidsteer Loaders (approx. 1 tonne)	110	85
Dozer (tracking) - equiv. CAT D8	118	93
Dozer (tracking) - equiv. CAT D9	120	95
Dozer (tracking) - equiv. CAT D10	121	96
Backhoe/FE Loader	111	86
Dump Truck (approx. 15 tonne)	108	83
Concrete Truck	112	87
Concrete Pump	109	84
Concrete Vibrator	105	80
Bored Piling Rig	110	85
Scraper	110	85
Grader	110	85
Vibratory Roller (approx. 10 tonne)	114	89
Vibratory Pile Driver	121	96
Impact Piling Rig	134	109
Compressor (approx. 600 CFM)	100	75
Compressor (approx. 1500 CFM)	105	80
Concrete Saw	118	93
Jackhammer	113	88

Equipment	Maximum Allowable Sound Power Level (dB) LAmax	Maximum Allowable Sound Pressure Level (dB) LAmax at 7 m
Generator	104	79
Lighting Tower	80	55
Flood Lights	90	65
Cherry Picker	102	77
Mobile Crane	110	85

Where an item of construction equipment is not listed in **Table 11**, generic sound power levels presented in **Table 12** may be adopted.

Table 12: Generic Equipment or System Sound Power Level Limit[1]

Equipment	Maximum Allowable Sound Power Level (dB) LAmax	Maximum Allowable Sound Pressure Level (dB) LAmax at 7 m
Motorised (<25kW)	90	65
Motorised (<50kW)	95	70
Motorised (<100kW)	100	75
Motorised (<200kW)	105	80
Motorised (>200kW)	110	85
All other Auxiliary Equipment or Systems	90	65

Note 1: Sound Power Levels in dBA relative to 10 pW.

7.4. Auditing and Monitoring

All items of plant would have noise audits conducted in accordance with the procedures outlined in **Section 9** of this strategy upon arrival at a Sydney Metro construction site and at 6 month intervals thereafter.

Where it has been identified within this strategy that noise and/or vibration monitoring is required at the nearest sensitive receiver; however, the nearest sensitive receiver has refused monitoring at their property, monitoring would be undertaken at the near point to that receiver within the site boundary or at another suitable location determined by an acoustic consultant.

8. ADDITIONAL NOISE AND VIBRATION MITIGATION MEASURES

8.1. Overview

The implementation of the standard management measures, compliance with maximum sound power levels for plant and equipment, construction hour management and standard community consultation measures in this Strategy should significantly reduce the noise and vibration impacts on nearby sensitive receivers.

Nevertheless, due to the highly variable nature of construction activities and the likelihood of work outside the standard construction hours on Sydney Metro projects, exceedances of the construction noise and vibration management levels are likely to occur.

Where there is a potential exceedance of the construction noise and vibration management levels a number of additional measures to mitigate such exceedances – primarily aimed at pro-active engagement with affected sensitive receivers – would be explored and have been included in this Strategy. The additional mitigation measures to be applied are outlined in **Table 13**.

Table 13: Additional Management Measures

Measure	Description	Abbreviation
Alternative accommodation	Alternative accommodation options may be provided for residents living in close proximity to construction works that are likely to incur unreasonably high impacts over an extended period of time. Alternative accommodation will be determined on a case-by-case basis.	AA
Monitoring	Where it has been identified that specific construction activities are likely to exceed the relevant noise or vibration goals, noise or vibration monitoring may be conducted at the affected receiver(s) or a nominated representative location (typically the nearest receiver where more than one receiver have been identified). Monitoring can be in the form of either unattended logging or operator attended surveys. The purpose of monitoring is to inform the relevant personnel when the noise or vibration goal has been exceeded so that additional management measures may be implemented.	M
Individual briefings	Individual briefings are used to inform stakeholders about the impacts of high noise activities and mitigation measures that will be implemented. Communications representatives from the contractor would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities. Individual briefings provide affected stakeholders with personalised contact and tailored advice, with the opportunity to comment on the project.	IB
Letter box drops	For each Sydney Metro project, a newsletter is produced and distributed to the local community via letterbox drop and the project mailing list. These newsletters provide an overview of current and upcoming works across the project and other topics of interest. The objective is to engage and inform and provide project-specific messages. Advanced warning of potential disruptions (eg traffic changes or noisy works) can assist in reducing the impact on the community. Content and newsletter length is determined on a project-by-project basis. Most projects distribute notifications on a monthly basis. Each newsletter is graphically designed within a branded template.	LB
Project specific respite offer	The purpose of a project specific respite offer is to provide residents subjected to lengthy periods of noise or vibration respite from an ongoing impact.	RO
Phone calls and emails	Phone calls and/or emails detailing relevant information would be made to identified/affected stakeholders within 7 days of proposed work. Phone calls and/or emails provide affected stakeholders with personalised contact and tailored advice, with the opportunity to provide comments on the proposed work and specific needs etc.	PC
Specific notifications	Specific notifications would be letterbox dropped or hand distributed to identified stakeholders no later than 7 days ahead of construction activities that are likely to exceed the noise objectives. This form of communication is used to support periodic notifications, or to advertise unscheduled works.	SN

8.2. Applying Additional Mitigation Measures

In circumstances where - after application of the standard mitigation measures - the $L_{Aeq(15minute)}$ construction noise and vibration levels are still predicted to exceed the noise or vibration objectives, the relevant Additional Mitigation Measures Matrix (AMMM) (see **Table 14** to **Table 16**) is to be used to determine the additional measures to be implemented. This requirement is supplemental to the basic requirements in the ICNG.

Using the relevant AMMM, the following steps need to be carried out to determine the additional mitigation measures to be implemented:

- Determine the duration (time period) when the work is to be undertaken.
- Determine the level of exceedance.
- From the relevant AMMM table, identify the additional mitigation measures to be implemented (using the abbreviation codes - expanded in **Table 13**).

Table 14: Additional Mitigation Measures Matrix (AMMM) - Airborne Construction Noise

Time Period		Mitigation Measures			
		Predicted $L_{Aeq(15minute)}$ Noise Level Above Background (RBL)			
		0 to 10 dB	10 to 20 dB	20 to 30 dB	> 30 dB
Standard	Mon-Fri (7.00 am - 6.00 pm)	-	-	M, LB,	M, LB
	Sat (8.00 am - 1.00 pm)				
	Sun/Pub Hol (Nil)				
OOHW	Mon-Fri (6.00 pm - 10.00 pm)	-	LB	M, LB	M, IB, LB, PC, RO,SN
	Sat (1.00 pm - 10.00 pm)				
	Sun/Pub Hol (8.00 am - 6.00 pm)				
OOHW	Mon-Fri (10.00 pm - 7.00 am)	-	M, LB,	M, IB, LB, PC, RO, SN	AA, M, IB, LB, PC, RO, SN
	Sat (10.00 pm - 8.00 am)				
	Sun/Pub Hol (6.00 pm - 7.00 am)				

Table 15: AMMM - Ground-borne Construction Noise

Time Period		Mitigation Measures		
		Predicted $L_{Aeq(15minute)}$ Noise Level Exceedance		
		0 to 10 dB	10 to 20 dB	> 20 dB
Standard	Mon-Fri (7.00 am - 6.00 pm)	LB	LB	M, LB, SN,
	Sat (8.00 am - 1.00 pm)			
	Sun/Pub Hol (Nil)			
OOHW	Mon-Fri (6.00 pm - 10.00 pm)	LB	M, LB, SN,	M, IB, LB, PC, RO, SN
	Sat (1.00 pm - 10.00 pm)			
	Sun/Pub Hol (8.00 am - 6.00 pm)			
OOHW	Mon-Fri (10.00 pm - 7.00 am)	M, LB, SN,	AA, M, IB, LB, PC, RO, SN	AA, M, IB, LB, PC, RO, SN
	Sat (10.00 pm - 8.00 am)			
	Sun/Pub Hol (6.00 pm - 7.00 am)			

Table 16: AMMM - Ground-borne Vibration

Time Period		Mitigation Measures Predicted Vibration Levels Exceed Maximum Levels
Standard	Mon-Fri (7.00 am - 6.00 pm)	M, LB, RP
	Sat (8.00 am - 1.00 pm)	
	Sun/Pub Hol (Nil)	
OOHW	Mon-Fri (6.00 pm - 10.00 pm)	M, IB, LB, PC, RO, SN
	Sat (1.00 pm - 10.00 pm)	
	Sun/Pub Hol (8.00 am - 6.00 pm)	
OOHW	Mon-Fri (10.00 pm - 7.00 am)	AA, M, IB, LB, PC, RO, SN
	Sat (10.00 pm - 8.00 am)	
	Sun/Pub Hol (6.00 pm - 7.00 am)	

9. MONITORING, AUDITING AND REPORTING

9.1. Plant Noise Auditing, Compliance Evaluation and Reporting

In order to compare the noise levels of plant and equipment with the values in Section 7, the following guidelines are recommended:

- Measurements of Sound Pressure Level (SPL) at 7 m (with plant or equipment stationary) shall be undertaken using procedures that are consistent with the requirements of Australian Standard AS2012–1990 Acoustics – Measurement of Airborne Noise Emitted by Earthmoving Machinery and Agricultural Tractors – Stationary Test Condition Part 1: Determination of Compliance with Limits for Exterior Noise.
- Measurements of Sound Power Level (SWL) shall be determined using procedures that are consistent with the requirements of International Standard ISO9614-2 1996 Acoustics – Determination of sound power levels of noise sources using sound intensity - Part 2: Measurement by scanning.
- If measuring the SPL at 7 m of moving plant, compliance measurements would be guided by the requirements of Australian Standard AS2012–1977 Method for Measurement of Airborne Noise From Agricultural Tractors and Earthmoving Machinery.

For all measurements, the plant or equipment under test would be measured while operating under typical operating conditions. If this is not practical, it may be appropriate to conduct a stationary test at high idle.

In the case of an exceedance in sound power levels the item of plant would either be replaced, or the advice of an acoustic consultant would be sought to provide suitable mitigation measures, which may include:

- ensuring all bolts are tightened and no parts are loose
- cleaning and/or lubricating moving parts
- replacing old or worn parts

- implementing additional or upgrading existing muffling devices
- building enclosures around items of stationary plant (eg pumps or generators).

A register of measured sound power levels for each item of plant would be kept for reference where future noise audits are conducted. The register would be reviewed annually in conjunction with this strategy and corresponding revisions made to the Sound Power Levels presented in Section 7 to represent contemporary plant noise emission levels.

9.2. Noise Monitoring

Where a CNIS report has been prepared for a Sydney Metro construction site and it has been predicted that noise levels may be in excess of the nominated construction noise goals at a noise sensitive receiver, noise monitoring would be conducted at:

- the affected receiver; or
- if more than one affected receiver has been identified, at the nearest affected receiver; or
- where the nearest affected receiver refuses noise monitoring on their property, at the near point to that receiver within the site boundary.
- If it can be demonstrated that direct measurement of noise from the construction site is impractical, alternative means of determining construction noise levels may be adopted in accordance with Chapter 11 of the NSW Industrial Noise Policy.

All noise monitoring results would be assessed against the nominated noise goals and compiled into a report to be forwarded to the construction contractor and project manager. Reporting would be submitted to the construction contractor and project manager within one week of being undertaken or at weekly intervals for continuous monitoring. All noise monitoring reports would also be made available to the public through a publically accessible website.

9.3. Vibration Monitoring

Where it is anticipated that an item of plant will exceed the cosmetic damage criteria given in Section **5.4.3**, vibration monitoring would be required at the nearest affected receiver. Where it is anticipated that an item of plant will exceed the human response / ground borne noise criteria and concerns have been raised regarding vibration, vibration monitoring would also be required at the receiver(s) under question.

All vibration monitoring results would be assessed against the nominated vibration goals and compiled into a report to be forwarded to the construction contractor and project manager. Reporting would be submitted to the construction contractor and project manager within one week of being undertaken or at weekly intervals for continuous monitoring. All vibration monitoring reports would also be made available to the public through the publically accessible website.

9.4. Blast Monitoring

- As specified in the minimum requirements presented in Section 5.7, vibration and overpressure monitoring would be conducted for all PCF and blasting activities which take place on Sydney Metro construction sites.
- Monitoring would be conducted as a minimum at the sensitive receiver(s) likely to receive the maximum vibration and/or overpressure emissions from the blast as identified by an acoustic consultant.

All blast monitoring results would be assessed against the nominated goals and compiled into a report to be forwarded to the construction contractor and project manager. All blast monitoring reports would also be made available to the public through the Sydney Metro website.

As the effect of vibration and overpressure from blasting have the potential to cause structural damage to buildings and services, accurate records of all blasts are required to be maintained. Such records would describe the location of the blast and all the blastholes, the design of the blast in terms of type of explosives, mass of explosives, initiating system used, ground vibration and overpressure measurement data.

Records of every blast would be kept for a minimum of seven years. A longer period of retention of the records may be warranted if a construction project is blasted over an extended or disrupted period.

For any section of tunnel construction where blasting is proposed, a series of initial trials at reduced scale shall be conducted prior to production blasting to determine site-specific blast response characteristics and to define allowable blast sizes to meet the airblast overpressure and ground vibration limits.

9.5. Dilapidation Surveys

If construction activities have the potential to cause damage through vibration to nearby public utilities, structures, buildings and their contents, an Existing Condition Inspection of these items is required to be undertaken in accordance with AS 4349.1 "*Inspection of Buildings*".

Prior to conducting the Existing Condition Inspections, the property owners will be advised of the inspection scope and methodology and the process for making a property damage claim. At the same time, maintain a register of all properties inspected and of any properties where owners refused the inspection offer.

The findings of all dilapidation surveys conducted for each Sydney Metro construction site would be complied into a report to be forwarded to the construction contractor and project manager. Follow-up Condition Inspections would be required at the completion of certain major works (eg completion of shaft bulk excavation works).

10. COMPLAINT HANDLING

All complaints handling would be in accordance with the Sydney Metro Construction Complaints Management System.

11. COMMUNITY CONSULTATION AND LIAISON

All community consultation would be in accordance with Sydney Metro Overarching Stakeholder and Community Involvement Plan.

12. DOCUMENTATION REQUIREMENTS

Any acoustic assessment, CNIS or CNVMP undertaken for the Sydney Metro project must document the following as a minimum (where applicable):

- Acoustic Terminology / Glossary
- Overview of the Project / Works
- Secretary's Environmental Assessment Requirements

- EPL conditions (if applicable)
- Site Plan and Sensitive Receivers
- Ambient Noise Monitoring: methodology, locations, analysis and results
- Construction Noise and Vibration Criteria
  - Construction Airborne Noise Criteria
  - Construction Tunnelling Ground-borne Noise Criteria (if applicable)
  - Construction Ground-borne Noise Criteria
  - Construction Vibration Criteria
- Construction Noise and Vibration Assessment
  - Construction Airborne Noise Methodology / Predictions
  - Construction Tunnelling Ground-borne Noise Methodology / Predictions (if applicable)
  - Construction Ground-borne Noise Methodology / Predictions
  - Construction Vibration Methodology / Predictions
- Summary of Noise and Vibration Impacts
- Summary of all Standard and Additional Mitigation Measures
- References

All noise and vibration predictions are to be presented (as a minimum) as facade noise maps for a distance of at least 300 m in all directions from each work site / project area under assessment.

13. REFERENCES

Related Documents and References
• ANZECC, 1990, Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration. Australian and New Zealand Environment Council.
• APTA, 1981, Guidelines for Design of Rapid Transit Systems. American Public Transit Association.
• AS 2107, 2000, Acoustics - Recommended design sound levels and reverberation times for building interiors. Standards Australia.
• AS 2012 Part 1, 1990, Acoustics - Measurement of airborne noise emitted by earth-moving machinery and agricultural tractors - Stationary test condition - Determination of compliance with limits for exterior noise. Standards Australia.
• AS 2187, Part 2, 2006, Explosives - Storage and Use - Part 2: Use of Explosives. Standards Australia.
• AS 2436, 1981, Guide to Noise Control on Construction, Maintenance and Demolition Sites. Standards Australia.
• AS 4349, 2007, Inspection of buildings - General requirements. Standards Australia.
• BS 6472, 2008, Evaluation of Human Exposure Vibration in Buildings. The British Standards Institution.
• BS 7385 Part 2, 1993, Evaluation and Measurement for Vibration in Buildings Part 2. The British Standards Institution.
• Colin G. Gordon, 1999, Generic Vibration Criteria for Vibration-Sensitive Equipment. International Society for Optical Engineering.
• The Association of Australian Acoustical Consultants (AAAC) Technical Guideline on Child Care Centre Noise Assessments
• DECC, 1999, Environmental Criteria for Road Traffic Noise. NSW Department of Environment and Climate Change.
• DECC, 2009, Interim Construction Noise Guideline. NSW Department of Environment and Climate Change NSW.
• EN ISO 9641, Part 2, 1996, Acoustics - Determination of sound power levels of noise sources using sound intensity – Part 2: Measurement by scanning. International Organization for Standardization.
• EPA, 2000, NSW industrial noise policy. NSW Environment Protection Authority.
• RTA, 2001, Environmental noise management manual, NSW Roads and Traffic Authority.
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• TIDC, 2007, Construction noise strategy. Transport Infrastructure Development Corporation (NSW).

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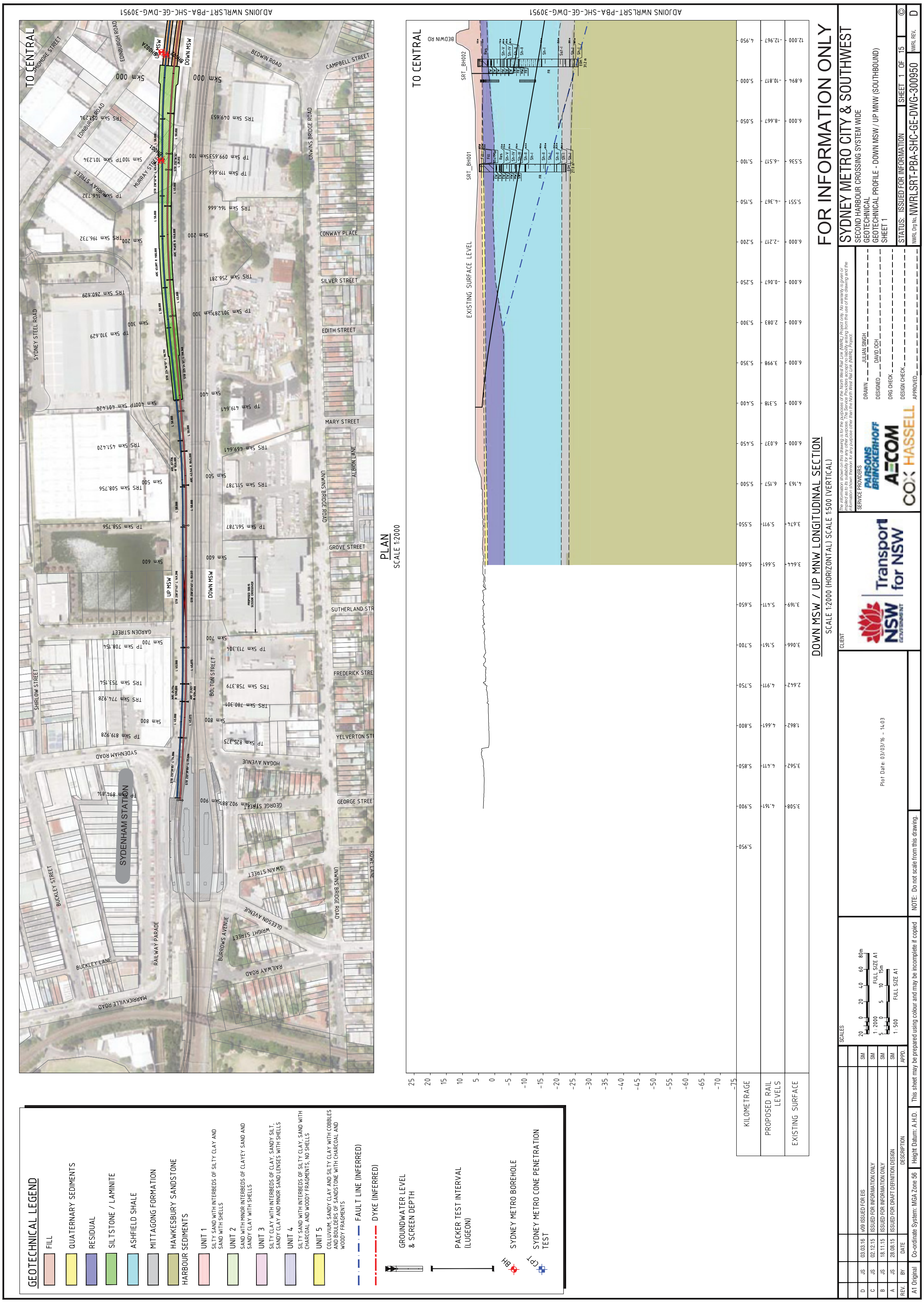
GEOLOGICAL LONG SECTION

APPENDIX F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UNIT 2
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UNIT 3
SILTY CLAY WITH INTERBEDS OF CLAY, SANDY SILT, SANDY CLAY AND MINOR SAND LENSES WITH SHELLS
UNIT 4
SILTY SAND WITH INTERBEDS OF SILTY CLAY, SAND WITH CHARCOAL AND WOODY FRAGMENTS, NO SHELLS
UNIT 5
COLLUVIUM, SANDY CLAY AND SILTY CLAY WITH COBBLES AND BOULDERS OF SANDSTONE WITH CHARCOAL AND WOODY FRAGMENTS
FAULT LINE (INFERRED)
DYKE (INFERRED)
GROUNDWATER LEVEL & SCREEN DEPTH
PACKER TEST INTERVAL (LUGEON)
SYDNEY METRO BOREHOLE
SYDNEY METRO CONE PENETRATION TEST
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ADJOINS NWRLSRT-PBA-SHC-GE-DWG-30951
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SRT_BH002
BEDWIN RD
KILOMETRAGE
PROPOSED RAIL LEVELS
EXISTING SURFACE
DOWN MSW / UP MNW LONGITUDINAL SECTION
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FOR INFORMATION ONLY
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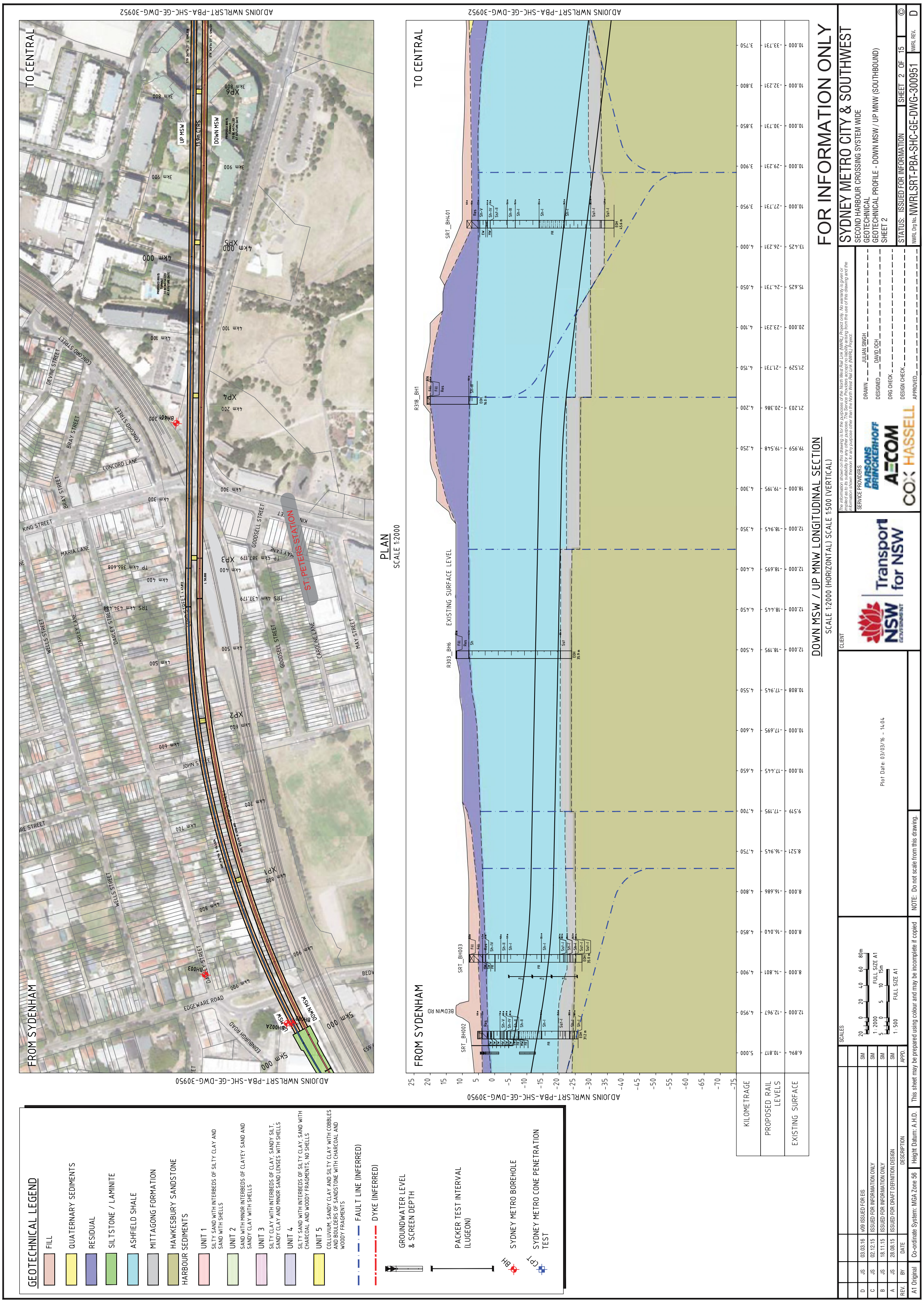
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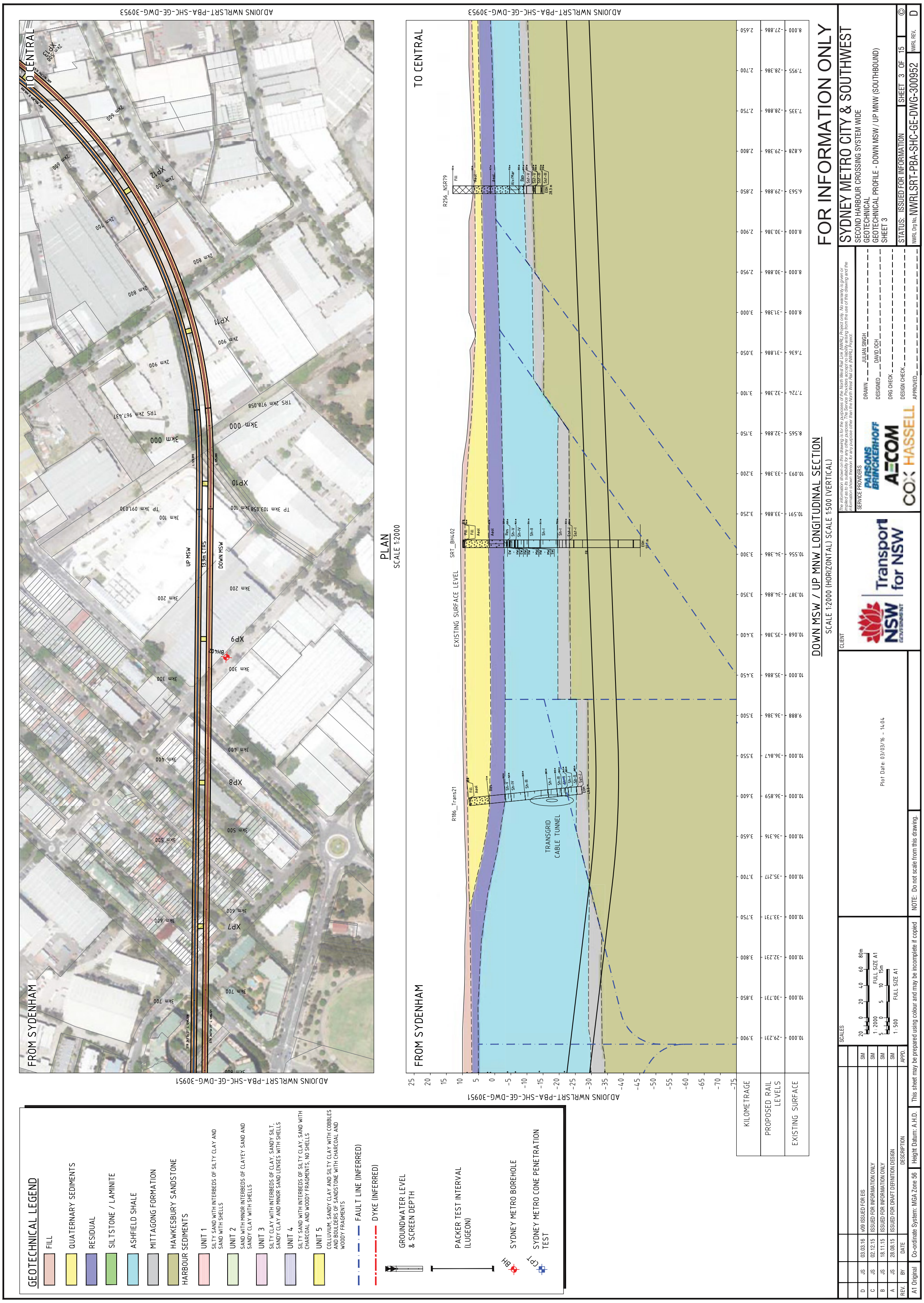
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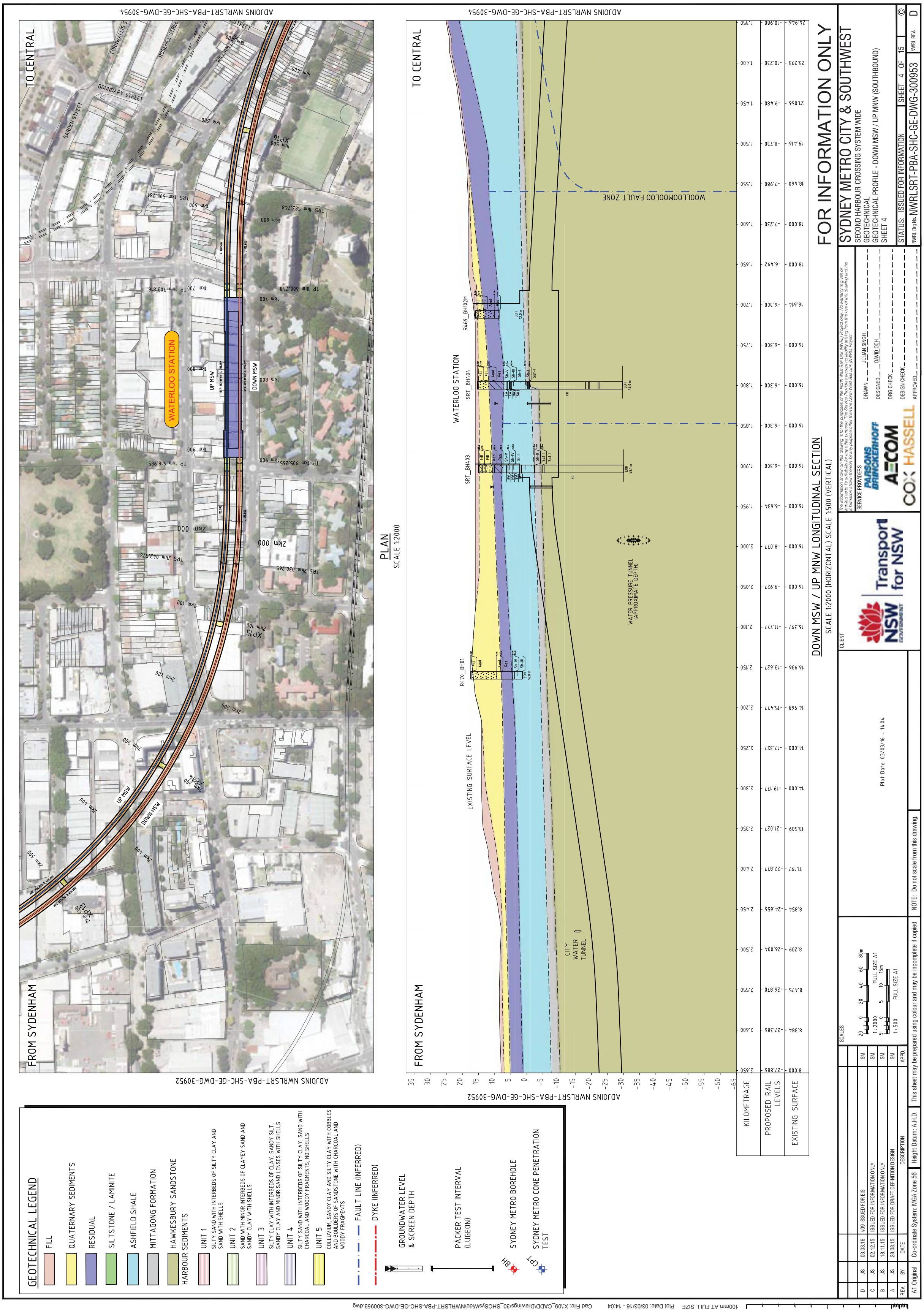
Transport for NSW



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WATER PRESSURE TUNNEL (APPROXIMATE DEPTH)
CITY WATER TUNNEL
KILOMETRAGE
PROPOSED RAIL LEVELS
EXISTING SURFACE
GEOTECHNICAL LEGEND
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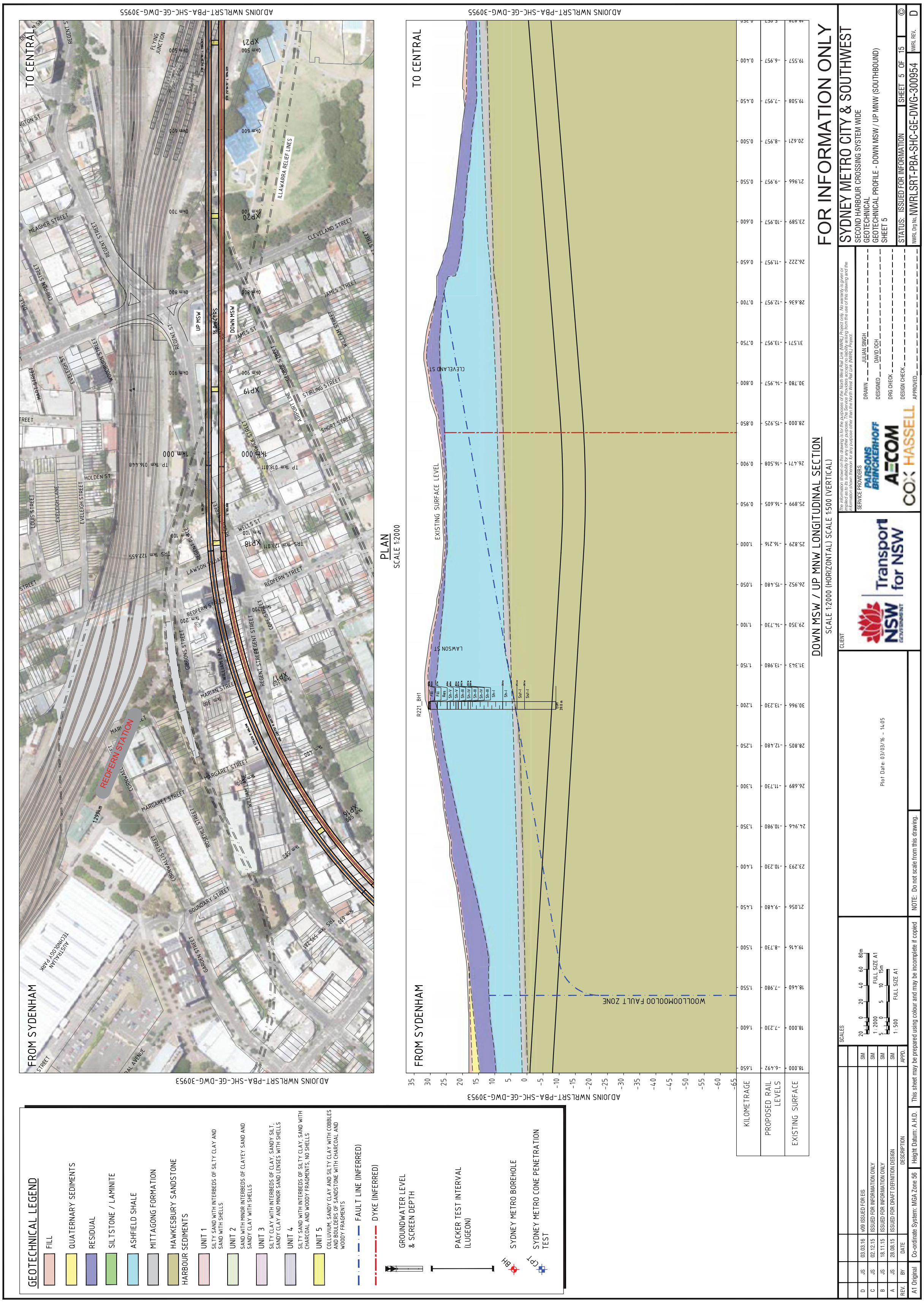

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SYDNEY METRO CONE PENETRATION TEST
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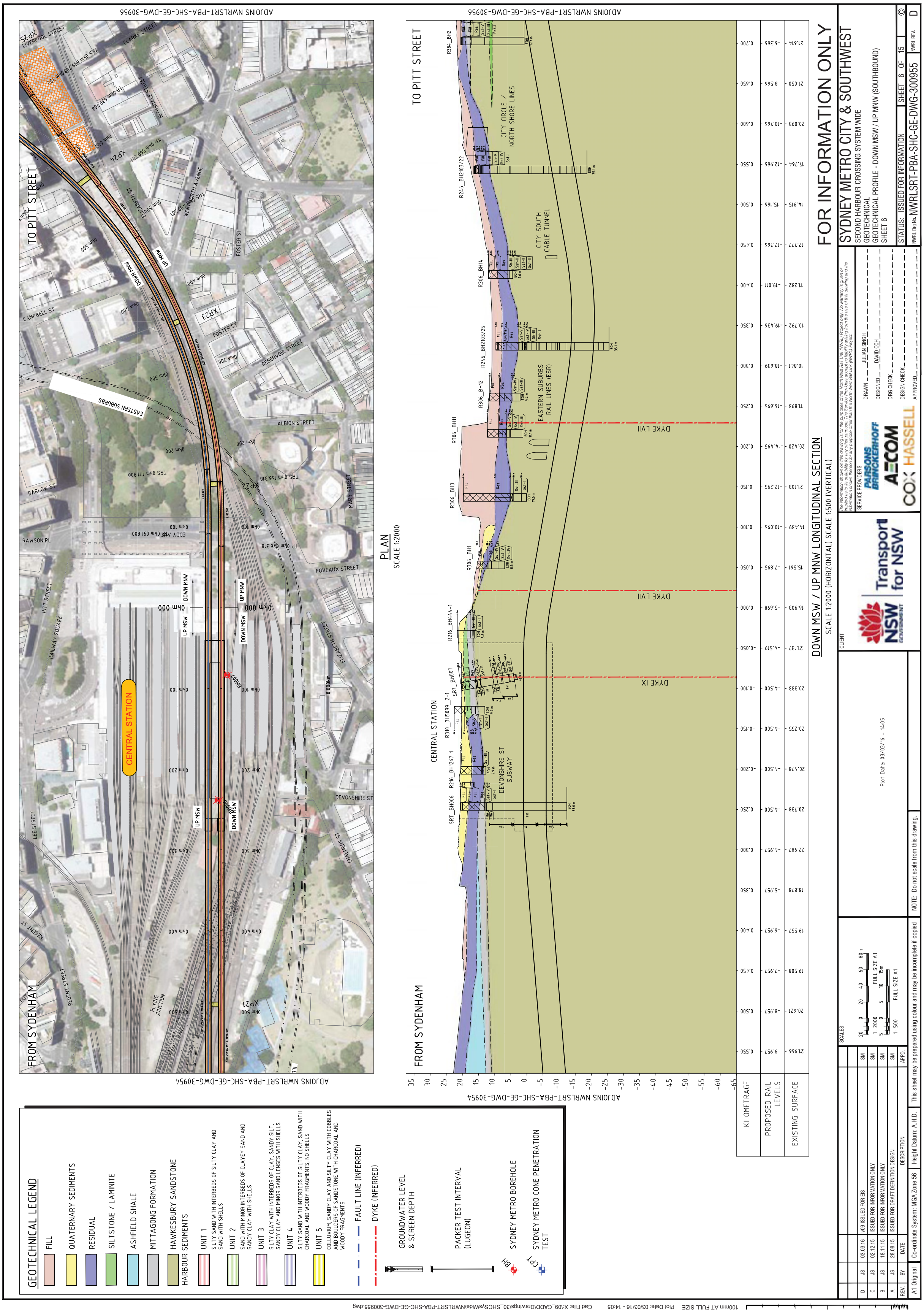
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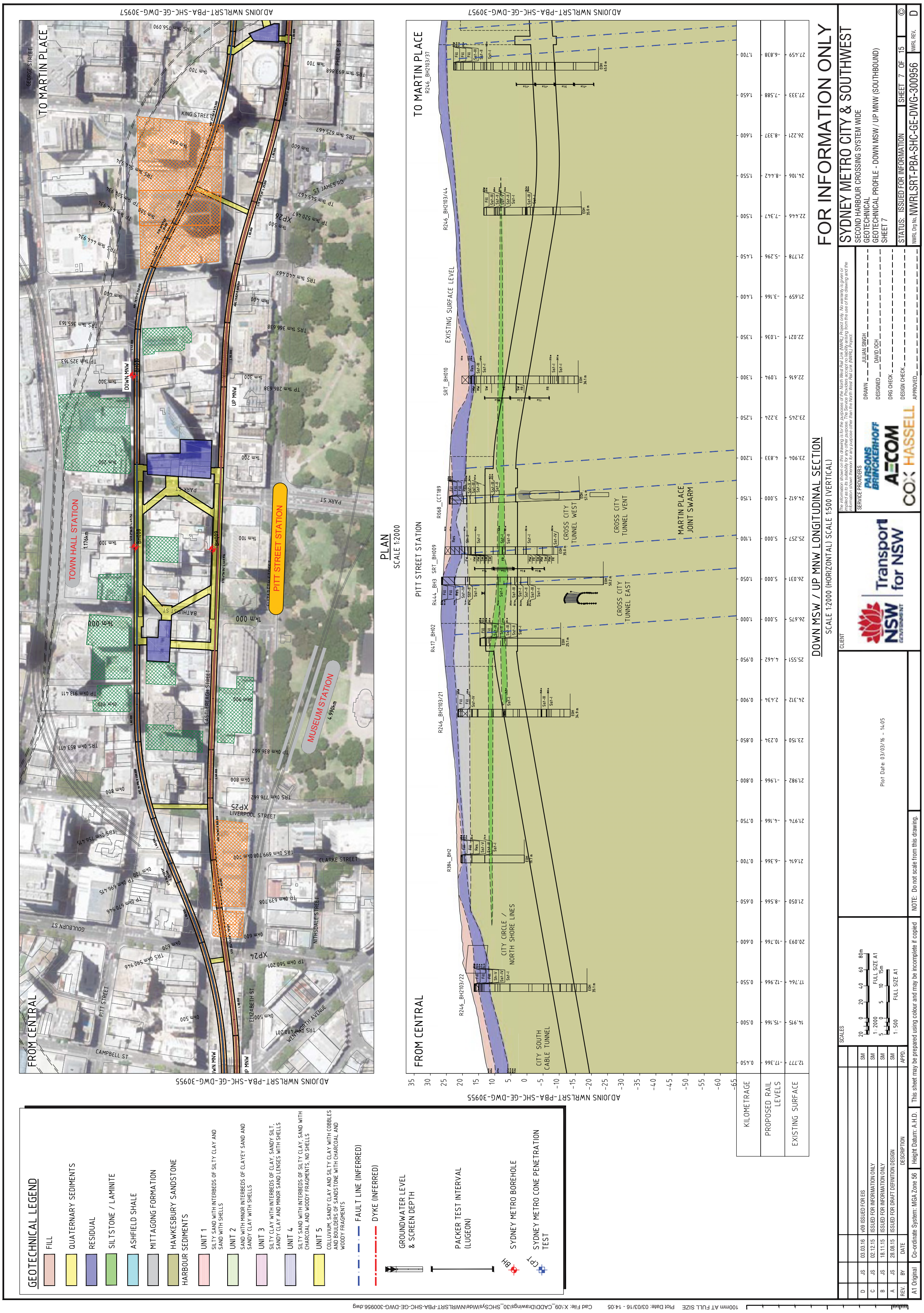

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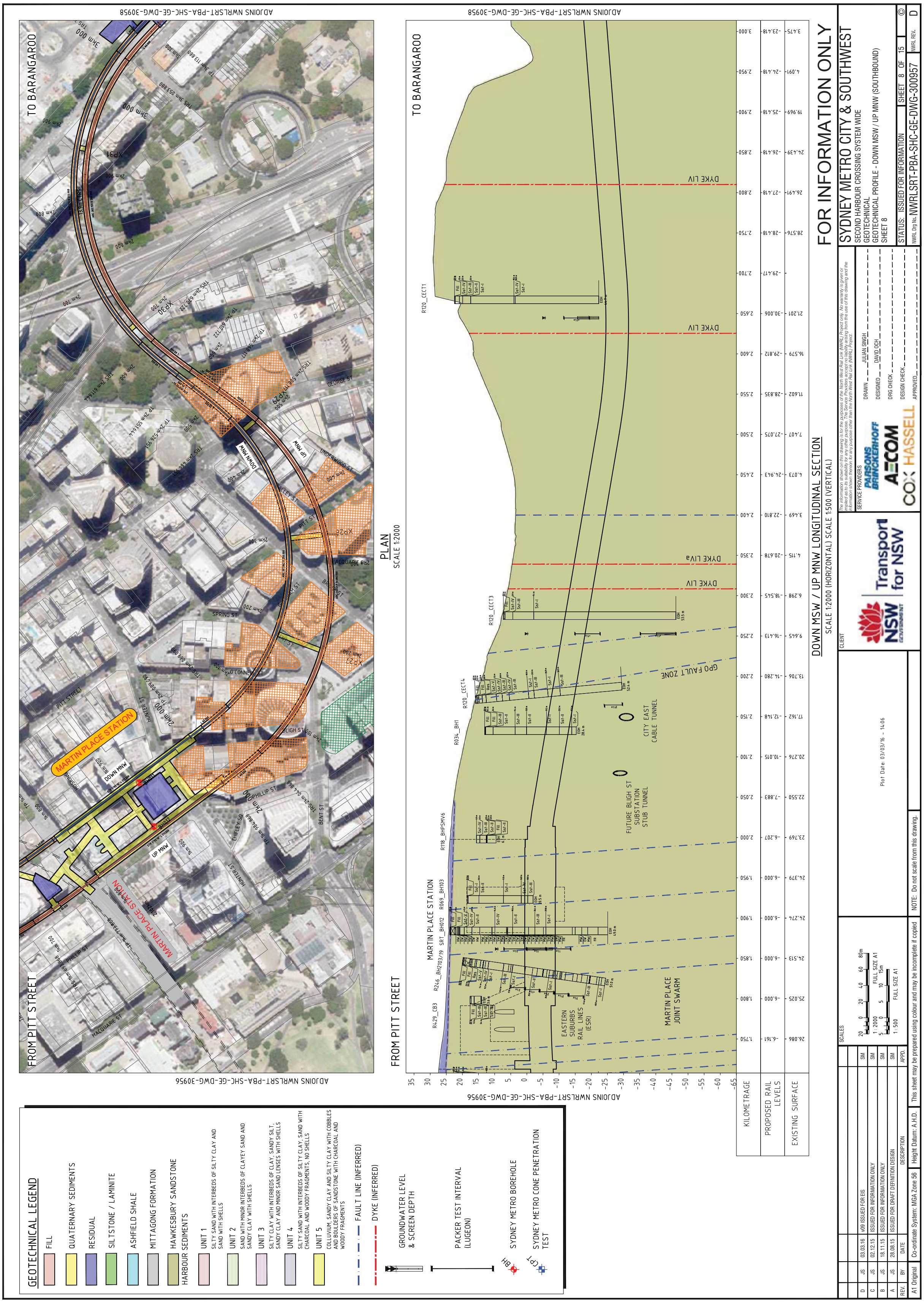
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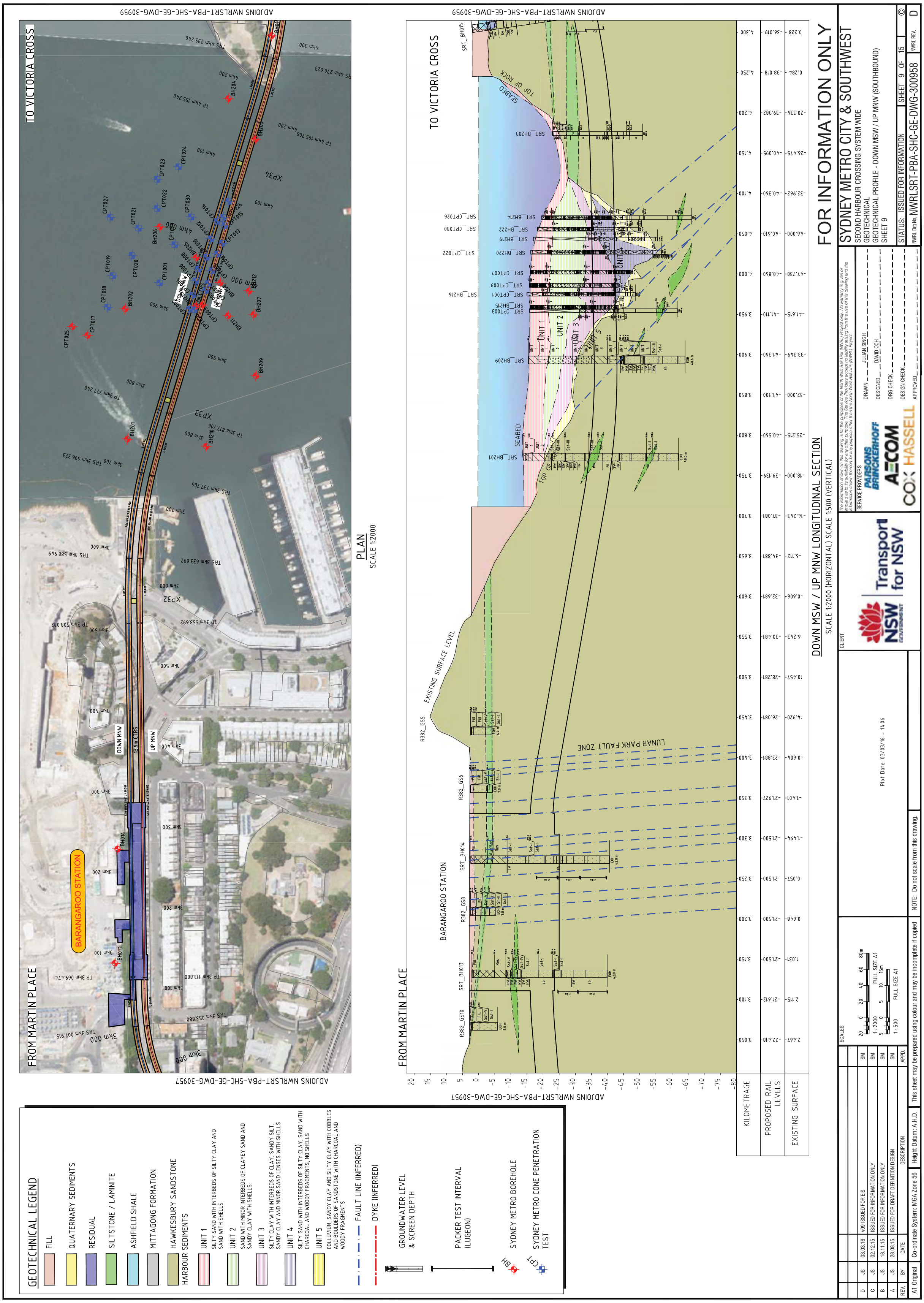
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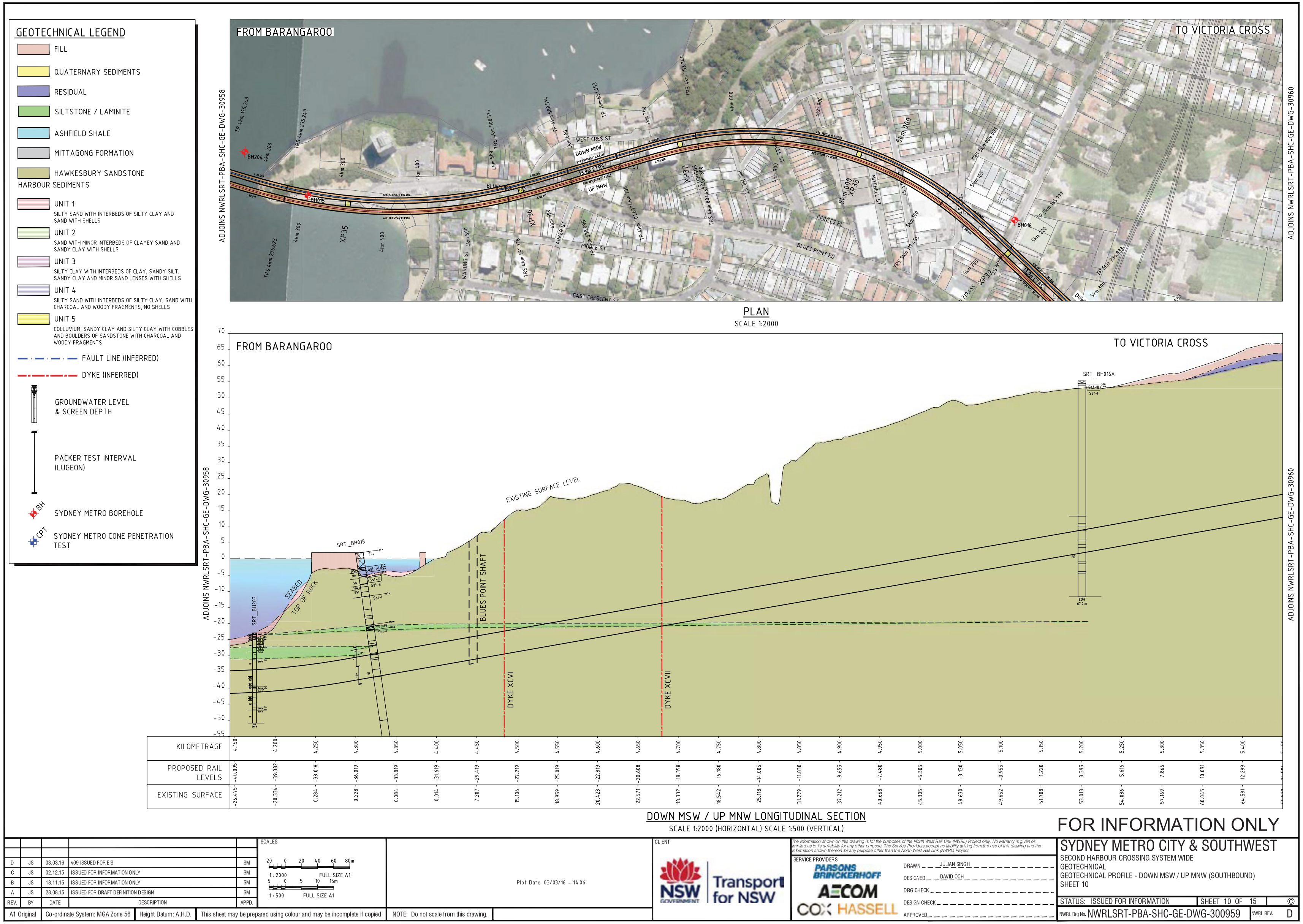
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UNIT 3
SILTY CLAY WITH INTERBEDS OF CLAY, SANDY SILT, SANDY CLAY AND MINOR SAND LENSES WITH SHELLS
UNIT 4
SILTY SAND WITH INTERBEDS OF SILTY CLAY, SAND WITH CHARCOAL AND WOODY FRAGMENTS, NO SHELLS
UNIT 5
COLLUVIUM, SANDY CLAY AND SILTY CLAY WITH COBBLES AND BOULDERS OF SANDSTONE WITH CHARCOAL AND WOODY FRAGMENTS
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DESIGNED DAVID OCH
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Transport for NSW
PARSONS BRINCKERHOFF
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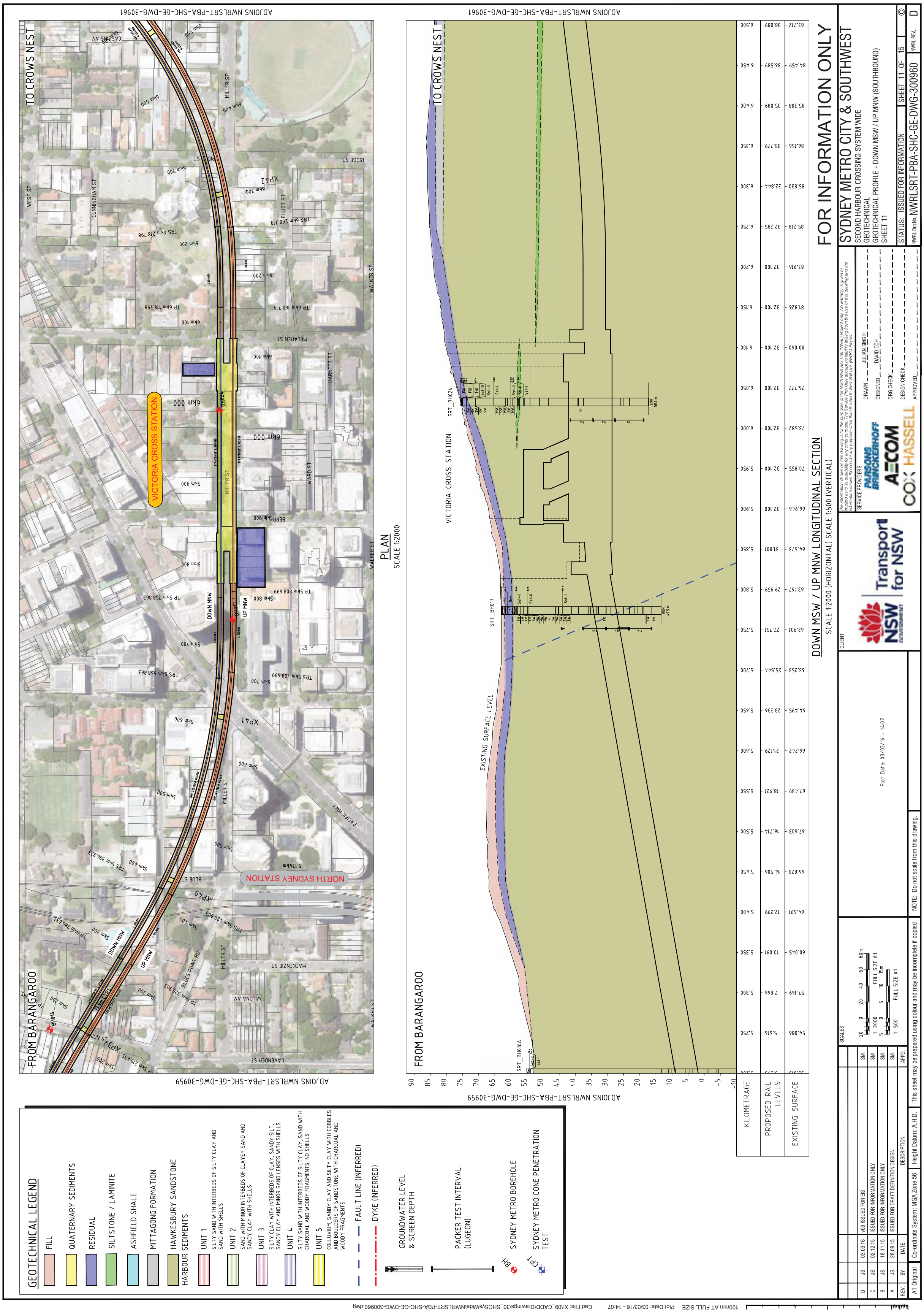
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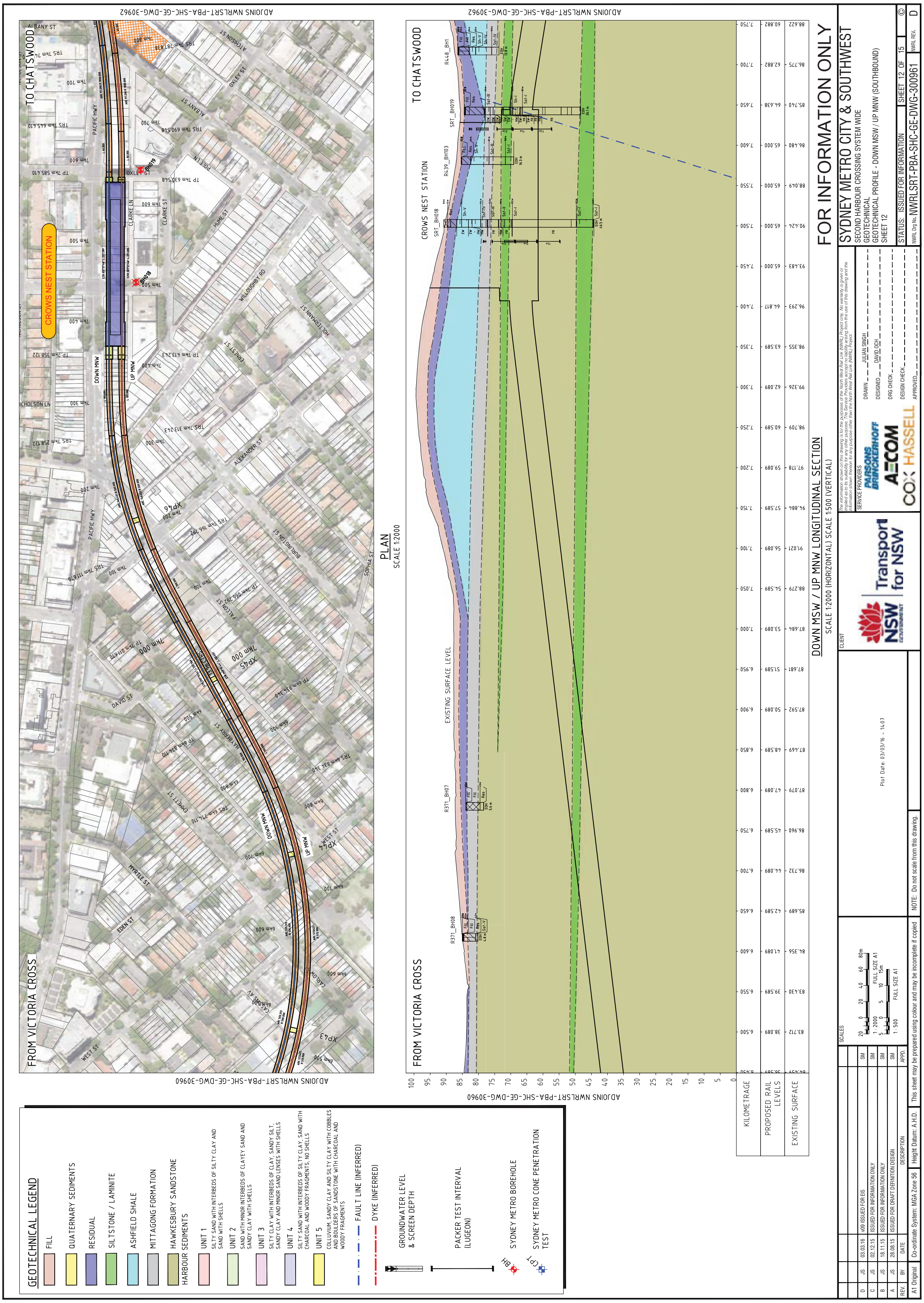

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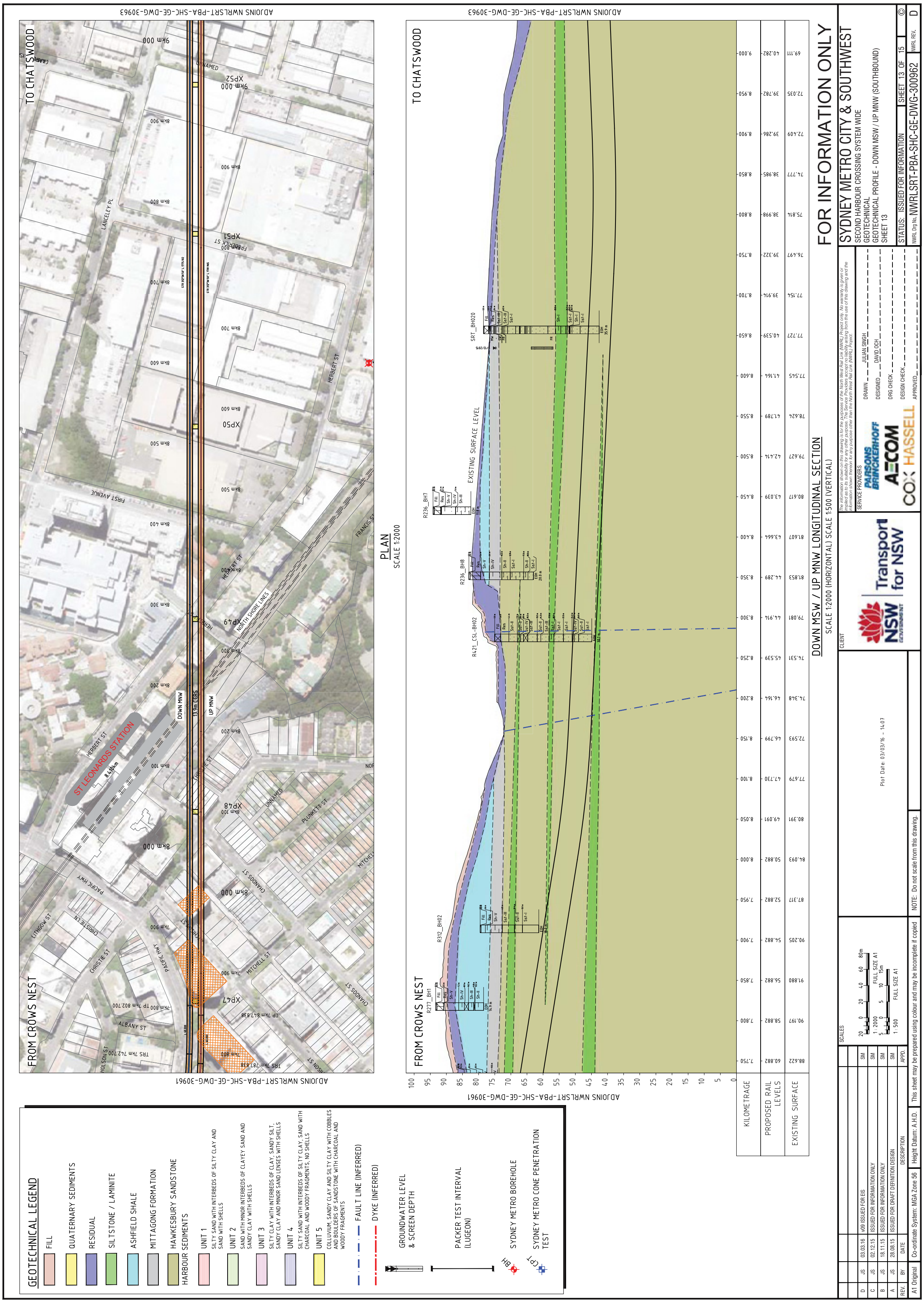

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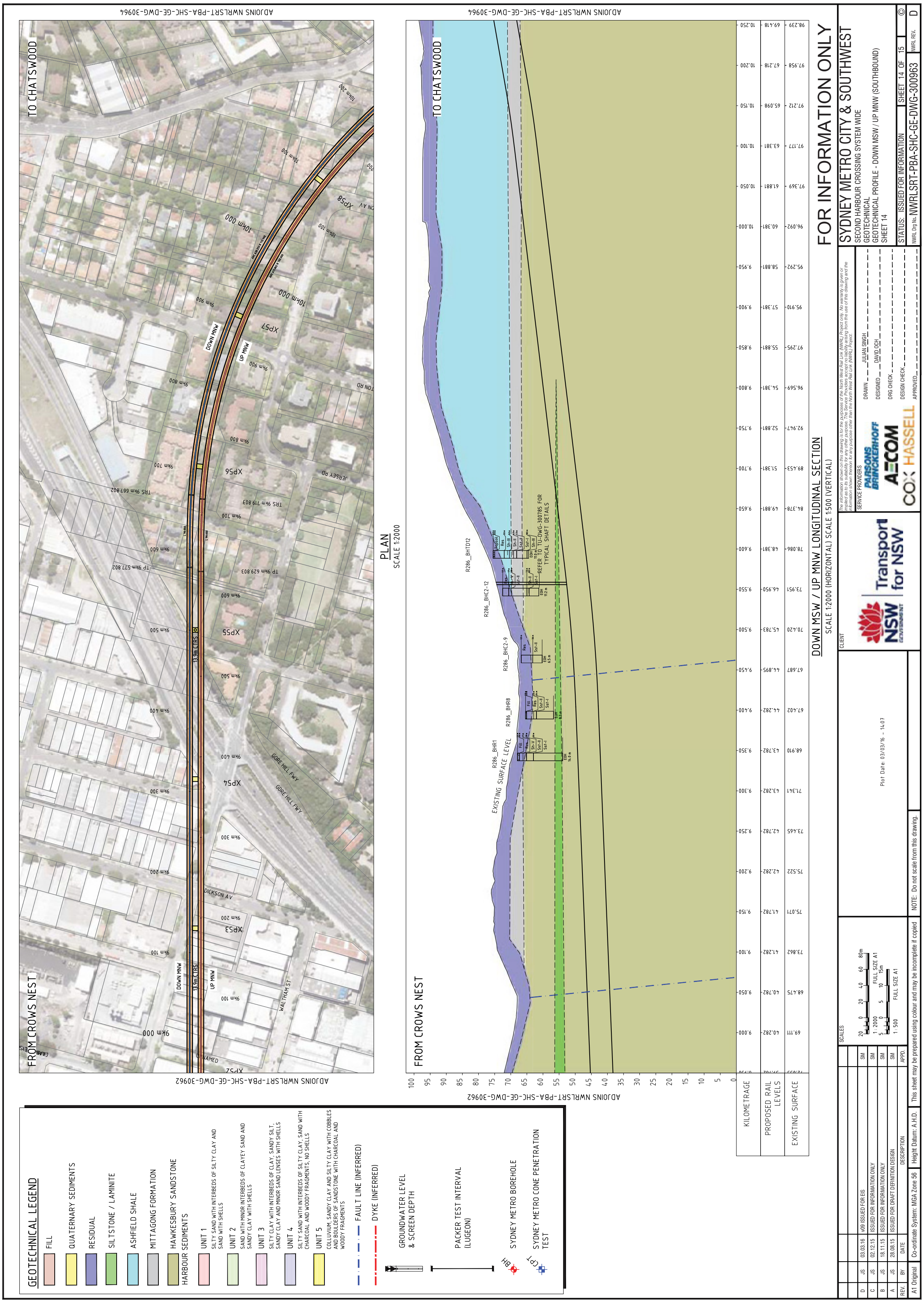
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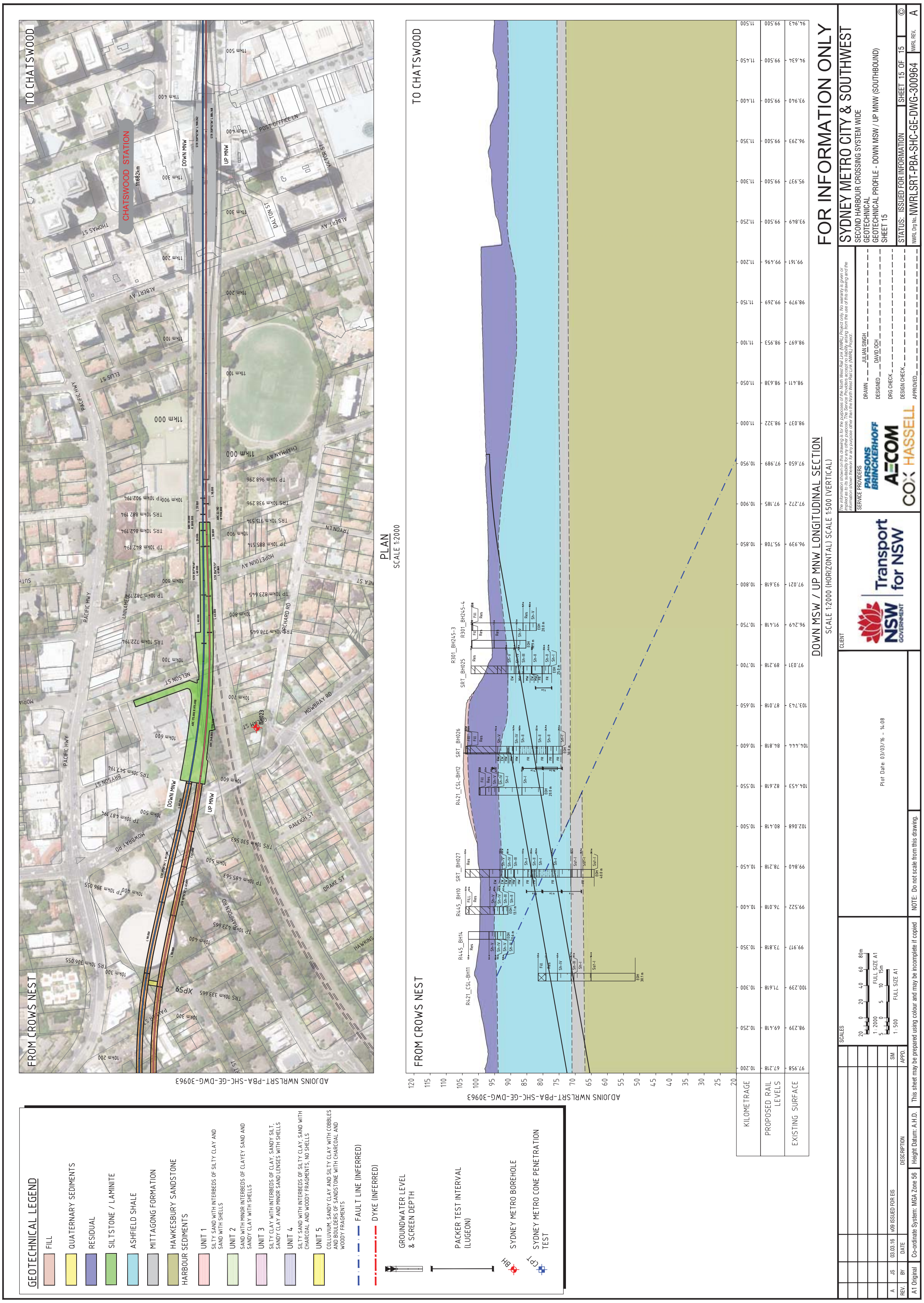
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SYNTHESIS OF ENVIRONMENTAL IMPACT STATEMENT

APPENDIX G

Contents

1 Introduction

1.1 Purpose of this document

This synthesis provides a technical summary of the Environmental Impact Statement. The main body of the Environmental Impact Statement should be referred to for further details. This synthesis includes:

- A brief description of the project including project uncertainties
- The key impacts of the project, based on the project description
- The consolidated mitigation measures for the project, as an outcome of the environmental impact assessment process
- The environmental performance outcomes for the project, based on the results of the assessment and the implementation of the mitigation measures
- The need for the project and a summary of the justification of the project.

The Secretary's environmental assessment requirements relating to this synthesis and where they are addressed are outlined in Table 1-1.

Table 1-1 Secretary's environmental assessment requirements – synthesis of the Environmental Impact Statement

Ref.	Secretary's environmental assessment requirements	Where addressed
2. Environmental Impact Statement		
2.1 (o)	The EIS must include, but not necessarily be limited to, the following: (o) a chapter that synthesises the environmental impact assessment and provides:	
	• a succinct but full description of the project for which approval is sought;	A project description is provided in Section 2. A detailed project description is provided in Chapters 6 and 7 of the main Environmental Impact Statement document.
	• a description of any uncertainties that still exist around design, construction methodologies and/or operational methodologies and how these will be resolved in the next stages of the project;	A list of the project uncertainties (design, construction methods and/or operational methods) that have been identified at this stage of the project development and that would be further considered / investigated in the next stages of the project are described in Section 2.9.
	• a compilation of the impacts of the project that have not been avoided;	Impacts that have not been avoided form the basis on which the assessment provided in the Environmental Impact Statement has been carried out. That is, the impacts that have not been avoided are effectively the actual impacts of the project. A summary compilation of key impacts is provided in Section 3.
	• a compilation of the proposed measures associated with each impact to avoid or minimise (through design refinements or ongoing management during construction and operation) or offset these impacts;	The proposed measures associated with each impact to avoid or minimise (through design refinements or ongoing management during construction and operation) or to offset these impacts, are fully described in Chapter 27 of the Environmental Impact Statement. A summary compilation is provided in Section 4.

Ref.	Secretary's environmental assessment requirements	Where addressed
	- a compilation of the outcome(s) the proponent will achieve; and	The performance outcomes are described in Chapter 27 of the Environmental Impact Statement. A summary compilation is provided Section 5.
	- the reasons justifying carrying out the project as proposed, having regard to the biophysical, economic and social considerations, including ecologically sustainable development and cumulative impacts.	The justification of the project is fully described in Chapter 29 of the Environmental Impact Statement. A summary is provided in Section 6.

1.2 Environmental performance

The avoidance and minimisation of adverse environmental impacts is considered at all stages of the project. Figure 1 1 provides an overview of the project approach to environmental mitigation and management. This includes:

- Project design – measures which are inherent in the design of the project to avoid and minimise impacts. Further detail on these aspects of the project are provided in Section 3.1
- Mitigation measures – additional to the project design which are identified through the environment impact assessment in Chapters 8 to 26 of the Environmental Impact Statement. These measures are consolidated in Section 4
- Construction environmental management framework – details the management processes and documentation for the project. The construction environmental management framework is provided in Appendix D of the Environmental Impact Statement
- Construction noise and vibration strategy – identifies how Sydney Metro proposes to manage construction noise and vibration. The construction noise and vibration strategy is provided in Appendix E of the Environmental Impact Statement
- Design guidelines – provides an assurance of end-state design quality. The design guidelines are provided in Appendix B of the Environmental Impact Statement
- Environmental performance outcomes – which establish the intended outcomes which would be achieved by the project. The performance outcomes are identified in Section 5.

The construction environmental management framework, construction noise and vibration strategy and design guidelines would be reviewed and updated periodically throughout delivery of the project.

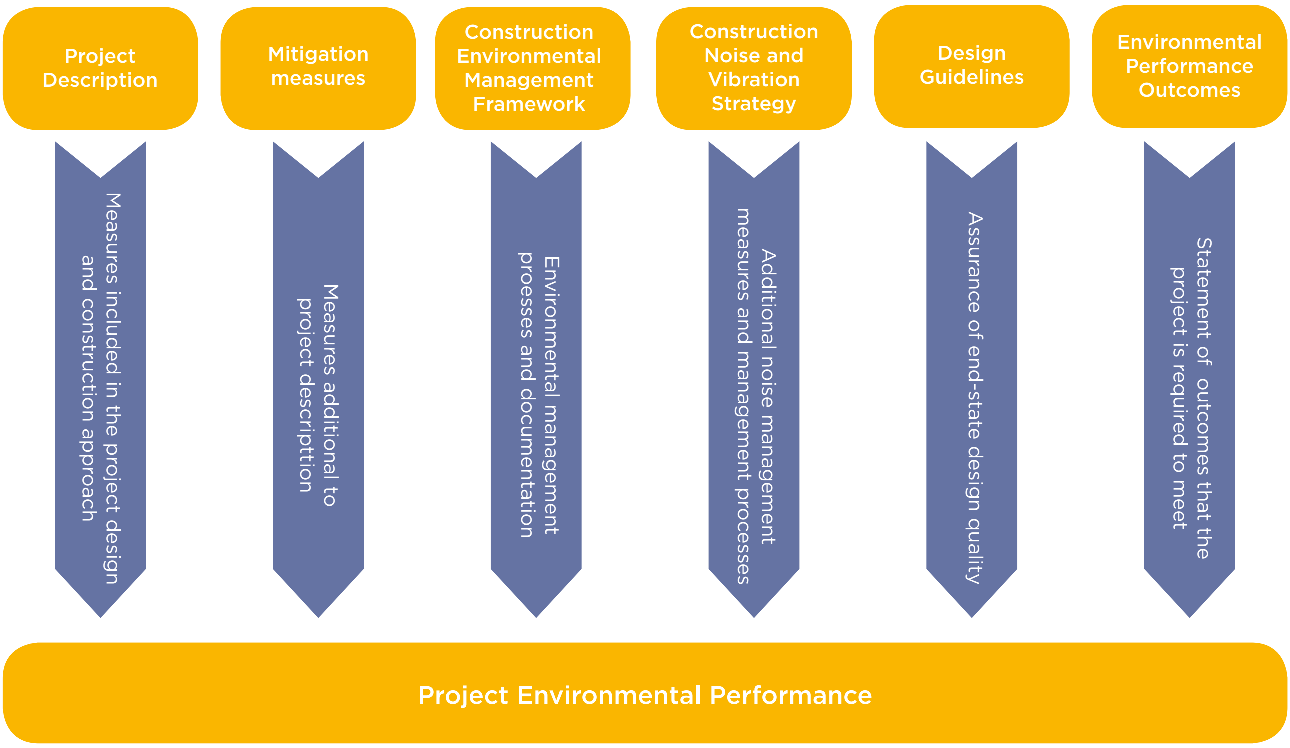

Figure 11 Project approach to environmental mitigation and management

2 Project overview

The Sydney Metro Chatswood to Sydenham project (the project) involves the construction and operation of a metro rail line and associated stations between Chatswood Station and just north of Sydenham Station. A summary of the key features of the project are described below and shown in Figure 2-1(a) to (h). A full description is provided in Chapters 6 and 7 of the Environmental Impact Statement.

Key features of the project include:

- About 15.5 kilometres of twin rail tunnels (that is, two tunnels located side-by-side) between Mowbray Road, Chatswood and Bedwin Road, Marrickville
- Realignment of T1 North Shore Line surface track within the existing rail corridor between Chatswood Station and Brand Street, Artarmon, including a new bridge for a section of the Sydney Trains 'down' (northbound) track to pass over the proposed Chatswood dive structure
- About 250 metres of aboveground metro tracks between Chatswood Station and the Chatswood dive structure
- A dive structure (about 400 metres long) and tunnel portal south of Chatswood Station and north of Mowbray Road, Chatswood (the Chatswood dive structure)
- A substation (for traction power supply) at Artarmon
- Metro stations at Crows Nest, Victoria Cross, Barangaroo, Martin Place, Pitt Street and Waterloo; and new underground platforms at Central Station
- A dive structure (about 400 metres long) and tunnel portal between Sydenham Station and Bedwin Road, Marrickville (the Marrickville dive structure)
- A services facility beside the Marrickville dive structure and tunnel portal, including a tunnel water treatment plant and a substation (for traction power supply).

The project would also include a number of ancillary components, including new and alterations to existing overhead wiring, signalling, access tracks / paths, rail corridor fencing, noise walls, fresh air ventilation equipment, temporary and permanent alterations to the road network, facilities for pedestrians, and other construction related works.

Figure 2-1a The project Map 1

Figure 2-1b The project Map 2

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Figure 2-1c The project Map 3

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Figure 2-1d The project Map 4

Figure 2-1e The project Map 5

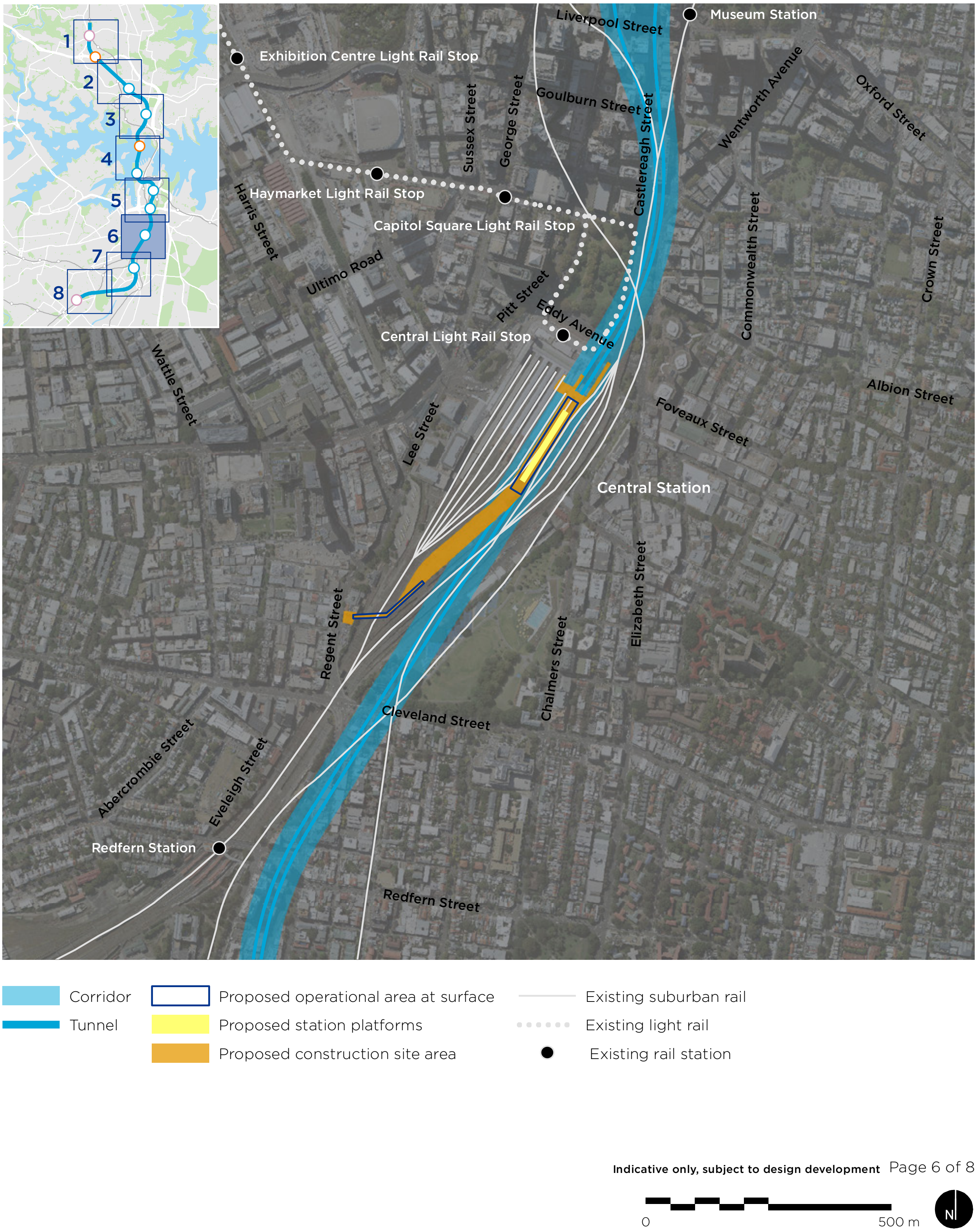

Figure 2-1f The project Map 6

Figure 2-1g The project Map 7

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Figure 2-1h The project Map 8

2.1 Metro operations

The project would operate in conjunction with Sydney Metro Northwest (currently under construction) and the Sydenham to Bankstown upgrade project. All Sydney Metro operations would be controlled and monitored from the Sydney Metro Trains Facility at Tallawong Road, Rouse Hill.

The project is being designed as a 'turn up and go' service. The proposed service frequency at the time of opening would be:

- Weekday morning and evening peaks – a six car train at least every four minutes (20 trains per hour)
- Weekday daytime off-peak – a six car train every five minutes through the Sydney CBD (12 trains per hour)
- Weekday early mornings, late at night and on weekends – a six car train every ten minutes with options to increase based on level of demand (six trains per hour).

The project would be designed to cater for long term growth in travel demand. When required to meet increased demand, capacity would be increased by increasing from six car to eight car trains and increasing the service frequency from 20 trains per hour to up to 30 trains per hour through the Sydney CBD in peak periods. That is, at ultimate capacity the service frequency would be an eight car train every two minutes through the Sydney CBD. The assessment within this Environmental Impact Statement is based on this ultimate capacity.

2.2 Metro stations

The location and key features of the Metro stations are shown in Figure 2-2 to Figure 2-8 and summarised in Table 2-1.

Table 2-1 Metro Station design elements

Station Type	Transport interchange	Station entry / egress	Transport and access
Crows Nest Station			
Single-span (cut-and-cover) cavern with island platform	Walking, cycling, bus, taxi and kiss-and-ride	• On the corner of Hume and Clarke Streets • On the corner of Pacific Highway and Oxley Street	• New signalised pedestrian crossing on northern side of Pacific Highway / Oxley Street intersection • New pedestrian crossings on Clarke, Hume and Oxley streets • New bike parking on Hume and Oxley streets • New on-road marked cycle links on Hume Street • Existing bus stops close to the station retained on the Pacific Highway • New kiss-and-ride and taxi bays on Clarke Street
Victoria Cross Station			
Single-span (mined) cavern with island platform	Walking, cycling, bus, taxi and kiss-and-ride	• Via a pedestrian plaza opening to Miller, Denison and Berry streets	• New bike parking near the corner of Miller and Berry streets • Existing bus stops close to the station retained on Miller Street • New kiss-and-ride bays on Berry Street

Station Type	Transport interchange	Station entry / egress	Transport and access
Barangaroo Station			
Single-span (cut-and-cover) cavern with island platform	Walking, cycling, bus, taxi and ferry	• Within Central Barangaroo and Barangaroo Reserve	Transport and access arrangements would be developed in consultation with Barangaroo Delivery Authority. At this stage, they are expected to include: • New pedestrian crossings on Hickson Road, Little Clyde Street and Agar Street • New bike parking on Little Clyde and Agar streets • Relocation of bus stops on Hickson Road closer to the station entry • New kiss-and-ride and taxi bays on Hickson Road
Martin Place Station			
Binocular cavern (mined) with two single side platforms	Walking, cycling, taxi, bus, light rail and suburban rail	• A northern entry via a pedestrian plaza opening to Castlereagh, Hunter and Elizabeth streets • A northern entry via an underground pedestrian connection below Hunter Street to O'Connell Street and / or Bligh Street (subject to further investigation) • A southern entry via a pedestrian plaza opening to Martin Place and Castlereagh Street	• New underground pedestrian link between the existing suburban Martin Place Station platforms and the metro station platforms • New underground pedestrian connection between the station platform at O'Connell Street and / or Bligh Street (subject to further investigation) • New bike parking on Castlereagh Street at both station entries • Existing bus stops close to the station retained on Elizabeth and Castlereagh streets • Existing taxi ranks close to the station retained on Elizabeth and Castlereagh streets
Pitt Street Station			
Binocular cavern (mined) with two single side platforms	Walking, cycling, taxi, bus and light rail	• A northern entry via a pedestrian plaza opening to Pitt and Park streets • A southern entry via a pedestrian plaza opening to Bathurst Street	• New bike parking on Park and Bathurst streets • Existing bus stops close to the station retained on Park and Castlereagh streets • Existing taxi bays close to the station retained on Castlereagh and Pitt streets

Station Type	Transport interchange	Station entry / egress	Transport and access
Central Station platforms			
Single-span (cut-and-cover) cavern with island platform	Walking, cycling, intercity rail, suburban rail, light rail, bus taxi and kiss-and-ride	• Via the existing northern station entry from Eddy Avenue and the main northern concourse • Via the existing paid underground pedestrian connections	• Connect to the northern concourse and existing paid underground pedestrians links within Central Station for interchange • Existing bike parking retained • Existing bus stops retained • Existing kiss-and-ride and taxi ranks retained
Waterloo Station			
Single-span (cut-and-cover) cavern with island platform	Walking, cycling, bus, taxi, and kiss-and-ride	• At the northern end of the station on the corner of Raglan and Cope streets	• New pedestrian crossings on Raglan and Cope streets • New bike parking on Cope Street • New on-road marked cycle link on Raglan Street • Existing bus stops retained northbound along Botany Road • Relocation of the bus stops southbound on Botany Road closer to Raglan Street • Relocation of the bus stops on Cope Street to Botany Road • New taxi and kiss-and-ride bays on Cope Street

KEY

- Metro entry
- Pedestrian plaza/station lobby
- Operational area
- Proposed cycle parking
- Proposed pedestrian crossing
- Proposed signalised pedestrian crossing
- Proposed on road marked cycle route
- Proposed taxi rank
- Proposed kiss-and-ride
- Services
- Metro alignment

Figure 2-2 Crows Nest Station – location and indicative layout

KEY

- Metro entry
- Pedestrian plaza/station lobby
- Operational area
- Proposed cycle parking
- Proposed kiss-and-ride
- Services
- Metro alignment

Figure 2-3 Victoria Cross Station – location and indicative layout

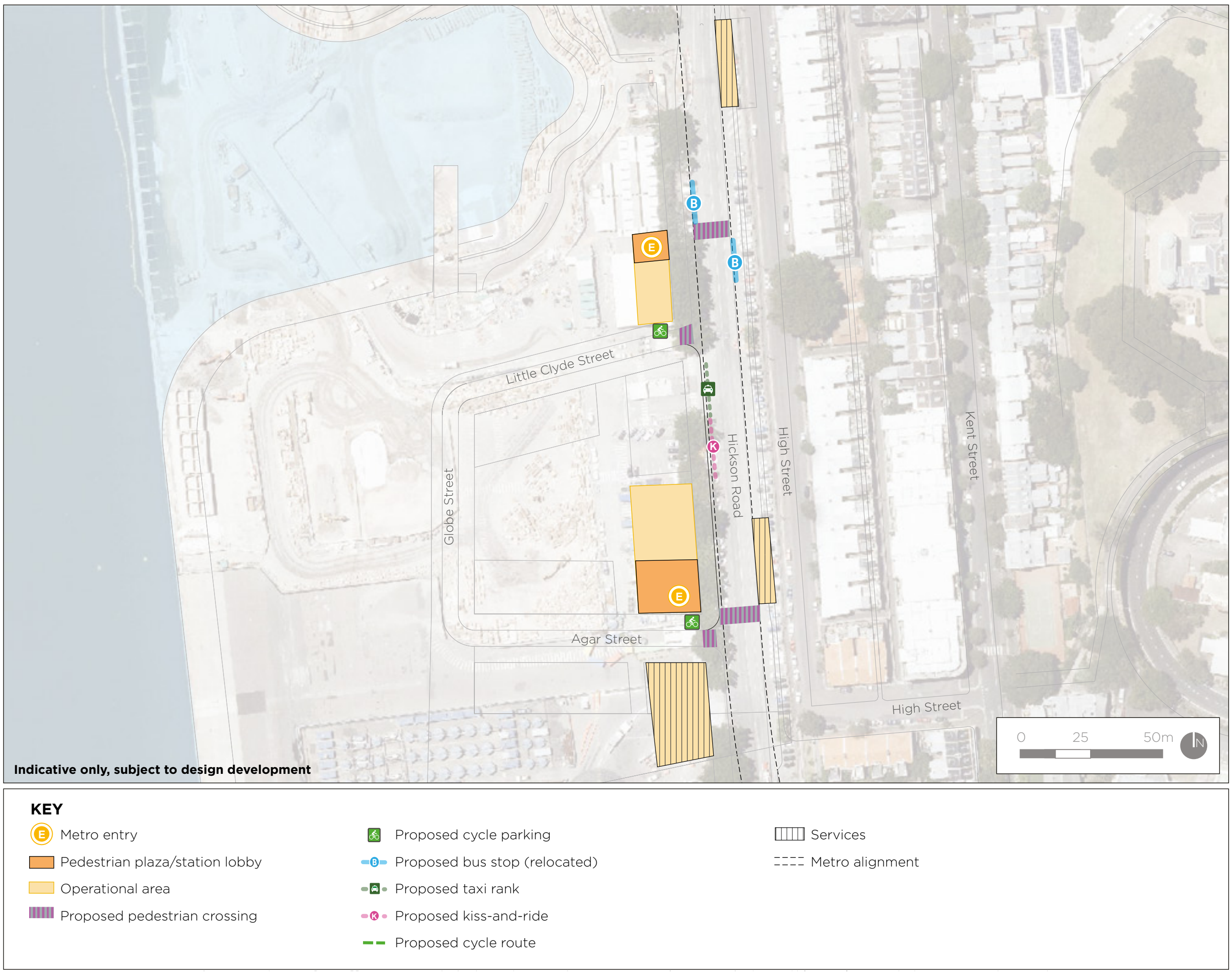


Figure 2-4 Barangaroo Station – location and indicative layout

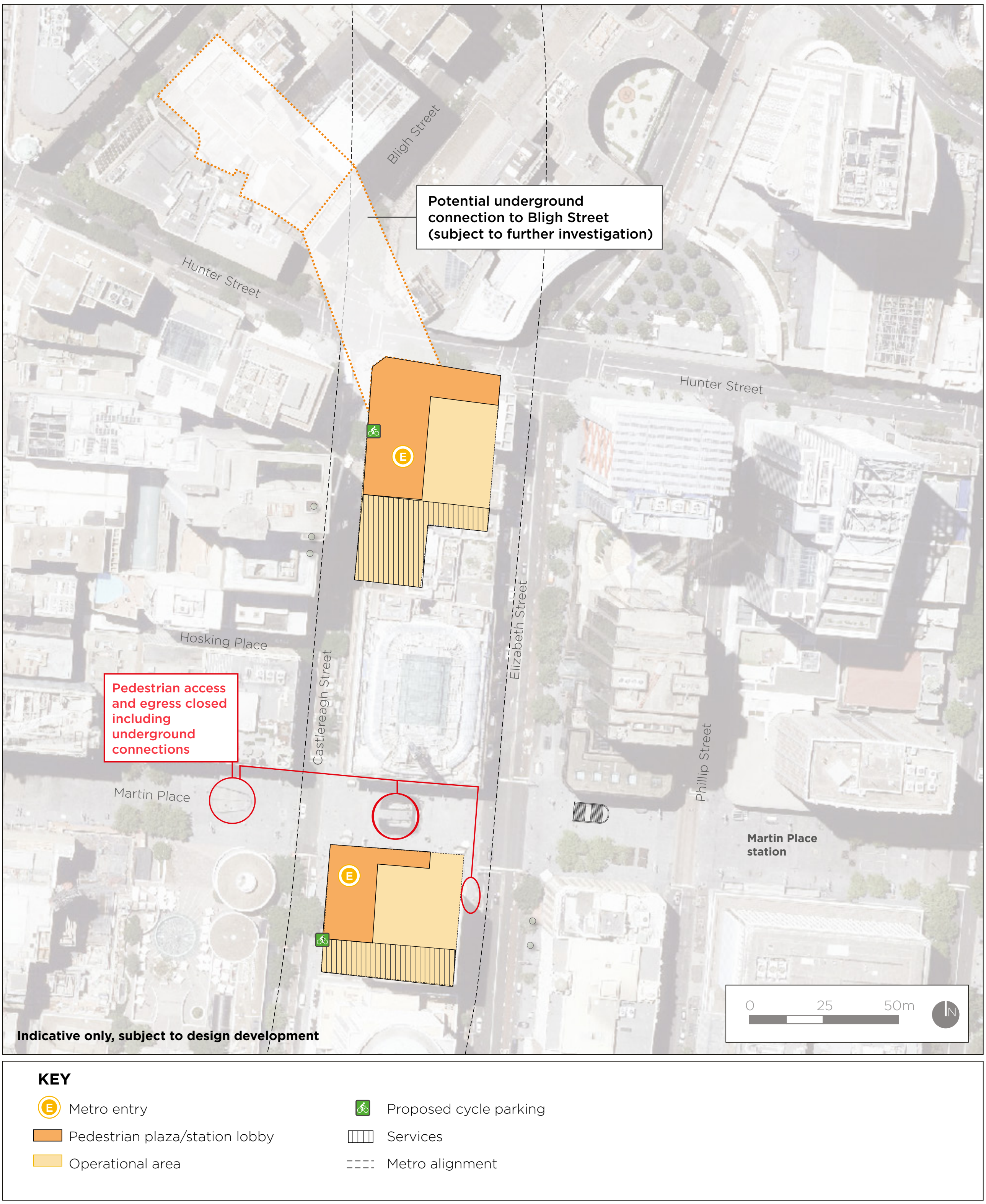


Figure 2-5 Martin Place Station – location and indicative layout

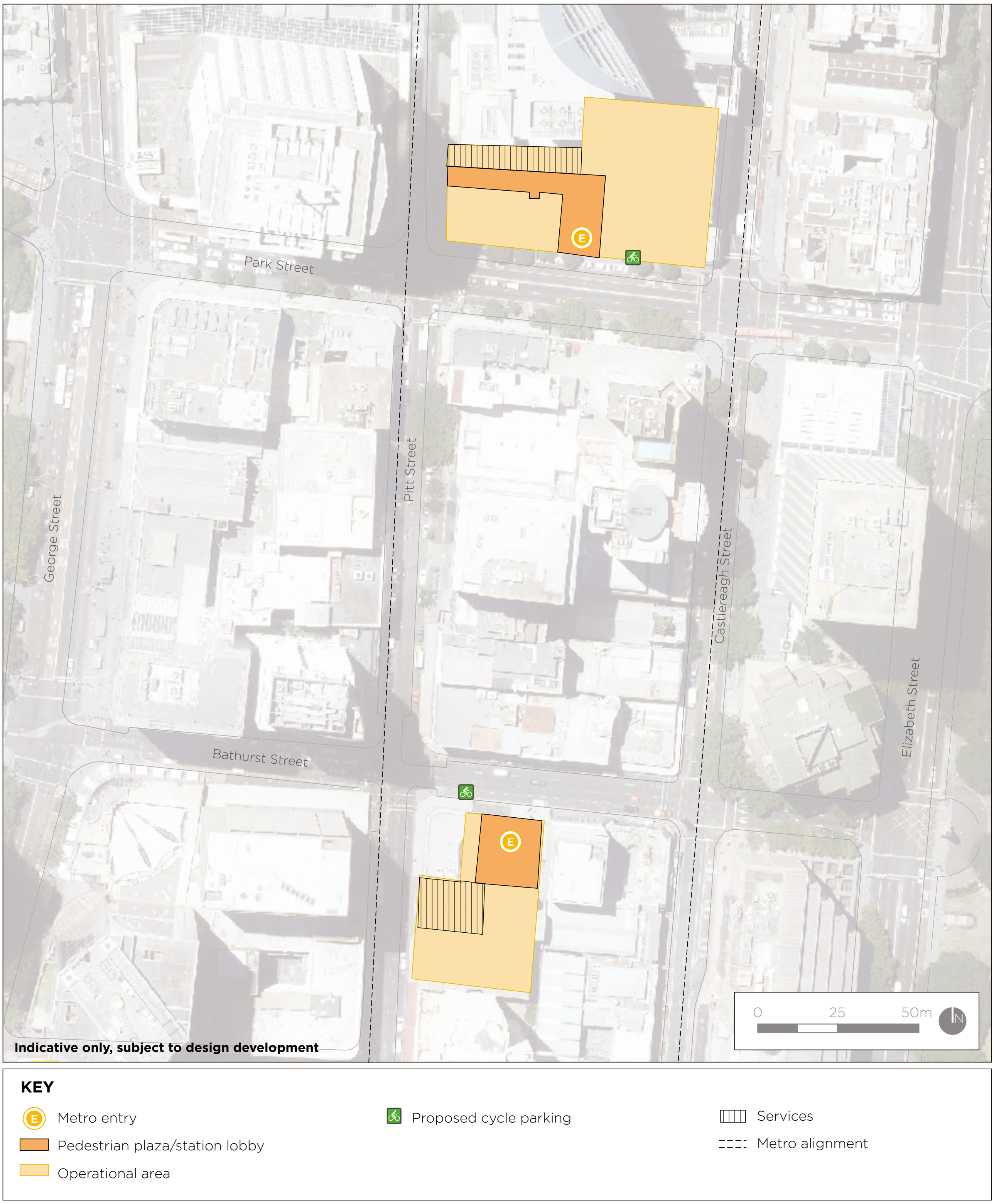


Figure 2-6 Pitt Street Station – location and indicative layout

Figure 2-7 Central Station – location and indicative layout

KEY

- Metro entry
- Pedestrian plaza/station lobby
- Operational area
- Proposed cycle parking
- Proposed pedestrian crossing
- Proposed on road marked cycle route
- Proposed taxi rank
- Proposed kiss-and-ride
- Proposed bus stop (relocated)
- Metro alignment
- Services

Figure 2-8 Waterloo Station – location and indicative layout

2.3 Metro rail tunnels

The twin underground metro rail tunnels would extend about 15.5 kilometres between the Chatswood tunnel portal (north of Mowbray Road, Chatswood) and the Marrickville tunnel portal (south of Bedwin Road, Marrickville).

The tunnel alignment (as shown on Figure 2-1(a) to (h)) is indicative at this stage, and has been used for the purposes of the environmental impact assessment including all specialist investigations. During detailed design the alignment may change (horizontally and / or vertically). Any changes to the alignment would be reviewed for consistency with the assessment contained in this Environmental Impact Statement including relevant mitigation measures, performance outcomes and any future conditions of approval.

There would be a future statutory corridor for the project established through the *State Environmental Planning Policy (Infrastructure) 2007*. Any future development within this corridor would be referred to Transport for NSW for concurrence. A preliminary project corridor, which extends 30 metres either side of the tunnel alignment, is shown on Figure 2-1(a) to (h). This corridor would be confirmed consistent with any changes to the alignment described above.

Key features of the metro rail tunnels include:

- The tunnels would have a circular cross-section with an internal diameter of about six metres (radius of about three metres)
- The tunnels would be lined with pre-cast concrete segments to maximise the tunnel lifespan and minimise groundwater inflow
- The tunnels would provide space for other equipment and services including rail signalling, controls and communication, overhead traction power, ventilation, fire and life safety systems, lighting and drainage.

2.4 Dive structures and tunnel portals

Dive structures and tunnel portals would be provided at each end of the project, as follows:

- The Chatswood dive structure would commence about 250 metres south of Chatswood Station, while the Chatswood tunnel portal would be located to the north of Mowbray Road
- The Marrickville dive structure would commence about 400 metres north of Sydenham Station and the Marrickville tunnel portal would be located in the suburb of Marrickville about 840 metres north of Sydenham Station (to the south of Bedwin Road).

The dive structures would comprise an initial length of open trough, which would then transition to a cut-and-cover structure (the tunnel portals). A fire protection wall would be installed along the entire length of the dive structures to provide separation between the two metro tracks.

2.5 Surface tracks

Surface metro tracks would be provided at the northern end of the project for about 250 metres of surface metro tracks between the Chatswood dive structure and Chatswood Station, connecting to the Sydney Metro Northwest tracks. The surface metro tracks would be located between the T1 North Shore Line tracks.

The T1 North Shore Line tracks and rail systems would also be adjusted between the southern end of Chatswood Station and Brand Street, Artarmon to accommodate the metro surface tracks and Chatswood dive structure. Between Chatswood Station and the Chatswood dive structure the T1 North Shore Line tracks would be re-located to the outside of the metro tracks. To accommodate the metro tracks, including the dive structure and tunnel portal, the T1 North Shore Line ‘down’ (northbound) track would be relocated to the west and would pass over the metro dive structure on a bridge.

2.6 Operational ancillary infrastructure

Operational ancillary infrastructure would be required for the project including:

- A substation at Artarmon (between the northern tunnel portal and Crows Nest Station) to provide traction power to the tunnels. The substation would be located above the tunnels near the edge of the Gore Hill Freeway
- A services facility adjacent to the Marrickville tunnel portal, including a tunnel water treatment plant and a traction substation.

2.7 Other operational features

2.7.1 Permanent closure of Nelson Street bridge

The Chatswood dive structure and tunnel portal would result in the demolition and permanent closure of the Nelson Street bridge. The primary role of the Nelson Street bridge is to enable motorists travelling south on the Pacific Highway to access Mowbray Road westbound via Orchard Road. Nelson Street also provides local vehicle access to residents of Nelson Street. To maintain this primary movement, it is proposed to construct an all vehicle right-turn movement from the Pacific Highway southbound to Mowbray Road westbound. This would require the widening of the Pacific Highway to the north of the Mowbray Road intersection.

As part of the project, Frank Channon Walk (a shared path currently connection Chatswood Station to Nelson Street) would be extended from Nelson Street to Mowbray Road on the western side of the rail line to provide an enhanced facility for pedestrians and cyclists and provide continued access between Chatswood Station and residential areas to the south.

2.7.2 Sydney Yard Access Bridge

To provide access for Sydney Metro and Sydney Trains once the project is operational, an access bridge for maintenance vehicles at Central Station would be provided from Regent Street to ‘Sydney Yard’, located between the suburban and intercity rail lines.

The bridge would be about 170 metres long with a central span of about 50 metres, crossing the Intercity rail lines. The bridge deck would be about nine metres above the ground.

Because of the prominence of the bridge and the heritage sensitivity associated with its setting, the following principles would guide its detailed design:

- The bridge would be of high quality design and integrate with the industrial rail context
- The bridge architecture would draw reference from the existing forms, materials and colours of Sydney Yard
- The bridge structure and abutments would be of masonry construction
- Where throw screens are required they would be of largely transparent material and construction
- Lighting of the bridge would be inconspicuous and not cause nuisance in the public domain or spill towards Mortuary Station.

2.8 Construction

2.8.1 Overview

The key construction activities to be carried out for the project include:

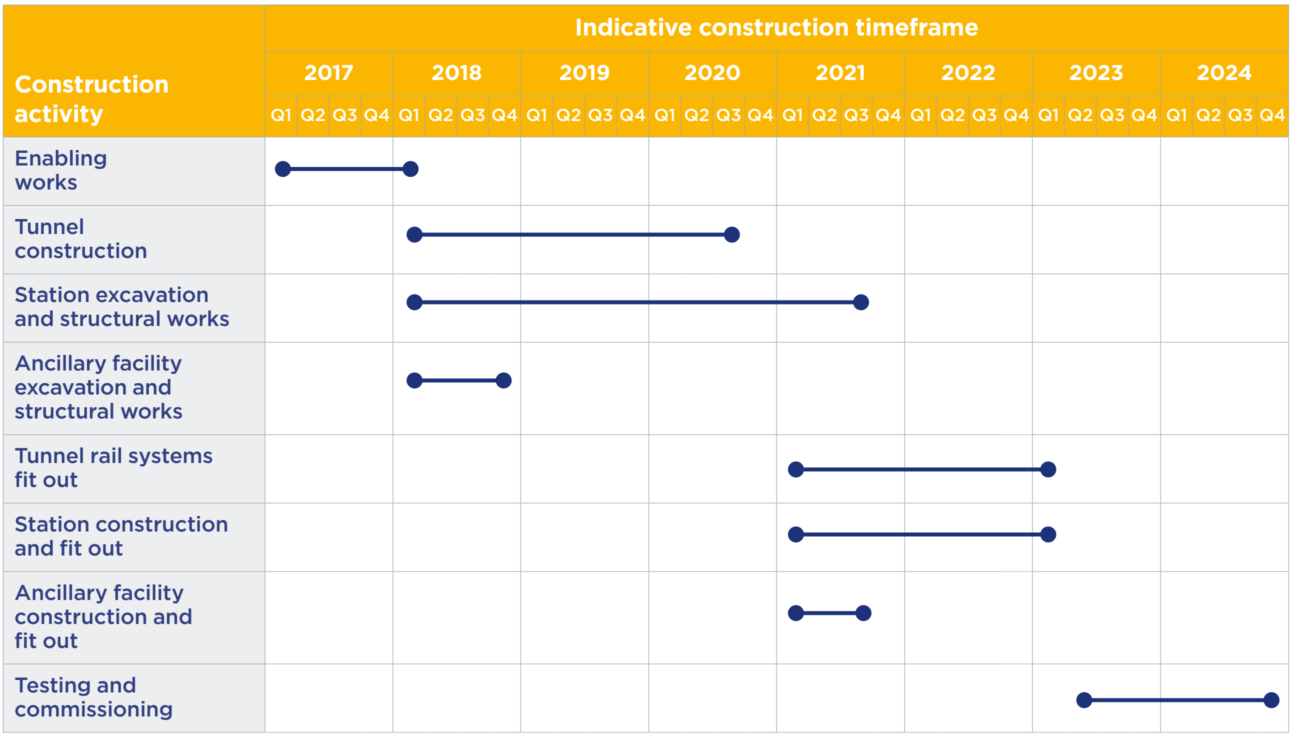
- Demolishing buildings and structures at the station sites and other construction sites
- Constructing dive structures and tunnel portals
- Constructing tunnels, adits and cross passages
- Excavating a shaft for a temporary tunnel boring machine retrieval site at Blues Point
- Excavating, constructing and fitting out metro stations
- Carrying out surface works between Chatswood Station and Brand Street, Artarmon
- Excavating a shaft, carrying out structural work and fitting out ancillary infrastructure at Artarmon
- Carrying out structural work and fitting out ancillary infrastructure at Marrickville
- Fitting out the tunnel with rail operating systems
- Testing and commissioning of stations, tunnels, ancillary infrastructure, rail systems and trains.

A number of construction sites would be required to construct the project (as shown on Figure 2-1(a) to 2.1(h)). These include locations for tunnel equipment and support, stations, surface track and ancillary facilities.

2.8.2 Program

Enabling works (preliminary construction activities required to facilitate substantial construction) would likely commence in early 2017, with substantial construction of the project planned to commence in early 2018. The total period for construction would be about seven years, with the project expected to be opened to the public in 2024. An indicative construction program is shown in Table 2-2.

Table 2-2 Indicative construction program



2.8.3 Tunnels

Tunnel excavation

Tunnel boring machines are likely to be used to excavate the majority of the twin tunnels. Each tunnel boring machine would typically consist of a shielded cutting head and trailing backup support services and mechanisms. At the front of the shield is a rotating cutter head, and behind the cutter head is a chamber where the excavated rock and sediments (spoil) are removed. The spoil is transferred to a conveyor or slurry pipe to transport the spoil to the tunnel boring machine launch site for removal.

Roadheaders would be used to excavate irregular shaped tunnels such as stub tunnels, niches and cross-passages. A roadheader is an excavation machine consisting of a boom mounted rotating cutter head mounted on bulldozer style tracks, a loading device, and a crawler track to move the machine forward into the rock face. Excavators with rock hammer attachments would also be used to excavate cross passages and niches within the tunnels.

It is anticipated that tunnelling would occur from three tunnel boring machine launch and support sites:

- A site in Chatswood (south of Chatswood Station and north of Mowbray Road), referred to as the Chatswood dive site (northern). This site would support two tunnel boring machines for the drive to Blues Point
- A site in Marrickville (north of Sydenham Station and south of Bedwin Road), referred to as the Marrickville dive site (southern). This site would support two tunnel boring machines for the drive to Barangaroo. A pre-cast facility would also be established at this site to manufacture the pre-cast concrete tunnel lining segments
- A site at the proposed Barangaroo Station for the crossing of Sydney Harbour (Barangaroo Station construction site). Due to the different ground conditions under Sydney Habour, this site would support a specialised tunnel boring machine for the drive Blues Point.

A temporary site would also be established at Blues Point for the retrieval of the cutter head and shields of the tunnel boring machine driven from the Chatswood dive site and the Barangaroo Station construction site.

Tunnelling from the tunnel boring machine launch sites would occur concurrently, with the use of five tunnel boring machines.

Sydney Harbour sediment ground improvement

Due the expected ground conditions underneath Sydney Harbour, ground improvement work is likely to be required prior to excavation of the tunnels to reduce construction risks and allow for maintenance of the tunnel boring machine cutters prior to driving through the rock-sediment transition zones. Ground improvement work is likely to involve the establishment of solid blocks (each about 35 metres wide by 20 metres long by 16 metres deep) at the two points where the tunnel alignment passes through a rock-sediment transition zone.

The preferred method of ground improvement is through jet grouting, although alternative approaches such as ground freezing may be considered during detailed design. Jet grouting would involve the injection of a cement grout from barges via a crane and drilling lead.

Tunnel fit-out

Tunnel fit-out would include the installation of fresh air ventilation equipment; the track slab and rail fasteners; rail fixing and welding; signaling, communications and power cables equipment; overhead traction power conductor bars; and other equipment such as lighting, drainage and fir and life safety systems.

The main access points for the tunnel fit-out would be via the Chatswood dive site and the Marrickville dive site. Secondary access via the underground stations would be possible, however this access would diminish as the station fit-out progresses.

2.8.4 Stations

Station construction would involve excavation, structural work, aboveground building and station fit-out.

Excavation

Station excavation would initially involve the use of rock hammers and excavators. Once appropriate offset depths are reached, blasting would be used to excavate the remainder of the stations and shafts (except for Central Station). Blast charge sizes would be designed to comply with the relevant blasting criteria.

For cut-and-cover stations (Crows Nest, Barangaroo, Central and Waterloo stations) excavation of the station would progress down to the level of the base slab. The base slab and permanent structural elements would then be built up from the bottom of the excavation. The last element of the structure would be the roof slab – leaving only discrete entry and exit points.

For mined stations (Victoria Cross, Martin Place and Pitt Street) shaft excavation would be carried out to an intermediate floor level. Roadheaders and other excavation equipment would then be lowered through the shaft to excavate the underground station and pedestrian connections.

Structural work

Following excavation, the station works would involve the construction of structural elements using cast in-situ or pre-fabricated concrete. Structural elements would include platforms, vertical supports, intermediate floors and roof slabs.

Aboveground building

Aboveground buildings associated with station entry and exit points, services and emergency egress would generally be constructed following the station structural works. Buildings would be constructed using conventional steel frame or reinforced concrete methods.

Fit-out

The station fit-out would involve:

- Mechanical and electrical fit-out including the tunnel rail systems located at the stations and the services required for the function of the stations. The initial fit-out of mechanical and electrical services would likely occur concurrently with the structural work via openings left in the floors and roof structure (for cut-and-cover stations) or through the vertical transport shaft (for mined stations). This would include the installation of large equipment such as fresh air ventilation fans. The final fit-out of services would occur after the completion of structural work
- Architectural fit-out would occur after completion of the station structural works. It would include elements such as glazing, wall and ceiling cladding, and floor finishes.

2.8.5 Surface works and dive structures

Construction of the Chatswood and Marrickville dive structures and tunnel portals would generally involve:

- Cast in-situ concrete piling along the edge of the dive structure to form the walls
- Excavating below track level
- Placing of pre-cast and cast in-situ concrete for the cut-and-cover section and to form the tunnel portal.

Surface works would be carried out at the northern end of the project between the southern end of Chatswood Station and the Chatswood dive structure. This would involve the relocation of the T1 North Shore Line and associated rail infrastructure, the construction of the metro rail tracks and associated rail infrastructure, and ancillary components such as access maintenance access points and noise barriers.

2.8.6 Ancillary infrastructure

Artarmon substation

Construction of the Artarmon substation would involve excavating a vertical shaft to the tunnels below, lining and reinforcing the shaft, building aboveground components, and installing electrical equipment.

Southern services facility

The southern services facility, located within the Marrickville dive site, would incorporate a tunnel water treatment plant and a traction substation for use during the operation of the project.

The tunnel water treatment plant would typically be a modular unit constructed on a concrete base slab. Drainage pipes would connect the water treatment plant with the tunnels.

The traction substation would consist of an aboveground building and installation of electrical equipment. Trenching and / or aboveground conduits would be provided to reticulate electrical cables into the tunnels.

2.8.7 Construction hours

Proposed construction hours are shown in Table 2-3. These hours have been developed based on a balanced consideration of the construction program and the need to minimise noise and traffic related impacts. As the tunnel boring machines would operate continuously, the tunnelling and associated support activities would need to be carried out up to 24 hours per day and seven days per week.

The majority of the station fit-out and other aboveground construction activities would be carried out during the following hours:

- 7 am to 6 pm Monday to Friday
- 8 am to 1 pm Saturdays
- No works on Sundays or Public Holidays.

However, other substantial activities (as identified in Table 2-3) would need to be carried out outside these hours.

Table 2-3 Proposed construction hours

Activity	Construction hours	Comments or exceptions
Underground construction activities		
Tunnelling	24 hours per day, seven days per week	Activities that support tunnelling may need to occur 24 hours per day, up to seven days per week. Rock hammering in the tunnel between 10 pm and 7 am would be precluded except where there would be no impact on sensitive receivers. Drill and blast, if required, would be carried out during periods anticipated to have the least impact on receivers.
Underground excavation at station and ancillary sites	24 hours per day, seven days per week	May need to occur outside standard daytime construction hours provided appropriate noise mitigation is in place. Drill and blast would be carried out during periods anticipated to have the least impact on receivers
Tunnel and station fit-out (underground)	24 hours per day, seven days per week	Activities that support tunnel and station fit-out may need to occur 24 hours per day, up to seven days per week.
Aboveground construction activities		
Demolition **Station and ancillary facility fit-out and construction (aboveground)**	• 7 am to 6 pm Monday to Friday • 8 am to 1 pm Saturdays • No works on Sundays and Public Holidays	Aboveground work supporting underground construction activities (eg concrete pumping, truck loading) are expected to be required 24 hours per day, up to seven days per-week where noise mitigation is in place. Non-disruptive preparatory work, repairs or maintenance may be carried out on Saturday afternoons between 1 pm and 5 pm or Sundays between 8 am and 5 pm. Activities requiring the temporary possession of roads or to accommodate road network requirements may need to be carried out outside the standard daytime construction hours during periods of low demand to minimise safety impacts and inconvenience to commuters. Activities requiring rail possessions may need to be carried out outside the standard construction hours up to 24 hours per day, seven days per week.

Activity	Construction hours	Comments or exceptions
Construction traffic for material supply to, and spoil removal from, tunnelling and underground excavation (station and ancillary facility sites)	24 hours per day, seven days per week	Restrictions would be in place during peak hours and special events. At locations where night-time sensitive noise receivers are close to construction sites, significant construction vehicle movements are likely to be restricted during evening and night-time periods.

Other activities that would be carried out outside of the standard daytime construction hours would include:

- Work determined to comply with the relevant noise management level (NML) at the nearest sensitive receiver
- Work required to be carried out during rail possessions
- The delivery of materials outside approved hours as required by the NSW Police or other authorities (including Roads and Maritime) for safety reasons
- Emergency situations where it is required to avoid the loss of lives and property and / or to prevent environmental harm
- Situations where agreement is reached with affected receivers.

With the exception of emergencies, activities would not take place outside standard daytime construction hours without prior notification of local residents, businesses and the Environment Protection Authority.

2.8.8 Other key construction activities

Demolition

It is anticipated that construction would require the demolition of about 58 commercial buildings, six residential buildings and 15 industrial buildings. Some demolition would occur in the enabling works phase before substantial construction begins. This would result in less chance of vandalism and assist in managing potential conflicts between the scheduling of the metro station construction and the construction of the CBD and South East Light Rail.

Demolition would be carried out by licensed demolition contractors and in stages where possible. Typically, building demolition would involve:

- Establishment of hoarding, scaffolding and protection barriers around the perimeter of the site
- All services into the buildings would be decommissioned, made safe and redundant
- Soft stripping internal building materials
- Demolition of the building using an excavator, bobcat cranes or other conventional methods following a top-down approach. Temporary propping and / or waterproofing would be provided for structural integrity of adjacent structures as required during the demolition works.

A hazardous materials analysis would be carried out prior to stripping and demolition of the main structure. Any hazardous materials would be removed and disposed of in accordance with the relevant legislation, codes of practice and Australian Standards.

Materials such as bricks, tiles, timber, plastics and metals would be sorted where practicable and sent to a waste facility with recycling capabilities.

Structures other than buildings to be demolished, include:

- Nelson Street road bridge at the Chatswood dive site
- The pedestrian bridge across Denison Street connecting Berry Square and Tower Square adjacent to the Victoria Cross Station site
- The pedestrian connection beneath Martin Place between Castlereagh and Elizabeth streets
- Existing platforms, canopies, overhead supports and underground pedestrian connections at Central Station.

Power supply

High voltage (11 kV) power supply would be required for the operation of tunnel boring machines at the Chatswood dive site, the Marrickville dive site, Barangaroo Station and potentially at Pitt Street Station; and for roadheaders at the station sites. The power supply for each site would need to be brought in from a substation outside the project corridor. Table 2-4 describes the power supply required at each construction site. The supply route for the Pitt Street site would also be used to supply the permanent power supply to the Pitt Street traction substation. This would involve replacing the 11 kV cables with 33 kV cables within the same conduits.

Power supply routes would generally be located within existing road reserves. Construction of these power supply routes would generally be carried out by open trench. Underbores would be used when crossing major infrastructure or to avoid other major constraints.

Any construction power supply for Artarmon substation and Blues Point temporary site would be provided directly from the local grid.

Preliminary consultation has been carried out with energy suppliers. A program of ongoing consultation is underway to further assess the requirements for the project.

Table 2-4 Construction power for tunnel boring machines

Site	Supply source	Distance to site	Power (mega volt ampere)
Chatswood dive site (northern)	Chatswood substation	100 m	15
Crows Nest Station	Existing cables in Clarke Lane	30 m	3
Victoria Cross Station	Existing cables in Berry Street	50 m	6
Barangaroo Station	City North substation	950 m	12
Martin Place Station	City North substation	1.3 km	7
Pitt Street Station	Surry Hills substation or Pyrmont substation	1.5 km 1.7 km	15
Central Station	Belmore Park substation	600 m	3
Waterloo Station	Zetland substation	850 m	3
Marrickville dive site (southern)	Existing cables in Princes Highway	850 m	14

2.9 Project uncertainties and ongoing design development

The Environmental Impact Statement is based on the concept design developed for the project. The detailed design of the project in ongoing and may result in changes to the project. Any changes to the project would be reviewed for consistency with the assessment contained in the Environmental Impact Statement including relevant mitigation measures, environmental performance outcomes and any future conditions of approval.

In addition to the standard detailed design process, the current key project uncertainties that have been identified at this stage of the project for which Transport for NSW is continuing to investigate opportunities are:

- Requirements for track cross-overs for operational efficiency and flexibility
- The details of the underground pedestrian connection from the northern station entry at Martin Place Station to O'Connell Street and / or Bligh Street
- Enhancement of pedestrian facilities in Denison Street North Sydney with high pedestrian volumes at Victoria Cross Station
- Operational transport and access arrangement around Barangaroo Station which would be developed in consultation with Barangaroo Delivery Authority
- The location of a landside facility to support ground improvement work for the crossing of Sydney Harbour
- Options for barging of spoil rather than transport by road from the Barangaroo Station construction site and the Blues Point temporary site
- The heritage response of project infrastructure within Central Station and the potential re-use of heritage significant fabric with input from a heritage architect and the Sydney Metro Design Review Panel and in consultation with Sydney Trains and the Heritage Council of NSW
- Construction site layout including flow diversions to manage potential overland flows in flood events at the Marrickville dive site
- Cumulative impacts – particularly construction traffic in the Sydney CBD. Given the highly dynamic and time / activity specific nature are difficult to define in any detail at this stage of the assessment process.

Updates on these project scope issues would be provided at the Submissions Report stage of the assessment.

Notwithstanding these uncertainties, Transport for NSW has committed to performance based outcomes (refer to Section 5) to provide confidence that any impacts would be still meet best practice requirements and be within appropriate and acceptable criteria.

3 Summary of project impacts

This section provides a summary of the impacts of the project. These impacts are discussed in detail in Chapters 8 through to 26 in the Environmental Impact Statement.

Many potential impacts have been avoided through the earlier design and project development process which included input from key stakeholders. Further refinement of the design including consideration of community issues through the Environmental Impact Statement exhibition process may further reduce and if possible avoid impacts.

These potential impacts would also be further avoided and minimised, where possible, through the implementation of the mitigation measures identified in section 4 and complying with the performance outcomes identified in section 5.

3.1 Key impact avoidance strategies

The design and construction planning has been influenced by a number of community and environmental and engineering / design factors. In general, the project has been designed to:

- Avoid known structures including buildings, basements, utilities and infrastructure (including other rail and road infrastructure)
- Minimise the potential for direct and indirect impacts to heritage items
- Minimise direct impact on property.

Specific impact avoidance strategies are summarised in Table 3.1.

Table 3-1 Adverse impacts avoided or minimised through design

Environmental aspect	Design response
Operation	
Noise	• Provision of track form to meet ground-borne noise and vibration goals • Provision of new noise barriers and increases to the height of existing noise barriers at the northern end of the project to mitigate airborne noise from train operations • Location of the northern dive structure minimises the extent of surface track and potential airborne noise impacts.
Property and land use	• Provision of mined stations at Victoria Cross, Martin Place and Pitt Street to avoid more extensive property acquisition • Location of the Artarmon substation to avoid the need to acquire residential, commercial or industrial property • Location of the Marrickville dive structure to avoid potential impacts on Sydney Water assets and a Transgrid 330 kilovolt (kV) underground cable.

Heritage	• The design has avoided the following listed heritage items:
	  ♦ Mowbray House adjacent to the Chatswood dive structure
	  ♦ The brutalist building adjacent to Crows Nest Station
	  ♦ The Edinburgh Castle Hotel adjacent to Pitt Street Station
	  ♦ The Congregational Church adjacent to Waterloo Station
	  ♦ The Sydney Water Pit and Drainage Pumping Station near the Marrickville dive structure.
	• The design has minimised impacts to the Lost Property Office at Central Station.

Environmental aspect	Design response
Groundwater	• Provision of tanked tunnels, mined stations and cut-and-cover stations at Barangaroo and Waterloo to minimise the inflow of groundwater • Provision of a tanked station at Barangaroo to minimise the potential for contaminated groundwater inflow.
Biodiversity	• Location of the northern dive structure avoids impacts to Blue Gum High Forest at Artarmon Reserve.
Construction methodology	
Traffic and transport	• Two main tunnel support sites (at Chatswood and Marrickville) were selected because they are located at either end of the tunnel, allowing the majority of tunnelling spoil to be managed away from the critical Sydney CBD section • All three tunnel support sites (at Chatswood, Barangaroo and Marrickville) are located close to major arterial roads, which would minimise the use of local roads for spoil haulage • The location of the northern dive structure minimises the extent of construction works within the T1 North Shore Line corridor and disruption to customers at Artarmon Station • The location of Marrickville dive structure minimises the potential need for rail possessions within the T3 Bankstown Line corridor and the T4 Eastern Suburbs and Illawarra Line corridor • Development of haul routes to minimise impacts on the road network.
Noise	• Location of the two main tunnel boring machine support sites (at Chatswood and Marrickville) on light industrial land to minimise noise to residential areas • Arrangement of haul routes to minimise the use of local roads • Adoption of blasting as an excavation method at station sites to minimise the duration of impacts associated with rock hammering.
Property and land use	• Location of the two main tunnel boring machine support sites (at Chatswood and Marrickville) in light industrial areas to minimise acquisition of residential properties and changes in land use • Construction footprints consistent with operational footprint as much as feasible to minimise property acquisition • Barangaroo Station construction site arranged to minimise the potential to delay the adjacent Barangaroo development.
Groundwater	• A hybrid tunnel boring machine was in part selected for the section of tunnel beneath Sydney Harbour as it includes a slurry operation that pressurises the cut materials between the cutter head and the tunnel face, preventing uncontrolled sudden groundwater inflow and collapse of the tunnel face.
Social and community facilities	• Selection of tunnel boring machines to excavate the twin tunnels because they operate faster than other excavation machinery, resulting in a reduced construction timeframe and less disruption for the local community.
Waste	• Selection of tunnel boring machines to excavate the twin tunnels because they cut the ideal circular profile for a rail tunnel, thereby minimising spoil generation.

3.2 Key impacts

The impacts that have not been avoided effectively represent the actual impacts of the project. These impacts are assessed in detail in Chapters 8 through to 26 in the Environmental Impact Statement. A summary complication of the key impacts for each of the issues identified in the Environmental Impact Statement is provided in Table 3-2.

Table 3-2 Key project impacts

Key project impacts
Construction traffic and transport
○ The introduction of construction vehicles would result in the minor deterioration in the performance of some intersections near construction sites. ○ Construction works at the Chatswood dive site (northern) would require the permanent demolition of the Nelson Street bridge over the T1 North Shore Rail Line. To maintain the primary movement facilitated by Nelson Street, an all vehicle right-turn movement would be provided from the Pacific Highway southbound to Mowbray Road westbound ○ Key pedestrians impacts would include: ♦ Temporary closure of some of the paid underground pedestrian connections at Central (a temporary pedestrian bridge would be provided) ♦ Temporary closure of Devonshire Street pedestrian tunnel for a period of around two weeks ♦ Temporary partial closure of Martin Place and closure of entry / exits at Martin Place Station over a period of about six months ♦ Temporary closure of Hume Street over a period of about six months ♦ Short-term temporary (weekend) closures of Frank Channon Walk. ♦ Safe alternative surface pedestrian and cyclist access would be provided during these closures ○ Other general impacts identified include: ♦ Reduced pedestrian and cyclist access or flows due to construction ♦ Potential impacts to pedestrian, cyclist and motorist safety ♦ Temporary relocation of bus stops ♦ Impacts on reliability of public transport services (Sydney Trains and buses) ♦ Increased travel times for customers during rail possessions ♦ Short-term temporary road or lane closures (most likely to occur overnight) ♦ Loss of parking spaces ♦ Impacts on access to private property ○ Potential impacts on marine traffic and shipping channels.
Operational traffic and transport
○ When operational the project would provide significant improvements to the public transport network capacity and efficiency including new public transport interchange facilities at and around stations. It would improve reliability across the rail network by reducing train crowding, platform and station crowding. It is also expected to provide wider road network benefits by encouraging greater use of public transport. ○ Additional pedestrian load on existing infrastructure resulting in less efficient pedestrian movements, particularly around: ♦ Victoria Cross Station ♦ Martin Place Station ○ Minor deterioration in intersection performance at Pacific Highway / Mowbray Road. ○ Minor deterioration in intersection performance at Pacific Highway / Oxley Street.

Key project impacts
Construction noise and vibration
• Given the nature and duration of works and the close proximity of receivers, airborne noise during construction is expected the exceed noise management levels at all sites – and at some sites by possibly more than 20dB(A). During the night-time, airborne noise levels are expected to generally comply with the criteria though there would some moderate exceedances at some locations • Ground-borne noise during construction from excavation activities is expected to be very high at a number of the station excavation sites – and potentially higher than 75 dBA during the day and 45 dBA during the night. In order to reduce the duration of these impacts, blasting is proposed to be used as an excavation method at the majority of stations. Preliminary blasting scenarios developed to comply with the blasting criteria show substantial reductions in the duration of rock hammering impacts at most station sites. Further work would be carried out during detailed construction planning including trial blasts with small charge sizes to determine site specific characteristics and to assess the level of predictability. Blasts would be designed to comply with the relevant levels for air-blast overpressure and ground vibration. • For tunnelling, a number of exceedances for ground borne noise levels are also expected to occur – the highest exceedances (up to 10dB(A) above criteria), are predicted at residential receivers between the Chatswood tunnel portal and Artarmon substation, around Pitt Street and Waterloo stations and just north of the Marrickville dive site. These levels are not expected to occur for longer than a few days • Construction vibration levels are anticipated to remain below the cosmetic damage vibration screening criteria, with some exceptions • At Chatswood dive site, Crows Nest and Victoria Cross, construction traffic noise is predicted to exceed the relevant criteria.
Operation noise and vibration
• When operational, through the provision of measures incorporated into the design (such as track form in the tunnels and noise barriers) the project would generally comply with all relevant noise and vibration criteria • There are residual noise levels above guidelines at one receiver at Chatswood.
Land use and property

• 98 total property acquisitions and three partial property acquisitions would be required along the alignment including a mix of residential, commercial, mixed use, industrial, retail, and road and rail infrastructure
• During construction, land use issues would largely relate to indirect impacts associated with reduced amenity such as traffic, noise, air quality and access. These issues have been addressed in the specific topic areas
• There would be a temporary loss of open space areas associated with the temporary works at Blues Point Reserve
• Other impacts include:
  ♦ Direct impacts on other infrastructure during construction including utilities and Sydney Trains property
  ♦ Potential restrictions on future development within a defined corridor due to subsurface tunnels
• When operational, the project would have no major direct impacts on land use, though would offer substantial future development opportunities.

Key project impacts
Business impacts
• Construction of the project would result in broad economic benefits by way of job generation and construction multipliers. Locally, many businesses would receive positive impacts with construction workers requiring food and beverage services and other goods • Negative impacts during construction would include direct impacts to businesses where properties are to be acquired, and altered access and visibility to businesses • Indirect business impacts during construction would include temporary constraints or restrictions on servicing and delivery / access, amenity issues such as increased traffic congestion, noise, vibration and dust, changes to customer access and parking • When operational, impacts would be largely positive due to the enhanced capacity and frequency of transport services with improved access to the Sydney CBD including Barangaroo. The new stations at Victoria Cross, Crows Nest, Barangaroo and Waterloo would also enhance the appeal and attraction of visiting, investing, living and working in these precincts • Negative impacts during operation would include altered access and visibility to businesses, increased commercial rents and amenity related impacts.
Non-Aboriginal heritage

• Direct physical impact on three State heritage listed properties:
  ♦ Millers Point & Dawes Point Village Precinct (minor impact)
  ♦ Martin Place Railway (moderate impact)
  ♦ Sydney Terminal and Central Railway Station Group (moderate to major impact)
• Direct physical impact to seven local heritage items:
  ♦ Mowbray House (minor impact)
  ♦ Shop at 187 Miller Street (Major impact – complete demolition)
  ♦ North Sydney Bus Shelters (Moderate impact)
  ♦ Blues Point Waterfront Group (minor to moderate impact)
  ♦ McMahons Point South Heritage Conservation Area (minor to moderate impact)
  ♦ Flat building, including interior (7 Elizabeth Street) (Major impact – complete demolition)
  ♦ Martin Place (moderate impact)
• There would also be potential indirect impacts to, around eight State heritage listed properties and around 28 local heritage listed properties (ie vibration or visual changes)
• Potential for impacts on unknown heritage items (eg archaeological items) during construction
• Potential for unsympathetic design that detracts from the heritage significance of a nearby item.

Aboriginal heritage
• Construction of the project would not directly or indirectly impact on any previously recorded Aboriginal heritage sites. • There is a moderate to high potential for previously unrecorded items of Aboriginal heritage significance to be present in sub-surface contexts at Barangaroo Station, Blues Point temporary site, and portions of the construction sites for Martin Place, Pitt Street, Central and Waterloo stations and the Marrickville dive site (southern) in situations where there are surviving portions of 'A' horizon soils.

Key project impacts
Landscape character and visual amenity
• In general the construction stage would result in minor to moderate adverse impacts • The exception would be high adverse visual impacts, due the sensitivity of these sites to visual changes, on viewpoints from Blues Point and McMahons Point associated with the obstruction of views to the open water of the Sydney Harbour and the incongruent character of the construction work • Viewpoints from Martin Place are considered to be of state visual sensitivity. Construction works would result in a considerable reduction in visual amenity for these viewpoints. In particular, the demolition of the 20 storey office tower at 39 Martin Place, which is visually prominent from Martin Place, would be a highly visible • When operational visual impacts are anticipated to be minor to moderate beneficial.
Groundwater and geology
• Potential groundwater drawdown levels during construction would generally be within the natural variation of groundwater levels. As such, impacts are not anticipated at any existing groundwater supply site • Ground settlement associated with groundwater drawdown or tunneling would be minor • When operational, groundwater captured from any drained station excavations and caverns would be transferred to a water treatment plant at Marrickville prior to discharge to stormwater. The discharge water quality level would be determined in consultation with the NSW Environment Protection Authority during detailed design, taking into consideration the current water quality of the receiving watercourse.
Soils, contamination and water quality
• Given the relatively small areas of surface disturbance anticipated during construction, soil erosion would be adequately managed in accordance with proven standard mitigation measures • There is a high probability of encountering acid sulfate soils at Barangaroo and between Waterloo Station and the Marrickville dive site • The project has a high likelihood of encountering contamination at construction sites at Chatswood and Barangaroo, and the ground improvement work in Sydney Harbour • Due to the expected ground conditions underneath Sydney Harbour, ground improvement to the seabed would be required prior to excavation of the tunnels. There is potential for water quality impacts due to disturbance of the seabed. In addition, the storage of materials (grout and spoil) would be required on barges on Sydney Harbour, which has the potential for spills or leaks.
Social impacts and community facilities
• Direct loss of community facilities, including a child care centre at Martin Place, and post shops at Crows Nest and Pitt Street • Temporary loss of public open space at Blues Point • Altered access to community facilities during construction • Reduced amenity such as traffic, noise, air quality and access. These issues have been addressed in the specific topic areas of the Environmental Impact Statement.
Biodiversity
• Removal and / or modification of hollow-bearing trees, buildings, and a bridge that could provide roosting and foraging habitat for the threatened Eastern Freetail Bat and Eastern Bent-wing Bat • Removal of planted fig trees that provide potential foraging habitat at Barangaroo and Chatswood for the threatened Grey-headed Flying-fox • Potential impacts to aquatic ecology from the mobilisation of contaminants with Sydney Harbour seabed sediments.

Key project impacts
Flooding and hydrology
• The majority of construction sites are currently impervious to infiltration and have well-established drainage systems to cater for stormwater flows. At these sites construction activities would not result in any major increase in stormwater volumes or peak flow rates • At some sites, construction may result in minor changes to existing localised surface water and / or stormwater flow regimes • When operational, the aboveground station infrastructure would be located within the footprint of existing development and would have a negligible impact on the existing surface hydrology • The Marrickville dive site could result in overland flow impacts in flood events during construction • Flood modelling indicates that the permanent Marrickville dive structure would result in a worst case increase in flood levels within the existing rail corridor of about 470 mm in a 100 year annual recurrence interval flood event. These increases would only occur only in areas that already experience flooding – that is, no additional private properties would be flood-affected as a result of the project. The flood level increases would also be largely confined to the existing rail corridor and roads.
Air quality
• In general air quality impacts (dust and exhaust emissions) are expected to be minor and manageable through well proven and established mitigation and management measures.
Hazard and risk
• Potential impacts associated with the storage, use and transport of dangerous goods and hazardous substances. Construction site planning would ensure hazardous materials are stored appropriately and at an appropriate distance from sensitive receivers, in accordance with the thresholds established under Applying SEPP 33. • Risk of impacts to underground utilities. The risk would be minimised by carrying out utility checks (such as dial before you dig searches and non-destructive digging), consulting with the relevant utility providers and, if required, relocating and / or protecting utilities in and around the project prior to construction.
Waste management
• Indicatively, the project would generate about 2.4 million cubic metres of spoil • Other waste material would include concrete, bricks, tiles, timber (treated and untreated), metals, plasterboard, carpets, electrical and plumbing fittings and furnishings (such as doors and windows), hazardous waste (including asbestos and insulation). Much of this would be associated with demolition activities.
Sustainability

• Sustainability principles have been incorporated throughout the design development process. Key impacts identified include:
  ♦ Emissions of greenhouse gases from operational energy use and embodied energy in materials
  ♦ Emissions of greenhouse gases from construction activities including energy use for tunnel boring machines
  ♦ Impact of climate change on rail operations and infrastructure
  ♦ Impact of climate change on customer and staff comfort
  ♦ Increased electricity use during operation
  ♦ Increased demand on electricity and water supply during construction
  ♦ Increased demand on local and regional resources including sand and aggregate during construction
  ♦ Increased diesel use during construction.

Key project impacts
Cumulative impacts
○ The cumulative impacts have been a particularly important consideration given the potential overlap of construction with a considerable number of large infrastructure projects particularly in the Sydney CBD. These cumulative impacts would be highly dynamic and time / activity specific, so are difficult to define in any detail at this stage of the assessment process ○ Key issues identified include: ♦ Construction noise and traffic associated with CBD and South East Light Rail ♦ Construction noise and traffic associated with WestConnex ♦ Spoil management and disposal from multiple tunneling projects in Sydney (eg WestConnex and NorthConnex) ♦ Other stages of Sydney Metro such as Sydney Metro Northwest and Sydenham to Bankstown upgrade ♦ Construction noise and traffic associated with other developments.

4 Consolidated mitigation measures

This section provides a consolidated list of the mitigation measures (in Table 4-1) identified as a result of the assessments in Chapters 8 through to 26 in the Environmental Impact Statement. Further information regarding environmental mitigation and management is provided in Chapter 27 of the Environmental Impact Statement.

These mitigation measures are in addition to the measures which are inherent in the design of the project to avoid and minimise adverse impacts. Further details on these aspects of the project are provided in Section 3.1.

Based on the outcomes of the assessment and the implementation of the mitigation measures in Table 4-1, environmental performance outcomes have been established for the project. The environmental performance outcomes are identified in Section 5.

Table 4-1 Consolidated environmental mitigation measures

ID	Mitigation measure	Applicable location (s)[1]
Construction traffic and transport		
T1	Ongoing consultation would be carried out with (as relevant to the location) the CBD Coordination Office, Roads and Maritime Services, Sydney Trains, NSW Trains, local councils, emergency services and bus operators in order to minimise traffic and transport impacts during construction.	All except metro rail tunnels
T2	Road Safety Audits would be carried out at each construction site. Audits would address vehicular access and egress, and pedestrian, cyclist and public transport safety.	All except metro rail tunnels
T3	Directional signage and line marking would be used to direct and guide drivers and pedestrians past construction sites and on the surrounding network. This would be supplemented by Variable Message Signs to advise drivers of potential delays, traffic diversions, speed restrictions, or alternate routes.	All except metro rail tunnels
T4	In the event of a traffic related incident, co-ordination would be carried out with the CBD Coordination Office and / or the Transport Management Centre's Operations Manager.	All except metro rail tunnels

ID	Mitigation measure	Applicable location (s)[1]
T5	The community would be notified in advance of proposed road and pedestrian network changes through media channels and other appropriate forms of community liaison.	All except metro rail tunnels
T6	Vehicle access to and from construction sites would be managed to ensure pedestrian, cyclist and motorist safety. Depending on the location, this may require manual supervision, physical barriers, temporary traffic signals and modifications to existing signals or, on occasions, police presence.	All except metro rail tunnels
T7	Additional enhancements for pedestrian, cyclist and motorist safety in the vicinity of the construction sites would be implemented during construction. This would include measures such as: - Use of speed awareness signs in conjunction with variable message signs near construction sites to provide alerts to drivers - Shared experience educational events that allow pedestrians, cyclists or motorists to sit in trucks and understand the visibility restrictions of truck drivers, and for truck drivers to understand the visibility from a bicycle - Specific construction driver training to understand route constraints, expectations, safety issues and to limit the use of compression braking - Safety devices on construction vehicles that warn drivers of the presence of a vulnerable road user located in the vehicles' blind spots and warn the vulnerable road user that a vehicle is about to turn.	All except metro rail tunnels
T8	Access to existing properties and buildings would be maintained in consultation with property owners.	All except metro rail tunnels
T9	All trucks would enter and exit construction sites in a forward gear, where feasible and reasonable.	All except metro rail tunnels
T10	Any relocation of bus stops would be carried out by Transport for NSW in consultation with Roads and Maritime Services, the CBD Coordination Office (for relevant locations), the relevant local council and bus operators. Wayfinding and customer information would be provided to notify customers of relocated bus stops.	All except metro rail tunnels
T11	For special events that require specific traffic measures, those measures would be developed in consultation the CBD Coordination Office (for relevant locations), Roads and Maritime Services, and the organisers of the event.	BN, MP, PS, CS
T12	Construction sites would be managed to minimise construction staff parking on surrounding streets. The following measures would be implemented: - Encouraging staff to use public or active transport - Encouraging ride sharing - Provision of alternative parking locations and shuttle bus transfers where feasible and reasonable.	All except metro rail tunnels
T13	Construction site traffic would be managed to minimise movements in the AM and PM peak periods.	All except metro rail tunnels
T14	Construction site traffic immediately around construction sites would be managed to minimise movements through school zones during pick up and drop off times.	All except metro rail tunnels

ID	Mitigation measure	Applicable location (s)[1]
T15	Pedestrian and cyclist access would be maintained at Crows Nest during the temporary closure of Hume Street, and at Martin Place during the temporary partial closure of Martin Place. Wayfinding and customer information would be provided to guide pedestrians and cyclists to alternative routes.	CN, MP
T16	Timing for the temporary closure of the Devonshire Street tunnel would avoid periods of peak pedestrian demand. Wayfinding and customer information would be provided to guide pedestrians to alternative routes.	CS
T17	Consultation would occur with the Harbour Master, Roads and Maritime Services and Sydney Ferries to ensure shipping channels are maintained during the Sydney Harbour ground improvement works.	GI
T18	During the closure of existing entrances to Martin Place Station, marshalls would be provided during the AM and PM peak periods to direct customers to available access and egress points.	MP
T19	Where existing parking is removed to facilitate construction activities, alternative parking facilities would be provided where feasible and reasonable.	All except metro rail tunnels
T20	Alternative pedestrian routes and property access would be provided where these are affected during the construction of the power supply routes.	PSR
Operational traffic and transport		
OpT1	Enhancement of pedestrian infrastructure in the vicinity of Victoria Cross and Martin Place stations would be investigated further in consultation with (as relevant to the location) the CBD Coordination Office, Roads and Maritime Services and the relevant local council.	VC, MP
OpT2	Access would be maintained to neighbouring properties.	All except metro rail tunnels
Construction noise and vibration		
NV1	The Construction Noise and Vibration Strategy would be implemented with the aim of achieving the noise management levels where feasible and reasonable. This would include the following example standard mitigation measures where feasible and reasonable: • Provision of noise barriers around each construction site • Provision of acoustic sheds at Chatswood dive site, Crows Nest, Victoria Cross, Barangaroo, Martin Place, Pitt Street, Waterloo and Marrickville dive site • The coincidence of noisy plant working simultaneously close together would be avoided • Offset distances between noisy plant and sensitive receivers would be increased • Residential grade mufflers would be fitted to all mobile plant • Dampened rock hammers would be used • Non-tonal reversing alarms would be fitted to all permanent mobile plant • High noise generating activities would be scheduled for less sensitive period considering the nearby receivers • The layout of construction sites would consider opportunities to shield receivers from noise.	All

ID	Mitigation measure	Applicable location (s)[1]
NV2	Unless compliance with the relevant traffic noise criteria can be achieved, night time heavy vehicle movements at the Chatswood dive site, Crows Nest Station and Victoria Cross Station sites would be restricted to: • The Pacific Highway and Mowbray Road at the Chatswood dive site • The Pacific Highway, Hume Street and Oxley Street at the Crows Nest Station construction site • McLaren Street, Miller Street and Berry Street at the Victoria Cross Station construction site.	CDS, CN, VC
NV3	Where vibration levels are predicted to exceed the screening criteria, a more detailed assessment of the structure and attended vibration monitoring would be carried out to ensure vibration levels remain below appropriate limits for that structure. For heritage items, the more detailed assessment would specifically consider the heritage values of the structure in consultation with a heritage specialist to ensure sensitive heritage fabric is adequately monitored and managed.	All except metro rail tunnels
NV4	Feasible and reasonable measures would be implemented to minimise ground-borne noise where exceedences are predicted.	All
NV5	Feasible and reasonable mitigation measures would be implemented where power supply works would result in elevated noise levels at receivers. This would include: • Carrying out works during the daytime period when in the vicinity of residential receivers • Where out of hours works are required, scheduling the noisiest activities to occur in the evening period (up to 10 pm) • Use of portable noise barriers around particularly noisy equipment such as concrete saws.	PSR
Operational noise and vibration		
OpNV1	The height and extent of noise barriers adjacent to the northern surface track works would be confirmed during detailed design with the aim of not exceeding trigger levels from the *Rail Infrastructure Noise Guidelines* (Environment Protection Authority, 2013). At property treatments would be offered where there are residual exceedances of the trigger levels.	STW
OpNV2	Track form would be confirmed during the detailed design process in order to meet the relevant ground-borne noise and vibration criteria from the *Rail Infrastructure Noise Guidelines* (EPA, 2013) and the *Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects* (DECC, 2007).	Metro rail tunnels
OpNV3	Stations and ancillary facilities including train breakout noise from draught relief shafts would be designed to meet the applicable noise criteria derived from the *Industrial Noise Policy* (EPA, 2000).	All except metro rail tunnels

ID	Mitigation measure	Applicable location (s)[1]
Business impacts		
BI1	Specific consultation would be carried out with businesses potentially impacted during construction. Consultation would aim to identify and develop measures to manage the specific construction impacts for individual businesses.	All
BI2	A business impact risk register would be developed to identify, rate and manage the specific construction impacts for individual businesses.	All
BI3	Appropriate signage would be provided around construction sites to provide visibility to retained businesses.	All except metro rail tunnels
Non-Aboriginal heritage		
NAH1	Archival recording and reporting of the following heritage items would be carried out in accordance with the NSW Heritage Office's *How to Prepare Archival Records of Heritage Items* (1998), and *Photographic Recording of Heritage Items Using Film or Digital Capture* (2006): • The internal heritage fabric and any non-original elements removed from within the curtilage of Mowbray House, Chatswood • The interior, exterior and setting of the shop at 187 Miller Street, North Sydney • The fabric and setting of the North Sydney bus shelters requiring removal and temporary relocation at Victoria Cross Station and Blues Point temporary site • Any component of the Blues Point Waterfront Group and the McMahons Point South heritage conservation area to be directly affected or altered, including vegetation and significant landscape features • Hickson Road wall in the vicinity of proposed ventilation risers and skylights for Barangaroo Station • The interior, exterior and setting of the 'Flat Building' at 7 Elizabeth Street, Sydney • Martin Place, between Elizabeth and Castlereagh streets, Sydney • The heritage fabric of areas of the existing Martin Place Station affected by the project • The Rolling Stock Officers Garden, Rolling Stock Officers Building and Cleaners Amenities Building in Sydney Yard and any other component of the Sydney Terminal and Central Railway Stations group to be removed or altered.	CDS, VC, BP, MP, CS
NAH2	An archaeological research designs would be prepared and implemented to identify the need for archaeological testing or monitoring. Archaeological mitigation measures recommended in the archaeological research design would be carried out in accordance with Heritage Council guidelines, and where identified in the archaeological research design, would be supervised by a suitably qualified Excavation Director with experience in managing State significant archaeology.	CDS, CN, VC, BP, BN, MP, PS, CS, WS, PSR
NAH3	An Exhumation Policy and Guideline would be prepared and implemented. It would be developed in accordance with the *Guidelines for Management of Human Skeletal Remains* (NSW Heritage Office, 1998b).	All except metro rail tunnels

ID	Mitigation measure	Applicable location (s)[1]
NAH4	The method for the demolition of existing buildings and / or structures at Chatswood dive site, Victoria Cross Station, Martin Place Station, Pitt Street Station, Central Station and Waterloo Station would be developed to minimise direct and indirect impacts to adjacent and / or adjoining heritage items.	CDS, VC, MP, PS, CS, WS
NAH5	Prior to total or partial demolition of heritage items at Victoria Cross and Martin Place stations, heritage fabric for salvage would be identified and reuse opportunities for salvaged fabric considered. This would include salvage and reuse of heritage tiles to be impacted at Martin Place Station.	VC, MP
NAH6	An appropriately qualified and experienced heritage architect would form part of the Sydney Metro Design Review Panel and would provide independent review periodically throughout detailed design.	All
NAH7	The project design would be sympathetic to heritage items and, where reasonable and feasible, minimise impacts to the setting of heritage items. The detailed design for Martin Place Station and Central Station would be developed with input from a heritage architect.	STW, CDS, CN, VC, BN, MP, PS, CS, WS, MDS
NAH8	Appropriate heritage interpretation would be incorporated into the design for the project in accordance with the *NSW Heritage Manual*, the NSW Heritage Office's *Interpreting Heritage Places and Items: Guidelines* (August 2005), and the NSW Heritage Council's *Heritage Interpretation Policy*.	CDS, CN, VC, BP, BN, MP, PS, WS
NAH9	A Central Station heritage interpretation plan would be developed and implemented in consistent with the *Central Station Conservation Management Plan* (Rappoport and Government Architects Office, 2013) and in accordance with the guidelines identified in NAH9.	CS
NAH10	The design of the Sydney Yard Access Bridge would be sympathetic to surrounding heritage items and minimise impacts to sight lines, views and setting of surrounding heritage items, including to Mortuary Station and the Sydney Terminal and Central Railway Stations group. As a minimum the design would: • Incorporate materials and finishes sympathetic to the heritage context of the railway station • Minimise height and bulk of the structure.	CS
NAH11	Except for heritage significant elements affected by the project, direct impact on other heritage significant elements within the following items would be avoided: • The Blues Point Waterfront Group (including the former tram turning circle, stone retaining wall, bollards and steps) • The Millers Point and Dawes Point Village Precinct • The existing Martin Place Station • Sydney Terminal and Central Railway Stations group • Sydney Yard (including the Shunters Hut and Prince Alfred Sewer).	BP, BN, MP, CS
NAH12	Power supply works would be designed and constructed to avoid impacts to the Tank Stream and Bennelong Stormwater Channel.	PSR

ID	Mitigation measure	Applicable location (s)[1]
NAH13	The design and detailed construction planning of work at Central Station would consider the requirements of the *Central Station Conservation Management Plan* (Rappoport and Government Architects Office, 2013) and include consideration of opportunities for the retention, conservation and / or reuse of original and significant heritage fabric. Consultation would be carried out with Sydney Trains and the Heritage Council of NSW during design development.	CS
Aboriginal heritage		
AH1	Aboriginal stakeholder consultation would be carried out in accordance with the NSW Office of Environment and Heritage's *Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010*.	All
AH2	An Aboriginal cultural heritage assessment report would be prepared in accordance with the OEH *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW*. The Aboriginal cultural heritage assessment report would include: • Details of Aboriginal stakeholder consultation conducted in accordance with AH1 • An assessment of cultural significance for the project area and identification of any specific areas of cultural significance based on consultation with Aboriginal stakeholders • A methodology for archaeological management including test excavation and salvage (refer to AH3).	All
AH3	Archaeological test excavation (and salvage when required) would be carried out where intact natural soil profiles with the potential to contain significant archaeological deposits are encountered at the Blues Point temporary site, Barangaroo Station, Martin Place Station, Pitt Street Station, Central Station, Waterloo Station and Marrickville dive site. Excavations would be conducted in accordance with the methodology outlined in the Aboriginal cultural heritage assessment report	BP, BN, MP, PS, CS, WS, MDS
AH4	Appropriate Aboriginal heritage interpretation would be incorporated into the design for the project in consultation with Aboriginal stakeholders.	All
AH5	Feasible and reasonable mitigation at the ground improvement locations would be identified in consultation with the Office of Environment and Heritage.	GI
AH6	The Aboriginal cultural heritage assessment report would address areas of archeological potential associated with the power supply routes.	PSR
Landscape character and visual amenity		
Construction		
LV1	Where feasible and reasonable, the elements within construction sites would be located to minimise visual impacts, for example materials and machinery would be stored behind fencing.	All except metro rail tunnels
LV2	Existing trees to be retained would be protected prior to the commencement of construction in accordance with Australian Standard *AS4970 the Australian Standard for Protection of Trees on Development Sites and Adjoining Properties.*	All except metro rail tunnels
LV3	Lighting of construction sites would be oriented to minimise glare and light spill impact on adjacent receivers.	All except metro rail tunnels

ID	Mitigation measure	Applicable location (s)[1]
LV4	Visual mitigation would be implemented as soon as feasible and reasonable after the commencement of construction, and remain for the duration of the construction period.	All except metro rail tunnels
LV5	Opportunities for the retention and protection of existing street trees would be identified during detailed construction planning.	All except metro rail tunnels
LV6	The design and maintenance of construction site hoardings would aim to minimise visual amenity and landscape character impacts, including the prompt removal of graffiti. Public art opportunities would be considered.	All except metro rail tunnels
LV7	The selection of materials and colours for acoustic sheds would aim to minimise their visual prominence.	CDS, CN, VC, BN, MP, PS, WS, MDS
LV8	Tunnel boring machine retrieval works at the Blues Point temporary site would be timed to avoid key harbour viewing events.	BP
LV9	Benching would be used where feasible and reasonable at Blues Point temporary site to minimise visual amenity impacts.	BP
Operation		
LV10	Cut off and direct light fittings (or similar technologies) would be used to minimise glare and light spill onto private property.	CDS, AS, MDS
LV11	Where feasible and reasonable, vegetation would be provided to screen and visually integrate sites with the surrounding area.	CDS, AS, MDS
LV12	Identify and implement appropriate landscape treatments for Frank Channon Walk.	STW, CDS
LV13	The architectural treatment of Artarmon substation would minimise visual amenity and landscape character impacts.	AS
LV14	The Harbour cycles sculpture at North Sydney would be reinstated at a location determined in consultation with North Sydney Council.	VC
LV15	The P&O Fountain at 55 Hunter Street would be reinstated at a location determined in consultation with City of Sydney Council.	MP
LV16	Opportunities would be investigated to provide a permanent wall for street art at Marrickville dive site in consultation with Marrickville Council.	MDS
LV17	Noise barriers would be transparent where they are augmenting existing transparent noise barriers.	STW

ID	Mitigation measure	Applicable location (s)[1]
Groundwater and geology		
GWG1	A detailed geotechnical model for the project would be developed and progressively updated during design and construction. The detailed geotechnical model would include: • Assessment of the potential for damage to structures, services, basements and other sub-surface elements through settlement or strain • Predicted changes to groundwater levels, including at nearby water supply works. Where building damage risk is rated as moderate or higher (as per the CIRIA 1996 risk-based criteria), a structural assessment of the affected buildings / structures would be carried out and specific measures implemented to address the risk of damage. With each progressive update of the geotechnical model the potential for exceedance of the following target changes to groundwater levels would be reviewed: • Less than 2.0 metres – general target • Less than 4.0 metres – where deep building foundations present • Less than 1.0 metre – residual soils • Less than 0.5 metre – residual soils (Blues Point) (fill / Aeolian sand). Where a significant exceedance of target changes to groundwater levels are predicted at surrounding land uses and nearby water supply works, an appropriate groundwater monitoring program would be developed and implemented. The program would aim to confirm no adverse impacts on groundwater levels or to appropriately manage any impacts. Monitoring at any specific location would be subject to the status of the water supply work and agreement with the landowner.	All
GWG2	Condition surveys of buildings and structures in the vicinity of the tunnel and excavations would be carried out prior to the commencement of excavation at each site.	All
Soil, contamination, water quality		
Construction		
SCW1	Updated desktop contamination assessments would be carried out for Chatswood dive site, Blues Point temporary site, Barangaroo Station, Central Station and Waterloo Station. If sufficient information is not available to determine the remediation requirements and the impact on potential receivers, then detailed contamination assessments, including collection and analysis of soil and groundwater samples would be carried out. Detailed contamination assessment would also be carried out for the Barangaroo power supply route within Hickson Road and the Marrickville power supply route adjacent to Sydney Park and Camdenville Oval. In the event a Remediation Action Plan is required, these would be developed in accordance with *Managing Land Contamination: Planning Guidelines SEPP 55 – Remediation of Land* (Department of Urban Affairs and Planning and Environment Protection Authority, 1998) and a site auditor would be engaged.	CDS, BP, BN, CS, WS, PSR

ID	Mitigation measure	Applicable location (s)[1]
SCW2	Prior to ground disturbance in high probability acid sulfate areas at Barangaroo Station, Waterloo Station and Marrickville dive site, testing would be carried out to determine the presence of acid sulfate soils. If acid sulfate soils are encountered, they would be managed in accordance with the *Acid Sulfate Soil Manual* (Acid Sulfate Soil Management Advisory Committee, 1998).	BN, WS, MDS
SCW3	Erosion and sediment control measures would be implemented in accordance with *Managing Urban Stormwater: Soils and Construction Volume 1* (Landcom, 2004) and *Managing Urban Stormwater: Soils and Construction Volume 2* (Department of Environment and Climate Change, 2008). Measures would be designed as a minimum for the 80th percentile; 5-day rainfall event.	All except metro rail tunnels
SCW4	Discharges from the construction water treatment plants would be monitored to ensure compliance with the discharge criteria in an environment protection licence issued to the project.	All except metro rail tunnels
SCW5	A silt curtain would be used around the Sydney Harbour ground improvement work barges.	GI
SCW6	A water quality monitoring program would be implemented to monitor water quality within Sydney Harbour during ground improvement work. The water quality monitoring program would be carried out to detect any potential impacts on the water quality of Sydney Harbour from the ground improvement work and inform management responses in the event any impacts are identified. Specific monitoring locations and frequencies would be determined during the development of the program in consultation with the Environment Protection Authority.	GI
Operation		
SCW7	Discharges from the tunnel water treatment plant would be monitored to ensure compliance with the discharge criteria determined in consultation with the NSW Environment Protection Authority.	MDS
Social impacts and community infrastructure		
SO1	Direct impacts to public open space at the Blues Point temporary site would be minimised.	BP
SO2	Specific consultation would be carried out with sensitive community facilities (including aged care, child care centres, educational institutions and places of worship) potentially impacted during construction. Consultation would aim to identify and develop measures to manage the specific construction impacts for individual sensitive community facilities.	All except metro rail tunnels
Biodiversity		
B1	An ecologist would be present during the removal of any hollow-bearing trees.	CDS
B2	Potential bat roosting locations at Central Station, Waterloo Station and Marrickville dive sites would be checked by a qualified ecologist or wildlife handler prior to demolition. Any bats found would be relocated.	CS, WS, MDS
B3	The local WIRES group and / or veterinarian would be contacted if any fauna are injured on site or require capture and / or relocation.	All except metro rail tunnels

ID	Mitigation measure	Applicable location (s)[1]
B4	Procedures would be developed and implemented, in accordance with the National System for the Prevention and Management of Marine Pest Incursions, during Sydney Harbour ground improvement works to avoid transportation of marine pests from other locations, particularly the marine alga *Caulerpa taxifoli*.	GI
Flooding and hydrology		
Construction		
FH1	Detailed construction planning would consider flood risk at Barangaroo Station, Martin Place Station and the Waterloo Station construction sites. This would include identification of measures to avoid, where feasible and reasonable, construction phase flooding impacts on the community and on other property and infrastructure.	BN, MP, WS
FH2	The site layout and staging of construction activities at Marrickville dive site would avoid or minimise obstruction of overland flow paths and limit the extent of flow diversion required.	MDS
FH3	Overland flow diversions during construction at the Marrickville dive site would meet the following criteria: • Increases in flood levels during events up to and including the 100-year average recurrence interval would be minimised particularly within private properties • Any increase in flow velocity for events up to and including a 100-year average recurrence interval event would not increase the potential for soil erosion and scouring • Dedicated evacuation routes would not be adversely impacted in flood events up to and including the probable maximum flood. Construction planning for the Marrickville dive site would be carried out in consultation with the State Emergency Services and Marrickville Council.	MDS
Operation		
FH4	Where feasible and reasonable, detailed design would result in no net increase in stormwater runoff rates in all storm events unless it can be demonstrated that increased runoff rates as a result of the project would not increase downstream flood risk.	STW, AS, MDS
FH5	Where space permits, on-site detention of stormwater would be introduced where stormwater runoff rates are increased. Where there is insufficient space for the provision of on-site detention, the upgrade of downstream infrastructure would be implemented where feasible and reasonable.	STW, AS, MDS
FH6	Detailed design would occur in consultation with Marrickville Council to ensure future drainage improvement works around the Marrickville dive site would not be precluded.	MDS
FH7	Consultation would be carried out with Marrickville Council to ensure flood-related outcomes of the project are consistent with any future floodplain risk management study and / or plan developed for the Marrickville Valley Catchment.	MDS
FH8	The frequency of Sydney Trains rail service disruptions due to flooding would not be increased in the vicinity of the Marrickville dive structure.	MDS

ID	Mitigation measure	Applicable location (s)[1]
FH9	Design of the Marrickville dive structure would be reviewed to, where feasible and reasonable, further reduce flood levels for events up to and including the 100-year annual recurrence interval, including at private properties, within the road reserve at Bolton Street and around Sydenham Station. Flood modelling to support detailed design would be carried out in accordance with the following guidelines: • *Floodplain Development Manual* (NSW Government, 2005) • *Floodplain Risk Management Guideline: Practical Consideration of Climate Change* (DECC, 2007) • *Floodplain Risk Management Guide: Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments* (DECCW, 2010) • *New guideline and changes to section 117 direction and EP&A Regulation on flood prone land, Planning Circular PS 07-003* (NSW Department of Planning, 2007).	MDS
Air Quality		
AQ1	The engines of all on-site vehicles and plant would be switched off when not in use for an extended period.	All
AQ2	Plant would be well maintained and serviced to minimise emissions. Emissions from plant would be considered as part of pre-acceptance checks.	All
AQ3	Construction site layout and placement of plant would consider air quality impacts to nearby receivers.	All except metro rail tunnels
AQ4	Hard surfaces would be installed on long term haul routes and regularly cleaned.	All except metro rail tunnels
AQ5	Unsurfaced haul routes and work area would be regularly damped down in dry and windy conditions.	All except metro rail tunnels
AQ6	All vehicles carrying loose or potentially dusty material to or from the site would be fully covered.	All except metro rail tunnels
AQ7	Stockpiles would be managed to minimise dust generation.	All except metro rail tunnels
AQ8	Demolition would be managed to minimise dust generation.	All except metro rail tunnels
AQ9	Ventilation from acoustic sheds would be filtered.	CDS, CN, VC, BN, MP, PS, WS, MDS
Hazard and risk		
Construction		
HR1	All hazardous substances that may be required for construction would be stored and managed in accordance with the *Storage and Handling of Dangerous Goods Code of Practice* (WorkCover NSW, 2005) and *Hazardous and Offensive Development Application Guidelines: Applying SEPP 33* (Department of Planning, 2011).	All
HR2	Dial before you dig searches and non-destructive digging would be carried out to identify the presence of underground utilities.	All

ID	Mitigation measure	Applicable location (s)[1]
HR3	A hazardous material survey would be completed for those buildings and structures suspected of containing hazardous materials (particularly asbestos) prior to their demolition. If asbestos is encountered, it would be handled and managed in accordance with relevant legislation, codes of practice and Australian standards.	CDS, CN, VC, MP, PS, CS, WS, MDS
HR4	The method for delivery of explosives would developed prior to the commencement of blasting in consultation with the Department of Planning and Environment and be timed to avoid the need for on-site storage.	CN, VC, BN, MP, PS, WS
Operation		
HR5	All hazardous substances that may be required for operation would be stored and managed in accordance with the Storage and Handling of Dangerous Goods Code of Practice (WorkCover NSW, 2005) and *Hazardous and Offensive Development Application Guidelines: Applying SEPP 33* (Department of Planning, 2011).	All
Waste management		
Construction		
WM1	All waste would be assessed, classified, managed and disposed of in accordance with the *NSW Waste Classification Guidelines.*	All
WM2	100 per cent of spoil that can be reused would be beneficially reused in accordance with the project spoil reuse hierarchy.	All
WM3	A recycling target of at least 90 per cent would be adopted for the project.	All
WM4	Construction waste would be minimised by accurately calculating materials brought to the site and limiting materials packaging.	All
Operation		
WM5	Generation of operation phase waste would be minimised.	All
Sustainability		
Construction		
SUS1	Sustainability initiatives would be incorporated into the detailed design and construction of the project to support the achievement of the project sustainability objectives.	All
SUS2	A best practice level of performance would be achieved using market leading sustainability rating tools during design and construction.	All
SUS3	A workforce development and industry participation strategy would be developed and implemented during construction.	All

ID	Mitigation measure	Applicable location (s)[1]
SUS4	Climate change risk treatments would be incorporated into the detailed design of the project including: • Ensuring that adequate flood modelling is carried out and integrated with design • Testing the sensitivity of air-conditioning systems to increased temperatures, and identify potential additional capacity of air-conditioning systems that may be required within the life of the project, with a view to safeguarding space if required • Testing the sensitivity of ventilation systems to increased temperatures and provide adequate capacity.	All
SUS5	An iterative process of greenhouse gas assessments and design refinements would be carried out during detailed design and construction to identify opportunities to minimise greenhouse gas emissions. Performance would be measured in terms of a percentage reduction in greenhouse gas emissions from a defined reference footprint.	All
SUS6	25 per cent of the greenhouse gas emissions associated with consumption of electricity during construction would be offset.	All
Operation		
SUS7	Sustainability initiatives would be incorporated into the operation of the project to support the achievement of the project sustainability objectives.	All
SUS8	Periodic review of climate change risks would be carried out to ensure ongoing resilience to the impacts of climate change.	All
SUS9	A workforce development and industry participation strategy would be developed and implemented during operation.	All
SUS10	100 per cent of the greenhouse gas emissions associated with consumption of electricity during operation would be offset.	All

ID	Mitigation measure	Applicable location (s) [1]
Cumulative impacts		

CU1	Transport for NSW would manage and co-ordinate the interface with projects under construction at the same time. Co-ordination and consultation with the following stakeholders would occur, where required:
	- CBD Coordination Office
	- Department of Planning and Environment
	- Roads and Maritime Services
	- Sydney Trains
	- NSW Trains
	- Sydney Buses
	- Sydney Water
	- Port Authority of NSW
	- Willoughby Council
	- North Sydney Council
	- City of Sydney Council
	- Marrickville Council
	- Sydney Motorways Corporation
	- Barangaroo Delivery Authority
	- Emergency service providers
	- Utility providers
	- Construction contractors.
	Co-ordination and consultation with these stakeholders would include:
	- Provision of regular updates to the detailed construction program, construction sites and haul routes
	- Identification of key potential conflict points with other construction projects
	- Developing mitigation strategies in order to manage conflicts. Depending on the nature of the conflict, this could involve:
	  - Adjustments to the Sydney Metro construction program, work activities or haul routes; or adjustments to the program, activities or haul routes of other construction projects
	  - Co-ordination of traffic management arrangements between projects.
		All

5 Environmental performance outcomes

The Secretary's environmental assessment requirements identify a number of desired performance outcomes. These desired performance outcomes outline the broader objectives to be achieved by the proponent in the design, construction and operation of the project.

Table 5-1 identifies the environmental performance outcomes based on the outcomes of the assessment (identified in Section 3) and the implementation of the mitigation measures (identified in Section 4). Future design development and any design changes would be considered against these environmental performance outcomes.

Table 5-1 Environmental performance outcomes

Relevant Secretary's environmental assessment requirements desired performance outcomes	Environmental performance outcome
Construction traffic and transport	
Transport and traffic Network connectivity, safety and efficiency of the transport system in the vicinity of the project are managed to minimise impacts. The safety of transport system customers is maintained. Impacts on network capacity and the level of service are effectively managed. Works are compatible with existing infrastructure and future transport corridors.	• The project would minimise impacts to the road network • Pedestrian and cyclist safety would be maintained • Effective coordination would be carried out to minimise cumulative network impacts • Access to properties would be maintained.
Operational traffic and transport	
Transport and traffic Network connectivity, safety and efficiency of the transport system in the vicinity of the project are managed to minimise impacts. The safety of transport system customers is maintained. Impacts on network capacity and the level of service are effectively managed. Works are compatible with existing infrastructure and future transport corridors.	• The project would appropriately integrate with existing and planned future transport infrastructure including active transport • Access to properties would be maintained • Metro customers would be provided with a safe and secure service • The project would reduce station crowding, increase rail network reach and use, improve network resilience, and improve travel times within the global economic corridor.
Construction noise and vibration	
• Noise and vibration – amenity Construction noise and vibration (including airborne noise, ground-borne noise and blasting) are effectively managed to minimize adverse impacts on acoustic amenity. **Noise and vibration – structural** Construction noise and vibration (including airborne noise, ground-borne noise and blasting) are effectively managed to minimize adverse impacts on the structural integrity of buildings and items including Aboriginal places and environmental heritage.	• Noise levels would be minimised with the aim of achieving the noise management levels where feasible and reasonable • The project would avoid any damage to buildings from vibration.

Relevant Secretary's environmental assessment requirements desired performance outcomes	Environmental performance outcome
Operational noise and vibration	
Noise and vibration – amenity Increases in noise emissions and vibration affecting nearby properties and other sensitive receivers during operation of the project are effectively managed to protect the amenity and well-being of the community. **Noise and vibration – structural** Increases in noise emissions and vibration affecting environmental heritage as defined in the *Heritage Act 1977* during operation of the project are effectively managed.	• Noise levels would comply with the *Rail Infrastructure Noise Guidelines* (Environment Protection Authority, 2013). • The project would avoid any damage to buildings from vibration.
Landuse and property	
Socio-economic, land use and property The project minimises impacts to property and business and achieves appropriate integration with adjoining land uses, including maintenance of appropriate access to properties and community facilities, and minimisation of displacement of existing land use activities, dwellings and infrastructure.	• The project would be appropriately integrated into local landuse planning strategies • The surface footprint of the project would be minimised • The project would provide substantial future development opportunities.
Business impacts	
Socio-economic, land use and property The project minimises adverse social and economic impacts and capitalises on opportunities potentially available to affected communities. The project minimises impacts to property and business and achieves appropriate integration with adjoining land uses, including maintenance of appropriate access to properties and community facilities, and minimisation of displacement of existing land use activities, dwellings and infrastructure.	• The project would minimise impacts on businesses during construction • During operation, the project would improve access to businesses for employees and customers, and connectivity between businesses within the global economic corridor.
Non-Aboriginal heritage	
Heritage The design, construction and operation of the project facilitates, to the greatest extent possible, the long term protection, conservation and management of the heritage significance of items of environmental heritage and Aboriginal objects and places. The design, construction and operation of the project avoids or minimises impacts, to the greatest extent possible, on the heritage significance of environmental heritage and Aboriginal objects and places.	• The project would be sympathetic to heritage items and, where feasible and reasonable, avoid and minimise impacts to non-Aboriginal heritage items and archaeology • The design of the project would reflect the input of an independent heritage architect, relevant stakeholders and the design review panel.

Relevant Secretary's environmental assessment requirements desired performance outcomes	Environmental performance outcome
Aboriginal heritage	
Heritage The design, construction and operation of the project facilitates, to the greatest extent possible, the long term protection, conservation and management of the heritage significance of items of environmental heritage and Aboriginal objects and places. The design, construction and operation of the project avoids or minimises impacts, to the greatest extent possible, on the heritage significance of environmental heritage and Aboriginal objects and places.	• The project would be sympathetic to heritage items and, where feasible and reasonable, avoid and minimise impacts to Aboriginal heritage items and archaeology • The design of the project would reflect the input of an independent heritage architect, relevant stakeholders and the design review panel.
Landscape character and visual amenity	
Urban design The project design complements the visual amenity, character and quality of the surrounding environment. The project contributes to the accessibility and connectivity of communities. **Visual amenity** The project minimises adverse impacts on the visual amenity of the built and natural environment (including public open space) and capitalises on opportunities to improve visual amenity.	• During operation, the project would make a positive contribution to the quality of the urban environment at each station site • During operation, the project would minimise change to landscape character in the vicinity of the dive structures and Artarmon substation • The project would be visually integrated with its surroundings.
Groundwater and geology	
Water – hydrology Long term impacts on surface water and groundwater hydrology (including drawdown, flow rates and volumes) are minimised. The environmental values of nearby, connected and affected water sources, groundwater and dependent ecological systems including estuarine and marine water (if applicable) are maintained (where values are achieved) or improved and maintained (where values are not achieved). Sustainable use of water resources.	• The project would make good any impacts on groundwater users • The project would avoid any damage to buildings from settlement.

Relevant Secretary's environmental assessment requirements desired performance outcomes	Environmental performance outcome
Soils, contamination and water quality	
Soils The environmental values of land, including soils, subsoils and landforms, are protected. Risks arising from the disturbance and excavation of land and disposal of soil are minimised, including disturbance to acid sulfate soils and site contamination. **Water – quality** The project is designed, constructed and operated to protect the NSW Water Quality Objectives where they are currently being achieved, and contribute towards achievement of the Water Quality Objectives over time where they are currently not being achieved, including downstream of the project to the extent of the project impact including estuarine and marine waters (if applicable).	• Erosion and sediment controls during construction would be implemented in accordance with *Managing Urban Stormwater: Soils and Construction Volume 1* (Landcom, 2004) and *Managing Urban Stormwater: Soils and Construction Volume 2* (Department of Environment and Climate Change, 2008a) • There would be no impacts on aquatic environments associated with the disturbance of acid sulfate soils during construction • Any contamination on project sites would be remediated to suit future land use • The project would protect or contribute to achieving the Water Quality Objectives, during construction and operation • Construction water quality discharge would comply with the requirements of an environment protection licence issued to the project • Operation water quality discharge would comply with a discharge criteria determined in consultation with the NSW Environment Protection Authority.
Social impacts and community facilities	
Socio-economic, land use and property The project minimises adverse social and economic impacts and capitalises on opportunities potentially available to affected communities. The project minimises impacts to property and business and achieves appropriate integration with adjoining land uses, including maintenance of appropriate access to properties and community facilities, and minimisation of displacement of existing land use activities, dwellings and infrastructure.	• The project would avoid long term impacts (during operation) on the availability and quality of public open space and community facilities • The project, during operation, would help to improve access to local facilities, services and destinations, supporting opportunities for community interaction.

Relevant Secretary's environmental assessment requirements desired performance outcomes	Environmental performance outcome
Biodiversity	
Biodiversity The project design considers all feasible measures to avoid and minimise impacts on terrestrial and aquatic biodiversity. Offsets and/or supplementary measures are assured which are equivalent to any remaining impacts of project construction and operation.	• The biodiversity outcome would be consistent with the Framework for Biodiversity Assessment • The project would minimise impacts to biodiversity.
Flooding and hydrology	

Flooding
The project minimises adverse impacts on existing flooding characteristics. Construction and operation of the project avoids or minimises the risk of, and adverse impacts from, infrastructure flooding, flooding hazards, or dam failure.
Water – hydrology
Long term impacts on surface water and groundwater hydrology (including drawdown, flow rates and volumes) are minimised. The environmental values of nearby, connected and affected water sources, groundwater and dependent ecological systems including estuarine and marine water (if applicable) are maintained (where values are achieved) or improved and maintained (where values are not achieved).
Sustainable use of water resources.
	• Changes to overland flow diversions during construction would meet the following criteria:
	  ♦ Increases in flood levels during events up to and including the 100-year average recurrence interval would be minimised particularly within private properties
	  ♦ Any increase in flow velocity for events up to and including a 100-year average recurrence interval event would not increase the potential for soil erosion and scouring
	  ♦ Dedicated evacuation routes would not be adversely impacted in flood events up to and including the probable maximum flood.
	• There would be no additional private properties affected by flooding up to and including the 100-year average recurrence interval event during operation
	• Flood levels would be increased by a maximum of 470 mm during the 100-year average recurrence interval event in the vicinity of the Marrickville dive structure during operation
	• The performance of the downstream drainage network would be maintained during operation.

Relevant Secretary's environmental assessment requirements desired performance outcomes	Environmental performance outcome
Air quality	
There are no Secretary's environmental assessment requirements relevant to air quality.	- Dust and exhaust emissions during construction would be minimised.
Hazard and risk	
There are no Secretary's environmental assessment requirements relevant to hazard and risk.	- The storage, use and transport of dangerous goods and hazardous substances would comply with *Hazardous and Offensive Development Application Guidelines: Applying SEPP 33* (Department of Planning, 2011) - There would be no unplanned or unexpected disturbance of utilities.
Waste Management	
Waste All wastes generated during the construction and operation of the project are effectively stored, handled, treated, reused, recycled and/or disposed of lawfully and in a manner that protects environmental values.	- All waste would be assessed, classified, managed and disposed of in accordance with the NSW Waste Classification Guidelines - 100 per cent of spoil that can be reused would be beneficially reused in accordance with the project spoil reuse hierarchy. - A recycling target of at least 90 per cent would be adopted for the construction of the project.
Sustainability	
Sustainability The project reduces the NSW Government's operating costs and ensures the effective and efficient use of resources. Conservation of natural resources is maximised.	- The project would be carried out in accordance with the Sydney Metro City & Southwest Environment and Sustainability Policy - 25 per cent of the greenhouse gas emissions associated with consumption of electricity during construction would be offset - 100 per cent of the greenhouse gas emissions associated with consumption of electricity during operation would be offset.

6 Justification and conclusions

Rail is, and will continue to be, the dominant mode of public transportation for commuters traveling to and from the Sydney CBD. It is projected that travel by rail will experience the highest growth in demand when compared to buses and car use. Sydney Metro, together with signalling and infrastructure upgrades across the existing network, would increase the capacity of the rail network through the Sydney CBD from about 120 per hour during peak periods today, to up to 200 services per hour beyond 2024, including capacity for up to 60 metro trains per hour during peak periods (or 30 trains per hour in each direction). This would equate to an increase of up to 60 per cent capacity across the network. Sydney Metro would also result in travel time improvements and a reduction in congestion on trains and platforms.

Alternative transport modes would have limited capacity to absorb Sydney's forecast long-term travel demand growth. For example while extra buses can carry more people, these services would not be necessarily faster or more reliable. Without measures to improve journey times, adding more buses would add to congestion and each bus becomes less effective in meeting customer needs.

The justification of the project has been based on project need, how well the project satisfies its project objectives, having regard to the biophysical, economic and social considerations including the principles of ecologically sustainable development and cumulative impacts.

6.1 Project need

The project has been developed within the framework of the transport and planning strategies identified in State government policies. In particular this includes the 12 NSW Premier priorities (established to grow the economy, deliver infrastructure, and improve health, education and other services across NSW), *Sydney's Rail Future: Modernising Sydney's Trains, Draft Metropolitan Strategy for Sydney 2031* and the *NSW Long Term Transport Master Plan.*

These polices indicate a strategic need to:

- Significantly increase transport capacity in key parts of the network, especially to the Sydney CBD and the Global Economic Corridor
- Drive productivity through integrated transport and land use planning to realise the productivity benefits of having businesses close together enabling increased interaction, knowledge sharing and collaboration
- Effectively develop infrastructure to cement Sydney's position among the world's most liveable cities and Australia's only global city.

Sydney Metro would deliver a step-change in the capacity of Sydney's rail network by providing a fully automated rail system across Sydney, supporting high demand with a high capacity, turn-up-and-go service.

Sydney Metro, together with signalling and infrastructure upgrades across the existing network, would increase the capacity of the rail network through the Sydney CBD from about 120 per hour during peak periods today, to up to 200 services per hour beyond 2024, including capacity for up to 60 metro trains per hour during peak periods (or 30 trains per hour in each direction). This would equate to an increase of up to 60 per cent capacity across the network. This means that the railway network across greater Sydney would have room for an extra 100,000 train customers per hour in the peak. The fully automated, Sydney Metro network would have the ultimate capacity to operate 30 trains an hour through the Sydney CBD in each direction – a train every two minutes each way. The proposed new stations would alleviate congestion at Wynyard, Town Hall, Central, Redfern and Green Square stations.

Other key benefits of the project include:

- Doubling the number of train paths available from the north
- Strengthening connections and access across Sydney, particularly within the Global Economic Corridor
- Providing new connections to the rail network – including connections to the T4 Eastern Suburbs Line, and direct connections between the Sydney CBD with the north west
- Improving the capacity, reliability and efficiency of the existing transport system, by relieving the pressure on existing rail lines, Sydney CBD train stations, Sydney CBD, North Sydney and Sydney South bus routes, and the Sydney CBD road network
- Providing the opportunity for urban development opportunities particularly around the new stations at Crows Nest, Victoria Cross, Barangaroo and Waterloo
- Providing the opportunity for the progressive renewal of the ageing Waterloo social housing estate including a mix of private, affordable and social housing
- Improving network resilience through the Sydney CBD and across Sydney Harbour by providing an additional route during planned and unplanned events affecting other Sydney CBD and harbour links
- Health benefits with the creation of safer and more appealing conditions for pedestrians, cyclists and other transit users in the areas around the stations.

Sydney Metro would also provide important urban renewal and development opportunities through the application of transit oriented development principles that support government objectives to achieve a more sustainable and efficient use of land to meet Sydney's growth.

6.2 Project objectives

Table 6-1 provides a summary assessment of how project would satisfy its objectives.

Table 6-1 Summary assessment of project objectives

Project objectives	Assessment
Improve the quality of the transport experience for customers	• New Sydney CBD stations and platforms provided at Barangaroo, Martin Place, Pitt Street and Central would spread station loading and decrease crowding at Wynyard and Town Hall Stations • The project is being developed with an emphasis on supporting the needs of customers for 'door to door' journeys from origin to destination. It would deliver a new tier for Sydney's rail network, supporting high demand with a high-capacity, turn-up-and-go service. 'Turn up and go' frequencies means there is no need for a timetable • Operational performance requirements that include 98 per cent on time running and clean platforms and trains • Wheelchair spaces, separate priority seating and emergency intercoms inside trains • Safety benefits including security cameras on trains and the ability for customers to see inside the train from one end to the other • Video help points at platforms, connecting directly with train controllers – an Australian first • Level access between the platform and train and three double doors per side per carriage for faster loading and unloading.
Provide a transport system that is able to satisfy long-term demand	• Provides the largest increase in capacity to the Sydney rail network for 80 years • At ultimate capacity, the Sydney Metro network would be able to run up to 30 trains per hour in each direction through Sydney's CBD, providing the foundation for a 60 per cent increase in the number of trains that could operate in the peak periods and catering for an extra 100,000 customers per hour. At ultimate capacity, the Chatswood to Sydenham component would provide additional capacity for more than 40,000 passengers per hour through the Sydney CBD in each direction.
Grow public transport patronage and mode share	• The railway network across greater Sydney would have room for an extra 100,000 train customers per hour.
Support the productivity of the Global Economic Corridor	• Provides faster and more reliable access and by fostering clusters of activities that support more economic growth. In particular this would include improvement to links to the strategic centres of Chatswood, Macquarie Park, Castle Hill, Norwest and Rouse Hill.
Serve and stimulate urban development	• Provides opportunities for a higher intensity of land use around new stations, including potential higher density residential areas which could offer more affordable housing options with better access to services and employment, and support more liveable, vibrant communities.
Improve the resilience of the transport network	• Provides an additional route during planned and unplanned events affecting other Sydney CBD and harbour links.
Improve the efficiency and cost effectiveness of the public transport system	• Increases service accessibility and rail capacity across the Sydney CBD, particularly at Wynyard and Town Hall stations, through the provision of new stations at Barangaroo, Martin Place and Pitt Street • Provides extra connectivity and interchange capacity at Central Station and Martin Place.

Project objectives	Assessment
Implement a feasible solution recognising impacts, constraints and delivery risk.	- Impacts have been reduced through a comprehensive assessment process including close iteration and interactions between the design and environment specialists. Previous, current and ongoing stakeholder and community consultation would also help to improve project outcomes and reduce impacts - The project represents the best value for money.

6.3 Biophysical, economic and social considerations

Sydney Metro would significantly improve reliability across the rail network by addressing current and emerging constraints such as train crowding, platform and station crowding, and network complexity. It would be capable of carrying more people, more quickly, than any other form of public transport ever seen in Sydney.

Sydney Metro would improve travel times for customers by providing more direct connections to higher capacity Sydney CBD stations (such as Martin Place and Pitt Street) and improved interchange capability at key locations such as Central Station, including reduced train and station crowding on the existing rail network. It would also result in benefits for customers using the existing bus network as there would be fewer buses accessing the Sydney CBD.

Sydney Metro would provide important urban renewal and development opportunities through the application of transit oriented development principles that support government objectives to achieve a more sustainable and efficient use of land to meet Sydney's growth. Medium and higher density dwellings realised by transit oriented development are demonstrated to have a lower average consumption profile of electricity, gas and water when compared to lower density dwellings and therefore result in improved resource use / conservation and savings for household budgets.

In addition to the broader Sydney transport operational benefits, the 'door-to-door' experience provided by Sydney Metro would result in major health benefits with the creation of safer and more appealing conditions for pedestrians, cyclists and other transit users.

Specific biophysical, economic and social issues have been considered and assessed in the impact assessment as summarised in Section 3. Key biophysical, economic and social considerations have also been incorporated in the principles of ecologically sustainable development as identified in Section 6.4.

6.4 Principles of ecologically sustainable development

Table 6-2 provides a summary assessment of how project would meet the principles of ecologically sustainable development.

Table 6-2 Summary assessment of the principles of ecologically sustainable development

Principle	Assessment
Precautionary principle	The detailed assessment carried out in preparing this Environmental Impact Statement indicates that there would be no threat of serious or irreversible damage to the environment. In addition the lack of full scientific certainty has not been used as a reason for postponing measures to prevent environmental degradation. For example targeted threatened species which were not found during the field surveys have, in line with the precautionary principle, been assumed to be present in the study area.

Principle	Assessment
Intergenerational equity	Once operational, the project would leave a positive legacy for future generations. It would provide long term benefits by strengthening connections and access across Sydney, providing improved connectivity on the rail network and improving the capacity, reliability and efficiency of the existing transport system.
	In addition to the broader Sydney transport operational benefits, the 'door-to-door' experience provided by Sydney Metro would also result in long-term health benefits with the creation of safer and more appealing conditions for pedestrians, cyclists and other transit users. These benefits would also flow through to future generations.
Conservation of biological diversity and ecological integrity	The project construction footprint has been developed to avoid or minimise impact to areas of high ecological value. Detailed assessments have been carried out to identify flora and fauna impacts and a range of mitigation measures identified for implementation. Impacts on biological diversity and ecological integrity have been assessed as minor.
Improved valuation and pricing of environmental resources	Economic appraisal of the project draws on a number of established methodologies which provide for the valuation of externalities, including environmental externalities, and their inclusion in the appraisal process. Environmental parameters which can be valued include air pollution, greenhouse gas emissions, noise pollution, water run-off, nature and landscape and urban separation.
	The value placed on the environment was inherent in the development of the project design. In addition the costs associated with the planning and design of measures to avoid or minimise adverse environmental impacts and the costs to implement them have been built into the overall project costs. Ongoing and detailed design of the project together with specific issue-based management plans would represent further commitment to the recognition of the value of protecting environmental resources.

6.5 Conclusions

The project has been justified in relation to its strategic transport need and its anticipated benefits, taking into account the objectives of the *Environmental Planning and Assessment Act 1979* and matters of ecologically sustainable development. The project is considered to best meet the objectives when compared to all other alternatives considered.

Key environmental issues have been examined throughout the design development process. Consultation has been carried out with affected stakeholders to identify key potential impacts at an early stage, and where possible, avoided or appropriate mitigation measures developed. This has resulted in a number of design changes that have mitigated many of the potential significant impacts. Provided the measures and commitments specified in the Environmental Impact Statement are applied and effectively implemented during the design, construction and operational phases, the identified environmental impacts are considered to be acceptable and manageable.