

# **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
<b>2. Environmental Impact Statement</b>		
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).
<b>19. Utilities</b>		
19.1	The proponent must consider: <ul style="list-style-type: none"> <li>a. the impact of the project on the integrity of truck assets and the need to augment or relocate</li> <li>b. opportunities to support initiatives adopted by Councils and utilities providers</li> <li>c. how access to assets will be maintained during construction.</li> </ul>	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	<ul style="list-style-type: none"> <li>○ 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</li> <li>○ 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</li> <li>○ 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</li> <li>○ 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</li> <li>○ Development of haul routes to minimise impacts on the road network.</li> </ul>
Noise	<ul style="list-style-type: none"> <li>○ Location of the two main tunnel boring machine support sites (at Chatswood and Marrickville) on light industrial land to minimise noise to residential areas</li> <li>○ Arrangement of haul routes to minimise the use of local roads</li> <li>○ Adoption of blasting as an excavation method at station sites to minimise the duration of impacts associated with rock hammering.</li> </ul>
Property and land use	<ul style="list-style-type: none"> <li>○ 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</li> <li>○ Construction footprints consistent with operational footprint as much as feasible to minimise property acquisition</li> <li>○ Barangaroo Station construction site arranged to minimise the potential to delay the adjacent Barangaroo development.</li> </ul>
Groundwater	<ul style="list-style-type: none"> <li>○ 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.</li> </ul>
Social and community facilities	<ul style="list-style-type: none"> <li>○ 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.</li> </ul>
Waste	<ul style="list-style-type: none"> <li>○ 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.</li> </ul>

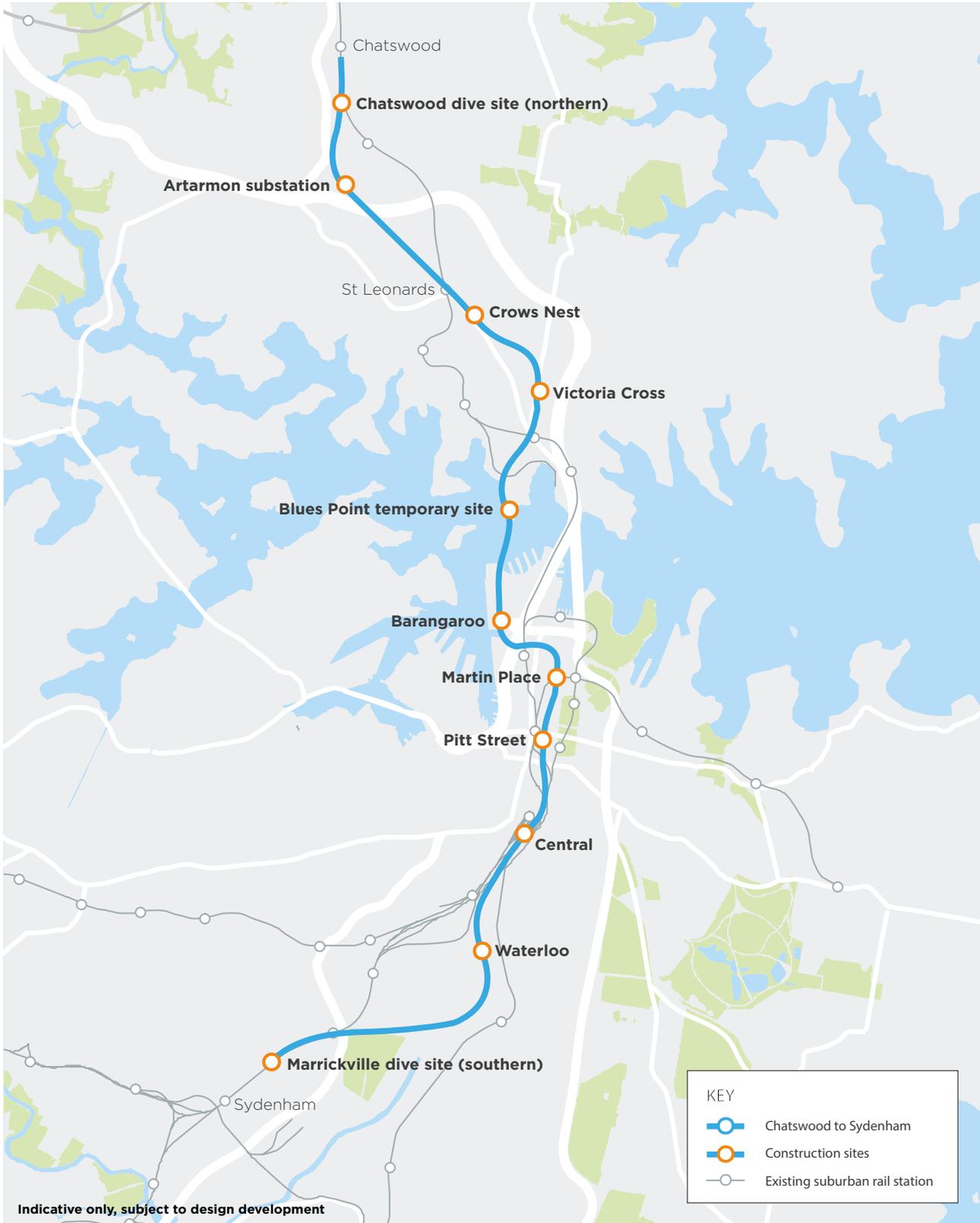


Figure 7-1 Construction sites



## 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<sup>2</sup>

### 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 m<sup>2</sup>

### **Sydney Harbour sediment ground improvement**

Due to 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.

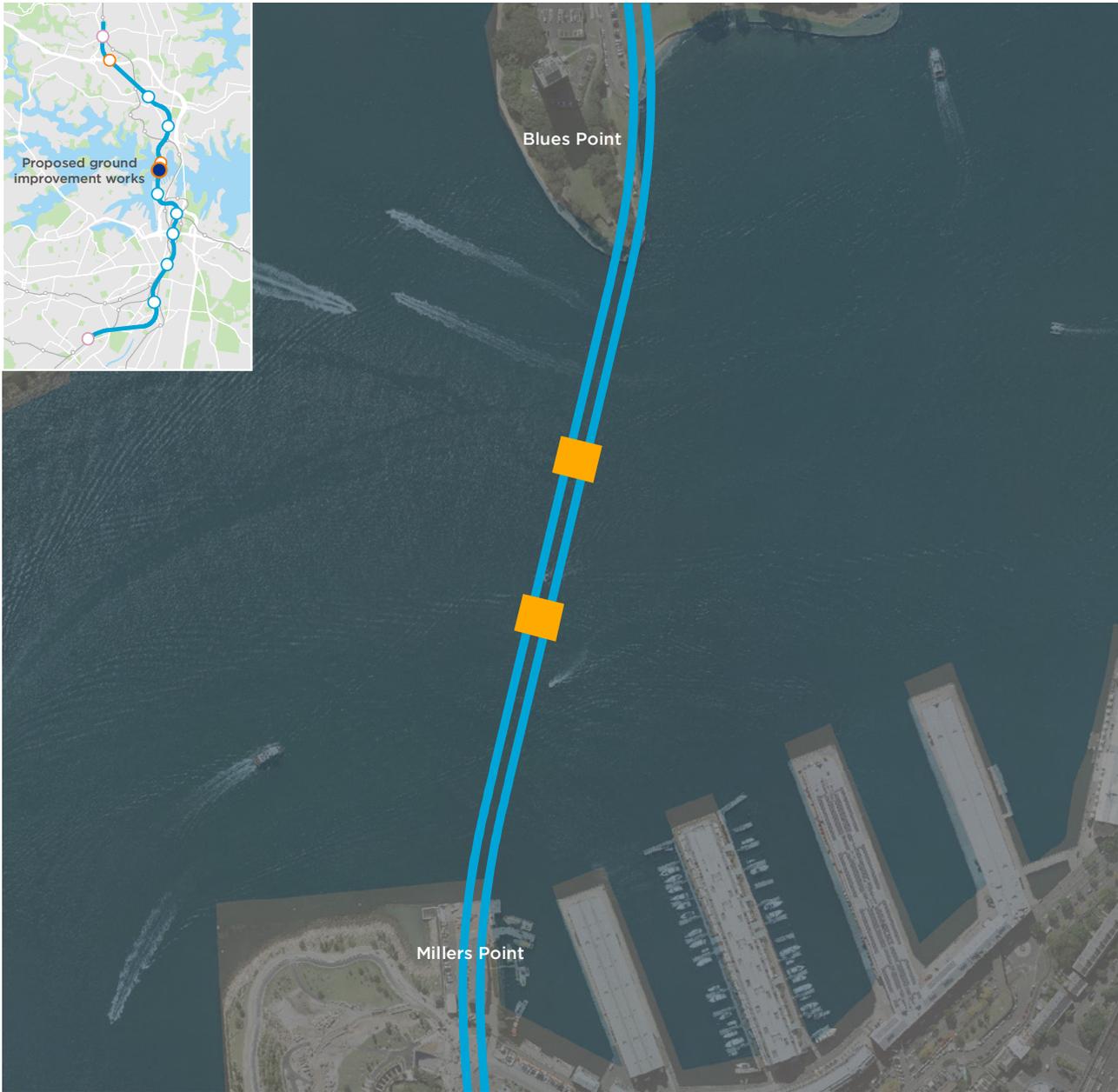
Based on the current design, the preferred method of ground improvement is through jet grouting, although alternative approaches such as ground freezing may be considered during detailed design. Jet grouting would involve the injection of a cement grout from barges via a crane and drilling lead. This 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.



**KEY**  
— Chatswood to Sydenham    ■ Proposed ground improvement work

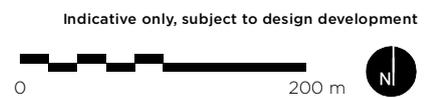


Figure 7-2 Indicative locations of ground improvement work

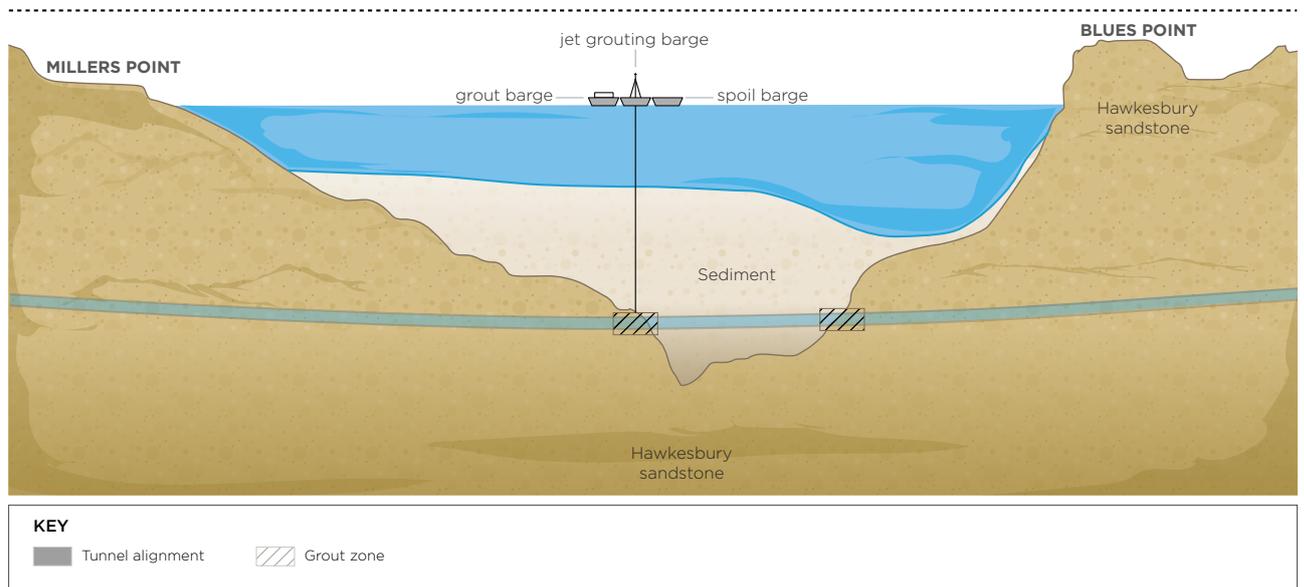


Figure 7-3 Ground improvement work process

## 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.

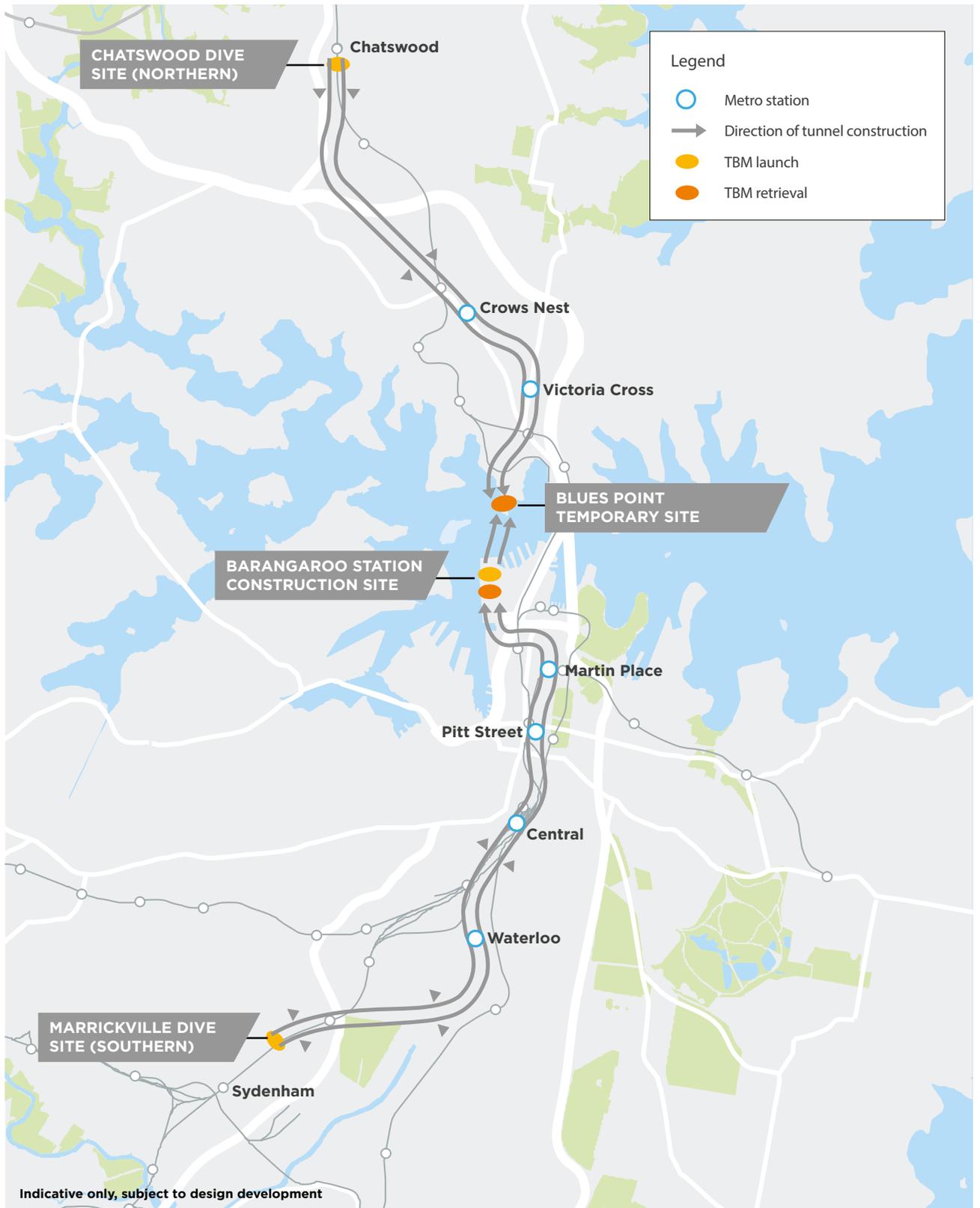


Figure 7-4 Indicative tunnelling sequence

### 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
<b>Fresh air ventilation</b>	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.
<b>Track slab and rail fastening</b>	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)).
<b>Rail installation, fixing and welding</b>	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.
<b>Cable and equipment installation</b>	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.
<b>Overhead traction power</b>	Overhead traction power is likely to be provided through a conductor bar with a main support located centrally over the track.
<b>Other equipment</b>	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.

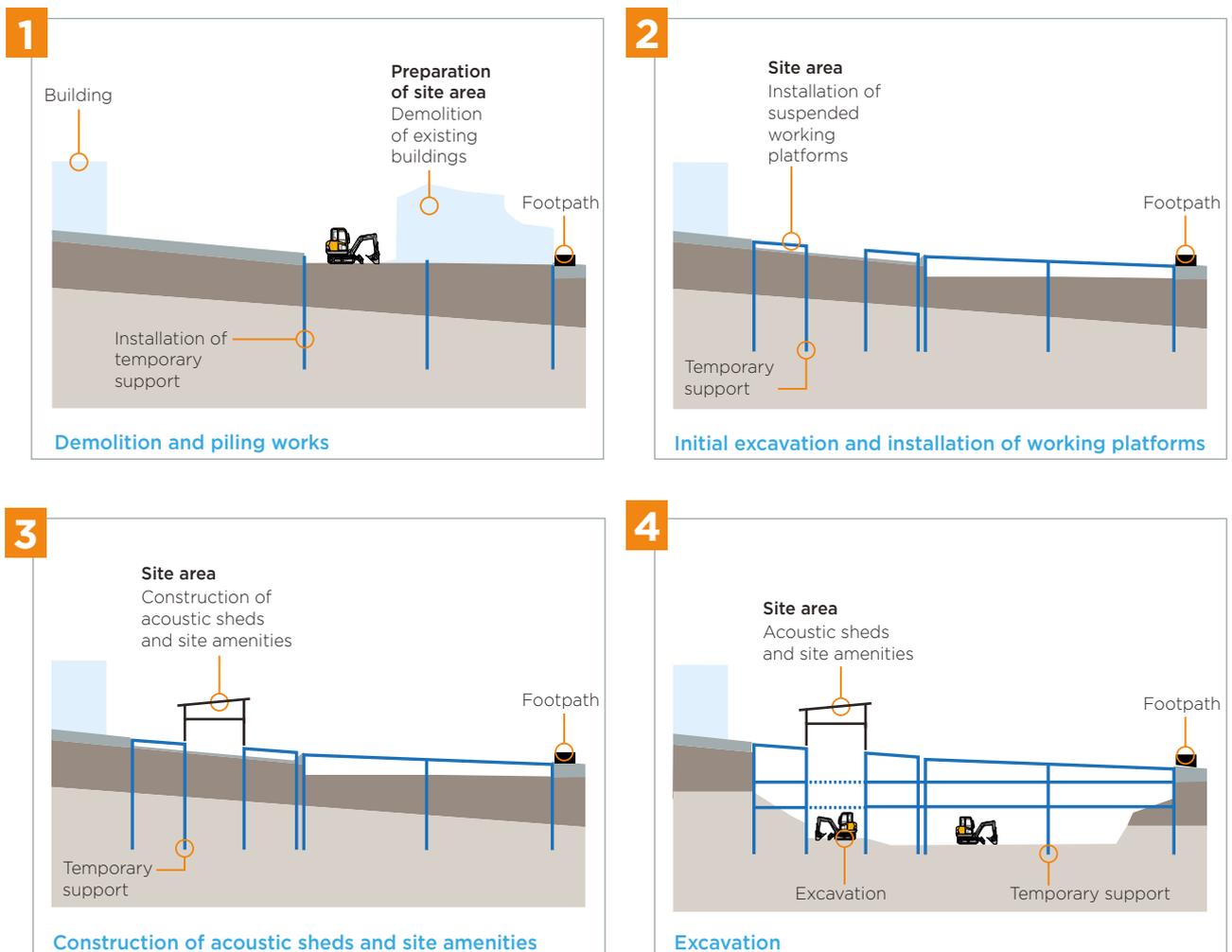


Figure 7-5 Typical cut-and-cover station construction

### 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.

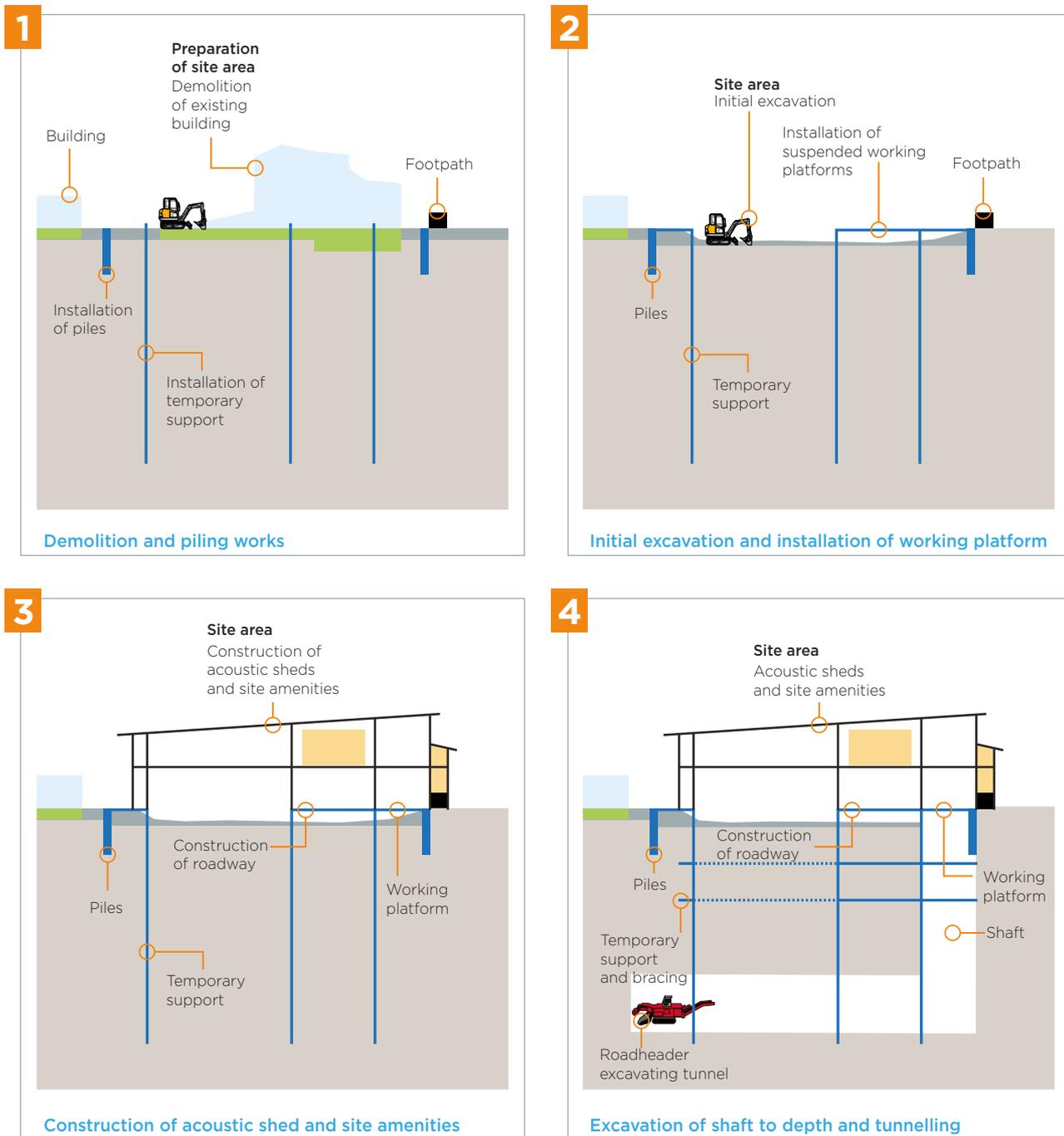


Figure 7-6 Typical mined station construction

## 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.

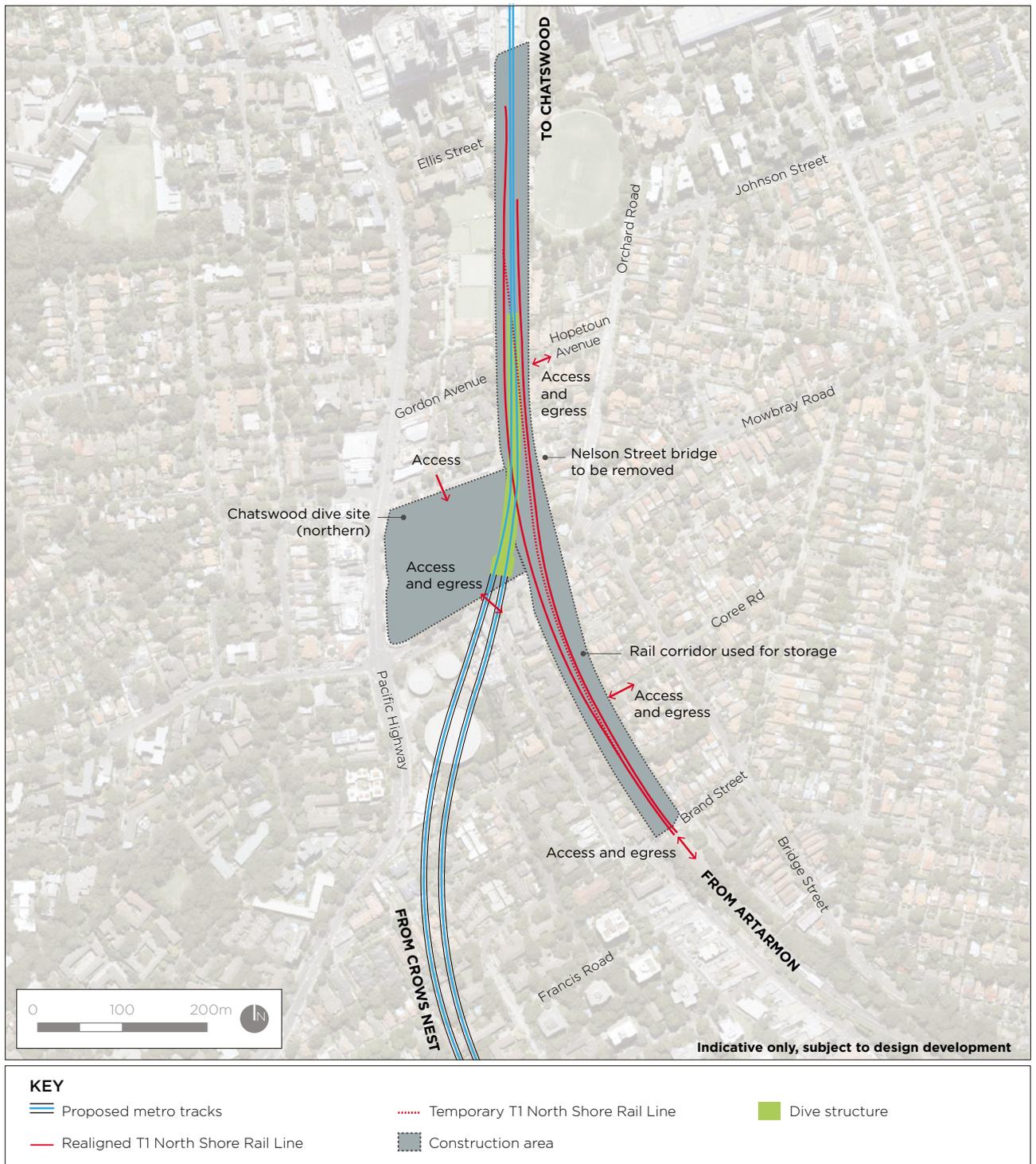


Figure 7-7 Northern surface track works

## 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 (m <sup>2</sup> )	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**

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 Blues Point									●	—	—	—	●																				
Tunnel rail systems fitout																	●	—	—	—	●												
T1 North Shore Line surface works					●	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
Metro surface works																	●	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
Rail systems testing and commissioning																					●	—	—	—	—	—	—	—	—	—	—	—	

### **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																																

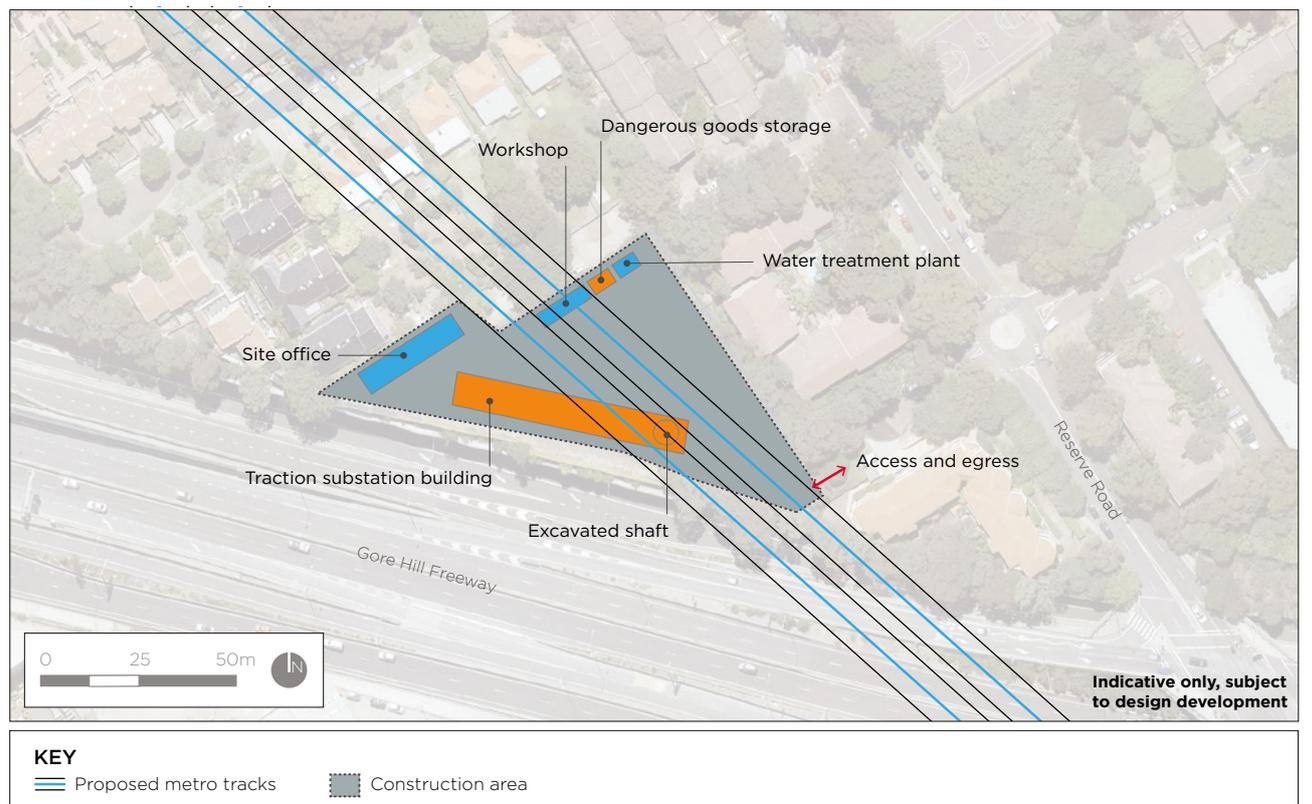


Figure 7-9 Artarmon substation construction site indicative layout

### 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 retrieval (Barangaroo drive 1)																																
TBM Retrieval (northern drives)													●	—	●																	
TBM retrieval (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 construction 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 retrieval (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.

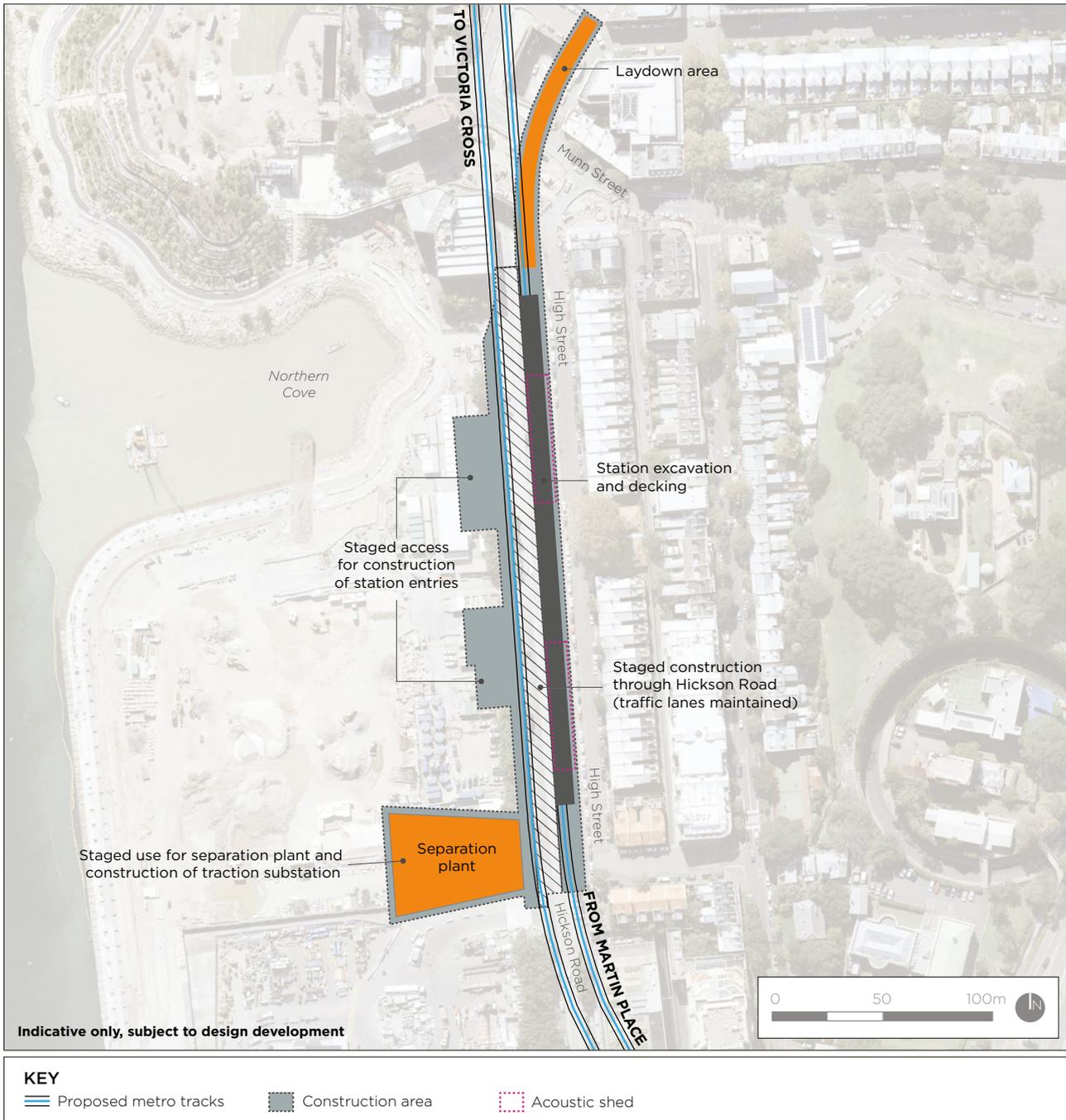


Figure 7-13 Barangaroo Station construction site indicative layout

### 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																																	

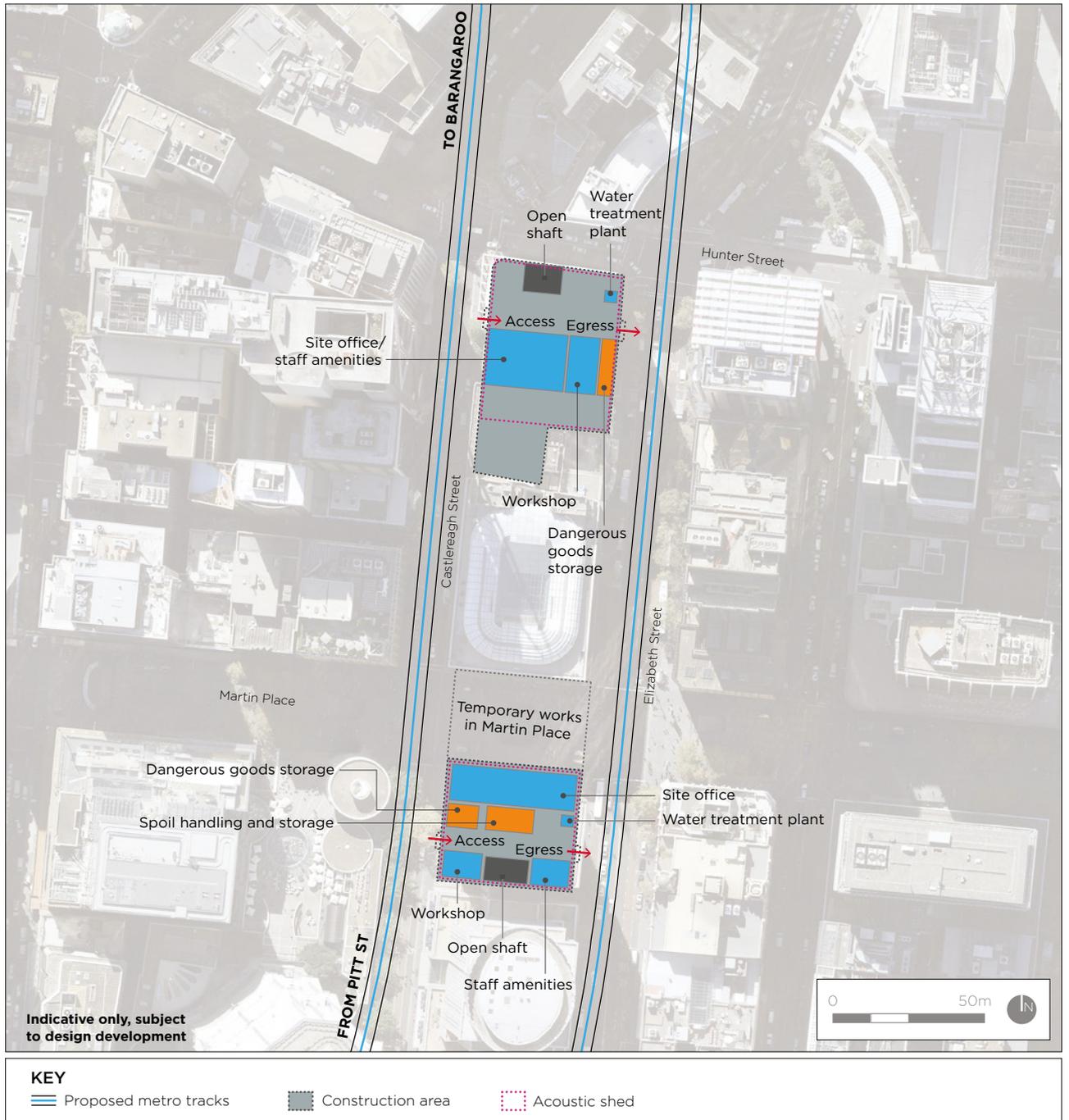


Figure 7-14 Martin Place Station construction sites indicative layout

### 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**

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 7-15 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**

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																					●——●											

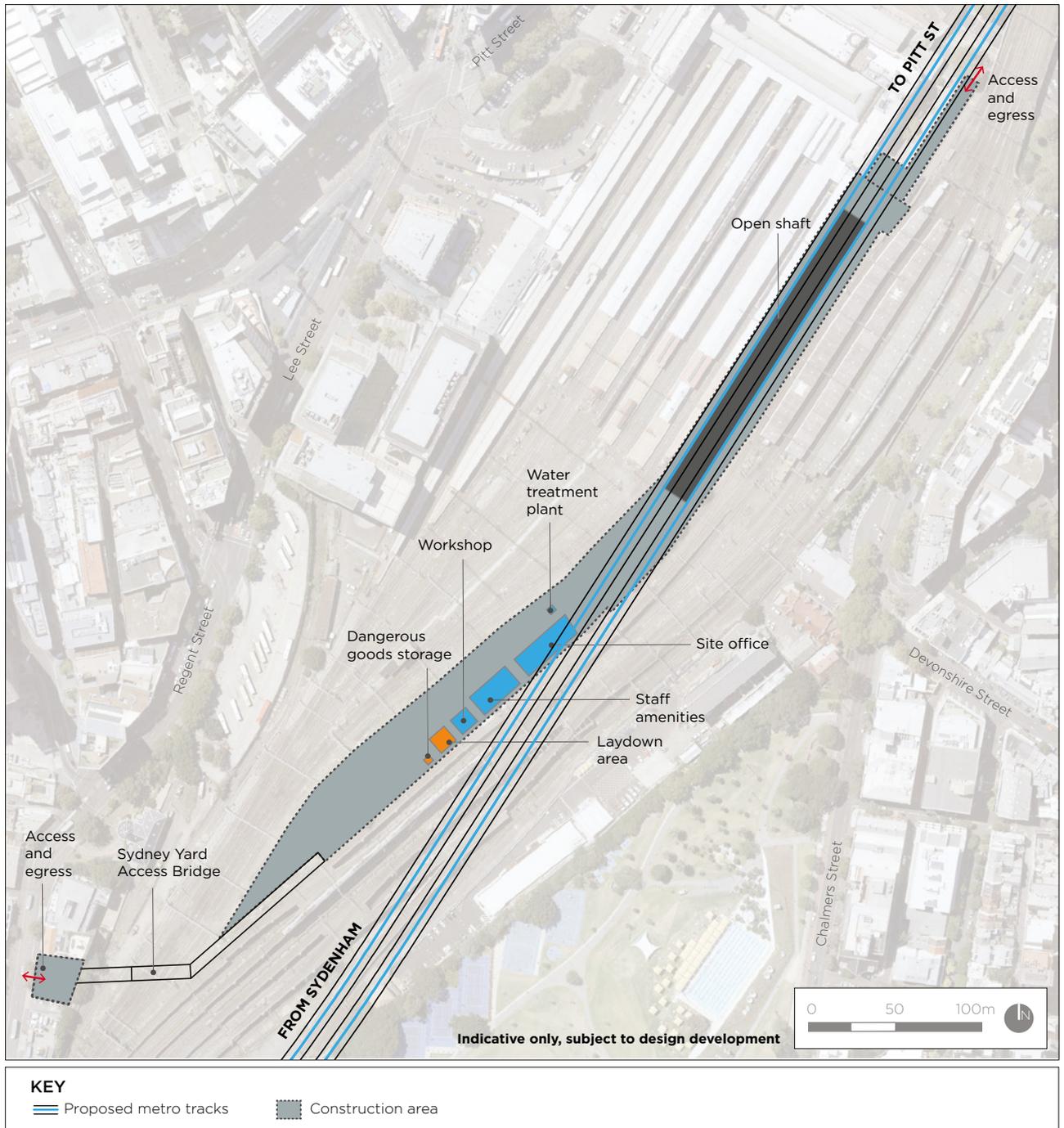


Figure 7-16 Central Station construction sites indicative layout

### 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.

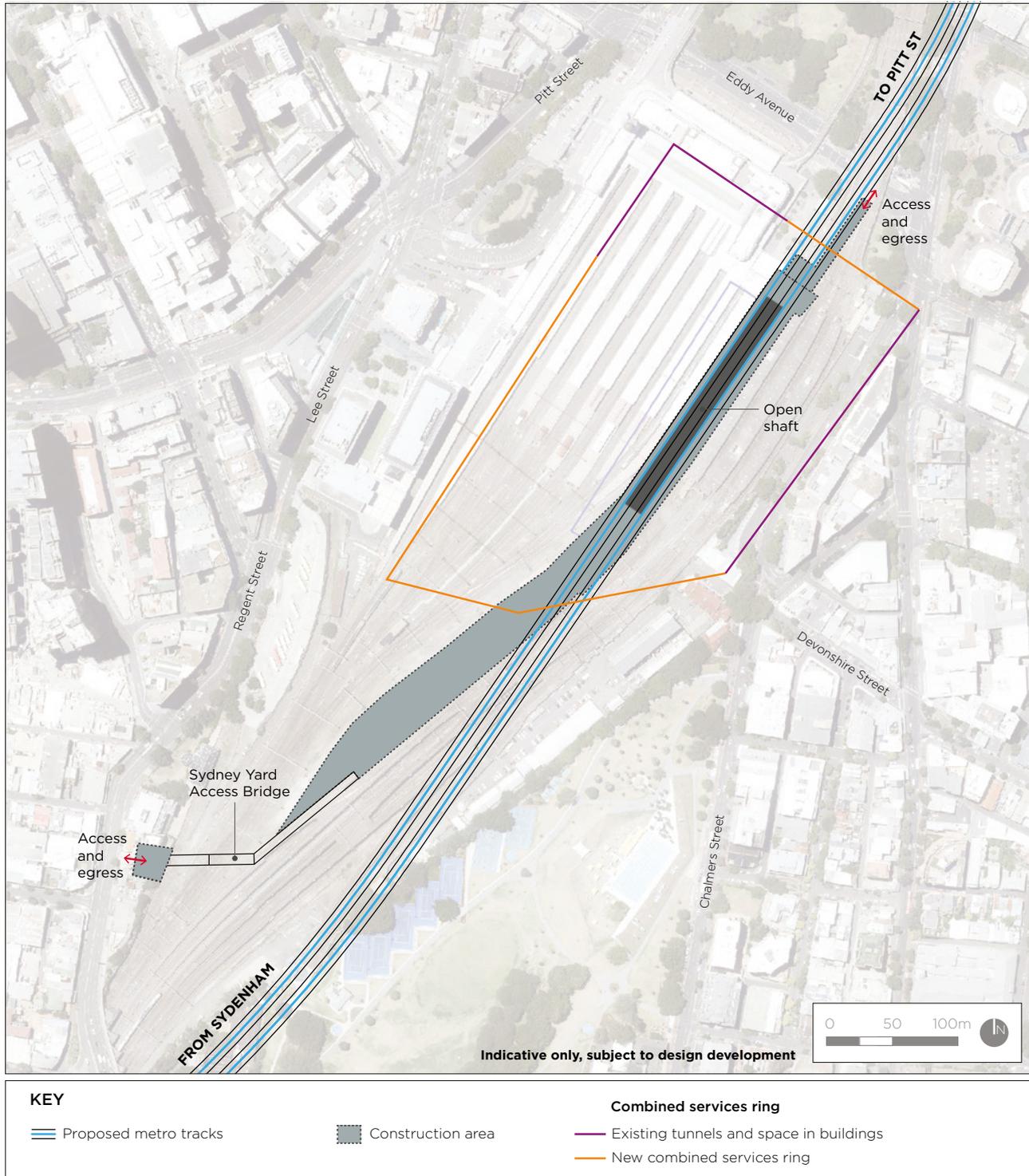


Figure 7-17 Central Station indicative combined services ring

### 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.

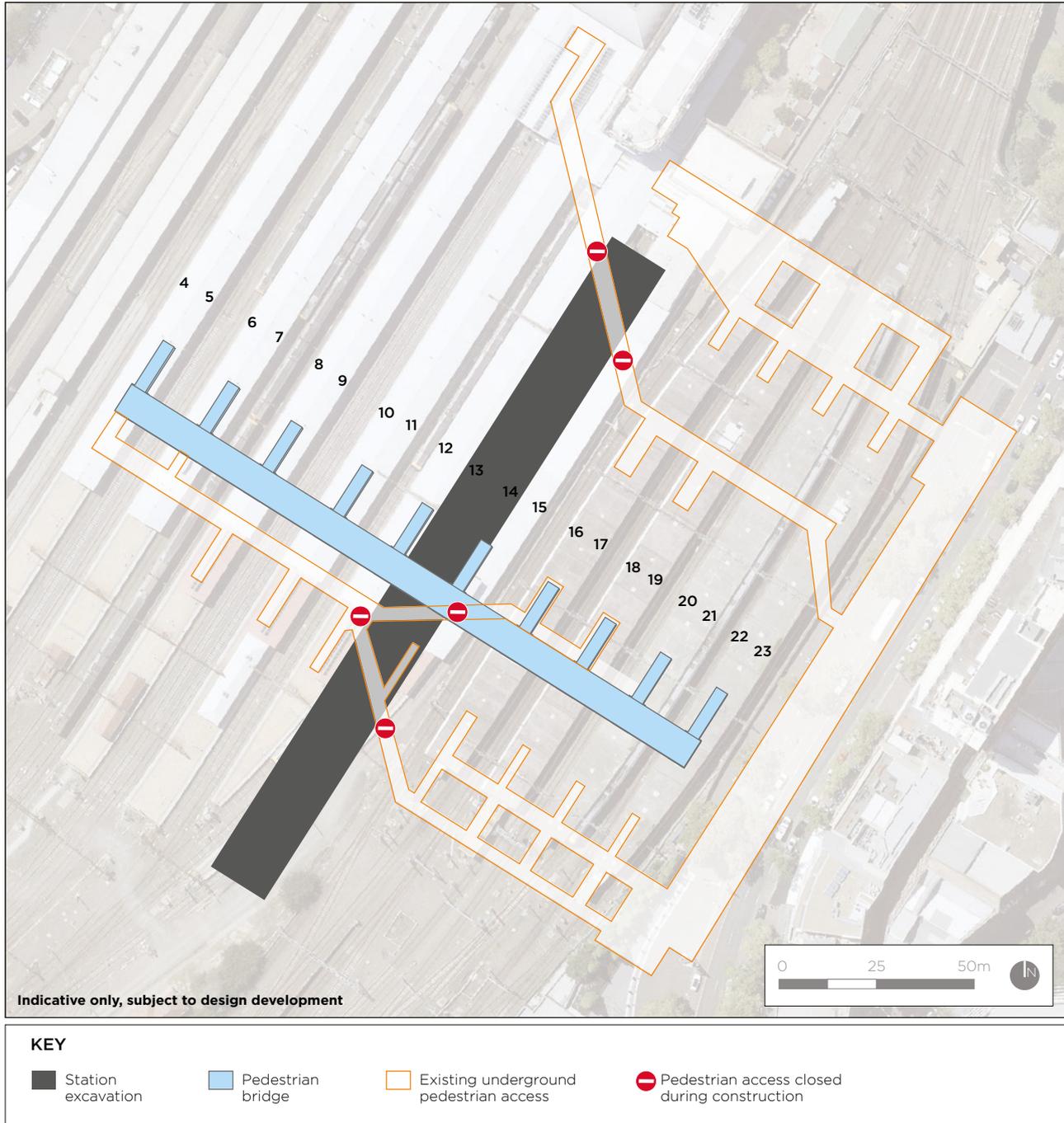


Figure 7-18 Central Station temporary pedestrian bridge



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



### **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.

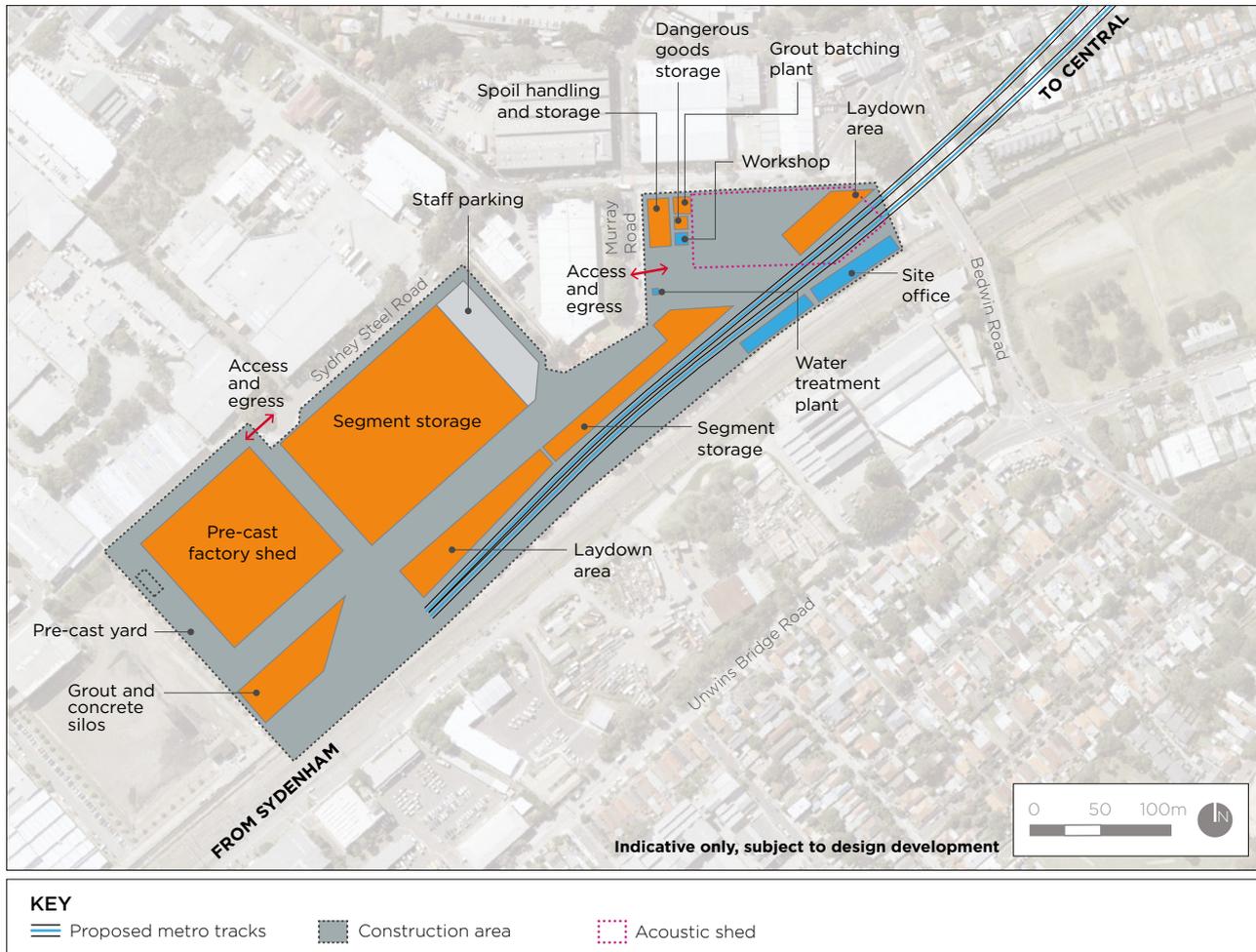


Figure 7-21 Marrickville dive site (southern) indicative layout

### 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 <sup>3</sup> )	Truck type <sup>1</sup>
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
<b>TOTAL</b>	<b>2,400,000</b>	

<sup>1</sup> A truck and dog is the common term for a tipper truck and trailer.

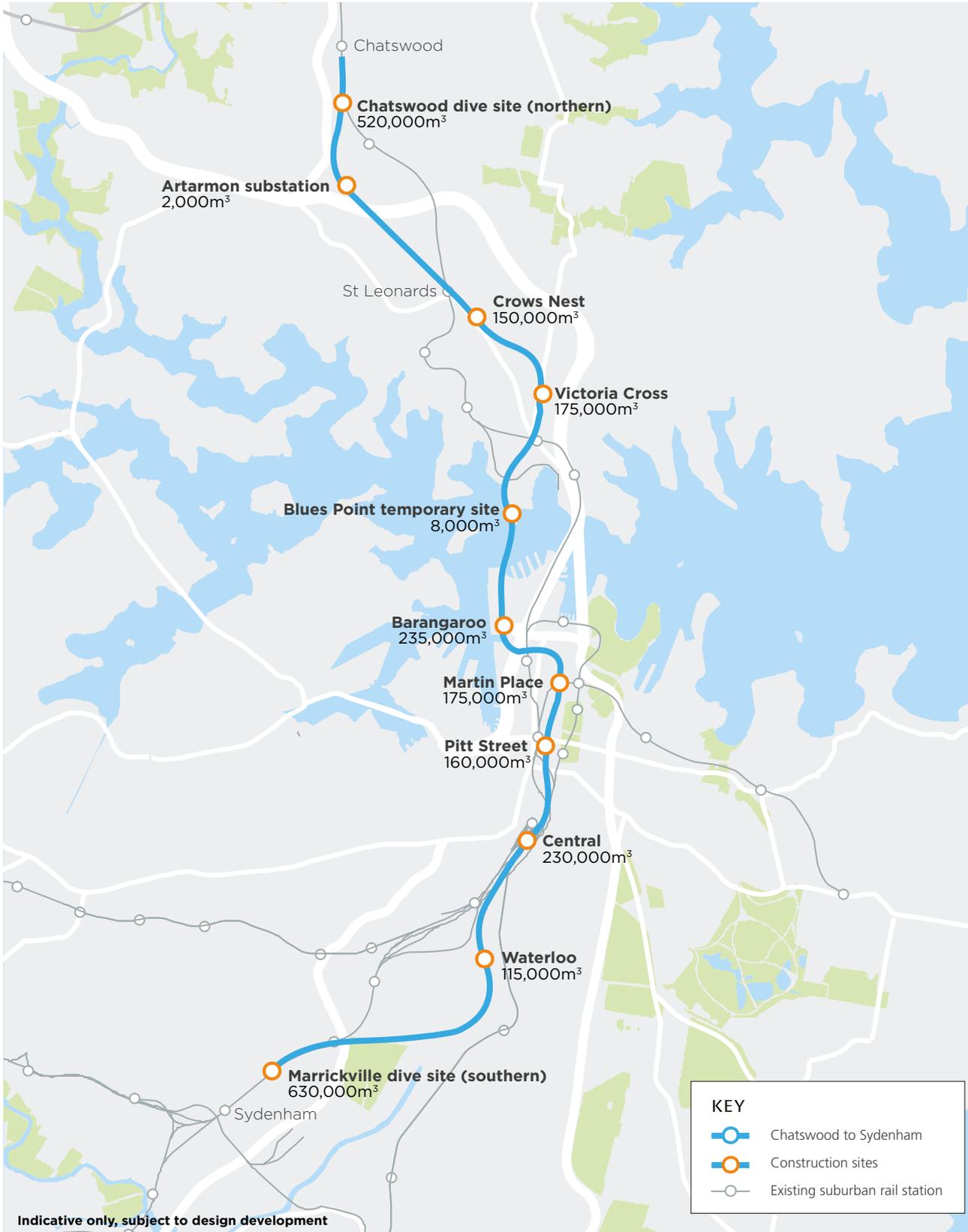


Figure 7-22 Indicative spoil generation volumes

## 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	<b>North site</b> Hume Street ; Clarke Street (left-out); Clarke Lane (left-out)
	<b>South site</b> Hume Street
Victoria Cross Station	<b>North site</b> Miller Street (left-in, left-out)
	<b>South site</b> 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	<b>North site</b> Castlereagh Street (left-in); Elizabeth Street (left-out)
	<b>South site</b> Castlereagh Street (left-in); Elizabeth Street (left-out)
Pitt Street Station	<b>North site</b> Pitt Street (right-in); Castlereagh Street (left-in, right-out)
	<b>South site</b> 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
<b>Underground construction activities</b>		
<b>Tunnelling</b>	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.
<b>Underground excavation at station and ancillary sites</b>	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.
<b>Tunnel and station fit-out (underground)</b>	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.
<b>Aboveground construction activities</b>		
<b>Demolition Station and ancillary facility fit-out and construction (aboveground)</b>	<ul style="list-style-type: none"> <li>○ 7 am to 6 pm Monday to Friday</li> <li>○ 8 am to 1 pm Saturdays</li> <li>○ No works on Sundays and Public Holidays</li> </ul>	<p>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.</p> <p>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.</p> <p>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.</p> <p>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.</p>

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.

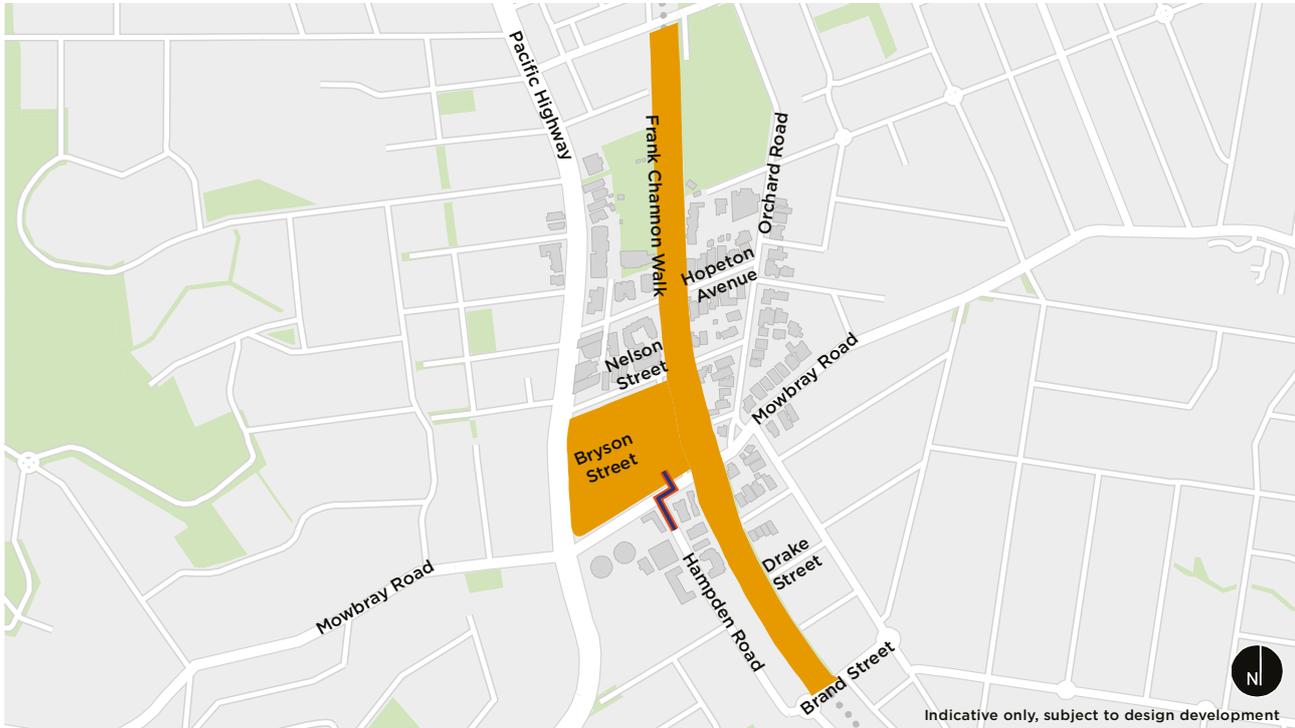
Any construction power supply for Artarmon substation and Blues Point temporary site would be provided directly from the local grid.

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).

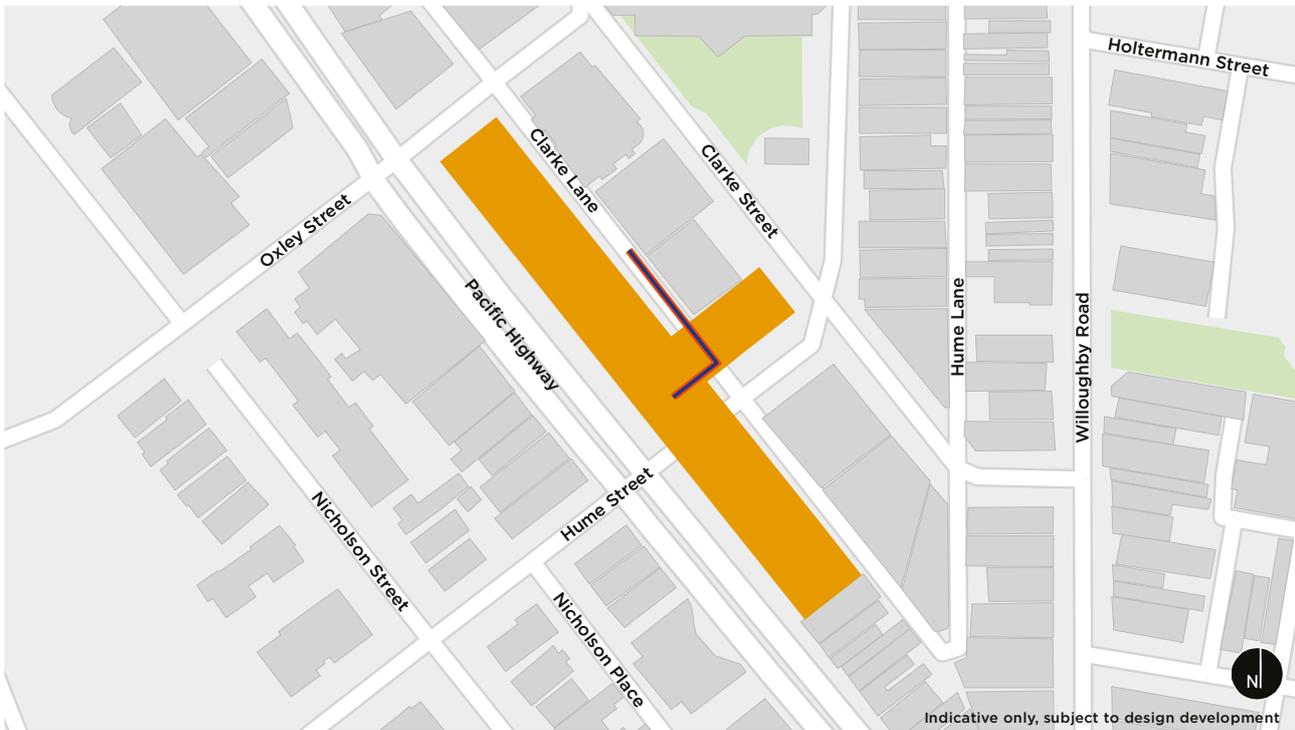
**Table 7-22 Construction power for tunnel boring machines**

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 Pymont 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



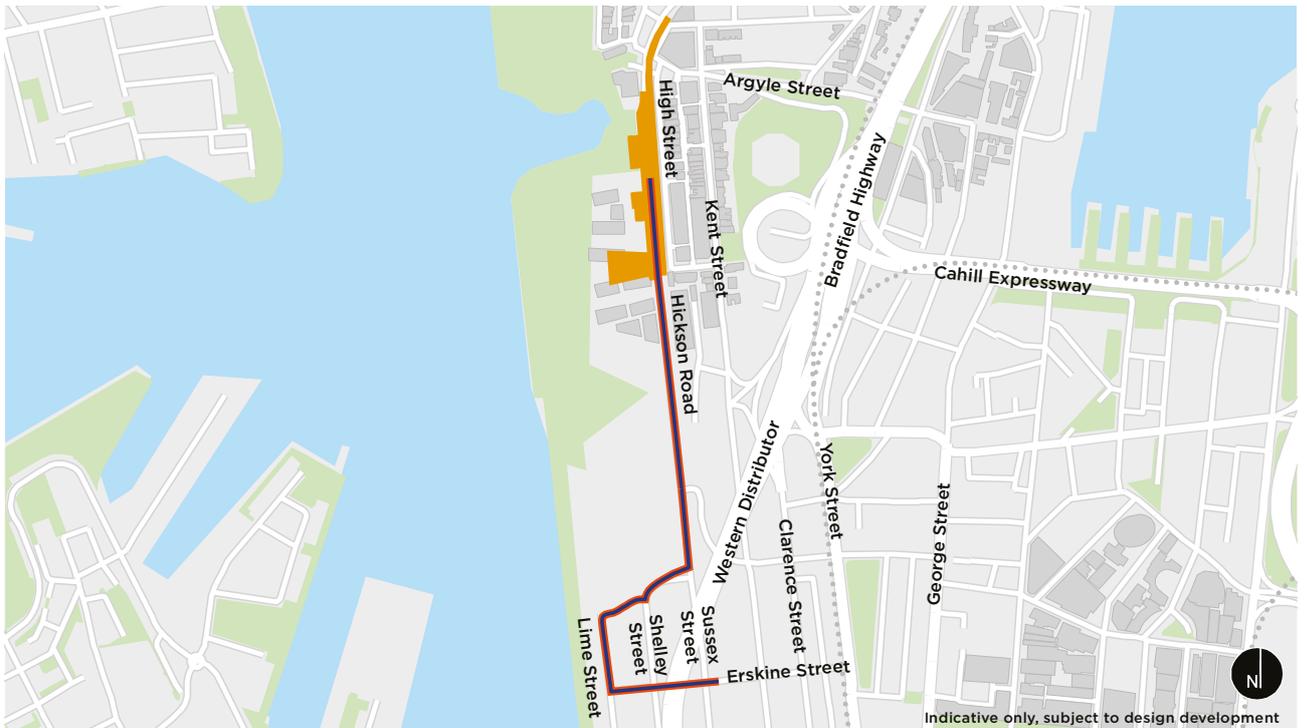
**KEY**  
 Proposed construction site area   
 Power supply route

Figure 7-24 Crows Nest Station – power supply route



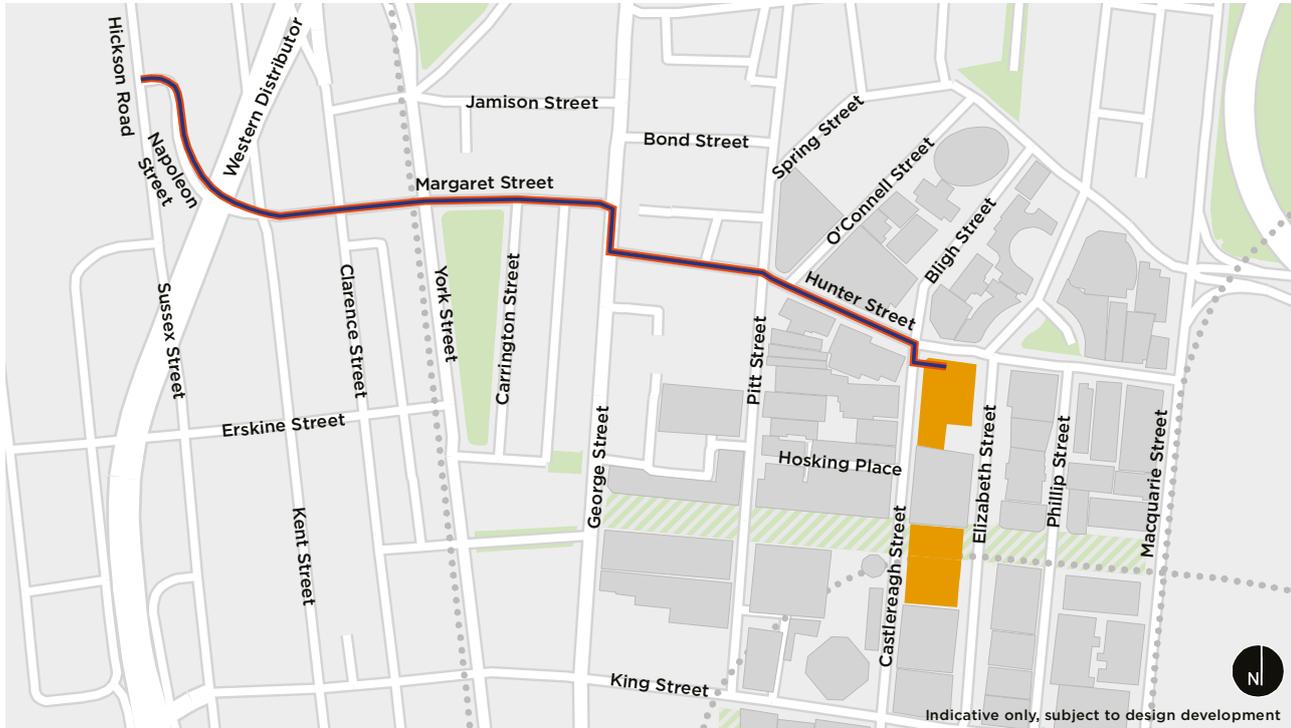
**KEY**  
 Proposed construction site area     Power supply route

Figure 7-25 Victoria Cross Station - power supply route



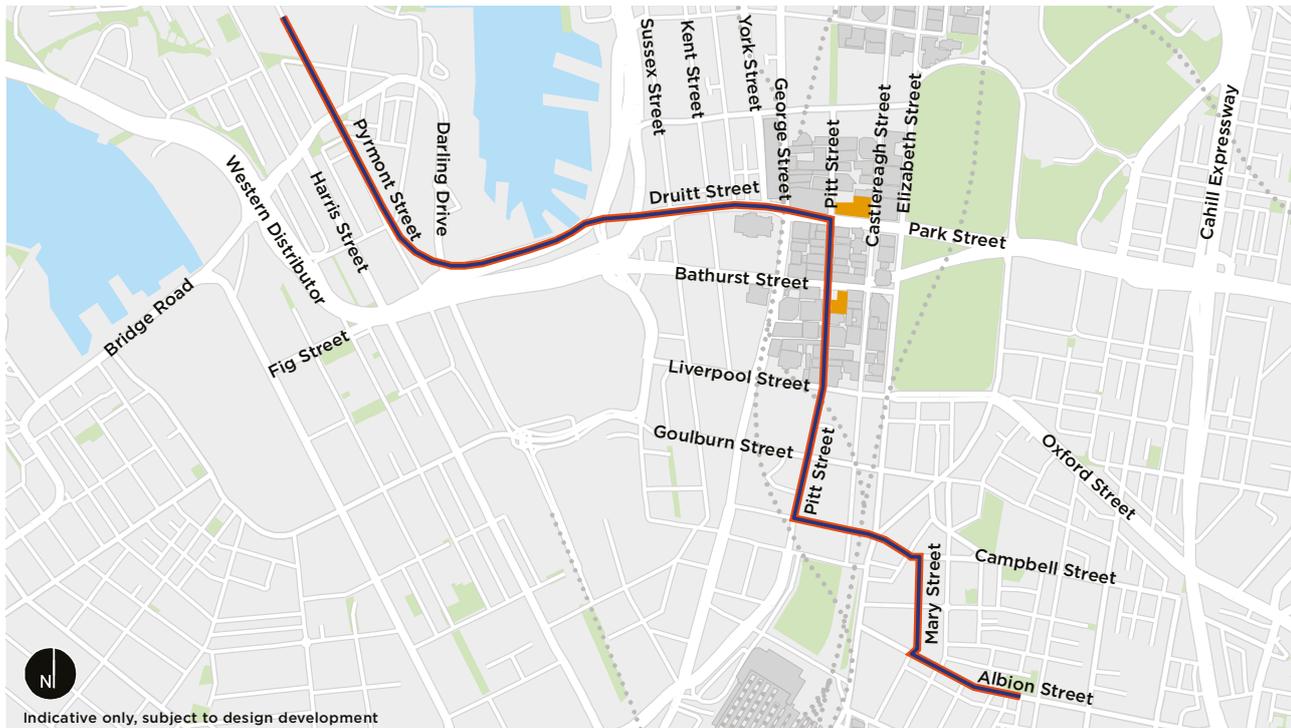
**KEY**  
 Proposed construction site area     Power supply route     Existing suburban rail

Figure 7-26 Barangaroo Station - power supply route



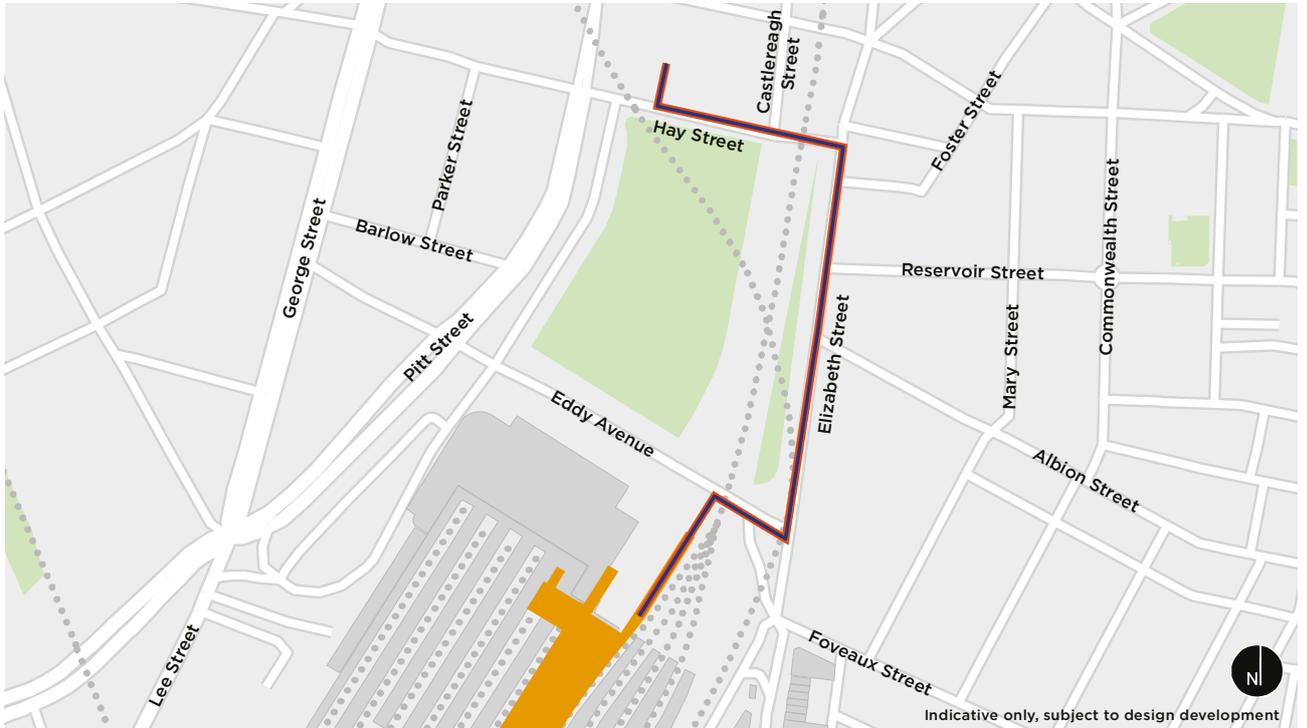
**KEY**  
 Proposed construction site area   
 Power supply route   
 Existing suburban rail

**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)	<ul style="list-style-type: none"> <li>Protection of Telstra cables along the 'down' (northbound) side of the T1 North Shore Line rail corridor</li> <li>Adjustments to T1 North Shore Line rail systems</li> </ul>
Martin Place Station	<ul style="list-style-type: none"> <li>Protection and / or relocation of services within the underground pedestrian connection beneath Martin Place</li> </ul>
Barangaroo Station	<ul style="list-style-type: none"> <li>Protection and / or relocation of underground services in Hickson Road</li> </ul>
Central Station	<ul style="list-style-type: none"> <li>Protection and / or relocation of Sydney Trains rail, station and building services</li> </ul>
Marrickville dive site (southern)	<ul style="list-style-type: none"> <li>Widening and strengthening of existing bridge structures to provide access over the existing stormwater channel</li> <li>Protection and / or relocation of a Transgrid 330kv cable</li> </ul>

### 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)	<ul style="list-style-type: none"> <li>Nelson Street – permanent closure and demolition of the road overbridge</li> <li>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</li> <li>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.</li> </ul>
Artarmon substation	<ul style="list-style-type: none"> <li>No modifications</li> </ul>
Crows Nest Station	<ul style="list-style-type: none"> <li>Clarke Lane – temporary closure near Hume Street. Clarke Lane to be made two-way to the north</li> <li>Hume Street – temporary closure during construction of the station</li> <li>Hume Street – removal of 2-4 on street parking spaces</li> <li>Clarke Lane – removal of off street parking spaces. however these are likely currently used by businesses that would be acquired.</li> </ul>
Victoria Cross Station	<ul style="list-style-type: none"> <li>Miller Street – removal of 2-4 parking spaces.</li> </ul>

Location	Indicative road network modifications
Blues Point temporary site	<ul style="list-style-type: none"> <li>○ Blues Point Road – removal of 4 on street parking spaces at the end of Blues Point Road during shaft excavation</li> <li>○ Blues Point Road – occupation of the end of Blues Point Road during tunnel boring machine removal</li> <li>○ Blues Point Road – removal of on street parking spaces at the end of Blues Point Road during tunnel boring machine removal</li> <li>○ Blues Point Road – potential short term closure during tunnel boring machine transport.</li> </ul>
Barangaroo Station	<ul style="list-style-type: none"> <li>○ 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</li> <li>○ Hickson Road – removal of 125 on street parking spaces.</li> </ul>
Martin Place Station	<ul style="list-style-type: none"> <li>○ Full or partial temporary closures (night time only).</li> </ul>
Pitt Street Station	<ul style="list-style-type: none"> <li>○ Full or partial temporary closures (night time only).</li> </ul>
Central Station	<ul style="list-style-type: none"> <li>○ No modifications.</li> </ul>
Waterloo Station	<ul style="list-style-type: none"> <li>○ Raglan Street – removal of 2-4 on street parking spaces</li> <li>○ Cope and Wellington streets – removal of car parking during demolition.</li> </ul>
Marrickville dive site (southern)	<ul style="list-style-type: none"> <li>○ Bedwin Road / Edinburgh Road / Edgeware Road intersection – provision of new traffic signals</li> <li>○ Unwins Bridge Road / Bedwin Road / May Street – traffic signal modifications to allow signalised right turn from May Street into Bedwin Road</li> <li>○ Edinburgh Road – removal of 2-4 on street parking spaces.</li> </ul>

## 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	<ul style="list-style-type: none"> <li>○ Likely rail track possessions for: <ul style="list-style-type: none"> <li>◆ demolition of the Nelson Street road bridge</li> <li>◆ adjustments to the T1 North Shore Line including track slewing, signalling, overhead wiring, and other rail services</li> <li>◆ Metro track and rail systems works within the T1 North Shore Line corridor.</li> </ul> </li> </ul>
Chatswood dive site (northern)	<ul style="list-style-type: none"> <li>○ Likely rail track possessions for track slewing and other surface track works</li> <li>○ Relocation of the bus stop at 575 Pacific Highway, Chatswood.</li> </ul>
Artarmon substation	No modifications.
Crows Nest Station	<ul style="list-style-type: none"> <li>○ Relocation of the bus stop at 497 Pacific Highway, Crows Nest.</li> </ul>
Victoria Cross Station	<ul style="list-style-type: none"> <li>○ Relocation of the bus stop at 194 Miller Street, North Sydney.</li> </ul>
Blues Point temporary site	<ul style="list-style-type: none"> <li>○ Relocation of the bus stop on Henry Lawson Avenue.</li> </ul>
Barangaroo Station	No modifications.

Location	Indicative public transport network modifications
Martin Place Station	<ul style="list-style-type: none"> <li>○ Likely rail track possessions for: <ul style="list-style-type: none"> <li>◆ possible service relocations and strengthening works to existing rail tunnels</li> <li>◆ modifications to existing underground pedestrian facilities.</li> </ul> </li> </ul>
Pitt Street Station	No modifications.
Central Station	<ul style="list-style-type: none"> <li>○ Alterations to the Sydney Trains and NSW TrainLink timetable due to closure of platforms 13, 14 and 15 during construction</li> <li>○ Likely rail track possessions, including extended rail possessions of selected rail lines, for: <ul style="list-style-type: none"> <li>◆ construction of access bridge from Regent Street to Sydney Yard and associated adjustments to existing rail systems</li> <li>◆ construction of the temporary pedestrian bridge</li> <li>◆ adjustments to rail systems around platforms 13, 14 and 15 to facilitate cut-and-cover construction of the station</li> <li>◆ adjustments to rail systems around platforms, the paid underground pedestrian connections and Devonshire Street tunnel to facilitate cut-and-cover construction of the station.</li> </ul> </li> </ul>
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	<ul style="list-style-type: none"> <li>○ Frank Channon Walk – temporary closure of the shared path linking Chatswood Station and Nelson Street</li> <li>○ Nelson Street – permanent removal of pedestrian and cyclist connectivity at Nelson Street over the T1 North Shore Line.</li> </ul>
Artarmon substation	No modifications.
Crows Nest Station	<ul style="list-style-type: none"> <li>○ Hume Street and Pacific Highway – footpaths adjacent to the site narrowed by about 600 millimetres over a distance of about 300 metres</li> <li>○ Hume Street – re-routing of pedestrians and cyclists over the demolished building area during cut-and-cover works through Hume Street.</li> </ul>
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	<ul style="list-style-type: none"> <li>○ Blues Point Road – closure of the footpath adjacent to Blues Point Reserve during tunnel boring machine removal</li> <li>○ Blues Point Road – temporary removal of street furniture and infrastructure along Blues Point Road for tunnel boring machine transport.</li> </ul>

Location	Indicative modifications to pedestrian and cyclist facilities
Barangaroo Station	<ul style="list-style-type: none"> <li>○ Hickson Road – footpath narrowed by about 600 millimetres over a distance of about 600 metres</li> <li>○ Hickson Road – periodic closures of the footpath adjacent to the site during construction.</li> </ul>
Martin Place Station	<ul style="list-style-type: none"> <li>○ Elizabeth and Castlereagh streets – footpaths adjacent to the site narrowed by about 600 millimetres over a distance of about 200 metres</li> <li>○ Martin Place (between Castlereagh and Elizabeth streets) – closed during cut-and-cover work with pedestrians and cyclists re-routed</li> <li>○ Underground connections to Martin Place Station – closed west of Elizabeth Street during cut-and-cover work in Martin Place.</li> </ul>
Pitt Street Station	<ul style="list-style-type: none"> <li>○ Pitt, Bathurst and Castlereagh streets – footpaths adjacent to the site narrowed by about 600 millimetres over a distance of about 150 metres.</li> </ul>
Central Station	<ul style="list-style-type: none"> <li>○ Devonshire Street Tunnel – short term closure (about 2 weeks)</li> <li>○ 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.</li> </ul>
Waterloo Station	<ul style="list-style-type: none"> <li>○ 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.</li> </ul>
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).

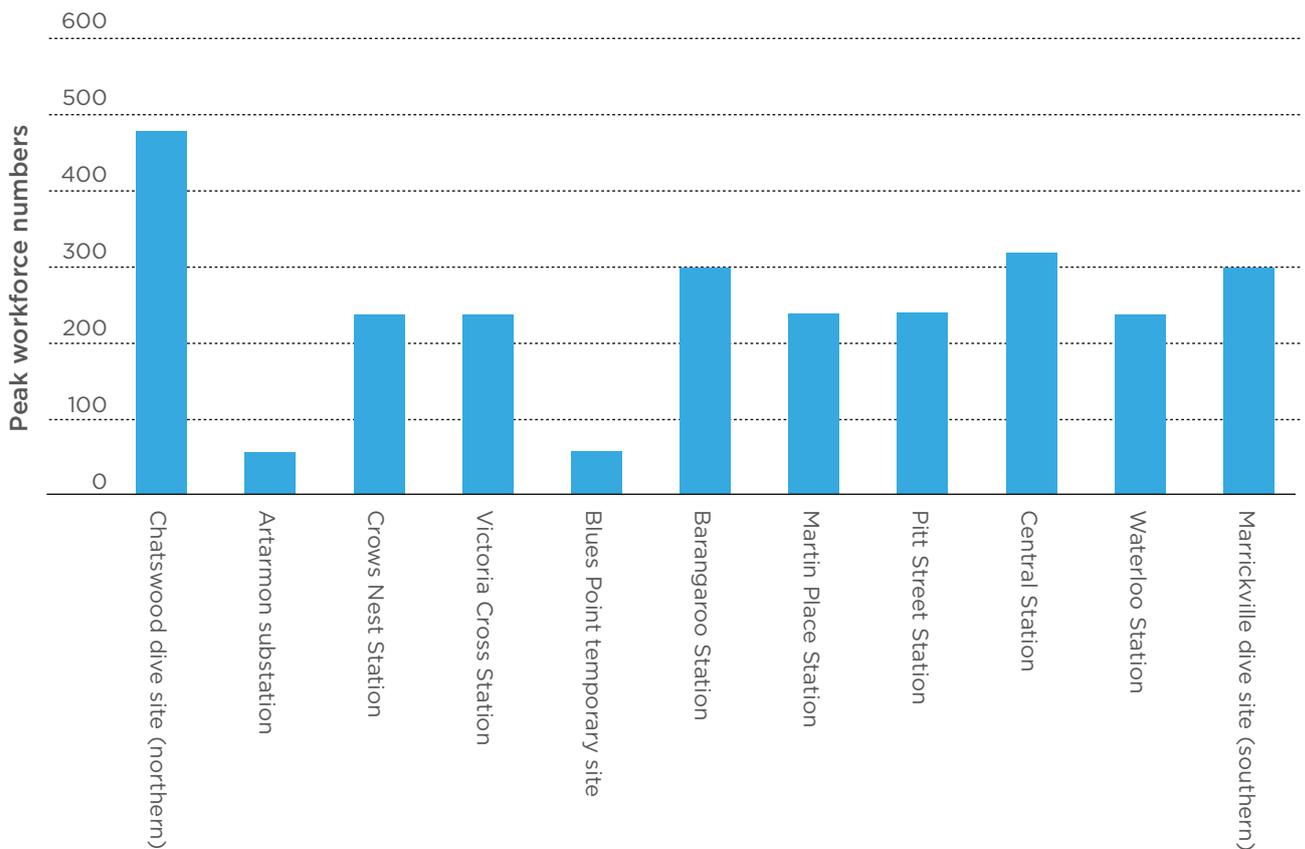


Figure 7-32 Construction workforce

### 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.