20. Soils and contamination

This chapter provides an assessment of the potential soil and contamination impacts of the project. The Secretary's environmental assessment requirements addressed in this chapter are listed in Table 20.1.

Table 20.1 Secretary's environmental assessment requirements – soils

Ref	Secretary's environmental assessment requirements - soils	Where addressed
11.1	The Proponent must assess whether the land is likely to be contaminated and identify if remediation of the land is required, having regard to the ecological and human health risks posed by the contamination in the context of past, existing and future land uses. Where assessment and/or remediation is required, the Proponent must document how the assessment and/or remediation would be undertaken in accordance with current guidelines.	The potential for contamination is considered in Section 20.2.4. The need for remediation would be confirmed as an outcome of the more detailed contamination assessment to be undertaken for the detailed design, as described in Sections 20.3.2 and 20.4.1.

20.1 Assessment approach

20.1.1 Legislation and policy context for the assessment

Legislation and policies relevant to the assessment and management of contaminated land include:

- *Managing Land Contamination: Planning Guidelines SEPP 55 – Remediation of Land* (Department of Urban Affairs and Planning and the Environment Protection Authority, 1998)
- *Acid Sulfate Soil Manual* (ASSMAC, 1998)
- *AS4482:2005 Guide to the investigation and sampling of sites with potentially contaminated soil*
- *Guidelines for Consultants Reporting on Contaminated Sites* (Office of Environment and Heritage, 2011)
- *National Environment Protection (Assessment of Site Contamination) Amendment Measure (No.1)* (National Environment Protection Council (NEPC), 2013)
- *Waste Classification Guidelines* (EPA, 2014a)
- *Guidelines on the Duty to Report Contamination under the Contaminated Land Management Act 1997* (EPA, 2015a).

20.1.2 Methodology

The assessment generally involved:

- a review of available contamination assessments relevant to the study area, including a preliminary contamination ('environmental site') assessment undertaken as an input to the design
- a review of available geotechnical information relevant to the study area, including information on soil characteristics

- a review of publicly available data and web-based information searches, including:
  - the Contaminated Sites Register and Record of Notices under Section 58 of the *Contaminated Land Management Act 1997*, maintained by the NSW Environment Protection Authority
  - environment protection licences, applications, notices, audits or pollution studies and reduction programs
  - Australian Soil Resource Information System (maintained by the Commonwealth Scientific and Industrial Research Organisation (CSIRO))
  - *Sydney 1:100,000 Geological Map 9130* (NSW Department of Mineral Resources, 1983)
  - *Soil Landscapes of the Sydney 1:100,000 Sheet map (9130)* (Chapman, G.A. et al, 2009)
  - NSW Soil and Land Information System (maintained by the Office of Environment and Heritage)
- identification of the potential to disturb acid sulfate soils and areas of salinity
- recommendations for additional investigations, where necessary
- identification of mitigation measures to address potential soil and contamination impacts.

It is noted that the contamination assessment undertaken as an input to the design was a preliminary assessment only. The purpose of the assessment was to identify areas of potential contamination, and provide recommendations for future more detailed investigations if required. It did not involve any soil sampling, or identify the need for any remediation. This would be undertaken as part of a more detailed contamination assessment, to be undertaken at the detailed design stage.

20.2 Existing environment

20.2.1 Topography

The project area ranges in elevation from the lowest point, which is about 3.5 metres above Australian height datum near Marrickville Station, to the highest point, which is about 36 metres above Australian height datum near Wiley Park Station. Bankstown Station is located about 23 metres above Australian height datum.

Between Punchbowl and Bankstown stations, the project area is located on or near a localised ridgeline. East of Punchbowl Station, the natural topography varies through a series of ridges and gullies. Between Marrickville and Sydenham stations, the project area is located in low-lying terrain.

20.2.2 Geology

The project area traverses six regional geological units, summarised in Table 20.2.

Table 20.2 Geology along the project alignment

Geological unit	Description
Fill	Located in former industrial sites and embankments along the T3 Bankstown Line (e.g. at Marrickville, Dulwich Hill, Wiley Park, and Lakemba stations), below track level within the existing rail corridor, and a thin layer at the top of most cuttings.
Quaternary sediments	Alluvium and estuarine deposits – ranging from sands to sandy clays, to clays, located in vicinity of Marrickville station, and the Cooks River.

Geological unit	Description
Wianamatta Group	Comprising: • Bringelly Shale - siltstone and claystone interbedded with fine sandstone • Minchinbury Sandstone - fine to medium sandstone, bedrock outcropping identified in vicinity of Wiley Park Station • Ashfield Shale – with bedrock outcropping identified between Canterbury and Punchbowl stations.
Mittagong Formation	Interbedded fine to medium sandstone and shale, often disturbed. Bedrock outcropping identified between Dulwich Hill and Canterbury stations.
Hawkesbury Sandstone	Medium to coarse quartzic sandstone, either massive, cross bedded or with occasional shale interbeds. Bedrock outcropping identified between Marrickville and Canterbury stations.
Dykes	Volcanic intrusions - dykes are located at Marrickville, Canterbury and Belmore. Faults and joint swarms (which act as preferential drainage paths) are located near Canterbury, Marrickville, and Bankstown stations.

20.2.3 Soils

The following soil types underlie the project area:

- Blacktown, mapped across most of the project area
- Gymea, mapped as a larger patch between Canterbury and Dulwich Hill stations, and a smaller area between Dulwich Hill and Marrickville stations
- Glenorie, mapped north of Bankstown Station
- Birrong, mapped west of Cooks River, and local occurrences in Belmore and Wiley Park
- disturbed terrain, mapped west of Punchbowl Station.

There is a substantial amount of fill material along and within 100 metres of the project area, including railway ballast, gravel, building debris, and excavated soil material. The majority of the project area consists of fill associated with railway embankments, or exposed bedrock associated with cuttings and overlain with rail ballast or fill.

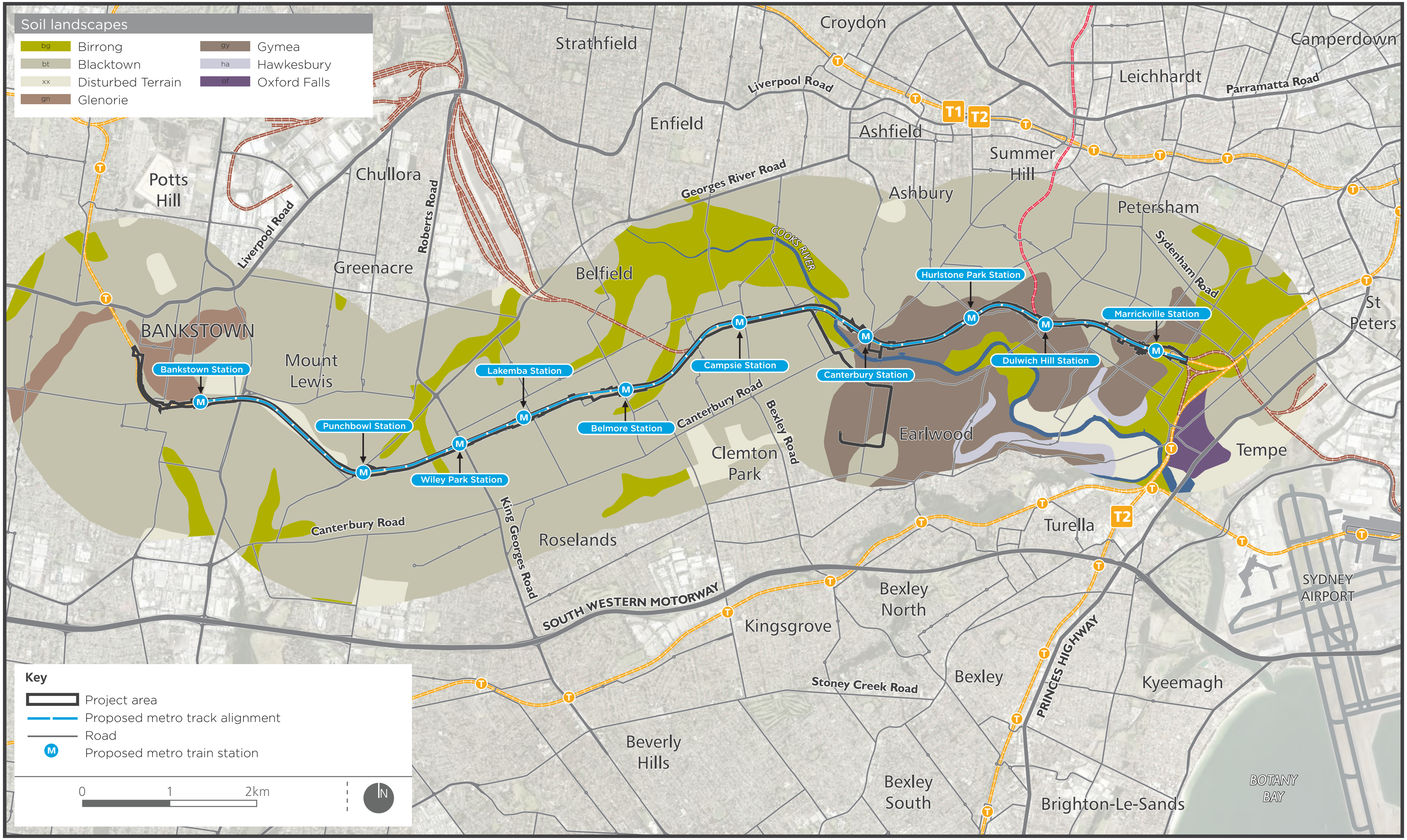
Soil types are shown on Figure 20.1.

Soil salinity

Areas prone to salinity are usually located at low points in the landscape, such as floodplains, valley floors, or at the foot of a ridge. As shown in Figure 20.2, potential saline soils are located west of Punchbowl Station, including:

- high salinity potential soils on either side of Stacey Street and north of Gordon Street
- moderate salinity potential soils between Punchbowl and Bankstown stations.

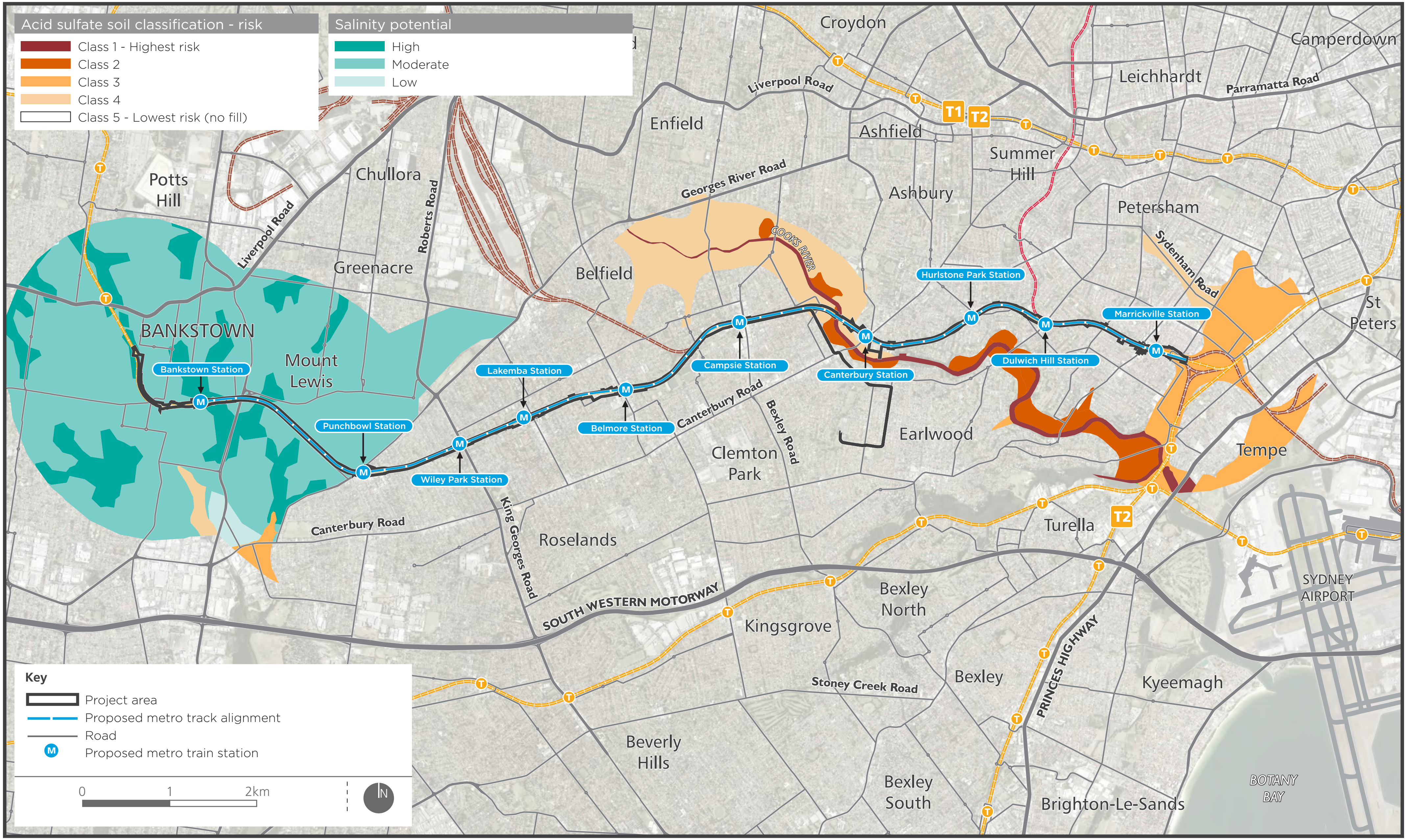
The remainder of the project area is not mapped as having salinity potential. However, there may be areas of salinity potential in these areas.



sydney METRO | city & southwest

Soils types along the project alignment

FIGURE 20.1



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Salinity potential and acid sulfate soils risk

FIGURE 20.2

Acid sulfate soils

Acid sulfate soils are naturally occurring soils containing iron sulfides, which, on exposure to air, oxidise and create sulfuric acid. This increase in acidity can result in the mobilisation of aluminium, iron, and manganese from the soils. As shown in Figure 20.2, potential acid sulfate soils are located near the Cooks River at Canterbury, which is mapped as having a high likelihood of acid sulfate soils. Areas mapped with a low likelihood of acid sulfate soils are located between Canterbury and Campsie stations. Acid sulfate soils may also be encountered in areas mapped as ‘disturbed terrain’, including around Canterbury Station, and between Canterbury and Campsie stations.

20.2.4 Potential for contamination

Contaminated sites

No site listed on the EPA’s contaminated land register are located within 100 metres of the project area. However, three sites which have been notified to the EPA are located within 100 metres of the project area, as listed in Table 20.3.

Table 20.3 Registered contamination sites

Suburb	Site name and address	Site activity	Contamination status	Location in relation to the project area
Marrickville	Way Street	XPT Maintenance Facility, other industry	Regulation under CLM Act not required	East of the project area between Sydenham and Marrickville stations
Marrickville	2 Carrington Road	Unclassified	Regulation under CLM Act not required	Within the project area between Sydenham and Marrickville stations
Belmore	348 Burwood Road	Rail land, unclassified	Regulation under CLM Act not required	Within the project area between Belmore and Lakemba stations

Note: 1: CLM Act - *Contaminated Land Management Act 1997*

Potentially contaminated areas

The preliminary environmental site assessment identified the potential risk of contamination along the project area. The assessment concluded that there is a risk of contamination along the length of the project area, albeit a low to medium risk for the majority of the project area, with potential contamination sources being historical rail activities, and commercial and residential land use in surrounding areas. Potential contaminants identified in low to medium risk areas included:

- asbestos
- hydrocarbons
- heavy metals
- herbicides.

Sections of the project area are suspected have a medium to high risk of contamination are listed in Table 20.4.

Table 20.4 Areas with a medium to high contamination risk in the project area

Location	Potential contamination sources	Potential contaminants present
Between Sydenham and Marrickville stations	• previous site investigations identified asbestos in soil and petroleum aromatic hydrocarbons in groundwater north of the project area, at 361 Victoria Road	Within the vicinity of 361 Victoria Road: • asbestos in soil • petroleum aromatic hydrocarbons in groundwater
Between Campsie and Belmore stations (triangular area within the rail corridor)	• historical rail activities • historical commercial and residential land use	• arsenic in ballast • asbestos • hydrocarbons (including chlorinated hydrocarbons in fill) • heavy metals (including in groundwater) • herbicides
Between Punchbowl and Bankstown stations (car park at North Terrace)	• historical rail activities • historical commercial and residential land use	• asbestos • hydrocarbons (in soil and groundwater) • heavy metals • herbicides

20.3 Impact assessment

20.3.1 Risk assessment

Potential risks

The environmental risk assessment for the project, undertaken for the State Significant Infrastructure Application Report, identified the following as the main soil and contamination risks:

- exposure of acid sulfate soils during construction
- disturbance of contaminated land during construction
- encountering contaminated building structures during demolition works
- contamination of land, groundwater or waterways due to leaks and spills.

Other potential risks include ground disturbance as a result of vegetation removal and the creation of embankments, increasing the potential for erosion and sedimentation.

How potential impacts would be avoided

In general, potential soils and contamination impacts would be avoided by:

- managing risks associated with contamination in accordance with relevant legislative and policy requirements, as described in Section 20.4
- designing, constructing, and operating the project in a way to minimise impacts associated with soils and contamination
- implementing standard soil and contamination mitigation measures described in Section 20.4.

20.3.2 Construction

Excavation and ground disturbance activities would expose and disturb soils, which, if not adequately managed, could result in:

- erosion of exposed soil and stockpiled materials
- dust generation
- an increase in sediment loads entering the stormwater system and/or local runoff, and therefore nearby receiving waterways
- increase in salinity levels in soil
- acid sulfate soil conditions
- mobilisation of contaminated sediments, with resultant potential for environmental and human health impacts.

Potential impacts as they relate to soils and contamination are considered below. Potential water quality impacts, including impacts caused by increased sediment loads, are considered in Chapter 21 (Hydrology, flooding and water quality), air quality (dust) impacts are considered in Chapter 23 (Air quality), and health and safety risks, including as a result of contamination and hazardous materials, are considered in Chapter 25 (Hazards, risks and safety).

Soils

Soil erosion

Construction of the project would temporarily expose the natural ground surface and sub-surface through the removal of vegetation, overlying structures (such as buildings and footpaths), and excavation. The exposure of soil to runoff and wind can increase soil erosion potential, particularly where construction activities are undertaken in soil landscapes characterised by a high and extreme erosion hazard. These include the:

- Birrong landscape, which underlies the project area west of Cooks River, and local occurrences in Belmore and Wiley Park
- Glenorie landscape, which underlies the area north of Bankstown Station.

Soil erosion impacts are expected to be minimal for the majority of project as a result of the relatively limited areas of excavation and earthworks, the overall topography of the project area, and the temporary nature of exposure.

Regardless of the amount of excavation required, the potential for erosion impacts would be minimised by implementing standard soil erosion management measures during construction, as described in Section 20.4.

Acid sulfate soils

The exposure of acid sulfate soils can impact water quality and structures. Soils excavated from potential acid sulphate areas would be subject to the provisions of an acid sulphate soil management plan. Once acid sulphate soils have been treated, depending on the results of testing, they could either be reused on site, or disposed of at an appropriate facility.

Salinity

Excavation would be undertaken in areas with high to moderate potential for salinity surrounding Bankstown and Punchbowl stations. In addition, construction may also disturb soils in areas with unidentified salinity potential in the rest of the project area.

Impacts may occur as a result of the erosion and off-site transport of saline sediments, resulting in impacts on the receiving environment.

The potential for impacts would be minimised by implementing the mitigation measures provided in Section 20.4.

Contamination

Excavation may disturb any contamination and hazardous materials present in soil. If inadequately managed, the disturbance of areas of contamination has the potential for:

- direct contact and/or inhalation by site workers, users, and visitors
- impacts to surrounding environmental receivers (including surrounding ecosystems and flora and fauna, where present)
- mobilisation and migration of surface and subsurface contaminants via leaching, runoff and/or subsurface flow, impacting nearby soils, surface water, and groundwater.

Prior to the disturbance of areas identified to have the potential for contamination (described in Section 20.2.4), further investigation and testing would be undertaken in accordance with the recommendations of the preliminary contamination assessment and any subsequent assessments, to determine the likely risk and appropriate management protocols. This may include the requirement for remediation in certain areas. Relevant mitigation measures are provided in Section 20.4. The need for any remediation would be determined as an outcome of a future, more detailed site assessments.

If inadequately managed, construction activities have the potential to result in the contamination of soil due to spills and leaks of fuel, oils, and other hazardous materials. These potential impacts would be minimal with the implementation of standard mitigation measures, provided in Section 20.4.

Hazardous materials

The demolition of buildings and structures may result in disturbance of hazardous materials. Mishandling of hazardous material waste has the potential to contaminate soils. Mitigation measures are provided in Section 20.4.2 and Chapter 25 (Hazards, risks and safety) to minimise the potential impacts of hazardous materials.

20.3.3 Operation

Contamination

Operation has the potential to result in contamination of soils due to any spills and leaks of fuel, oils, and other hazardous materials from the routine operation of trains, maintenance vehicles, and other project infrastructure, including operation and maintenance activities at substations.

The potential for contamination as a result of general maintenance activities is considered to be low, based on the amount of vehicles and equipment which would likely be used during maintenance. This impact would be minimised by implementing procedures to manage spills during operation of the rail network similar to those used on existing Sydney Trains/Transport for NSW operations.

Bunding designed in accordance with the applicable standards and guidelines would be incorporated into the design of relevant facilities, including substations, to contain any chemical spills or leaks.

20.4 Mitigation measures

20.4.1 Approach to mitigation and management

Site-specific investigations and analysis would be undertaken during detailed design as an input to the design of the project and identification of appropriate treatment measures (as required) prior to construction.

Soils

Construction erosion and sediment control measures would be developed and implemented in accordance with *Managing Urban Stormwater: Soils and Construction Volume 1* (Landcom, 2004) and *Managing Urban Stormwater: Soils and Construction Volume 2A* (Department of Environment and Climate Change, 2008). Measures would be designed as a minimum for the 80th percentile; five-day rainfall event.

As described in Section 9.1.2, environmental management during construction would be guided by the Construction Environmental Management Framework (provided in Appendix D). The framework requires preparation of a soil and water management plan as one of the components of the Construction Environmental Management Plan. The soil and water management plan is required to define the management and monitoring measures that would be implemented to manage, in accordance with relevant guidelines:

- surface and groundwater impacts
- contaminated material
- erosion and sediment control.

Further information on the approach to environmental management during construction is provided in Section 28.4.

Contamination and the need for remediation

Further contamination assessments would be undertaken based on the results of the preliminary assessment, to confirm the risk of contamination and management requirements. This would include intrusive soil investigations in areas known or suspected to be contaminated, to confirm the extent of contamination, and identify appropriate management and remediation requirements. Hazardous material surveys would also be undertaken for structures to be removed.

Requirements for remediation would be driven by the site specific exposure scenarios and environmental risk. Where contamination cannot be managed appropriately in accordance with standard construction processes, a remediation action plan (RAP) would be developed, and an Environment Protection Authority Accredited Site Auditor would be engaged to audit the works. Triggers for a RAP and the involvement of an auditor include the management of hazardous waste or contaminated groundwater remediation for the purposes of managing human health or environmental risk. The excavation and disposal of waste to a licenced facility for construction and operational purposes does not trigger the need for a RAP, and this be managed as described in Chapter 26 (Waste Management). Where practicable, any remediation required would be integrated with construction activities to achieve efficiencies in the use of plant, equipment, and materials.

20.4.2 List of mitigation measures

The mitigation measures that would be implemented to address potential soil and contamination impacts are listed in Table 20.5.

Table 20.5 Mitigation measures – soils and contamination

ID	Impact/issue	Mitigation measures	Relevant locations(s)
Design/pre-construction			
SC1	General soil and erosion management	Erosion and sediment control measures would be implemented in accordance with *Managing Urban Stormwater: Soils and Construction Volume 1* (Landcom, 2004) and *Managing Urban Stormwater: Soils and Construction Volume 2A* (DECC, 2008). Measures would be designed as a minimum for the 80th percentile, five day rainfall event.	All
SC2	Acid sulfate soils	Prior to ground disturbance in high probability acid sulfate areas, testing would be carried out to determine the presence of acid sulfate soils. If acid sulfate soils are encountered, they would be managed in accordance with the *Acid Sulfate Soil Manual* (Acid Sulfate Soil Management Advisory Committee, 1998), and the *Waste Classification Guidelines* - Part 4: Acid Sulfate Soils (EPA, 2014).	Canterbury station, and sections between Sydenham and Marrickville stations, and Canterbury and Campsie stations
SC3	Saline soils	Prior to ground disturbance in areas of potential soil salinity, testing would be carried out to confirm the presence of saline soils. If saline soils are encountered, they would be managed in accordance with *Site Investigations for Urban Salinity* (DLWC, 2002).	Area surrounding Bankstown and Punchbowl stations
SC4	Contamination	WorkCover dangerous goods searches would be carried out for properties that have potential contamination near Belmore Station, to provide additional site characterisation and identify the risk of contamination in these areas.	Belmore Station
SC5		A detailed contamination assessment would be undertaken in areas with a medium to high risk of contamination, to confirm the nature and extent of contamination, specific requirements for further investigation and any remediation, and/or management requirements of any contamination.	Between Sydenham and Marrickville stations, Campsie and Belmore stations; and Punchbowl and Bankstown stations
SC6		Hazardous materials surveys would be undertaken during detailed design for all proposed demolition activities, and for utility adjustments as required.	All
SC7		In the event a remediation action plan is required, it would be developed in accordance with *Managing Land Contamination: Planning Guidelines SEPP 55 – Remediation of Land* (Department of Urban Affairs and Planning and Environment Protection Authority, 1998), and a NSW Environment Protection Authority Accredited site auditor would be engaged to audit the works.	Between Sydenham and Marrickville stations, Campsie and Belmore stations; and Punchbowl and Bankstown stations

ID	Impact/issue	Mitigation measures	Relevant locations(s)
Construction			
SC8	Unexpected contamination	In the event that indicators of contamination are encountered during construction (such as odours or visually contaminated materials), work in the area would cease, and the finds would be managed in accordance with the unexpected contamination finds procedure.	All
Operation			
SC9	Soil erosion and sedimentation	During any maintenance work where soils are exposed, sediment and erosion control devices would be installed in accordance with *Managing Urban Stormwater: Soils and Construction Volume 1* (Landcom, 2004).	All

20.4.3 Consideration of the interactions between mitigation measures

There are interactions between the mitigation measures for soils and contamination (summarised in Section 20.4) and those for water quality (Chapter 21), waste (Chapter 26), and hazardous materials (Chapter 25). Together, all these measures would ensure appropriate management of soil, including contaminated soils and materials, to minimise the potential for impacts to the community and environment.

The implementation of erosion control measures and devices during construction has the potential to result in some potential impacts on overland flow paths. Impacts on overland flow paths are considered to be manageable, as all measures would be installed in accordance with *Managing Urban Stormwater: Soils and Construction Volume 1* and *Managing Urban Stormwater: Soils and Construction Volume 2A*.

20.4.4 Managing residual impacts

The mitigation measures provided in Section 20.4.2 are expected to reduce the potential for soil and contamination impacts during construction and operation. With the implementation of these measures, residual impacts are expected to be minimal.

21. Hydrology, flooding and water quality

This chapter provides a summary of the results of the hydrology, flooding and water quality assessment. A full copy of the assessment report is provided as Technical paper 8 – Hydrology, flooding and water quality assessment. This chapter also includes consideration of the potential impacts on groundwater. The Secretary's environmental assessment requirements relevant to hydrology, flooding and water quality (including groundwater), together with a reference to where the results of the assessment are summarised in this chapter, is provided in Table 21.1.

Table 21.1 Secretary's environmental assessment requirements – hydrology, flooding and water quality

Ref	Secretary's environmental assessment requirements – hydrology, flooding and water quality	Where addressed
6. Flooding and hydrology		
6.1	The Proponent must assess and model (where appropriate), taking into account any relevant Council-adopted flood model or latest flood data available from Councils, the impacts on flood behaviour during construction and operation for flood events ranging from the 1% AEP up to the probable maximum flood (taking into account sea level rise and storm intensity due to climate change) including:	A summary of the results of the hydrology, flooding and water quality assessment is provided in this chapter. The full results are provided as Technical paper 8.
	(a) detrimental increases in the potential flood affectation of other properties, assets and infrastructure; (b) consistency (or inconsistency) with applicable Council floodplain risk management plans; (c) compatibility with the flood hazard of the land; (d) compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land (e) downstream velocity and scour potential; (f) impacts the development may have upon existing community emergency management arrangements for flooding. These matters must be discussed with the State Emergency Services and Council; (g) impacts the development may have on the social and economic costs to the community as consequence of flooding.	Requirements (a) – (g) are addressed in Sections 21.3.2 and 21.3.4.
6.2	The Proponent must describe (and map) the existing hydrological regime for any surface and groundwater resource (including reliance by users and for ecological purposes) likely to be impacted by the project, including stream orders, as per the Framework for Biodiversity Assessment (FBA).	Section 21.2
6.3	The Proponent must assess (and model if appropriate) the impact of the construction and operation of the project and any ancillary facilities (both built elements and discharges) on surface and groundwater hydrology in accordance with the current guidelines, including:	
	(a) minimising the effects of proposed stormwater and wastewater management during construction and operation on natural hydrological attributes (such as volumes, flow rates, management methods and re-use options) and on the conveyance capacity of existing stormwater systems where discharges are proposed through such systems; and	Sections 21.3.2 and 21.3.4
	(b) water take (direct or passive) from all surface and groundwater sources with estimates of annual volumes during construction and operation.	Section 21.3.2

Ref	Secretary's environmental assessment requirements – hydrology, flooding and water quality	Where addressed
6.4	The Proponent must identify any requirements for baseline monitoring of hydrological attributes.	Section 21.4.1
15. Water quality		
15.1	The Proponent must:	
	(a) state the ambient NSW Water Quality Objectives (NSW WQO) and environmental values for the receiving waters relevant to the project, including the indicators and associated trigger values or criteria for the identified environmental values;	Section 21.2.5
	(b) identify pollutants that may be introduced into the water cycle and describe the nature and degree of impact that any discharge(s) may have on the receiving environment, including consideration of all pollutants that pose a risk of non-trivial harm to human health and the environment;	Sections 21.3.3 and 21.3.5
	(c) identify the rainfall event that the water quality protection measures will be designed to cope with; (d) assess the significance of identified impacts including consideration of the relevant ambient water quality outcomes; (e) demonstrate how construction and operation of the project will, to the extent that the project can influence, ensure that: - where the NSW WQOs for receiving waters are currently being met they will continue to be protected; and - where the NSW WQOs are not currently being met, activities will work toward their achievement over time; (f) justify, if required, why the WQOs cannot be maintained or achieved over time;	Requirements (c) to (f) - limited water quality modelling was undertaken as described in Section 21.1.2. Further information is provided in Technical paper 8.
	(g) demonstrate that all practical measures to avoid or minimise water pollution and protect human health and the environment from harm are investigated and implemented;	Section 21.4
	(h) identify sensitive receiving environments (which may include estuarine and marine waters downstream) and develop a strategy to avoid or minimise impacts on these environments; and	Sections 21.2 and 21.4
	(i) identify indicative monitoring locations, monitoring frequency and indicators of surface and groundwater quality.	Section 21.4.1

21.1 Assessment approach

21.1.1 Legislative and policy context to the assessment

Relevant legislation, policies, and guidelines are summarised below.

Hydrology and water quality

The main legislation relevant to water management in NSW are the *Water Management Act 2000* (the Water Management Act), the *Water Act 1912* (the Water Act), and the POEO Act.

Water Management Act* and *Water Act

The Water Management Act and the Water Act control the extraction of water, the use of water, the construction of works such as dams and weirs, and the carrying out of activities in or near water sources in NSW. The Water Management Act recognises the need to allocate and provide water for the environmental health of NSW's rivers and groundwater systems. The provisions of the Water Management Act are being progressively implemented to replace the Water Act. Since July 2004, the licensing and approvals system under the Water Management Act has been in effect in areas of NSW covered by water sharing plans.

The area in which the project is located is subject to the *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011*. This is a statutory instrument made under section 50 of the Water Management Act, which includes rules for protecting the environment, water extractions, managing licence holders' water accounts, and water trading.

A controlled activity approval under the Water Management Act is required for certain types of developments and activities carried out in or near waterfront land that have the potential to affect water quality. It is noted that, as per section 115ZG of the EP&A Act, an activity approval (including a controlled activity approval) under section 91 of the Water Management Act is not required for critical State significant infrastructure. However, to minimise the potential for impacts to water quality, design and construction of the project would take into account the NSW Office of Water's guidelines for controlled activities on waterfront land.

Protection of the Environment Operations Act

Section 120 of the POEO Act prohibits the pollution of waters by any person. Under section 122, holding an environment protection licence is a defence against accidental pollution of watercourses. The Act permits (but does not require) an environment protection licence to be obtained for a non-scheduled activity for the purpose of regulating water pollution resulting from that activity.

Policies and strategies

The *National Water Quality Management Strategy* is a nationally agreed set of policies, processes, and 21 guideline documents, developed jointly by the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) and the Australian and New Zealand Environment and Conservation Council (ANZECC). The strategy establishes objectives to achieve sustainable use of the nation's water resources by protecting and enhancing their quality.

The *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (known as the ANZECC 2000 guidelines) (ANZECC/ARMCANZ, 2000a) forms part of the strategy. This document sets water quality guidelines (numerical concentration limits or descriptive statements) for a range of ecosystem types, water uses (environmental values), and water quality indicators for Australian waters.

In 2006, water quality and river flow objectives were developed for 31 river catchments in NSW based on the ANZECC 2000 guidelines. These include the Cooks River catchment, in which the majority of the project is located, and the Georges River catchment, which the Salt Pan Creek catchment is contained within. These objectives (known as the *NSW Water Quality and River Flow Objectives*) are the agreed environmental values and long-term goals for NSW's surface water receptors. Guidance on the use of the ANZECC 2000 guidelines and the NSW water quality objectives is provided by *Using the ANZECC Guidelines and Water Quality Objectives in NSW* (DEC, 2006b).

Other relevant policies and strategies for the Cooks River and Georges River catchments are the *Greater Metropolitan Regional Environmental Plan No 2 – Georges River Catchment* (a deemed State environmental planning policy) and the *Cooks River Catchment Management Strategy* (Cooks River Catchment Management Committee, 1999).

Groundwater

The *NSW Aquifer Interference Policy* (NSW Office of Water, 2012) explains the water licensing and impact assessment processes for aquifer interference activities under the Water Management Act and other relevant legislation.

Flooding

The *New South Wales Floodplain Development Manual: the management of flood liable land* (DIPNR, 2005) ('the floodplain development manual') defines the main requirements for floodplain development in NSW. The manual highlights requirements to manage flooding risks and reduce the impact of flooding on owners.

The floodplain development manual incorporates the NSW Government's Flood Prone Land Policy, which provides for the development of sustainable strategies for the occupation and use of the floodplain. Implementation of the policy is primarily the responsibility of local government. By applying the floodplain development manual, local councils can balance the conflicting objectives of the floodplain by developing and implementing floodplain risk management plans.

Consideration of the potential impacts on flooding is a requirement for developments proposed in the floodplain.

Other guidelines that support the implementation of the Flood Prone Land Policy include:

- *Floodplain Risk Management Guide Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments* (DECCW, 2010)
- *Floodplain Risk Management Guideline: Practical Considerations of Climate Change* (DECC, 2007)
- *Planning circular: New guideline and changes to section 117 direction and EP&A Regulation on flood prone land* (Department of Planning, 2007).

21.1.2 Methodology

A summary of the methodology for the hydrology, flooding and watery quality assessment is provided in this section. Further information is provided in Technical paper 8.

Hydrology and water quality

The hydrology and water quality assessment involved:

- reviewing background information relevant to the study area to define the existing environment, including previous studies, mapping, survey data, and topography
- identifying water quality objectives for the catchments in which the project area is located, based on the *NSW Water Quality and River Flow Objectives* website
- a site visit to ground truth the results of the desktop review
- identifying and assessing construction and operational activities that may impact on the surface water hydrology and water quality of watercourses within the study area
- identifying potential impacts on groundwater
- identifying mitigation measures to minimise potential impacts on surface water and groundwater hydrology and water quality.

Flooding

The project involves upgrading rail infrastructure in areas subject to regular existing flooding – particularly in Marrickville. As a result, a flooding assessment was undertaken as an input to the design of the project. The aim of the assessment was to determine the existing flooding and drainage characteristics and any impacts of the project. The flooding assessment involved:

- hydraulic modelling to quantify flood behaviour, using catchment study reports and GIS drainage data obtained from the local councils

- an assessment of flooding impacts and risks associated with the project at key locations, including around Marrickville and the remainder of the railway corridor to Bankstown
- developing measures to minimise potential changes to the flood regime as a result of the project.

A full range of flooding events, from the 63 per cent to the one per cent annual exceedance probability (AEP) event, were modelled in the vicinity of Marrickville Station. The AEP represents the likelihood of occurrence of a flood of given size or larger occurring in any one year. A one per cent AEP event is a rainfall event with a one per cent chance of being exceeded in magnitude in any year. In all cases, the one per cent AEP event included a 10 per cent allowance for climate change.

The probable maximum flood (PMF) event was also modelled for the Marrickville area. The PMF is considered to be the worst case flood event for an area. The PMF represents extreme flooding conditions and defines the extent of flood prone/liable land.

West of Marrickville, more limited flood modelling was undertaken at selected locations and for selected design events. This was on the basis that existing flood conditions are less severe, and that the influence of the project would be unlikely to result in noticeable changes.

Water quality

Water quality modelling undertaken was limited to a test site at Punchbowl Station, and involved using the MUSIC (Model for Urban Stormwater Conceptualisation) computer software model. This site was modelled to assess the potential effect of increases in impervious areas on pollutant generation and retention rates. Punchbowl Station was modelled as it would have one of the largest increases in impervious areas of all the stations to be upgraded.

The results indicated that provision of a gross pollutant trap coupled with either a bioretention swale or rain garden would generally meet the pollutant reduction targets for the project. The assessment also concluded that, because the project area represents a very small proportion of the overall catchment, proposed water quality treatment measures would have a minimal effect on pollutant concentrations at discharge locations.

21.2 Existing environment

21.2.1 Catchments

As shown in Figure 21.1, the project area is located in two water catchments. The majority of the project area, between Marrickville and Punchbowl stations, is located in the Cooks River catchment. Between Punchbowl and Bankstown stations, the project area drains to Salt Pan Creek, which is located in the Georges River catchment.

Both catchments are highly urbanised, meaning that the rainfall-runoff response of the catchments has been altered from a natural state. This has resulted in changes to the quantity and speed of runoff within the catchment.

Cooks River catchment

The Cooks River catchment, located in the inner to middle south-western suburbs of Sydney, has an area of about 102 square kilometres. The majority of the catchment is highly developed. The Cooks River itself is about 23 kilometres long, and flows from Chullora in the west to Botany Bay in the east. The river discharges into the north of Botany Bay, near Sydney Airport. The river is tidally influenced as far as South Enfield. Major tributaries of the river include:

- Coxs Creek
- Cup and Saucer Creek
- Wolli Creek
- Alexandra Canal
- Muddy Creek
- Eastern Channel
- Western Channel.

Parts of the Cooks River remain in a natural state, while other sections were lined with concrete from the 1940s onwards. Sydney Water has undertaken progressive channel naturalisation works at three locations to restore the river closer to its natural state. Between 2008 and 2012, the former Sydney Metropolitan Catchment Management Authority undertook, in consultation with local councils, a number of wetland remediation projects along the Cooks River.

Georges River catchment

The Georges River catchment, located in the southern and western suburbs of Sydney, covers an area of about 960 square kilometres. With a population of over one million people, it one of the most highly urbanised catchments in Australia. Georges River itself is about 96 kilometres long, and flows from Appin in the south in a northerly direction to Chipping Norton, then in an easterly direction to Botany Bay. The river discharges into the south of Botany Bay, between Sans Souci and Kurnell.

The western most portion of the project area drains to Salt Pan Creek, which is one of the major tributaries of the Georges River. Salt Pan Creek has a catchment area of about 26 square kilometres. The creek itself is about seven kilometres long, and flows in a generally southerly direction to the Georges River, at Riverwood. The creek is tidally influenced as far west as Fairford Road at Bankstown.

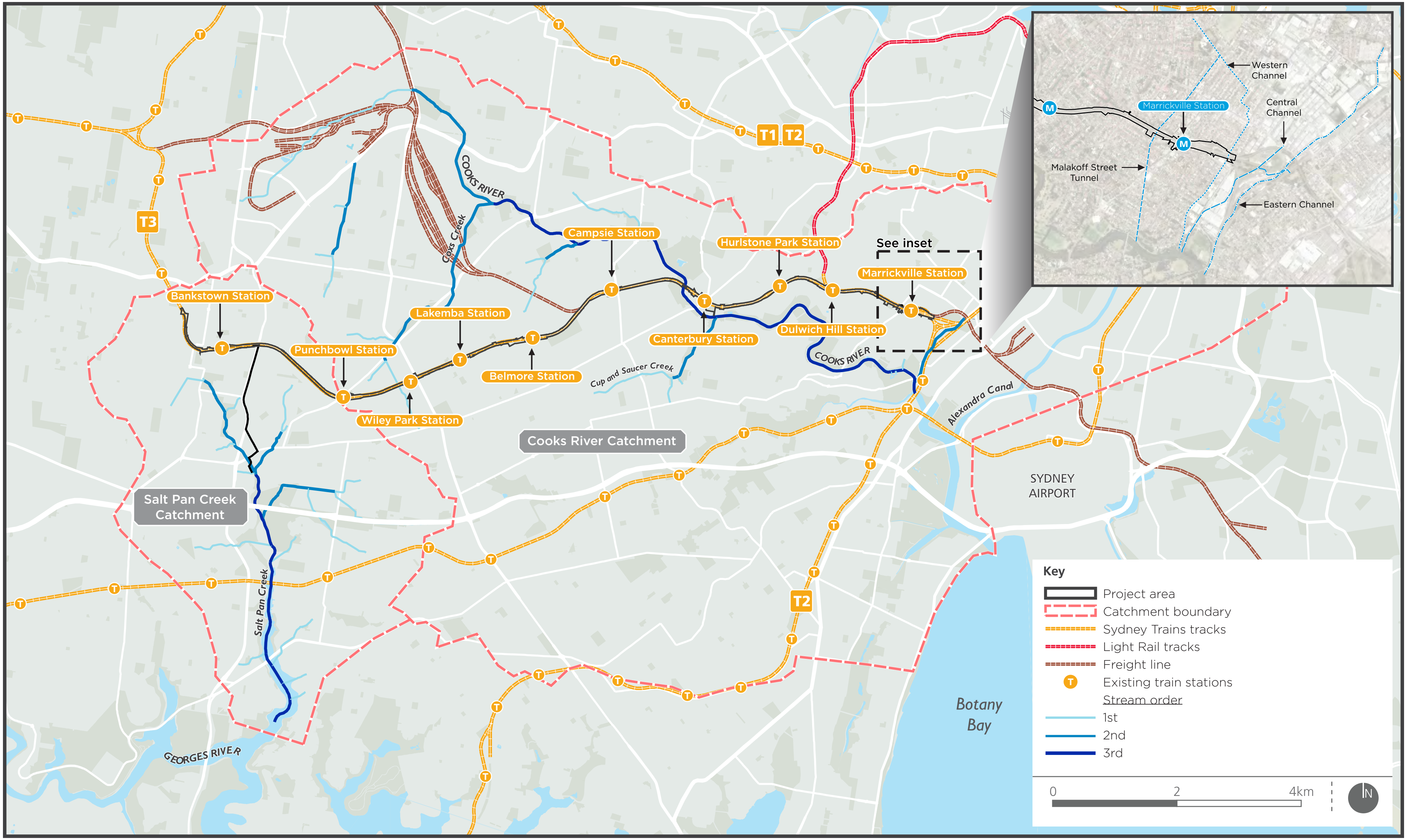
The upper reaches of the creek are highly modified and are generally concrete lined, with limited vegetation until the Canterbury Road crossing. There are no recognised tributaries for the creek on available mapping, however a number of unnamed channels drain to its upper reaches.

The project is located in the upper reaches of the Salt Pan Creek catchment. Upstream (north) of the project area, the catchment is relatively steep, and surface water runoff is managed by the existing stormwater drainage network.

21.2.2 Key watercourses

Key watercourses in the vicinity of the project area are shown in Figure 21.1. The project area crosses the following watercourses:

- Western Channel (a tributary of the Cooks River) in Marrickville, located about 450 metres east of Marrickville Station
- Cooks River at Canterbury, about 400 metres north-west of Canterbury Station
- a tributary of Coxs Creek at Wiley Park, about 250 metres west of Wiley Park Station
- the proposed route for the electricity feeder cable crosses Cup and Saucer Creek in Earlwood.



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Catchment areas and watercourse locations

FIGURE 21.1

21.2.3 Existing flooding and drainage conditions

As noted above, the Cooks River and Salt Pan Creek catchments are both highly urbanised and dominated by impervious surfaces. This means that these systems experience very low flows during dry periods and very high flows after storms, causing erosion and flooding. Key flooding information relevant to the project area is summarised below.

Cooks River catchment

The *Marrickville Valley Flood Study* (Marrickville Council and NSW Government, 2013) identifies that four major trunk drainage lines discharge to the Cooks River in the area subject to the study – the Eastern Channel, Central Channel, Western Channel, and the Malakoff Street Tunnel. The Malakoff Street Tunnel is a significant drainage asset which conveys stormwater from the Malakoff Street area, under the rail corridor, and through McNeilly Park to the Cooks River.

Marrickville Oval (located in Marrickville Park, about one kilometre to the north of the project area) is as an important flood storage location, acting as a detention basin during flood events. McNeilly Park, which adjoins the project area to the west of Marrickville Station, also acts a flood storage area during flood events.

The *Marrickville Valley Flood Study* notes that the existing rail corridor and surrounds near Marrickville Station are susceptible to flooding, with flooding predicted to occur in events as frequent as the 39 per cent AEP. Flood depths in the rail corridor are estimated to be up to one metre in a one per cent AEP event near the Illawarra Road bridge. Most of the rail corridor between Livingstone Road and Illawarra Road, and a section of corridor about 150 metres east of Marrickville Station, is identified as a high flood hazard area during the one per cent AEP event.

In other areas of the catchment, the draft *Overland Flow Study Canterbury LGA Cooks River Catchment* (Cardno, 2016) indicates that a section of the existing rail corridor located east of Canterbury Station is subject to flooding during the five per cent AEP event. The study also identifies that sections of the rail corridor 100 metres east of Canterbury Station and 100 metres west of Campsie Station are high flood hazard areas during the one per cent AEP event. The majority of the remainder of the rail corridor is either not classified as a flood hazard, or is classified as a low flood hazard in short sections.

Salt Pan Creek catchment

Mapping undertaken for the *Salt Pan Creek Stormwater Catchment Study* (Bankstown City Council, 2011a) indicates the potential for flooding of the rail corridor during the one per cent AEP event at several locations. The mapping indicates:

- Ponding on the north side of the rail corridor adjacent to Marion Street in Bankstown near the intersection with Bungalow Crescent, in events as frequent as a 63 per cent AEP event.
- Flooding and surface ponding from the local drainage network near the rail corridor on Olympic Parade and short sections of North Terrace and South Terrace in Bankstown during the one per cent AEP event.
- Downstream of the rail corridor, a number of residential properties would be impacted by flooding in events as small as the 18 per cent AEP event.

The report also identifies velocity-depth information for the rail corridor between Punchbowl Station and west of Bankstown Station. A section of the rail corridor 400 metres west of Punchbowl Station is likely to be associated with a low flood hazard. Shorter sections of the corridor, about 200 metres in length, around Stacey Street and to the east of Bankstown Station, are likely to be classified as low flood hazard areas.

The *Salt Pan Creek Catchments Floodplain Risk Management Study and Plan* (Bankstown City Council, 2013) identifies drainage issues and mitigation for the Bankstown CBD, including the need for works to improve the overland flow path near the rail corridor underpass adjacent to North Terrace.

21.2.4 Surface hydrology and identified project-specific flooding conditions

The stormwater drainage network controls stormwater flows for the smaller storm events throughout the project area, mainly from roads and urban areas. There are numerous stormwater drainage crossings beneath the rail corridor, including more than 40 drainage culverts that are larger than 450 millimetres in diameter.

Existing drainage issues within the rail corridor are generally related to one or both of the following:

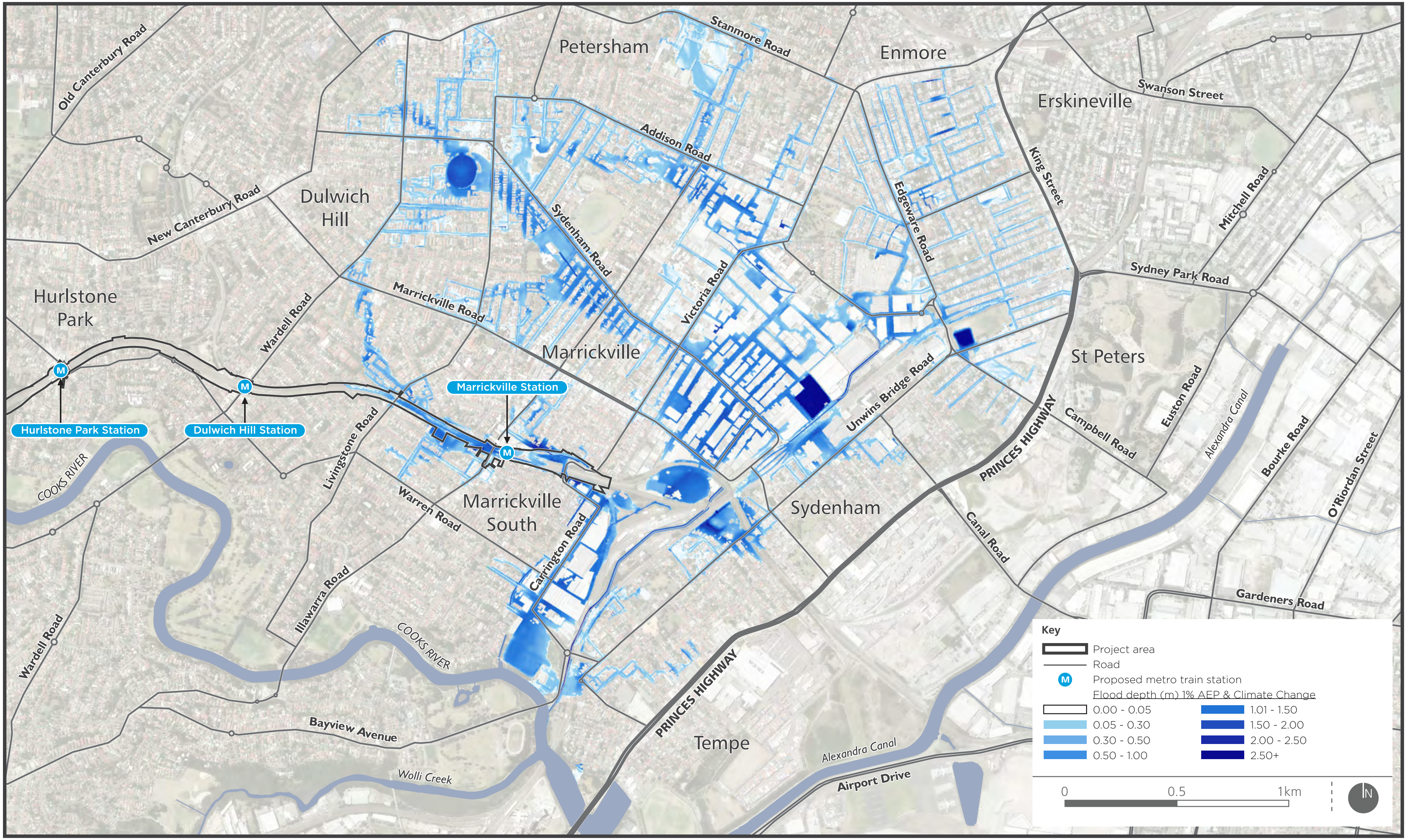
- insufficient capacity within the surrounding local stormwater drainage network, which overflows into the rail corridor during flood events
- lack of drainage infrastructure within the rail corridor to capture flows from external catchments – this is particularly the case where the ARTC freight tracks are located up-slope of the Sydney Trains tracks.

Marrickville

The most flood affected parts of both the project area and surrounding areas are located in the vicinity of Marrickville Station. Modelling of existing flood conditions was undertaken by the design team for the one per cent AEP event, with a ten per cent allowance for an increase in peak rainfall intensity (to account for climate change). This is referred to as the one per cent AEP climate change event. Modelling was also undertaken for the PMF event, which is the maximum flood which can theoretically occur. The extent and depth of existing flooding for the one per cent AEP climate change event and the PMF is shown in Figure 21.2 and Figure 21.3 respectively. The existing provisional flood hazard mapping for the one per cent AEP and PMF events are shown in Figure 21.4 and Figure 21.5 respectively.

The mapping shows:

- flooding of the rail corridor with flood depths greater than one metre between Livingstone Road and Illawarra Road near Marrickville Station in a one per cent AEP event
- most of the rail corridor between Livingstone Road and Illawarra Road, and a section of corridor east of Marrickville Station, is identified as a high flood hazard area during the one per cent AEP event
- in the one per cent AEP event, high flood hazard areas are also located along public roads (Sydenham Road and Carrington Road in particular) and open channels, consistent with their definition as floodways
- during the PMF, these same roads and areas are more severely affected, including the rail corridor between Livingstone Road and Illawarra Road, Sydenham Road (and roads leading south), Carrington Road, Meeks Road/Fitzroy Street, and areas to the east
- access routes around Marrickville Station, including some used for emergency access, would be flooded, including Railway Parade, Sydenham Road, Marrickville Road, Illawarra Road, Schwebel Street, and Arthur Street.



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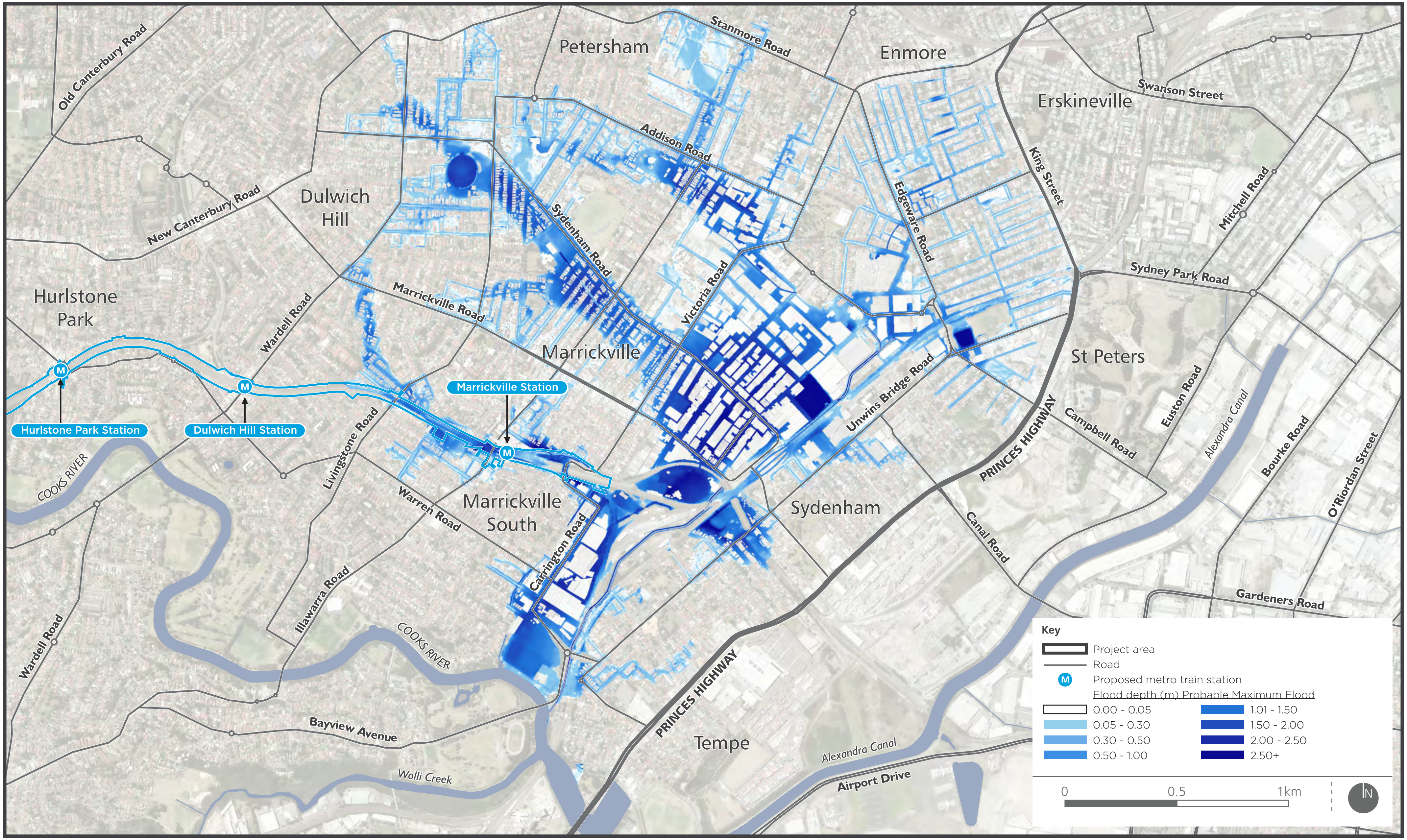
Marrickville and surrounds – existing flood depth and extent - one per cent AEP plus climate change

FIGURE 21.2



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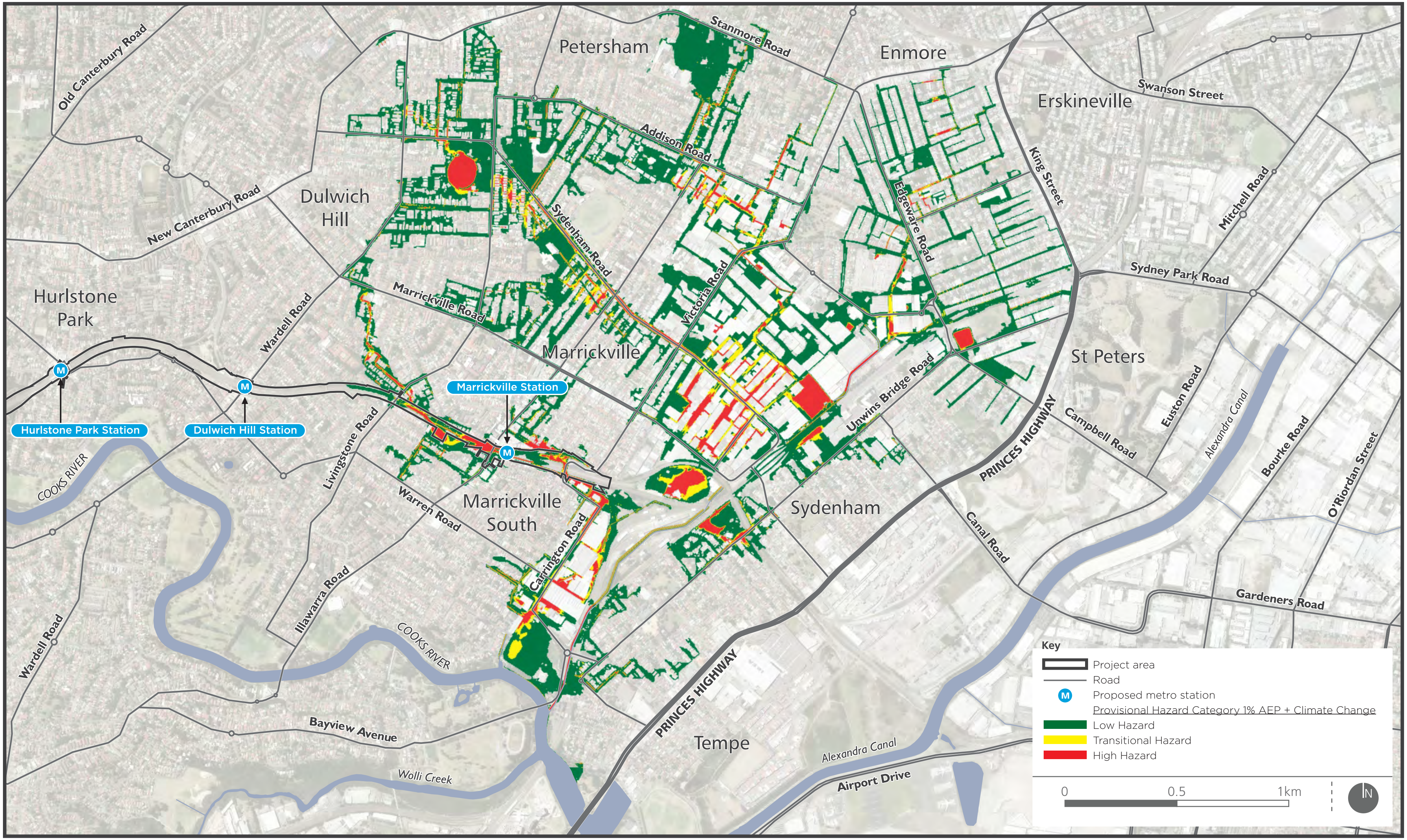
Marrickville and surrounds – existing flood depth and extent - probable maximum flood

FIGURE 21.3



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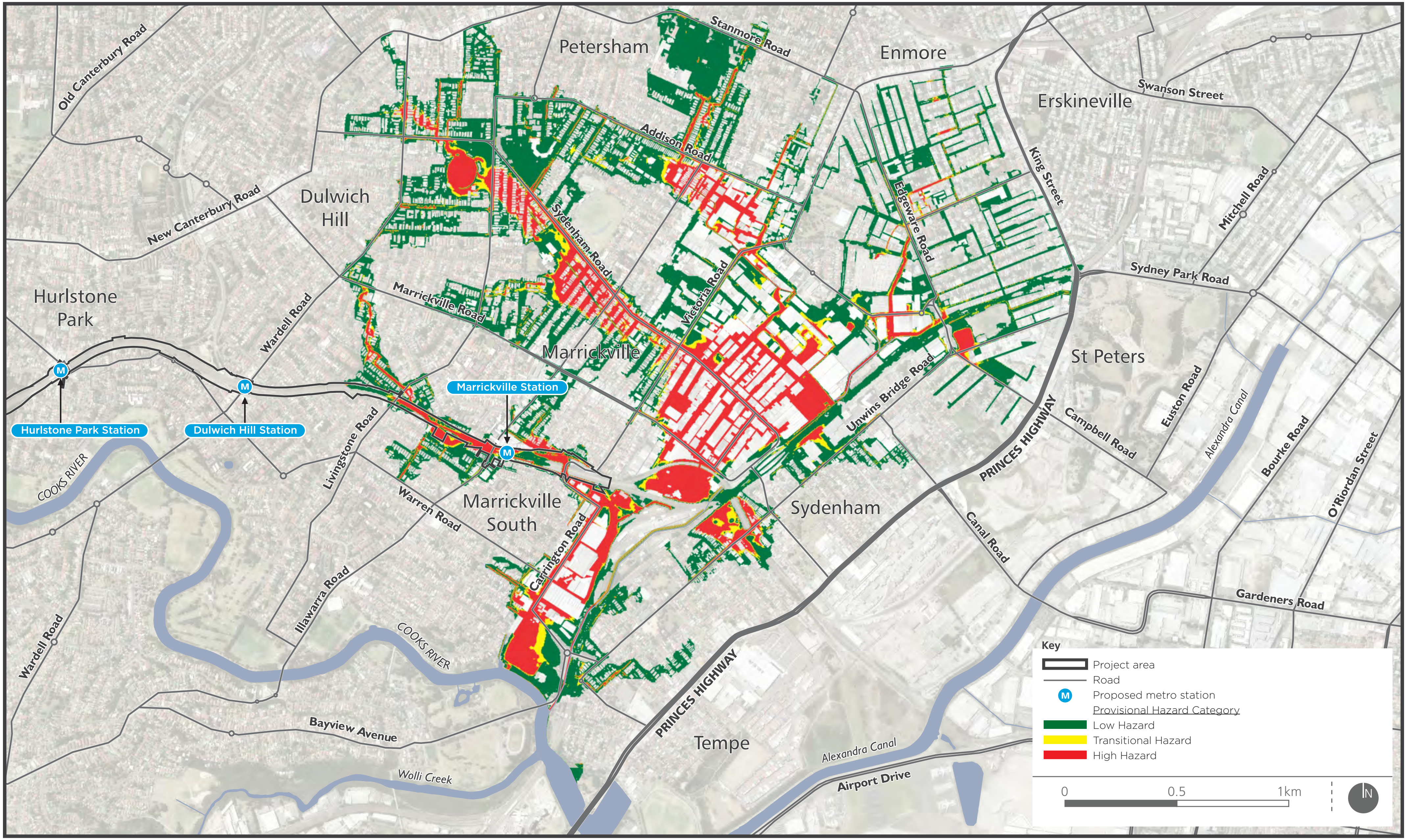
Marrickville and surrounds - existing provisional flood hazard - one per cent AEP plus climate change

FIGURE 21.4



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Marrickville and surrounds - existing provisional flood hazard - probable maximum flood

FIGURE 21.5

Rest of the project area

Table 21.2 lists the flooding and drainage issues occurring in the remainder of the project area between Dulwich Hill and Bankstown stations. These issues are generally considered to be more minor than at Marrickville Station.

Table 21.2 Summary of other drainage and flooding conditions – rest of project area

Location	Existing issues identified
Dulwich Hill Station to Canterbury Station	Overland flooding into the rail corridor occurs in some locations where existing cross drainage capacity is exceeded. These include: • substantial overland flooding east of Canterbury Station (high flood hazard area) • minor overland flooding potential west of Canterbury Station (low flood hazard area).
Campsie Station	Overland flooding into the rail corridor occurs: • from west of Campsie Station (high flood hazard area) during events greater than the 10% AEP • near the Belmore triangle area during events greater than the 39% AEP.
Belmore Station	Local drainage capacity constraints outside the rail corridor in some locations. Rail alignment in fill, therefore no predicted overland flood issues.
Lakemba Station	East of the station there is a risk of flooding in the rail corridor for events equal to and greater than the 5% AEP. West of the station there is limited cross drainage capacity however the rail corridor is on fill.
Wiley Park Station	Limited cross drainage capacity however rail line is mostly in fill.
Punchbowl Station	East of the rail corridor there are a number of culverts with varying capacities, and potential for overflows into the rail corridor. West of the rail corridor, modelling indicates overflows into the rail corridor at one location for the 1% AEP climate change event.
Bankstown Station	Rail line mostly in fill with limited potential for flooding of rail corridor.

Scour potential

The results of flood modelling for the one per cent AEP event under existing conditions indicates that 10 of the 40 culverts located within the project area with diameters greater than 450 millimetres have flow velocities greater than 2.5 metres per second. This corresponds to the velocity above which scour and erosion may occur. The culvert locations where flow velocities are considered to be relatively high are listed in Table 21.3.

Table 21.3 Culverts with high flow velocities

Culvert number[1]	Approximate location	Dimensions (m)	1% AEP discharge (m^3/s)	1% AEP velocity (m/s)	Existing capacity (AEP)
9	West of Melford Street, Canterbury	Box 0.75 x 0.8m	1.27	6	>1% AEP
13	West of Loch Street, Campsie	Box 1.1 x 0.7m	1.76	5	< 39% AEP
16	Near Marie Lane, Belmore	Box 0.9 x 0.9m	3.1	3.5	< 39% AEP
17	East of Dennis Street, Lakemba	Arch 0.9 x 0.9m	1.75	4.8	< 5% AEP
18	East of Quigg Street South, Lakemba	Arch 0.9 x 0.9m	2.2	4.6	Not available

Culvert number[1]	Approximate location	Dimensions (m)	1% AEP discharge (m^3/s)	1% AEP velocity (m/s)	Existing capacity (AEP)
24	Adjacent Rosemont Street South, Punchbowl	0.9m diameter	1.9	5.3	< 18% AEP
25	Adjacent Matthews Street, Punchbowl	0.9m diameter	1.7	4.8	< 2% AEP
26	Adjacent Matthews Street, Punchbowl	0.75m diameter	1.4	3.2	< 5% AEP
27	West of Kelly Street, Punchbowl	0.9m diameter	1.5	3.5	> 1% AEP
28	West of Scott Street, Bankstown	Arch 0.9 x 0.9m	3.45	5.4	> 1% AEP

Note: 1. Culvert numbers correspond to those shown on Figures 3-9 to 3-14 in Technical paper 8.

Emergency management

The relevant emergency management plan for the study area is the *South West Metropolitan Emergency Management District Disaster Plan* (NSW Government, July 2012). No other currently published flood plans for the area are available on the NSW State Emergency Service Floodsafe webpage.

Flood emergency management is incorporated into the design criteria for the proposed upgrade to stations. Flood emergency management procedures would also be incorporated into the project's operational emergency management plans.

The project team has held preliminary discussions with the NSW State Emergency Service who identified Unwins Bridge Road in the Marrickville area as being a key evacuation route in advance of a flood event. However, it was noted that in recent flood history, flood events at this location have been up to the 20 per cent AEP event.

21.2.5 Water quality

As a consequence of the heavily urbanised nature of the catchments, water quality is generally relatively poor, with stormwater runoff fouling the river systems with litter, petroleum derivatives, excess nutrients, and other pollutants. No existing water quality treatment measures within the project area were identified in the desktop research or site visit.

Cooks River catchment

Water quality within the Cooks River is generally considered to be poor and unfit for contact by humans (Cooks River Alliance, 2014). The main sources of poor water quality within the river are wastewater overflows, illegal dumping, and litter. The *Cooks River Alliance Management Plan 2014* targets, amongst other objectives, the improvement of water quality.

Further downstream in the Cooks River estuary, water quality is monitored as part of OEH's Beachwatch program. The most relevant monitoring location is at Kyeemagh Baths. The most recent State of the Beaches annual report noted that Kyeemagh Baths was graded as 'good', with the microbial water quality suitable for swimming most of the time, but that the water may be susceptible to pollution from a number of potential sources of faecal contamination, including the Cooks River, stormwater, and sewage overflows (OEH, 2016).

Salt Pan Creek catchment

Development in the Salt Pan Creek catchment, including construction impacts and litter, as well as other influences such as wastewater overflows and a landfill operation, have resulted in poor water quality. Since about 2009/2010, water quality has improved following the efforts of local councils and others. Salt Pan Creek is now considered to have good water quality (Georges River Combined Councils Committee, 2016).

A number of beaches in the lower Georges River are monitored as part of OEH's Beachwatch program. The most recent State of the Beaches annual report noted that these locations were graded as 'good', meaning that the quality of the water was appropriate for swimming most of the time (OEH, 2016).

Water quality objectives and criteria

The *NSW Water Quality and River Flow Objectives* provide water quality objectives for the Cooks River and Georges River catchments, for the protection of the following (within waterways affected by urban development, or estuaries):

- aquatic ecosystems
- visual amenity
- secondary contact recreation
- primary contact recreation.

Waterways affected by urban development are defined as streams within urban areas, which are frequently substantially modified and generally carry poor quality stormwater. The majority of watercourses within the study area meet this definition, with the exception of the Cooks River, which meets the definition of an estuary, as it is dominated by saline conditions.

The water quality objective for aquatic ecosystems is to 'maintain or improve the ecological condition of waterbodies and their riparian zones over the long term'. The indicators and criteria (trigger values) for this objective are listed in Table 21.4. While it is likely that watercourses within the study area would be classified as highly disturbed systems (being urban streams receiving road and stormwater runoff), the ANZECC 2000 guidelines recommend that the guideline trigger values for slightly to moderately disturbed systems should also apply to highly disturbed ecosystems wherever possible. Therefore, the water trigger values provided in Table 21.4 are based on the ANZECC 2000 guideline default trigger values for the protection of aquatic ecosystems in slightly disturbed river ecosystems in south-eastern Australia.

A detailed list of the indicators and criteria for the other water quality objectives for the Cooks River and Georges River catchments is provided in Technical Paper 8.

Table 21.4 Water quality trigger values for aquatic ecosystems

Indicator	Criteria (lowland rivers)
Total phosphorus	50 ug/L
Total nitrogen	500 ug/L
Chlorophyll-a	5 g/L
Turbidity	6–50 NTU
Salinity (electrical conductivity)	125–2,200 uS/cm
Dissolved oxygen (per cent saturation)	85–110 %
pH	6.5–8.5

21.2.6 Groundwater

The groundwater level along most of the project area was recorded at between about 2.3 metres below ground level (to the east of the project area in Marrickville) and about 10.3 metres below ground level (near Bankstown Station).

Groundwater has been observed discharging from open cuttings along the rail corridor. The surface groundwater system is likely to be recharged by rainfall and percolation from irrigation of residential gardens and open spaces, as well as incidental runoff from impervious surfaces, such as roads and footpaths.

A search of the NSW Water Register was undertaken on 22 September 2016 to identify existing users and extraction rates. The search identified 17 groundwater boreholes located within 400 metres of the project area, the majority of which were registered as monitoring bores/wells.

Quaternary alluvium underlies the Cooks River and its tributaries and forms an aquifer. Groundwater is also present within localised alluvial deposits in some gullies. Groundwater salinity within the Quaternary alluvium and localised alluvial deposits is expected to vary from lower salinity in the upper reaches of the Cooks River, to higher salinity in the lower reaches due to mixing and tidal influences.

Groundwater encountered at deeper levels within the Mittagong Formation and Hawkesbury Sandstone is expected to have lower salinity and low concentrations of dissolved metals and nutrients.

21.3 Impact assessment

21.3.1 Risk assessment

Potential risks

A sensitive receiving environment is one that has a high conservation value, or supports human uses of water that are particularly sensitive to degraded water quality (DECC, 2008). With regard to the study area, sensitive receiving environments are considered to include:

- threatened ecological communities associated with aquatic ecosystems
- known and potential habitats for threatened fish
- key fish habitats
- recreational swimming areas
- areas that contribute to drinking water catchments.

Cooks River is mapped as key fish habitat, and threatened fauna species listed under the *Fisheries Management Act 1994* have been recorded or are predicted to occur in the study area. However, based on the poor quality of the river, previous records, and habitat requirements, these species are considered unlikely to occur. The other watercourses in the project area are considered unlikely to contain any significant sensitive environments.

The environmental risk assessment for the project, undertaken for the State Significant Infrastructure Application Report, identified the following as the main hydrology, flooding and water quality risks:

- impacts on flood-prone areas during construction and operation (e.g. increase in flood risk outside the project area)
- impacts on construction activities due to flooding
- flooding impacts on project infrastructure during operation
- water quality impacts due to spills and erosion during construction and operation
- adverse impacts on groundwater flows, quality, and levels due to excavation.

Other potential risks include:

- temporary impact to the behaviour of local surface water systems during construction
- blockages of flow paths affecting low flows through construction within watercourses and through erosion and sedimentation control structures
- reduced water quality (including increased total suspended solids and turbidity) as a result of erosion and sedimentation near watercourses
- modification to existing drainage infrastructure resulting in water quality impacts
- impact to surface water quality and receiving environments due to increased runoff from impervious areas.

How potential impacts would be avoided

In general, potential flooding impacts would be avoided by implementing the proposed drainage works described in Section 8.1.3, and the mitigation measures in Section 21.4.

Potential water quality impacts would be avoided by managing water quality in accordance with the requirements of the POEO Act and the environment protection licence for the project, and implementing the mitigation measures in Section 21.4.

21.3.2 Construction impacts – hydrology and flooding

Potential for detrimental increases in the flood affectation of other properties, assets and infrastructure

During construction, there may be a need to temporarily disconnect or divert existing stormwater drainage pipes, which could result in localised modifications to existing flooding patterns, flow volumes, and velocities.

Temporary diversions would be required to transfer runoff around construction work areas. This may involve excavations and embankments, which would alter localised flow patterns. These changes would be temporary and limited to the construction phase. The landform would be restored as close as practicable to the pre-works condition following construction.

Construction would result in a small increase in impervious areas, which would have the potential to increase the volume of water flowing to watercourses. However, the change in impervious area would be negligible compared to the overall catchment area.

Temporary changes to the stormwater drainage system during construction would be subject to further design and analysis to confirm the potential impacts and to identify any required mitigation. Any flood impacts during construction are expected to be localised and relatively minor, and would be managed by implementing the measures provided in Section 21.4.2. This would include, wherever possible, implementation of replacement drainage in advance of any disconnections or diversions.

The locations of work areas and compounds within designated flood hazard areas would not result in flood affectation of other properties, assets, and infrastructure (refer explanation below).

Consistency with Council floodplain risk management plans

Relevant plans are described in Section 21.2.1. The *Salt Pan Creek Catchments Floodplain Risk Management Study and Plan* proposes drainage modifications near Wattle Street in Bankstown, which is close to the project area. Construction of the project would not prevent or compromise these proposed works. The proposed works are therefore considered to be consistent with Council's floodplain risk management plans.

Compatibility with the flood hazard of the land

Some construction activities, work sites, and compounds would be located in areas where there is an existing flood hazard. However, due to the generally small sizes of compounds and work sites relative to the size of the floodplain, minimal impacts on flood hazard would result. The layout of construction compounds and work sites would be undertaken with consideration of overland flow paths and avoid flood liable land where practicable. The location of compounds and work sites would be reviewed during construction planning to avoid, where possible, high hazard areas. Following completion of construction, no further impacts would occur.

Compatibility with the hydraulic functions of flow conveyance in floodways and storage areas of the land

Some areas of construction are located in areas with overland flow paths that may constitute floodways. Obstruction of flow paths and floodways due to the presence of construction works and equipment has the potential to redistribute flood flows and impact downstream properties, and/or mobilise construction equipment or debris, which could result in downstream safety or water quality impacts.

Careful review of the proposed layout of construction compounds, including siting of buildings and plant, would be undertaken where these are located within or partially within flood liable land. However, given their small size relative to the overall floodplain area, minimal impacts are expected. Following completion of construction, no further impacts would occur.

Some modifications to flood storage areas, including at McNeilly Park, are proposed. Construction flood management planning would incorporate measures to maintain the storage function of those areas in a flood event.

Downstream velocity and scour potential

There is the potential for temporary drainage works to impact overland flow paths during construction. This could divert or concentrate flows, potentially resulting in the scouring of downstream areas, particularly where soil has been exposed during construction.

Soil and water management measures would be implemented in accordance with *Managing Urban Stormwater: Soils and Construction, Volume 1* (Landcom, 2004) and *Managing Urban Stormwater: Soils and Construction, Volume 2A* (DECC, 2008), to minimise any potential impacts resulting from runoff and flooding during construction.

Impacts on existing emergency management arrangements

Preliminary consultation was undertaken with the NSW State Emergency Service and local councils regarding existing flood evacuation routes and the potential impacts of the project. A number of roads providing access to the project area around Marrickville are subject to flooding under existing conditions (described in Section 21.2.4).

With the implementation of mitigation measures provided in Section 21.4.2, no impacts on existing emergency management arrangements are expected during construction. Ongoing liaison would be undertaken with relevant stakeholders during detailed design and the construction period.

Social and economic costs to the community

Although there would be temporary changes during construction, including installation of drainage and culvert works, there is not expected to be any social and economic costs to the community as a result of these works.

Groundwater levels and flows

The project would involve limited excavation. Piling may intercept groundwater where encountered at depth, however potential impacts can be effectively managed by implementing the standard mitigation measures provided in Section 21.4.2. Negligible impacts on groundwater levels are expected, and no major dewatering activities are likely to be required. Construction of the project is unlikely to impact on groundwater flows.

Interaction between surface water and groundwater

Excavation of some cuttings would be undertaken during construction. These works have the potential to intersect dykes or faults which may require management to minimise risks to structural stability and interference with groundwater. Piling work could also result in the connection of surface water with deeper aquifers during pile shaft excavation, depending on the depth of the piles and the presence of perched water. These potential impacts are considered to be relatively minor as a result of the nature of the works and the limited excavation required. Mitigation measures are provided in Section 21.4.2.

Construction water usage

Water would be required for dust control, soil compaction, and vegetation establishment. The required volume of water would depend on climatic conditions during construction. It is expected that potable or recycled water (preferably) would be used for this purpose, with the construction contractor to investigate the various sources of water available and obtain any necessary approvals. No groundwater extraction or surface water harvesting is proposed for the construction of the project.

Water usage during construction could also increase infiltration rates and surface water runoff in the project area. The impact of this additional discharge is expected to be minimal, as the additional flow and infiltration would be negligible compared to regional rainfall levels. Any impacts would be short term.

21.3.3 Construction impacts – water quality

Construction presents a risk to downstream water quality if standard construction management measures are not implemented, monitored and maintained throughout the construction period. If inadequately managed, construction activities can impact water quality if they disturb soil or watercourses, result in uncontrolled discharges of substances to watercourses, or generate contamination. Potential sources of water quality impacts include:

- increased sediment loads from exposed soil transported off-site to downstream watercourses during rainfall events
- increased sediment loads from discharge of sediment laden water from dewatering of excavations
- increased levels of nutrients, metals, and other pollutants, transported in sediments to downstream watercourses or via discharge of water to watercourses
- chemicals, oils, grease, and petroleum hydrocarbon spills from construction machinery directly polluting downstream watercourses
- litter from construction activities polluting downstream watercourses
- contamination of watercourses due to runoff from contaminated land.

The downstream effects of water quality impacts include:

- smothering aquatic life and/or inhibiting photosynthesis conditions for aquatic and riparian flora

- impacts to breeding and spawning conditions of aquatic fauna
- changes to water temperature due to reduced light penetration
- impacts to the ecosystems of downstream sensitive watercourses, wetlands, and floodplains
- increased turbidity levels above the design levels of water treatment infrastructure
- reduced visibility in recreation areas.

The potential for soil and contamination impacts during construction, including the potential for contamination of surface water and groundwater due to spills and leaks, and/or the mobilisation of contaminants encountered during demolition of structures, are considered in Chapter 20 (Soils and contamination). Potential water quality impacts are considered in this section.

Changes to surface water flows

Changes to surface water flows can impact water quality – an increase in flow rate and volume can lead to increased erosion and turbidity. The potential impacts of changes to surface water flows are considered in Section 21.3.2.

Works in watercourses

The project would involve works in and around watercourses, including the Cooks River and Cup and Saucer Creek. These works could disturb the bed and banks, and potentially lead to localised erosion and sediment transport downstream. The NSW Office of Water's guidelines for controlled activities would be considered when undertaking works on waterfront land to minimise the potential for impacts to water quality. It is noted that Cup and Saucer Creek is a lined concrete channel in the vicinity of the proposed route for the electricity feeder cable, which is proposed to cross the creek via an existing road bridge.

Earthworks, demolition, stockpiling and general runoff from construction sites

Construction can impact water quality in downstream watercourses as a result of erosion. Runoff from stockpiles has the potential to impact downstream water quality during rainfall if stockpiles are not managed appropriately. Sediments from the stockpiles could wash into watercourses, increasing levels of turbidity.

Stockpiling cleared vegetation creates a risk of tannins leaching into watercourses, resulting in an increased organic load. Discharge of water high in tannins can increase the biological oxygen demand of the receiving environment, which may in turn result in a decrease in available dissolved oxygen. Once discharged to the environment, tannins may also reduce visibility, light penetration, and change the pH of receiving waters. These impacts may affect aquatic ecosystems in receiving environments.

Sediment loads in watercourses can increase in the vicinity of hard surfaces (such as roads) and compacted areas due to increased surface runoff.

Although the project has the potential to temporarily reduce water quality from pollutants and run-off, it would not be expected to cause significant impacts to the overall condition of surrounding waterways. Construction is unlikely to result in any long-term water quality impacts in the study area.

The mitigation measures provided in Section 21.4.2 would be implemented to minimise the potential for water quality impacts during construction.

Minimising the effects of proposed stormwater and wastewater management during construction on natural hydrological attributes

Surface water at construction sites would be managed by implementing standard erosion and sediment control measures in accordance with *Managing Urban Stormwater: Soils and Construction* volumes 1 and 2A.

Groundwater quality

Potential risks to groundwater quality during construction include:

- contamination by hydrocarbons from accidental fuel and chemical spills
- contaminants contained in turbid runoff from impervious surfaces.

Surface water from site runoff may infiltrate and impact groundwater sources. As the infiltration process is generally effective in filtering polluting particles and sediment, the risk of contamination of groundwater from any pollutants bound in particulate form in surface water run-off, such as heavy metals, is generally low.

Soluble pollutants, such as pH altering solutes, salts and nitrates, as well as soluble hydrocarbons, can infiltrate soils and contaminate the groundwater system. Under certain pH conditions, metals may also become soluble and could infiltrate groundwater.

The mitigation measures provided in Section 21.4.2 would be implemented to minimise the potential for groundwater quality impacts.

The presence of salinity within the project area is considered in Chapter 19. Given the limited amount of excavation proposed, and the low likelihood of intercepting groundwater during works, impacts to groundwater resources and hydrology due to soil salinity are considered unlikely. However, any potential impacts would be mitigated by implementing standard erosion and sediment control measures during construction, including measures to minimise infiltration of increased surface water, and backfilling soil units in the order they were excavated.

21.3.4 Operation impacts – hydrology and flooding

Potential for detrimental increases in the flood affectation of other properties, assets and infrastructure

As noted in Section 21.2, the most flood affected parts of both the project area and surrounding study area are located in the vicinity of Marrickville Station. The key outcomes in relation to flooding in Marrickville are summarised in Table 21.5 and shown on Figure 21.6 to Figure 21.11.

Table 21.5 Performance against flood criteria in Marrickville

Key design criteria[1]	Marrickville Station	Adjacent lands	Public roads
Maximum increase in time of inundation of one hour in a 1% AEP event	Achieved	For the 1% AEP climate change event: • no increase in flooding in the majority of the study area • reduction in flood levels of up to 300 mm along the rail corridor west of Marrickville Station, and between 50 to 150 mm further to the west • reduction in flood levels between 50 to 100 mm east of Marrickville station. For events up to the 1% AEP climate change event, where there are increases, these are only up 50 mm. A floor level survey and a detailed analysis is required to assess the above floor impacts at +/- 10 mm accuracy. Flood level increases are expected in the PMF. Flood level changes elsewhere are still to be assessed, but are expected to be relatively minor.	A reduction in the flood level of between 150 to 200 mm is predicted in the vicinity of Byrnes Street, O'Hara Street, and Cavey Street. A reduction in the flood level of between 50 to 100 mm is predicted at the southern end of Carrington Road and Richardsons Crescent, including Mackey Park and the Carrington Road industrial area. The only exception is the section of Junction Street between Ruby and Schwebel Street, where an increase of 100 mm is predicted for the 39% AEP event. For the PMF event, a reduction in the flood level of between 50 to 100 mm is predicted at the northern end of Carrington Road and the industrial area. For events up to the 1% AEP climate change event, where there are increases, these are only up 50 mm. For the PMF event, flood level increases are predicted on access routes already flooded under existing conditions. Flood level changes elsewhere are still to be assessed, but are expected to be relatively minor.
Maximum increase of 10 mm in flood level at properties where floor levels are already exceeded in a 1% AEP event	Floor level survey not available. Any potential flooding above-floor level would be assessed during detailed design.		
Maximum increase of 50 mm in flood level at properties where floor levels are not exceeded in a 1% AEP event	Achieved		
Increase in flood velocities - identification of mitigation measures	Many locations benefit from flood velocity decreases. Selected locations of velocity increase are generally less than 0.25 m/s for all flood events with further development of mitigation measures to be undertaken during the next stage of design.		

Note:1. Refers to design criteria outlined in Table 4-2 of Technical paper 8

At other locations along the corridor between Marrickville and Bankstown stations, more limited modelling was undertaken to confirm that the introduction of the proposed infrastructure would not result in downstream impacts.

The conclusion of the assessment is that the proposed drainage measures would generally be effective at limiting downstream impacts. While detailed assessment of flooding at Canterbury Station was not undertaken, based on the draft *Overland Flow Study Canterbury LGA Cooks River Catchment* (Cardno, 2016), flooding was found to occur along the rail corridor at Canterbury Road, with flood depths of up to two metres for the five per cent AEP, one per cent AEP, and PMF events.

In general, it was identified that peak flow rates from cross drainage structures would increase where no detention basins are currently proposed. It was also identified that the overall peak flow rates in the drainage systems would not increase, due to differences in the timing of peak flows between the rail culverts and the wider drainage network.

Further analysis and design would confirm the required design mitigation measures and impacts at lower risk locations.

Consistency (or inconsistency) with applicable Council floodplain risk management plans

As noted in Section 21.3.2, drainage works associated with the project are compatible with local floodplain risk management plans, and would result in generally a reduction of existing flood extent and depth.

Compatibility with the flood hazard of the land

Results of flood modelling indicate that the project would not result in a change to existing flood hazard in or surrounding the rail corridor.

Compatibility with the hydraulic functions of flow conveyance in floodways and storage areas of the land

Drainage works have been designed to mitigate potential adverse impacts on more minor floodways (such as roads) in events up to the PMF.

Detention capacity in McNeilly Park (and at other locations) would be increased to cater for additional flows. Therefore, the project is considered to be compatible with the floodway and flood storage functions of the floodplain.

Downstream velocity and scour potential

At Marrickville, changes in velocities are estimated to be generally less than 0.25 metres per second at all locations for the full range of flood events. As in the case of flood levels, many of the areas would benefit from a net reduction in velocities as a result of the project.

Modelling of existing conditions indicates that about 10 of the existing culverts have exit velocities greater than 2.5 metres per second, which is the velocity above which scour and erosion could occur. While an increase in velocities is predicted to occur at two culverts, following implementation of the project, the level of increase would be small, and the velocity would be less that the design limit.

Appropriate methods of scour protection at identified locations would be identified during detailed design.

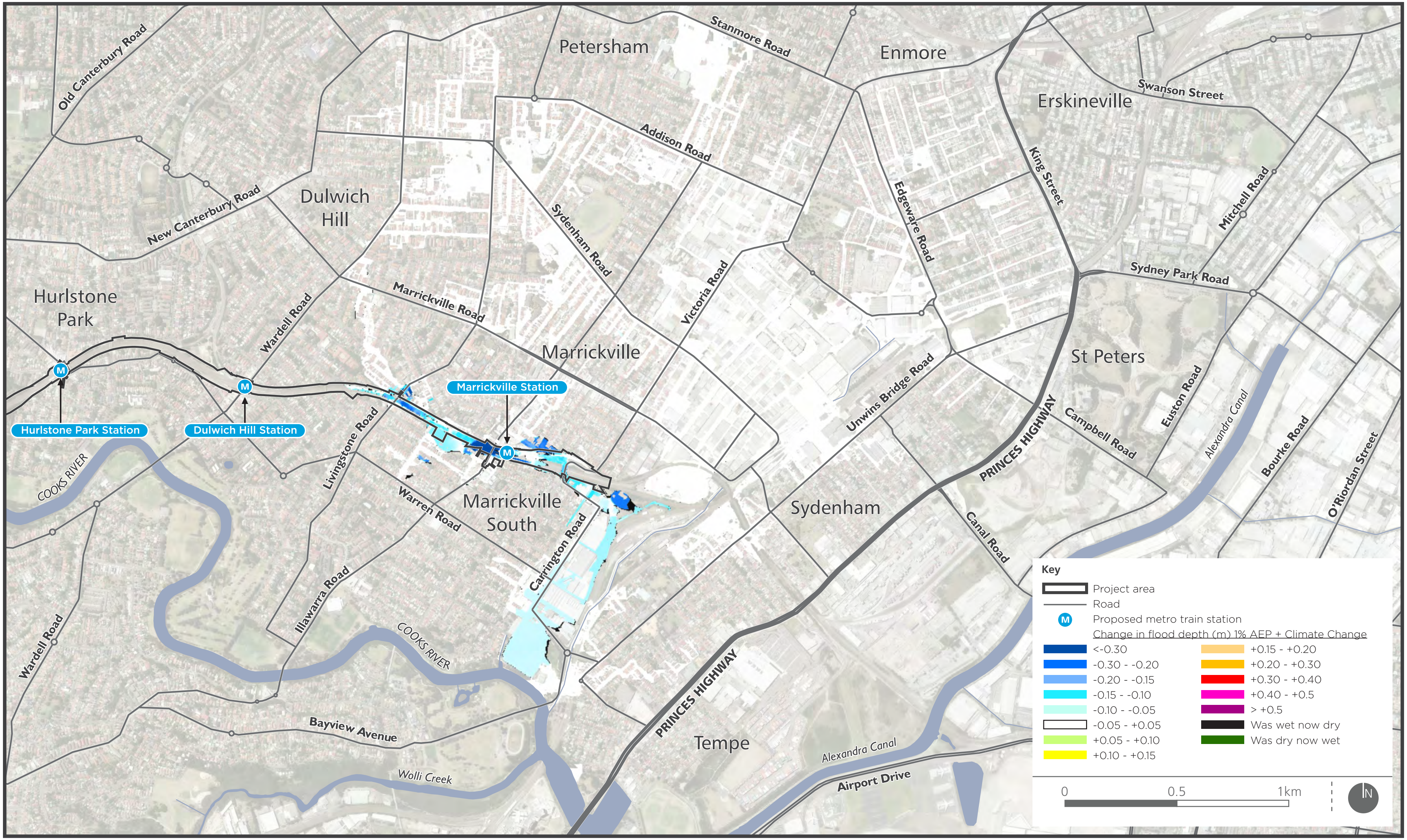
Impacts of flooding on existing emergency management arrangements

Preliminary consultation was undertaken with the NSW State Emergency Service regarding existing flood evacuation routes and the potential impacts of the project. Roads identified to be flooded under existing conditions, which provide access to the project area around Marrickville (described in Section 21.2.4) are also expected to be flooded once the project is operational. For the PMF event, no changes to existing flood levels on emergency flood access routes are expected.

Flood emergency management is incorporated in the design criteria for station infrastructure. Flood emergency management procedures would be incorporated in Sydney Metro's operational emergency management plans.

Social and economic consequences

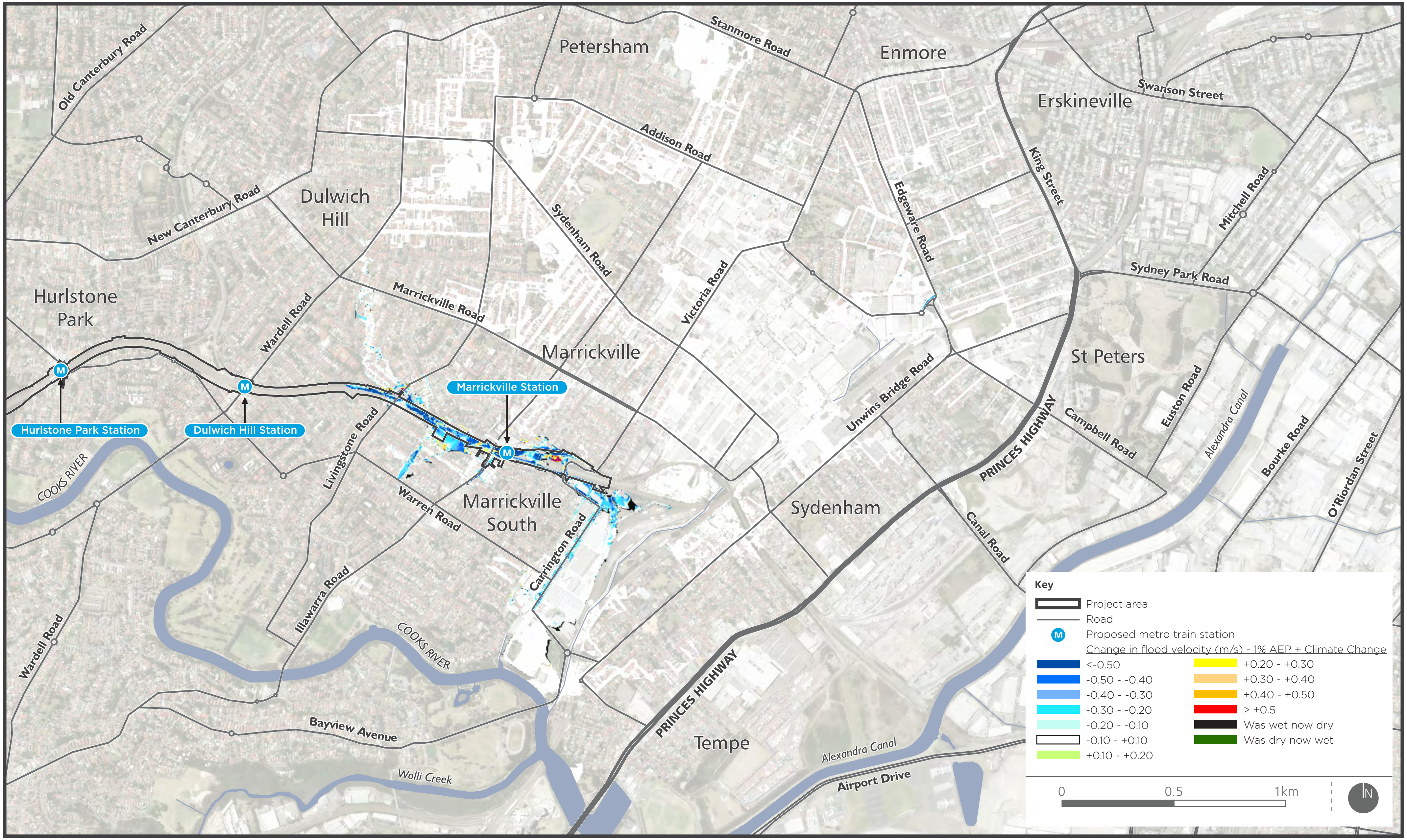
The analysis undertaken during design development indicates that there are limited adverse flooding and hydrology impacts resulting from the project, and no change or an improvement to many aspects relative to existing conditions under a range of potential flood events. The impacts identified are mainly increases in velocity at a limited number of locations. The economic and social consequences of the project (with respect to flooding) are considered to be negligible.



sydney METRO | city & southwest

Marrickville and surrounds – change in flood depth and extent with the project - one per cent AEP plus climate change

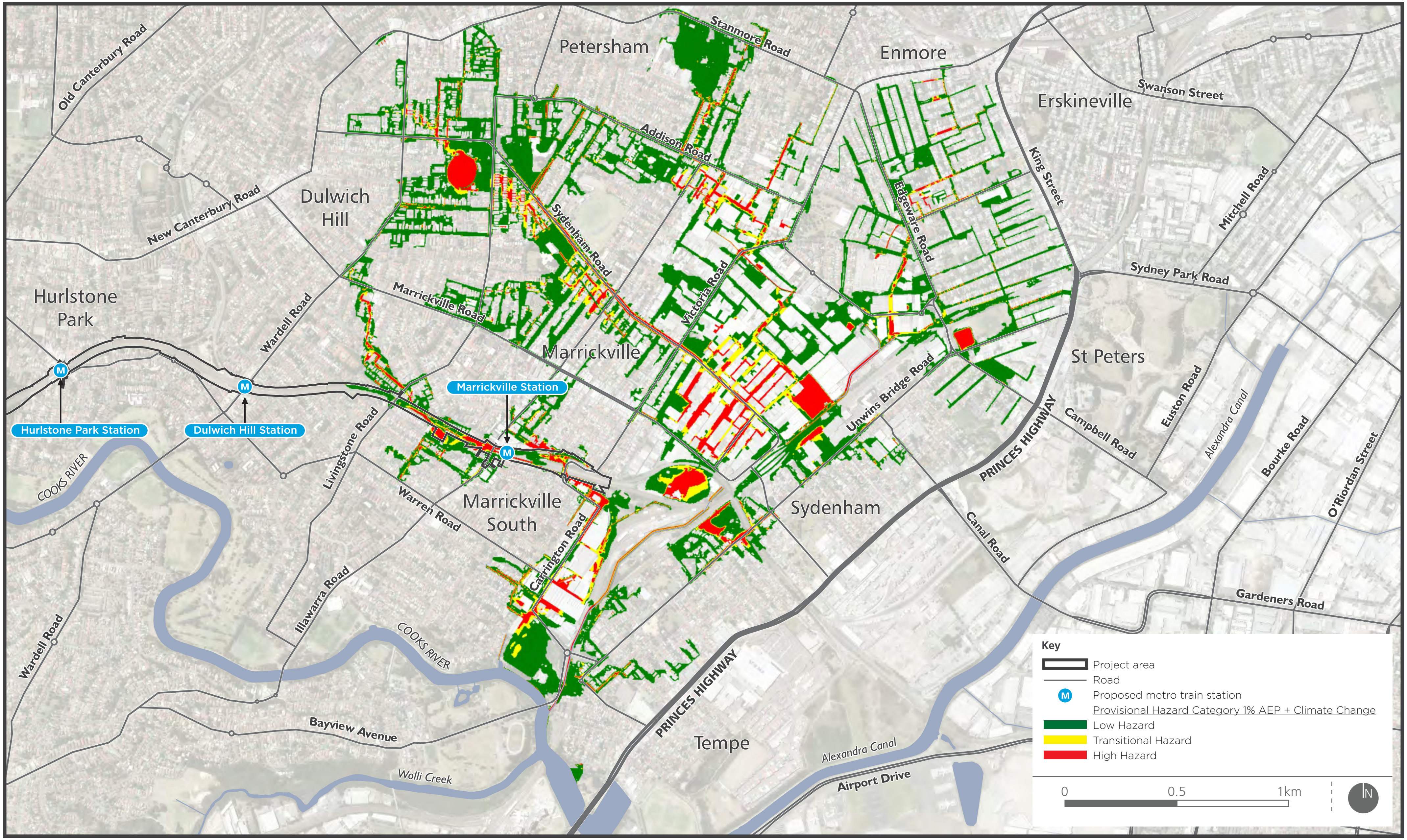
FIGURE 21.6



sydney METRO | city & southwest

Marrickville and surrounds – change in flood velocity - one per cent AEP plus climate change

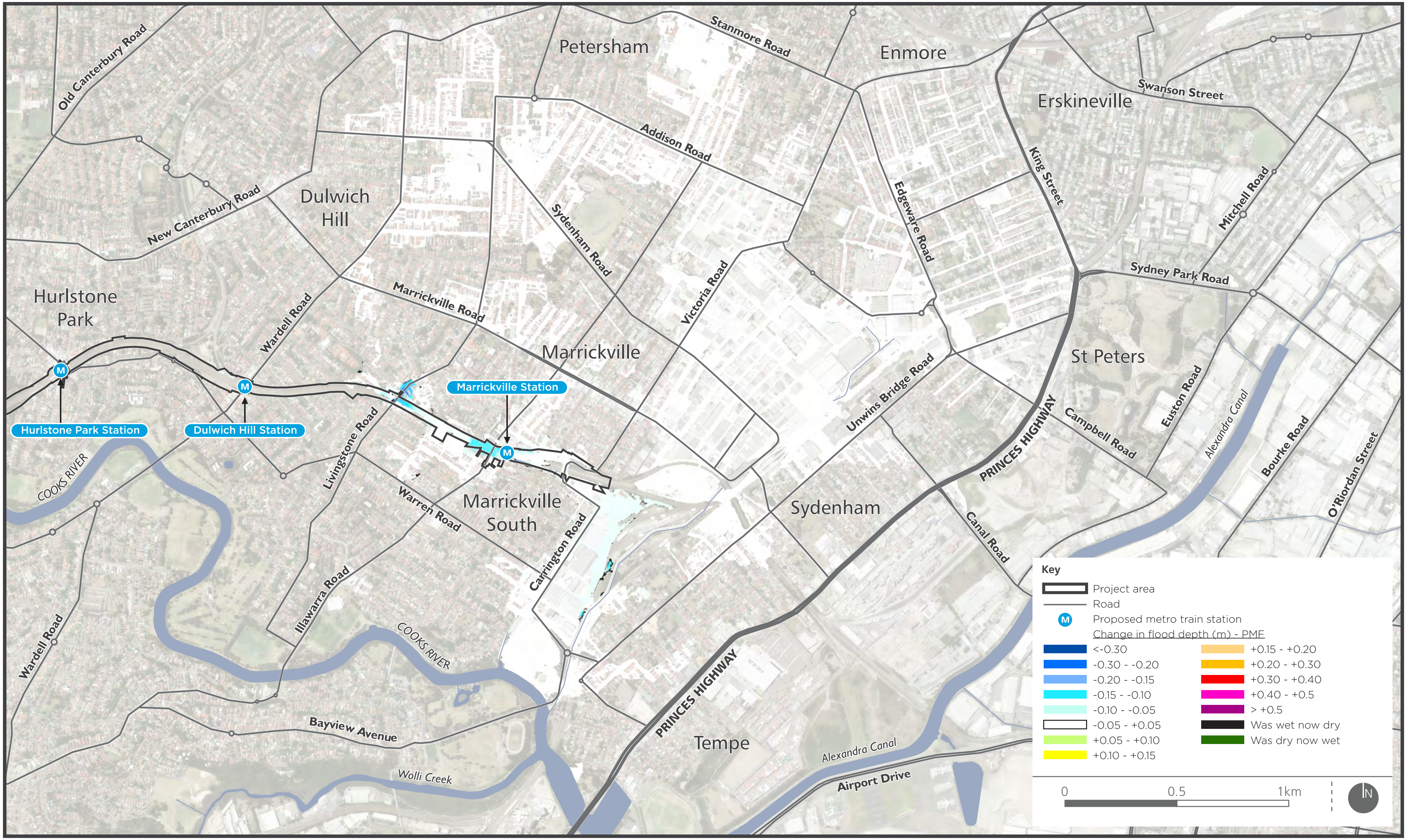
FIGURE 21.7



sydney METRO | city & southwest

Marrickville and surrounds – flood hazard - one per cent AEP plus climate change

FIGURE 21.8



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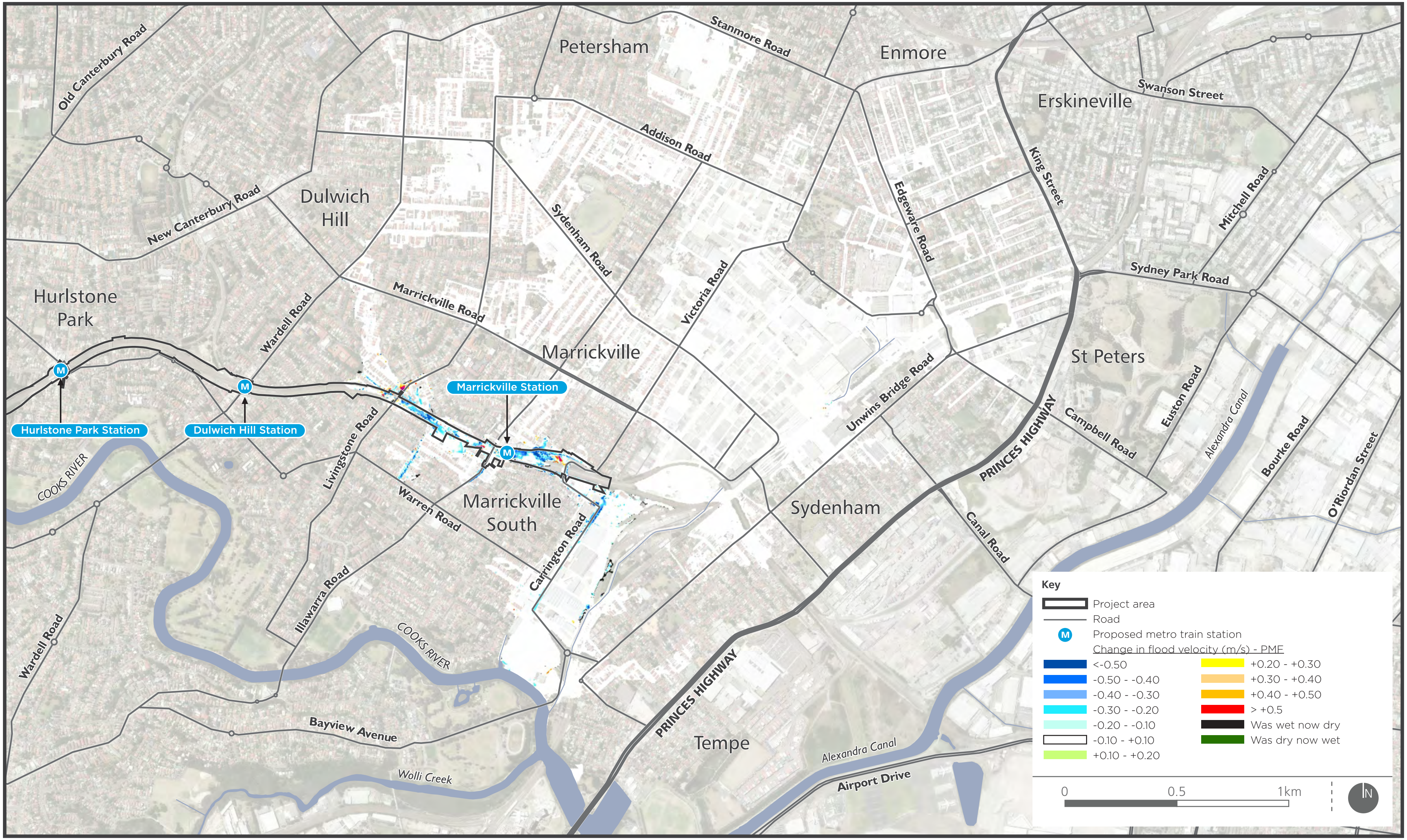
Marrickville and surrounds – change in flood depth and extent – probable maximum flood

FIGURE 21.9



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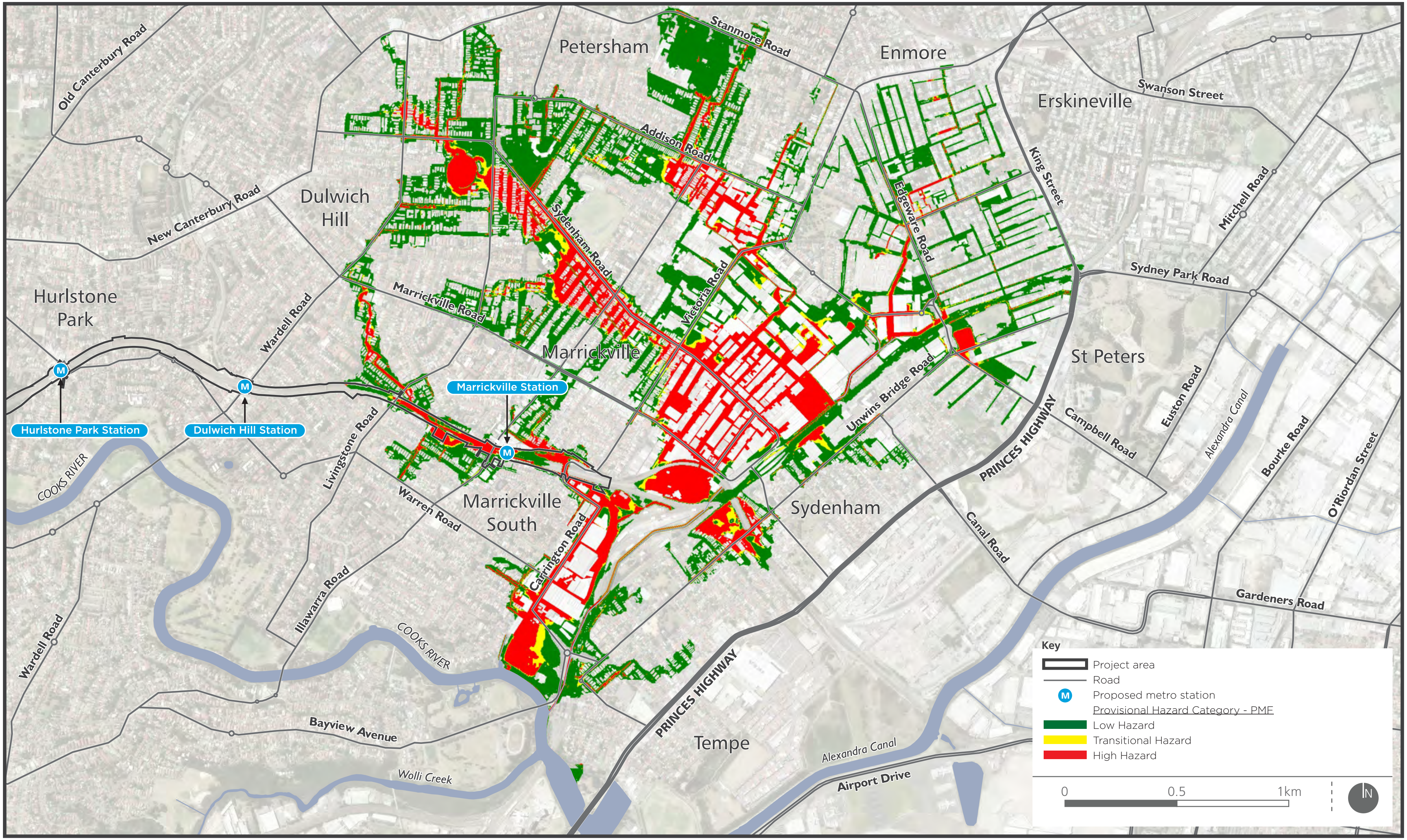
Marrickville and surrounds – change in flood velocity - probable maximum flood

FIGURE 21.10



Marrickville and surrounds – flood hazard - probable maximum flood

FIGURE 21.11

Sydney METRO | city & southwest

21.3.5 Operation impacts – water quality

During operation, the project has the potential to result in water quality impacts mainly from changes in hydrology leading to an increase in erosion and sedimentation, and the mobilisation of pollutants from the rail corridor.

As outlined in Section 21.1, gross pollutant traps and rain gardens would be implemented to manage water quality outcomes from the project area in accordance with the project water quality guidelines.

Table 21.6 provides details of the proposed water quality treatment measures by location, including indicative sizing. It is noted that the impervious area of each station is very small relative to the total catchment area, ranging from only 0.02 to 1.56 per cent. Consequently, there would be very little influence on overall catchment water quality.

Table 21.6 Proposed water quality treatment measures

Location	Total station impervious area[1] (ha)	Total catchment area (ha)	% station impervious area[2]	Rain garden area (m^2)	Number of gross pollutant traps
Marrickville	0.23	68	0.34	n/a[3]	1
Dulwich Hill	0.45	42	1.07	55	1
Hurlstone Park	0.10	41	0.24	15	1
Canterbury	0.23	1150	0.02	30	1
Campsie	0.61	39	1.56	75	1
Belmore	0.39	100	0.39	50	1
Lakemba	0.34	69	0.49	45	2
Wiley Park	0.16	118	0.14	20	2
Punchbowl	0.73	118	0.62	90	1
Bankstown	0.55	127	0.43	70	1

Notes:
1. Hardstand area within station precinct under proposed development conditions.
2. Station precinct hardstand area as a percentage of catchment area.
3. Marrickville Station precinct has a net reduction in impervious area of about 700 m^2 after development, and hence no rain garden is proposed.

Change in pollutants entering watercourses

Contamination of watercourses could occur through increased stormwater runoff containing typical pollutants, such as oils and greases, petrochemicals, and heavy metals, as a result of the operation of rolling stock, track operational wear, and any uncontrolled spills within stations or other facilities. Any contamination of watercourses could result in a reduction in water quality, which could impact biodiversity in downstream areas. However, as the proposed use of the railway corridor would be similar to the existing, the potential increase in contamination from these types of pollutants is expected to be very small.

Erosion and sedimentation

Changes in stormwater flows from any areas that are not adequately stabilised could result in increased erosion and sedimentation impacts. Such impacts could occur in areas that were not previously subject to such flows, such as the embankments near Marrickville Station.

An increase in impervious areas could also result in increased flow volumes and velocities, which have the potential to result in erosion and sedimentation at discharge locations if not adequately mitigated.

The change in impervious areas resulting from the project would be very small compared with the level of urbanisation which already exists in the catchment as a whole (refer to Table 21.6). Additionally, the design would provide necessary flow retardation structures, including scour protection, to minimise the erosion potential of stormwater flows. As such, potential impacts would be limited and localised in nature.

Minimising the effects of proposed stormwater and wastewater management during construction and operation on natural hydrological attributes

Elsewhere in the corridor, peak flow rate increases would generally be mitigated by providing the proposed detention basins at drainage outlets. In some locations, a localised increase in peak flow would be accommodated where modelling indicates that the total peak flow in the stormwater network immediately downstream would not be impacted.

Achieving water quality objectives

As outlined in Table 21.6, water quality control devices are proposed to be incorporated into station areas where space allows. The measures would be variously designed to retain litter and course sediments, and oils and grease where necessary, in accordance with the design guidelines.

As outlined in Section 21.1, the results of preliminary MUSIC modelling indicate that the proposed measures would be effective at reducing pollutant loads to the design guideline targets. However, it is noted that:

- treatment is not proposed within the rail corridor itself
- the targets may not be met at each discharge location, however it is expected that the average would meet the design guideline targets.

To mitigate potential spills of hazardous materials, the project design team would also consider the need for spill containment to be included along with the currently proposed water quality treatment measures.

It is noted that the water quality outcomes have not yet been assessed against the ANZECC 2000 guideline criteria. An assessment against these criteria would be undertaken during the detailed design.

Provision of the proposed water quality treatment measures is expected to contribute to improved water quality overall, although further analysis would be required during detailed design to confirm this. Implementation of effective water quality treatment measures would mean that the project would not impact on the ability of the catchment to meet the water quality objectives over time.

21.3.6 Cumulative impacts

Various drainage works are proposed for flood mitigation purposes, including works by the relevant councils. The design has been prepared taking these into account where details are available. Modelling of the impacts of the project has indicated some reductions in flooding, which may reduce the scope of works required. Ongoing consultation with local councils would be undertaken during detailed design to confirm where the project would interact with local drainage networks.

The project adjoins the Chatswood to Sydenham project. Interface and coordination meetings are being undertaken to ensure that there are no conflicts in scheduling, and that potential cumulative impacts can be avoided. Additional measures would also be confirmed during detailed design for the Chatswood to Sydenham project, with the aim of further reducing flood levels in existing flood areas, including levels at private property.

Urban renewal activities along the corridor include the potential construction of medium and high-rise buildings, within 400 metres of railway stations. It is assumed that all buildings and associated infrastructure would be designed in accordance with relevant council standards and guidelines with respect to flooding.

Considering that the study area is already highly urbanised, it is expected that redevelopment along the corridor would not have any significant impacts in terms of increased runoff and flow velocities. On this basis, no adverse cumulative impacts are expected.

21.4 Mitigation measures

21.4.1 Approach to mitigation and management

The detailed design of the project would continue to take into account necessary measures to minimise the potential for hydrology, flooding, and water quality impacts. Further consideration of measures would, where possible, account for forecast future growth under the draft *Sydenham to Bankstown Urban Renewal Corridor Strategy*.

Mitigation measures are provided in this section to mitigate the potential impacts that have not been avoided by the project design to date.

The main water quality risks are associated with erosion and sedimentation, and works within or near watercourses. The Construction Environmental Management Framework (described in Section 9.1) requires the preparation of a soil and water management plan. This would define the management and monitoring measures that would be implemented to manage water quality impacts, erosion, and sediment control in accordance with relevant guidelines. Soil and water management measures would be developed and implemented in accordance with *Soils and Construction - Managing Urban Stormwater Volume 1* (Landcom 2004) and *Volume 2A* (DECC 2008). In accordance with these guidelines, management measures would be designed to manage a 10 per cent AEP rainfall event.

Where discharge to surface watercourses is required, a monitoring program would be implemented as part of the construction environmental management plan to assess water quality prior to discharge. Indicative requirements for the monitoring program would involve monitoring at six locations, for the duration of construction or as otherwise determined, at monthly intervals. Monitoring parameters would be as per the water quality objectives defined in Section 21.2.5. Proposed monitoring locations are as follows:

- Cooks River downstream of Canterbury Station – at Charles Street, corner of Broughton Street, Canterbury
- Cooks River upstream of Canterbury Station – at Close Street, Canterbury
- upstream channel of Salt Pan Creek – Stacey Street, near Marcella Street, Bankstown
- channel south of Salvia Street, upstream of Salt Pan Creek.

During operation, water quality would be managed to comply with the project's operational environment protection licence.

The Construction Environmental Management Framework also requires preparation of stormwater and flooding management plans for relevant construction sites, to identify the appropriate design standard for flood mitigation based on the duration of construction, proposed activities, and flood risks. These plans would include develop procedures to ensure that threats to human safety and damage to infrastructure are not exacerbated during the construction period.

21.4.2 List of mitigation measures

The mitigation measures that would be implemented to address potential hydrology, flooding and water quality impacts are listed in Table 21.7.

Table 21.7 Mitigation measures – hydrology, flooding and water quality

ID	Impact/issue	Mitigation measures	Relevant location(s)
Design/pre-construction			
FHW1	Flooding	The design would be reviewed to, where feasible and reasonable, not worsen existing flooding characteristics up to and including the one per cent AEP event (incorporating a 10 per cent allowance for climate change) in the vicinity of the project. Detailed flood modelling would consider: • potential changes to flood prone land and flood levels, including areas of flood risk not already addressed • potential changes to overland flow paths • redistribution of surface runoff as a result of project infrastructure • behaviour of existing stormwater runoff, including the results of any recent flood events • results of detailed asset surveys (e.g. floor levels) • potential changes required to flood evacuation routes, flood warning systems and signage. Flood modelling to support detailed design would be carried out in accordance with the following guidelines: • *Floodplain Development Manual* (DIPNR, 2005) • *Floodplain Risk Management Guideline: Practical Consideration of Climate Change* (DECC, 2007) • *Floodplain Risk Management Guide: Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments* (DECCW, 2010c) • *New guideline and changes to section 117 direction and EP&A Regulation on flood prone land, Planning Circular PS 07-003* (NSW Department of Planning, 2007). Flood modelling and consideration of mitigation measures would be carried out in consultation with the relevant local councils, and the NSW State Emergency Service.	All
FHW2	Stormwater runoff	Where feasible and reasonable, detailed design would result in no net increase in stormwater runoff rates in all storm events, unless it can be demonstrated that increased runoff rates as a result of the project would not increase downstream flood risk.	All
FHW3		Where space permits, on-site detention of stormwater would be introduced where stormwater runoff rates are increased. Where there is insufficient space for the provision of on-site detention, the upgrade of downstream infrastructure would be implemented where feasible and reasonable.	All
FHW4	Consultation	Where relevant, detailed design and construction planning would occur in consultation with the NSW State Emergency Service, and the Inner West and Canterbury-Bankstown councils, to ensure that flood related outcomes are consistent with floodplain risk management studies.	All
FHW5	Scour potential	Further analysis of potential scour would be undertaken during detailed design. This would include the development of appropriate mitigation measures where required, including the installation of detention basins for the duration of construction.	All

ID	Impact/issue	Mitigation measures	Relevant location(s)
FHW6	Water quality	The project would be designed to ensure there is minimal potential for water quality impacts, including incorporating water sensitive urban design elements.	All
Construction			
FHW7	Flooding	Detailed construction planning would consider flood risk for all compounds and work sites. This would include identification of measures to not worsen existing flooding characteristics. Not worsen is defined as: • a maximum increase in flood levels of 50 mm in a one per cent AEP event • a maximum increase in time of inundation of one hour in a one per cent AEP event • no increase in the potential for soil erosion and scouring from any increase in flow velocity in a one per cent AEP flood event.	All
FHW8		The site layout and staging of construction activities would: • avoid or minimise obstruction of overland flow paths and limit the extent of flow diversion required • consider how works would affect the existing stormwater network such that alternatives are in place prior to any disconnection or diversion of stormwater infrastructure.	All
FHW9	Watercourse impacts	Works within or near watercourses (including the Cooks River) would be undertaken with consideration given to the NSW Office of Water's guidelines for controlled activities.	All
FHW10	Water quality	Erosion and sediment mitigation measures would be installed and maintained for the duration of the construction period.	All
FHW11	Water quality monitoring	A water quality monitoring program would be developed and implemented, to monitor water quality at identified discharge points. The program would include relevant water quality objectives, parameters, and criteria and specific monitoring locations identified in consultation with DPI (Water) and the EPA.	All
FHW12		Discharges from construction water treatment devices would be monitored to ensure compliance with the discharge criteria in the environment protection licence.	All
Operation			
FHW13	Water quality	Operational water discharges would be managed in accordance with the water quality management requirements specified in the environment protection licence.	All

21.4.3 Consideration of the interactions between mitigation measures

In addition to the measures for water quality measures described above, there are interactions between the mitigation measures for soils and contamination (Chapter 20), waste (Chapter 26 (Waste management)), and hazardous materials (Chapter 25 (Hazards, risks and safety)). Together, all these measures would ensure appropriate management of water quality, to minimise the potential for impacts to the community and environment.

21.4.4 Managing residual impacts

It is expected that with the appropriate mitigation measures in place, residual impacts during construction are likely to be negligible.

Residual operational impacts of the project could include increases in flood level in rare to extreme flood events of greater than the one per cent AEP climate change event. This could include impacts to surrounding properties, including increased flood depth, potential flood damages during a flood event, and emergency access during times of flooding. Further consultation with relevant stakeholders and consideration of these potential impacts during the detailed design phase would reduce any residual impacts to an acceptable level.

22. Biodiversity

This chapter provides a summary of the results of the biodiversity assessment of the proposal undertaken in accordance with the *Framework for Biodiversity Assessment* (Office of Environment and Heritage, 2014a). A full copy of the assessment report is provided as Technical paper 9 – Biodiversity assessment report. The Secretary's environmental assessment requirements relevant to biodiversity, together with a reference to where the results of the assessment are summarised in this chapter, is provided in Table 22.1.

Table 22.1 Secretary's environmental assessment requirements – biodiversity

Ref	Secretary's environmental assessment requirements - biodiversity	Where addressed
5. Biodiversity		
5.1	The Proponent must assess biodiversity impacts in accordance with the current guidelines including the Framework for Biodiversity Assessment (FBA).	A summary of the results of the biodiversity assessment is provided in this chapter. The full results are provided as Technical paper 9.
5.2	The Proponent must assess any impacts on biodiversity values not covered by the FBA as specified in s2.3.	Section 22.3.7
5.3	The Proponent must assess impacts on the Long-nosed Bandicoot Inner Western Sydney Population (including an assessment of vehicle strike (from more frequent trains) and a loss of threatened species and their habitat which is not associated with vegetation (e.g. building demolition, bridge reconstruction, etc.) and provide the information specified in s9.2 of the FBA.	Sections 22.3.2, 22.3.3 and 22.3.5
5.4	The Proponent must identify whether the project as a whole, or any component of the project, would be classified as a Key Threatening Process in accordance with the listings in the *Threatened Species Conservation Act 1997*, *Fisheries Management Act 1994* and *Environmental Protection and Biodiversity Conservation Act 2000*.	Section 22.3.4

22.1 Assessment approach

22.1.1 Legislation and policy context to the assessment

In addition to the EP&A Act, the following legislation is relevant to the biodiversity assessment:

- TSC Act – provides the statutory framework for the conservation and management of biota of conservation significance in NSW. It lists terrestrial flora, fauna, populations, and communities that must be assessed to determine if an activity would have a significant impact and further assessment or approval is required.
- FM Act – aims to conserve, develop and share the fishery resources of the State for the benefit of present and future generations. It lists aquatic flora, fauna, populations, and communities that must be assessed to determine if an activity would have a significant impact and further assessment or approval is required.
- *Noxious Weeds Act 1993* – provides for the declaration of noxious weeds. It identifies certain classes of noxious weed and required controls. All private landowners, occupiers, public authorities, and councils are required to control noxious weeds on their land.
- EPBC Act – lists matters of national environmental significance, which relevantly include listed threatened species and communities, listed migratory species, Ramsar wetlands of

international significance, and the Commonwealth marine environment, and outlines the approval process where there is the potential for significant impacts to these matters.

The *NSW Biodiversity Offsets Policy for Major Projects* (Office of Environment and Heritage, 2014b) ('the Biodiversity Offsets Policy') provides guidance in relation to biodiversity offsetting for major project approvals. A key principle underpinning the policy is that offset requirements should be based on a reliable and transparent assessment of biodiversity losses and gains. The policy:

- establishes a set of offsetting principles for major projects
- defines key thresholds for when offsetting is required
- adopts an assessment methodology to quantify and describe the offset required
- defines the mechanisms required to establish offset sites
- provides a range of flexible options that can be used in lieu of providing offsets, including rehabilitation actions and supplementary measures.

The Biodiversity Offsets Policy is underpinned by the *Framework for Biodiversity Assessment*. The framework sets out:

- requirements for a reliable and transparent assessment of biodiversity values on land to:
  - identify the biodiversity values subject to a proposed major development
  - determine the impacts of the development on biodiversity
  - quantify and describe the biodiversity offsets required for the unavoidable impacts of the development on biodiversity values
- types of conservation measures that are available to offset the unavoidable impacts of major projects, and how they may be used by a proponent to prepare a biodiversity offset strategy.

Under the *Framework for Biodiversity Assessment*, should biodiversity credits be required to offset impacts, a Biodiversity Offset Strategy must be prepared to outline how the proponent intends to offset the impacts of a major project.

Where a proponent is proposing to establish an offset site as part of a biodiversity offset strategy for a major project, the *Framework for Biodiversity Assessment* requires that the Biobanking Assessment Methodology be used to:

- assess the biodiversity values of the offset site
- identify the number and type of biodiversity credits that may be created on the offset site.

22.1.2 Methodology

The main components of the methodology for the biodiversity assessment were:

- A desktop assessment was undertaken to describe relevant features of the existing environment and to identify the suite of threatened biota potentially affected by the project.
- Field surveys were undertaken to describe the biodiversity values of the project area and wider study area, to determine the likelihood of threatened biota and their habitats occurring in the project area and/or being potentially impacted by the project.
- Calculations were undertaken in accordance with the *Framework for Biodiversity Assessment,* using the credit calculator (version 4.1), to quantify the biodiversity impacts of the project, and determine the biodiversity credits required to offset these impacts.

Study area

The study area for the biodiversity assessment included the project area with buffers in some locations to include areas of adjoining vegetation or biodiversity value. The study area is shown in Figure 22.1.

Literature review and database searches

Existing information on the biodiversity of the study area was obtained from a range of sources, including databases, aerial photographs and maps, and previous studies carried out in the study area. Previous documents and reports relevant to the study area were reviewed, including previous biodiversity studies, environmental attribute mapping, and previous impact assessments. Digital aerial photography was reviewed to identify spatial patterns in vegetation, land use, and landscape features.

Searches were undertaken of species databases to identify:

- threatened flora and fauna species, populations and ecological communities, listed under the TSC Act and FM Act
- nationally threatened native species, ecological communities, and native migratory species listed under the EPBC Act.

The search area adopted was a radius of ten kilometres around the study area.

Likelihood of occurrence

The database searches identified threatened flora and fauna species either recorded or considered likely to occur in the search area. The probability of each threatened species occurring within the study area was rated as low, moderate, high, or known, based on the criteria provided in Technical paper 9.

Survey effort

Staged surveys of the study area were conducted with reference to Section 6 of the *Framework for Biodiversity Assessment* and relevant targeted survey guidelines. This included taking into consideration the threatened biota that may occur given the urban context of the study area and the modified nature of habitats present.

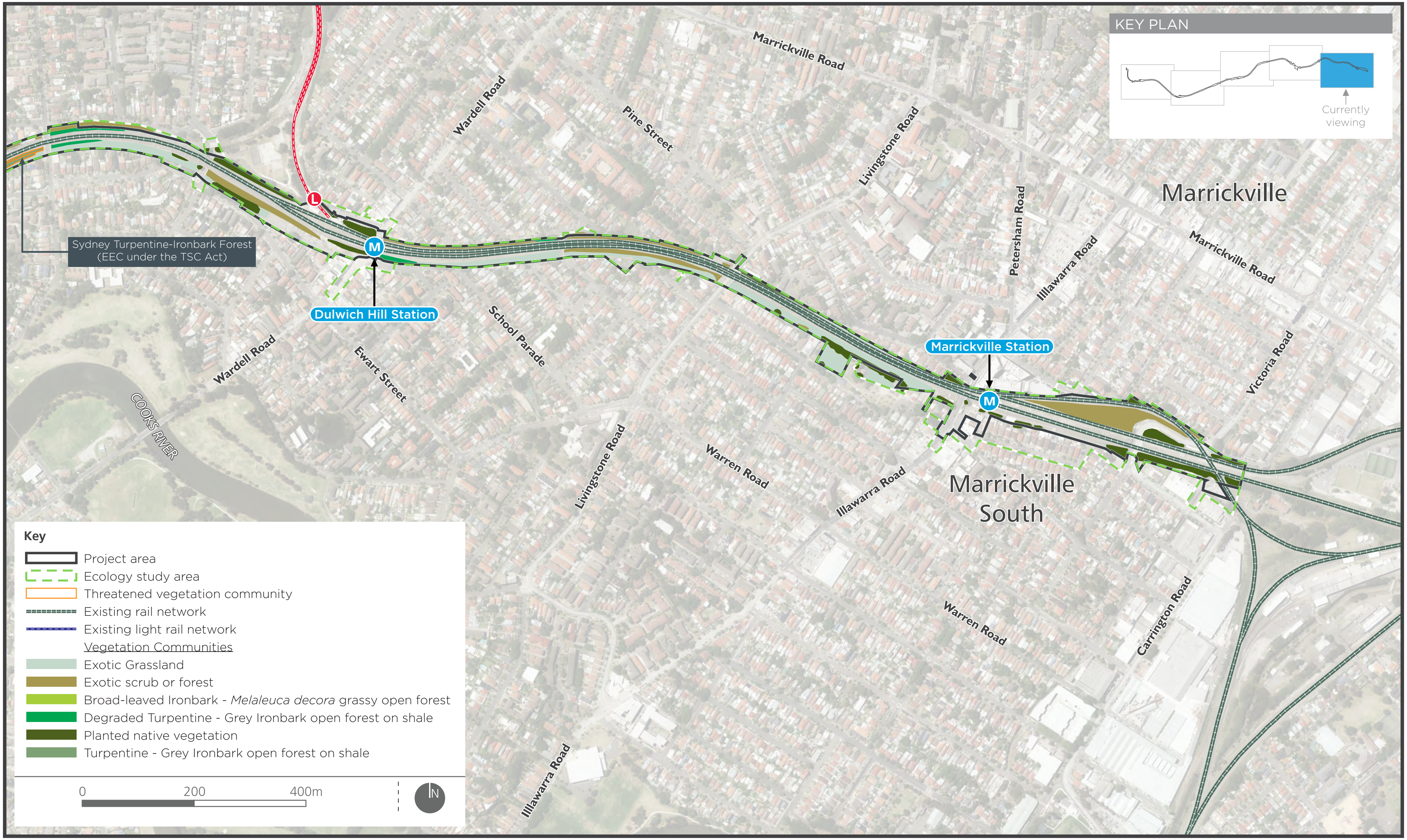
Surveys were undertaken on 16 June 2016, 22-23 June 2016 and 5 October 2016.

Biodiversity credits

The Biobanking Assessment Methodology sets out how biodiversity values are to be assessed, establishes rules for calculating the number and class of biodiversity credits, and determines the trading rules that will apply. The methodology includes a software package known as the BioBanking Credit Calculator, which processes site survey and assessment data by:

- assessing the biodiversity on a project site
- calculating the number and type of credits required to offset impacts on biodiversity and to be created on a biobank site
- estimating the approximate area of land required for an offset.

The credit calculator was used to determine the number and type of biodiversity credits required to offset the impacts of the project.



sydney METRO | city & southwest

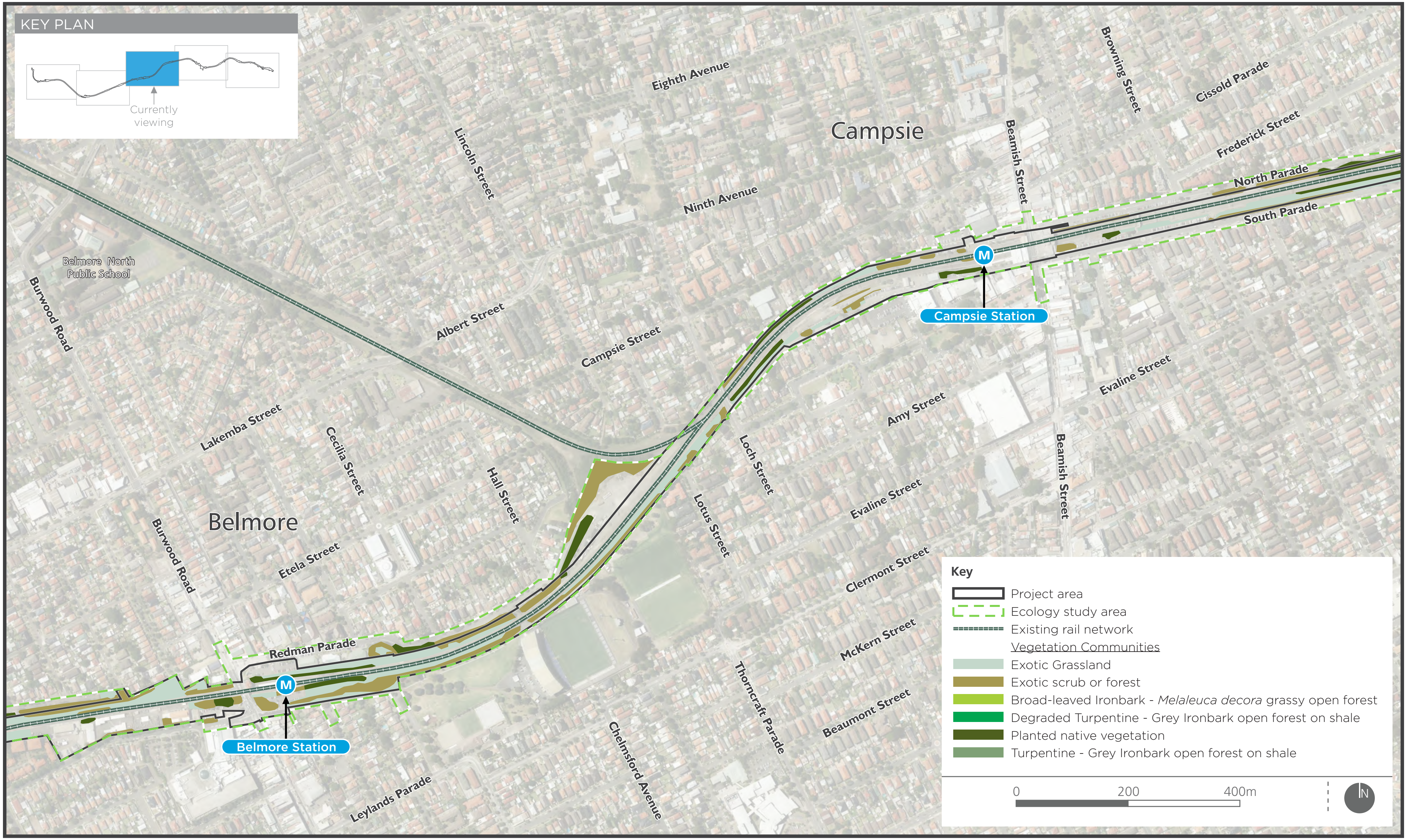
Biodiversity study area, vegetation and threatened species - map 1

FIGURE 22.1

sydney METRO | city & southwest

Biodiversity study area, vegetation and threatened species - map 2

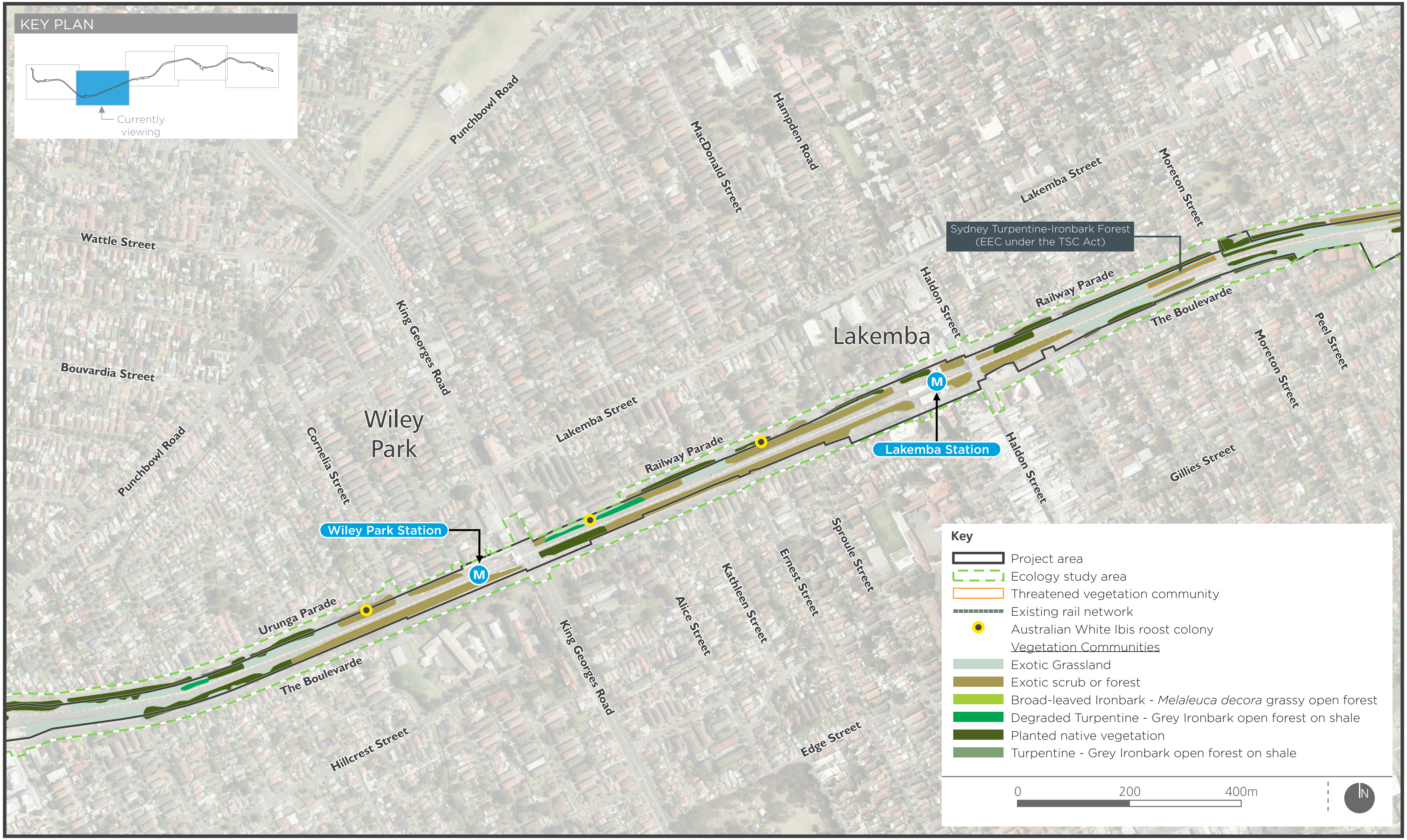
FIGURE 22.1



sydney METRO | city & southwest

Biodiversity study area, vegetation and threatened species - map 3

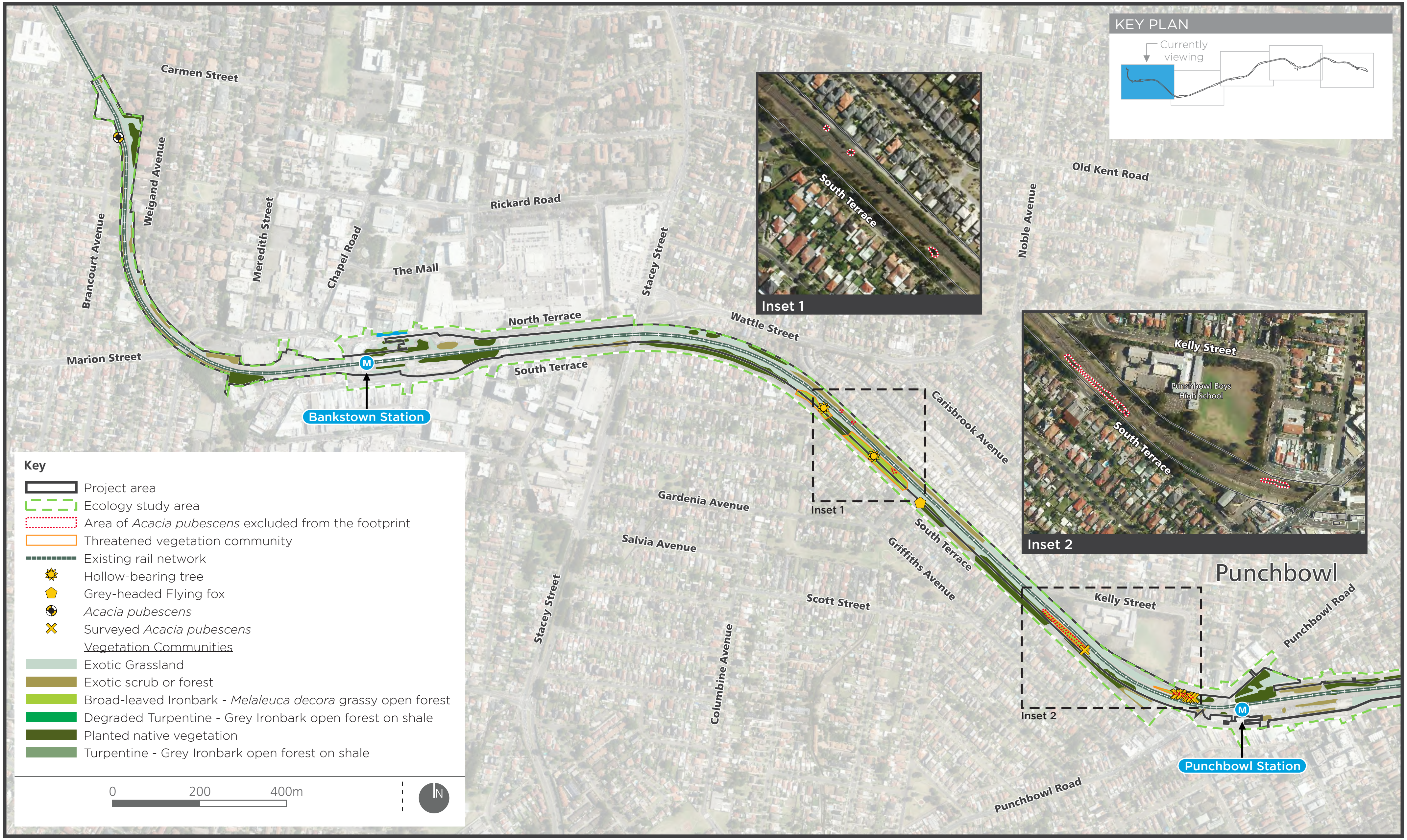
FIGURE 22.1



sydney METRO | city & southwest

Biodiversity study area, vegetation and threatened species - map 4

FIGURE 22.1



sydney METRO | city & southwest

Biodiversity study area, vegetation and threatened species - map 5

FIGURE 22.1

Flora surveys

Vegetation was mapped in the field via systematic walked transects across the entire study area, which was divided into relatively homogenous or discrete units. The remainder of the study area (containing non-native vegetation) was divided into separate map units based on observed structure and species composition.

Threatened plant surveys were conducted throughout the study area during field surveys. Threatened plants potentially present were identified based on the desktop assessment results and the species credit-type threatened species identified by the preliminary *Framework for Biodiversity Assessment* credit calculations. Habitat for these species was identified based on threatened species profiles. A supplementary threatened flora survey was conducted over one day, including targeted threatened flora searches in areas of previously identified habitat, and precise mapping of the locations of threatened plants.

Fauna surveys

The survey methodology included relatively limited targeted fauna survey techniques. This was because of the limited extent and quality of fauna habitat in the study area, and because the *Framework for Biodiversity Assessment* assesses the majority of threatened fauna species that could occur based on habitat.

An assessment was made of the type and quality of habitats present in the study area for native fauna. Habitat quality was based on the level of breeding, nesting, feeding, and roosting resources available. The study area was searched for habitat features, such as hollow-bearing trees, feed trees for the Grey-headed Flying-fox, and shelter habitat for the Long-nosed Bandicoot. Culverts and bridges were inspected for signs of roosting bats (such as bat droppings) or bird nests.

Spotlighting for nocturnal fauna was also carried out, targeting the Long-nosed Bandicoot, Grey-headed Flying-fox, and other nocturnal fauna. Spotlighting was conducted within the rail corridor near Dulwich Hill and Marrickville stations, and between Bankstown and Punchbowl stations. Call playback for the Barking Owl and Powerful Owl was also conducted.

Three motion activated infra-red cameras were set in the rail corridor between Hurlstone Park and Marrickville stations, particularly targeting potential habitat for the Long-nosed Bandicoot. Searches for bandicoot diggings were also conducted in grassland areas between Hurlstone Park and Marrickville.

22.2 Existing environment

22.2.1 Flora

The majority of the study area has been heavily modified by past and ongoing disturbances associated with urban development and the active rail corridor. Urban development, clearance, and ongoing maintenance of the rail corridor has resulted in fragmentation, a high level of disturbance, and degradation of vegetation communities.

The majority of vegetation in the project area and surrounding study area comprises exotic or planted native species on highly modified landforms. There are small isolated patches of remnant or regrowth native vegetation in small portions of the study area associated with rail cuttings with less disturbed soil profiles.

Native vegetation and habitat within the project area is in medium to poor condition, and features impacts from existing maintenance activities, edge effects, weed infestation, and exotic pests.

Database search results

A search of relevant databases indicated that 38 threatened flora species or populations listed under the TSC Act, 25 threatened flora species listed under the EPBC Act, and six threatened ecological communities listed under the TSC Act and/or the EPBC Act have been recorded or are predicted to occur in the search area.

Threatened species with the potential to occur, given nearby records and potential presence of suitable habitat, include:

- a small shrub (*Pultenaea parviflora*), listed as an endangered species under the TSC Act and a vulnerable species under the EPBC Act
- Matted Pea Bush, listed as an endangered species under the TSC Act
- Narrow-leafed Wilsonia, listed as a vulnerable species under the TSC Act
- Downy Wattle, listed as a vulnerable species under the TSC Act and the EPBC Act
- Austral Toadflax, listed as a vulnerable species under the TSC Act and the EPBC Act.

Vegetation mapping

According to *Native vegetation of the Sydney Metropolitan Area,* the most extensive vegetation map unit in the study area is 'Urban/exotic/native'. No native vegetation is mapped within the study area. A linear strip of 'Estuarine Mangrove Forest' is mapped immediately adjacent to the study area where it crosses the Cooks River.

Flora survey results

There is relatively low native species richness within the study area, which confirms that the native vegetation has been extensively modified and is in moderate to poor condition.

A total of 129 flora species from 40 families were recorded within the study area, comprising 63 native and 66 exotic species. Poaceae (grasses, 22 species, 11 native), Myrtaceae (flowering shrubs and trees, 20 species, 13 native), Fabaceae (23 species, 17 native), and Asteraceae (flowering herbs, 11 species, 2 native) were the most diverse families recorded. One threatened flora species (Downy Wattle) was recorded in the study area, outside the project area.

Plant communities

Plant communities in the study area are summarised in Table 22.2 and shown in Figure 22.1.

The majority of vegetation in the study area (97 per cent) comprises exotic or planted native species. About 0.6 hectares of the native vegetation matches two plant community types according to the *Framework for Biodiversity Assessment*:

- Turpentine - Grey Ironbark open forest on shale (PCT ID 1281, Biometric vegetation type HN604)
- Broad-leaved Ironbark - Grey Box - *Melaleuca decora* grassy open forest (PCT ID 724, Biometric vegetation type HN512).

Table 22.2 Vegetation in the study area

Plant community type	Condition	Conservation significance	Extent in study area (hectares)
Turpentine - Grey Ironbark open forest on shale	Moderate/good - medium	Conforms to the TSC Act listed endangered ecological community *Sydney Turpentine Ironbark Forest in the Sydney Basin Bioregion*	0.2
Degraded Turpentine - Grey Ironbark open forest on shale	Moderate/good - poor	Not an endangered ecological community because it does not contain characteristic canopy species.	0.4
Broad-leaved Ironbark - Grey Box - *Melaleuca decora* grassy open forest	Moderate/good	Conforms to the TSC Act endangered ecological community *Shale Gravel Transition Forest in the Sydney Basin Bioregion*	0.4
Subtotal – native vegetation			***1.0***
Exotic grassland	Cleared/non-native vegetation	Very low (exotic vegetation)	12.5
Exotic scrub or forest	Cleared/non-native vegetation	Very low (exotic vegetation)	9
Planted native species	Cleared/non-native vegetation	Low (non-indigenous native vegetation)	7.3
Subtotal – exotic or planted native vegetation			***28.8***
Total vegetation in study area			**29.8**

Noxious weeds

Fifteen species of noxious and environmental weeds are broadly distributed throughout the study area. Many of these are also listed as ‘weeds of national significance’, which are recognised as Australia’s worst invasive plants.

Threatened flora species

No listed threatened flora species were recorded in the project area. One threatened plant species Downy Wattle (*Acacia pubescens)* listed as vulnerable under the EPBC Act and TSC Act, was recorded in the study area. Around 650 stems are located near the project area as shown in Figure 22.1.

The patches of stems recorded are located mainly in the vicinity of Punchbowl Station, with around two stems recorded in the rail corridor, and one stem in a Council reserve around 100 metres east of the Yagoona substation. The project has been designed to avoid impacting on the recorded locations of this species.

Threatened ecological communities

As noted in Table 22.2, two of the native plant communities identified conform to the following threatened ecological communities listed under the TSC Act:

- *Sydney Turpentine Ironbark Forest in the Sydney Basin Bioregion* (Sydney Turpentine Ironbark Forest)
- *Shale Gravel Transition Forest in the Sydney Basin Bioregion* (Shale Gravel Transition Forest).

No threatened ecological communities listed under the EPBC Act are located in the study area.

Groundwater dependent ecosystems

The National Atlas of Groundwater Dependent Ecosystems, maintained by the Bureau of Meteorology, maps known groundwater dependent ecosystems and ecosystems that potentially use groundwater. No groundwater dependent ecosystems are located in the study area.

Some patches of vegetation along Wolli Creek downstream of the study area are mapped as potential groundwater dependent ecosystems. Wolli Creek is subject to pollution from urban environments, and its interaction with the Cooks River, which is heavily polluted.

22.2.2 Terrestrial fauna

Database search results

A total of 60 threatened fauna species listed under the TSC Act and 25 threatened fauna species listed under the EPBC Act have been recorded or are predicted to occur in the search area. Most of these threatened species are considered unlikely to occur, as they rely on specific habitat that is not present in the project area.

Species considered most likely to occur include:

- the Grey-headed flying-fox, listed as a vulnerable species under the TSC Act and the EPBC Act
- microchiropteran bats, such as the Eastern Bentwing Bat and Large-footed Myotis, listed as vulnerable species under the TSC Act
- a range of threatened bird species listed, under the TSC Act and/or the EPBC Act, which may forage in planted trees or along the Cooks River on occasion.

Terrestrial fauna habitats

Several general fauna habitat types were identified during field surveys. Each of these habitat types has a range of characteristics that influence habitat value, and the range of fauna species with the potential to be present. These are summarised below.

Exotic and native grassland

The majority of the rail corridor is cleared and vegetated with introduced grasses and herbs, interspersed with bare ground, ballast, and other artificial substrates. Some areas with native groundcover species are present. These areas are devoid of shrubs and trees. Exotic and native grassland contains few habitat resources of relevance to most native species.

Exotic forest and scrub and planted native species

Patches of weeds and planted native or exotic trees and shrubs within the study area provide potential foraging habitat for a range of common bird species (the Noisy Miner was the most abundant species observed) and mammal species (including the Common Brushtail Possum and Common Ringtail Possom).

Three roosting colonies of the Australian White Ibis were observed in planted trees in the rail corridor near Wiley Park Station.

Native woodland and forest

Occasional hollow-bearing trees, which could provide potential nesting habitat for arboreal mammals or birds, were recorded in the Punchbowl to Bankstown section of the study area. A range of flowering shrubs and trees are present, including Tallowood, Sydney Blue Gum, Turpentine, and Red Ironbark, which provide foraging resources for a range of birds, including cockatoos, parrots, honeyeaters, and arboreal mammals.

Two hollow-bearing trees were identified within the rail corridor at Punchbowl. These would potentially be used by common and introduced species. They could also be used by microbat species as roosting habitat.

No large hollows suitable for threatened owls were identified. Species such as the Powerful Owl may forage for arboreal mammals (including possums) within the rail corridor.

Culverts and bridges

Culverts provide potential temporary roosting habitat for microbat species, such as the threatened Eastern Bentwing Bat and Large-footed Myotis. The Eastern Bentwing Bat breeds in specific maternity roosts and would not breed in these structures. However, there is potential for the Large-footed Myotis to breed in these structures. No bats were observed in the culverts inspected during surveys, and no bat droppings were detected.

No bird nests were observed in any culverts inspected during the surveys, although it is possible that species such as Welcome Swallows and Fairy Martins could use these built features for nesting.

Many rail bridges are present in the project area. These provide breeding habitat for the introduced Rock Dove. No evidence of roosting bats or bat droppings were detected at any of the bridges inspected.

A number of structures (e.g. station buildings, warehouses, and residential buildings) within the project area may provide roosting habitat for the introduced Rock Dove and native species, such as Welcome Swallows and Fairy Martins. Microbats, including the Gould's Wattled Bat, were recorded by Arcadis (2016) in the Marrickville area during surveys for the Chatswood to Sydenham project.

Urban gardens

Urban gardens are known to provide shelter and foraging habitat for the Long-nosed Bandicoot. However, no evidence of bandicoots was recorded during targeted surveys, and no evidence of bandicoots was recorded in 2016 during four months of infra-red camera surveys along the light rail line or from the associated community survey.

Fauna survey results

A low diversity of fauna species was recorded during the field surveys, as would be expected in a highly modified urban environment. A total of 23 native species were recorded during surveys, which included 17 bird species, two mammal species, three reptile species, and one frog species. No microbat species were recorded. Five introduced bird species and three introduced mammal species were also recorded. One threatened fauna species, the Grey-headed Flying-fox, was recorded.

Literature review

The Long-nosed Bandicoot population in inner western Sydney is known or predicted to occur in the study area. The rail corridor is located along the southern boundary of the mapped core area of records of the population. The exact area occupied by the population is not clearly defined, but it includes parts of the former local government areas of Marrickville and Canada Bay, with the likelihood that it also includes parts of the former Canterbury, Ashfield, and Leichhardt local government areas. Potential habitat for the bandicoot is present in parts of the study area.

Threatened fauna species and populations

The Grey-headed Flying-fox, which is listed as vulnerable under the TSC Act and EPBC Act, was recorded in the study area. The location of this record is shown in Figure 22.1. No microbats were recorded during anabat surveys. This may suggest there is only limited habitat for these species, and that none rely on the habitats present for their foraging requirements. Nevertheless, the following species listed as vulnerable under the TSC Act are considered likely to occur:

- Eastern Bentwing Bat
- Large-footed Myotis
- Eastern Freetail Bat
- Yellow-bellied Sheath-tail Bat.

Although the Long-nosed Bandicoot population in inner western Sydney is known or predicted to occur in the study area, no evidence of the population was found, either from searches for diggings or camera surveys, and there have been no records of the population or any recent sightings since 2014. Spotlighting undertaken during the assessment did not identify any records of this species.

The biodiversity assessment concluded that the Long-nosed Bandicoot is unlikely to occur in the project area, as a result of:

- the lack of evidence of the species in the project area and surrounding area, despite recent targeted surveys
- limited presence of shelter habitat
- high abundance of introduced predators
- difficulty of access to the rail corridor.

22.2.3 Aquatic ecology

Cooks River

The project area crosses the Cooks River to the west of Canterbury Station. The Cooks River is also located downstream of the study area between Marrickville and Campsie stations. The Cooks River is mapped as key fish habitat.

Two threatened fauna species listed under the FM Act have been recorded or are predicted to occur in the study area. However, based on previous records and habitat requirements, these species are considered unlikely to occur.

Sampling carried out in 2007 in Wolli Creek, which flows into the Cooks River at Tempe, identified six native fish species in the freshwater section above the Henderson Street weir at Turella:

- Empire Gudgeon
- Flathead Gudgeon
- Striped Gudgeon
- Firetail Gudgeon
- Common Galaxia
- Long-Finned Eel.

The following species were collected immediately below the weir and are likely to occur along the Cooks River:

- Sea Mullet
- Yellow-fin Bream
- Port Jackson Perchlet
- Toadfish.

Table drains

Aquatic habitats within the project area are mostly limited to a number of shallow table drains alongside the rail line. Most ditches are shallow, with no emergent vegetation, however some display emergent rushes (*Typha*). Table drains are generally fed by seepages from embankments. Some drains run into concrete gutters before exiting from the railway corridor. The Common Eastern Froglet was heard calling from table drains.

No threatened species listed under the FM Act have potential habitat in these table drains. Table drains do not classify as key fish habitat.

Cup and Saucer Creek

The route for the proposed high voltage electricity feeder cable between the proposed Campsie traction substation and the existing Ausgrid Canterbury electrical substation would cross Cup and Saucer Creek. At the crossing location, the creek consists of a concrete canal. The canal is concrete-lined to its confluence with the Cooks River, about 250 metres to the north, and for a number of kilometres upstream. A stormwater treatment wetland (Cup and Saucer Wetland) was constructed by Sydney Water in 2010 near the confluence of the creek and the river to filter some of the stormwater in Cup and Saucer Creek.

22.2.4 Other matters of national environmental significance

The protected matters search tool identified six World Heritage Properties, six National Heritage Places, and one wetland of international importance within the search area. The project would not impact on the World Heritage Properties and National Heritage Places as they are outside the study area. The wetland of international importance, Towra Point Nature Reserve, is located on the southern side of Botany Bay, over four kilometres from the mouth of the Cooks River. This location is well beyond the maximum extent of potential impacts arising from the project.

A large number of migratory species were reported in the search area by the protected matters search tool based on species behaviour and habitat presence. However, only three of these species were considered to have the potential to occur within the study area on an occasional or transient basis – Satin Flycatcher, Rufous Fantail, and Rainbow Bee-eater. No potential habitat for these wetland species is present in the project area.

22.3 Impact assessment

22.3.1 Risk assessment

Potential risks

The environmental risk assessment for the project, undertaken for the State Significant Infrastructure Assessment Report, identified the following as the main potential biodiversity risks:

- impacts to the Long-nosed Bandicoot listed under the TSC Act, and areas of known habitat
- loss of foraging habitat for the threatened Grey-headed Flying Fox (vegetation adjoining the corridor) and foraging and roosting habitat (e.g. culverts and bridges) for threatened microchiropteran bats
- impacts to patches of remnant or regenerating vegetation, comprising potential habitat for threatened ecological communities and/or threatened plants
- impacts to riparian and aquatic habitats associated with the Cooks River crossing
- removal of street trees, particularly at stations.

Other potential risks include:

- clearing of native vegetation resulting in direct impacts on threatened species and endangered populations and communities, loss of fauna habitat, habitat fragmentation, and loss of connectivity
- potential for pest plants and animals
- indirect impacts due to increased dust, sedimentation and erosion, noise, and light
- disturbance to aquatic habitats
- alterations to surface water flow regimes and interruptions to fish passage
- fauna mortality from vehicle strikes.

How potential impacts have been avoided or minimised

In general, potential impacts on biodiversity have been avoided or minimised by:

- designing the project to minimise the potential for impacts outside the rail corridor
- placement of construction compounds within already cleared areas where practicable (e.g. carparks)
- the location of project infrastructure at Punchbowl Station was refined to avoid impacts on Downy Wattle
- areas of Downy Wattle between Punchbowl and Bankstown stations were excluded from the project area and would be protected during construction.

22.3.2 Construction impacts

Potential impacts on biodiversity during construction include:

- direct impacts as a result of clearing of vegetation in the project area
- indirect impacts on flora and fauna located outside the project area as a result of activities within the project area.

A summary of the results of the impact assessment is provided below.

Vegetation clearing

As described in Chapter 9 (Project description - construction), it is assumed that construction of the project would require removal of all vegetation located along the rail corridor in the project area. This would involve removal of 29.8 hectares of vegetation. The majority of this vegetation comprises exotic plants or planted (often non-indigenous) native species on fill material, with native vegetation making up around three per cent of the direct disturbance footprint. Removing all vegetation in the rail corridor would impact a total of one hectare of native vegetation.

The project has been designed to avoid impacts on the local population of the endangered plant species Downy Wattle. There are no Downy Wattle stems in the project area, and none would be impacted during construction.

As described in Section 9.3, a number of trees of varying sizes would also need to be removed to facilitate works at each station. This impact, which has the potential to affect the amenity and character of station areas, is considered in Section 19.3.2. Impacts to trees would be managed in accordance with the proposed tree management and replacement strategy (described in Section 9.3). This would include preparation of comprehensive tree reports by a qualified arborist for each tree requiring protection, pruning, or removal, to guide the approach to managing each tree during construction.

Terrestrial habitat removal

Only a small area of fauna habitat would be removed, as most of the project area is already cleared land. The vegetation that would be removed or modified provides limited habitat resources for native fauna species, due to its existing highly modified nature and the surrounding urban environment. Fauna habitat resources that would be removed include foraging and shelter resources for mainly common native fauna typical of urban environments. It is highly unlikely that any threatened species or any fauna populations would rely on the habitat resources within the project area for their survival.

Loss of fauna habitat would involve the following:

- removal of one hectare of native vegetation, and 7.3 hectares of planted native species, which would provide nesting and foraging habitat for common species of birds and possums
- removal of 7.9 hectares of foraging habitat for the threatened Grey-headed Flying-fox, Eastern Bentwing Bat and other threatened fauna species with known or potential habitat in the study area
- removal of 21.5 hectares of exotic vegetation with a forest, scrub, or grassland structure, which provides nesting and potential foraging habitat for species such as the Long-nosed Bandicoot and common small birds, as well as shelter and foraging habitat for reptiles and frogs
- removal of aquatic habitat associated with drainage channels
- possible removal of potential roost sites for common microbats associated with two hollow-bearing trees at Punchbowl, and impacts to bridges and culverts
- removal or disturbance of vegetation providing habitat for the Australian White Ibis near Wiley Park Station, resulting in dispersal of individuals to other locations.

Fragmentation or isolation of habitat

The vegetation within the study area is currently fragmented by the existing rail corridor, roads, and urban development. It is unlikely that the project would create an additional barrier to movement. Therefore, the project is unlikely to affect the life cycle of either common or threatened flora species.

The only remnant vegetation adjacent to the study area is a narrow, linear strip along the banks of the Cooks River. The removal of a small area of vegetation at the edge of this patch would not sever this connecting link, and is unlikely to significantly increase the degree of fragmentation of native vegetation and habitat in the local area. Connectivity of terrestrial, riparian, and aquatic habitat would be maintained.

Works to overbridges and culverts have been designed to minimise the impact on hydrology and flooding. Once construction is complete, connectivity of aquatic habitats would be relatively unaffected.

Fauna injury or mortality

Construction has the potential to result in injury or mortality of some individuals of less mobile fauna species, and other small terrestrial fauna that may be sheltering in vegetation within the project area. The potential injury or mortality of individuals is highly unlikely to affect an ecologically significant proportion of any local populations. More mobile native fauna, such as native birds, bats, terrestrial, and arboreal mammals are likely to be able to evade injury during construction activities.

Impacts on the Long-nosed Bandicoot Inner Western Sydney population

As noted in Section 22.2.2, the biodiversity assessment concluded that the Long-nosed Bandicoot is unlikely to occur in the project area. As a result, no direct impacts of the project on this species are predicted.

Construction traffic has the potential to introduce a vehicle strike risk to any individuals that may be present in the surrounding area. However, given the lack of evidence of a resident population in the project area and its position at the edge of the mapped habitat area, it is unlikely that this would occur.

The project would not increase the predation risk of the bandicoot in the region, as it would not result in an increase in foxes or cats.

Noise and vibration from construction and operation has the potential to disturb fauna adjacent to the project area. However, individuals are likely to be accustomed to existing noise from trains, road traffic, and the urban environment, as well as lights from trains, cars, streetlights, and buildings. While there would be localised increases in noise and light that could temporarily create disturbance, increases in noise and light above existing background levels are unlikely to result in a significant impact.

Aquatic habitat

The project would remove small areas of low quality aquatic habitat associated with drainage structures and small depressions. There would be no direct impacts (such as blockage of fish passage or removal of key fish habitat) on the Cooks River.

Impacts on groundwater dependent ecosystems

Any runoff (including water, sediments and contaminants) during construction would be managed to minimise the potential for indirect impacts on downstream areas, including the groundwater dependent ecosystems present along Wolli Creek.

Indirect impacts

Indirect impacts could include the following:

- Edge effects – these can occur in adjoining areas of vegetation and habitat as a result of weed growth, increased noise and light, erosion and sedimentation, and can result from vegetation clearance, where a new edge is created between vegetation and cleared areas, or from widening or extending cleared easements through existing vegetation.
- Light and noise – these could impact breeding, foraging, and roosting activities where fauna are located close to construction activities.
- Erosion, sedimentation, and dust generation – uncontrolled erosion can cause weed problems, reduce habitat values, and stifle plant growth.
- Weeds – dispersal of weed propagules (seeds, stems and pollen) into areas of native vegetation could occur as a result of erosion (wind and water) and the movement of workers and vehicles.
- Plant pathogens – potential spread of soil-borne pathogens of native plants (such as Phytophthora) spread on machinery.
- Disease – potential spread of Chytrid fungus into local native frog populations, through soil and water carried on machinery and by the movement of workers between different areas.
- Aquatic habitat disturbance – as a result of works near the Cooks River and potential water quality impacts.

These impacts can be managed through the implementation of standard construction soil and water management measures (listed in Chapters 20 (Soils and contamination) and 21 (Hydrology, flooding and water quality)), and the mitigation measures listed in Section 22.4. With the implementation of these measures, no significant indirect impacts on biodiversity are predicted.

22.3.3 Operation impacts

The project area is dominated by existing rail and road infrastructure, and is located in a highly modified environment. Vegetation adjoining the project area is already subject to weed infestation and other edge effects. Fauna that occupies habitats within the project area and adjacent areas are likely to be accustomed to noise from trains, road traffic, and the urban environment. Given the highly modified habitats present, additional train movements are unlikely to significantly increase the risk of collisions.

In this context, the project is likely to comprise only a minor increase in any of these potential impacts. The project is unlikely to increase the extent, duration, or magnitude of these impacts, to the extent that a significant negative effect on biodiversity values would result during operation.

As noted in Section 22.3.2, the Long-nosed Bandicoot is not considered likely to occur within the project area. However, for any individual present, operation of the project has the potential to increase the risk of vehicle strike due to an increased frequency of metro services along the corridor compared to existing services. Given the lack of evidence of a resident population in the project area, and the project area's position at the edge of the mapped habitat area, any increase in the number of train services is unlikely to impact the bandicoot.

Similar to the potential for construction impacts, any additional noise or light during operation is unlikely to impact any local population of the Long-nosed Bandicoot. Bandicoots (if present) are likely to be accustomed to existing noise and light from trains, road traffic, and the urban environment. Increases in noise and light above existing background levels are unlikely to result in a significant change in impacts.

22.3.4 Key threatening processes

A key threatening process is as an action, activity, project or potential threat, listed under the TSC Act, FM Act, and EPBC Act, which:

- adversely affects two or more threatened species, populations, or ecological communities
- could cause species, populations or ecological communities that are not currently threatened to become threatened.

The key threatening processes relevant to the project are considered in Table 22.3. The project itself does not constitute a key threatening process, and is unlikely to exacerbate those processes. Implementation of the mitigation measures described in Section 22.4 would minimise the potential impacts identified.

Table 22.3 Key threatening processes relevant to the project

Key threatening process	Listing	Assessment
Clearing of native vegetation	TSC Act EPBC Act	The project would involve clearing of one hectare of remnant and regrowth native vegetation, and would not affect the viability of remnant vegetation in the study area, or reduce the extent of habitat below the minimum size required for any fauna species. The majority of vegetation to be removed is in relatively poor condition, and on the edge of remnant patches adjacent to the rail corridor.
Clearing of hollow-bearing trees	TSC Act	Surveys undertaken for the biodiversity assessment indicated that the project would remove two hollow bearing trees as part of the clearing of native vegetation within the rail corridor.
Removal of dead wood and dead trees	TSC Act	The project area contains very little fallen timber. Construction may result in the removal or disturbance of the minimal amounts of timber that occur.
The degradation of native riparian vegetation along NSW water courses	FM Act	Planted riparian vegetation is located along the banks of the Cooks River (near Canterbury Station). The project would not impact this vegetation.
Human-caused climate change	TSC Act EPBC Act	Combustion of fuels associated with construction and operation would contribute to emissions of greenhouse gases. The project does not pass through any areas mapped as coastal corridors for climate change.

22.3.5 Impacts on biodiversity related matters of national environmental significance

Threatened ecological communities

There are no threatened ecological communities listed under the EPBC Act in the study area. There is native vegetation in the study area that is floristically similar to Cumberland Plain Woodland and Shale-gravel Transition Forest or Sydney Turpentine Ironbark Forest, both of which are listed as Critically Endangered Ecological Communities under the EPBC Act. The vegetation in the study area does not meet the patch size or condition criteria required to comprise occurrences of these Critically Endangered Ecological Communities as defined under the EPBC Act.

Threatened species

The study area contains around 650 stems of Downy Wattle, which is listed as a vulnerable species under the EPBC Act. The project has been purposefully designed to avoid impacts on the population of this threatened plant. There are no Downy Wattle stems in the project area. An assessment of the likely significance of impacts on Downy Wattle was prepared as part of the biodiversity assessment in accordance with the EPBC Act significant impact guidelines. The assessment concluded that the project would remove around 0.6 hectares of potential habitat for this species. This would result in indirect effects on occupied habitat through increased fragmentation of habitat, reduction in native vegetation cover, and disturbance of surface soil in the vicinity of occupied habitat. The local population has persisted in a highly modified environment adjacent to heavy rail infrastructure. The post-construction environment would be very similar to the existing environment.

The project would not directly harm any individuals of this species, and construction and environmental management measures are likely to mitigate the risk of indirect impacts. Based on these considerations, the project is not likely to have a significant impact on Downy Wattle.

The Grey-headed Flying-fox was recorded foraging within the project area during surveys. The project would remove foraging habitat for this species. An assessment of the likely significance of impacts on the Grey-headed Flying-fox was prepared in accordance with the EPBC Act significant impact guidelines. The Grey-headed Flying-fox may forage on occasion in the project area, especially when figs are fruiting or eucalypts are in flower. The project would not directly or indirectly affect roost camps. Construction would remove 7.9 hectares of foraging habitat, including remnant, regrowth and planted native tree species in the project area. The habitat to be removed comprises a minor proportion of the available habitat resources in the wider region, which includes many thousands of individual blossom or fruit bearing trees in streetscapes, parks and gardens. Based on these considerations, the project is not likely to have a significant impact on the Grey-headed Flying-fox.

No other threatened fauna species listed under the EPBC Act are likely to be impacted by the project. Given the minor magnitude of impacts on threatened fauna and their habitats further assessment or approval under the EPBC Act is highly unlikely to be required and a referral is not required.

Migratory species

No migratory bird species listed under the EPBC Act were recorded during field surveys. However, there is potential habitat for species such as the Rufous Fantail and Rainbow Bee-eater in the project area and study area. As discussed previously, vegetation in the study area is highly modified, fragmented, and would have limited value for these migratory species. Individuals that may occur would occur on a transient basis only.

The study area is not considered important habitat for migratory species according to the significant impact criteria for migratory species (Department of the Environment, 2013). No assessments of significance have been prepared for migratory species. Based on the above considerations, the project is unlikely to significantly impact any of the listed migratory fauna species that were predicted to occur.

22.3.6 Assessment against the Framework for Biodiversity Assessment

The *Framework for Biodiversity Assessment* requires assessment of the project against a number of factors. The results of the assessment are presented in the Biodiversity Assessment Report (Technical paper 9) and summarised below.

Impacts on biodiversity that require further consideration

Under the *Framework for Biodiversity Assessment,* impacts that require further consideration include:

- significant impacts on landscape features
- impacts on endangered ecological communities that are likely to significantly affect the persistence or viability of that community
- impacts on critical habitat or on threatened species that are likely to significantly affect the persistence or viability of a population of a threatened species.

The project has been designed to avoid impacts on biodiversity values as far as is practicable. The project has been designed to avoid impacts on Downy Wattle.

The project would result in minor impacts on Sydney Turpentine Ironbark Forest and Shale Gravel Transition Forest, but would not significantly affect the persistence or viability of these communities.

Although the project would result in the loss of very small areas of foraging habitat, it would not affect any critical habitat for the Grey-headed Flying-fox, threatened microbats, or other mobile threatened fauna that may potentially occur. The project would remove low quality, potential habitat for the endangered population of the Long-nosed Bandicoot in Inner Western Sydney located outside of its known area of occupancy. However, this is highly unlikely to threaten the viability of these species or population.

The project would not threaten the persistence or viability of any threatened species.

The project would not impact on matters that require further consideration.

Impacts requiring biodiversity offsets

The project would result in the removal of one hectare of native vegetation requiring biodiversity offsets. The biodiversity credits that would be required to offset impacts are summarised in Table 22.4. A biodiversity offset strategy has been prepared to offset the required credits and is discussed in Section 22.4.2.

Table 22.4 Ecosystem credits required to offset impacts of the project

Plant community type	Area (ha)	Loss in landscape value	Loss in site value score	Threatened species with highest credit requirement	Threatened species offset multiplier	Credits required
Turpentine - Grey Ironbark open forest on shale (ME041)	0.2	6.00	39.58	Greater Broad-nosed Bat	2.2	6
Turpentine - Grey Ironbark open forest on shale (ME041)	0.4	6.00	24.48	Greater Broad-nosed Bat	2.2	8
Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils (ME004)	0.4	6.00	38.54	Greater Broad-nosed Bat	2.2	13
Total credits required						**27**

Areas not requiring offset determination

The majority of native flora in the project area is contained within patches of planted native species. These areas were identified as planted, rather than regrowth or remnant native vegetation, because they contained sub-mature, even aged plants arranged in straight lines and are located on cuttings or fill material associated with unnatural landforms such as embankments. Further, many of these native plant species are not native to the Sydney region or are garden cultivars.

These planted native species would provide some habitat for threatened species, including the Grey-headed Flying-fox. However, the vegetation lacks the structural and species diversity of native vegetation communities. In addition, it does not contain species credit type threatened species or their habitats. Therefore, this vegetation does not require offset calculation, and is not included in the above calculations.

Areas not requiring assessment

The assessment did not address non-native or exotic vegetation, gravel tracks, hardstand areas, and other infrastructure with occasional plants associated with cracks or shallow soil deposits that clearly do not comprise native vegetation within the meaning of the *Framework for Biodiversity Assessment*.

22.3.7 Impacts on biodiversity values not covered by the Framework for Biodiversity Assessment

The Secretary's environmental assessment requirements specify that the biodiversity assessment must assess impacts on biodiversity values not covered by the *Framework for Biodiversity Assessment*, and that these should include values specified for consideration by the Office of Environment and Heritage. The framework nominates a number of biodiversity values that are not considered under the framework as requiring further consideration. No additional values where specified by the Office of Environment and Heritage for consideration (refer to the summary of responses provided by government agencies during consultation for the Secretary's environmental assessment requirements, provided in Appendix A).

The following values are not assessable under the framework, but are considered to be relevant to the project and were assessed by the biodiversity assessment:

- vehicle strike
- aquatic biodiversity
- downstream impacts on terrestrial and aquatic vegetation, including groundwater dependent ecosystems.

Vehicle strike was considered as a potential operational impact in general, and for the Long-nosed Bandicoot Inner Western Sydney population in particular (refer to Section 22.3.3). Potential construction impacts on aquatic biodiversity and downstream areas are considered in Section 22.3.2.

22.3.8 Cumulative impacts

The study area is located within a developed urban area, with an extensive rail and road network, and urban development.

The project would involve the removal of small patches of already highly fragmented, predominantly planted vegetation. Future infrastructure and road projects, as well as residential development along the Sydenham to Bankstown corridor, would result in the removal of mainly planted vegetation and associated fauna habitats. These losses in biodiversity are likely to be restricted in area, given their location in a highly modified environment. Together, these projects and other developments would result in the further loss of habitat from an already modified environment with limited natural biodiversity values.

22.4 Mitigation measures

22.4.1 Approach to mitigation and management

The overall approach to managing impacts to biodiversity is, in order of importance, to:

- avoid impacts on habitat, through the planning and design process
- mitigate impacts on habitat, through the use of a range of mitigation measures
- offset any residual impact that could not be avoided or mitigated.

The project is largely contained within an existing rail corridor. The project area falls within land which has been previously modified by land clearing and development. Impacts on native flora and fauna are substantially less than would be associated with an undisturbed 'greenfield' site. There is no practical alternative to the location of the project. As such, there is little opportunity to further avoid impacts, other than through the micro-siting of infrastructure.

Mapping of biodiversity values early in the design process has allowed some impacts to be avodied. Notably, the project has been purposefully designed to avoid direct impacts to Downy

Wattle. Siting construction compounds in cleared areas has also been able to avoid or minimise impacts on native flora and fauna.

The Construction Environmental Management Framework (Appendix D) provides for the development and implementation of a Flora and Fauna Management Plan during construction. Additional mitigation measures are identified in Table 22.5.

22.4.2 List of mitigation measures

The mitigation measures that would be implemented to address potential biodiversity impacts are listed in Table 22.5.

Table 22.5 Mitigation measures – biodiversity

ID	Impact/issue	Mitigation measures	Relevant location(s)
Design/pre-construction			
B1	Direct impacts to biodiversity	Detailed design and construction planning would minimise direct impacts to vegetation mapped as threatened ecological communities as far as practicable, and have regard to the habitat management measures provided in the biodiversity assessment report.	All
B2		Pre-clearing surveys and inspections for endangered and threatened flora and fauna species would be undertaken by qualified ecologists prior to any clearing occurring. The surveys and inspections, and any subsequent relocation of species, would be undertaken in accordance with the measures provided in the biodiversity assessment report.	All
B3	Biodiversity offsets	The biodiversity offset strategy prepared for the Environmental Impact Statement would be updated to confirm the approach to retiring the required biodiversity credits (including appropriate biobank sites). It would also include a timeframe to retire the required credits based on the confirmed construction schedule and biobank site owner agreements/ requirements.	All
Construction			
B4	Direct impacts to biodiversity	Areas of biodiversity value outside the project area would be marked on plans, and fenced or signposted where practicable, to prevent unnecessary disturbance.	All
B5		Impacts to Downy Wattle would be avoided. The locations of Downy Wattle stems would be marked on plans, fenced on site, and avoided.	Punchbowl and Bankstown stations
B6		Equipment storage and stockpiling would be restricted to identified compound sites and already cleared land.	All
B7		A trained ecologist would be present during the clearing of native vegetation or removal of potential fauna habitat (including underbridges) to avoid impacts on resident fauna, and to salvage habitat resources as far as is practicable.	All
B8	Management of weeds	Noxious weeds would be managed in accordance with the *Noxious Weeds Act 1993*. Weeds of national environmental significance would be managed in accordance with the *Weeds of National Significance Weed Management Guide*.	All
Operation			
B9	Management of weeds	Annual inspections would be undertaken for weed infestations and to assess the need for control measures.	All

ID	Impact/issue	Mitigation measures	Relevant location(s)
B10		Any outbreak of noxious and/or weeds of national environmental significance would be managed in accordance with the relevant guidelines.	All

22.4.3 Consideration of the interactions between mitigation measures

Measures to minimise potential impacts associated with noise, air quality, soils, hydrology, and water quality and would also assist in minimising potential impacts to biodiversity. These mitigation measures are provided in Chapters 12, 13, 20, 21, and 23.

22.4.4 Managing residual impacts

Despite measures taken to avoid and mitigate impacts, the project would result in some unavoidable residual adverse impacts, including removal of native vegetation and habitat resources, and edge effects on adjoining areas of native vegetation.

Residual impacts following implementation of the mitigation measures in Section 22.4.2 are predicted to include:

- removal or modification of one hectare of native vegetation and associated habitat resources
- removal or modification of 7.3 hectares of planted native species that provide potential habitat for threatened species
- noise, light, traffic and altered environmental conditions associated with construction and operation.

The above residual impacts are small in extent and magnitude, and would comprise a minor reduction in biodiversity values in the study area. The biodiversity offset strategy (described below) would assist in mitigating residual impacts.

Biodiversity offset strategy

A biodiversity offset strategy has been developed to compensate for the unavoidable loss of ecological values as a result of the project. Transport for NSW commits to the retirement of the required credits in accordance with the *Framework for Biodiversity Assessment* and the NSW offsets policy. The Biodiversity Offset Strategy requires the purchase and retirement of biodiversity credits calculated in accordance with the *Framework for Biodiversity Assessment*. Transport for NSW would consult with the vendor/s of the biodiversity credits detailed in Technical Paper 9, and arrange to purchase and retire a total of 27 biodiversity credits appropriate to offset the impacts of the project.

23. Air quality

This chapter provides an assessment of the potential impacts of the project on air quality. Although there are no Secretary's environmental assessment requirements directly relevant to air quality, the assessment has been undertaken as air quality was identified as a potential risk by the State Significant Infrastructure Application Report, particularly in terms of the potential for amenity impacts.

23.1 Assessment approach

23.1.1 Legislative and policy context relevant to the assessment

The main legislation and guidelines relevant to the assessment and management of air quality are summarised below.

Protection of the Environment Operations Act 1997

As described in Section 20.1, the POEO Act provides the statutory framework for managing pollution in NSW. It includes procedures to regulate the potential for pollution, including the issue of environment protection licences, in relation to aspects such as air pollution. Air quality requirements (including criteria) are specified by environment protection licences. Environment protection licences would be obtained for both the construction and operation of the project, and the project would comply with requirements related to the minimisation of air quality impacts.

Clean Air Regulation

The *Protection of the Environment Operations (Clean Air) Regulation 2010* (the Clean Air Regulation) provides regulatory requirements to control emissions from motor vehicles, fuels, and industry. The project would be constructed and operated to ensure it complies with the Clean Air Regulation.

Approved Methods

Air quality impact assessment is guided by the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (DEC, 2005) (known as 'the Approved Methods'). The Approved Methods generally apply to stationary sources of air pollution. However, the qualitative assessment described in this chapter gave consideration to the Approved Methods, including relevant criteria and the assessment methodology.

Air NEPM

The *National Environment Protection (Ambient Air Quality) Measure* ('the Air NEPM') sets non-binding standards and ten-year goals. The Air NEPM has a goal for particulate matter with an aerodynamic diameter of less than 10 microns (PM_{10}) of 50 micrograms per cubic metre ($\mu g/m^3$) as a 24-hour average (no exceedances per year), and a $PM_{2.5}$ goal of 25 $\mu g/m^3$ as a 24-hour average. Consideration was given to these goals as part of the assessment.

23.1.2 Methodology

The main risk of the project with respect to air quality is emissions (mainly dust) during construction. These potential impacts would be temporary, confined to the construction period, and readily managed through the implementation of standard construction management measures.

As such, potential air quality impacts of the project have been assessed qualitatively, involving:

- a desktop review of the background air quality environment, including:
  - air quality data sourced from the NSW Office of Environment and Heritage's air quality monitoring stations, located at Earlwood, Chullora, and Liverpool (the closest stations to the project area)
  - the National Pollutant Inventory maintained by the Australian Government Department of the Environment and Energy, to identify any facilities that may be contributing to local/regional air quality conditions
- identifying sensitive receivers with the potential to be adversely affected by air quality impacts
- reviewing the construction and operational aspects of the project with the potential to generate air emissions
- a qualitative assessment of potential air quality impacts
- identifying appropriate mitigation and management measures, as necessary.

23.2 Existing environment

23.2.1 Ambient air quality

Ambient air quality in Sydney is influenced by a number of factors, including topography, prevailing meteorological conditions (such as wind and temperature, which vary seasonally), and local and regional air pollution sources (such as motor vehicles, industrial facilities and bushfires). Consequently, regional air quality can be highly variable and impacted by events occurring a significant distance away.

Air quality surrounding the project area is typical of a highly developed urban area that consists of a mix of land uses. Local air quality is mainly affected by vehicles on the road network, in particular on major roads such as Canterbury Road, King Georges Road, and Stacey Street/Fairford Road. Air quality is also affected by the operation of diesel freight trains along the rail corridor between east of Marrickville Station and west of Campsie Station.

The NSW Office of Environment and Heritage uses a standardised measure known as the air quality index to characterise air quality at a location and compare it in relative terms with other locations throughout NSW. The average daily air quality index values for the monitoring stations at Earlwood, Chullora, and Liverpool (refer to Table 23.1) varied between 46 and 51 in the available monitoring years. These values correspond with an air quality index outcome of 'good', indicating that air quality is generally of an acceptable quality.

23.2.2 Local emission sources

The desktop review identified the following potential air pollution sources in the study area:

- industrial facilities that reported air emissions during the 2014-2015 reporting period, including:
  - petroleum and coal product manufacturing facility (in Alexandria)
  - Sydney Trains Sydenham Maintenance Centre (in Sydenham)
  - airport operations and other air transport support services (in Mascot)
  - ceramic product manufacturing facility (in Punchbowl)
  - basic chemical manufacturing facility (in Bankstown)
- vehicle exhaust emissions from road and rail networks

- commercial businesses, such as service stations and smash repairs
- domestic activities, such as wood-fired home heaters and lawn mowing.

Only one air pollution source, the XPT Maintenance Centre located on Way Street in Sydenham, is located in the immediate vicinity of the project area (about 200 metres south-east). All other sources are located more than one kilometre from the project area.

23.2.3 Background air quality data

Air quality monitoring data sourced from the monitoring stations is summarised in Table 23.1. The data shows that the concentrations of air pollutants were generally below the applicable air quality criteria, with the exception of occasional days when PM_{10} exceeded 50 µg/m^3. These occurrences are generally the result of natural events such as dust storms and bushfires.

Table 23.1 Background air quality data

Pollutant	Averaging period	Criteria	Earlwood			Chullora			Liverpool		
			2013	2014	2015	2013	2014	2015	2013	2014	2015
PM_{10} (µg/m^3)	Maximum 24-hour	50	63	45	67	69	40	65	99	41	69
	95th percentile 24-hour	50	35	30	28	32	30	29	37	33	31
	Annual	30	20	18	17	18	18	18	21	19	19
Carbon monoxide (CO) (mg/m^3)	Maximum 1-hour	30	-	-	-	3	2	2	3	3	2
Nitrogen dioxide (NO_2) (µg/m^3)	Maximum 1-hour	246	97	81	107	111	130	109	113	89	122
	Annual	62	20	16	16	26	26	26	22	20	20
Sulphur dioxide (SO_2) (µg/m^3)	Maximum 1-hour	570	-	-	-	34	54	40	-	-	-
	Annual	60	-	-	-	3	3	3	-	-	-

23.2.4 Sensitive receivers

The project area is surrounded by a wide range of sensitive receivers, including residential properties, community facilities (such as schools, childcare centres, places of worship, and medical facilities), and recreational areas. A number of these receivers are located immediately adjacent to the project area.

Land uses surrounding the project area are described in Chapter 16 (Land use and property). Figure 12.1 shows sensitive receivers located generally within about 250 metres of the project area.

23.3 Impact assessment

23.3.1 Risk assessment

Potential risks

The environmental risk assessment for the project, undertaken for the State Significant Infrastructure Application Report, identified the following as the main air quality risks:

- impacts to local air quality due to the operation of construction plant and equipment.
- impacts to local air quality due to increased vehicle movements from replacement bus services and transport of construction materials
- impacts to local air quality due to dust generation from exposed surfaces.

As the project would be powered by electricity, there is expected to be minimal risk of air quality impacts during operation.

Chapter 24 (Sustainability and climate change) provides estimates of electricity use, and the initiatives and targets proposed to be considered further during detailed design. A preliminary estimate of construction emissions from plant and equipment use was prepared as part of greenhouse gas assessment (refer to Chapter 24).

How potential risks and impacts would be avoided

In general, potential air quality impacts would be avoided by:

- managing air quality in accordance with relevant legislative and policy requirements, as described in Section 23.1.1
- managing air quality in accordance with the environment protection licences for construction and operation
- implementing the air quality management measures described in Section 23.4.

23.3.2 Construction

Construction activities, including earthworks, storage and transport of spoil and waste materials, demolition of buildings, and exhaust emissions from construction equipment and vehicles, have the potential to impact on local air quality. The main potential impacts on air quality during construction are described below.

Dust generation

The processes that have the potential to generate particulate matter during construction are:

- mechanical disturbance − dust emissions as a result of earthworks/excavation and the operation/movement of construction vehicles and equipment
- wind erosion − dust emissions from disturbed soil surfaces and stockpiles in windy conditions.

Construction activities with the greatest potential to generate dust would include:

- demolition of buildings and infrastructure
- excavations and trenching for the installation of footings and new infrastructure
- transport, handling, stockpiling, loading, and unloading of spoil and imported materials

- creation of exposed surfaces through the clearing of vegetation, stripping of topsoil and other overlying structures (such as road and footpath pavements)
- other general construction activities that would occur along the length of the corridor.

The volume of dust generated would depend on the:

- type of equipment used
- construction technique employed
- type, particle size, and moisture content of material
- size of the exposed area
- meteorological conditions (in particular wind conditions).

Without the implementation of effective mitigation measures, dust emissions from construction could reduce local air quality and impact on nearby sensitive receivers.

The project would involve surface works in the project area, including track realignment, and other civil works to adjust drainage, install noise barriers, maintain embankments, upgrade and replace bridges, and to demolish and upgrade station buildings and structures. However, no major earthworks are required.

As a result of the limited scale of earthworks and nature of the works proposed, dust emissions are expected to be manageable through the implementation of standard erosion control and dust management measures applied successfully to other similar rail infrastructure projects, as required by the Construction Environmental Management Framework (refer to Section 23.4).

Exhaust emissions

The main source of emissions would be from the combustion of diesel fuel and petrol from heavy vehicles, mobile excavation machinery, and stationary combustion equipment as well as from the handling and/or on-site storage of fuel and other chemicals.

The volume of emissions from construction vehicles and machinery would depend on the type of fuel used, the power output and condition of the engine, and duration of operation.

Exhaust emissions would involve periodically localised emissions of carbon monoxide, particulate matter (PM_{10} and $PM_{2.5}$), nitrous oxides, sulphur dioxide, volatile organic compounds, and polycyclic aromatic hydrocarbons associated with the combustion of diesel fuel and petrol.

The highest potential for air quality impacts from plant emissions would be associated with works where multiple items of equipment operate simultaneously.

Exhaust emissions generated during construction would not significantly contribute to emissions in the project area, given the existing levels of vehicle use. These emissions would be managed by the implementation of standard construction mitigation measures, described in Section 23.4. As such, no long-term adverse impacts to air quality are anticipated.

23.3.3 Operation

Local impacts

There is the potential for minor air quality impacts. Any greenhouse gas emissions associated with the consumption of electricity during operation would be fully offset. Further information is provided in Chapter 24.

As the project would be powered by electricity, local emissions during operation are expected to be minimal and highly dispersed. Minor quantities of particulate matter (PM_{10}) emissions would be generated along the corridor, mainly due to the wear of the train brake pads, vaporisation of metals due to sparking, and wear of steel due to friction between wheels and rail. These emissions would be in very low concentrations, and are not expected to be different from the current operational rail corridor.

Regional impacts

The project would not to result in any substantial regional air quality impacts as any emissions would be highly dispersed in the local area and would not impact on any areas away from the project.

23.3.4 Cumulative impacts

Cumulative air quality impacts may result from increased dust generation and emissions from other projects occurring concurrently to the project. The Chatswood to Sydenham project is the only identified project that would coincide spatially with the project area, at the eastern extent of the project near Fraser Park. The surface sections of WestConnex Stage 2 are located about two kilometres south of the project area at Lakemba, and about one kilometre south of Sydenham Station. Therefore, it is unlikely that these projects would combine with the project to generate cumulative air quality impacts.

The linear extent of the project and the scope and nature of the emission sources means that any cumulative impacts, are likely to be limited. The adoption of standard control measures, are expected to result in the successful management of dust and other emissions from the project, including any cumulative impacts.

As described in Section 23.3.3, operational air quality impacts are expected to be minor. Cumulative impacts associated with operation of the project and other local emissions sources are not expected.

23.4 Mitigation measures

23.4.1 Approach to mitigation and management

Potential impacts to air quality would be managed in accordance with the Construction Environmental Management Framework (as described in Chapter 28 (Synthesis of the Environmental Impact Statement)), which provides for development and implementation of an air quality management plan, to include (as a minimum):

- air quality mitigation measures, including those provided in the framework
- requirements of the environmental protection licence
- site plans or maps indicating locations of sensitive receivers and key air quality/dust controls
- responsibilities of key project personnel with respect to the implementation of the plan
- air quality and dust monitoring requirements
- compliance record generation and management.

During operation, air quality would be managed in accordance with the operational environment protection licence, in accordance with the operational environmental management plan.

23.4.2 List of mitigation measures

Table 23.2 provides the relevant mitigation measure for air quality impacts.

Table 23.2 Mitigation measures – air quality impacts

ID	Impact/issue	Mitigation measures	Applicable location(s)
Design/pre-construction and construction			
AQ1	Air quality impacts	An air quality management plan would be prepared and implemented during construction, to define the measures to minimise air quality impacts during construction.	All

23.4.3 Consideration of the interactions between mitigation measures

Measures to minimise the potential for air quality impacts would overlap with the measures proposed for the control of erosion and sedimentation (described in Chapter 20 (Soils and contamination)), as the major pollutant of concern is dust. As described in Section 20.4, soil and erosion control measures would be implemented during construction in accordance with *Soils and Construction - Managing Urban Stormwater Volume 1* (Landcom, 2004) and *Volume 2A* (DECC, 2008). Implementation of these measures would be guided by a soil and water management plan prepared in accordance with the Construction Environmental Management Framework.

Other interactions include measures relating to the emission of contaminated substances (also described in Chapter 20), sustainability and climate change measures to be implemented to manage impacts of electricity use during construction and operation (described in Chapter 24), and measures to manage impacts as a result of hazardous materials (described in Chapter 25). Implementation of these measures, together with the requirements of the Construction Environmental Management Framework, would minimise the potential for air quality impacts.

23.4.4 Managing residual impacts

The mitigation and management measures proposed are expected to minimise the potential for impacts to air quality. With the implementation of these measures, residual impacts are expected to be minimal.