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.

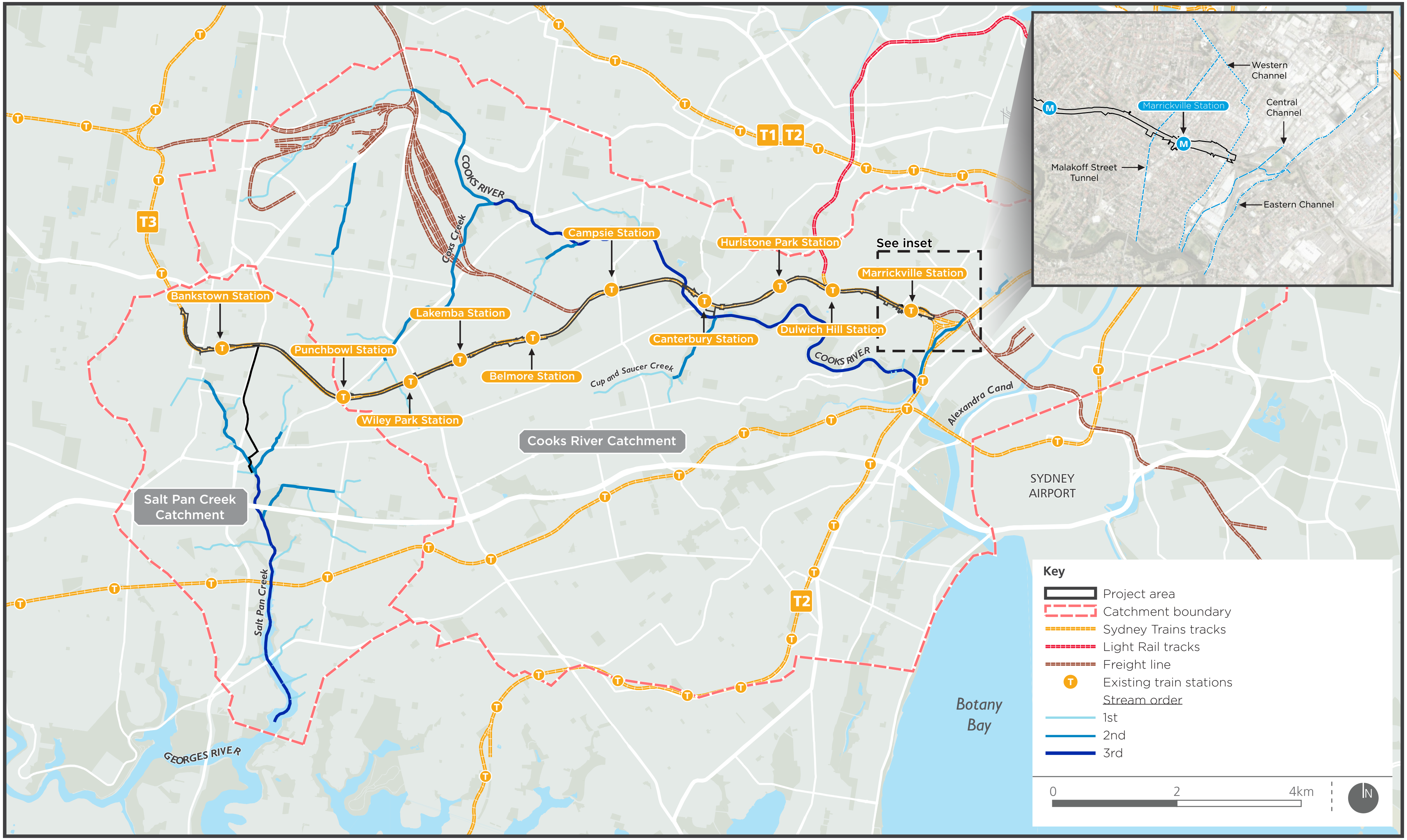
The upper reaches of the creek are highly modified and are generally concrete lined, with limited vegetation until the Canterbury Road crossing. There are no recognised tributaries for the creek on available mapping, however a number of unnamed channels drain to its upper reaches.

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:

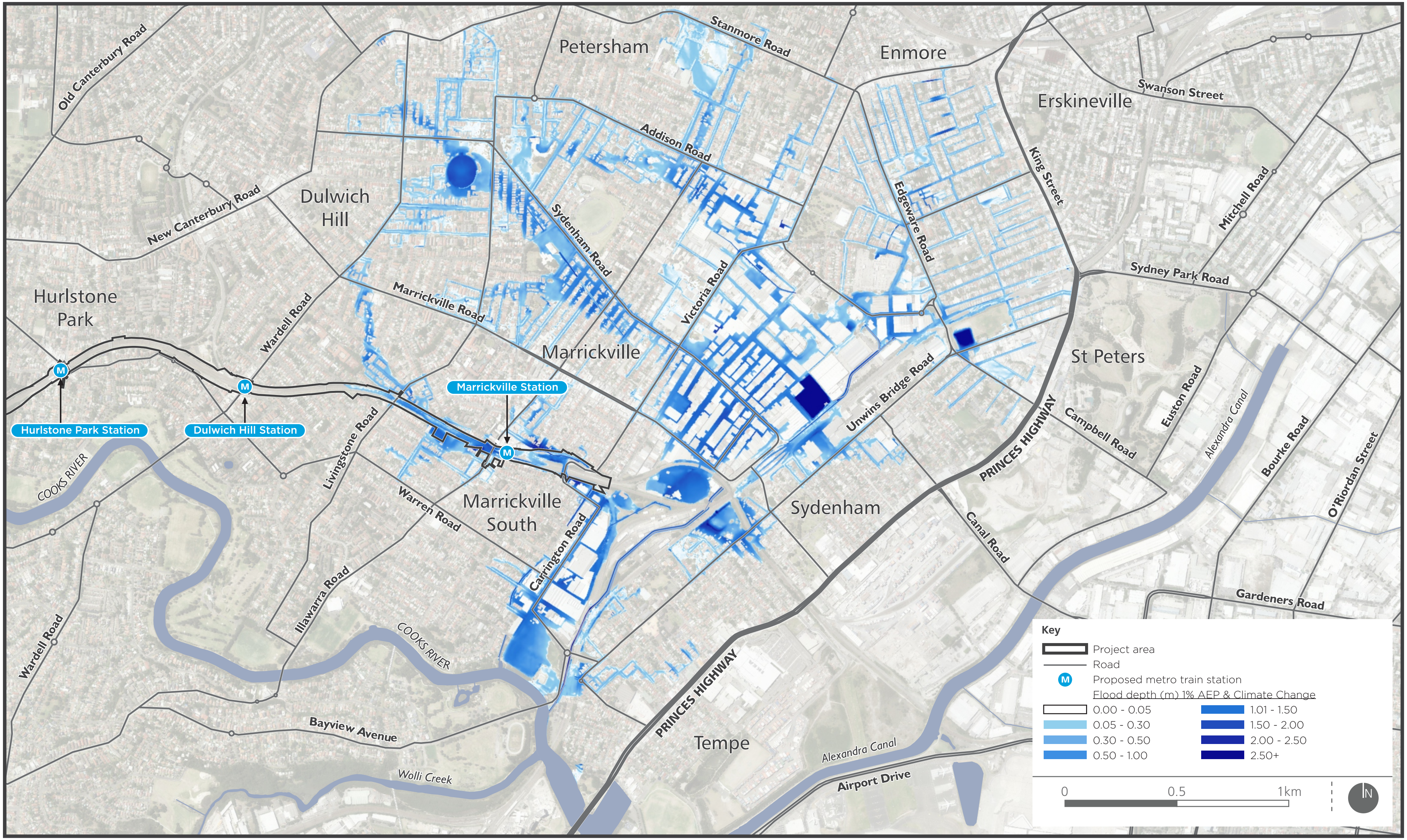
- insufficient capacity within the surrounding local stormwater drainage network, which overflows into the rail corridor during flood events
- lack of drainage infrastructure within the rail corridor to capture flows from external catchments – this is particularly the case where the ARTC freight tracks 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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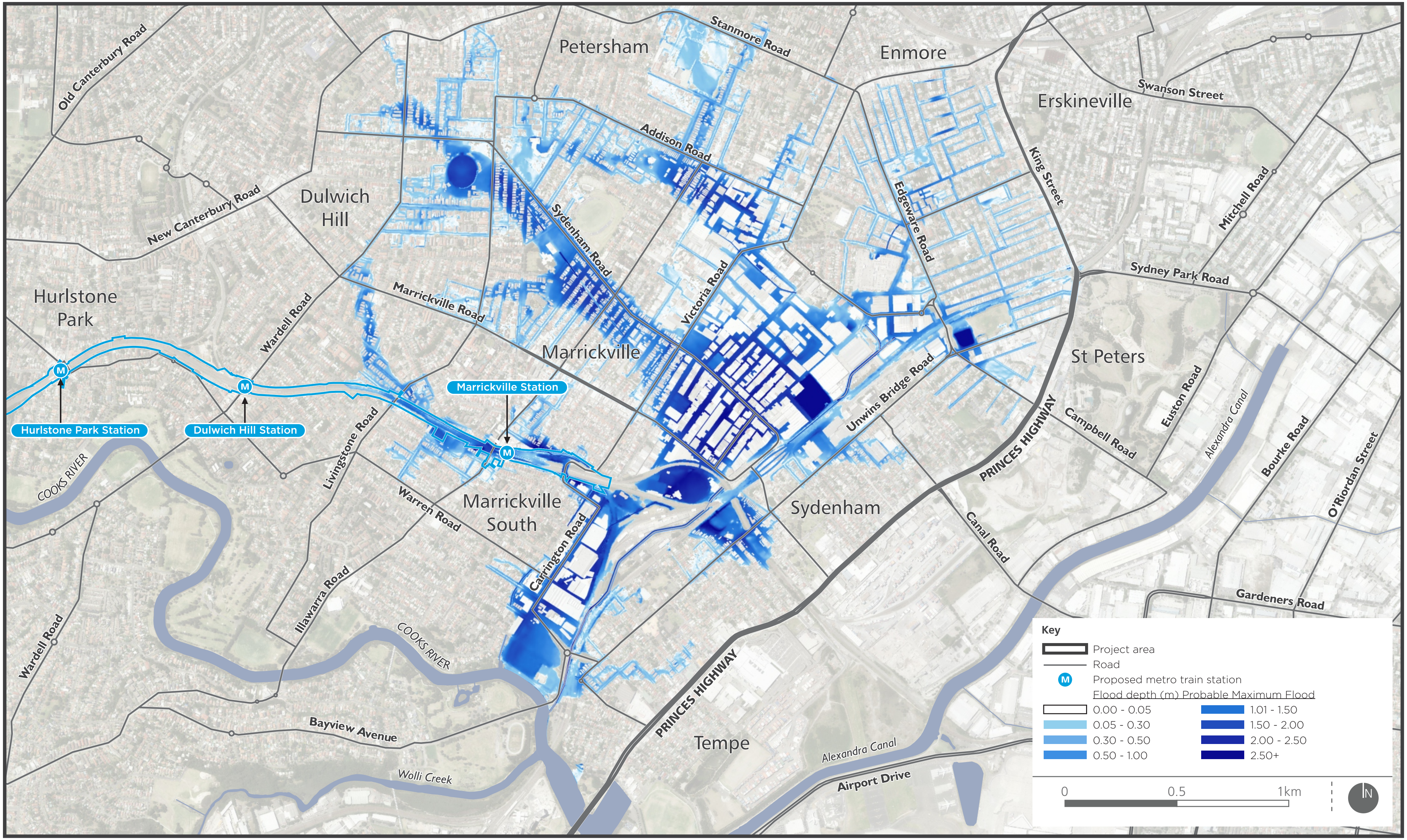
Marrickville and surrounds – existing flood depth and extent - one per cent AEP plus climate change

FIGURE 21.2



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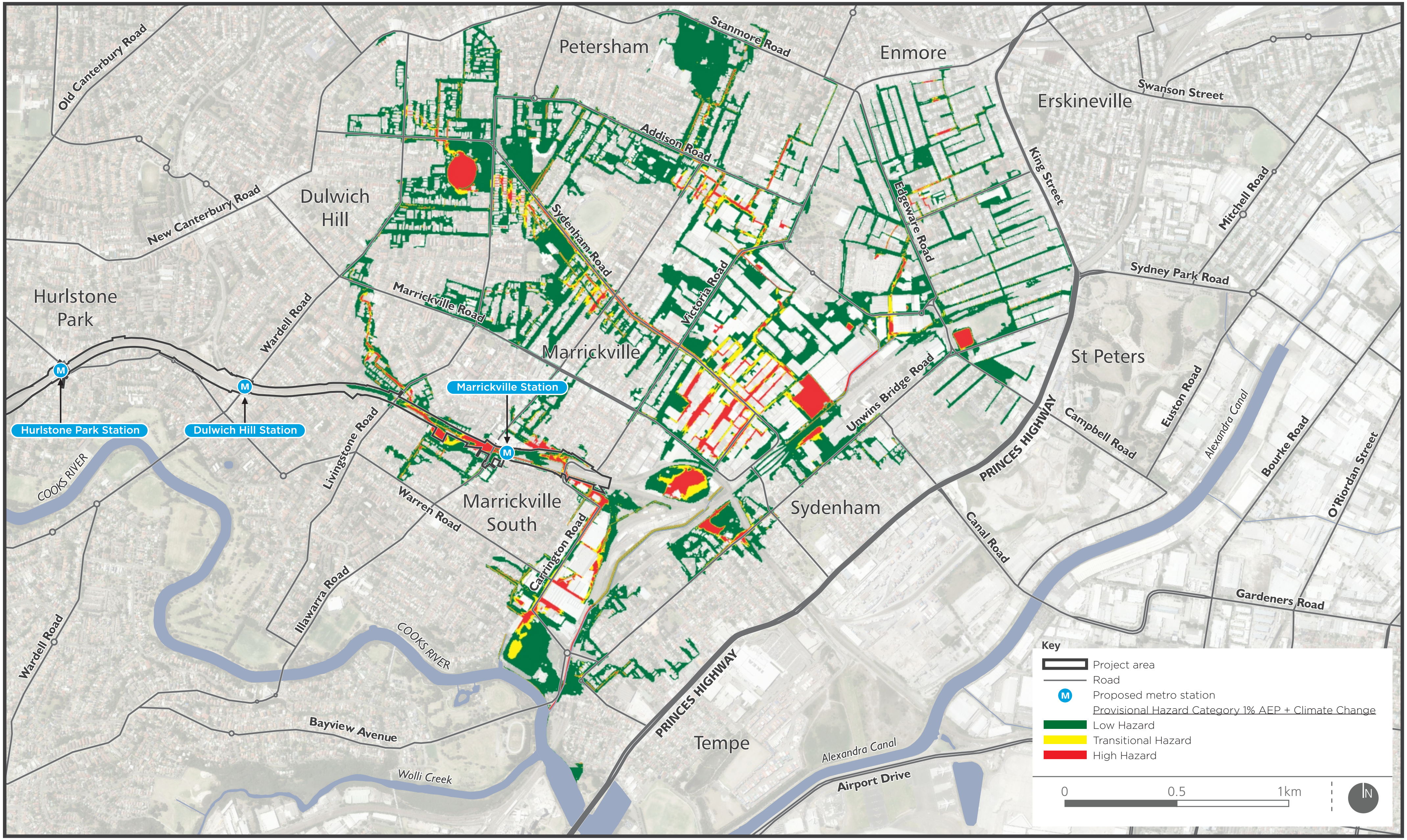
Marrickville and surrounds – existing flood depth and extent - probable maximum flood

FIGURE 21.3



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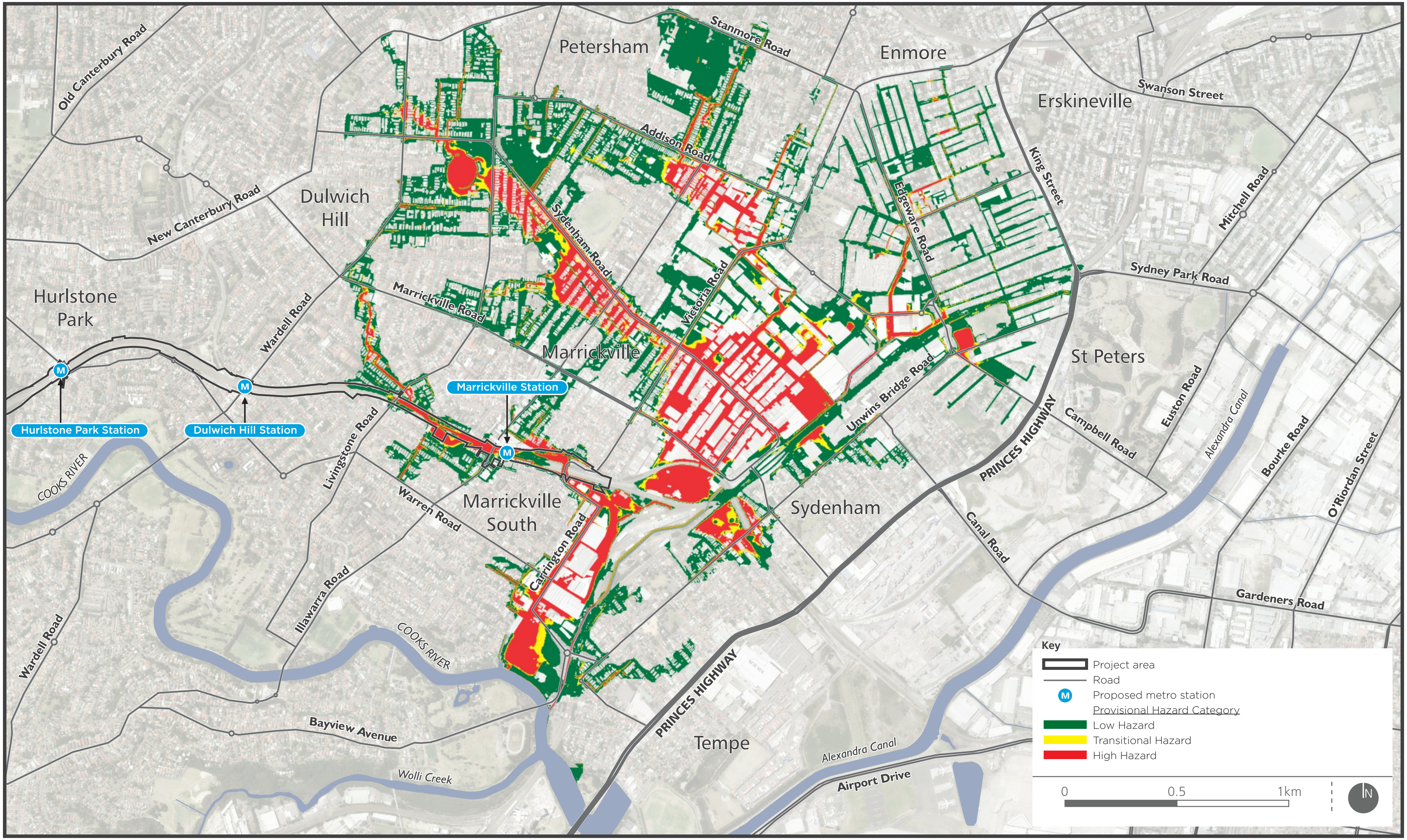
Marrickville and surrounds - existing provisional flood hazard - one per cent AEP plus climate change

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.

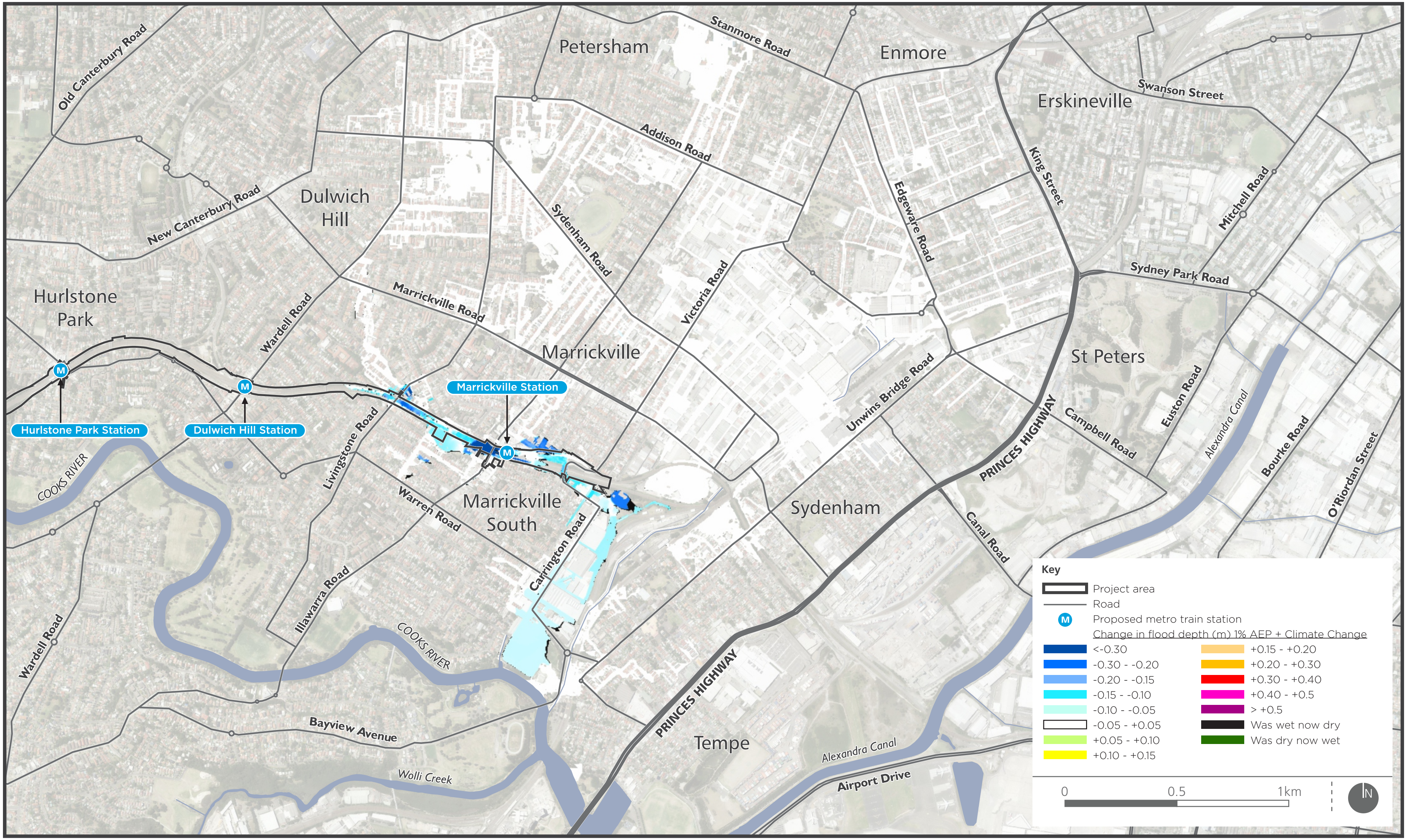
Impacts of flooding on existing emergency management arrangements

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

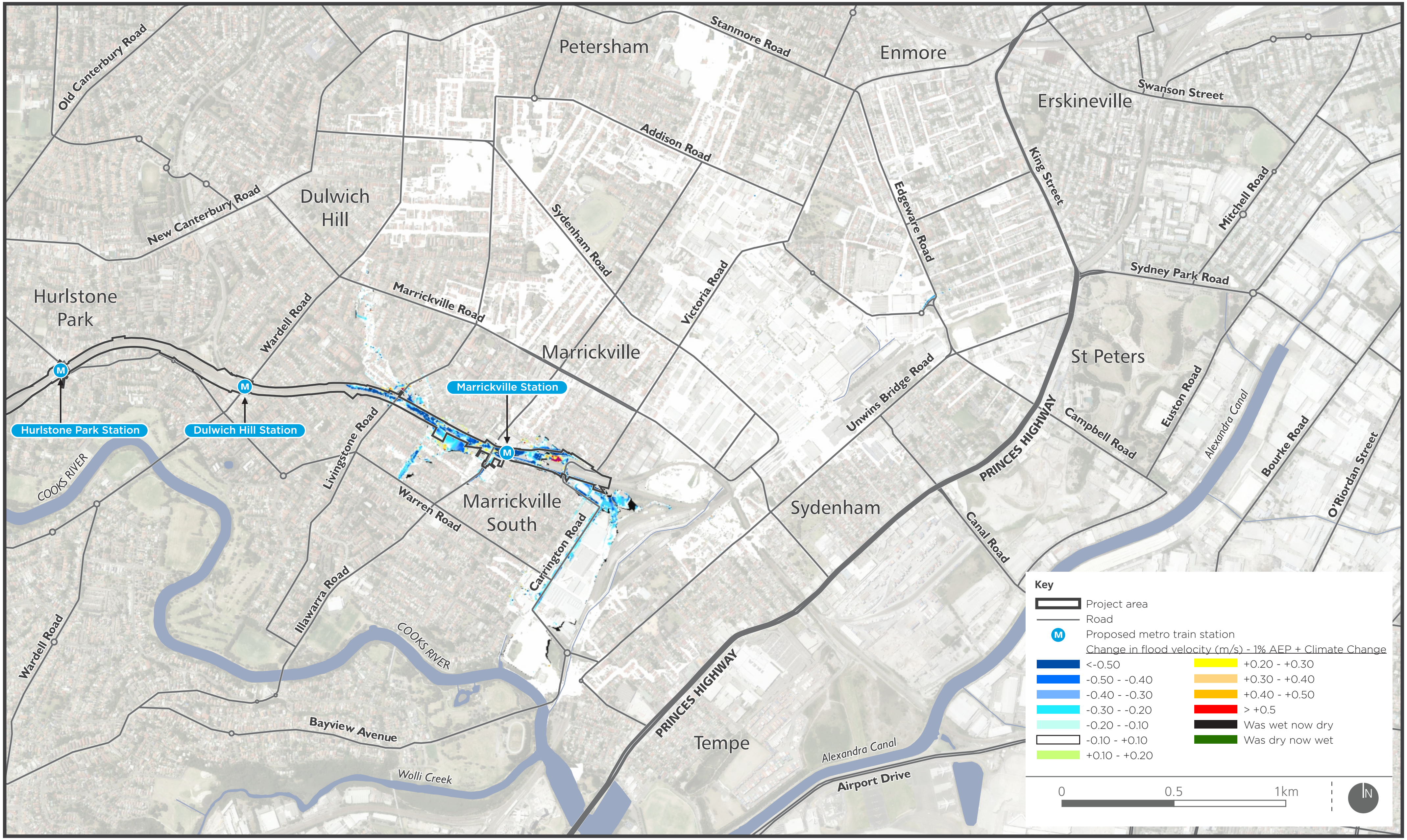
The analysis undertaken during design development indicates that there are limited adverse flooding and hydrology impacts resulting from the project, and no change or an improvement to many aspects relative to existing conditions under a range of potential flood events. The impacts identified are mainly 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

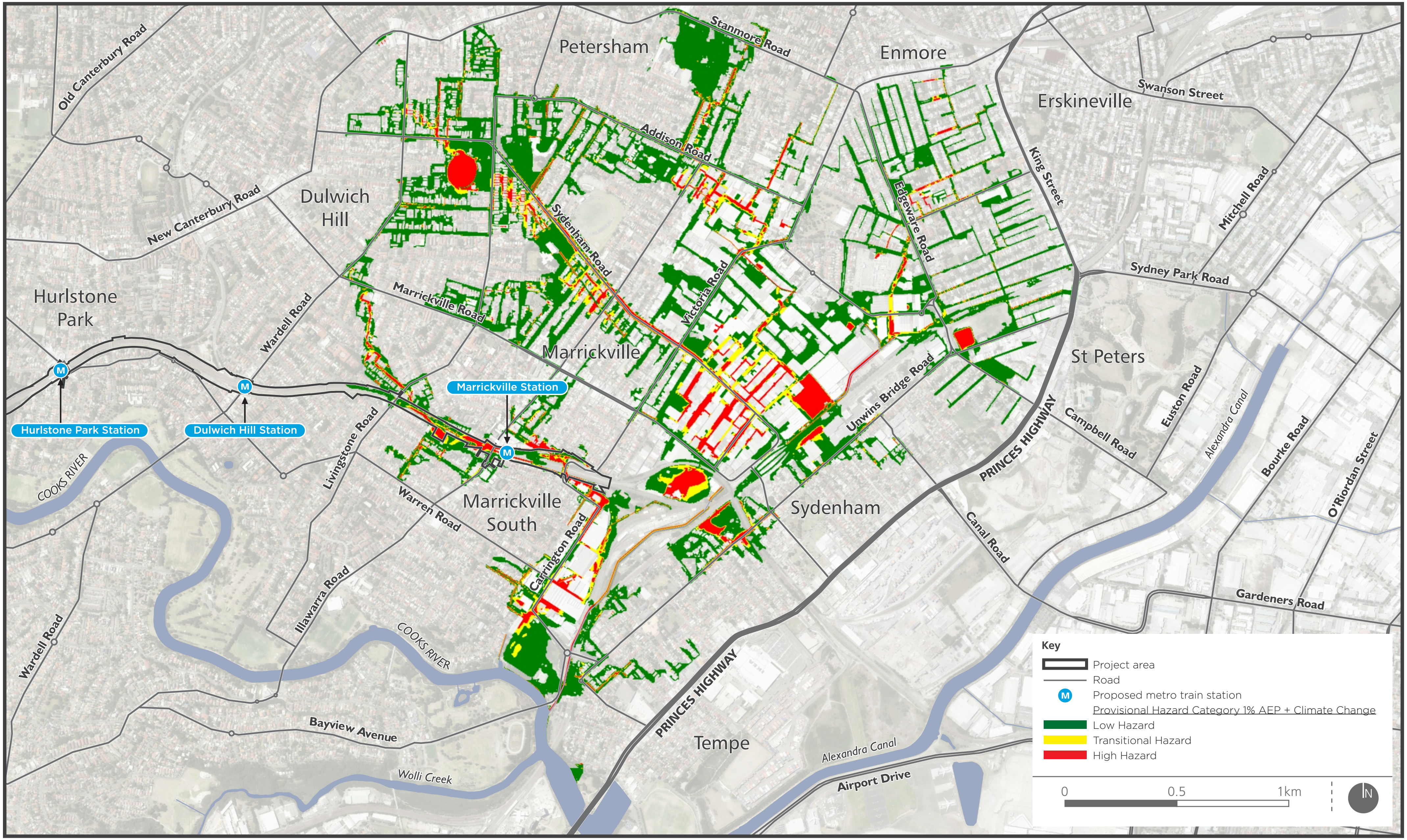
FIGURE 21.6



sydney METRO | city & southwest

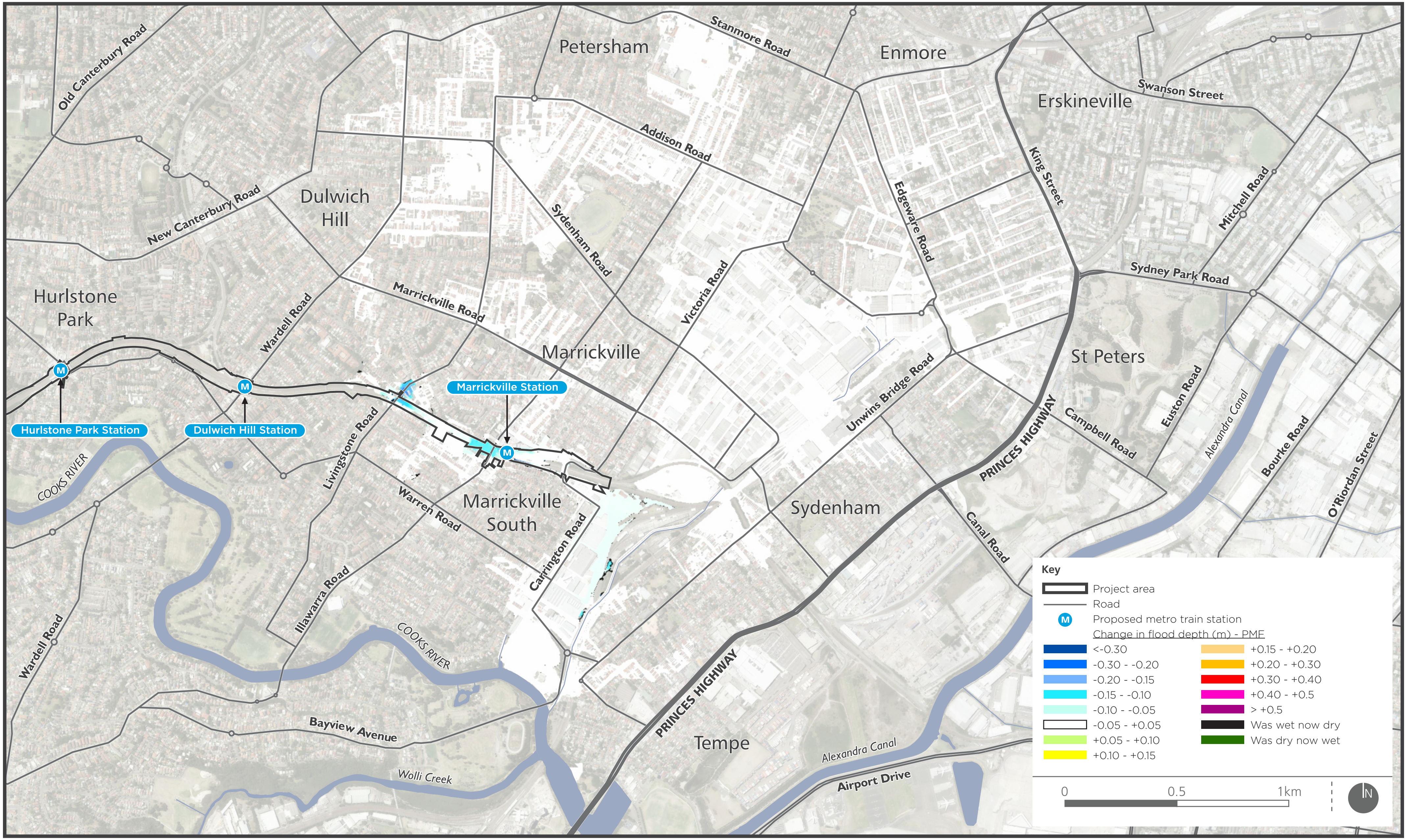
Marrickville and surrounds – change in flood velocity - one per cent AEP plus climate change

FIGURE 21.7



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

FIGURE 21.8



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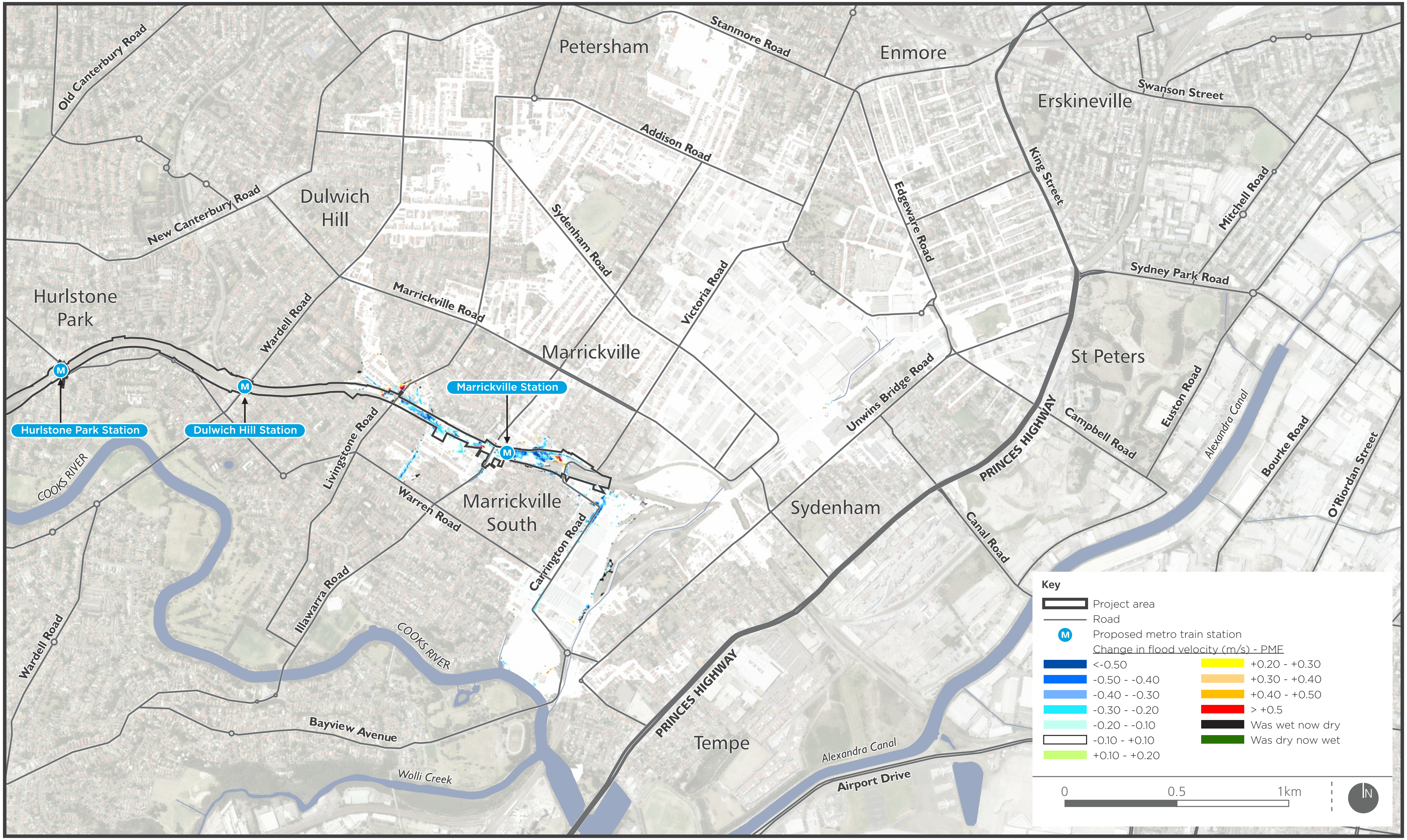
Marrickville and surrounds – change in flood depth and extent – probable maximum flood

FIGURE 21.9



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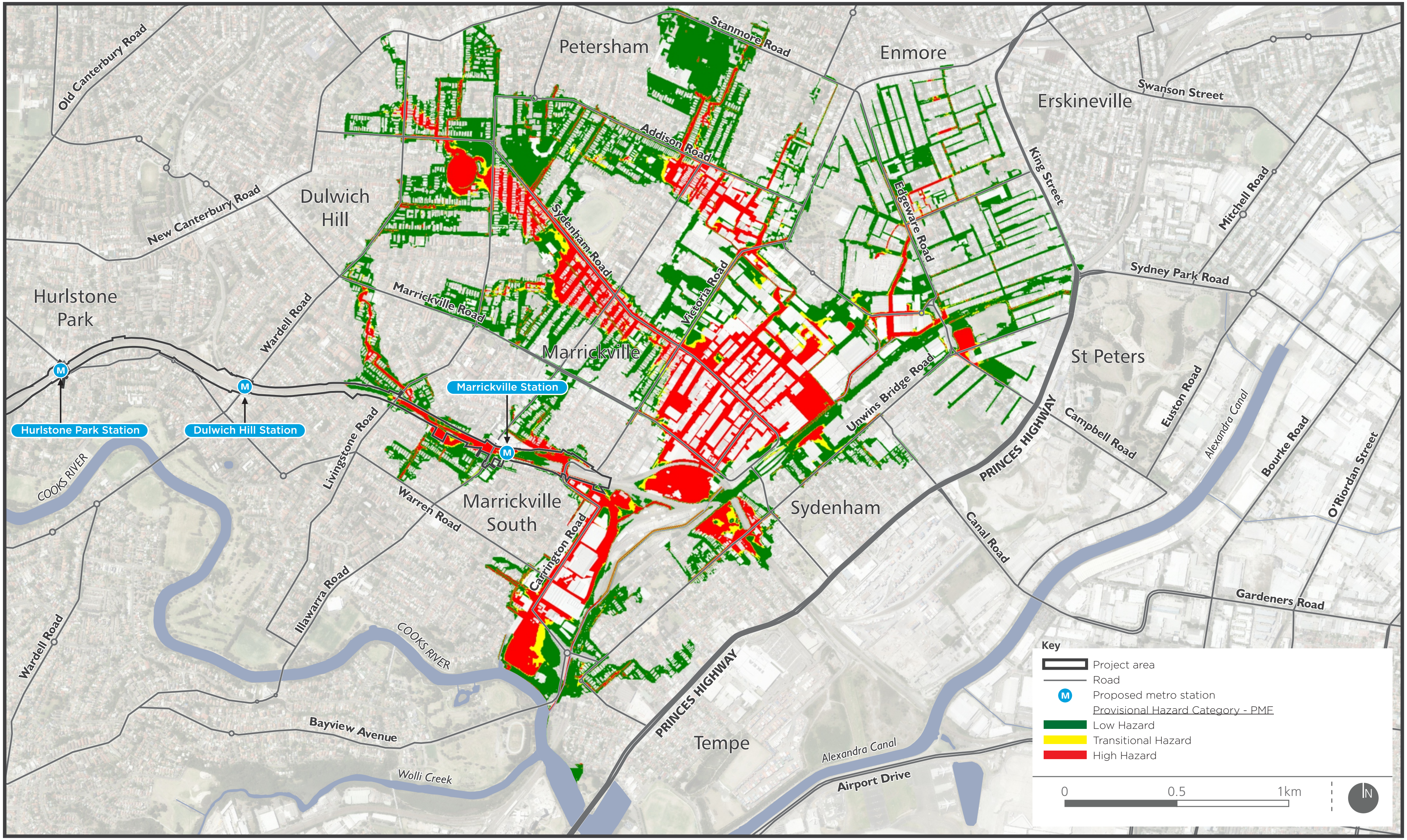
Marrickville and surrounds – change in flood velocity - probable maximum flood

FIGURE 21.10



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Marrickville and surrounds – flood hazard - probable maximum flood

FIGURE 21.11

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.