Transport for NSW

Chapter 17
Water

NSW GOVERNMENT

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17. Water

This chapter provides a summary of the assessments of potential impacts to water, including hydrology, flooding and water quality impacts. It describes the existing environment, identifies potential impacts during construction and operation, and provides measures to mitigate and manage the impacts identified. Further information is provided in Technical Paper 10 (Hydrology, Flooding and Water Quality).

17.1 Approach

The project would involve constructing new infrastructure within and close to watercourses, particularly the Parramatta River, and the floodplain associated with these watercourses. As a result, the project has the potential to affect a number of water-related aspects, including surface water quality, groundwater movement and quality, flooding, hydrology and the stability of the Parramatta River. Hydrology, flooding and water quality assessments have been undertaken to assess the potential impacts on these aspects in accordance with:

- the SEARs (see Appendix A (SEARs compliance table))
- applicable legislation and environmental planning policies, including the *Coastal Management Act 2016* (NSW) (Coastal Management Act), *Water Management Act 2000* (NSW), POEO Act and State Environmental Planning Policy (Resilience and Hazards) 2021 (Resilience and Hazards SEPP)
- relevant guidelines and polices, including:
  – hydrology and flooding assessment – Floodplain Development Manual (DIPNR, 2005), Australian Rainfall and Runoff: A Guide to Flood Estimation (Ball et al., 2019) and Lower Parramatta River Floodplain Risk Management Study (SKM, 2005)
  – water quality assessment – the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (Australian and New Zealand Governments (ANZG), 2018) and *NSW Water Quality and River Flow Objectives* (Department of Environment, Climate Change and Water (DECCW), 2006)
  – groundwater assessment – *NSW Aquifer Interference Policy* (Office of Water, 2012), *NSW Water Quality and River Flow Objectives* (Department of Environment, Climate Change and Water, 2006).

A detailed description of the legislative and policy context for the assessment is provided in Chapter 2 of Technical Paper 10 (Hydrology, Flooding and Water Quality). An overview of the approach to the assessment is provided below. Further information on the assessment methodology is provided in Chapter 3 of Technical Paper 10.

An assessment was also undertaken of coastal hazard and process issues associated with the Parramatta River, as defined by the Resilience and Hazards SEPP, the *Parramatta River Estuary Coastal Zone Management Plan* (Cardno, 2013) and *Greater Sydney Harbour Coastal Management Program Scoping Study* (BMT, 2018).

17.1.1 Study area

The study area for the assessments includes the project site as described in Chapter 2 (Location and setting) and adjoining areas. It includes watercourses that are crossed by and/or are located close to the project site, and groundwater aquifers beneath the project site.

17.1.2 Key tasks

Hydrology and flooding assessment

The hydrology and flooding assessment involved the following key tasks:

- reviewing information and data on drainage infrastructure and flooding conditions
- establishing flood management objectives for the project
- updating existing flood models with current data, including data on council and Sydney Olympic Park Authority drainage infrastructure
- modelling (using the TUFLOW hydraulics model) and mapping existing flooding conditions and conditions with the project in place, for the five per cent annual exceedance probability (AEP), one per cent AEP, and probable maximum flood (PMF) events
- modelling potential climate change affects
- assessing potential flooding and hydrology impacts and risks, including using the results of modelling to assess the potential impacts of constructing and operating the project on buildings, infrastructure and land uses
- recommending measures to minimise changes to the flood regime as a result of the project.

Water quality assessment

The water quality assessment involved the following key tasks:

- reviewing information and data on water quality, including monitoring data from the City of Parramatta Council and Parramatta Light Rail Stage 1
- identifying appropriate water quality objectives based on the Australian and New Zealand Guidelines for Fresh and Marine Water Quality and NSW Water Quality and River Flow Objectives
- modelling using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) to identify existing pollutants and those that may be generated by the project, including the effect of water quality treatment measures to identify potential reductions that could be achieved for key pollutants (gross pollutants, total suspended solids, total phosphorous and total nitrogen)
- assessing potential impacts on water quality during construction and operation
- recommending measures to avoid and mitigate the potential impacts identified.

Groundwater assessment

The groundwater assessment involved the following key tasks:

- reviewing data and studies describing the geotechnical, groundwater and hydrogeological environments
- analytical modelling of areas of potential risk in terms of interaction with groundwater aquifers
- identifying potential groundwater impacts
- recommending measures to avoid and mitigate the impacts identified.

Assessment of potential impacts on Parramatta River coastal hazards and processes

Areas defined as coastal environment and coastal wetlands by the Resilience and Hazards SEPP are located in the study area along the Parramatta River (see section 17.2.6). As a result, an assessment was undertaken to identify coastal hazards and processes within the study area, and to assess the potential impacts of the project as it relates to these aspects. The assessment involved the following key tasks:

- reviewing data, mapping, plans and reports relevant to Parramatta River coastal hazards and processes
- considering the potential impacts on the Parramatta River and associated coastal hazards and processes
- recommending measures to avoid and mitigate the impacts identified.

17.1.3 Flood management and water quality objectives

Project-specific flood management objectives have been established to provide criteria against which potential impacts are assessed and managed in relation to changes in flooding conditions. Similarly, project-specific water quality and river flow objectives have also been established to provide criteria against which potential impacts are assessed and managed in relation to changes in water quality. These objectives are listed below.

Flood management objectives

The following flood management objectives have been defined:

- for operational flood levels in events up to the one per cent AEP there should be no increase in flood levels relative to the existing condition (afflux) greater than:
  - 10 millimetres in residential zoned land
  - 20 millimetres in commercial/industrial zoned land
  - 50 millimetres in public land (defined as any land (including a public reserve) vested in or under the control of the council)
- the potential for soil erosion and scouring is minimised for events up to and including a one per cent AEP flood event
- no change in flood hazard category in residential and commercial/industrial zoned land
- no change to the hazard category for events up to and including the one per cent AEP flood event for dedicated evacuation routes.

Water quality objectives

NSW water quality and river flow objectives

The *NSW Water Quality and River Flow Objectives* provide agreed environmental values and long-term goals for water quality and river flow for NSW's surface waters. These objectives are consistent with the national framework for assessing water quality set out in the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. For the upper Parramatta River, which is highly urbanised and affected by stormwater and wastewater overflows, the nominated objectives are:

- water quality – aquatic ecosystems, visual amenity, secondary contact recreation and primary contact recreation
- river flow – maintain wetland and floodplain inundation, minimise effects of weirs and other structures and maintain or rehabilitate estuarine processes and habitats.

Project-specific water quality and river flow objectives

During construction and operation there is potential for contaminated runoff to leave the project site, which if untreated, could result in further degradation of water quality.

Appropriate objectives have been established with reference to existing water quality and NSW water quality objectives (see Table 17.1). These would be further refined based on the proposed water quality monitoring program (see section 17.6) to ensure they are based on all available water quality data. These would assist with working towards achieving the NSW water quality objectives. Further information on development of these criteria and objectives is provided in section 2.1.3 of Technical Paper 10.

Table 17.1 Project-specific water quality and river flow objectives

Parameter	Trigger value / objective
Water quality	
Chlorophyll-a (µg/L)	4
Total Phosphorous (TP) (µg/L)	30
Filterable Reactive Phosphorus (FRP) (µg/L)	5
Total Nitrogen (TN) (µg/L)	300
Oxides of nitrogen (NOx) (µg/L)	15
Ammonia (NH4) (µg/L)	15
Dissolved Oxygen (DO)	80%-110%
Turbidity (NTU)	0.5 to 10
pH	7 to 8.5
River flow	
Flow regimes	Minimise changes in river and groundwater flows

17.1.4 How potential impacts have been avoided or minimised

The approach to design development included a focus on avoiding and/or minimising the potential for impacts during key phases of the design process. As described in Chapter 5 (Alternatives and options) a project corridor and alignment options assessment process was undertaken to identify the preferred alignment. This process considered a range of factors, including potential impacts on flooding, water quality, the Parramatta River and other watercourses/wetland areas.

The design has been refined to avoid impacts where possible, including:

- maximising use of existing road reserves and disturbed areas
- minimising changes to surface levels that could substantially alter overland flows
- minimising depths of excavation to avoid and/or minimise interaction with groundwater
- selecting construction techniques that minimise interaction with contaminated soil and sediments.

17.2 Existing environment

17.2.1 Catchment and key watercourses

The Parramatta River catchment encompasses an area of about 252 square kilometres. The project is located within the upper Parramatta River section of the catchment (see Figure 17.1), which is controlled by a series of weirs that define the tidal boundary with the lower Parramatta River.

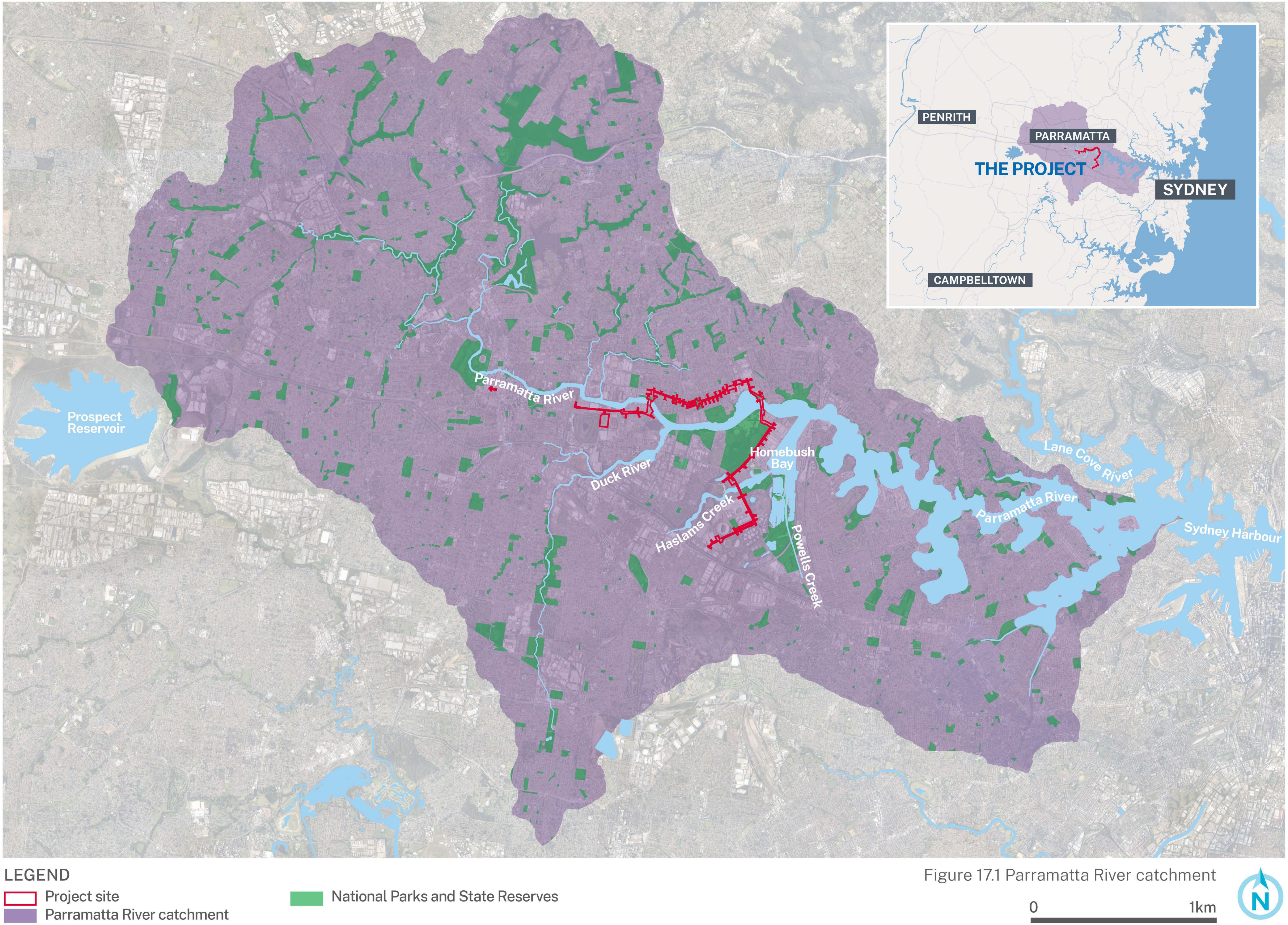


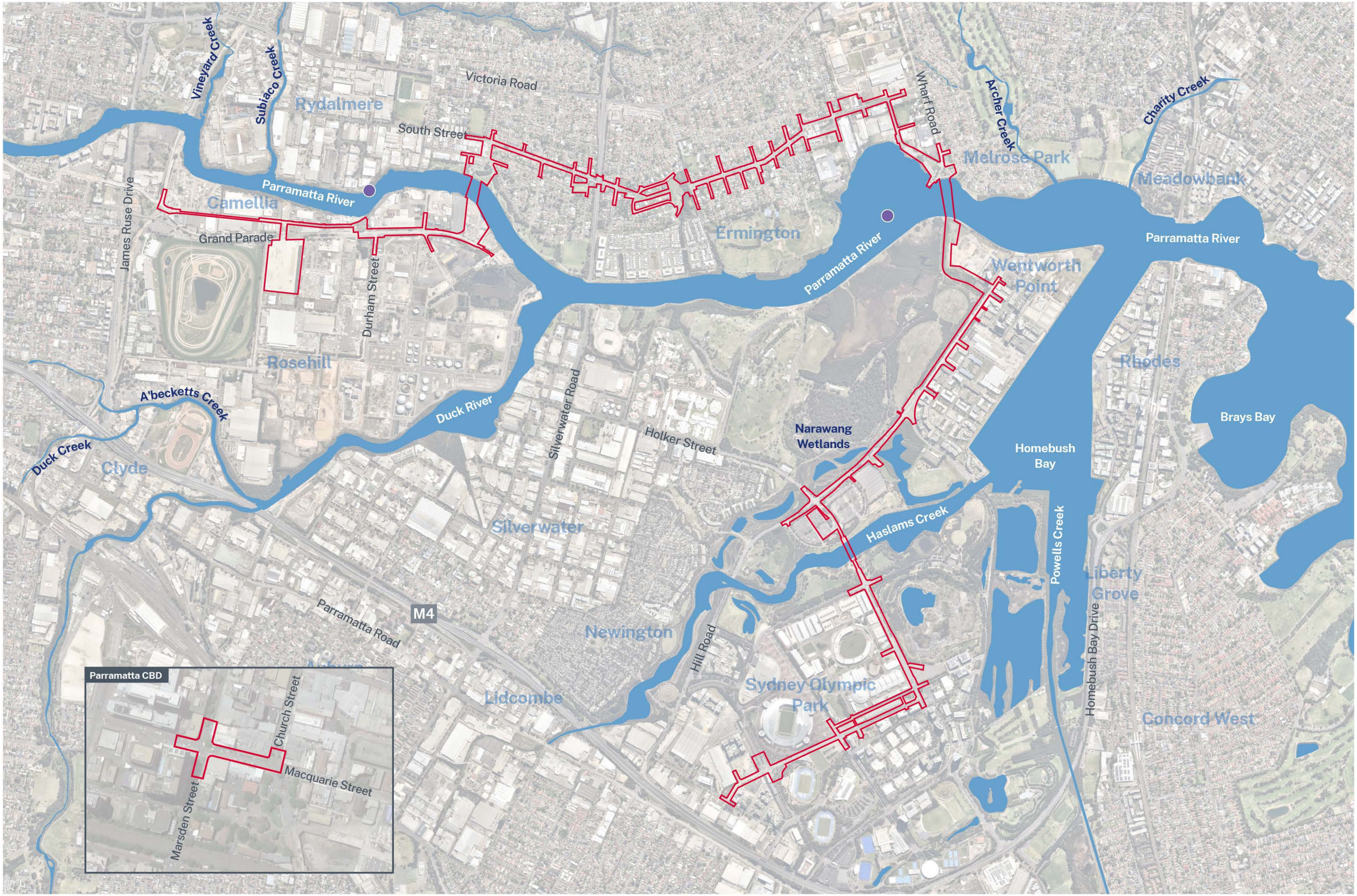
Figure 17.1 Parramatta River catchment

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

Watercourses within the study area are shown on Figure 17.2. Key watercourses with the potential to be affected by the project (as a result of their close proximity to the project site) are listed in Table 17.2.

Table 17.2 Key watercourses within the study area

Watercourse	Description	Relationship to the project site
Parramatta River	The headwaters of the Parramatta River (a large fourth order stream) are formed in the upper catchment by the confluence of Toongabbie Creek and Darling Mills Creek. Parramatta River is a major tributary of Sydney Harbour and is freshwater upstream of Charles Street weir (located adjacent to the Parramatta CBD) and saline downstream.	The project site crosses the Parramatta River in two locations via the proposed new bridges between Camellia and Rydalmere, and between Melrose Park and Wentworth Point.
Haslams Creek	Haslams Creek is a highly modified second order stream, which enters the Parramatta River at Homebush Bay. The creek's catchment is highly urbanised (including the M4 Motorway and Sydney Olympic Park). The upper extent of the creek is generally concrete lined open channels and pipes. Within the study area, the creek is estuarine, with wetland areas adjoining the creek within the Millennium Parklands (Sydney Olympic Park).	Haslams Creek is located close to the project site where it runs along Hill Road and the Holker Busway in Wentworth Point/Sydney Olympic Park. The project site crosses Haslams Creek via the existing bridge (to which works are proposed as part of the project) on the Holker Busway in Sydney Olympic Park.
Narawang Wetland	Narawang Wetland forms part of the constructed wetlands within the Millennium Parklands in Sydney Olympic Park (see Figure 2.5 and Figure 17.2). The wetland provides combined functions of flood mitigation, water storage and habitat for the Green and Golden Bell Frog and breeding waterbirds such as the Latham's Snipe. Narawang Wetland is connected to Nuwi Wetland via a floodway under Hill Road. Nuwi Wetland is open to Haslams Creek and is subject to tidal flushing. The floodway allows flood flows from Haslams Creek to enter Narawang Wetland.	The project site is located adjacent to Narawang Wetland where it runs along Hill Road. The project site crosses the floodway via the existing bridge (to which works are proposed as part of the project) on Hill Road.



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Project site

Watercourses

Existing City of Parramatta Council monitoring sites

Figure 17.2 Watercourses near the project site

0 1km

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17.2.2 Surface water quality

All watercourses within the study area are highly modified and subject to a number of historical issues and processes that influence water quality, including historical contamination, the presence of fill materials, and urban runoff.

Existing water quality

The Parramatta River and its banks (particularly adjacent to Camellia) are regarded as contaminated, with water and soil quality affected by a wide variety of chemicals and substances (see Chapter 18 (Soils and contamination)).

Water quality in the Parramatta River has been monitored at two locations (upstream and downstream of Duck River – refer Figure 17.2) by the City of Parramatta between 2012 and 2016. The available data is limited and indicates the following:

- pH and dissolved oxygen levels were below guideline values
- turbidity and chlorophyll-a median concentrations exceeded the guideline values.

These are common physical and chemical stressors that often occur in urban waterways and can cause degradation of aquatic ecosystems. These stressors, together with historical and current land uses, affect water quality. Further information on land contamination and historical land use is provided in Chapter 18 (Soils and contamination).

Between June 2019 and May 2020, water quality monitoring was undertaken in the Parramatta River, Clay Cliff Creek, Vineyard Creek, Subiaco Creek, Domain Creek and A'becketts Creek as part of the Parramatta Light Rail Stage 1 project. While these sites are located mostly upstream of the project, the data indicates pH, dissolved oxygen, turbidity, aluminium, copper, manganese and iron levels all above guideline values, during both wet and dry weather events.

There is limited data for other watercourses in the study area, with key available information indicating generally poor water quality in particular, elevated nutrients, turbidity and heavy metals.

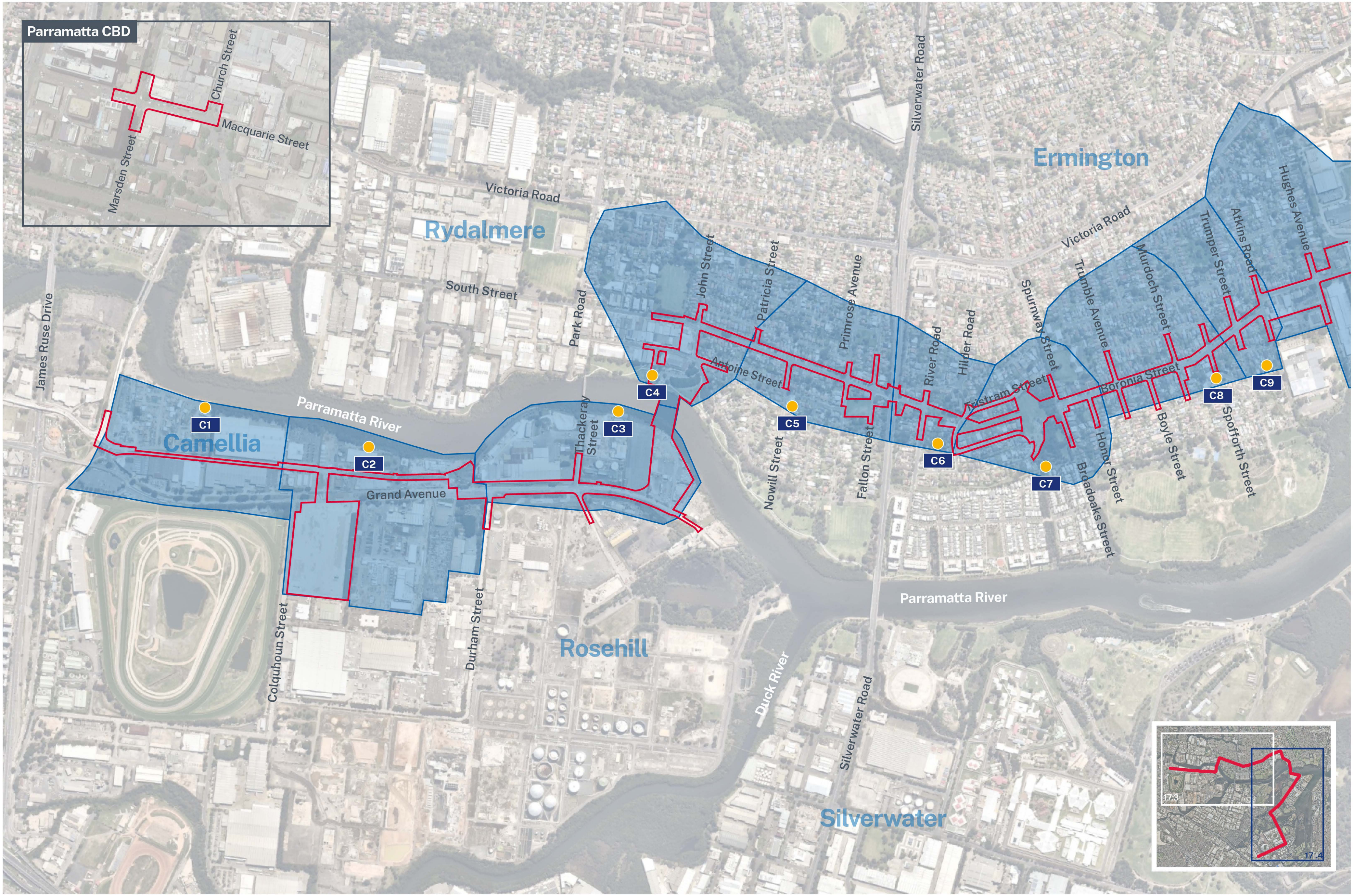
The water quality data confirms that project site is located in a highly urbanised environment that has been substantially altered from its natural state and water quality is typical of that for urban catchments in Sydney

Modelling results

For the purposes of characterising the existing quality of pollutant runoff a MUSIC model was developed, with 20 sub-catchments identified (see Figure 17.3 and Figure 17.4). The MUSIC model enables relative changes in total suspended solids (TSS), total nitrogen (TN) and total phosphorus (TP) to be understood. The modelling outputs show that water quality in most sub-catchments does not currently comply with the NSW water quality objectives for protection of aquatic ecosystems, with the following key findings:

- total phosphorous complies only in six sub-catchments (C1, C12 and C14 to C17)
- total nitrogen complies only in four sub-catchments (C14 to C17).

Further information on water quality monitoring results is provided in sections 4.1 and 4.9 of Technical Paper 10 (Hydrology, Flooding and Water Quality).



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Project site

Catchment areas

Discharge points

Figure 17.3 MUSIC model sub catchments – map 1

0 1km

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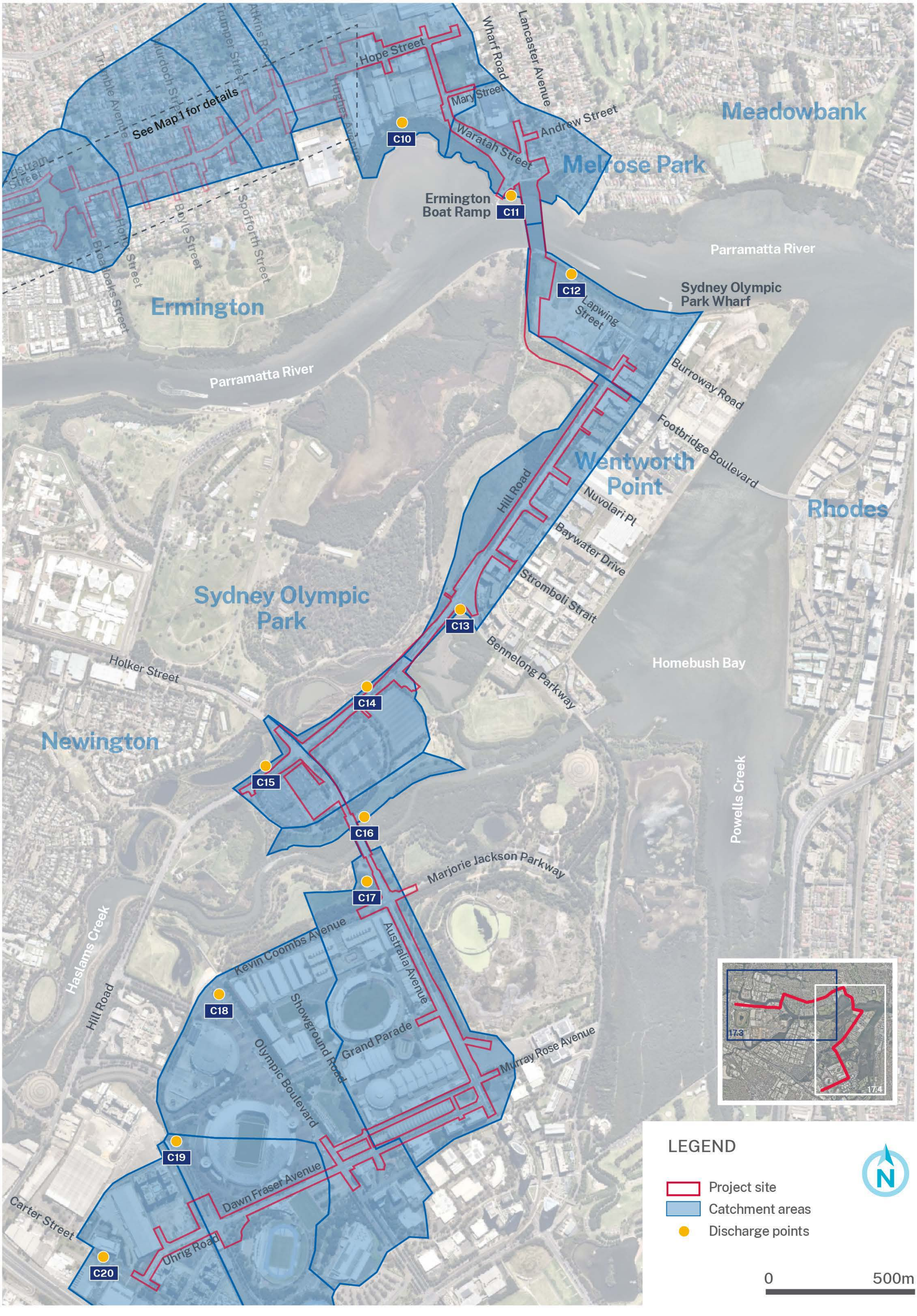


Figure 17.4 MUSIC model sub catchments – map 2

17.2.3 Groundwater

Groundwater aquifers and bores

The groundwater aquifers in the study area reflect the underlying geology (see Chapter 18 (Soils and contamination)). The aquifers are all unconfined and hydraulically interconnected (i.e. the water can freely move vertically and horizontally).

A search of the Bureau of Meteorology groundwater database identified that five licensed bores are located within two kilometres of the project site (see Figure 17.5). Two bores are located within/close to the project site:

- bore GW063660, which was licensed for mining exploration purposes, is located within the project site in Camellia
- bore GW107659, which is used for commercial and industrial water, is located in Camellia about 100 metres from the project site and 170 metres from the Parramatta River.

Groundwater bores within shales and sandstones indicate that the aquifers are typically low yielding aquifers (ie produce low volumes of water) and saline within the shales. Geotechnical investigations undertaken for the project indicate that groundwater levels in the study area range from 0.54 to 3.34 metres below ground level.

Groundwater quality

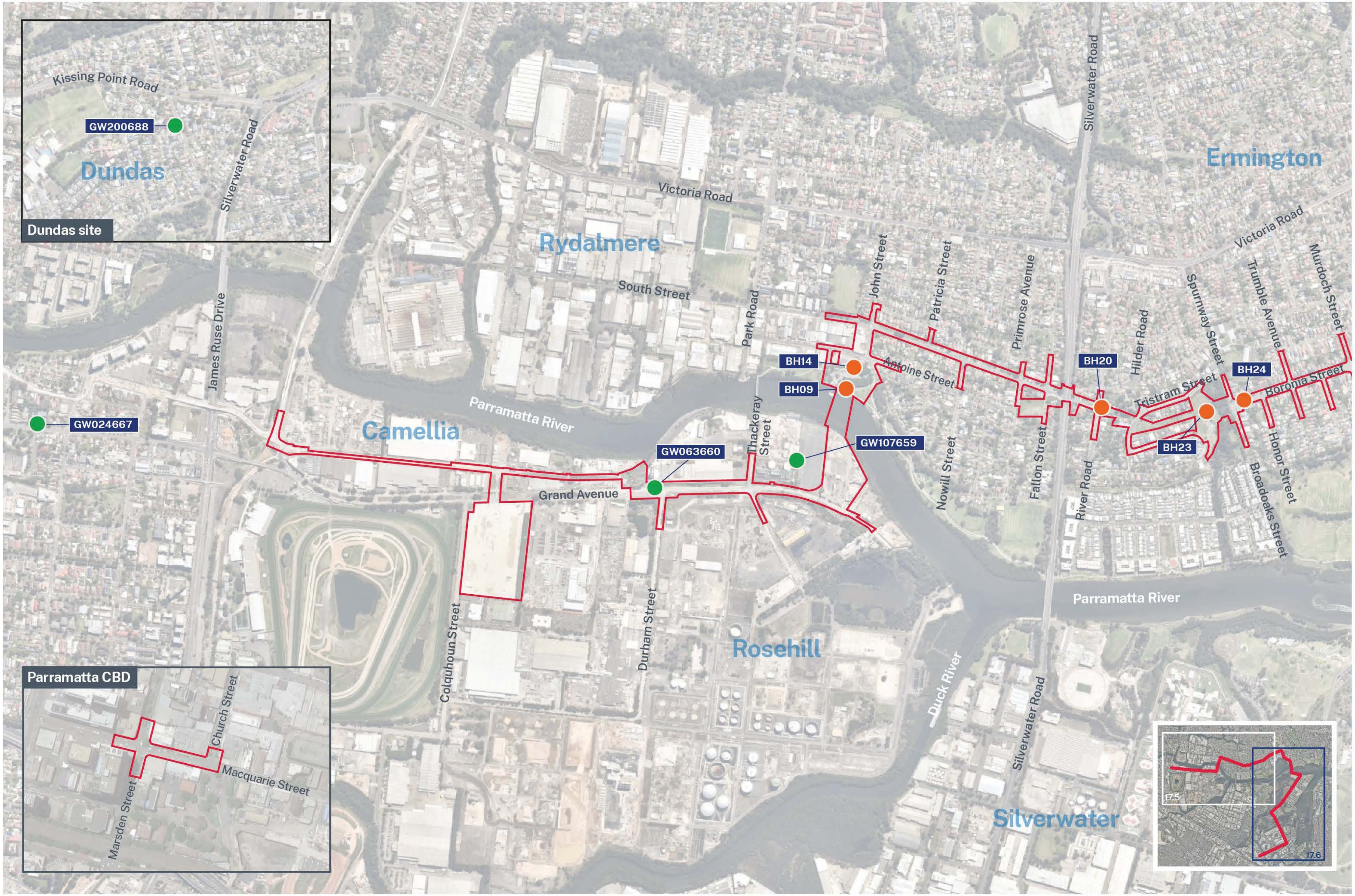
There is limited publicly available data on groundwater quality. Historical contamination investigations have identified a number of potential contaminants of concern (including hexavalent chromium, hydrocarbons and heavy metals) within parts of the study area associated with former and current land uses (see Chapter 18 (Soils and contamination)). Geotechnical investigation undertaken by Coffey Services Australia Pty Ltd ('Coffey') in 2019 for the project included installing and collecting samples from seven groundwater monitoring wells (BH09, BH14, BH20, BH23, BH37, BH41, BH44 (see Figure 17.5 and Figure 17.6)) to establish baseline groundwater quality. The results of this monitoring indicate that:

- copper, nickel and zinc are above guideline values but are considered to represent background concentrations rather than specific point sources of contamination
- total recoverable hydrocarbons, are marginally above laboratory reporting limits in two of the wells (BH20 and BH37. The source of the total recoverable hydrocarbons is unknown, however may be attributed to natural sources and/or localised contamination
- all other parameters were not detected above the laboratory reporting limit and/or the adopted assessment criteria in the groundwater samples collected as part of the Coffey investigation.

17.2.4 Sensitive receiving environments

A sensitive receiving environment is defined as one that has a high conservation or community value, or one that supports ecosystems or human uses of water. These environments are typically sensitive to pollution, degradation of water quality, and changes to natural processes. Sensitive receiving environments also include protected and sensitive lands as described in Chapter 16 (Biodiversity) and mapped on Figure 16.15 and Figure 16.16), and the Parramatta River coastal environment area (see section 17.2.6).

Further information about biodiversity values within these areas is provided in Chapter 16.



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Project site

Borehole

Groundwater monitoring well

Figure 17.5 Groundwater bores – map 1

0 1km

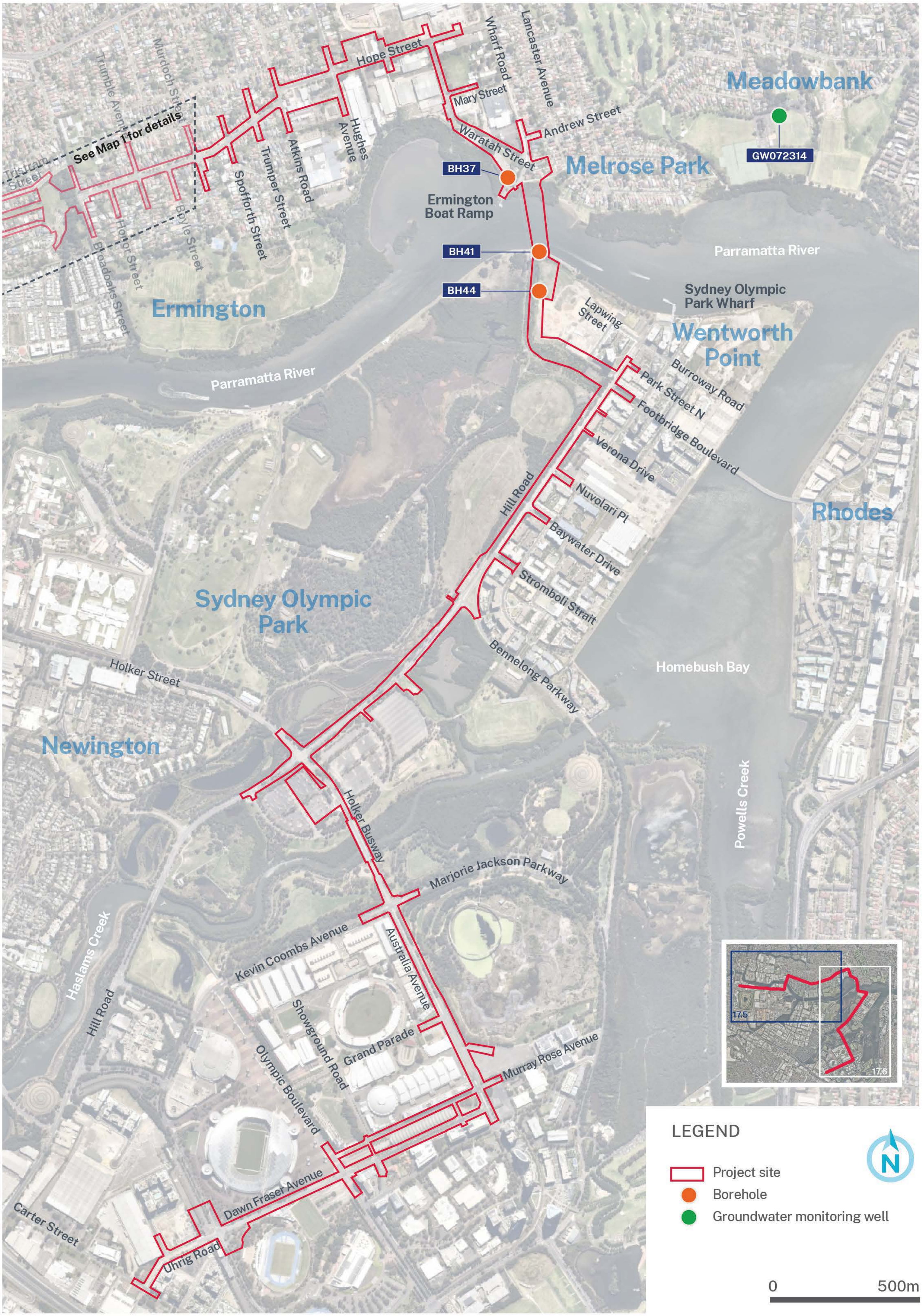


Figure 17.6 Groundwater bores – map 2

17.2.5 Flooding

Parts of the study area are subject to flooding from the Parramatta River and its tributaries, and overland flooding when rainfall exceeds the capacity of the local stormwater drainage system.

Modelling for large regional flood events is documented in the *Lower Parramatta River Floodplain Risk Management Study* (SKM, 2005) with key results summarised in Table 17.3 for the proposed new bridge locations over the Parramatta River.

Table 17.3 Regional flood events

	Bridge between Camellia and Rydalmere		Bridge between Melrose Park and Wentworth Point	
Event	**Flood level (metres Australian Height Datum (mAHD))**	**Velocity (metres per second (m/s))**	**Flood level (mAHD)**	**Velocity (m/s)**
One per cent AEP	3.6	1.6	1.42	2
PMF	6	2.5	2.79	2.9

The key findings of the updated modelling of existing flooding conditions for the study area indicate that:

- The flooded extent of the Parramatta River floodplain is largely limited to the river and open spaces up to the one per cent AEP event. In larger events there is further inundation of properties beyond the limits of open space, and large portions of Camellia becomes inundated.
- Camellia, Rydalmere to Melrose Park and around Hill Road experience overland flows in the five per cent and one per cent AEP events, and ponding in local road low points. Generally, the flood hazard is low, being safe for pedestrians and vehicles, with the exception of locations along Hill Road that may reach an unsafe level of hazard (unsafe for vehicles, children and the elderly) and some local low points and open spaces on the banks of Parramatta River.
- In the PMF event Camellia and Hill Road are inundated and unsafe for people and vehicles. Local roads through Rydalmere to Melrose Park and Sydney Olympic Park, south of Hill Road, experience overland flows and ponding at road low points, but otherwise are safe for people and vehicles.

Detailed flood mapping is provided in Appendix 1 of Technical Paper 10 (Hydrology, Flooding and Water Quality).

17.2.6 Parramatta River – coastal hazards and processes

Coastal management context and relevance to the Parramatta River and study area

The objectives of the Coastal Management Act are to manage the coastal environment of the state in a manner consistent with the principles of ecologically sustainable development. The Act defines the coastal zone as land comprised of the following 'coastal management' areas:

- coastal wetlands and littoral rainforests area – land that displays the hydrological and floristic characteristics of coastal wetlands or littoral rainforests and land adjoining those features
- coastal vulnerability area – land subject to coastal hazards, such as erosion and tidal inundation
- coastal environment area – lands with natural coastal features, such as beaches, rock platforms, coastal lakes and lagoons, undeveloped headlands, and marine and estuarine waters
- coastal use area – land adjacent to coastal waters, estuaries and coastal lakes and lagoons, and where development may be carried out.

The Resilience and Hazards SEPP provides mapping for coastal wetlands, littoral rainforests, coastal environment and coastal use areas. No mapping of coastal vulnerability areas has been undertaken to date.

Within the study area, the Parramatta River is located within the mapped coastal environment area and contains coastal wetland areas defined by the Resilience and Hazards SEPP. There are no mapped littoral rainforest areas or coastal use areas in the study area.

The SEARs require the project to consider potential impacts associated with coastal hazards and processes. This would normally require consideration of lands mapped within the coastal vulnerability area. However, in the absence of this mapping, the assessment has taken a conservative approach and considered potential coastal hazards and processes that exist within the Parramatta River for the coastal environment area (defined as the Parramatta River and foreshore areas) and coastal wetlands (see Figure 16.15 and Figure 16.16).

Since 2013, coastal hazards and risks within the Parramatta River have been managed in accordance with the *Parramatta River Estuary Coastal Zone Management Plan* (Cardno, 2013), which was made under the former *Coastal Protection Act 1979*. A new coastal management plan for the Greater Sydney Harbour, including the Parramatta River, is currently being developed in accordance with the requirements of the Coastal Management Act. The current status of the plan is documented in the *Greater Sydney Harbour Coastal Management Program Scoping Study* (BMT, 2018).

Issues, objectives and actions relevant to coastal processes in the study area have been considered based on both these plans. The key relevant risk mitigation strategies identified in the plans include:

- improving water quality
- management of foreshore development
- protection and reinstatement of riparian vegetation
- removal of seawalls where feasible and upgrade to seawalls to be retained.

The plans also defined recommended works.

Coastal processes

The main physical processes that have determined the shape of the Parramatta River near the project site are generally limited to hydrodynamic processes and bank condition.

Key hydrodynamic processes in the Parramatta River estuary include ocean tides (tidal flushing), freshwater inflows (in particular during periods of heavy rainfall), and wind and wave driven flows. These hydrodynamic processes are also influenced by the estuary's bathymetry (bed form of the estuary). Maintenance of tidal inundation is an important factor for the function of intertidal habitats and associated flora and fauna along the river. Estuarine water levels may also become elevated beyond the typical tidal range due to factors, such as king tides, storm surge and freshwater flood flows. At such times, the elevated water levels can present a hazard to human users and assets along the foreshore. Some coastal hazards will be exacerbated by climate change, particularly extreme estuarine water levels, which will result in an increase in risk for natural areas, foreshore users and assets over time.

Bank erosion in the upper areas of the Parramatta River is attributed to vessel wash, wind induced waves, high river flow after rainfall, and the loss of riparian vegetation. Seawalls have been constructed extensively along the shoreline to protect foreshore assets, guard against inundation, and support reclaimed parklands. Despite extensive urbanisation along the banks of the Parramatta River, areas of undeveloped foreshore remain.

Coastal hazards and risks

The key coastal hazards identified by the coastal management plans are tidal and wave inundation, flooding, shoreline erosion and sea level rise. With predicted sea level rises, tidal inundation will threaten to inundate foreshore areas and increase the risk of bank erosion unless further protection works are undertaken.

Existing conditions in the project site

With the exception of the two proposed bridges over the Parramatta River, most of the project would have no interaction with coastal hazards and processes. A description of the conditions at the two proposed bridge locations is provided below.

Bridge between Camellia and Rydalmere

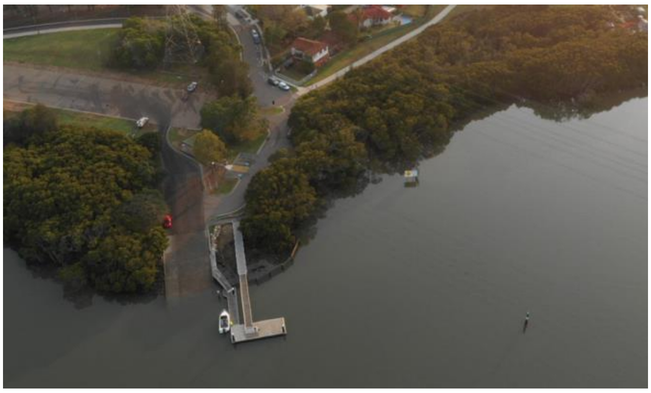
A low seawall has been constructed on the northern bank of the river and mangroves have recolonised at the base of the seawall (see Figure 17.7). The southern bank is vegetated by mangroves. It was identified by the *Parramatta River Estuary Coastal Zone Management Plan* as being in a failed condition, most likely due to erosion caused by boats. A review of aerial photographs in 2009 and 2021 indicates that generally the river banks have not significantly changed. At this location the river is about 3.5 metres deep at its deepest point, with the main channel being towards the northern side.

Figure 17.7 View of the northern river bank in the vicinity of the proposed location for the bridge between Camellia and Rydalmere

Bridge between Melrose Park and Wentworth Point

The northern bank of the river mostly remains a natural foreshore vegetated with mangroves, with the exception of the Ermington Boat Ramp and a timber structure to stabilise the adjacent river bank (see Figure 17.8). The *Parramatta River Estuary Coastal Zone Management Plan* identified the northern river bank as being in a failed condition, most likely due to erosion caused by boats.

The southern river bank is comprised of a seawall with a small area of mangroves (see Figure 17.8). A review of aerial photographs in 2009 and 2021 indicates that generally the river banks have not significantly changed. At this location the river is about 5.5 metres deep at its deepest point, with the main channel being centrally located in the river.


Northern bank at Melrose Park


Southern bank at Wentworth Point

Figure 17.8 View of the river banks in the vicinity of the proposed location for the bridge between Melrose Park and Wentworth Point

17.3 Assessment of construction impacts

17.3.1 Surface water quality

Potential water quality impacts

Construction activities may present a risk to water quality in receiving watercourses/waterbodies if mitigation and management measures are not effectively implemented. Potential sources of water quality impacts include:

- increased sediment loads from exposed soil transported off site during rainfall events and from discharge of sediment-laden water
- increased levels of nutrients, metals and other pollutants from construction near waterways and stormwater drains, transported in sediments to downstream watercourses or via discharge of wastewater to watercourses
- contamination of watercourses due to runoff from contaminated land and disturbance of sediments in the bed and banks of the Parramatta River during construction of the bridges
- exposure of actual or potential acid sulfate soils, which may generate acidic runoff
- increased alkalinity and pH of downstream watercourses due to runoff from concrete activities (concrete dust, slurry or washout water)
- spills or leaks from construction machinery (including chemicals, oils, grease, and petroleum hydrocarbons) and gross pollutants such as litter polluting downstream watercourses
- contaminated groundwater discharged into receiving watercourses.

The downstream effects of water quality impacts include:

- reduced hydraulic capacity of the watercourse or drainage system
- increased potential for bioaccumulation of heavy metals in aquatic species
- reduced dissolved oxygen levels that could impact aquatic species
- increased sedimentation smothering aquatic life and affecting aquatic ecosystems
- increased turbidity levels affecting aquatic species and the aesthetics of the water for recreational activities
- changes to water temperature due to reduced light penetration.

The likelihood and magnitude of impact would vary depending on the stage of construction, the area of disturbance and occurrence of high rainfall or wind weather events. Key potential impacts from construction activities are considered below.

Earthworks, stockpiling and general runoff from construction sites

Excavations, embankment construction and general construction activities that result in ground disturbance, in particular close to watercourses or drainage systems and on steeper slopes, could result in water quality impacts through erosion and sedimentation. Runoff from stockpiles has the potential to impact downstream water quality during rainfall if the stockpiles are not managed appropriately. Sediments from the stockpiles could wash into watercourses, increasing levels of turbidity and resulting in transport of contaminants and impacts generally as described above.

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.

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

Gross pollutants (such as litter) from construction areas and accidental spills or leaks (including chemicals, oils, grease, and petroleum hydrocarbons) could occur from the use, maintenance or re-fuelling of construction plant and equipment at construction sites. Removing buildings and structures also has the potential to mobilise contaminants such as asbestos (if present) and other gross pollutants. These can affect general water quality including through accumulation of material in watercourses and changes in chemical composition of receiving waters. In addition, these pollutants can be ingested by aquatic fauna and result in dead or sick marine life.

Although the project has the potential to temporarily reduce water quality from pollutants and runoff, it would not be expected to cause significant impacts on the overall condition of surrounding watercourses or any long-term water quality impacts. As described in Chapter 7 (Project description – construction) sedimentation basins and soil, water and groundwater treatment facilities would be provided as required. The measures provided in section 17.6 would be implemented to minimise the potential for water quality impacts as a result of earthworks, stockpiling and general runoff from construction sites.

Bridge works

Bridge construction activities have the potential to affect water quality and sensitive receiving environments at the Parramatta River, Haslams Creek and Narawang Wetland.

The works would involve riparian vegetation clearing and topsoil stripping. Exposure and disturbance of soils, some of which are contaminated, in these areas would increase the risk of sediment erosion and transport into the adjacent watercourses.

Bridge construction activities, such as piling within the Parramatta River, would disturb sediments (some of which are contaminated) resulting in potential for mobilisation into the water. As described in section 7.3.2 it is proposed to construct the piers from barges in deeper water and from temporary working platforms in shallower water. Construction of the temporary working platforms would also require temporary piers. Pier construction would use driven piles and coffer dams (or similar) within an area protected by silt curtains, to provide a dry working environment and minimise risk of mobilisation of contaminated sediments. The temporary working platforms would extend into the river to a depth of approximately two metres at low tide. This would result in a localised instream barriers causing water to flow under and around the working platforms. During further design development modelling would be undertaken to minimise the risk of erosion to nearby river banks.

Appropriate construction controls would also be implemented in relation to the bridge works at Hill Road and Holker Busway to minimise the potential for impacts to Haslams Creek and Narawang Wetland.

The potential for water quality impacts would be managed by implementing the measures described in section 17.6.

Concrete pours would be required for bridge construction and potential impacts would be managed as described below.

Concrete activities

Concrete construction could result in the discharge of concrete dust, concrete slurries or washout water to watercourses. This could potentially increase the pH of watercourses, which can be harmful to aquatic life. Concrete solids also have the potential to cause increased turbidity. Concrete would be delivered to work areas as needed and poured on site for elements such as light rail track slabs and bridge decks. Appropriate controls would be implemented in accordance with the soil and water management plan that would be prepared as part of the CEMP (see section 17.6) to prevent concrete spillage from entering watercourses.

Changes to surface water flows

The project has the potential to alter surface water flows. This could affect water quality by increasing flow rates and/or volume resulting in erosion and turbidity. The potential impacts of changes to surface water flows are considered in section 17.3.3.

Disturbance of acid sulfate soils, saline soils and contaminated land and groundwater

As described in Chapter 18 (Soils and contamination), excavation would be required in potentially contaminated soil and groundwater as well as areas containing potential or actual acid sulfate soils and saline soils. Surface water runoff may also come into contact with contaminated materials within the project site. Potential disturbance of contaminated soils and groundwater could result in the mobilisation of pollutants by stormwater runoff and subsequent transportation to downstream watercourses, potentially increasing contaminant concentrations in the receiving environment.

Construction activities such as excavation and clearing pose a risk to water quality when the activity is carried out in areas of actual or potential acid sulfate soils. Disturbance and exposure of acid sulfate soils to oxygen during construction activities could generate sulphuric acid and toxic quantities of aluminium and other heavy metals that could be readily released into the surrounding watercourses.

With the implementation of the measures described in section 18.6.2, including an acid sulfate soil management plan and a remediation action plan, no significant impacts are expected. Further discussion regarding management of groundwater quality is provided in section 17.3.2.

Runoff from exposed saline soils can dissolve and mobilise salts and cause their accumulation in other areas. Excessive concentrations of salt in such areas can affect plant growth, soil chemistry and cause weakening and degradation of construction materials such as concrete and steel. The potential for impacts due to the presence of saline soils is considered low. Any potential impacts would be temporary and managed by implementing standard erosion and sediment control measures.

Maintaining or achieving the water quality objectives

The area occupied by the project site constitutes only a small component of the Parramatta River catchment. Progress towards meeting the water quality objectives depends on activities in the catchment as a whole. As described in section 17.2.2, watercourses in the study area are highly degraded and currently do not meet the water quality objectives.

Water quality impacts would generally be limited to the construction phase. Construction would be undertaken in accordance with the measures provided in section 17.6, which would minimise the potential for the project to reduce the quality of water in receiving watercourses. Additionally, sedimentation basins and soil, water and groundwater treatment facilities would be provided at some construction compounds as described in Chapter 7 (Project description – construction). These would further minimise the potential for a reduction in water quality in surrounding watercourses. Discharge from the project site, where required, would be undertaken in accordance with the environment protection licence for the project, the *Water Discharge and Reuse Guideline* DMS-SD-024 (Transport for NSW, 2019c), project specific objectives and the monitoring program outlined in section 17.6.1. This means any discharged water would meet the water quality objectives provided in section 17.1.3 and would be of better quality than that within the surrounding watercourses. It is considered unlikely that the project would have a material effect on the achievement of the NSW water quality objectives for the Parramatta River catchment.

17.3.2 Groundwater

Groundwater levels, flow and connectivity

Most excavation work is unlikely to intercept groundwater. However, during periods of high rainfall, there is potential for elevated groundwater levels to seep into some excavations, in particular where they are located close to the Parramatta River and Haslams Creek. Raised groundwater levels may require dewatering in some cases. This potential impact would be localised and temporary.

A cutting about three metres deep and 140 metres long would be required at Boronia Street in Ermington. Based on observed groundwater levels the lower part of this cutting could intercept groundwater. Analytical modelling predicts that groundwater inflows could range between 340 and 1,350 litres per day depending on rainfall. It is predicted that an area of groundwater drawdown of about 40 to 60 metres on each side of the cutting would occur. This is not predicted to result in any noticeable changes to groundwater levels, flow or connectivity. In addition, there are no registered groundwater bores or users near the cutting.

If dewatering is required the groundwater quality would be assessed to determine compliance with the environment protection licence for the project, prior to discharge. Any discharges of groundwater would be undertaken in accordance with Transport for NSW *Water Discharge and Reuse Guideline* DMS-SD-024 (2019c),project specific objectives, and, if applicable, the environment protection licence for the project or a Trade Waste Agreement.

One method for managing extracted groundwater would be to discharge it to the stormwater drainage network or nearby watercourses. This could affect surface water quality if the groundwater being discharged is not of suitable quality. As described in Chapter 18 (Soils and contamination), shallow groundwater near the Parramatta River has the potential to be contaminated with a number of contaminants including petroleum hydrocarbons and hexavalent chromium. If dewatering activities are not appropriately managed, discharges of groundwater have the potential to affect surrounding receiving environments (including surface water quality). A dewatering management strategy would be developed to minimise the need to dewater and confirm the appropriate management of extracted groundwater (see section 17.6). The dewatering management strategy would include options to treat and dispose of contaminated groundwater encountered during works within the locations of the engineered landfills in Sydney Olympic Park. Groundwater that has come into contact with waste material in the locations of the landfills is considered to be leachate. Further information regarding the potential to encounter contaminated groundwater, including leachate, is provided in Chapter 18 (Soils and contamination).

Implementing these measures would minimise the potential for impacts on surface water quality and ensure that extracted groundwater is treated to a level that, at a minimum, is consistent with the existing water quality of nearby watercourses and their dependent ecosystems.

Groundwater quality

Potential risks to groundwater quality include:

- contamination by hydrocarbons from accidental fuel and chemical spills
- disturbance of acid sulfate soils and contaminated land and groundwater
- 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 runoff, 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 17.6 would be implemented to minimise the potential for groundwater quality impacts due to contamination from leaks and spills, and runoff.

While groundwater would be captured during groundwater dewatering, any oxidised sediments would potentially continue to generate low pH groundwater that could discharge to surface water environments. This would significantly lower the beneficial use potential (environmental values) of these waterways on a short-term basis. With the implementation of controls and mitigation measures detailed in section 18.6.2, including an acid sulfate soil management plan and a remediation action plan, no significant impacts are expected. Further information on acid sulfate soils and contamination and how they would be managed is provided in Chapter 18 (Soils and contamination).

Groundwater users/groundwater bores

The project would have the following impacts on groundwater bores located within/close to the project site (as described in section 17.2.3):

- Bore GW063660 may need to be decommissioned in consultation with the owner. The bore is not used for water supply purposes. Its exact location would be confirmed during further design development. If the area in which the bore is located could be avoided during construction, then it could be retained.
- The area of drawdown surrounding the bore GW107659 may extend below the project site. Mitigation measures would be implemented to minimise the risk of water quality or other direct impacts to the bore (see section 17.6).

Groundwater dependent ecosystems

Construction would be undertaken close to areas mapped as groundwater dependent ecosystems (see section 17.2.2). As construction would not involve any deep excavations close to groundwater dependent ecosystems there are no predicted groundwater drawdown impacts. However, other potential impacts such as groundwater quality and changes to groundwater flow could affect groundwater dependent ecosystems that are close to the project site.

The project site passes through or immediately near to mapped groundwater dependent ecosystem at Melrose Park (at the northern bank of the Parramatta River) and Sydney Olympic Park (various wetland areas and Haslams Creek). The majority of construction activities at these locations would be located above the water table and would not affect groundwater flows through drawdown or compaction effects. Minor interaction with the water table could be required for shallow excavations and bridge piling however, these would not affect overall groundwater conditions. In addition, the project would not take water from or directly discharge to the underlying groundwater. Potential risks to these groundwater dependent ecosystems due to groundwater quality would be managed as described above and are not expected to be significant.

17.3.3 Hydrology and flooding

Hydrology

Potential surface hydrology impacts include changes to runoff volumes and localised redirection of overland flows. Obstruction of flow paths due to the presence of construction works and equipment has the potential to redistribute flood flows, impact downstream properties, and/or mobilise construction equipment or debris. This may result in downstream safety or water quality impacts.

Changes in runoff volumes are anticipated to be minor, including temporary reductions in runoff volumes where pavements are removed and infiltration to the soil is increased, and temporary increases in runoff volumes in the case of working platforms (such as compounds) comprised of a hardstand pavement.

Construction would not involve the extraction of water from surface water sources nor would it affect any natural processes.

Section 17.3.4 describes potential changes to hydrological processes in the Parramatta River.

Flooding

Construction compounds and activities have the potential to change overland flow patterns and exacerbate flooding by affecting areas of flood conveyance and storage, potentially changing levels of inundation upstream. Potential flooding impacts include:

- localised changes to flood behaviour because of changes to flow paths and installation of compounds, temporary buildings and other structures (such as temporary working platforms) within the floodplain or waterway area
- mobilisation of pollutants and construction materials from compounds and other work sites in the event of a flood event inundating these areas.

Some construction compounds would be located in areas subject to flooding, and appropriate protection measures such as bunding may be required. This could cause changes to localised flooding behaviour, resulting in inundation of surrounding properties in some cases. The location and layout of construction work sites and compounds would be prepared with consideration of overland flow paths, avoiding flood liable land and minimising changes to flow paths where practicable to minimise impacts. While the findings of the initial assessment provide an indication of the potential impacts of construction activities on flood behaviour, further assessment would be carried out during further design development, as layouts and construction staging strategies are developed.

The temporary working platforms and coffer dams (or similar) required to construct the bridges over the Parramatta River would partially obstruct the river and have the potential to result in short term minor changes in flood behaviour. The temporary working platforms would extend into the river to a depth of about two metres at low tide. This would result in a localised instream barrier causing water to flow under and around the working platforms. During further design development modelling would be undertaken, and appropriate adjustments made, to ensure this would not result in any additional flooding to nearby areas. The coffer dams would be limited to bridge pier locations and as such, there would still be substantial waterway area to maintain tidal flow regimes.

During periods of high flood flows the Parramatta River conveys a substantial amount of water. Under these conditions water levels in the river would flow over the temporary working platforms and coffer dams. Impacts to flow velocities from these temporary structures are likely to be minor and localised. Bridge construction activities would be planned to minimise waterway obstructions from a navigation perspective (see Chapter 9 (Transport and traffic)). A construction flood emergency response plan would be prepared setting out measures aimed at mitigating risks in the event of a flood occurring during construction (see section 17.6.2).

Due to the temporary nature of construction, and the small size of construction areas relative to the Parramatta River catchment, minimal impacts to flood hazard, hydraulic function or community emergency management arrangements are expected. As a result, construction would be consistent with the *Lower Parramatta River Floodplain Risk Management Study* (SKM, 2005). Where new temporary drainage is required appropriate erosion and sedimentation controls would be implemented in accordance with the CEMP's soil and water management plan.

Social and economic costs

Although there would be temporary changes during construction, including establishment of site compounds and various construction works, there is not expected to be a material change in flooding behaviour compared with existing conditions. Given the relatively short duration of construction, no social or economic costs to the community are expected as a result of potential flooding impacts.

17.3.4 Parramatta River impacts – coastal hazards and processes

The main potential impacts to coastal hazards and processes at the Parramatta River are associated with construction of the proposed new bridges over the river. These potential impacts are discussed further below.

Water quality impacts would generally be limited to the construction phase and would be short-term only. Construction would be undertaken in accordance with the management measures provided in section 17.6, which would minimise the potential for the project to reduce the quality of water in sensitive areas such as coastal wetlands.

During bridge construction there would be changes to the river banks associated with temporary working platforms and bridge abutments. This would require some clearing of vegetation, potentially exposing the river banks to localised foreshore erosion and destabilisation. With the implementation of appropriate erosion and sedimentation controls these impacts are expected to be minimal. The seawalls at the proposed bridge locations would remain in place and not be modified.

The project would use a combination of temporary working platforms and barges to construct the bridges (see Chapter 7 (Project description – construction)). As described in section 17.3.3, the temporary working platforms would partially obstruct the waterway and result in short term minor changes in hydrodynamic processes such as tides (tidal flushing), freshwater inflows (in particular during periods of heavy rainfall), and wind and wave driven flows. This could result in localised erosion and scour of the river bank as water flows under and around the working platforms in particular, during flood flows. During further design development modelling would be undertaken to minimise the risk of further river bank destabilisation. The temporary construction barges would be used in deeper water and would have minimal to no impact as the water can readily flow around and under the barges. There are potential impacts from barge anchorage such as sediment disturbance and riverbed alteration; however, they are expected to be negligible.

At bridge pier locations silt curtains and coffer dams (or similar) would be used to minimise the risk of mobilisation of sediments that could affect water quality. As the coffer dams would be limited to bridge pier locations there would still be substantial waterway area to maintain flow regimes.

During construction there would be temporary restrictions on public use of some foreshore areas; however, these would be limited as far as practicable and alternative access arrangements provided. Further information about potential access impacts is provided in Chapter 9 (Transport and traffic).

Overall, the construction impacts are predicted to be minor and not cause significant impacts to natural processes or significantly alter hazards within/surrounding the Parramatta River. A soil and water management plan would be developed and implemented prior to construction (see section 17.6). Following completion of construction, disturbed areas would be stabilised and rehabilitated in accordance with the rehabilitation strategy (see Chapter 18 (Soils and contamination)).

17.4 Assessment of operation impacts

17.4.1 Surface water quality

During operation, light rail vehicles would produce minimal pollutants and chemicals. Small amounts of metals, oils and particulates may be generated such as during braking. Increases in impervious surfaces could result in the build-up of contaminants in dry weather, which during rainfall events, could be transported to surrounding watercourses as stormwater. The main pollutants relating to surface runoff include:

- sediments from the impervious surfaces from atmospheric deposition
- small amounts of heavy metals attached to particles washed off the impervious surfaces
- small amounts of oil and grease and other hydrocarbon products
- gross pollutants such as litter
- nutrients such as nitrogen and phosphorus (organic compounds) from biological matter and from natural atmospheric deposition of fine soil particles.

The emphasis in stormwater quality management for surface runoff includes managing the export of suspended solids and associated contaminants such as heavy metals, nutrients, hydrocarbons and organic compounds. Pollutants such as nutrients, heavy metals and hydrocarbons are usually attached to fine sediments. As a result, trapping suspended solids is the primary focus of the water quality management strategy during operation.

Modelling has been undertaken to predict reduction rates for key pollutants (gross pollutants, total suspended solids, total phosphorous and total nitrogen) that may be achieved with the implementation of potential water quality treatment measures as detailed in section 6.2.1 of Technical Paper 10. A rainfall event equivalent to the first flush (3-month storm) was used to determine which water quality treatment measures would be required. The first flush is the initial surface runoff from a rainfall event and generally has the highest pollutant generation. These measures are indicative and would be further refined during design development. The modelling predicts that by implementing these potential measures the project can contribute to working towards achieving the NSW water quality objectives. In addition, they would provide for the protection of nearby sensitive receiving environments and minimise impacts to natural processes.

17.4.2 Groundwater

During the operational stage the nominal seepage into the Boronia Street cutting (see section 17.3.2) would be the only groundwater seepage requiring dewatering. It is estimated that the quantities would be less than three megalitres per annum, and no water licence would be required. Given the nominal seepage, minimal impacts to groundwater works, riparian areas or wetlands are expected.

There is not anticipated to be any ongoing risk to groundwater quality, groundwater users or groundwater dependent ecosystems once the project is operational.

17.4.3 Hydrology and flooding

Hydrology

Most of the project is located within existing road reserves and involves minimal changes to surface levels. As such, changes to surface hydrology would be relatively minor. At the approaches to the two new bridges over the Parramatta River, and where the project crosses Ken Newman Park, there would be localised increases in impervious surfaces. The project would include new and upgraded drainage infrastructure to cater for the predicted stormwater volumes.

As a result of the variability of existing drainage infrastructure, the design standards that would apply to new and upgraded infrastructure also vary, as described in section 5.1 of Technical Paper 10. In some cases these would be constructed to a higher standard than the existing infrastructure and would assist with alleviating existing drainage issues.

Operation would not involve the extraction of any water from surface water sources nor would it affect any natural processes.

Flooding

During operation, potential flooding impacts have been assessed in relation to:

- localised changes in overland flow paths and volumes due to increased impervious surfaces and local changes in surface levels
- changes to peak flood levels of the Parramatta River due to new bridges.

Detailed mapping of changes in flooding conditions for the five per cent AEP and one per cent AEP flood events (with and without climate change) is provided in Appendix 1 of Technical Paper 10.

Local design surface impacts

Many locations within the project site are subject to flooding caused by stormwater exceeding the capacity of local drainage networks. The proposed upgrades and changes to stormwater drainage systems would generally increase the capacity of the local stormwater system and reduce potential impacts to properties during flood events. Some discrete areas may experience increases in flooding greater than the flood management objectives where overland flows are affected. These typically occur in areas of existing ponding, including localised overland flow paths in:

- Grand Avenue in Camellia, affecting commercial properties
- John Street and South Street in Rydalmere, affecting commercial and residential properties
- Hope Street and Hughes Avenue in Melrose Park, affecting residential properties
- Ken Newman Park, affecting public land
- Hilder Road in Ermington, affecting residential properties
- localised increases upstream of the proposed duplication of Hill Road bridge in Wentworth Point
- roads in Sydney Olympic Park – Dawn Fraser Avenue, Australia Avenue and Hill Road.

There are minimal changes to flow velocities due to the project.

The project's stormwater drainage system would be designed to meet the operational requirements of the project and to avoid or minimise, as part of suite of potential mitigation solutions, the risk of, and adverse impacts from, flooding. Most of the drainage infrastructure would discharge to existing systems, which in some cases have a lower capacity.

During ongoing design development additional stormwater drainage capacity or alternate arrangements would be considered to further reduce the potential for impacts.

Bridge structure impacts

The proposed bridges over the Parramatta River are predicted to result in minor increases in upstream flood levels of up to 50 millimetres in the one per cent AEP event at properties that are already impacted by flooding under existing conditions (based on the current design). These properties are located close to the river at Camellia and Wentworth Point. Similar increased flood levels are also predicted within Newington Nature Reserve. These impacts are mostly due to the pile cap structures. During ongoing design development bridge designs would be further refined to minimise these potential impacts.

In-stream structures (such as bridge piers) may promote channel scouring resulting in further erosion. Channel migration may change the position of the low flow path and localised changes to the bed and instream habitat may occur. Changes in river flow velocities due to the bridges, in particular the bridge piers, are minor and localised, with no significant changes to flow predicted. Appropriate erosion and scour protection measures would be provided at the bridges, with details to be finalised during ongoing design development.

The predicted minor changes would not significantly impact the NSW river flow objectives or any sensitive receiving environments.

Consistency with floodplain risk plans and emergency management arrangements

The project would result in minimal to localised minor changes to existing flood hazard conditions, overland flow routes and overland flow path capacities, and would be consistent with the *Lower Parramatta River Floodplain Risk Management Study* (SKM, 2005). In addition, with the proposed mitigation the project is not predicted to alter community emergency management arrangements for flooding as defined in the *Parramatta Local Emergency Management Plan*. Details of consultation that has been undertaken, and would continue to be undertaken, with key stakeholders is provided in section 3.3.4 of Technical Paper 10.

Social and economic costs to the community

As described above, the project is predicted to result in minimal to localised minor changes to existing flooding conditions and is consistent with flood management planning arrangements. As such, and with the approach to mitigation described in section 17.6, social and economic costs to the community are predicted to be negligible.

17.4.4 Parramatta River impacts – coastal hazards and processes

The project would have limited impacts to hydrological processes in the Parramatta River with overall tidal, current and wave conditions remaining largely unaffected. Public use of foreshore areas would be reinstated. Minor potential impacts would include:

- scour around the bridge piers, which is expected to be highly localised
- the bridge abutments would encroach in the main channel system of the river; however, the area is small in comparison to the unrestricted waterway area and would not inhibit navigation
- small areas of mangrove vegetation would be permanently removed (see Chapter 16 (Biodiversity)); however, this equates to a very small portion of the total area of this vegetation in the area and is not anticipated to cause changes in the sediment transport regime of the Parramatta River.

Appropriate scour protection measures would be implemented into the design of the bridges to minimise the potential for scouring in the river.

17.5 Cumulative impacts

A detailed assessment of cumulative impacts of the project with identified key developments is provided in section 7 of Technical Paper 10, And is summarised below. The potential cumulative impacts associated with the project and other key developments would be further considered during design development and detailed construction planning. Transport for NSW would coordinate activities with the proponents of these other developments to minimise potential cumulative impacts.

17.5.1 Hydrology and flooding

Potential cumulative hydrology and flooding impacts could arise through changes to overland flow paths and loss of floodplain storage associated with the project and other identified key developments. Cumulative flood modelling was undertaken and is provided in Appendix 1 of Technical Paper 10. This modelling was based on available design information for other developments, which is some cases is limited. The modelling generally indicates that for most other developments the cumulative impacts are minimal. However, for others in close proximity to the project, in particular where there is limited design information, there is potential for cumulative impacts. It is expected that as these other developments progress through detailed design, they would include appropriate measures to limit hydrology and flooding impacts.

17.5.2 Surface water and groundwater

Potential cumulative surface water and groundwater quality impacts could arise through erosion and sedimentation, disturbance of contaminated materials and generation of litter. There are no expected groundwater level or flow cumulative impacts. With the implementation of recommended mitigation measures any surface water and groundwater cumulative impacts are likely to be negligible over the long term in the broader area.

17.6 Mitigation and management measures

17.6.1 Approach to mitigation and management

Water quality

A soil and water management plan would be prepared as part of the CEMP and implemented during construction. The plan would detail processes, responsibilities and measures to manage potential soil and water quality impacts during construction. The plan would be prepared in accordance with relevant guidelines and standards, including *Managing Urban Stormwater – Soils and Construction*, Volume 1 (Landcom, 2004) (referred to as the 'Blue Book') and the *Best Practice Erosion & Sediment Control* (International Erosion Control Association (Australasia), 2008) (IECA Manual). The development of mitigation measures in the plan would be guided by the Blue Book to determine the magnitude of rainfall events to which the capacity of the construction mitigation measures should be designed. Measures in the plan would be reviewed for adequacy by a soil conservation specialist to confirm they maintain local water quality. Further information, including an outline of the plan, is provided in Chapter 23 (Approach to environmental management and mitigation).

During operation, water quality would be protected through implementation of a range of water quality treatment measures that would reduce pollutant loads leaving the project site, contribute to working towards achieving the NSW water quality objectives, and protect nearby sensitive receiving environments. Potential measures treatment measures would be confirmed during ongoing design development.

Other mitigation measures proposed to minimise potential water quality impacts are listed in Table 17.4

Water quality monitoring

The effectiveness of the mitigation measures would be monitored by developing and implementing a water monitoring program. The monitoring program would confirm baseline water quality conditions and to confirm project-specific water quality criteria. The water quality monitoring program would be designed in accordance with the National Water Quality Management Strategy (and associated guidelines such as the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*) and the *NSW Water Quality and River Flow Objectives*. The monitoring program would be confirmed in consultation with Sydney Olympic Park Authority in relation to works in and adjacent to watercourses and receiving waterbodies in Sydney Olympic Park.

Given the present degraded state of surface waters, the primary objective of the program would be to demonstrate the project would work towards achieving the NSW water quality objectives.

The program would involve the collection and analysis of surface and groundwater samples at selected locations close to the project, including at Parramatta River, Haslams Creek and Narawang Wetland. Within each watercourse, sites would be selected at the watercourse crossing point, upstream to provide an indication of the reference condition upstream, and downstream to provide an indication of any decrease in water quality. In-situ parameters that would be measured include pH, conductivity, dissolved oxygen and turbidity, in addition to laboratory analysis of collected samples.

The number of sampling events required is generally determined by the variability of the water quality data. However, an indicative monitoring regime would require a minimum of four sampling events over both dry weather and wet weather events during the pre-construction phase, and prior to any discharge of water during the construction phase.

Further information on the requirements for the monitoring program is provided in section 8.3 of Technical Paper 10.

Groundwater

A dewatering management strategy would be developed to ensure groundwater is appropriately managed when intersected during construction. The strategy would include:

- reviewing groundwater conditions to provide adequate background information
- identifying proposed management options, including treatment on-site, discharge to surface water, infiltration, reinjection, disposal to the wastewater network and disposal at a waste facility
- assessing the feasibility of each proposed option, considering site-specific constraints, details of when each option is appropriate and any associated environmental impacts
- developing procedures to limit exposure of receptors (for example, use of personal protective equipment requirements for construction workers)
- identifying requirements of relevant regulatory authorities in relation to each management option
- confirming the measures to be implemented to manage groundwater during dewatering activities.

Works in the Parramatta River

Bridge construction works in the Parramatta River have the potential to cause water quality impacts, affect flooding regimes, and result in changes to hydrological processes. These potential impacts would primarily be associated with the clearing of vegetation, temporary working platforms and construction of bridge piers.

A soil and water management plan would be developed and implemented prior to construction commencing. The plan would detail the measures to manage potential changes to hydrodynamic processes within the Parramatta River and to ensure appropriate mitigation measures are implemented to minimise erosion, scour and destabilisation of the river banks.

Minimising the potential for flooding impacts

Additional flood modelling would be undertaken during design development to inform the design responses that would be implemented to minimise the localised flooding impacts as far as practicable. This would consider the design of the bridges in order to minimise flow disruption, and the capacity of the existing and proposed stormwater drainage systems.

The location and layout of construction work sites and compounds would be prepared with consideration of overland flow paths, avoiding flood liable land and minimising changes to flow paths where practicable to minimise impacts.

The presence of temporary structures and work areas within and next to the Parramatta River and other watercourses in the study area, could pose an environmental and safety risk in the event of a flood event. Floodwaters could mobilise pollutants and construction materials from these areas. A construction flood emergency response plan would be prepared that sets out measures which are aimed at mitigating the risks in the event of a flood occurring during construction.

17.6.2 List of mitigation measures

Measures that will be implemented to address potential impacts on water are listed in Table 17.4

Table 17.4 Water mitigation measures

Impact/issue	Ref	Mitigation measure	Timing
Flooding impacts	W1	A flood management strategy will be prepared, building on the results of the assessment presented in Technical Paper 10 (Hydrology, Flooding and Water Quality), to inform further design development and demonstrate how: • the project will achieve the Flood Management Objectives and Flood Immunity Standards • the risk of flooding to the project will be minimised • the potential impacts of the project on flood behaviour (under pre-project conditions) will be managed such that flooding characteristics will not be adversely impacted. The flood management strategy will: • confirm the project's level of flood immunity • confirm the impacts of the project on flood behaviour in accordance with the NSW Floodplain Development Manual (DIPNR, 2005) • identify design responses and management measures to minimise: – flooding impacts above the one per cent AEP by adopting climate change adaptation measures – flooding impacts to flood sensitive areas and infrastructure within Sydney Olympic Park, including the Narawang Wetland, the Brick Pit and the existing leachate system – potential impacts to the flood capacity and potential for scour as a result of the bridge piers. The strategy will be prepared by a suitably qualified and experienced specialist in consultation with City of Parramatta Council, City of Ryde Council, Sydney Olympic Park Authority, NSW State Emergency Service and the Department of Planning and Environment.	Design
Flooding impacts	W2	Drainage and flood management infrastructure will be designed with regard to relevant drainage design requirements and guidelines, including the *Development Engineering Design Guidelines* (City of Parramatta Council, 2018) and *Sydney Olympic Park Authority Policy - Stormwater Management and Water Sensitive Urban Design* (Sydney Olympic Park Authority, 2016).	
Water quality impacts	W3	The location and specification of water quality treatment measures will be determined with reference to the NSW and project-specific water quality objectives and existing water quality.	Design
Impacts on bores	W4	Further investigations and consultation with the owner of groundwater bore GW107659 will be undertaken to identify the potential for the project to affect existing water extraction and to identify appropriate management measures in accordance with the *NSW Aquifer Interference Policy* (Department of Primary Industries, 2012).	Design

Impact/issue	Ref	Mitigation measure	Timing
	W5	Further investigations and consultation with the owner of groundwater bore GW063660 will be undertaken to identify if the bore can be retained. Any decommissioning required will be undertaken in accordance with the *Minimum Construction Requirements for Water Bores in Australia* (National Uniform Drillers Licensing Committee, 2012). Decommissioning will be developed in consultation and agreement with the bore owner.	Design
Flooding impacts	W6	Construction planning and the layout of construction work sites and compounds will be undertaken with consideration of overland flow paths and flood risk, avoiding flood liable land as far as practicable.	Pre-construction
	W7	A flood and emergency response plan will be prepared and implemented. The plan will include measures, process and responsibilities to minimise the potential impacts of construction activities on flood behaviour as far as practicable. It will also include measures to manage flood risks and address flood recovery during construction.	Pre-construction, construction
	W8	Ongoing consultation will occur with the NSW State Emergency Service and relevant councils in relation to potential impacts to existing community emergency management arrangements for flooding,	Design, pre-construction, construction and operation
Water quality impacts	W9	A soil and water management plan will be prepared as part of the CEMP and implemented during construction. The plan will detail processes, responsibilities and measures to manage potential soil and water quality impacts during construction, including measures to minimise potential for pollutants to enter surface water and groundwater. The plan will be prepared in accordance with relevant guidelines and standards, including *Managing Urban Stormwater – Soils and Construction* - Volume 1 (Landcom, 2004) and Volume 2D *Main Road Construction* (DECC, 2008b) (the Blue Book), *Best Practice Erosion and Sediment Control* (International Erosion Control Association (Australasia), 2008), and *Sydney Olympic Park Authority Policy - Stormwater Management and Water Sensitive Urban Design* (Sydney Olympic Park Authority, 2016) (for works in Sydney Olympic Park).	Pre-construction, construction
	W10	Discharge to surface water will be undertaken in accordance with Transport for NSW's *Water Discharge and Reuse Guideline DMS-SD-024* (2019b), and project specific objectives.	Construction
Water quality monitoring	W11	A water quality monitoring program will be developed and implemented as part of the soil and water management plan to monitor potential surface water quality impacts. The program will define: • monitoring parameters • monitoring locations • frequency and duration of monitoring. The monitoring program will include monitoring prior to the commencement of construction to validate the baseline water quality of potential receiving waters and confirm project-specific water quality criteria. Water quality monitoring will continue for a minimum of 12 months following the completion of construction, or until affected watercourses are rehabilitated to an acceptable condition (or as otherwise required by any project conditions of approval). The monitoring program will assess compliance with the project-specific water quality objectives and the efficacy of the mitigation measures. It will be developed in consultation with the NSW EPA, City of Parramatta Council and Sydney Olympic Park Authority.	Pre-construction, construction

Impact/issue	Ref	Mitigation measure	Timing
Work within the Parramatta River	W12	Hydrodynamic modelling will be undertaken to inform the final bridge construction methodology to minimise the risk of river bank destabilisation or additional flooding to nearby areas. The modelling will also identify if additional measures, such as scour protection are required.	Pre-construction
	W13	The soil and water management plan will detail measures to manage potential changes to hydrodynamic processes within the Parramatta River and ensure appropriate mitigation measures are implemented to minimise erosion, scour and destabilisation of the river banks.	Pre-construction, construction
Works within watercourses	W14	Works within or near watercourses will be undertaken with consideration of the *Guidelines for watercourse crossings on waterfront land* (DPI, 2012) and *Guidelines for controlled activities on waterfront land – Riparian corridors* (NRAR, 2018).	Construction
Groundwater impacts	W15	Impacts on groundwater during construction will be minimised as far as practicable by: • avoiding the need to extract groundwater • minimising groundwater inflows and volumes into excavations.	Construction
	W16	A dewatering management strategy will be prepared as part of the soil and water management plan and implemented during construction. The plan will detail measures for the appropriate management of extracted groundwater, including leachate.	Pre-construction, construction
Emergency management	W17	Emergency management arrangements will be developed to manage flood risks to people and vehicles accessing stops and facilities.	Operation