Technical Paper

Hydrology, flooding and water quality

8

Sydney Metro West

Rail infrastructure, stations, precincts and operations

Environmental Impact Statement

Technical Paper 8: Hydrology, flooding and water quality

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Mott MacDonald Australia Pty Ltd

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Sydney is expanding and the NSW Government is working hard to deliver an integrated transport system that meets the needs of customers now and in the future. Sydney Metro is Australia's biggest public transport program.

Sydney Metro West is a new 24-kilometre metro line that will connect Greater Parramatta with the Sydney CBD. Confirmed stations include Westmead, Parramatta, Sydney Olympic Park, North Strathfield, Burwood North, Five Dock, The Bays, Pyrmont and Hunter Street (Sydney CBD). This infrastructure investment will double the rail capacity of the Greater Parramatta to Sydney CBD corridor with a travel time target between the two centres of about 20 minutes.

The delivery of Sydney Metro West is critical to keeping Sydney moving and is identified in a number of key strategic planning documents including the Greater Sydney Region Plan: A Metropolis of Three Cities – connecting people (Greater Sydney Commission, 2018), Building Momentum: State Infrastructure Strategy 2018-2038 (Infrastructure NSW, 2018) and Future Transport Strategy 2056 (Transport for NSW, 2018).

Sydney Metro West is being assessed as a staged infrastructure application under section 5.20 of the Environmental Planning & Assessment Act 1979 (EP&A Act). The previous Sydney Metro West planning applications included:

- The Concept and major civil construction work for Sydney Metro West between Westmead and The Bays (Stage 1 of the planning approval process, application number SSI-10038), was approved by the Minister for Planning and Public Places on 11 March 2021.
- Stage 2 of the planning approval process includes all major civil construction between The Bays and Sydney CBD. An Environmental Impact Statement for major civil construction between The Bays and Sydney CBD was exhibited between 3 November 2021 and 15 December 2021.

Stage 3 of the planning approval process is seeking planning approval to enable the approved Concept to be realised by undertaking the tunnel fit-out, construction of stations, ancillary facilities and station precincts, and operation and maintenance of the Sydney Metro West line (this proposal).

Major civil construction including station excavation and tunnelling work associated with the previous Sydney Metro West planning applications does not form part of this proposal. This proposal includes the activities required to complete construction ready for operations of Sydney Metro West.

This hydrology, flooding and water quality technical paper is one of several technical papers that form part of the Environmental Impact Statement of this proposal. The purpose of this technical paper is to identify and assess the potential impacts of this proposal in relation to hydrology, flooding and surface water quality.

Assessments have been undertaken based on relevant Commonwealth, State and Local Government guidelines.

This hydrology, flooding and water quality assessment

The objectives of this Technical Paper include:

- Characterise existing flooding behaviour and identify flood risks during construction and operation of the rail stations and service facilities
- Assess hydrology, flooding and surface water quality impacts which could occur as a consequence of this proposal
- Cumulative assessment of the potential cumulative flood impacts of this stage with other proposed development
- Identify mitigation measures for this proposal.
- Construction aspects covered in this paper are limited to those works associated with stations, or at the Clyde stabling and maintenance facility and Rosehill services facility after construction completion for the major civil construction work is completed as part of the previous Sydney Metro West planning applications.

This technical paper along with the groundwater assessment presented in the Environmental Impact Statement will address the Secretary's environmental assessment requirements in relation to Hydrology, Flooding and Water Quality.

Assessment methodology

The flooding assessments undertaken and documented in this technical paper include several key steps, as follows:

- An evaluation of available historic catchment information
- Review and updating of existing flood models or development of new flood models where necessary
- Hydraulic modelling of scenarios representative of the construction and operation phases and of this proposal and cumulative assessment of permanent works against the baseline of the previous Sydney Metro West planning applications
- Reviewing potential impacts and preparing appropriate mitigation measures to minimise these impacts.

Hydrological modelling has been based on the Australian Rainfall and Runoff 2019 guidelines (Ball et al, 2019). Hydraulic modelling undertaken considers flood events up to the Probable Maximum Flood (PMF). Results have been analysed to document potential increases in flood risk and flood affection on adjacent properties and assets and changes in relation to flood hazard and council floodplain risk management. Where required, mitigation measures have been identified.

The water quality analysis has been undertaken by understanding the existing catchment environment, water quality and water users within each area, identifying the environmental values for receiving waterways, and assessing potential construction and operation impacts on water quality. Appropriate water quality measures have been identified to minimise the impacts and protect water quality.

Components of this proposal are subject to further design development, and changes may be made during the ongoing design which would take into account the outcomes of community and stakeholder engagement and environmental investigations.

Existing conditions

The baseline modelling, representing the existing conditions at each site, includes the excavated station boxes, shafts and caverns constructed as part of the previous Sydney Metro West planning applications. The qualities of the existing environment have been outlined, including the catchment topography and drainage near the site, the climate and rainfall of the area, existing water quality conditions, and conditions and considerations for the receiving waterways and the associated treatment approach.

The assessment of existing surface water quality conditions includes a review of acid sulfate soils, ground water interactions and quality. It also includes a review of ground water ingress into the proposed station boxes, shafts and caverns.

The existing flood conditions outline the background to the hydrologic and hydraulic modelling undertaken at each site and a review of the baseline flood levels, hazard and considerations on access and evacuation routes. Flood maps showing flood depth, water surface level and flood hazard for the 5% Annual Exceedance Probability (AEP) flood event, 1% AEP flood event and the PMF event have been included. These events include climate change considerations.

Potential impacts

Hydraulic modelling has been undertaken and documented outlining the change in flood impact and behaviour from the baseline to operational scenarios at each station site. Flood maps showing the flood depth, water level, flood hazard and change in water level have been included in Appendix A – Baseline environment flood maps, Appendix B – “With Proposal” flood maps and Appendix C – Impact assessment flood maps. The incremental impacts associated with this proposal are generally very localised. The operational phase impacts of the proposed stations on flooding and flood hazard have been noted where they differ to the construction impacts.

Tunnel fit-out work and the construction of station and ancillary facilities have the potential to further degrade the water quality of the waterways within the proposal area due to the release of pollutants. The water quality impacts include potential effects on the environment from construction works, earthworks and stockpiling, accidental spills, disturbance of acid sulfate soils and concrete works. A review of potential impacts from water treatment plant discharge has also been undertaken.

Water quality during the operations phase has the potential to impact and degrade the water quality of receiving waterways through the discharge of polluted water flows or airborne contaminants (e.g. particulate matter).

Proposed management and mitigation measures

Environmental management for this proposal would be undertaken through the environmental management approach as detailed in Chapter 20 (Synthesis) of the Environmental Impact Statement.

Potential flooding impacts during operation of this proposal have been addressed by the inclusion of a number of mitigation measures to address issues that have arisen during the progression of the design for this proposal.

Localised changes to overland flows associated with this proposal are generally limited in their scale to the immediate vicinity of this proposal’s construction sites. Potential flooding and stormwater impacts during construction and operation of this proposal have been addressed by the inclusion of mitigation measures as outlined in Section 7.2 which would be supported by the mitigation measures included in the Sydney Metro Construction Environmental Management Framework. Such measures include design refinement and engagement with NSW State Emergency Service and the relevant local council.

As a result of this proposal, residual flood impacts during a PMF event would be experienced during operations at Parramatta.

Application of appropriate design standards and industry best practice, as well as mitigation measures throughout the life of the construction and operation of this proposal, would minimise impacts to the receiving waterbodies around this proposal.

Glossary and terms of abbreviation

<table>
<tr><th>Term</th><th>Definition</th></tr>
<tr><td>Australian Height Datum (AHD)</td><td>A common national surface level datum approximately corresponding to mean sea level.</td></tr>
<tr><td>Annual Exceedance Probability (AEP)</td><td>The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. In this study AEP has been used consistently to define the probability of occurrence of flooding. The following relationships between AEP and ARI applies to this study (Ball et al, 2019).
<table>
<tr><th>Frequency Descriptor</th><th>EY</th><th>AEP (%)</th><th>AEP (1 in x)</th><th>ARI</th></tr>
<tr><td rowspan="6">Very frequent</td><td>12</td><td></td><td></td><td></td></tr>
<tr><td>6</td><td>99.75</td><td>1.002</td><td>0.17</td></tr>
<tr><td>4</td><td>98.17</td><td>1.02</td><td>0.25</td></tr>
<tr><td>3</td><td>95.02</td><td>1.05</td><td>0.33</td></tr>
<tr><td>2</td><td>86.47</td><td>1.16</td><td>0.50</td></tr>
<tr><td>1</td><td>63.2</td><td>1.58</td><td>1.00</td></tr>
<tr><td rowspan="5">Frequent</td><td>0.69</td><td>50.00</td><td>2</td><td>1.44</td></tr>
<tr><td>0.5</td><td>39.35</td><td>2.54</td><td>2.00</td></tr>
<tr><td>0.22</td><td>20.00</td><td>5</td><td>4.48</td></tr>
<tr><td>0.2</td><td>18.13</td><td>5.52</td><td>5.00</td></tr>
<tr><td>0.11</td><td>10.00</td><td>10.00</td><td>9.49</td></tr>
<tr><td rowspan="3">Infrequent</td><td>0.05</td><td>5.00</td><td>20</td><td>20.0</td></tr>
<tr><td>0.02</td><td>2.00</td><td>50</td><td>50.0</td></tr>
<tr><td>0.01</td><td>1.00</td><td>100</td><td>100</td></tr>
<tr><td rowspan="4">Rare</td><td>0.005</td><td>0.50</td><td>200</td><td>200</td></tr>
<tr><td>0.002</td><td>0.20</td><td>500</td><td>500</td></tr>
<tr><td>0.001</td><td>0.10</td><td>1000</td><td>1000</td></tr>
<tr><td>0.0005</td><td>0.05</td><td>2000</td><td>2000</td></tr>
<tr><td rowspan="5">Extremely Rare</td><td>0.0002</td><td>0.02</td><td>5000</td><td>5000</td></tr>
<tr><td></td><td></td><td rowspan="4">↓</td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>Extreme</td><td></td><td></td><td>PMP</td><td></td></tr>
</table>
</td></tr>
<tr><td>ARR</td><td>Australian Rainfall and Runoff (ARR) is a national guideline document used for the estimation of design flood characteristics in Australia. Reference is made to either ARR1987 (3rd edition) or ARR2019 (4th edition) as specified.</td></tr>
</table>

Term	Definition
Average Recurrence Interval (ARI)	The long-term average number of years between the occurrences of a flood as big as or larger than the selected flood event. For example, floods with a discharge as great as or greater than the 20-year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event. Also refer to Average Exceedance Probability (AEP), which is the industry standard terminology for definition of design flood events.
Catchment	The land area draining through the mainstream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
DRAINS	The DRAINS program typically performs design and analysis calculations for urban stormwater systems and models the flood behaviour on both rural and urban catchments. The user data inputs required by DRAINS include catchment areas, flow path lengths, time of concentration, pervious and impervious areas, IFD rainfall intensities and flow path roughness. Modelling is performed through the development of a network of pipes, pits, overland flows and nodes to represent both the proposed and existing scenarios on site.
Exceedances per year (EY)	The number of times a flood event is likely to occur or be exceeded within any given year.
Facility	This refers to Clyde stabling and maintenance facility and Rosehill services facility.
Flood risk	Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk is divided into 3 types, existing, future and continuing risks. They are described below. Existing flood risk: the risk a community is exposed to due to its location on the floodplain. Future flood risk: the risk a community may be exposed to due to new development on the floodplain. Continuing flood risk: the risk a community is exposed to after floodplain risk management measures have been implemented. For an area protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.
Flood planning level (FPL)	Are the combination of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. The FPLs for this proposal are specified in Section 5.

Term	Definition
Freeboard	Provides reasonable certainty that the risk exposure selected in deciding on a particular flood event chosen as the basis for the FPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc.
Hydrologic modelling	Hydrologic modelling refers to the conversion of the design rainfall and runoff into flow hydrographs that are applied to the hydraulic model to define flood depths, flood extents, velocities and hazards for a range of design storms.
Hydrology	The study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
Hydraulic modelling	Hydraulic modelling uses the rainfall, catchment and watercourse topography to predict flood behaviour including flood levels, flood extents, flood velocities and the duration of inundation in the catchment and watercourse.
Matter of national environmental significance (MNES)	A matter of national environmental significance (MNES) protected by a provision of Part 3 of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).
Probable Maximum Flood (PMF)	The largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation coupled with the worst flood producing catchment conditions. The PMF defines the extent of flood prone land, that is, the floodplain.
Rain on grid Hydraulic model	For this technical paper, hydrological assessment has been incorporated directly into the hydraulic models, rather than employing a separate hydrological model to derive flow hydrographs. Along with topographic information and model parameters reflecting the catchment and watercourse, flood behaviour including flood levels, flood extents, flood velocities and the duration of inundation in the catchment and watercourse can be predicted.
SOBEK	SOBEK is a computer program used to study the effects of dam breaks, river floods, dike breaches, urban flooding. The hydrodynamic 1D/2D simulation engine allows the combined simulation of pipe, river-, channel- and overland flow through an implicit coupling of 1D and 2D flow equations.
Triangulated irregular network	Triangulated irregular networks are a means of digital representation of three-dimensional surface by triangulating a set of points or vertices. Connecting the vertices together forms a network of triangles in this case representing either the existing situation or a proposed design scenario. The data points are sourced from field recorded spot elevations through a variety of means including conventional surveying and remote sensing techniques. Generally, this will be referred to throughout this report as a modelled surface topography.

Term	Definition
TUFLOW	TUFLOW is a computer program which is used to simulate free-surface flow for flood and tidal wave propagation. It provides coupled 1D and 2D hydraulic solutions using a powerful and robust computation. The engine has seamless interfacing with GIS and is widely used across Australia. There are two schemes available for solving the two-dimensional Shallow Water Equation (SWE). Testing indicates that Classic and HPC produce results with are consistent with each other (BMT, 2019). There is no exact solution to the SWE, which is why there are several solvers available.
TUFLOW Classic	TUFLOW classic is the original TUFLOW solver which uses a 2nd order implicit finite difference solution. It uses a fixed timestep. The Classic solver's turbulence model is dependent on cell size with a fixed timestep.
TUFLOW HPC	The TUFLOW HPC (Heavily Parallelised Compute) solver uses a 2nd order explicit finite volume solution. TUFLOW HPC has increased stability with an adaptive timestep compared with Classic. The HPC model uses an updated turbulence scheme, which is cell size insensitive.

1 Introduction

1.1 Context and overview

Sydney is expanding and the NSW Government is working hard to deliver an integrated transport system that meets the needs of customers now and in the future. Sydney Metro is Australia's biggest public transport program.

Sydney Metro West is a new 24-kilometre metro line that will connect Greater Parramatta with the Sydney CBD. Confirmed stations include Westmead, Parramatta, Sydney Olympic Park, North Strathfield, Burwood North, Five Dock, The Bays, Pyrmont and Hunter Street (Sydney CBD). This infrastructure investment will double the rail capacity of the Greater Parramatta to Sydney CBD corridor with a travel time target between the two centres of about 20 minutes.

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Sydney Metro West is being assessed as a staged infrastructure application under section 5.20 of the *Environmental Planning & Assessment Act 1979* (EP&A Act). The previous Sydney Metro West planning applications included:

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Stage 3 of the planning approval process is seeking planning approval to enable the approved Concept to be realised by undertaking the tunnel fit-out, construction of stations, ancillary facilities and station precincts, and operation and maintenance of the Sydney Metro West line (this proposal).

Major civil construction including station excavation and tunnelling work associated with the previous Sydney Metro West planning applications does not form part of this proposal. This proposal includes the activities required to complete construction ready for operations of Sydney Metro West.

The main elements of Sydney Metro West are shown in Figure 1-1.

Figure 1-1 Sydney Metro West

1.2 Key features

This proposal would involve:

- Fit-out of tunnels including systems for metro train operations
- Construction, fit-out and operation of:
  - metro station buildings and the surrounding metro precincts
  - services facility and traction substations
  - a control centre, test track and stabling and maintenance facility at Clyde
- Space for non-station uses at metro station (e.g. retail, commercial and/or community facilities)
- Provisions for over and/or adjacent station development within metro precincts
- Rail interchange support works, including work to the existing T1 Western Line at Westmead and T9 Northern Line at North Strathfield
- Transport network modifications such as new interchange facilities and changes to public transport networks to serve metro stations
- Subdivision of sites
- Operation and maintenance of the Sydney Metro West line.

Components of this proposal are subject to further design development, and changes may be made during the ongoing design that take into account the outcomes of community and stakeholder engagement and environmental investigations.

Further details of this proposal are provided in Chapter 5 (Proposal description – operation) and Chapter 6 (Proposal description – construction) of the Environmental Impact Statement.

1.3 Purpose and scope of this report

This technical paper is one of a number of technical papers that form part of this Environmental Impact Statement. The purpose of this technical paper is to identify and assess the potential impacts of this proposal in relation to hydrology, flooding and water quality of surface waters. It responds directly to the Secretary's environmental assessment requirements outlined in Section 1.3.1.

1.3.1 Secretary's environmental assessment requirements

The Secretary's environmental assessment requirements for this proposal were issued on 16 August 2021. The requirements specific to hydrology, flooding and water quality, and where these requirements are addressed in this technical paper, are outlined in Table 1-1.

The Secretary's environmental assessment requirements also makes reference to the *Sydney Metro West Scoping Report – Rail infrastructure, stations, precincts and operations* (Sydney Metro, 2021), which identified the proposed scope of investigations and assessment. How this technical paper addresses these matters is outlined in Table 1-2.

Table 1-1: Secretary's environmental assessment requirements – Hydrology, flooding and water quality

Secretary's environmental assessment requirements	Where addressed
Flooding	
1. Flood management objectives must be clearly identified and justified to address the characteristics of the environment and relevant legislative, management and guidance requirements.	Section 3.1.4

Secretary's environmental assessment requirements	Where addressed
2. Flood behaviour during construction and operation for a full range of flood events up to the Probable Maximum Flood (taking into account sea level rise and storm intensity due to climate change) including: (a) maps featuring flood prone lands, flood planning areas (areas below the flood planning level), hydraulic categorisation (flood ways and flood storage areas) and flood hazards; (b) assessment of potential flood affectation of other properties, assets and infrastructure against the flood management objectives; (c) consistency (or inconsistency) with applicable Council floodplain risk and stormwater management plans and other similar initiatives; (d) compatibility with the flood hazard of the land; (e) compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land; (f) the likelihood of erosion, siltation, destruction of riparian vegetation on riverbanks and watercourses; (g) impacts the development may have upon existing community emergency management arrangements for flooding. These matters must be discussed with the State Emergency Services and Council; and (h) any impacts the development may have on the social and economic costs to the community as consequence of flooding.	Section 5, Section 7, Table 7-1, Maps are located in Appendix A – Baseline environment flood maps, Appendix B – "With Proposal" flood maps and Appendix C – Impact assessment flood maps along with the tables in Section 5 which describe the relevant features. The potential social and economic costs are presented in Section 5.2.12. Targeted consultation with the State Emergency Services and relevant councils has commenced for precincts in which this proposal may have an impact upon existing community emergency management arrangements for flooding. Sydney Metro would continue engagement with these stakeholders through detailed design to minimise impacts.
3. Identify measures to achieve the flood management objectives.	Section 7 and Table 7-1

Water – Hydrology	
1. Describe (and map where relevant) the existing hydrological regime for any surface water resource (including reliance by users and for ecological purposes) likely to be impacted by the proposal, including stream orders, as per the Framework for Biodiversity Assessment (FBA).	Section 4 including the following tables with details of stream order: Section 4.1.5, Table 4-2, Table 4-4, Table 4-6, Table 4-8, Table 4-10, Table 4-12, Table 4-14, Table 4-16, Table 4-18 and Table 4-20
2. Provide a water balance for surface water including the proposed intake and discharge locations, volume, frequency and duration.	Section 3.1, Section 6.1.2 and Section 6.2.1
1) Surface hydrology impacts of the construction and operation of the proposal and any ancillary facilities (both built elements and discharges) in accordance with the current guidelines, including: 1) natural processes within rivers, wetlands, estuaries, marine waters and floodplains that affect the health of the fluvial, riparian, estuarine or marine system and landscape health (such as modified discharge volumes, durations and velocities), aquatic connectivity and access to habitat for spawning and refuge; (a) changes to environmental water availability and flows, both regulated / licensed and unregulated / rules-based sources; (b) direct or indirect increases in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses; (c) 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 (d) water take (direct or passive) from all surface water sources with estimates of annual volumes during construction and operation.	Section 3.1, Section 5.1 and Section 6
3. Identify any requirements for baseline monitoring of hydrological attributes.	Section 7 and Table 7-1

Water - Quality	
1. Surface water and groundwater quality impacts, including: (a) identifying and estimating the discharge water quality 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; (b) identifying the rainfall event that the water quality protection measures will be designed to comply with; (c) assessing the significance of identified impacts including consideration of the relevant ambient water quality outcomes; 2. Demonstrating how construction and operation of the proposal will, to the extent that the proposal can influence, ensure that: (a) where the NSW WQOs for receiving waters are currently being met they will continue to be protected; (b) where the NSW WQOs are not currently being met, activities will work toward their achievement over time; (c) justifying, if required, why the WQOs cannot be maintained or achieved over time.	Surface water: Section 6, Section 7 and Table 7-1 Groundwater: Refer to groundwater quality assessment presented in the Environmental Impact Statement.

Table 1-2: Scoping Report investigations and assessment – Hydrology, flooding and water quality

Scoping report investigations and assessment	Where addressed
The assessment of hydrology and flooding impacts will include:	
Review of relevant existing flood study reports and description of flood behaviour for the existing conditions.	Section 3.1 and Section 3.3.4
Identification of the existing water quality conditions and the hydrological regime for surface water, including surface catchments and watercourses	Section 4
Identification and assessment of potential impacts on stormwater quantity during construction and operation	Section 6
Identification of potential impacts on surface water quality during construction and operation, including an indicative water balance	Section 3.1 and Section 6
Broad assessment of the potential change in stormwater runoff (increase or decrease) during construction and operation, including consideration of changes to flooding behaviour in response to climate change (sea level rise and rainfall intensity)	Section 5 and Section 6
Identification of any potential changes to flood levels (including flood affectation of other properties, assets and infrastructure) during construction and operation, including discharges, velocities, duration of flood inundation and flood hazards for the five per cent and one per cent Annual Exceedance Probability flood events, and the Probable Maximum Flood. This assessment will take into consideration the assessment carried out in previous Sydney Metro West planning applications	Section 5
A review of consistency with the applicable Council Floodplain Risk Management Study	Section 5
A review of compatibility with the flood hazard and hydraulic functions of the land	Section 5
Identification of appropriate mitigation and management measures.	Section 7

1.3.2 Purpose of this report

The objectives of this hydrology, flooding and water quality assessment are to:

- Characterise existing flooding behaviour and identify flood risks during construction and operation of the rail stations and service facilities
- Assess hydrology, flooding and water quality impacts which could occur as a consequence of this proposal
- Cumulative assessment of the potential cumulative flood impacts of this stage with other proposed development
- Identify mitigation measures for this proposal.

Aspects covered in this paper are limited to those works associated with the construction of stations, or at the Clyde stabling and maintenance facility and Rosehill services facility after work carried out under the previous Sydney Metro West planning applications. Where underground pedestrian passages are proposed these will have been constructed previously along with the station boxes with the exception of Westmead metro station where the pedestrian access from the existing station would be constructed as part of this proposal. Further earthworks at Sydney Olympic Park metro station and excavation and construction of the basement for the over and adjacent station developments at Parramatta metro station have been assessed as part of this proposal.

Section 3.3 outlines the context within which information in this report is presented.

1.3.3 Study area

The study area is located within the Sydney Harbour and Parramatta River catchments of the Sydney Coast Georges River portion of the South East Coast drainage division (Bureau of Meteorology, 2012). Figure 1-2 indicates the locations of focus which include:

- Westmead metro station construction sites
- Parramatta metro station construction site
- Sydney Olympic Park metro station construction site
- North Strathfield metro station construction sites
- Burwood North Station construction sites
- Five Dock Station construction sites
- The Bays Station construction site
- Pyrmont Station construction sites
- Hunter Street Station (Sydney CBD) construction sites
- Clyde stabling and maintenance facility and the Rosehill service facility construction site.

The majority of station construction sites and the Clyde stabling and maintenance facility construction site ultimately drain to the Parramatta River. The Bays Station construction site drains to White Bay in the lower estuary of Sydney Harbour. Pyrmont Station and Hunter Street Station (Sydney CBD) construction sites respectively drain to Pyrmont and Blackwattle Bays, and Circular Quay within Sydney Harbour.

This proposal is located within the following Local Government Areas:

- Cumberland City Council
- City of Parramatta
- Municipality of Strathfield
- City of Canada Bay
- Municipality of Burwood
- Inner West Council
- City of Sydney.

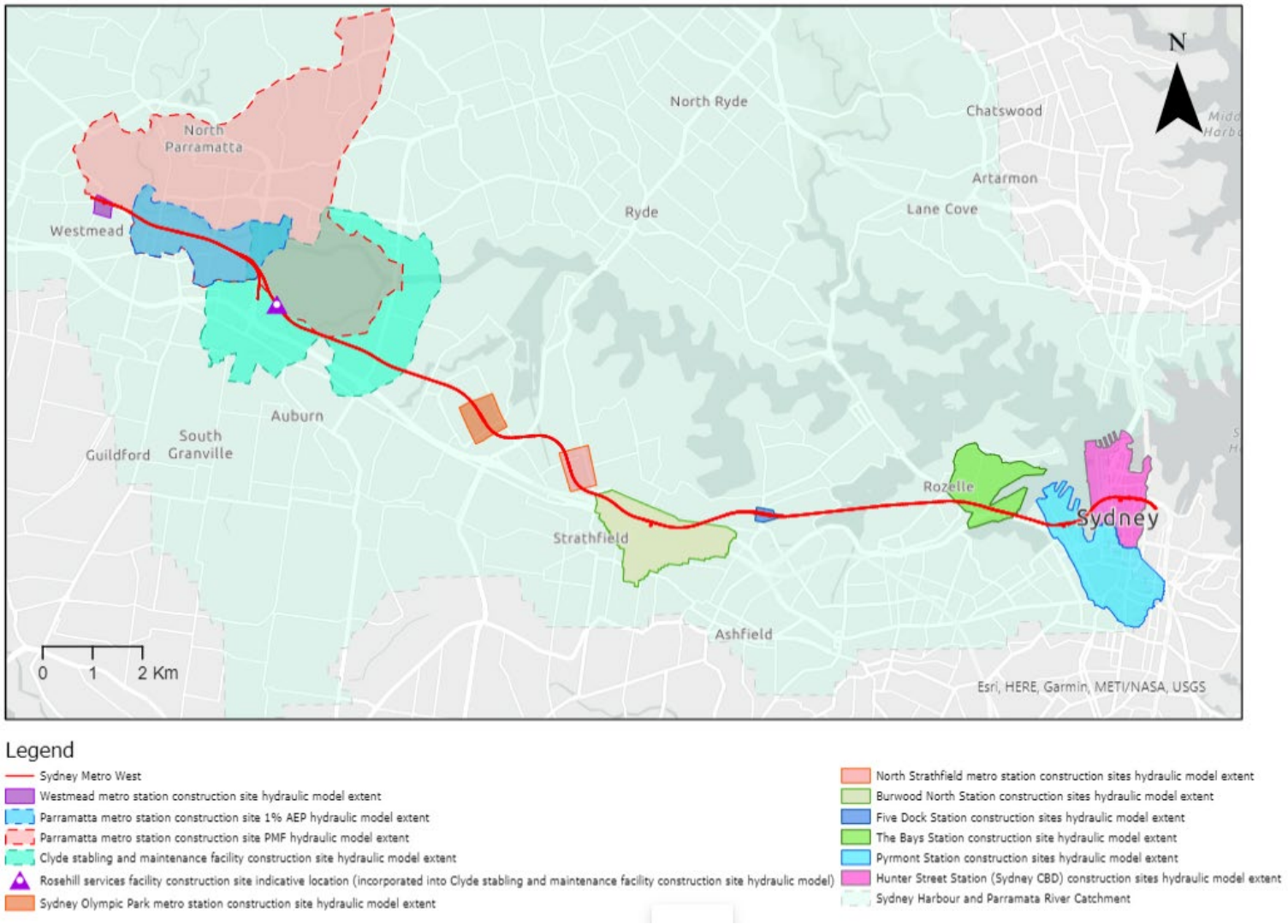

Figure 1-2 Locations of focus within study area

1.4 Structure of this report

This technical paper is structured as follows:

- Chapter 1 (this chapter) provides the context, overview and key features of this proposal
- Chapter 2 summarises the legislation, policy and best practice guidelines relevant to this proposal
- Chapter 3 outlines the assessment methodologies applied in this study
- Chapter 4 describes the qualities of the baseline environment in the study area
- Chapter 5 describes the potential hydrology and flood impacts of this proposal on the baseline environment in the study area
- Chapter 6 describes potential the water quality impacts of this proposal on the baseline environment in the study area
- Chapter 7 outlines the management and mitigation strategies to address the potential proposal impacts of this proposal.

2 Legislative and policy context

This chapter presents the relevant legislative and policy context as it pertains to this hydrology, flooding and water quality assessment.

2.1 Commonwealth policy

2.1.1 National Water Quality Management Strategy

The *National Water Quality Management Strategy* (NWQMS) is the adopted national approach to protecting and improving water quality in Australia. It consists of a number of guideline documents, with specific documents relating to the protection of surface water and groundwater resources.

The primary document relevant to the assessment of groundwater risks for the study area is the *Guidelines for Groundwater Quality Protection in Australia* (Australian Government, 2013). This document sets out a high-level risk-based approach to protecting or improving groundwater quality for a range of groundwater beneficial uses (called 'environmental values'). The beneficial uses are as follows:

- Aquatic ecosystems, comprising the animals, plants and micro-organisms that live in water, and the physical and chemical environment and climatic conditions with which they interact
- Primary industries, including irrigation and general water users, stock drinking water, aquaculture and human consumption of aquatic foods
- Recreation and aesthetic values, including recreational activities such as swimming and boating, and the aesthetic appeal of water bodies
- Drinking water, which is required to be safe to use and aesthetically pleasing
- Industrial water, such as water used for industrial processes including cooling towers, process water or wash water
- Cultural and spiritual values, which may relate to a range of uses and issues of a water source, particularly for indigenous people, including spiritual relationships, sacred sites, customary use, the plants and animals associated with water, drinking water or recreational activities.

Each beneficial use has a unique set of water quality criteria designed to protect the environmental value of the groundwater resource. For the purposes of this assessment, 'environmental values' pertaining to aquatic ecosystems, primary industries, industrial water, and cultural values are considered potentially applicable. The majority of creeks that pass beneath at depth of the proposed underground activities have been identified as having high visual amenity value and may be fed by groundwater baseflow at times. A few have also been identified as having primary or secondary contact recreation (e.g. White Bay).

2.1.2 The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018)

The *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG, 2018) is a key guideline within the NWQMS that is used to identify catchment and waterway specific water quality management goals. These guidelines are an updated version of the previous guidelines, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC/ARMCANZ, 2000).

The ANZG 2018 guidelines provide a process for assessing existing water quality condition and developing water quality objectives to sustain current or likely future environmental values for water resources. Guideline trigger values for water quality indicators are provided for different environmental values as generic starting points for assessing water quality where site specific information is not available.

The guideline trigger values are used to evaluate the existing water quality conditions against long term water quality goals. It should be noted that the trigger values have not been designed for direct application in activities such as discharge consents, recycled water quality or stormwater quality. These guideline trigger values are provided for various levels of protection of waterways which are considered when describing the existing water quality and key indicators of concern. The level of protection applied in this assessment when assessing ambient water quality is for slightly disturbed to moderately disturbed ecosystems. The ANZG guidelines provide updated databases to derive guideline values for toxicants and sediments in aquaculture and aquatic foods, physical and chemical stressors and for guideline values for agricultural water users. These databases and values have not been updated for all regions of Australia and in some regions, the values as used in the previous ANZECC 2000 guidelines still apply.

The project environmental values, based on ANZG 2018 guideline trigger values for the selected toxicants, would be for the protection of 95 percent of species in slightly disturbed to moderately disturbed systems. For physical and chemical stressors, the ANZG 2018 guidelines are the same as the ANZECC 2000 and provide guideline trigger values for slightly disturbed ecosystems in lowland rivers in south-east Australia as shown in Table 2-1.

Table 2-1 ANZG 2018 guideline water quality trigger values for physical and chemical stressors for slightly disturbed ecosystems in lowland rivers in south-east NSW

Parameter	Trigger Value or Criteria
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	7-8.5

2.2 NSW legislation

2.2.1 Water Act 1912, Water Management Act 2000 and Water Management Regulation 2018

Water resources in NSW are administered under the *Water Act 1912* and the *Water Management Act 2000* by the NSW Department of Planning, Industry and Environment. The *Water Management Act 2000* governs the issue of water access licences and approvals for those water sources (rivers, lakes, estuaries and groundwater) in NSW where Water Sharing Plans have commenced. The Water Sharing Plan for the study area has commenced, and the area is therefore governed under the *Water Management Act 2000*.

In accordance with Section 5.23(1) of the EP&A Act, the following approvals, which may have otherwise been required, would not be required for approved State Significant Infrastructure:

- Water use approval under Section 89 of the Water Management Act 2000
- Water management work approval (including a water supply works approval) under Section 90 of the Water Management Act 2000
- Activity approval under Section 91 of the Water Management Act 2000.

These requirements have been noted for clarity but as this proposal is State Significant Infrastructure, these approvals would not be required.

2.2.2 Water Management Regulation

Water sharing plans, following the introduction of the *Water Management Act 2000*, provide the basis for equitable sharing of surface water and groundwater between water users, including the environment.

The majority of NSW is now covered by Water Sharing Plans. If an activity leads to a take from a groundwater or surface water source covered by a Water Sharing Plan, then an approval and / or licence is required. In general, the *Water Management Act 2000* requires:

- A water access licence to take water
- A water supply works approval to construct a work
- A water use approval to use the water.

As indicated earlier there is no surface water take to consider.

2.2.3 Protection of the Environment Operations Act 1997

Section 120 of the *Protection of the Environment Operations Act 1997* (POEO Act) prohibits the pollution of waters by any person. If a person is charged with the offence of pollution of waters, Section 122 of the *POEO Act* provides a defence if the pollution was regulated by an environment protection licence, and conditions of that licence were not breached in relation to the pollution of waters.

2.2.4 Coastal Management Act 2016

The objectives of the *Coastal Management Act 2016* are to manage the coastal environment of the state in a manner consistent with the principles of ecologically sustainable development. The Act introduced coastal management programs, the development and implementation of which is supported by the *Coastal Management*

Manual. Coastal management programs shall replace coastal zone management plans which were required under former legislation. These coastal zone management plans continue in force until the coastal management programs are adopted. It is noted that adoption is required by 31 December 2021.

Applicable coastal management programs and coastal zone management plans include:

- Greater Sydney Harbour Coastal Management Program
- Parramatta River Estuary Coastal Zone Management Plan.
- The Greater Sydney Harbour Coastal Management Program is under development. The Parramatta River Estuary Coastal Zone Management Plan includes a range of actions for authorities including various local government authorities, Roads and Maritime Services (now Transport for NSW), Sydney Olympic Park Authority, Sydney Water and the Parramatta River Estuary Management Committee. Actions outlined within the Parramatta River Estuary Coastal Zone Management Plan which have the potential to impact this proposal include:
- Investigate the potential for channel naturalisation of Powells Creek, Brickfield Creek, Dobroyd Canal, St Lukes Park Canal and Whites Creek as they require asset renewal and/or replacement
- Provide for the ongoing monitoring, conservation and management of saltmarsh, swamp oak floodplain forest and mangrove communities in the Mason Park wetlands to enhance estuarine habitats in these areas and allow for their future landward migration with sea level rise
- Strathfield Council are developing a management plan for the Mason Park Wetlands which are adjacent to Powells Creek and downstream of the North Strathfield Station construction site. Mason Park Wetlands and Powells Creek are not directly connected except in rare flood events (WMAwater, 2016e).

2.3 NSW policy

2.3.1 NSW water quality and river flow objectives

The NSW Government has developed water quality objectives that are consistent with the National Water Quality Management Strategy, and in particular, with the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018).

The water quality objectives relate to fresh and estuarine surface waters and in this report they are relevant to the Sydney Harbour and Parramatta River catchments and a number of tributary watercourses of these catchments. Surface and groundwater quality must therefore be maintained to a level that does not degrade any receiving surface water environments. The guidelines set out:

- The community’s values and uses for NSW rivers, creeks, estuaries and lakes (i.e. healthy aquatic life, water suitable for recreational activities like swimming and boating, and drinking water)
- A range of water quality indicators to help assess whether the current condition of waterways supports those values and uses.

2.3.2 Flood Prone Land Policy

The *Flood Prone Land Policy* and the accompanying *Floodplain Development Manual* (NSW Government, 2005) guide development on flood prone land and apply across the state. The key objectives of this policy are to identify potential hazards and risks, reduce the impact of flooding and flood liability on owners and occupiers of flood prone property, and to reduce public and private losses resulting from floods. This policy also recognises the benefits of the use, occupation and development of flood prone land.

Pursuant to this, Councils will have commissioned floodplain management studies and plans that determine flood planning levels and areas along with hydraulic and hazard categorisation for proposed development within these catchments and their boundaries. Such relevant studies and plans have been identified across the study area and are discussed in further detail in later sections of this report.

The assessment of potential flooding impacts of this study on existing flood regimes has been conducted in accordance with the requirements of the *Floodplain Development Manual*. The assessment and management of potential flooding impacts would follow the guidelines from the *Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia* (Australian Institute for Disaster Resilience, 2017).

During 2020, the Department of Planning, Infrastructure and Environment undertook consultation[1] on revisions to this policy to build greater resilience in people and communities within floodplains by requiring the full range of flood events to be considered when undertaking strategic land use planning. On the 14 July 2021, the State Environmental Planning Policy Amendment (Flood Planning) 2021 amended all Local Environmental Plans (LEP) with the Standard Instrument (Local Environmental Plans) Amendment (Flood Planning) Order 2021. The amendment inserted a compulsory clause following Clause 5.20 with an additional optional clause for those councils that had opted in.

The amendment introduces the concept of Flood Planning Areas (FPA) which is the area of land at or below the Flood Planning Level (FPL) where the FPL is a combination of the flood level from the defined flood event and freeboard selected for flood risk management purposes (Department of Planning, Infrastructure and Environment, 2021).

LEPs relevant to this technical paper are listed in Section 2.4.

2.3.3 State Environmental Planning Policy (Coastal Management) 2018

The *State Environmental Planning Policy (Coastal Management) 2018* aims to promote an integrated and co-ordinated approach to land use planning in the coastal zone which is consistent with the *Coastal Management Act 2016*. The associated mapping (NSW Department of Planning and Environment, 2020 in Table 2-2 indicates the areas subject to this policy.

[1] https://www.planningportal.nsw.gov.au/flood-prone-land-package

Table 2-2 State Environmental Planning Policy (Coastal Management) 2018 mapping

	Area mapping			
Proposal location	**Coastal Wetlands**	**Proximity Coastal Wetlands**	**Coastal Environment***	**Coastal Use**
The Bays Station			●	●
Powells Creek[1]		●	●	
Mason Park Wetlands[2]	●			
Badu Mangroves[3]	●	●	●	
Clyde stabling and maintenance facility		●	●	●
Duck Creek	●	●	●	●
Duck River	●	●	●	●
A'Becketts Creek		●		
Parramatta River[4]	●	●		

[1]Coastal Environment Area mapping does not apply to areas covered by the Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005 Foreshores and Waterways Area

[2]Downstream of North Strathfield Station construction sites

[3]Downstream of Sydney Olympic Park metro station construction site

[4]Downstream of Parramatta metro station construction site

The Pyrmont Station construction sites are just outside of the extents of the *State Environmental Planning Policy (Coastal Management) 2018* mapping.

2.4 Planning controls

Section 5.22 of the EP&A Act provides that environmental planning instruments (such as LEPs) do not apply to SSI projects. Notwithstanding, the following environmental planning instruments have been considered as part of the development of this proposal:

- Auburn Local Environmental Plan 2010
- Holroyd Local Environmental Plan 2013
- Parramatta Local Environmental Plan 2011
- City of Parramatta's Development Control Plan 2011
- Burwood Local Environmental Plan 2012
- Burwood Development Control Plan 2021
- Canada Bay Local Environmental Plan 2013
- City of Canada Bay Development Control Plan 2020
- Strathfield Local Environmental Plan 2012
- Leichardt Local Environmental Plan 2013
- Sydney Local Environmental Plan 2012
- Sydney Local Environmental Plan 2005
- Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005[2]
- Sydney Harbour Foreshore Area Development Control Plan 2005
- Sydney Regional Environmental Plan No 24 – Homebush Bay Area
- Sydney Regional Environmental Plan No 26 - City West.

It is noted that none of the relevant councils have adopted Clause 5.22 Special flood considerations, as outlined in the Standard Instrument (Local Environmental Plans) Amendment (Flood Planning) Order 2021, within their applicable LEP.

Although there is an amendment under consideration to update Clause 6.2 of the Burwood Local Environmental Plan 2012 to identify flood affected land it does not apply to either of the Burwood North Station construction sites.

Strathfield Council is currently developing a revised local environmental plan. Public exhibition will occur at a future date.

The Draft Parramatta City Centre Development Control Plan was exhibited[3] until 13 December 2021. This includes a Floodplain Risk Management Map, which encompasses the area of the Parramatta metro station, with additional provisions in relation to sheltering in place or evacuation in the Probable Maximum Flood (PMF).

[2] Planning underway for this to be consolidated into the proposed Environment SEPP. https://uat.planning.nsw.gov.au/Policy-and-Legislation/State-Environmental-Planning-Policies-Review/Draft-Environment-SEPP

[3] https://participate.cityofparramatta.nsw.gov.au/cbd-DCP

As this proposal is State Significant Infrastructure, these instruments do not apply and at this time are not in force.

2.4.1 Guidelines for controlled activities on waterfront land

The *Guidelines for Controlled Activities on Waterfront Land* is a current area of focus by the Natural Resources Access Regulator (NRAR) established under the NSW Natural Resources Access Regulator Act 2017. This guideline outlines the requirements for undertaking controlled activities on waterfront land in relation to riparian corridors with a view to allowing for a range of works and activities so long as they cause minimal harm. Waterfront land includes the bed and bank of any river, lake or estuary and all land within 40 metres of the highest bank of the river, lake or estuary. Riparian corridors form a transition zone between the land and the river or watercourse. This guideline is not considered relevant for this proposal.

2.4.2 Transport for NSW Sustainable Design Guidelines

The *Transport for NSW Sustainable Design Guidelines Version 4.0* outline a range of initiatives to improve the sustainability performance of transport infrastructure. There are three parts which includes:

- The design guidelines
- Supporting tools appendices
- The checklist to demonstrate achievement of the required sustainable design guidelines rating.

There are 14 compulsory requirements and two sub requirements that must be considered when delivering a project. Each compulsory requirement has five performance levels (P1 – P5) where P1 is the minimum requirements and is compulsory in order to achieve a rating. Relevant requirements associated with this technical paper include:

- Compulsory Requirement 3 – Climate change risk
- Compulsory Requirement 6 – Water sensitive urban design
- Compulsory Requirement 7 – Construction water
- Compulsory Requirement 8 – Operational water.

2.5 Relevant best practice guidelines

The following best practice guidelines have been applied in assessments undertaken in this technical paper.

2.5.1 Australian Rainfall and Runoff

Australian Rainfall and Runoff (ARR) is a national guideline document used for the estimation of design flood characteristics in Australia. Since 1958 there have been 4 editions with the 3rd edition published in 1987 (ARR1987) and the 4th edition published in 2019 (ARR2019) being the relevant guidelines applicable to this study. ARR2019 is accompanied by Intensity Frequency Duration (IFD) design rainfall values (developed and published by Bureau of Meteorology in 2016) based on an additional 30 years of available data compared with the IFD design rainfall values which were published with ARR1987.

The guidelines require practitioners to apply their judgement about the appropriateness of a method to the particular situation and data. Further guidance (Office of Environment and Heritage, 2019) suggests that there are some situations where the 1987 IFD rainfall values may continue to be more appropriate.

2.5.2 Australian Disaster Reliance Handbook Collection

The *Australian Disaster Resilience Handbook Collection* is a series of guidelines providing authoritative knowledge about disaster resilience and is hosted by the Australian Institute for Disaster Resilience (AIDR).

Of particular relevance to this study is the guideline on managing the floodplain and flood hazard definition. Flood hazard mapping, where the flood hazard is rated thematically based on the flooding depth and velocity at any one time during a flood event, has traditionally been undertaken based on the definition in the *Floodplain Development Manual*. More recently, a comprehensive approach to defining hazard with six classifications (H1 – H6) has been adopted (Australian Institute for Disaster Resilience, 2017b), see Figure 2-1 below.

The combined hazard curves relate to the vulnerability of the community and allow a greater breakdown as compared to the *Floodplain Development Manual* which was limited to definitions of high/medium and low flood hazard conditions with little differentiation between the susceptibility of different members of the community and of different types of assets and property.

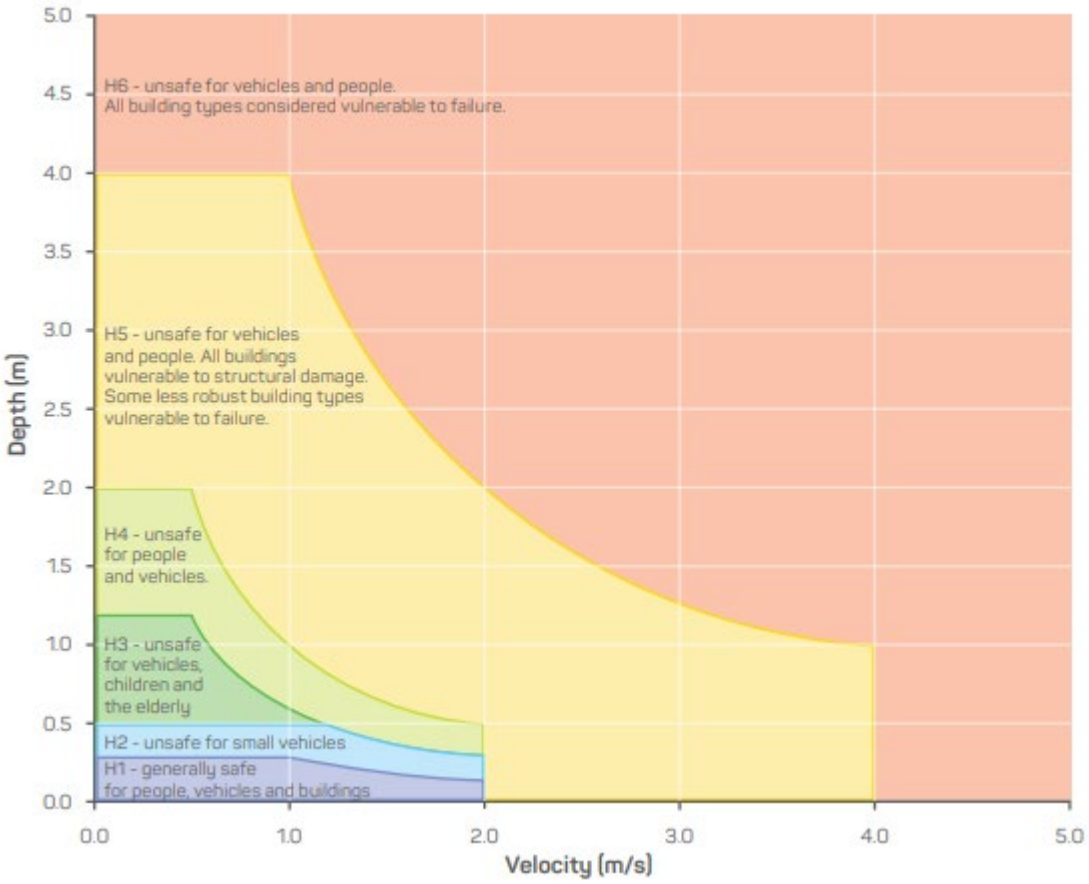

Figure 2-1 Thresholds for stability in floods

The hazard conditions shown in the figure are defined below:

- H1: Generally safe for vehicles, people and buildings
- H2: Unsafe for small vehicles
- H3: Unsafe for vehicles, children and the elderly
- H4: Unsafe for vehicles and people
- H5: Unsafe for vehicles and people. All building types vulnerable to structural damage. Some less robust building types vulnerable to failure
- H6: Unsafe for vehicles and people. All building types considered vulnerable to failure.

2.5.3 Managing urban stormwater series

The soils and construction series provide guidance on how to reduce the impacts of land disturbance on waterways by better management of soil erosion and sediment control. This series, commonly referred to as the 'Blue Book', includes the following publications relevant to this proposal:

- Managing Urban Stormwater: Soils and Construction – Volume 1, 4th edition (Landcom, 2004)
- Managing Urban Stormwater: Soils and construction – Volume 2D, Main road construction (Department of Environment and Climate Change, 2008).

Erosion and sediment measures would be implemented at all construction sites in accordance with the principles and requirements in Managing Urban Stormwater – Soils and Construction, Volumes 1 and 2D.

3 Assessment methodology

The methodology adopted to assess the impact of this proposal is outlined below. This approach has been developed in line with relevant legislation and guidelines and with reference to the Secretary's environmental assessment requirements.

3.1 Hydrology and flooding assessment

A qualitative assessment of the surface hydrology impacts has been undertaken and is contained in Section 5.1. This approach is considered acceptable due to the following reasons:

- No surface water resources are taken pursuant to legislation described in Section 2.2.1 by this proposal
- Most sites in this proposal do not discharge directly to watercourses but rather to the major and minor drainage systems across the broader Sydney area which also receive considerable contribution from areas outside of this proposal
- Wastewater would be treated and reused where practicable.

The following methodology has been used to develop an understanding of existing (baseline) flood behaviour in the study area and to assess potential construction and operational phase flood impacts along with potential cumulative flood impacts. Key steps in the flooding assessment methodology are shown in Figure 3-1.

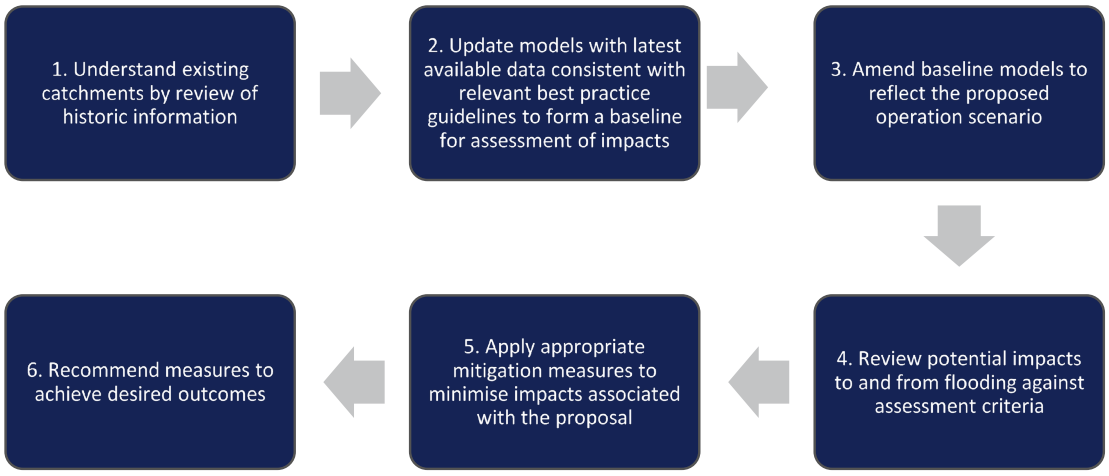

Figure 3-1 Flooding assessment methodology

A hydrology and flood impact assessment has been carried out for all locations within the study area listed in Section 1.3.3 based on the construction footprints in Appendix D – Construction footprint.

Flood maps have been developed for each site with flood hazard categories in accordance with the Australian Institute of Disaster Resilience (2017b) Guideline 7-3. Refer to Appendix A – Baseline environment flood maps Appendix B – "With Proposal" flood maps and Appendix C – Impact assessment flood maps for mapping associated with the existing (baseline) and impact (operations) assessments respectively.

3.1.1 Desktop review

Desktop review of publicly available flood study reports and models from local council(s) and other sources was carried out to characterise existing flooding conditions at all proposed station and services facility sites for this approval and the surrounding areas. Factors considered include:

- Topography in the vicinity of the sites and presence of flow paths and watercourses
- Flood hazard
- Flood depths and levels.

The outcome of this review was the adoption of the existing flood models as outlined in Section 3.3 and Table 3-5. The hydrological methodology applied in each case for the assessment is indicated in Table 3-3.

3.1.2 Assessment overview

Assessment of the potential impacts of this proposal on flooding consider flood events up to the PMF, which focuses on:

- Potential increases in flood risk and flood affectation on adjacent properties and assets as well as potential impacts to any emergency management arrangements
- Land use compatibility in relation to flood hazard
- Compatibility with council floodplain risk management in terms of safe velocities and depths for pedestrians and vehicles
- Where required mitigation and management measures have been identified.

Quantitative assessments have been carried out for this proposal at all station sites. Where possible, these have been based on flood models which have been validated and updated with construction or operational design information as appropriate and more detailed survey around each site, if available.

The flooding assessment is based on the criteria outlined in Section 3.1.4 along with a modelled surface topography (represented as a triangulated irregular network surface) to represent the baseline and “with proposal” scenarios at stations.

Existing publicly available community emergency management arrangements have been reviewed to understand important transport routes for evacuation. Targeted consultation with the State Emergency Services and relevant councils and authorities (including Sydney Olympic Park Authority and the City of Sydney and City of Parramatta Councils) has commenced for precincts in which this proposal may have an impact upon existing community emergency management arrangements for flooding. Sydney Metro would continue engagement with these stakeholders through detailed design to minimise impacts. Further detail on the specific sites where this applies is contained in Sections 5.2.1, 5.2.2, 5.2.3, 5.2.8 and 5.2.9.

The cumulative impact assessment has generally followed a qualitative approach based on a review of unrelated major developments proposed in the study area (refer to Section 5.2.11 for further details). Quantitative cumulative impact assessment considers the impact of the construction of permanent works that would be delivered in this proposal against a pre-development baseline associated with the previous Sydney Metro West planning applications depending on the location.

Section 3.3 outlines the assumptions, dependencies and limitations associated with the modelling and assessments carried out for this technical paper.

3.1.3 Modelling assessment

Modelling for this proposal has been largely based on existing hydraulic models and only where necessary supplemented by new models. A combination of hydrological modelling has been adopted in this study including inflow hydrographs from hydrological modelling, rainfall applied directly (rain on grid) to the digital elevation model (DEM) in TUFLOW and DRAINS. The choice of model used for assessments within this technical paper was largely based on the availability of existing models. Table 3-3 contains further details on these arrangements.

A TUFLOW one-dimensional/two-dimensional hydraulic model has been adopted for this proposal to convert runoff rates into flow depths and velocities for both the baseline (existing environment) scenario and the “with proposal” scenario.

The model has been prepared to assess the full range of infrequent flood events along with the extreme flood event. The flood events which will be presented for each assessment include the 5% AEP, 1% AEP and PMF events. Climate change has been directly incorporated into each assessment as outlined in Sections 3.1.4 and 3.3.

A key phase of building a suitable hydraulic model is the process of model calibration and validation. Calibration involves utilising historic flood event data (referred to as observed data) to change model inputs to get the model to replicate the historic flood event. Validation then involves checking the model inputs against another historic flood event. This is preferred so that the adopted model adequately predicts flood behaviour, where historic data is available. In the absence of historical data, models have been developed based on standard parameters from ARR2019 as outlined in Table 3-2.

With existing studies any calibration and validation would have been carried out previously when the models were originally developed.

3.1.4 Impact flooding criteria

The flood criteria applicable to this study are set out below:

- Metro tunnels and other critical infrastructure would be protected from the PMF, or the one per cent Annual Exceedance Probability flood level with an allowance for freeboard of 0.5 metres (whichever is greater)
- The one per cent Annual Exceedance Probability flood event (1% AEP flood event) and the five per cent Annual Exceedance Probability flood event (5% AEP flood event) will incorporate allowances for climate change impacts
- Minimise increases in flood levels due to temporary and permanent infrastructure during flood events up to and including the 1% AEP flood event
- No additional private properties would be affected by flooding up to and including the 1% AEP flood event due to permanent infrastructure delivered as part of this proposal
- The potential for soil erosion and scouring is minimised for events up to and including a 1% AEP flood event
- Dedicated evacuation routes would not be adversely impacted in flood events up to and including the PMF event.

These project specific flood criteria have been established based on a review of flood criteria adopted for other similar linear infrastructure projects (including the previous Sydney Metro West planning applications) as well as applicable policy and guideline documents including City of Sydney Council Interim Floodplain Management Policy (City of Sydney Council, 2014), City of Parramatta Council DCP (City of Parramatta Council, 2011) and the Flood Prone Land Package (Department of Planning, Industry and Environment, 2021) and have been adapted for use on this project.

3.2 Water quality analysis

The following methodology has been used to understand the existing (baseline) water quality environment in the study area and to assess potential construction phase, operational phase and cumulative water quality impacts. Key steps in the water quality assessment are shown in Figure 3-2.

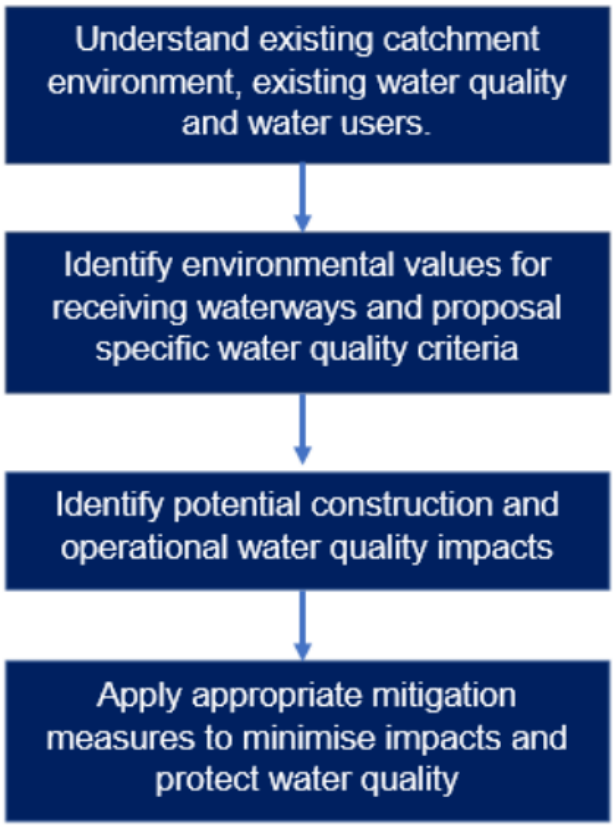

Figure 3-2 Water quality assessment methodology

3.2.1 Existing (baseline) water quality environment

Available water quality studies and assessments were reviewed to understand the baseline surface water quality conditions for this proposal. An overview of the existing baseline for each individual precinct is provided in Section 4.

A desktop assessment has been conducted to identify potential sensitive receiving environments, characterise the existing (baseline) environments and identify potential impacts of this proposal during construction and operation. This has included a review of existing literature on major project assessments and publicly available maps (including geological, topography, drainage and soil maps).

Site investigations for Sydney Metro West included the installation of groundwater monitoring infrastructure at 55 locations (46 groundwater monitoring wells, and 9 single vibrating-wire piezometers) between Westmead metro station and Hunter Street Station (Sydney CBD). The data collected from the monitoring infrastructure has been used to assess current groundwater conditions.

The ANZG (2018) guidelines provide the associated water quality indicators and guideline trigger values. While the guideline trigger values are adopted for this proposal, site specific water quality trigger values would be considered based on a monitoring program carried out during the pre-construction, construction and operational phases.

The NSW Water Quality and River Flow Objectives (NSW Department of Environment, Climate Change and Water, 2006) provide the guideline values for the Sydney Harbour and Parramatta River catchments and the tributary watercourses of these catchments (refer to Section 6).

A review of stream order classification has been carried out in accordance with Appendix 2 of the *Framework for Biodiversity Assessment* (FBA) (Office of Environment and Heritage, 2014) and stream order classifications have been identified in Section 4 for relevant watercourses.

3.2.2 Impact assessment

A qualitative assessment of the potential water quality impacts from this proposal has been carried out. This process has included:

- Understand baseline water quality conditions of the watercourses and catchments relevant to this proposal and the existing impacts to the surrounding environment. This has been completed through a review of existing water quality data gathered from the previous Sydney Metro West planning applications and available water quality literature, reports and assessments
- Review of the potential pollutants and impacts to the water quality environment from construction and operational activities
- Identification of the key water quality objectives (WQO's) in line with the NSW Water Quality and River Flow Objectives and the ANZG (2018) guidelines
- Development of the appropriate and feasible mitigation measures which can be readily implemented on site to minimise impacts to the water quality environment.

The impact assessment identifies potential impacts to water quality during operation of this proposal. At this stage the design of water quality and drainage infrastructure at the stations is not adequately progressed to allow for quantitative assessment of potential water quality impacts. Further design of this infrastructure would be carried out with consideration of the relevant pollutant reduction targets as outlined in relevant council, Transport for NSW, State and Commonwealth guidelines and legislation.

3.2.3 NSW Water Quality and River Flow Objectives

The *NSW Water Quality and River Flow Objectives* (NSW Department of Environment, Climate Change and Water, 2006), in line with the National Water Quality Management Strategy, provide a number of environmental objectives for Parramatta River and Sydney Harbour catchments, including aquatic ecosystems, visual amenity, primary contact recreation and secondary contact recreation. These objectives are consistent with the ANZG (2018) guidelines mentioned above. The default guideline values are used as a guideline for water quality discharge to maintain the water quality of the receiving surface water environments.

The *NSW Water Quality and River Flow Objectives* (NSW Department of Environment, Climate Change and Water, 2006) provide a number of environmental values for Sydney Harbour:

- Aquatic ecosystems - Maintaining or improving the ecological condition of waterbodies and their riparian zones over the long term
- Visual amenity – Aesthetic qualities of waters
- Primary contact recreation - Maintaining or improving water quality for activities such as swimming in which there is a high probability of water being swallowed
- Secondary contact recreation – Maintaining or improving water quality for activities such as boating and wading, where there is a low probability of water being swallowed
- Aquatic foods (cooked) - Protecting water quality so that it is suitable for the production of aquatic foods for human consumption and aquaculture activities.

Table 3-1 shows the environmental values assigned to the watercourses relevant to this proposal.

Table 3-1 Assigned environmental values for watercourses and receiving waters

	Environmental objective				
Watercourse and/or receiving waters	**Aquatic ecosystems**	**Visual amenity**	**Primary contact recreation**	**Secondary contact recreation**	**Aquatic foods (cooked)**
Domain Creek	●	●			
Clay Cliff Creek	●	●		●	
Duck River	●	●		●	
Haslams Creek	●	●		●	
Saleyards Creek		●		●	
Powells Creek	●	●			
St Lukes Park Canal	●	●			

Watercourse and/or receiving waters	Environmental objective Aquatic ecosystems	Visual amenity	Primary contact recreation	Secondary contact recreation	Aquatic foods (cooked)
Barnwell Park Canal	●	●			
Dobroyd Canal/ Iron Cove Creek	●	●			
White Bay	●	●	●	●	
Parramatta River and Sydney Harbour	●	●	●	●	●

3.2.4 Water quality mitigation and monitoring

The mitigation measures identified for construction and operation of this proposal aim to minimise and manage potential impacts to waterways. Potential surface water impacts during construction would be managed in accordance with Sydney Metro's Construction Environmental Management Framework, which describes the environmental management, monitoring and reporting approach during construction (Appendix F of this Environmental Impact Statement). Specifically, the Construction Environmental Management Framework outlines the requirements the construction contractor must address in developing the Construction Environmental Management Plan, sub-plans, and other supporting documents for each environmental aspect. Specific sub-plans outlined in the Construction Environmental Management Framework include:

- Soil and Water Management Plan
- Stormwater and Flooding Management Plan
- Progressive Erosion and Sediment Control Plan.

Key supporting guidelines to inform the development of these plans are:

- Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia, Handbook 7, Australian Institute for Disaster Resilience, 2017
- Managing Urban Stormwater – Soils and Construction, Landcom, 2004

Section 7.2 outlines a monitoring program focusing on the common water quality pollutants to assist construction and mitigation measures and complement existing historic data and monitoring programs.

In addition to management guidelines and requirements, other mitigation measures are identified for operation of this proposal to minimise and manage potential impacts to waterways. The mitigation measures focus on performance outcomes that would be used to inform design development of this proposal (refer to Section 7).

3.3 Assumptions, dependencies and constraints

3.3.1 Assumptions

The one per cent Annual Exceedance Probability flood event (1% AEP flood event) and the five per cent Annual Exceedance Probability flood event (5% AEP flood event) will incorporate allowances for climate change impacts including:

- Design for permanent infrastructure would incorporate allowance for climate change consistent with Representative Concentration Pathways (RCP) 8.5 in the year 2100. The RCP8.5 refers to the upper range projection of greenhouse gases concentrations in the atmosphere as adopted by the Intergovernmental Panel on Climate Change (IPCC) in 2014 for the assessment of climate change impacts
- Sea level rise of 0.9m over a period to 2100 (Westmead to the Bays and Sydney CBD Environmental Impact Statement Concept and Stage 1, Main Volume, Sydney Metro, 2020)
- Rainfall intensity uplift 21.3% in accordance with ARR2019.Climate change has been incorporated into the PMF event by applying elevated tailwater boundary conditions as appropriate.

Increases to rainfall intensity to reflect the impact of climate change have been derived from the approach outlined in ARR2019. The guidance for practitioners in ARR2019 on climate change considerations derives from a number of sources including the findings from the fifth assessment report of the Intergovernmental Panel on Climate Change. The Secretary's environmental assessment requirements refer to *Practical Consideration of Climate Change – Flood risk management guideline* (DECC, 2007) regarding flooding requirements which is based on findings associated with the fourth assessment report of the Intergovernmental Panel on Climate Change. Furthermore, the section on sensitivity analysis recommends scenarios for consideration as an interim measure until further research has been undertaken. Therefore, it is considered appropriate in this assessment to apply the approach outlined in ARR2019 to reflect the impact of climate change on rainfall intensities.

The Australian Rainfall and Runoff Datahub (ARR Datahub) was the source of hydrological modelling parameters. ARR Datahub produces a large list of hydrological input parameters. However, as they are linked to the geographical location and the date of access to the ARR Datahub, this information has been tabulated below to allow for reproducibility. The coordinates represent the station location, which are generally near the centroids of each catchment.

Table 3-2: Australian Rainfall and Runoff Datahub input parameters

Station/Facility	Latitude	Longitude	Access date
Westmead metro station	-33.808	150.988	January 2021
Parramatta metro station - Local Catchment	-33.818	151.009	April 2021
Parramatta metro station - River hydrographs	ARR1987. Hydrology is based on ARR1987, extracted from the MIKE11 one dimensional model. Refer Table 3-5 for further details.		

Station/Facility	Latitude	Longitude	Access date
Clyde stabling and maintenance facility and Rosehill services facility	ARR1987 Previously assessed as part of the Sydney Metro West Environmental Impact Statement – Westmead to The Bays and Sydney CBD (Sydney Metro, 2020a) – Technical Paper 9 Hydrology and Flooding.		
Sydney Olympic Park metro station	-33.849	151.07	March 2021
North Strathfield metro station	-33.863	151.08	February 2021
Burwood North Station	-33.868	151.104	May 2021
Five Dock Station	-33.868	151.138	February 2021
The Bays Station	-33.867	151.178	March 2021
Pyrmont Station	-33.869	151.192	June 2021
Hunter Street Station (Sydney CBD)	-33.855	151.216	June 2021

Table 3-3: Flood model and topographic source

Station/ Facility	Model	Topographic data sources
Westmead metro station	New Rain on grid hydrology within TUFLOW HPC - Uncalibrated	2019 LiDAR (Geoscience Australia), detailed survey. No design modelled surface topography representing the future design surface levels around the station is available. A grid size of 2 metres was adopted for the hydraulic model.
Parramatta metro station	Inflow hydrographs (for river) and Rain on grid (local catchments) hydrology within TUFLOW HPC {ARUP (2017), updated by Aurecon in 2020}	2013 LiDAR, detailed survey. Design modelled surface topography The local model, cut-down CBD model, was used to simulate the flooding conditions for the 5% AEP climate change and 1% AEP climate change flood events. A larger, regional model was used to simulate the PMF event. The grid sizes of these two models were 2 and 4 metres respectively

Station/ Facility	Model	Topographic data sources
Clyde stabling and maintenance facility and Rosehill services facility	Previously assessed as part of the Westmead to the Bays and Sydney CBD Environmental Impact Statement Concept and Stage 1, Technical Paper 9 Hydrology and Flooding (Sydney Metro, 2020a) and being managed in accordance with Conditions of Approval D10 and/or D11 of the previous Sydney Metro West planning application (CSSI 10038). (Refer Section 4.10.7 for more details)	
Sydney Olympic Park metro station	New DRAINS with New TUFLOW HPC - Uncalibrated	2019 LiDAR (Geoscience Australia), detailed survey. Station box blocked from floodwater as part of existing baseline scenario. Proposed station design and landscaping earthworks have been included in the developed case model. A grid size of 1 metre was adopted for the TUFLOW hydraulic model.
North Strathfield metro station	New DRAINS with New TUFLOW HPC - Uncalibrated	2019 LiDAR (Geoscience Australia), detailed survey. Station box blocked from floodwater as part of existing base case. Proposed station design and Queen Street road works have been included in the developed case model. A grid size of 1 metre was adopted for the TUFLOW hydraulic model.
Burwood North Station	DRAINS with Classic TUFLOW – updated to TUFLOW HPC	2013 LiDAR, detailed survey. No Design modelled surface topography. Assumed developed site is same watertight footprint as station box. A grid size of 2 metres was adopted for the TUFLOW hydraulic model.

Station/ Facility	Model	Topographic data sources
Five Dock Station	New DRAINS with New TUFLOW HPC – Uncalibrated	2020 LiDAR (Geoscience Australia), detailed survey. No Design modelled surface topography. Assumed developed site is same watertight footprint as station box. Developed site includes proposed changes to road design on Great North Road with the relocation of the existing pedestrian crossing and the inclusion of bus zones adjacent to the station entrance. A grid size of 1 metre was adopted for the TUFLOW hydraulic model.
The Bays Station	Rain on grid SOBEK model updated to TUFLOW HPC	2020 LiDAR (Geoscience Australia), detailed survey. 1D elements extracted from previously established SOBEK model. Proposed design modelled surface topography and drainage works have been incorporated on the site as part of the design. A grid size of 1 metre was adopted for the TUFLOW hydraulic model.
Pyrmont Station	Rain on grid within Classic TUFLOW – updated to TUFLOW HPC	2014 ALS (Airborne Laser Scanning). No Design modelled surface topography. Assumed developed site is same watertight footprint as station box. A grid size of 2 metre was adopted for the TUFLOW hydraulic model.
Hunter Street Station (Sydney CBD)	Rain on grid within Classic TUFLOW – updated to TUFLOW HPC	2014 ALS (Airborne Laser Scanning). No Design modelled surface topography. Assumed developed site is same watertight footprint as station box. A grid size of 2 metre was adopted for the TUFLOW hydraulic model.

Models for Hunter Street Station (Sydney CBD), Pyrmont Station, The Bays Station and Burwood North Station were updated to TUFLOW HPC in this study. TUFLOW's GPU-based HPC solver has superseded TUFLOW Classic as the industry standard software while also providing results which are acceptably close (Huxley et al, 2017). Further details on the SOBEK model conversion for The Bays Station is outlined in Appendix A of Technical Paper 9 (Hydrology and flooding) of the Sydney Metro West Environmental Impact Statement – Westmead to The Bays and Sydney CBD (Sydney Metro, 2020b).

All hydraulic model scenarios presented in Sections 4.1.7, 4.2.7, 4.3.7, 4.4.7, 4.5.7, 4.6.7, 4.7.7, 4.8.7, 4.9.7, 5.2.1, 5.2.2, 5.2.3, 5.2.4, 5.2.5, 5.2.6, 5.2.7, 5.2.8 and 5.2.9 assume vertical walls so that flood water cannot enter major excavations and underground works or the operational station arrangements. This represents the preferably passive or alternatively active flood mitigation arrangements which would be incorporated into the design of both permanent and selected temporary works to comply with the relevant system requirements specified for this proposal. Section 7.2 and Table 7-1 contain a corresponding mitigation measure (EIS-HF 1) to give effect to this assumption.

Further assessment would be undertaken as part of the design development, including the detailed design of site drainage systems and confirming the limits of any existing local stormwater capacity which the site drainage system interacts, within the context of relevant design criteria and approvals.

Further technical assumptions relating to modelling are included in the Risk Assumption Issue Dependency Opportunity and Constraint Register associated with this proposal.

3.3.2 Rainfall intensity sensitivity assessment

The Intensity Frequency Duration (IFD) design rainfall values, associated with ARR2019, is typically 20-30 per cent lower than for those associated with ARR1987 for some storm burst durations across the Sydney region (Rahman et al, 2017). Although the IFDs derived by Bureau of Meteorology in 2016 use a much larger and longer dataset than those from 1987 and support a broad-scale national approach, local factors may not be adequately represented (WMAwater, 2018). As indicated in Table 3-2, ARR2019 IFD data has been applied broadly across this proposal.

Sensitivity assessment has been undertaken in relation to the impact on flood assessment with the use of ARR1987 IFD data as further design being undertaken separately to this proposal indicates further consideration is warranted. Table 3-4 includes the difference between the ARR1987 and ARR2019 rainfall depths for the critical durations adopted at the North Strathfield metro station and The Bays Station. These stations were selected as their position both within and the relative size of their catchments differ from each other but are generally typical of the other stations in this proposal. The baseline scenario for this sensitivity assessment is the 1% AEP climate change flood event.

Table 3-4: Depth Comparison ARR1987 vs ARR2019

Station	Critical duration (mins)	ARR1987 increase in rainfall
North Strathfield metro station	10	5.3%
	20	9.8%
	180	35.7%
The Bays Station	15	6.9%
	45	17.6%

For North Strathfield metro station, the increase in rainfall was applied to the DRAINS model and the updated inflow hydrographs were simulated hydraulically for the baseline and “with proposal” case models. For The Bays Station model, the direct rainfall applied to the TUFLOW model was increased by the factor noted for the baseline and developed case models.

The water levels and hydraulic impact maps for both the ARR2019 and ARR1987 rainfall depths are included for the baseline and “with proposal” scenario in Appendix A – Baseline environment flood maps and Appendix B – “With Proposal” flood maps respectively.

The application of ARR1987 design rainfall depths when compared against the ARR2019 design rainfall values generally results in negligible change in hydraulic impacts across the model at North Strathfield metro station. Slightly larger increases occur in the area between the two construction sites which is an area that ponds under the baseline case due to the works associated with the flood wall at the existing station.

This is generally also the case at The Bays Station with increases up to approximately 0.1m in locations within the site that tend to pond, for example south of the station box. As the PMF event is the deciding event for design levels at this station this will have negligible influence on impacts presented later in this report.

For the purposes of the impact assessment, which is a comparison between two modelled surface topographies to understand the degree the proposal would affect other properties, application of ARR2019 design rainfall values should be adequate. This matter should be revisited at all sites so that detailed design of site drainage systems specifically consider the appropriateness of the applied Intensity Frequency Duration (IFD) data. Mitigation measure EIS-HF 1 in Table 7-1 would capture this action.

3.3.3 Dependencies

Table 3-5 summarises the available hydrological and hydraulic studies at each site used as part of this assessment. These references outline the calibration which has been applied to the associated models. For other models, there was inadequate information to develop a calibrated model. Parameters have been adopted in accordance with ARR2019.

Table 3-5: Sources of available data used for the hydrological and hydraulic assessment

Station/Facility	Data Sources
Westmead metro station	n/a
Parramatta metro station	Parramatta Light Rail Environmental Impact Statement Flooding Technical Paper (Arup, 2017)
Clyde stabling and maintenance facility and Rosehill services facility	Previous Sydney Metro West investigations and design
Sydney Olympic Park metro station	n/a
North Strathfield metro station	n/a

Station/Facility	Data Sources
Burwood North Station	Exile Bay, St Lukes and William Street Flood Study (WMAwater, 2019)
Five Dock Station	n/a
The Bays Station	Leichhardt Flood Study (Cardno, 2015) Leichhardt Floodplain Risk Management Study and Plan (Cardno, 2017)
Pyrmont Station	Darling Harbour Catchment Flood Study (BMT WBM, 2014b) Darling Harbour Catchment Floodplain Risk Management Study (WMA Water, 2016c) Darling Harbour Catchment Floodplain Risk Management Plan (WMA Water, 2016d)
Hunter Street Station (Sydney CBD)	City Area Catchment Flood Study (BMT WBM, 2014a) City Area Catchment Floodplain Risk Management Study (WMA Water, 2016a) City Area Catchment Floodplain Risk Management Plan (WMA Water, 2016b)

3.3.4 Constraints

Modelling and analysis has been undertaken on the basis of assumptions and dependencies listed above and within the context of the information available at the time of the assessment. The following constraints apply and should be noted in order to appreciate the context in which this information is presented:

- Modelling and analysis outlined in this report has been carried out based on the methodology previously outlined and in the context of the available information at the time of the assessment
- There is a degree of uncertainty associated with design flood estimation which derives from various sources including rainfall, streamflow and survey data quality and the mathematical simplification of the actual catchment processes
- A number of flooding and stormwater studies associated with this proposal are ongoing and may result in new or updated information, which may affect further outcomes of this assessment
- Assessment against the Secretary's environmental assessment requirements for both construction and operation phases have been undertaken in relation to elements that would be constructed under this proposal
- Assessment of impacts to emergency management arrangement against the Secretary's environmental assessment requirements excludes emergency management arrangements for private property such as major hazard facilities.

4 Baseline environment

This chapter describes the qualities of the existing (baseline) environment in the study area.

4.1 Westmead metro station

4.1.1 Topography and drainage

The Westmead metro station site is located near the ridge of the local catchment within a residential neighbourhood of the Cumberland Local Government Area. The station is located to the south of the existing rail line and would encompass what is currently a full residential block bounded by Hawkesbury Road, Alexandra Avenue, Bailey Street and Hassall Street. Hawkesbury Road, to the west of the site, is located on a local ridge and there is no significant catchment upstream of the site.

The local area is on sloping land which drains to the east, primarily through an underground stormwater system, into Domain Creek approximately 340 metres to the east of the site boundary and ultimately to Parramatta River.

The Westmead metro station site will have been subject to demolition and excavation as part of the work carried out under the previous Sydney Metro West planning application as indicated in Appendix D – Construction footprint. The existing pre-development elevations at the site range from 32-40.5 metres Australian Height Datum (AHD), with the floor level of the station box expected to be at about 38 metres AHD.

The local area is a combination of medium density residential buildings and roads.

4.1.2 Climate and rainfall

This site is located in Western Sydney, experiencing a temperate climate with a monthly average maximum temperature range of 17.5 to 28.6 degrees Celsius, and a monthly average minimum range of 6.2 to 17.7 degrees Celsius. Annual average rainfall total is 966 mm/year with the monthly variation as indicated in Figure 4-1 (Bureau of Meteorology, Parramatta North (Masons Drive)).

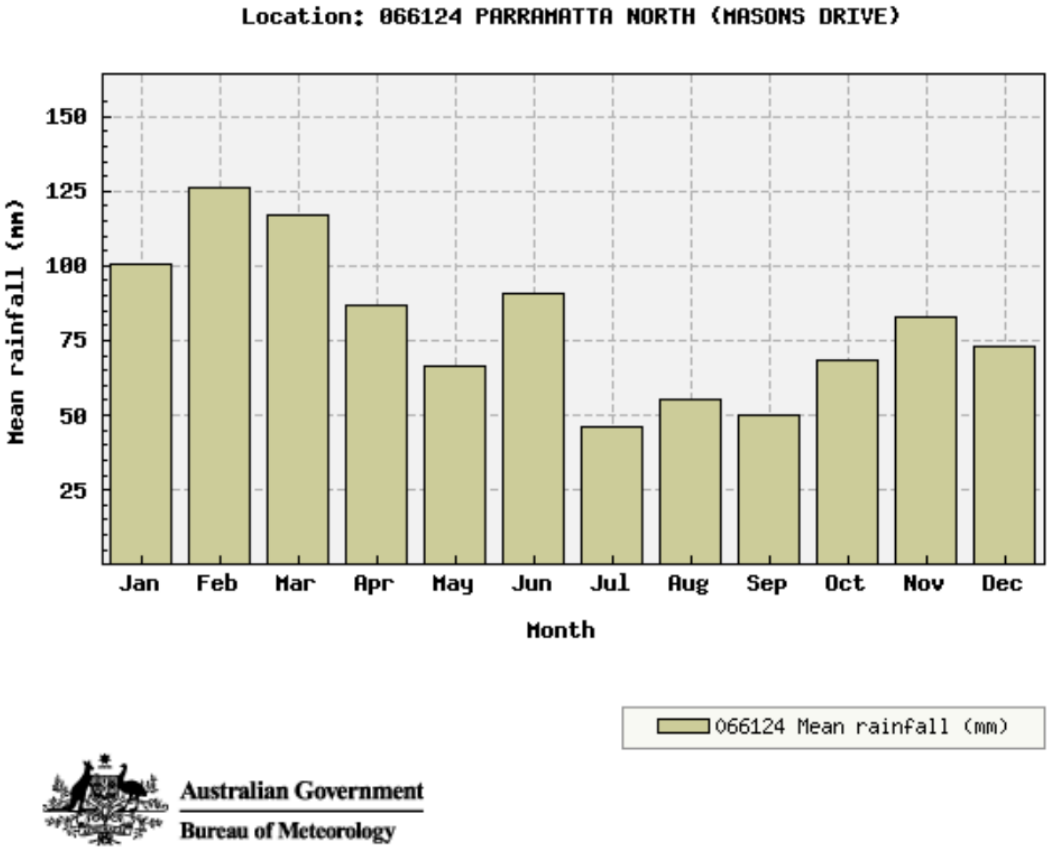

Figure 4-1 Monthly Rainfall Statistics Parramatta North (Masons Drive)

4.1.3 Acid sulfate soils

The Department of Planning, Industry and Environment acid sulfate soil risk data and mapping have been reviewed to assess the probability of acid sulfate soils being present across this proposal. The Westmead metro station site is located within areas where acid sulfate soils are unlikely to occur.

4.1.4 Groundwater interactions and groundwater quality

Interaction between groundwater and surface water along the alignment is generally expected to be limited to surface water infiltration contributing to groundwater, discharge from groundwater to surface watercourses and waterbodies (especially in low lying areas or deeply incised channels), and/or leakage from surface watercourses to groundwater (Sydney Metro, 2020a).

Previous investigations have identified the potential for groundwater in this area to be contaminated both within, and adjacent to the site footprint by hydrocarbons (total recoverable hydrocarbons; benzene, toluene, ethylbenzene, xylenes; polycyclic aromatic hydrocarbons) and volatile organic compounds. The potential contamination impact was assessed to be moderate for groundwater in this area (Sydney Metro, 2020c).

4.1.5 Catchment and watercourse health and receiving water quality

The Westmead metro station site is located to the south of Parramatta River catchment, with Parramatta River a main tributary of Sydney Harbour. This catchment is highly urbanised and altered from its natural state, with pockets of open spaces and parkland.

Three watercourses are located within 1.5 kilometres of Westmead metro station:

- Finlaysons Creek – Located about 1 kilometre west of Westmead metro station, this creek is a freshwater, first order watercourse (as per Appendix 2 of the FBA (OEH, 2014)) originating in South Wentworthville, flowing through residential areas and several parks. The majority of the creek is a modified and concrete lined channel with no instream aquatic habitat, and as such is not mapped as Key Fish Habitat
- Toongabbie Creek – Defined as a second order stream (as per Appendix 2 of the FBA (OEH, 2014)). It is located about 1 kilometre north of Westmead metro station, this creek is an urban creek in the upper Parramatta River catchment. The creek drains a heavily urbanised and industrialised catchment and water quality is influenced by diffuse sources of pollution including stormwater runoff and wastewater overflows in addition to the inflows from its tributaries. The waterway is mapped as Key Fish Habitat (Type 2 – Moderately Sensitive Key Fish Habitat) and is classified as Class 1 (major key fish habitat) as it is permanently flowing with suitable aquatic habitat features
- Domain Creek – The tunnels pass under Domain Creek approximately 25 metres below ground, 200 metres from the confluence with the Parramatta River, and 450 metres from the Westmead metro station. The Westmead metro station site is around 300 metres west of Domain Creek. Construction water treatment plant discharges would ultimately discharge to Domain Creek via the local stormwater network. Domain Creek is a freshwater, first order watercourse (as per Appendix 2 of the FBA (OEH, 2014)) and is a modified watercourse with sections of naturalised channel. Domain Creek is not mapped as Key Fish Habitat. However, it is classified as Class 1 (major key fish habitat) as it is permanently flowing.

The watercourses and catchments associated with this proposal are influenced by several factors including:

- Current and historical polluting land uses within the catchments
- Stormwater and sewage overflows and leachate from contaminated and/or reclaimed land
- Urbanisation of the catchments and subsequent reduction in permeable area, increasing run-off and pollutant loads entering waterways
- Illegal dumping.

A review of available data indicates the watercourses relevant to this proposal are generally in poor condition and are representative of a heavily urbanised system (Sydney Metro, 2020). Prior to this proposal, work carried out under the previous Sydney Metro West planning application will be undertaken at the Westmead metro station. This includes the installation of a temporary construction water treatment plant which will discharge treated water to Domain Creek via the local stormwater network. The water treatment plant would be configured so that treated water is compliant with the ANZG (2018) guideline values.

Table 4-1 identified the watercourses to which discharged water would be released during construction of this proposal. These watercourses have been assessed against the ANZG guidelines as part of the *Sydney Metro West Environmental Impact Statement – Westmead to The Bays and Sydney CBD* (Sydney Metro, 2020). The Water Quality and River Flow Objectives environmental values for the receiving waters are provided in Table 3-1, Section 3.2.3 of this assessment.

Table 4-1: Existing water quality conditions of watercourses relevant to Westmead Metro Station

Site	Watercourse	Water quality characteristics relevant to ANZECC/ARMCANZ (2000) indicators
Westmead metro station	Parramatta River	Elevated nutrient concentrations Elevated heavy metal concentrations High turbidity
	Domain Creek	Low dissolved oxygen levels Elevated nutrient concentrations

4.1.6 Sensitive receiving environments and wetlands

Waterways and water bodies have been identified as receiving environments of high sensitivity predominantly due to key fish habitat classification, Type 1 (highly sensitive Key Fish Habitat), Type 2 (moderately sensitive key fish habitat) and Class 1 (major key fish habitat), and/or proximity to coastal wetlands as defined by the coastal management SEPP. These watercourses have a high conservation or community value or support ecosystems or human uses of water that are particularly sensitive to pollution or degradation of water quality.

Table 4-2 identifies sensitive surface water receiving environments specific to the Westmead metro station site and describes their condition and sensitivity (Sydney Metro, 2020d).

Table 4-2: Sensitive surface water receiving environments at Westmead metro station

Watercourse	Surface water features	Condition	Sensitive receiving environment rating
Domain Creek	• Modified channel, with no SEPP Coastal Wetlands within 0.5 kilometres • First order waterway	Highly disturbed	Low

Watercourse	Surface water features	Condition	Sensitive receiving environment rating
Parramatta River	• Numerous SEPP Coastal Wetlands. • Potential habitat for threatened aquatic species and protected aquatic vegetation • Type 1 Key Fish Habitat • Fourth order waterway • Permanently flowing	Moderately disturbed	High

4.1.7 Baseline flooding conditions

Baseline flood depth and hazard maps from modelling of this proposal are included in Appendix A – Baseline environment flood maps. They indicate that flooding conditions at the Westmead metro station are as follows:

- The site is affected by shallow ponding and flooding from the rainfall falling on the site in the 5% AEP climate change and 1% AEP climate change flood events, however there is no significant conveyance through the site. In both cases, the ponding is isolated and located at the outer extents of the site.
- The existing area is affected by shallow sheet flow across the site from the direct rainfall and small areas of discharge onto the site from Bailey Street and Hawkesbury Road. Alexandra Avenue discharges much of the overland flow along the kerb and gutter drainage to the west along the northern portion of the site. The stormwater in Alexandra Avenue extends into the residential areas on the proposed site in the PMF event. Existing flood depths in the adjacent roads of Bailey Street, Hassall Street and Hawksbury Road are shallow at less than 0.1 metres in the 1% AEP climate change flood event and the PMF event. In the 5% AEP climate change flood event, the surrounding roads appear to have shallow gutter flow up to 0.05 metres. For all three flood events the verge at the intersection of Alexandra Avenue and Hassall Street shows depths of up to 0.2 metres, this is expected to be resolved once updated design modelled surface topography are available as the design progresses for inclusion in the TUFLOW model
- The station box is protected from inundation as outlined in Section 3.3.1
- The area is primarily classified as H1 hazard in the 5% AEP climate change and 1% AEP climate change flood events which is accepted as safe for people, vehicles and buildings. Small, localised areas typically on the roads excluding Hawkesbury Road show increasing hazard category up to H5. Access and evacuation routes are readily available via the adjacent streets. In the PMF event, the hazard along streets adjacent to the site increases to H5, with small, localised areas with a hazard of H6. Evacuation from the site can be undertaken via Hawkesbury Road, with low flood hazard (H1). Park Parade, Hassall and Bailey Streets between Hassall Street and the parkland would experience high hazard flows across the full width.

Private property impacts would be anticipated in the baseline PMF event for properties bounded by Priddle, Bailey and Hassall Streets, Alexandra Avenue and Park Parade and the parkland previously known as the Parramatta Golf Course.

Nearby educational facilities are predominantly outside of the catchment area of Westmead metro station as they are on the other side of Hawkesbury Road which is located generally along a ridge line (higher point).

4.2 Parramatta metro station

4.2.1 Topography and drainage

The Parramatta metro station site is located on a local high point within the Parramatta River floodplain and is in the City of Parramatta Local Government Area. The site is about 300 metres to the south of the Parramatta River just downstream of the Charles Street weir. The site and surrounding area are subject to mainstream flooding during rare and extreme flood events from the Parramatta River which has an upstream catchment area of about 110 square kilometres. The site is also subject to minor local catchment overland flooding. The main flooding constraint on the site and the surrounding area is related to mainstream flooding during rare flood events. Horwood Place runs through the site and may act as a flood flow path at the existing site in these large flood events.

The Parramatta metro station site will have been subject to demolition and excavation as part of the work carried out under the previous Sydney Metro West planning application as indicated in Appendix D – Construction footprint. Existing pre-development site elevations range from 9.0 metres AHD to 11.1 metres AHD.

4.2.2 Climate and rainfall

This site is located in Western Sydney, experiencing a temperate climate with a monthly average maximum temperature range of 17.5 to 28.6 degrees Celsius, and a monthly average minimum range of 6.2 to 17.7 degrees Celsius. Annual average rainfall total is 966 mm/year with the monthly variation as indicated in Figure 4-1 (Bureau of Meteorology, Parramatta North (Masons Drive)).

4.2.3 Acid sulfate soils

The Department of Planning, Industry and Environment acid sulfate soil risk data and mapping have been reviewed to assess the probability of acid sulfate soils being present. The Parramatta metro station site is located within areas which are considered to be disturbed, and where acid sulfate soils has the potential to occur due to its proximity to Parramatta River (Sydney Metro, 2020a).

It was identified in Technical Paper 7 Hydrogeology of the Sydney Metro West Environment Impact Statement – Westmead to The Bays and Sydney CBD (Sydney Metro, 2020a) that up to 23 metres of groundwater level drawdown is estimated in the area of the disturbed soil and that it is possible that excavation of the station box as part of the work carried out under the previous Sydney Metro West planning application could cause oxidation of potential acid sulfate soils in the area if they are present. This risk is considered to be low.

4.2.4 Groundwater interactions and groundwater quality

Interaction between groundwater and surface water along the alignment is generally expected to be limited to surface water infiltration contributing to groundwater, discharge from groundwater to surface watercourses and waterbodies (especially in low lying areas or deeply incised channels), and/or leakage from surface watercourses to groundwater (Sydney Metro, 2020a).

Previous investigations have identified the potential for groundwater in this area to be contaminated both within, and adjacent to the site footprint by hydrocarbons (total recoverable hydrocarbons; benzene, toluene, ethylbenzene, xylenes; polycyclic aromatic hydrocarbons) and Volatile organic compounds. The potential contamination impact was assessed to be moderate for groundwater associated with this area (Sydney Metro, 2020c).

4.2.5 Catchment and watercourse health and receiving water quality

The Parramatta metro station site is located to the south of Parramatta River catchment, with Parramatta River a main tributary of Sydney Harbour. This catchment is highly urbanised and altered from its natural state, with pockets of open spaces and parkland.

Two watercourses are located within 1.5 kilometres of the Parramatta metro station site:

- Clay Cliff Creek – Located 1.5 kilometres from Parramatta metro station site, this creek is a highly modified second order watercourse (as per Appendix 2 of the FBA (OEH, 2014)) that discharges into Parramatta River. Clay Cliff Creek is a concrete lined channel, contains no instream habitat, and is not mapped as Key Fish Habitat (classified as Class 4 (unlikely key fish habitat)). A coastal wetland listed under the Coastal Management SEPP is located downstream along the banks of the Parramatta River at the confluence with Clay Cliff Creek.
- Parramatta River – Located 300 metres from Parramatta metro station site, Parramatta River is the main tributary of Sydney Harbour and is defined as a fourth order watercourse as per Appendix 2 of the FBA (OEH, 2014). The water quality is dominated by catchment inputs, including stormwater and wastewater overflow resulting in elevated levels of nutrients and pollutants mapped as Key Fish Habitat (Type 1 – Highly sensitive Key Fish Habitat) and is classified as Class 1 (major key fish habitat) as it is a permanently flowing river.

The watercourses and catchments associated with this proposal are influenced by several factors including:

- Current and historical polluting land uses within the catchments
- Stormwater and sewage overflows and leachate from contaminated and/or reclaimed land
- Urbanisation of the catchments and subsequent reduction in permeable area, increasing run-off and pollutant loads entering waterways
- Illegal dumping.

Prior to this proposal, work carried out under the previous Sydney Metro West planning application will be undertaken at the Parramatta metro. This includes the installation of a temporary construction water treatment plant at Parramatta metro station site which will discharge treated water to Parramatta River via the local stormwater network. The water treatment plant would be configured so that treated water is compliant with the ANZG (2018) guideline values. The water treatment plant will be present at the commencement of construction of this proposal.

A review of available data indicates the watercourses relevant to this proposal are generally in poor condition and are representative of a heavily urbanised system (Sydney Metro, 2020). The watercourses which discharged water will be released to from the Parramatta metro station temporary water treatment plant has been assessed against the ANZG guidelines as part of the previous Sydney Metro West planning application is provided in Table 4-3. The Water Quality and River Flow Objectives environmental values for the receiving waters are provided in Table 3-1, Section 3.2.3 of this assessment.

Table 4-3: Existing water quality conditions of watercourses relevant to Parramatta metro station

Site	Watercourse	Water quality characteristics relevant to ANZECC/ARMCANZ (2000) indicators
Parramatta metro station	Parramatta River	• Elevated nutrient concentrations • Elevated heavy metal concentrations • High turbidity

4.2.6 Sensitive receiving environments and wetlands

Waterways and water bodies have been identified as receiving environments of high sensitivity predominantly due to key fish habitat classification, Type 1 (highly sensitive Key Fish Habitat), Type 2 (moderately sensitive key fish habitat) and Class 1 (major key fish habitat), and/or proximity to coastal wetlands as defined by the coastal management SEPP. These watercourses have a high conservation or community value or support ecosystems or human uses of water that are particularly sensitive to pollution or degradation of water quality.

Table 4-4 identifies sensitive surface water receiving environments specific to Parramatta Metro Station site and describes their condition and sensitivity (Sydney Metro, 2020d).

Table 4-4: Sensitive surface water receiving environments at Parramatta metro station site

Water course	Surface water features	Condition	Sensitive receiving environment rating
Parramatta River	Numerous SEPP Coastal Wetlands. Potential habitat for threatened aquatic species and protected aquatic vegetation Type 1 Key Fish Habitat Fourth order waterway Permanently flowing	Moderately disturbed	High

4.2.7 Baseline flooding conditions

Baseline flood depth and hazard maps from modelling of this proposal are included in Appendix A – Baseline environment flood maps. They indicate that flooding conditions at the Parramatta metro station are as follows:

- The site is affected by shallow ponding and flooding from the rainfall falling on the site in the 5% AEP climate change and 1% AEP climate change flood events, however there is no significant conveyance through the site. In both cases, the ponding is isolated and located at the outer extents of the site.
- In the PMF event, the site is inundated by floodwaters from both local and the Parramatta River catchments causing a maximum flood depth in excess of one metre with the exception of the station box which is protected from inundation as outlined in Section 3.3.1. This produces a flood level of between 10.5 metres AHD to the east of the site where George Street joins Smith Street and 12.5 metres AHD to the west of the site where Macquarie Street joins Church Street.
- Flood hazard is low in the 5% AEP climate change and 1% AEP climate change flood events, with the local stormwater drainage along the streets adjacent to the site being H2 or lower. Evacuation from the site is readily available via all adjacent streets. In the PMF event, the flood hazard is extreme, with areas of H5 and H6 adjacent to the site
- Evacuation is readily available in the 5% AEP climate change and 1% AEP climate change flood events via all adjacent streets. There are no evacuation routes available in the PMF event as all adjacent streets are inundated.

A number of educational facilities and childcare centres are located within the vicinity including Parramatta Public School, Arthur Phillip High School and Reggio Emilia Early Learning Childcare. The schools are located to the east on Macquarie Street in an elevated area which is outside of the PMF extents. The childcare centre is located at Level 1 100 George Street. At ground level in the PMF event, George Street would already experience some inundation that would likely already affect access to and from the building. Horwood Place is closed due to work required as part of the previous Sydney Metro West planning application and therefore the public would have limited access, including during a flood emergency for any potential horizontal evacuation.

4.3 Sydney Olympic Park metro station

4.3.1 Topography and drainage

The Sydney Olympic Park metro station site is located at the centre of the Olympic Park precinct and is bounded by Figtree Drive, Olympic Boulevard, and Herb Elliot Avenue. The local area is a combination of mixed use residential buildings, parkland, roads, and carparks. The site is located in the City of Parramatta Local Government Area. The site is located at a local highpoint within the Olympic Park precinct with stormwater flowing towards each of the bounding roads under existing conditions. Elevations within the site range from 16-25 metres AHD. There is a comprehensive underground stormwater system that drains the area.

Sydney Olympic Park metro station will have been subject to demolition and excavation as part of the work carried out under the previous Sydney Metro West planning application as indicated in Appendix D – Construction footprint.

4.3.2 Climate and rainfall

This site is located in central Sydney, experiencing a temperate climate with a monthly average maximum temperature range of 17.6 to 28.1 degrees Celsius, and a monthly average minimum range of 7.8 to 19.4 degrees Celsius. Annual average rainfall total is 911.8 mm/year with the monthly variation as indicated in Figure 4-2 (Bureau of Meteorology, Sydney Olympic Park).

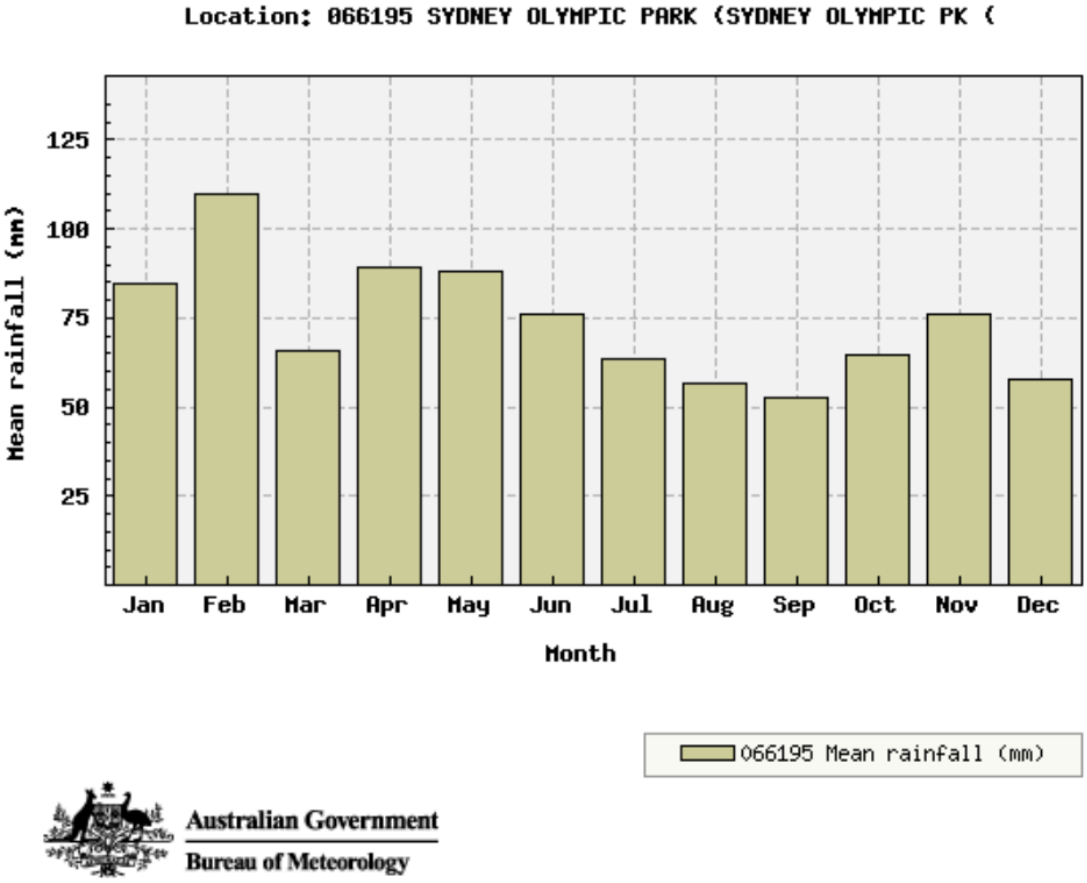

Figure 4-2 Monthly Rainfall Statistics Sydney Olympic Park

4.3.3 Acid sulfate soils

The Department of Planning, Industry and Environment acid sulfate soil risk data and mapping have been reviewed to assess the probability of acid sulfate soils being present across this proposal. acid sulfate soils were not identified in the area of Sydney Olympic Park metro station site. However, disturbed soils have been identified within this area (Sydney Metro, 2020a).

It was identified in Technical Paper 7 Hydrogeology of the Sydney Metro West Environment Impact Statement – Westmead to The Bays and Sydney CBD (Sydney Metro, 2020a) that up to four metres of groundwater level drawdown is estimated in the area of the disturbed soil and that it is possible that the work carried out under the previous Sydney Metro West planning application could cause oxidation of potential acid sulfate soils in the area if they are present. This risk is considered to be low.

4.3.4 Groundwater interactions and groundwater quality

Interaction between groundwater and surface water along the alignment is generally expected to be limited to surface water infiltration contributing to groundwater, discharge from groundwater to surface watercourses and waterbodies (especially in low lying areas or deeply incised channels), and/or leakage from surface watercourses to groundwater (Sydney Metro, 2020a).

Previous investigations have identified the potential for groundwater to be contaminated with nutrients, metals, hydrocarbons, volatile organic compounds, perfluorooctanesulfonic acid, asbestos and landfill gas. The potential contamination impact was assessed to be moderate to high for this area (Sydney Metro, 2020c).

4.3.5 Catchment and watercourse health and receiving water quality

Sydney Olympic Park metro station site is located to the south of Parramatta River catchment, with Parramatta River a main tributary of Sydney Harbour. This catchment is highly urbanised and altered from its natural state, with pockets of open spaces and parkland.

Four watercourses are located within 1.5 kilometres of Sydney Olympic Park metro station:

- Haslams Creek – Located about 900 metres east of Sydney Olympic Park metro station, this creek is a highly modified third order watercourse (as per Appendix 2 of the FBA (OEH, 2014)) which drains into the Parramatta River at Homebush Bay. Construction water treatment plant discharges would discharge to Haslams Creek from the Sydney Olympic Park metro station via the local stormwater network. The catchment of Haslams Creek is highly urbanised (including the M4 Motorway) with the upper extents generally concrete lined opened channels and pipes. Haslams Creek is mapped as Key Fish Habitat and is classified as Type 1 (Key Fish Habitat). It is also classified as Class 1 (major key fish habitat) as it is a permanently flowing river
- Powells Creek – Located 1.1 kilometres east of Sydney Olympic Park metro station, this creek is a concrete lined first order drainage channel (as per Appendix 2 of the FBA (OEH, 2014)), which becomes semi-naturalised downstream. The construction water treatment plant discharges would discharge to Powells Creek via the local stormwater network from the North Strathfield metro station. The Powells Creek catchment includes residential and recreational land uses including Bicentennial Park and Sydney Olympic Park. Powells Creek is mapped as Key Fish Habitat and is classified as Type 1 (Key Fish Habitat). It is also classified as Class 1 (major key fish habitat) as it is a permanently flowing river
- Salesyard Creek – Located about 350 metres from Sydney Olympic Park metro station, this creek is a highly modified first order watercourse (as per Appendix 2 of the FBA (OEH, 2014)) which is a concrete lined channel and contains minimal instream habitat. It is mapped as Key Fish Habitat, however given the creek is a first order stream and a concrete lined channel which contains little instream habitat, it is not considered Key Fish Habitat and is classified as Class 3 (minimal key fish habitat)
- Bicentennial Park Wetlands and Newington Wetlands – Located approximately 1.2 kilometres and 1.5 kilometres from Sydney Olympic Park metro station respectively, these two wetlands are the only Nationally Important Wetlands within

close proximity to this proposal. However, these wetlands are unlikely to be impacted. Whilst a large number of estuarine habitats have been lost due to the development of the foreshores, significant stands of mangroves still exist and nationally significant wetlands remain in Bicentennial Park and Newington Nature Reserve Wetland (Cardno, 2012).

The watercourses and catchments associated with this proposal are influenced by several factors including:

- Current and historical polluting land uses within the catchments
- Stormwater and sewage overflows and leachate from contaminated and/or reclaimed land
- Urbanisation of the catchments and subsequent reduction in permeable area, increasing run-off and pollutant loads entering waterways
- Illegal dumping.

Prior to this proposal, work carried out under the previous Sydney Metro West planning application will be undertaken at the Sydney Olympic Park metro station. This includes the installation of a temporary construction water treatment plant at Sydney Olympic Park metro station site which will discharge treated water to Haslams Creek via the local stormwater network. The water treatment plant would be configured so that treated water is compliant with the ANZG (2018) guideline values. The water treatment plant will be present at the commencement of construction of this proposal.

A review of available data indicates the watercourses relevant to this proposal are generally in poor condition and are representative of a heavily urbanised system (Sydney Metro, 2020). The watercourses which discharged water will be released to from the Sydney Olympic Park metro station temporary water treatment plant has been assessed against the ANZG guidelines as part of the previous Sydney Metro West planning application is provided in Table 4-5. The Water Quality and River Flow Objectives environmental values for the receiving waters are provided in Table 3-1, Section 3.2.3 of this assessment.

Table 4-5: Existing water quality conditions of watercourses relevant to Sydney Olympic Park metro station

Site	Watercourse	Water quality characteristics relevant to ANZECC/ARMCANZ (2000) indicators
Sydney Olympic Park metro station site	Haslams Creek	• Elevated nutrient concentrations • Elevated concentrations of faecal coliforms

4.3.6 Sensitive receiving environments and wetlands

Waterways and water bodies have been identified as receiving environments of high sensitivity predominantly due to key fish habitat classification, Type 1 (highly sensitive Key Fish Habitat), Type 2 (moderately sensitive key fish habitat) and Class 1 (major key fish habitat), and/or proximity to coastal wetlands as defined by the coastal management SEPP. These watercourses have a high conservation or community value or support ecosystems or human uses of water that are particularly sensitive to pollution or degradation of water quality. Table 4-6 identifies sensitive surface water receiving environments specific to Sydney Olympic Park metro station and describes their condition and sensitivity (Sydney Metro, 2020d).

Table 4-6: Sensitive surface water receiving environments at Sydney Olympic Park metro station

Watercourse	Surface water features	Condition	Sensitive receiving environment rating
Haslams Creek	Type 1 Key Fish Habitat SEPP Coastal Wetlands within 0.5 km Third order waterway	Moderately disturbed	High
Bicentennial Park Wetlands	Rehabilitated wetland/Nature Reserve SEPP Coastal Wetlands within 0.5 kilometres	Moderately disturbed	High
Salesyard Creek	Type 1 Key Fish Habitat SEPP Coastal Wetlands within 0.5 kilometres First order waterway Concrete-lined channel	Highly disturbed	Moderate
Powells Creek Mason Park Wetland	Highly modified channel with limited aquatic habitat SEPP Coastal wetlands within 0.5 kilometres First order waterway Permanently flowing Estuarine with tidal limit 0.1 kilometres upstream of Allen Street Bridge, Homebush	Moderately disturbed	Moderate

4.3.7 Baseline flooding conditions

The existing site is located on a local highpoint with the site primarily grading towards the north and experiences limited on site flooding. Drainage in the area is primarily confined to the kerb and gutter and the underground stormwater system.

Baseline flood depth and hazard maps from modelling of this proposal are included in Appendix A – Baseline environment flood maps. They indicate that flooding conditions at Sydney Olympic Park metro station are as follows:

- Discharge from the site is primarily north towards Herb Elliott Avenue, flowing over the road and continuing north along Showground Road. In Herb Elliott Avenue to the north of the site there is local ponding near the intersection with Showground Road. Flood depths of up to approximately 0.3 metres would be experienced in the 1% AEP climate change flood event. In the PMF event, this increases to 0.45 metres.
- Discharge into Figtree Drive at the south of the site leads to flooding within the roadway, which is generally confined to the kerb and gutter drainage in the 5% AEP climate change flood event. In the 1% AEP climate change flood event, the flood increases marginally with flood depths of up to approximately 0.13 metres within the road. In the PMF event, the flooding overtops the Figtree Road kerbs and flows to the south. Flood depths in the PMF event on the road are up to 0.31 metres. A small portion at the west of the site discharges toward Olympic Boulevard which contributes to the minor flooding within the kerb and gutter drainage on the roadway.
- The station box is protected from inundation as outlined in Section 3.3.1
- Flood hazard in the area of the site and the adjacent streets in the 5% AEP climate change and 1% AEP climate change flood events is generally low, with the area predominantly in the H1 category. There are localised areas of H2 to H5 to the north of the site on Showground Road within the kerb, which is due to the high flow velocity in excess of 2 metres per second. In the PMF event, there are localised areas of high hazard with a category of H5, primarily due to high velocity. The full width of Showground Road is H5 category in the PMF event
- Access and evacuation from the site is generally safe, with only localised areas with high flow velocity which would be unsafe for pedestrians and vehicles. Showground Road would not be suitable for access or evacuation during the PMF event due to the high hazard.
- The NSW State Health Emergency Operations Centre is located to the east of the Sydney Olympic Park metro station construction site on the opposite side of Herb Elliott Avenue. Vehicular access for emergency support vehicles to and from the NSW State Health Emergency Operations Centre may be affected by flooding in Herb Elliott Avenue in the baseline PMF event.

4.4 North Strathfield metro station

4.4.1 Topography and drainage

North Strathfield metro station site is located on the downstream slope of an area with several small overland flow paths draining the residential area to the east of the site. The local area is primarily medium density residential, with a small commercial district adjacent to the existing station. The site is located within the City of Canada Bay Local Government Area and is adjacent to the existing North Strathfield Station on the T9 Northern Line. The existing pre-development elevations at the site range from 14 to 20 metres AHD. The North Strathfield metro station will be located on the western slope of a local ridge with minor local overland flow paths near the north and south extents of the proposed site. The overland flow that discharges towards the existing station is captured and conveyed to an open drain on the upstream, western side of the existing rail line, which flows to the south and ultimately into Powells Creek. The natural catchment boundary is situated 200 metres to the east.

North Strathfield metro station northern site will have been subject to demolition and excavation as part of the work carried out under the previous Sydney Metro West planning application as indicated in Appendix D – Construction footprint.

4.4.2 Climate and rainfall

This site is located in central Sydney, experiencing a temperate climate with a monthly average maximum temperature range of 17.6 to 28.1 degrees Celsius, and a monthly average minimum range of 7.8 to 19.4 degrees Celsius. Annual average rainfall total is 911.8 mm/year with the monthly variation as indicated in Figure 4-2 (Bureau of Meteorology, Sydney Olympic Park).

4.4.3 Acid sulfate soils

The Department of Planning, Industry and Environment acid sulfate soil risk data and mapping have been reviewed to assess the probability of acid sulfate soils being present across this proposal. acid sulfate soils were not identified in the area of the North Strathfield metro station. However, disturbed soils have been identified within this area (Sydney Metro, 2020a).

It was identified in Technical Paper 7 Hydrogeology of the Sydney Metro West Environment Impact Statement – Westmead to The Bays and Sydney CBD (Sydney Metro, 2020a) that up to two meters of groundwater level drawdown has been estimated to the west of the site and that it is possible that the work carried out under the previous Sydney Metro West planning application could cause oxidation of potential acid sulfate soils in the area if they are present. This risk is considered to be low.

4.4.4 Groundwater interactions and groundwater quality

Interaction between groundwater and surface water along the alignment is generally expected to be limited to surface water infiltration contributing to groundwater, discharge from groundwater to surface watercourses and waterbodies (especially in low lying areas or deeply incised channels), and/or leakage from surface watercourses to groundwater (Sydney Metro, 2020a).

Previous investigations have identified the potential for groundwater to be contaminated with heavy metals, hydrocarbons, volatile organic compounds, surfactants, and perfluorooctanesulfonic acid. The potential contamination impact was assessed to be moderate for this area (Sydney Metro, 2020c).

4.4.5 Catchment and watercourse health and receiving water quality

The North Strathfield metro station site is located to the south of Parramatta River catchment, with Parramatta River a main tributary of Sydney Harbour. This catchment is highly urbanised and altered from its natural state, with pockets of open spaces and parkland.

Two watercourses are located within 1.5 kilometres of the North Strathfield metro station site:

- Powells Creek – located about 400 metres from North Strathfield metro station, this creek is a concrete lined first order drainage channel (as per Appendix 2 of the FBA (OEH, 2014)), which becomes semi-naturalised downstream and the temporary construction water treatment plant discharges would discharge to Powells Creek via the local stormwater network from the North Strathfield metro station. The Powells Creek catchment includes residential and recreational land uses including Bicentennial Park and Sydney Olympic Park. Powells Creek is mapped as Key Fish Habitat and is classified as Type 1 (Key Fish Habitat). It is also classified as Class 1 (major key fish habitat) as it is a permanently flowing river
- Saltwater Creek - a concrete lined canal located approximately 1.5 kilometres north-east of the North Strathfield metro station that discharges to Exile Bay at Concord. This creek is defined as a first order creek (as per Appendix 2 of the FBA (OEH, 2014)).

The watercourses and catchments associated with this proposal are influenced by several factors including:

- Current and historical polluting land uses within the catchments
- Stormwater and sewage overflows and leachate from contaminated and/or reclaimed land
- Urbanisation of the catchments and subsequent reduction in permeable area, increasing run-off and pollutant loads entering waterways
- Illegal dumping.

Prior to this proposal, work carried out under the previous Sydney Metro West planning application will be undertaken at the North Strathfield metro station. This includes the installation of a temporary construction water treatment plant at North Strathfield metro station site which will discharge treated water to Powells Creek via the local stormwater network. The water treatment plant would be configured so that treated water is compliant with the ANZG (2018) guideline values. This water treatment plant will be present at the commencement of construction of this proposal.

A review of available data indicates the watercourses relevant to this proposal are generally in poor condition and are representative of a heavily urbanised system (Sydney Metro, 2020). The watercourses which discharged water will be released to from the North Strathfield metro station temporary water treatment plant have been assessed against the ANZG guidelines as part of the previous Sydney Metro West planning application is provided in Table 4-7. The Water Quality and River Flow Objectives environmental values for the receiving waters are provided in Table 3-1, Section 3.2.3 of this assessment.

Table 4-7: Existing water quality conditions of watercourses relevant to North Strathfield metro station

Site	Watercourse	Water quality characteristics relevant to ANZECC/ARMCANZ (2000) indicators
North Strathfield metro station	Powells Creek	• Low dissolved oxygen levels • Elevated nutrient concentrations • Elevated heavy metal concentrations • High turbidity

4.4.6 Sensitive receiving environments and wetlands

Waterways and water bodies have been identified as receiving environments of high sensitivity predominantly due to key fish habitat classification, Type 1 (highly sensitive Key Fish Habitat), Type 2 (moderately sensitive key fish habitat) and Class 1 (major key fish habitat), and/or proximity to coastal wetlands as defined by the coastal management SEPP. These watercourses have a high conservation or community value or support ecosystems or human uses of water that are particularly sensitive to pollution or degradation of water quality.

Table 4-8 identifies sensitive surface water receiving environments specific to the North Strathfield metro station and describes their condition and sensitivity (Sydney Metro, 2020d).

Table 4-8: Sensitive surface water receiving environments at North Strathfield metro station

Watercourse	Surface water features	Condition	Sensitive receiving environment rating
Powells Creek Mason Park Wetland	Highly modified channel with limited aquatic habitat SEPP Coastal wetlands within 0.5 kilometres First order waterway Permanently flowing Estuarine with tidal limit 0.1 kilometres upstream of Allen Street Bridge, Homebush	Moderately disturbed	Moderate

4.4.7 Baseline flooding conditions

There are several construction sites at the North Strathfield metro station. These sites are affected by minor overland flows from the local catchments to the east. Flows from the catchment are generally contained in the road and trapped sag points in Queen Street. On the northern end of largest site, there are two trapped sag points at the corner of Beronga Street and Queen Street. On the southern side of the northern construction site near the intersection of Wellbank Street and Queen Street, there is a

substantial drainage system to capture the trapped water caused by the flood protection wall for the existing North Strathfield rail underpass.

Baseline flood depth and hazard maps from modelling of this proposal are included in Appendix A – Baseline environment flood maps. They indicate that flooding conditions at North Strathfield metro station are as follows:

- Overland flows from Waratah Street contribute to flooding in Queen Street. Flooding on Queen Street, along the eastern side of the station, is mostly contained in the kerb and gutter drainage at the intersection of Queen Street and Waratah Street in the 5% AEP climate change and 1% AEP climate change flood events. At the same location the depth of flooding in the channel is 0.3 metres during the PMF event. Flows are mostly contained within the channel, a characteristic of nuisance flooding.
- To the west of Wellbank Street, significant ponding on Queen Street of up to 0.3 metres is likely in the 1% AEP flood event. Ponding depth is up to one metre in the PMF event and encroaches the station building footprint and discharges over the flood protection wall and into the existing rail corridor.
- The station box is protected from inundation as outlined in Section 3.3.1
- Flooding presents predominantly low hazard in the 5% AEP climate change and 1% AEP climate change flood events in areas of the construction sites outside of the station box and on adjacent streets as the hazard category is H1. Access to and evacuation from the sites are safe in the 1% AEP climate change flood event. The surrounding streets would be likely to experience low hazard along with small, localised areas of elevated high hazard (H5) occurring in the street kerb drainage and the open drain running approximately parallel with Queen Street which may be a hazard for pedestrians or workers in the area.
- In the PMF event, the northern construction site is expected to experience localised areas of H5 hazard category within the streets to the east of the site particularly where streets intersect with Queen Street. To the west of the northern construction site the hazard increases up to H6, with high flood depth relating to floodwaters in the North Strathfield rail underpass adjacent to the existing station. Wellbank Street acts as an overland flow path during the PMF event with much of the area south of the station box and Wellbank Street having areas of H3 to H5 hazard.
- Access to and evacuation from in the PMF event would be available from the northern construction site with adjacent streets having lower hazard particularly at the northern end. The southern construction site is understood to be a site office. This site would be likely to experience low to mid-range hazard flooding across most of the area. There are localised areas of high hazard (H5) which may also restrict access and evacuation from this site. Queen Street in the vicinity of Wellbank Street would be expected to experience discharge resulting in high hazard (H5) which would not be safe for pedestrians or vehicles. The hazard category in the downstream drainage channel increases to H6.

Modelling suggests that several private properties would already experience inundation during flood events under baseline conditions. For the 1% AEP climate change flood event seven properties in Beronga Street and three properties in Queen Street (south of Wellbank Street) would already experience inundation. This increases to nine and four properties respectively in the baseline PMF event.

4.5 Burwood North Station

4.5.1 Topography and drainage

The Burwood North Station sites are located on the northern side of an overland flow path that flows through Burwood and ultimately into Canada Bay, approximately 1.5 kilometres downstream of the site. There are two sites - Burwood North Station southern site on the southern side of Parramatta Road within the Burwood Local Government Area and Burwood North Station northern site on the northern side of Parramatta Road within the City of Canada Bay Local Government Area. Existing, pre-development elevations at the southern site range from 11.6 metres AHD to 14.0 metres AHD and from 6.5 to 17 metres AHD at the northern site. Both sites slope down to the southeast. The sites drain through underground drainage and along Parramatta Road to the east before discharging into an open drain and ultimately into Canada Bay a further 1.3 kilometres downstream.

Burwood North Station sites will have been subject to demolition and excavation as part of the work carried out under the previous Sydney Metro West planning application as indicated in Appendix D – Construction footprint.

4.5.2 Climate and rainfall

This site is located in central Sydney, experiencing a temperate climate with a monthly average maximum temperature range of 17.6 to 28.1 degrees Celsius, and a monthly average minimum range of 7.8 to 19.4 degrees Celsius. Annual average rainfall total is 911.8 mm/year with the monthly variation as indicated in Figure 4-2 (Bureau of Meteorology, Sydney Olympic Park).

4.5.3 Acid sulfate soils

The Department of Planning, Industry and Environment acid sulfate soil risk data and mapping have been reviewed to assess the probability of acid sulfate soils being present across this proposal. Acid sulfate soils were not identified in the area of the Burwood North Station sites. However, disturbed soils have been identified within this area (Sydney Metro, 2020a).

It was identified in Technical Paper 7 Hydrogeology of the Sydney Metro West Environment Impact Statement – Westmead to The Bays and Sydney CBD (Sydney Metro, 2020a) that up to 14 meters of groundwater level drawdown is estimated in the area of the disturbed soil, to the north-west and north-east of the station excavation, and that it is possible that work carried out under the previous Sydney Metro West planning application could cause oxidation of potential acid sulfate soils in the area if they are present. This risk is considered to be low.

4.5.4 Groundwater interactions and groundwater quality

Interaction between groundwater and surface water along the alignment is generally expected to be limited to surface water infiltration contributing to groundwater, discharge from groundwater to surface watercourses and waterbodies (especially in low lying areas or deeply incised channels), and/or leakage from surface watercourses to groundwater (Sydney Metro, 2020a).

Previous investigations have identified the potential for groundwater to be contaminated with heavy metals, hydrocarbons, solvents (namely formaldehyde), chlorinated hydrocarbons, and volatile organic compounds. The potential contamination impact was assessed to be moderate for this area (Sydney Metro, 2020c).

4.5.5 Catchment and watercourse health and receiving water quality

Burwood North station sites are located to the south of Parramatta River catchment, with Parramatta River a main tributary of Sydney Harbour. This catchment is highly urbanised and altered from its natural state, with pockets of open spaces and parkland.

Three watercourses are located within 1.5 kilometres of Burwood North station sites:

- St Lukes Park Canal – located about 90 metres east of Burwood North Station, the temporary construction water treatment plant would discharge to the canal via the local stormwater network. This waterway is concrete lined and contains to instream aquatic habitat. It is defined as a first order watercourse (as per Appendix 2 of the FBA (OEH, 2014)). This waterway is not considered to be Key Fish Habitat in accordance with the Policy and guidelines for fish habitat conservation and management – Update 2013 ((NSW Department of Primary Industries, 2013) and is classified as Class 4 (unlikely key fish habitat).
- Barnwell Park Canal – located approximately one kilometre from Burwood North Station (and approximate one kilometre from Five Dock Station sites) this canal is situated wholly within Barnwell Park Golf Club. This waterway is a highly modified, concrete lined channel with no instream aquatic habitat. It is defined as a first order watercourse (as per Appendix 2 of the FBA (OEH, 2014)). This waterway is not considered to be Key Fish Habitat in accordance with the Policy and guidelines for fish habitat conservation and management – Update 2013 ((NSW Department of Primary Industries, 2013) and is classified as Class 4 (unlikely key fish habitat).

The watercourses and catchments associated with this proposal are influenced by several factors including:

- Current and historical polluting land uses within the catchments
- Stormwater and sewage overflows and leachate from contaminated and/or reclaimed land
- Urbanisation of the catchments and subsequent reduction in permeable area, increasing run-off and pollutant loads entering waterways
- Illegal dumping.

Prior to this proposal, work carried out under the previous Sydney Metro West planning application will be undertaken at Burwood North Station. This includes the installation of a temporary construction water treatment plant at Burwood North Station site which will discharge treated water to St Lukes Park Canal via the local stormwater network. The water treatment plant would be configured so that treated water is compliant with the ANZG (2018) guideline values. The water treatment plant will be present at the commencement of construction of this proposal.

A review of available data indicates the watercourses relevant to this proposal are generally in poor condition and are representative of a heavily urbanised system (Sydney Metro, 2020). The watercourses which discharged water will be released to from the Burwood North Station temporary water treatment plant has been assessed against the ANZG guidelines as part of the previous Sydney Metro West planning application is provided in Table 4-9. The Water Quality and River Flow Objectives environmental values for the receiving waters are provided in Table 3-1, Section 3.2.3).

Table 4-9: Existing water quality conditions of watercourses relevant to Burwood North Station

Site	Watercourse	Water quality characteristics relevant to ANZECC/ARMCANZ (2000) indicators
Burwood North station	St Lukes Park Canal	• Low dissolved oxygen levels • Elevated nutrient concentrations • Elevated heavy metal concentrations • High turbidity

4.5.6 Sensitive receiving environments and wetlands

Waterways and water bodies have been identified as receiving environments of high sensitivity predominantly due to key fish habitat classification, Type 1 (highly sensitive Key Fish Habitat), Type 2 (moderately sensitive key fish habitat) and Class 1 (major key fish habitat), and/or proximity to coastal wetlands as defined by the Coastal Management SEPP. These watercourses have a high conservation or community value or support ecosystems or human uses of water that are particularly sensitive to pollution or degradation of water quality.

Table 4-10 identifies sensitive surface water receiving environments specific to the Burwood North Station sites and describes their condition and sensitivity (Sydney Metro, 2020d).

Table 4-10: Sensitive surface water receiving environments at Burwood North Station

Watercourse	Surface water features	Condition	Sensitive receiving environment rating
St Lukes Park Canal	Type 1 Key Fish Habitat SEPP Coastal Wetlands within 0.5 kilometres First order waterway Estuarine Predominantly concrete-lined No instream aquatic habitat Mapped seagrasses within 500 metres of the point of discharge of this canal into the Parramatta River	Highly disturbed	Moderate

4.5.7 Baseline flooding conditions

An overland flow path is located to the south-west of the sites and drains an area of approximately 92 hectares. Each of the Burwood North Station sites are outside the riverine or the overland flow path that discharges through Burwood to the east of the site.

Baseline flood depth and hazard maps from modelling of this proposal are included in Appendix A – Baseline environment flood maps. They indicate that flooding conditions at Burwood North Station are as follows:

- Overland flow adjacent to the sites are contained within the roadways. The sites are only affected by shallow flood depth within kerb and gutter drainage of 0.2 metres and 0.22 metres on Parramatta Rd in the 5% AEP climate change and 1% AEP climate change flood events, respectively. This increases to 0.4 metres in the PMF event.
- The station box and shaft are protected from inundation as outlined in Section 3.3.1
- Flood hazard in the 5% AEP climate change and 1% AEP climate change flood events are generally low at H1, with small, localised areas of up to H5 along Parramatta Road, which is due to the elevated flow velocities in the kerbs of above 2 metres per second.
- Access to and evacuation in the 5% AEP climate change and 1% AEP climate change flood events is generally safe with adjacent roads being low hazard that is safe to pedestrians and vehicles. In the PMF event, much of Parramatta Road and sections of Burwood Road adjacent to the site have areas with a high hazard category of H5.

Modelling suggests that several private properties would already experience inundation during flood events. Three properties in Burton Street, five to six properties in Loftus Street and 22 properties in Burwood Road (from approximately Milton Street southwards) would already experience inundation in the baseline PMF event.

4.6 Five Dock Station

4.6.1 Topography and Drainage

Five Dock Station is on the northern side of the ridge which bisects the suburb of Five Dock within the City of Canada Bay LGA. There are two sites which are located near the top of a hill and ridge with land sloping to the north towards Hen and Chicken Bay. The existing pre-development sites have an elevation of around 16.5 to 20 metres AHD. This is a highly urbanised area which drains to the north through underground drainage and along streets adjacent to the sites. The catchment discharges into Canada Bay, approximately 750 metres to the north of the sites.

Five Dock Station sites will have been subject to demolition and excavation as part of the work carried out under the previous Sydney Metro West planning application as indicated in Appendix D – Construction footprint.

4.6.2 Climate and rainfall

This site is located to the west of the Sydney CBD, experiencing a temperate climate with monthly average maximum temperature range of 17 to 26 degrees Celsius, and a monthly average minimum range of 8.1 to 18.9 degrees Celsius. Annual average rainfall total for Observatory Hill are 1211mm/year with the monthly variation as indicated in the Bureau of Meteorology extract in Figure 4-3.

Figure 4-3 Observatory Hill Rainfall Station

4.6.3 Acid sulfate soils

The Department of Planning, Industry and Environment acid sulfate soil risk data and mapping have been reviewed to assess the probability of acid sulfate soils being present across this proposal. Five Dock Station is located within an area that has “no known occurrence” of acid sulfate soils (Sydney Metro, 2020a).

However, disturbed soil has been identified within the area and it was identified in Technical Paper 7 Hydrogeology of the Sydney Metro West Environment Impact Statement – Westmead to The Bays and Sydney CBD (Sydney Metro, 2020a) that up to nine meters of groundwater level drawdown is estimated in the area of the disturbed soil, to the north-west of the excavation. It is possible that previous excavation of the station cavern and shafts during the work carried out under the previous Sydney Metro West planning application could cause oxidation of potential acid sulfate soils in the area if they are present. This risk is considered to be low.

4.6.4 Groundwater interactions and groundwater quality

Interaction between groundwater and surface water along the alignment is generally expected to be limited to surface water infiltration contributing to groundwater, discharge from groundwater to surface watercourses and waterbodies (especially in low lying areas or deeply incised channels), and/or leakage from surface watercourses to groundwater (Sydney Metro, 2020a).

Previous investigations have identified the potential for groundwater be contaminated with heavy metals, hydrocarbons, solvents (namely formaldehyde) and volatile organic compounds. The potential contamination impact was assessed to be low to moderate for this area (Sydney Metro, 2020c).

4.6.5 Catchment and watercourse health and receiving water quality

Five Dock Station are located to the south of Parramatta River catchment, with Parramatta River a main tributary of Sydney Harbour. This catchment is highly urbanised and altered from its natural state, with pockets of open spaces and parkland.

Two watercourses are located within 1.5 kilometres of the Five Dock Station:

- Iron Cove Creek – also known as Dobroyd Canal, this Creek is located 600 metres to the north of Five Dock and discharges into Iron Cove Bay. Construction water treatment plant discharges would discharge to the creek via the local stormwater network. It is defined as a first order watercourse (as per Appendix 2 of the FBA (OEH, 2014)). The creek is mapped as Key Fish Habitat up to the Ramsay Road crossing
- Barnwell Park Canal – located approximately one kilometre from Five Dock Station sites (and approximate one kilometre from Burwood North Station sites) this canal is situated wholly within Barnwell Park Golf Club. This waterway is a highly modified, concrete lined channel with no instream aquatic habitat. It is defined as a first order watercourse (as per Appendix 2 of the FBA (OEH, 2014)). This waterway is not considered to be Key Fish Habitat in accordance with the Policy and guidelines for fish habitat conservation and management – Update 2013 ((NSW Department of Primary Industries, 2013) and is classified as Class 4 (unlikely key fish habitat).

The watercourses and catchments associated with this proposal are influenced by several factors including:

- Current and historical polluting land uses within the catchments
- Stormwater and sewage overflows and leachate from contaminated and/or reclaimed land
- Urbanisation of the catchments and subsequent reduction in permeable area, increasing run-off and pollutant loads entering waterways
- Illegal dumping.

Prior to this proposal, work carried out under the previous Sydney Metro West planning application will be undertaken at the Five Dock Station. This includes the installation of a temporary construction water treatment plant at Five Dock Station site which will discharge treated water to Iron Cove Creek via the local stormwater network. The water treatment plant would be configured so that treated water is compliant with the ANZG (2018) guideline values. The water treatment plant will be present at the commencement of construction of this proposal.

A review of available data indicates the watercourses relevant to this proposal are generally in poor condition and are representative of a heavily urbanised system (Sydney Metro, 2020). The watercourses which discharged water will be released to from the Five Dock station temporary water treatment plant have been assessed against the ANZG guidelines as part of the previous Sydney Metro West planning application is provided in Table 4-11. The Water Quality and River Flow Objectives environmental values for the receiving waters are provided in Table 3-1, Section 3.2.3).

Table 4-11: Existing water quality conditions of watercourses relevant to Five Dock Station

Site	Watercourse	Water quality characteristics relevant to ANZECC/ARMCANZ (2000) indicators
Five Dock Station	Iron Cove Creek	• Low dissolved oxygen levels • Elevated nutrient concentrations • Elevated heavy metal concentrations • High turbidity

4.6.6 Sensitive receiving environments and wetlands

Waterways and water bodies have been identified as receiving environments of high sensitivity predominantly due to key fish habitat classification, Type 1 (highly sensitive Key Fish Habitat), Type 2 (moderately sensitive key fish habitat) and Class 1 (major key fish habitat), and/or proximity to coastal wetlands as defined by the coastal management SEPP. These watercourses have a high conservation or community value or supports ecosystems or human uses of water that are particularly sensitive to pollution or degradation of water quality. Table 4-12 identifies sensitive surface water receiving environments specific to Five Dock Station sites and describes their condition and sensitivity (Sydney Metro, 2020d).

Table 4-12: Sensitive surface water receiving environments at Five Dock Station

Watercourse	Surface water features	Condition	Sensitive receiving environment rating
Barnwell Park Canal	Highly modified channel with limited aquatic habitat SEPP Coastal Wetlands greater than 0.5 kilometres downstream First order waterway Concrete lined channel No instream aquatic habitat	Highly disturbed	Moderate
Iron Cove Creek (also known as Dobroyd Canal)	Highly modified channel with limited aquatic habitat First order waterway Concrete-lined channel Mapped seagrasses within 500 metres of the point of discharge of this canal into Iron Cove	Moderately disturbed	High

4.6.7 Baseline flooding conditions

The western site is located between Great North Road and East Street and is currently occupied by high-density commercial properties. There is a highly urbanised catchment of 4,800 square metres to the south of the site which discharges along East Street and another 2,900 square metres which discharges onto Great North Road. The western portion of the site, with a catchment area of 2,600 square metres discharges to East Street with the remaining 1,900 square metres discharging to Great North Road. The eastern site is located on the western side of Waterview Street and the south of Second Avenue. The 2,180 square metres site is currently comprised of residential properties covering approximately 1,800 square metres discharging to Waterview Street and a 380 square metres car park at the western portion of the site discharging to Second Avenue.

Baseline flood depth and hazard maps from modelling of this proposal are included in Appendix A – Baseline environment flood maps. They indicate that flooding conditions at Five Dock Station are as follows:

- At the eastern site, shallow flood depths of up to 0.05 metres are present along the kerb and gutter of the adjacent roads, Waterview Street and Second Avenue. This stormwater does not affect the proposed site during the 5% AEP climate change and 1% AEP climate change flood events; however, it may affect access to the site during rare flood events such as the PMF
- At the western site, shallow flood depths of up to 0.1 metres are contained within the kerb and gutter along each side of the construction site on Great North Road and East Street. On East Street, the overland flow discharges into the existing carpark on the site. The filling of this area associated with the work carried out under the previous Sydney Metro West planning application will have resulted in negligible increases in flood level along East Street. The kerb and gutter flow along the adjacent streets may affect access to the western site during rare flood events
- The shafts are protected from inundation as outlined in Section 3.3.1
- In the 5% and 1% AEP climate change flood events, flood hazard is H1 on the streets adjacent to the site. In the 1% AEP climate change flood event and the PMF event, the flood hazard adjacent to the Five Dock Station western site experiences localised increases to H4 and H5, respectively, on Great North Road. This is likely due to the flow velocity along the streets exceeding two metres per second. The flow on nearby streets would be hazardous to pedestrians and vehicles during the PMF event restricting access and evacuation routes from the site.

Modelling suggests that several private properties would already experience inundation during flood events. One property on Henry Street and two properties fronted by both East Street and Great North Road would be expected to already experience a degree of flooding in the baseline 5% AEP climate change, 1% AEP climate change and PMF events.

4.7 The Bays Station

4.7.1 Topography and drainage

The Bays Station is located at the downstream end of a sub-catchment within the Inner West Council Local Government Area, comprising of mostly urban residential lots with limited infiltration.

The station would be situated on a low-lying former dockland site. There is a section of lower land immediately to the west (the former White Bay Power Station site) which forms part of a major overland flow path that drains an area stretching north-west towards Rozelle.

The site is generally flat land with little to no slope around White Bay. The existing pre-development site has an elevation typically around 3 - 4 metres AHD with some low-lying sections along White Bay and a small section of higher land associated with the Victoria Road embankment to the south-east of the site.

The Bays Station will have been subject to demolition and excavation as part of the work carried out under the previous Sydney Metro West planning application as indicated in Appendix D – Construction footprint.

4.7.2 Climate and rainfall

This site is located to the west of the Sydney CBD, experiencing a temperate climate with monthly average maximum temperature range of 17 to 26 degrees Celsius, and a monthly average minimum range of 8.1 to 18.9 degrees Celsius. Annual average rainfall total for Observatory Hill are 1211mm/year with the monthly variation as indicated in the Bureau of Meteorology extract in Figure 4-3.

4.7.3 Acid sulfate soils

The Department of Planning, Industry and Environment acid sulfate soil risk data and mapping have been reviewed to assess the probability of acid sulfate soils being present across this proposal. The Bays Station site is located within areas which are considered to be disturbed, and where acid sulfate soils has the potential to occur (Sydney Metro, 2020a).

It was identified in Technical Paper 7 Hydrogeology of the Sydney Metro West Environment Impact Statement – Westmead to The Bays and Sydney CBD (Sydney Metro, 2020a) that up to 28 metres of groundwater level drawdown is estimated due to the excavation of the station box as part of the work carried out under the previous Sydney Metro West planning application. This drawdown could cause oxidation of potential acid sulfate soils in the area if they are present. This risk is considered to be low.

4.7.4 Groundwater interactions and groundwater quality

At The Bays Station, a proportion of inflow to the station box is likely to come from White Bay, as water would be drawn from surrounding bays into the groundwater system.

Previous investigations have identified the potential for groundwater to be contaminated with heavy metals, hydrocarbons, polychlorinated biphenyls, asbestos and pesticides. The potential contamination impact was assessed to be moderate for this area (Sydney Metro, 2020c).

Laboratory analyses were carried out on previously collected samples for various combinations of test parameters (depending on sample). The results indicated samples exceeding the National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPM) criteria for human health levels for asbestos, Benzo(a)pyrene and lead. Additionally, samples indicated that copper, zinc, Benzo(a)pyrene, nickel and lead levels exceed the NEPM criteria for ecological levels (Sydney Metro, 2021b).

4.7.5 Catchment and watercourse health and receiving water quality

The Bays Station is located adjacent to the Sydney Harbour catchment. This catchment is highly urbanised and altered from its natural state, with pockets of open spaces and parkland. The catchment consists of numerous land uses, broadly including residential, commercial, environmental protection, education, industrial, open space and recreation services, and infrastructure.

Two watercourses are located within 1.5 kilometres of The Bays station:

- Whites Creek – located about 600 metres south-west of The Bays Station. It is defined as a first order watercourse (as per Appendix 2 of the FBA (OEH, 2014)).
- White Bay – located adjacent to The Bays Station, White Bay is a concrete lined, enclosed embayment, and the site drains to the Bay in the lower estuary of Sydney Harbour. It is defined as a fourth order watercourse (as per Appendix 2 of the FBA (OEH, 2014)). Construction water treatment plant discharges would ultimately discharge to White Bay via the local stormwater network. The upstream catchment is high density residential area, and water quality through the station site and into White Bay is expected to be poor due to sediments, toxicants and gross pollutants expected from such development (Sydney Metro, 2020). White Bay has been heavily modified for port purposes and is unlikely to contain significant aquatic habitat and is therefore not considered Key Fish Habitat.

The watercourses and catchments associated with this proposal are influenced by several factors including:

- Current and historical polluting land uses within the catchments
- Stormwater and sewage overflows and leachate from contaminated and/or reclaimed land
- Urbanisation of the catchments and subsequent reduction in permeable area, increasing run-off and pollutant loads entering waterways
- Illegal dumping.

Prior to this proposal, work carried out under the previous Sydney Metro West planning application will be undertaken at The Bays Station. This includes the installation of a temporary construction water treatment plant at The Bays Station which will discharge treated water to White Bay. The water treatment plant would be configured so that treated water is compliant with the ANZG (2018) guideline values. The water treatment plant will be present at the commencement of construction of this proposal.

A review of available data indicates the watercourses relevant to this proposal are generally in poor condition and are representative of a heavily urbanised system (Sydney Metro, 2020). The watercourses which discharged water will be released to from The Bays station temporary water treatment plant has been assessed against the ANZG guidelines as part of the previous Sydney Metro West planning application is provided in Table 4-13. The Water Quality and River Flow Objectives environmental values for the receiving waters are provided in Table 3-1, Section 3.2.3).

Table 4-13: Existing water quality conditions of watercourses relevant to The Bays Station

Site	Watercourse	Water quality characteristics relevant to ANZECC/ARMCANZ (2000) indicators
The Bays Station	White Bay	• Elevated nutrient concentrations • Elevated heavy metal concentrations • High turbidity

4.7.6 Sensitive receiving environments and wetlands

Waterways and water bodies have been identified as receiving environments of high sensitivity predominantly due to key fish habitat classification, Type 1 (highly sensitive Key Fish Habitat), Type 2 (moderately sensitive key fish habitat) and Class 1 (major key fish habitat), and/or proximity to coastal wetlands as defined by the coastal management SEPP. These watercourses have a high conservation or community value or support ecosystems or human uses of water that are particularly sensitive to pollution or degradation of water quality.

Table 4-14 identifies sensitive surface water receiving environments specific to The Bays Station site and describes their condition and sensitivity (Sydney Metro, 2020d).

Table 4-14: Sensitive surface water receiving environments at The Bays Station

Watercourse	Surface water features	Condition	Sensitive receiving environment rating
Sydney Harbour	Numerous SEPP Coastal Wetlands. Potential habitat for threatened aquatic species and protected aquatic vegetation Type 1 Key Fish Habitat Fourth order waterway Permanently flowing	Moderately disturbed	High
White Bay	Concrete-lined, enclosed embayment SEPP Coastal Wetlands within 0.5 kilometres	Highly disturbed	Low

4.7.7 Baseline flooding conditions

The sub-catchment draining to the site has an approximate area of 76 hectares, extending up to a ridgeline at Darling Street and discharges to White Bay through a Sydney Water culvert on Robert Street.

The site is bounded by Robert Street and White Bay Power Station at the north, the Anzac Bridge at the south and White bay to the east. The area around White Bay Power Station is a depression with lower elevations than much of the site. Port Access Road is located along the eastern side of the site and is raised and acts as a levee during extreme flood events.

Baseline flood depth and hazard maps from modelling of this proposal are included in Appendix A – Baseline environment flood maps. They indicate that flooding conditions at The Bays Station are as follows:

- Flood depths within the White Bay Power Station area are up to 0.8 and 1.2 metres in the 5% AEP climate change and 1% AEP climate change flood events, respectively. This increases to 2.3 metres in the PMF event
- On Robert Street at the north of the site, the maximum flood depth on the northern side of the road is 0.6 metres, 1.1 metres and 2.2 metres for the 5% AEP climate change and 1% AEP climate change flood events and the PMF event, respectively
- Within the site, there is ponding of water at the western extent of the station excavation delivered as part of the previous Sydney Metro West planning applications, with flood depths in the 5% AEP climate change and 1% AEP climate change events being similar at around 0.4 metres. In the PMF event this increases to 1.6 metres. There is ponding of flood water from a local catchment within the site that is captured at the south of the station excavation. This leads to flooding depth of up to 0.8 metres in the 5% AEP climate change and 1% AEP climate change flood events and up to 1.5 metres in the PMF event

- Peak flood levels along the western part of the site at the west of the station box are around 3.2 metres AHD for both the 5% AEP climate change and 1% AEP climate change flood events, with localised shallow ponded areas having varying water levels of up to 4.5 metres AHD along the southern boundary. The ponding of flood water from a local catchment within the site that is captured at the south of the station box causes flooding levels of up to 3.7 metres AHD in the 5% AEP climate change and 1% AEP climate change flood events and up to 4.6 metres AHD in the PMF event
- The station box is protected from inundation as outlined in Section 3.3.1
- In the 5% AEP climate change and 1% AEP climate change flood events the flood hazard within the site footprint is generally limited to H1, with small, localised ponding areas with greater depth having a higher hazard of H2 or H3. The area around the low-lying White Bay Power Station and on Robert Street to the north of the site is predominantly H3, due to the ponding water depth. In the PMF event the flood hazard within much of the site is increased to H4 hazard with Robert Street being predominantly H5 hazard with H6 on Mullens Street to the north of Robert Street
- Access and evacuation on Robert Street would be limited in the 5% AEP climate change and 1% AEP climate change flood events due to the depth of ponding on Robert Street. There may be limited access to the site via Sommerville Road at the east of the site. In the PMF event, there are localised areas of high hazard (H5) on the site, particularly near the site access from Robert Street. There is also high hazard (H5) on the roads at the east of the site on Sommerville Road
- Low-lying parts of the site are at two metres AHD, which is expected to be affected by coastal inundation, assuming an elevated ocean level of 1.45 metres AHD (Office of Environment and Heritage, 2015) plus 0.66 metres allowance for wind and wave effects (CSIRO and Bureau of Meteorology, 2015) for the 1% AEP flood event. Higher parts of the station site are sufficiently elevated and are not considered to be exposed to coastal inundation.

4.8 Pyrmont Station

4.8.1 Topography and Drainage

Pyrmont Station is situated in an urban area occupied by commercial properties within the City of Sydney Local Government Area. The area generally slopes east to west eventually draining to Pyrmont Bay and is characterised by undulating to rolling low hills with local relief (20-80 metres) and slopes of 10-25 per cent. Side slopes with narrow to wide outcropping sandstone rock benches (10-100 metres) are present and often form broken scarps of less than five metres.

From inspection of LiDAR survey existing pre-development elevations on Pyrmont Bridge Road and Edward Street appear to be approximately 14-15 metres AHD whereas Union Street is approximately 10 metres AHD.

The Pyrmont Station site will have been subject to demolition and excavation as part of the work carried out under the previous Sydney Metro West planning application as indicated in Appendix D – Construction footprint.

4.8.2 Climate and rainfall

This site is located to the west of the Sydney CBD, experiencing a temperate climate with monthly average maximum temperature range of 17 to 26 degrees Celsius, and a monthly average minimum range of 8.1 to 18.9 degrees Celsius. Annual average rainfall total for Observatory Hill are 1211 mm/year with the monthly variation as indicated in the Bureau of Meteorology extract below in Figure 4-3.

4.8.3 Acid sulfate soils

The Department of Planning, Industry and Environment acid sulfate soil risk data and mapping have been reviewed to assess the probability of acid sulfate soils being present across this proposal. Pyrmont Station is located west of an area which is considered to be disturbed, and where acid sulfate soils has the potential to occur (Sydney Metro, 2021c).

It was identified that up to 31 metres of groundwater level drawdown is estimated in the area of the disturbed soil and that it is possible that previous excavation of the station cavern and shafts during the work carried out under the previous Sydney Metro West planning application could cause oxidation of potential acid sulfate soils in the area if they are present (Sydney Metro, 2021b). This risk is considered to be low.

4.8.4 Groundwater interactions and groundwater quality

At Pyrmont Station, interaction between groundwater and surface water is generally expected to be limited due to the widespread impervious surface across the site and surrounding area.

Laboratory analyses were carried out on previously collected groundwater samples for various combinations of test parameters (depending on sample) for major ions, heavy metals, total recoverable hydrocarbons (TRH), benzene, toluene, ethyl benzene and xylene (BTEX), polycyclic aromatic hydrocarbons (PAH), nutrients, hexavalent chromium, total and speciated phenols, per- and polyfluoroalkyl substances, volatile organic compounds (VOC), organochlorine (OCP) and organophosphate pesticides (OPP), and tributyltins. The results did not indicate any samples exceeding the National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPM) criteria for human health levels (Sydney Metro, 2021b).

4.8.5 Catchment and watercourse health and receiving water quality

Pyrmont Station is located to the west of Pyrmont Bay (Darling Harbour catchment, a sub-catchment of Sydney Harbour catchment). The Darling Harbour catchment, comprising of Haymarket, Surry Hills, Pyrmont and Sydney CBD, is a receiving environment of both Pyrmont Station and Hunter Street Station(Sydney CBD). The harbour and its surrounding environment are fully developed with urban and commercial usage giving water very little opportunity to infiltrate due to large amounts of impervious areas. As a result, the harbour is characterised by elevated nutrient, heavy metal concentrations and high turbidity. The total catchment covers approximately 307 hectares which drains to Sydney Harbour at various locations (RPA Australia East, 2014).

Blackwattle Bay and Cockle Bay are located approximately 475 metres and 250 metres respectively from the Pyrmont Station sites and are considered, along with Pyrmont Bay, a receiving environment of Pyrmont Station sites. Blackwattle Bay and Cockle Bay are defined as a fourth order waterways (as per Appendix 2 of the FBA (OEH, 2014)). A parliamentary briefing paper from 2015 assessed water quality at

Blackwattle Bay and identified elevated levels of total nitrogen, total phosphorus, chlorophyll-a and enterococci. Blackwattle Bay, Cockle Bay and Pyrmont Bay lie within two kilometres of each other and are inherently interconnected. Water quality is likely to be reasonably consistent between the bays, and the data available suggests that the receiving waters are generally in a poor condition (RPA Australia East, 2014).

Prior to this proposal, work carried out under the previous Sydney Metro West planning application will be undertaken at the Pyrmont Station sites. This includes the installation of a temporary construction water treatment plant at Pyrmont Station site which will discharge treated water to Blackwattle Bay, Cockle Bay and Pyrmont Bay via the local stormwater network. The water treatment plant would be configured so that treated water is compliant with the ANZG (2018) guideline values. The water treatment plant will be present at the commencement of construction of this proposal.

A review of available data indicates the watercourses relevant to this proposal are generally in poor condition and are representative of a heavily urbanised system (Sydney Metro, 2020). The watercourses which discharged water will be released to from Pyrmont station temporary water treatment plant has been assessed against the ANZG guidelines as part of the previous Sydney Metro West planning application is provided in Table 4-15. The Water Quality and River Flow Objectives environmental values for the receiving waters are provided in Table 3-1, Section 3.2.3).

Table 4-15: Existing water quality conditions of watercourses relevant to Pyrmont station

Site	Watercourse	Water quality characteristics relevant to ANZECC/ARMCANZ (2000) indicators
Pyrmont Station	Blackwattle Bay, Cockle Bay and Pyrmont Bay	• Elevated nutrient concentrations • Elevated heavy metal concentrations • High turbidity

4.8.6 Sensitive receiving environments and wetlands

Waterways and water bodies have been identified as receiving environments of high sensitivity predominantly due to key fish habitat classification, Type 1 (highly sensitive Key Fish Habitat), Type 2 (moderately sensitive key fish habitat) and Class 1 (major key fish habitat), and/or proximity to coastal wetlands as defined by the coastal management SEPP. These watercourses have a high conservation or community value or supports ecosystems or human uses of water that are particularly sensitive to pollution or degradation of water quality. Table 4-16 identifies sensitive surface water receiving environments specific to Pyrmont Station and describes their condition and sensitivity (Sydney Metro, 2020d).

Table 4-16: Sensitive surface water receiving environments at Pyrmont Station

Watercourse	Surface water features	Condition	Sensitive receiving environment rating
Sydney Harbour	Numerous SEPP Coastal Wetlands. Potential habitat for threatened aquatic species and protected aquatic vegetation Type 1 Key Fish Habitat Fourth order waterway Permanently flowing	Moderately disturbed	High

4.8.7 Baseline flooding conditions

Pyrmont Station is situated on the northern side of Pyrmont Bridge Road. The western site is located between Paternoster Row and Pyrmont Street and the eastern site to the east of Edward Street. Surrounding land use mainly consists of high density residential and commercial properties.

Baseline flood depth and hazard maps from modelling of this proposal are included in Appendix A – Baseline environment flood maps. They indicate that flooding conditions at Pyrmont Station are as follows:

- The shafts at both sites are protected from inundation as outlined in Section 3.3.1
- Flooding is generally confined to the roads with minor pockets of ponding around the perimeter of the western site in the 5% AEP climate change and 1% AEP climate change flood events. These pockets of flooding are limited to depths of 0.05 metres. In the PMF event, the maximum flood depth occurs on Pyrmont Bridge Road with a depth of 0.12 metres. Roads adjacent to the sites have flood depths less than 0.1 metres
- Flood depths up to 0.2 metres occur in the 5% AEP climate change flood event in the northern side of the eastern site on Union Street, whilst depths in the 1% AEP climate change flood event are up to 0.3 metres. This higher depth is expected to be on the verge and is likely an anomaly of the lidar. Minor depths of up to 0.06 metres occur along Pyrmont Bridge Road, while depths of up to 0.03 metres are estimated on Edward Street in the 1% AEP climate change flood event.

- Access to and evacuation from is generally unimpeded during the 1% AEP climate change flood event with low hazard due to the low flow depth and velocity. Flood depths outside Union Street are considered relatively minor. In the PMF event, maximum flood depths of 0.4 metres.
- The flood hazard is generally within the H1 category across the sites in the 5% AEP climate change and 1% AEP climate change flood events, posing a minimal risk to vehicles and pedestrians. There are localised areas within the eastern site having a hazard of up to H3 due to ponding depth however this is a modelling artifact associated with the modelled surface topography. In the PMF event, Union and Pyrmont Streets and Pyrmont Bridge Road are within H5 category hazard. This is mainly due to the road being a major flow path which has flow velocities up to 2 metres per second.

Modelling suggests that some private properties would be expected to already experience a degree of flooding in the baseline PMF event.

4.9 Hunter Street Station (Sydney CBD)

4.9.1 Topography and drainage

Hunter Street Station (Sydney CBD) is situated in an urban area, heavily disturbed by human activity and falls towards Pitt Street from south to north. The disturbed areas are often landscaped and artificially drained. The landform elements present in the area include berms, cut faces, embankments, mounds, pits and trenches.

Local relief is generally usually less than two metres, but up to 10 metres at some locations. The urban areas surrounding Hunter Street Station (Sydney CBD) have slopes of less than three per cent. In terraced cut and fill areas short rises may be steeper than 30 per cent and the microtopography may be hummocky due to truck dumping of fill material.

The Hunter Street Station (Sydney CBD) site will have been subject to demolition and excavation as part of the work carried out under the previous Sydney Metro West planning application as indicated in Appendix D – Construction footprint.

4.9.2 Climate and rainfall

This site is located within the Sydney CBD, experiencing a temperate climate with monthly average maximum temperature range of 17 to 26 degrees Celsius, and a monthly average minimum range of 8.1 to 18.9 degrees Celsius. Annual average rainfall total for Observatory Hill are 1211mm/year with the monthly variation as indicated in the Bureau of Meteorology extract in Figure 4-3.

4.9.3 Acid sulfate soils

The Department of Planning, Industry and Environment acid sulfate soil risk data and mapping have been reviewed to assess the probability of acid sulfate soils being present across this proposal. Hunter Street Station (Sydney CBD) is located within areas which are not considered to be disturbed, and acid sulfate soils is not likely to occur within the construction area (Sydney Metro, 2021c).

It was identified that up to 29 metres of groundwater level drawdown is estimated in the area of the disturbed soil and that it is possible that previous excavation of the station cavern and shafts during the work carried out under the previous Sydney Metro West planning application could cause oxidation of potential acid sulfate soils in the area if they are present (Sydney Metro, 2021b). This risk is considered to be low.

4.9.4 Groundwater interactions and groundwater quality

At Hunter Street Station (Sydney CBD), interaction between groundwater and surface water is generally expected to be limited due to the widespread impervious surface across the site and surrounding area.

Laboratory analyses were carried out on previously collected groundwater samples for various combinations of test parameters (depending on sample) for major ions, heavy metals, total recoverable hydrocarbons (TRH), benzene, toluene, ethyl benzene and xylene (BTEX), polycyclic aromatic hydrocarbons (PAH), nutrients, hexavalent chromium, total and speciated phenols, per- and polyfluoroalkyl substances, volatile organic compounds (VOC), organochlorine (OCP) and organophosphate pesticides (OPP), and tributyltins. The results did not indicate any samples exceeding the National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPM) criteria for human health levels (Sydney Metro, 2021b).

4.9.5 Catchment and watercourse health and receiving water quality

Hunter Street Station (Sydney CBD) is located to the east of Darling Harbour catchment, a sub-catchment of Sydney harbour catchment. The Darling Harbour catchment, comprising of Haymarket, Surry Hills, Pyrmont and Sydney CBD, is a receiving environment of both Pyrmont Station and Hunter Street Station (Sydney CBD) sites. Both Darling Harbour and Sydney Harbour are defined as a fourth order waterways (as per Appendix 2 of the FBA (OEH, 2014)). The harbour and its surrounding environment are fully developed with urban and commercial usage giving water very little opportunity to infiltrate due to large amounts of impervious areas. As a result, the harbour is characterised by elevated nutrient, heavy metal concentrations and high turbidity. The total catchment covers approximately 307 hectares which drains to Sydney Harbour at various locations (RPS Australia East, 2014).

Prior to this proposal, work carried out under the previous Sydney Metro West planning application will be undertaken at the Hunter Street Station (Sydney CBD) sites. This includes the installation of a temporary construction water treatment plant at Hunter Street Station (Sydney CBD) site which will discharge treated water to Circular Quay via the local stormwater network. Circular Quay is defined as a fourth order waterway (as per Appendix 2 of the FBA (OEH, 2014)). The water treatment plant would be configured so that treated water is compliant with the ANZG (2018) guideline values. The water treatment plant will be present at the commencement of construction of this proposal.

A review of available data indicates the watercourses relevant to this proposal are generally in poor condition and are representative of a heavily urbanised system (Sydney Metro, 2020). The watercourses which discharged water will be released to from the Hunter Street station temporary water treatment plant has been assessed against the ANZG guidelines as part of the previous Sydney Metro West planning application is provided in Table 4-17. The Water Quality and River Flow Objectives environmental values for the receiving waters are provided in Table 3-1, Section 3.2.3).

Table 4-17: Existing water quality conditions of watercourses relevant to Hunter Street Station (Sydney CBD)

Site	Watercourse	Water quality characteristics relevant to ANZECC/ARMCANZ (2000) indicators
Hunter Street Station	Circular Quay	• Elevated nutrient concentrations • Elevated heavy metal concentrations • High turbidity

4.9.6 Sensitive receiving environments and wetlands

Waterways and water bodies have been identified as receiving environments of high sensitivity predominantly due to key fish habitat classification, Type 1 (highly sensitive Key Fish Habitat), Type 2 (moderately sensitive key fish habitat) and Class 1 (major key fish habitat), and/or proximity to coastal wetlands as defined by the coastal management SEPP. These watercourses have a high conservation or community value or supports ecosystems or human uses of water that are particularly sensitive to pollution or degradation of water quality.

Table 4-18 identifies sensitive surface water receiving environments specific to Hunter Street Station (Sydney CBD) and describes their condition and sensitivity (Sydney Metro, 2020d).

Table 4-18: Sensitive surface water receiving environments at Hunter Street Station

Watercourse	Surface water features	Condition	Sensitive receiving environment rating
Sydney Harbour	Numerous SEPP Coastal Wetlands. Potential habitat for threatened aquatic species and protected aquatic vegetation Type 1 Key Fish Habitat Fourth order waterway Permanently flowing	Moderately disturbed	High

4.9.7 Baseline flooding conditions

There are two Hunter Street Station (Sydney CBD) sites, the eastern site is located on the south east corner of Hunter Street and George Street intersection and the western site is located on north west site of the Hunter Street and Bligh Street intersection.

These sites are located in the CBD, with the majority of the surrounding land use consisting of commercial properties. Existing drainage arrangements have been identified within the sites and surrounds and included in the hydraulic model.

Baseline flood depth and hazard maps from modelling of this proposal are included in Appendix A – Baseline environment flood maps. They indicate that flooding conditions at Hunter Street Station (Sydney CBD) are as follows:

- The shafts are protected from inundation as outlined in Section 3.3.1
- Western site: flood depths up to 0.35 metres occur in the 1% AEP climate change flood event at the north eastern portion of the site between the northern site boundary and Hunter Street. However, the 5% AEP climate change flood event has much shallower depths up to 0.04 metres. Outside of the northern boundary, there are flood depths up to 0.2 metres between the western boundary and George Street in the 1% AEP climate change flood event. A similar trend is seen in the PMF event with the worst-case flooding occurring at the northern boundary with depths up to one metre. The western boundary is inundated up to 0.4 metres in the PMF event.
- Eastern site: flood depths up to 0.06 metres occur in the 5% AEP climate change flood event and 0.25 metres occur in the 1% AEP climate change flood event between the southern boundary of the excavation works and Bligh Street. Elsewhere, Hunter Street is inundated up to 0.07 metres in the 1% AEP climate change flood event and O'Connell Street experiences less than 0.1 metres. Flooding with the 5% AEP climate change flood event in these roads is very minor (0.02 metres). In the PMF event both Hunter Street and the southern portion of the site have flood depths up to 0.3 metres whilst O'Connell Street has depths up to 0.15 metres.

The flood hazards for the sites are outlined below:

- Western site: In the 5% AEP climate change flood event all roads surrounding the site are within a low H1 hazard category. In the 1% AEP climate change flood event the northern portion of the site along Hunter Street has a H5 hazard along with a small section of George Street. The remainder of the site surrounds appears to be within the low H1 hazard category (generally safe for vehicles, people and buildings). The PMF event produces higher hazard categories of H5 and H6 with only pockets of the streets falling within the low hazard (H1).
- Eastern site: In the 5% AEP climate change flood event all roads surrounding the site are within a low H1 hazard category. In both the 1% AEP climate change flood event and the PMF event, Hunter Street falls within a H5 hazard category whereas O'Connell Street and Bligh Street are both within the H1 hazard category.

Modelling suggests that some private properties would be expected to already experience a degree of flooding in the baseline PMF event.

4.10 Clyde stabling and maintenance facility and Rosehill services facility

4.10.1 Topography and drainage

The Clyde stabling and maintenance facility is located on the junction of Duck Creek and A'Becketts Creek upstream of Duck River and within the City of Parramatta Local Government Area. The site is bounded by the M4 Motorway to the south, James Ruse Drive to the west and Unwin Street to the north. The eastern side of the site is bounded by Duck Creek, which also runs through the site, and Shirley Street. The Rosehill services facility site is co-located with the Clyde stabling and maintenance facility site on the northern side of Duck Creek, opposite to the stabling and maintenance area.

As part of the previous Sydney Metro West planning application there would be major earthworks required at this location which would:

- import material at the stabling and maintenance facility site to bring the site above the PMF level
- excavate the dive portal and the Rosehill services facility.

The previous Sydney Metro West planning application will include the installation of waterway structures in both Duck Creek and A'Becketts Creek, which would also require creek diversion and downstream realignment, and trunk drainage along with water quality ponds sized for the operation of the Clyde stabling and maintenance facility. The relevant drawing in Appendix D – Construction footprint indicates the relative location of these features.

4.10.2 Climate and rainfall

This site is located in Western Sydney, experiencing a temperate climate with a monthly average maximum temperature range of 17.5 to 28.6 degrees Celsius, and a monthly average minimum range of 6.2 to 17.7 degrees Celsius. Annual average rainfall total is 966 mm/year with the monthly variation as indicated in Figure 4-1 (Bureau of Meteorology, Parramatta North (Masons Drive)).

4.10.3 Acid sulfate soils

The Department of Planning, Industry and Environment acid sulfate soil risk data and mapping have been reviewed to assess the probability of acid sulfate soils being present across this proposal. Acid sulfate soils were not identified in the area of the Clyde stabling and maintenance facility and the Rosehill services facility. However, disturbed soils have been identified within this area (Sydney Metro, 2020a).

It was identified in Technical Paper 7 Hydrogeology of the Sydney Metro West Environment Impact Statement – Westmead to The Bays and Sydney CBD (Sydney Metro, 2020a) that up to 25 meters of groundwater level drawdown is estimated in the area of the disturbed soil at Clyde stabling and maintenance facility site. It is possible that previous excavation of the tunnel portal and dive structure at Clyde stabling and maintenance facility site and excavation of the services facility shaft at Rosehill during the work carried out under the previous Sydney Metro West planning application could cause oxidation of potential acid sulfate soils in the area if they are present. This risk is considered to be low.

4.10.4 Groundwater interactions and groundwater quality

Previous investigations have identified contaminated sites located within the extent of the groundwater level drawdown at Clyde stabling and maintenance facility and Rosehill services facility. Any potentially contaminated groundwater within the extent of groundwater drawdown would migrate towards the excavation. The groundwater has the potential to be contaminated with heavy metals (e.g. iron and magnesium), hydrocarbons, solvents (namely formaldehyde) and volatile organic compounds. The potential contamination impact was assessed to be low to moderate for this area (Sydney Metro, 2020c).

4.10.5 Catchment and watercourse health and receiving water quality

Clyde stabling and maintenance facility is located to the south of Parramatta River catchment, with Parramatta River a main tributary of Sydney Harbour and defined as a fourth order watercourse (as per Appendix 2 of the FBA (OEH, 2014)). This catchment is highly urbanised and altered from its natural state, with pockets of open spaces and parkland.

Four watercourses are located within 1.5 kilometres of Clyde stabling and maintenance facility site:

- Duck River – Located less than 100 metres from the site, this creek is a third order estuarine watercourse (as per Appendix 2 of the FBA (OEH, 2014)). The upper extents are generally concrete lined open channels and pipes, becoming a semi-naturalised channel within the lower estuary. Duck River is mapped as Key Fish Habitat and is classified as Type 1 Key Fish Habitat. It is also classified as Class 1 (major key fish habitat) as it is a permanently flowing river
- Duck Creek – Located adjacent and within Clyde stabling and maintenance facility site, this creek is highly modified second order watercourse (as per Appendix 2 of the FBA (OEH, 2014)), which drains into Duck River. In the site, the channel of the creek contains mangrove vegetation, but the banks are dominated by exotic species with occasional planted native trees. The creek is mapped as Key Fish Habitat and is classified as Type 1 (Key Fish Habitat). It is also classified as Class 1 (major key fish habitat) as it is a permanently flowing estuarine river
- A'Becketts Creek – Located upstream and within the Clyde stabling and maintenance facility site, it is a highly modified first order watercourse (as per Appendix 2 of the FBA (OEH, 2014)), which drains into the Duck Creek at Clyde. A'Becketts Creek is estuarine within the site but becomes less saline and eventually freshwater in its upper reaches. The creek is not mapped as Key Fish Habitat however, it can be classified as Class 1 (major key fish habitat) as it is a permanently flowing estuarine river
- Clay Cliff Creek – Located 500 metres from Clyde stabling and maintenance facility site, this creek is a highly modified second order watercourse (as per Appendix 2 of the FBA (OEH, 2014)), that discharges into Parramatta River. Clay Cliff Creek is a concrete lined channel, contains no instream habitat, and is not mapped as Key Fish Habitat (classified as Class 4 (unlikely key fish habitat)). A coastal wetland listed under the Coastal Management SEPP is located downstream along the banks of the Parramatta River at the confluence with Clay Cliff Creek.

The watercourses and catchments associated with this proposal are influenced by several factors including:

- Current and historical polluting land uses within the catchments
- Stormwater and sewage overflows and leachate from contaminated and/or reclaimed land
- Urbanisation of the catchments and subsequent reduction in permeable area, increasing run-off and pollutant loads entering waterways
- Illegal dumping.

Prior to this proposal, work carried out under the previous Sydney Metro West planning application will be undertaken at the Clyde stabling and maintenance facility and Rosehill services facility sites. This includes the installation of a construction water treatment plant at or near the Rosehill services facility site, which will discharge treated water to Duck Creek, for the construction of the facility. The water treatment plant would be configured so that treated water is compliant with the ANZG (2018) guideline values. The water treatment plant will be present at the commencement of construction of this proposal.

A review of available data indicates the watercourses relevant to this proposal are generally in poor condition and are representative of a heavily urbanised system (Sydney Metro, 2020). An assessment of watercourses relevant to Clyde stabling and maintenance facility site against the ANZG guidelines as part of the previous Sydney Metro West planning application is provided in Table 4-19. The Water Quality and River Flow Objectives environmental values for the receiving waters are provided in Table 3-1, Section 3.2.3 of this assessment.

Table 4-19: Existing water quality conditions of watercourses relevant to Clyde stabling and maintenance facility

Site	Watercourse	Water quality characteristics relevant to ANZECC/ARMCANZ (2000) indicators
Clyde stabling and maintenance facility	Parramatta River	• Elevated nutrient concentrations • Elevated heavy metal concentrations • High turbidity
	Duck River	• Low dissolved oxygen levels • Elevated nutrient concentrations • High turbidity
	Duck Creek and A'Becketts Creek	• Elevated nutrient concentrations • Elevated concentrations of faecal coliforms

4.10.6 Sensitive receiving environments and wetlands

Waterways and water bodies have been identified as receiving environments of high sensitivity predominantly due to key fish habitat classification, Type 1 (highly sensitive Key Fish Habitat), Type 2 (moderately sensitive key fish habitat) and Class 1 (major key fish habitat), and/or proximity to coastal wetlands as defined by the coastal management SEPP. These watercourses have a high conservation or community value or support ecosystems or human uses of water that are particularly sensitive to pollution or degradation of water quality. Table 4-20 identifies sensitive surface water receiving environments specific to Clyde stabling and maintenance facility site and describes their condition and sensitivity (Sydney Metro, 2020d).

Table 4-20: Sensitive surface water receiving environments at Clyde stabling and maintenance facility and Rosehill services facility

Watercourse	Surface water features	Condition	Sensitive receiving environment rating
Duck River	Type 1 Key Fish Habitat SEPP Coastal Wetlands within 0.5 km Third order estuarine waterway Concrete-lined in upper reaches	Moderately disturbed	High
Duck Creek	Type 1 Key Fish Habitat Second order waterway Unlined	Moderately disturbed	High
A'Becketts Creek	Type 1 Key Fish Habitat First order waterway Concrete-lined channels along long sections	Highly disturbed	Moderate

4.10.7 Baseline flooding conditions

The potential flooding impact associated with filling this site to above the PMF level was considered in the previous Sydney Metro West planning application. The PMF is the defining flood event for those works and forms the baseline flooding environment for this assessment.

The Clyde stabling and maintenance facility site would not be inundated in the PMF event. This is also the case when sea level rise is considered with the PMF event. In the baseline environment, the area around the site is largely impacted in the PMF event with some areas upstream of the site also impacted in 1% AEP flood event.

Duck Creek, A'Becketts Creek and Duck River in the vicinity of the site are high hazard in both the 1% AEP flood event and the PMF event.

5 Hydrology and flooding impact assessment

This section describes the hydrology and flooding impact of this proposal on the surrounding environment within the study area and the impact of flooding on this proposal in the context of Secretary's environmental assessment requirements outlined in Table 1 1.

Hydrology impacts are covered within a single section for all the stations and facilities within this proposal. Flooding impact content has been structured based on the station or facility within this proposal. Climate change has not specifically been addressed in the following sections on flooding as it has been directly incorporated into the design as outlined in Section 3.1 and Section 3.3.

5.1 Surface hydrology impact assessment

Construction surface hydrology impacts (Table 5-1) and operation surface hydrology impacts (Table 5-2) of this proposal are described below in relation to the Secretary's environmental assessment requirements outlined in Table 1-1.

Table 5-1: Impacts on surface hydrology during construction

Secretary's environmental assessment requirements for hydrology	Response
Surface hydrology impacts of the construction of the proposal and any ancillary facilities (both built elements and discharges) in accordance with the current guidelines, including:	Refer Section 3.1 for details of the assessment approach
(a) natural processes within rivers, wetlands, estuaries, marine waters and floodplains that affect the health of the fluvial, riparian, estuarine or marine system and landscape health (such as modified discharge volumes, durations and velocities), aquatic connectivity and access to habitat for spawning and refuge;	At all construction sites except for the Clyde stabling and maintenance facility and Rosehill services facility construction sites, flood and stormwater discharges would enter the minor and major urban drainage system rather than directly entering nearby watercourses. Ultimately, these stormwater discharges would enter Sydney Harbour or the Parramatta River and therefore the degree of impact that these discharges may have on natural processes, such as modified discharge volumes, durations and velocities, is likely to be low as these watercourses have considerable contributing catchment areas. The Clyde stabling and maintenance facility and Rosehill services facility are located near Duck Creek which is tidal (Manly Hydraulics Laboratory, 2006) in this location. As part of the previous Sydney Metro West planning application stormwater and wastewater discharges points would be introduced and would enter the creek at several locations from immediately upstream of the waterway structures

Secretary's environmental assessment requirements for hydrology	Response
	underneath the Clyde stabling and maintenance facility along with several locations downstream of these structures. One of these outlets would be from the temporary wastewater treatment plant. The hydrological regime of the wastewater treatment plant discharge at the Clyde stabling and maintenance facility construction site is not expected to alter significantly from that considered during the previous Sydney Metro West planning application. Wastewater would be treated and reused where practicable. The other outlets would be stormwater discharge points which along with the trunk drainage and stormwater discharge ponds would be pre-existing having been constructed as part of the previous Sydney Metro West planning application. Trunk drainage including associated discharge structures would be designed to comply with applicable Transport for NSW standards. Water quality drainage features would be designed in accordance with relevant City of Parramatta Council standards to meet requirements of the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018). The hydrological regime of the internal drainage of the Clyde stabling and maintenance facility construction site is not expected to alter significantly from that considered during the previous Sydney Metro West planning application. Furthermore, the contributing catchment associated with this proposal is small in the context of the overall catchment for this creek. Consequently, impacts on these natural processes such as modified discharge volumes, durations and velocities due to construction of this proposal are likely to be low.
(b) changes to environmental water availability and flows, both regulated / licensed and unregulated / rules-based sources;	No surface water resources would be taken or interfered with by this proposal.

Secretary's environmental assessment requirements for hydrology	Response
(c) direct or indirect increases in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of riverbanks or watercourses;	At all construction sites except for the Clyde stabling and maintenance facility and Rosehill services facility construction sites, flood and stormwater would drain to minor and major urban drainage systems rather than directly entering nearby watercourses. At the Clyde stabling and maintenance facility and Rosehill services facility construction sites, stormwater flows would drain to Duck Creek via the trunk drainage, water quality ponds and discharge outlets that would have been constructed under the previous Sydney Metro West planning application. During construction, these flows would also be managed in accordance with the Construction Environmental Management Framework to address erosion and sediment control. Water quality measures would be employed as indicated in Section 6.1. The rehabilitation of Duck Creek would be undertaken in a staged approach to minimise potential erosion and bank instability. Native vegetation would be retained with removal of vegetation limited to weed species. This is further detailed in Chapter 17.14 (Biodiversity) of the Environmental Impact Statement. Collectively, these measures would be expected to limit velocities and sediment loads such that it would be unlikely that this proposal would result in instability of riverbanks or watercourses.
(d) minimising the effects of proposed stormwater and wastewater management during construction 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	As the catchments of the stations and ancillary facilities are highly urbanised and developed with widespread impervious surfaces, the amount of impervious area would not be significantly increased by this proposal and changes to natural hydrological attributes and conveyance capacity of existing stormwater systems would be limited. Wastewater would be treated prior to release and would be reused where practicable. Refer to Section 6.1.8 for more details on reuse of water during construction.
(e) water take (direct or passive) from all surface water sources with estimates of annual volumes during construction.	No surface water resources would be taken or interfered with by this proposal.

Table 5-2: Impacts on surface hydrology during operation

Secretary's environmental assessment requirements for hydrology	Response
Surface hydrology impacts of the operation of the proposal and any ancillary facilities (both built elements and discharges) in accordance with the current guidelines, including:	Refer Section 3.1 for details of the assessment approach.

(a) natural processes within rivers, wetlands, estuaries, marine waters and floodplains that affect the health of the fluvial, riparian, estuarine or marine system and landscape health (such as modified discharge volumes, durations and velocities), aquatic connectivity and access to habitat for spawning and refuge;	At all sites except for the Clyde stabling and maintenance facility and Rosehill services facility, flood and stormwater discharges would enter the minor and major urban drainage system, rather than directly entering nearby watercourses. The design of the stations would include onsite detention of stormwater, in accordance with applicable design standards. Ultimately these stormwater discharges would enter Sydney Harbour or Parramatta River and therefore the degree of impact on natural processes, such as modified discharge volumes, durations and velocities, is likely to be negligible as these watercourses have extensive contributing catchment areas. The Clyde stabling and maintenance facility and Rosehill services facility are located near Duck Creek which is tidal (Manly Hydraulics Laboratory, 2006) in this location. Stormwater and wastewater discharges would enter the creek at several locations from immediately upstream of the waterway structures underneath the Clyde stabling and maintenance facility along with several locations downstream of these structures. One of these outlets would be from the wastewater treatment plant and is anticipated to be between 0.5 and 1 megalitres of wastewater, treated for a marine environment. Duck Creek is considered perennial and with the tidal behaviour it is unlikely to have no flow when wastewater is being discharged during operations. The other outlets would be stormwater discharge points which along with the trunk drainage and stormwater discharge ponds would be pre-existing having been constructed as part of the previous Sydney Metro West planning application. Trunk drainage including associated discharge structures would be designed to comply with applicable Transport for NSW Asset Management Branch standards. Water quality drainage features would be designed in accordance with relevant City of Parramatta Council standards to meet requirements of the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018). The hydrological regime of the internal drainage of the Clyde stabling and maintenance facility is not expected to alter significantly from that considered during the previous Sydney Metro West planning application. Furthermore, the contributing catchment associated with this proposal is small in the context of the overall catchment for this creek. Consequently, impacts on these natural processes such as modified discharge volumes, durations and velocities due to this proposal are likely to be low.

Secretary's environmental assessment requirements for hydrology	Response
(b) changes to environmental water availability and flows, both regulated / licensed and unregulated / rules-based sources;	No surface water resources are taken or interfered with by this proposal.
(c) direct or indirect increases in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses;	At all sites except for the Clyde stabling and maintenance facility and Rosehill services facility, flood and stormwater would drain to minor and major urban drainage systems rather than directly entering nearby watercourses. At the Clyde stabling and maintenance facility and Rosehill services facility, stormwater flows would drain to Duck Creek via the trunk drainage, water quality ponds and discharge outlets that would have been constructed under the previous Sydney Metro West planning application. The water quality ponds would be designed to manage expected quality requirements for the end state. Water quality measures would be employed as indicated in Section 6.2. Collectively, these measures would be expected to limit velocities and sediment loads such that it would be unlikely that this proposal would result in instability of riverbanks or watercourses.

Secretary's environmental assessment requirements for hydrology	Response
(d) minimising the effects of proposed stormwater and wastewater management during 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	As the catchments of the stations and facilities are highly urbanised and developed with widespread impervious surfaces, the amount of impervious area would not be significantly increased by this proposal and the portion of the total catchment of associated watercourses is large compared with the portion associated with this proposal. Mitigation measures EIS-HF 1 and EIS-HF 4 (Section 7.2 and Table 7-1) make provision for augmentation of the existing stormwater system where required to comply with the Impact Flooding Criteria. It is therefore expected that along with onsite storage detention facilities that the impact on conveyance capacity of existing stormwater systems where discharges are proposed would be minimised. Stormwater and wastewater discharges would enter the creek at several locations from immediately upstream of the waterway structures underneath the Clyde stabling and maintenance facility along with several locations downstream of these structures. One of these outlets would be from the wastewater treatment plant and is anticipated to be between 0.5 and 1 megalitres of wastewater, treated for a marine environment. Duck Creek is considered perennial and with the tidal behaviour it is unlikely to have no flow when wastewater is being discharged during operations. The other outlets would be stormwater discharge points which along with the trunk drainage and stormwater discharge ponds would be pre-existing having been constructed as part of the previous Sydney Metro West planning application. Trunk drainage including associated discharge structures would be designed to comply with applicable Transport for NSW Asset Management Branch standards. Water quality drainage features would be designed in accordance with relevant City of Parramatta Council standards to meet requirements of the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018). The hydrological regime of the internal drainage of the Clyde stabling and maintenance facility is not expected to alter significantly from that considered during the previous Sydney Metro West planning application. Furthermore, the contributing catchment associated with this proposal is small in the context of the overall catchment for this creek. Collectively, these measures would be expected to minimise changes to natural hydrological attributes.

Secretary's environmental assessment requirements for hydrology	Response
(e) water take (direct or passive) from all surface water sources with estimates of annual volumes during operation.	No surface water resources are taken or interfered with by this proposal.

5.2 Flood impact Assessment

5.2.1 Westmead metro station

Construction phase flooding impacts (Table 5-3) and operation phase flooding impacts (Table 5-4) at Westmead metro station are described below in relation to the Secretary's environmental assessment requirements outlined in Table 1-1.

Table 5-3: Impacts on flood behaviour during construction at Westmead metro station

Secretary's environmental assessment requirements for flooding	Response
Full range of flood events up to the PMF (taking into account sea level rise and storm intensity due to climate change) including:	Refer Section 3.1.4
(a) maps featuring flood prone lands, flood planning areas (areas below the flood planning level), hydraulic categorisation (flood ways and flood storage areas) and flood hazards;	Refer Appendix A – Baseline environment flood maps

(b) assessment of potential flood affectation of other properties, assets and infrastructure against the flood management objectives	The baseline assessment is described in Section 4.1.7. Flood affectation as a result of construction of this proposal would have a similar risk profile to that outlined in the previous Sydney Metro West planning application. This proposal may be subject to the following general: • direct intense rainfall onto the site may cause nuisance flooding and drainage issues • continued potential interruption of overland flow paths from temporary construction site infrastructure and modifications to landforms • the potential interruption or diversion of existing flood routes away from the location of bunding or spoil within construction sites, resulting in a reduction of flood storage and an increased flood risk to adjacent sites • disruption of street kerb and gutter at construction site vehicle entry locations which may result in localised ponding • potential blocking of drainage networks through increased sedimentation of surface water. The additional construction footprint for this proposal includes some locations within the existing rail corridor (at and around the existing Westmead Station) which are affected by both the five per cent AEP and one per cent AEP events (both with climate change). Construction work within the rail corridor would generally be carried out during multiple short term rail possessions. This proposal also includes work to the existing rail embankment to support track realignment west of Hawkesbury Road. Work within the existing rail corridor would be carried out during scheduled Sydney Trains rail possessions and this location would be outside of the catchment within which the majority of the proposal is located (i.e. the track falls away westward from a point just west of the Hawkesbury Road rail overbridge). It is expected that impacts to drainage arrangements would be contained within the existing rail corridor. As such, potential impacts to flood behaviour associated with this work would be negligible. Mitigation measures included in the Construction Environment Management Framework would require that construction planning manages potential construction phase flooding risk within the rail corridor and at other locations that form part of the Westmead metro station construction site.
(c) consistency (or inconsistency) with	Cumberland City Council has no floodplain risk management plan applicable to this area. There is flood

Secretary's environmental assessment requirements for flooding	Response
applicable Council floodplain risk and stormwater management plans and other similar initiatives	control mapping under the State Environmental Planning Policy (Exempt and Complying Development Codes) 2008. This mapping indicates that several lots within the proposal along with others in adjacent blocks are listed as having ponding hazard which would be managed at future re-development.
(d) compatibility with the flood hazard of the land	The site is primarily classified within the H1 hazard in the 5% AEP with climate change and 1% AEP with climate change flood events which is accepted to be safe for people, vehicles and buildings (refer to Section 2.5.2 for hazard classifications). Localised areas show higher depths in Alexandra Avenue which correspond to an increase the hazard category to H5 in the 1% AEP with climate change flood event. These areas are indicated on Figure A-4 of Appendix A – Baseline environment flood maps and are generally along the side of Alexandra Avenue adjacent to the existing rail corridor. Access and evacuation routes are readily available via the adjacent streets. In the PMF event, the hazard along streets adjacent to the site increases to H5, with small, localised areas with a hazard of H6 which are away from the site further east along Alexandra Avenue. Sections of the rail corridor would experience H2/H3 hazard category. Evacuation from the site would be possible via Hawkesbury Road which is at a much higher elevation than the other surrounding roads and has a low hazard rating of H1. Potential hazard to people and vehicles accessing the site would be managed through measures outlined in the Construction Environmental Management Framework in rare and extreme flood events due to the high hazard in surrounding streets and the existing rail corridor.
(e) compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land	Cumberland City Council has flood control mapping under the State Environmental Planning Policy (Exempt and Complying Development Codes) 2008. This mapping indicates that the section of Alexandra Avenue from approximately Hassall Street to the parkland previously known as the Parramatta Golf Course is considered a flood way. With the measures outlined in (d) of this table it is expected that these hydraulic functions would be compatible with this proposal.

Secretary's environmental assessment requirements for flooding	Response
(f) the likelihood of erosion, siltation, destruction of riparian vegetation on riverbanks and watercourses	Flood and stormwater discharged from this site enter the minor and major urban drainage system rather than directly entering nearby watercourses such as Domain Creek. Given the measures outlined in the Construction Environmental Management Framework it is expected that the likelihood of erosion, siltation, destruction of riparian vegetation on riverbanks and watercourses is very low.
g) impacts the development may have upon existing community emergency management arrangements for flooding.	No major road or rail transport routes identified in the South West Regional Emergency Management Plan are close enough to be impacted by flood flows from this site. Rerouted ambulance route impacts would need to be managed so that it is not adversely impacted during construction. This would be addressed through the Construction Environmental Management Framework which makes provision for engagement with relevant agencies to coordinate planning in order to limit these impacts.
(h) any impacts the development may have on the social and economic costs to the community as consequence of flooding	Refer Section 5.2.12

Table 5-4: Impacts on flood behaviour during operations at Westmead metro station

Secretary's environmental assessment requirements for flooding	Response
Full range of flood events up to the PMF (taking into account sea level rise and storm intensity due to climate change) including:	Refer Section 3.1.4

Secretary's environmental assessment requirements for flooding	Response
(a) maps featuring flood prone lands, flood planning areas (areas below the flood planning level), hydraulic categorisation (flood ways and flood storage areas) and flood hazards;	Refer Appendix A – Baseline environment flood maps and Appendix B – "With Proposal" flood maps
(b) assessment of potential flood affectation of other properties, assets and infrastructure against the flood management objectives	For the 5% AEP climate change and 1% AEP climate change flood events and the PMF event: • Hydraulic impact maps included in Appendix C – Impact assessment flood maps show that the proposal has limited localised impacts on existing flooding behaviour. Generally, there is no increase in afflux in all events due to the proposal with the following exceptions: • Flood event modelling generally indicates localised increases in flood levels within the proposal area adjacent to the metro station and Alexander Avenue. This is due to assumptions related to the modelled surface topography • Mitigation measure EIS-HF 1 would require that the road design of Alexandra Avenue within the proposal would be developed to minimise flooding on Alexandra Avenue; that flooding does not result in ponding on Alexandra Avenue and that the final design of the proposal is compliant with the flood impact criteria outlined in Section 3.1.4 • Change in duration of inundation is negligible. Figure 5-1 indicates the 1% AEP climate change flood event impact of the proposal. Further hydraulic impact assessment maps are located in Appendix C – Impact assessment flood maps. No private property impacts are expected in the 5% AEP climate change and 1% AEP climate change flood events and the PMF event. The table below outlines the defining event for the design of station entry levels and the station design level relative to the flood level for the defining event. Further design refinement (mitigation measure EIS-HF 1) would be carried such that the design level of the station would be situated at a height at least equal to the 1% AEP climate change flood level plus freeboard which is the defining event for this metro station. Due to the nuisance nature of flooding at this site and owing to the location of the station within the catchment, 0.3 metres freeboard (rather than a typical freeboard of 0.5 metres) is considered adequate and would be adopted.

<table>
<tr><th>Secretary's environmental assessment requirements for flooding</th><th colspan="4">Response</th></tr>
<tr><td rowspan="3"></td><td>Location</td><td>Defining Event</td><td>Flood level (mAHD)</td><td>Design level (mAHD)</td></tr>
<tr><td>Alexandra Avenue access</td><td rowspan="2">1% AEP climate change with freeboard</td><td>37.725</td><td>38.00</td></tr>
<tr><td>Hawkesbury Road access</td><td>30.021</td><td>38.00</td></tr>
<tr><td>(c) consistency (or inconsistency) with applicable Council floodplain risk and stormwater management plans and other similar initiatives</td><td colspan="4">Cumberland City Council has no floodplain risk management plan applicable to this area. There is flood control mapping under the State Environmental Planning Policy (Exempt and Complying Development Codes) 2008. This mapping indicates that several lots within the proposal along with others in adjacent blocks are listed as having ponding hazard which would be managed at future re-development.</td></tr>
<tr><td>(d) compatibility with the flood hazard of the land</td><td colspan="4">Hazard categories are largely unchanged. Access and evacuation routes are readily available via the adjacent streets for the events considered in this proposal with Hawkesbury Road a safer choice during the PMF event. Mitigation measure EIS-HF 1 would ensure that the concourse connection linking Westmead metro station and the existing Westmead Station is compliant with relevant requirements.</td></tr>
<tr><td>(e) compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land</td><td colspan="4">Cumberland City Council has flood control mapping under the State Environmental Planning Policy (Exempt and Complying Development Codes) 2008. This mapping indicates that sections of Alexandra Avenue from Hassall Street to the parkland previously known as the Parramatta Golf Course are flood ways. The flow conveyance is largely within the road corridor of Alexandria Avenue which is also indicated in Figures B-4 and B-6 of Appendix B – "With Proposal" flood maps . These maps show the increasing high hazard sections of Alexandra Avenue as the flood events becomes rarer which is indicative of the conveyance behaviour associated with a flood way. With the measures outlined in (d) it is expected that these hydraulic functions would be compatible with this proposal.</td></tr>
</table>

Secretary's environmental assessment requirements for flooding	Response
(f) the likelihood of erosion, siltation, destruction of riparian vegetation on riverbanks and watercourses	Flood and stormwater discharged from this site would enter the minor and major urban drainage system rather than directly entering nearby watercourses such as Domain Creek. Water quality measures would be employed as indicated in Section 6.2. Furthermore, as these catchments are very small compared to the total catchment of the nearby watercourse indirect impacts are likely to be low.
g) impacts the development may have upon existing community emergency management arrangements for flooding.	No major road or rail transport routes in the South West Regional Emergency Management Plan are within the extent of influence of the model and therefore unlikely impacted by flood flows from this site. Based on the assessment of potential flooding impacts outlined earlier in this table and the associated mitigation measures outlined in Table 7-1, flooding impacts that are expected to result from this proposal are generally considered to minor and local.
(h) any impacts the development may have on the social and economic costs to the community as consequence of flooding	Refer Section 5.2.12

Figure 5-1 1% AEP climate change flood impact assessment map for Westmead metro station

5.2.2 Parramatta metro station

Construction phase flooding impacts (Table 5-5) and operation phase flooding impacts (Table 5-6) at Parramatta metro station are described below in relation to the Secretary's environmental assessment requirements outlined in Table 1-1.

Table 5-5: Impacts on flood behaviour during construction at Parramatta metro station

Secretary's environmental assessment requirements for flooding	Response
Full range of flood events up to the PMF (taking into account sea level rise and storm intensity due to climate change) including:	Refer Section 3.1.4
(a) maps featuring flood prone lands, flood planning areas (areas below the flood planning level), hydraulic categorisation (flood ways and flood storage areas) and flood hazards;	Refer Appendix A – Baseline environment flood maps
(b) assessment of potential flood affectation of other properties, assets and infrastructure against the flood management objectives	The baseline assessment is described in Section 4.2.7. Flood affectation as a result of construction of this proposal would have a similar risk profile to that outlined in the previous Sydney Metro West planning application. This proposal may be subject to the following general impacts: • direct intense rainfall onto the site may cause nuisance flooding and drainage issues • flow of water into basement excavation areas • continued potential interruption of overland flow paths from temporary construction site infrastructure and modifications to landforms • the potential interruption or diversion of existing flood routes away from the location of bunding or spoil within construction sites, resulting in a reduction of flood storage and an increased flood risk to adjacent sites • disruption of street kerb and gutter at construction site vehicle entry locations which may result in localised ponding • potential blocking of drainage networks through increased sedimentation of surface water. Mitigation measures included in the Construction Environment Management Framework would require that construction planning manages potential construction phase flooding risk at the Parramatta metro station Construction site.

Secretary's environmental assessment requirements for flooding	Response
(c) consistency (or inconsistency) with applicable Council floodplain risk and stormwater management plans and other similar initiatives	The City of Parramatta Council includes flood risk mapping online as part of their FloodSmart initiative. The mapping shows the site area as "Low Risk", which notes flooding is extremely rare but when this happens flooding will cover a large area with dangerous water in many places. This is consistent with the mapping in Appendix A – Baseline environment flood maps where the 5% AEP climate change and 1% AEP climate change flood events cause local flooding only as the Parramatta River would not have broken its banks. The City of Parramatta Council recently endorsed the Update of Parramatta Floodplain Risk Management Plans (Molino Stewart, 2021). Flood depths in the PMF are indicated as being between one and two metres which is consistent with the mapping in Appendix A – Baseline environment flood maps for the same flood event.
(d) compatibility with the flood hazard of the land	The site and surrounding streets are classified within the H1 hazard category for the 5% AEP climate change and 1% AEP climate change flood events, which is accepted as safe for people, vehicles and buildings. Access and evacuation routes are readily available via the adjacent streets though Smith Street is likely to have approximately 0.5 metres of water in the 1% AEP climate change flood event so it may be prudent to consider other routes. In the PMF event, the hazard increases mostly H5 with sections up to H6 due to the depth and flow velocity during these extreme floods. Floodwaters rise quickly in this catchment (Molino Stewart, 2021) and therefore would require careful consideration of consequential risks and how they should be managed. Potential risk to construction areas which are not protected from flood inundation along with danger to people and vehicles accessing or working within the construction site would be managed through measures outlined in the Construction Environmental Management Framework. Areas of the construction site north of the station box, would experience slightly lower hazard with large areas of H3 and H4 where H3 is unsafe for vehicles.

Secretary's environmental assessment requirements for flooding	Response
(e) compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land	Most of the Parramatta CBD is within the floodplain of the Parramatta River and therefore could be considered flood storage. Widespread flooding across the Parramatta CBD would be a rare occurrence and with the measures outlined in (d) it is expected these hydraulic functions would be compatible with this proposal.
(f) the likelihood of erosion, siltation, destruction of riparian vegetation on riverbanks and watercourses	Flood and stormwater discharged from this site would enter the minor and major urban drainage system rather than directly entering nearby watercourses. With implementation of measures outlined in the Construction Environmental Management Framework it is expected that the likelihood of erosion, siltation, destruction of riparian vegetation on riverbanks and watercourses is very low.
g) impacts the development may have upon existing community emergency management arrangements for flooding.	The site is located within the South West Metropolitan Regional and Parramatta local Emergency Management Plan Areas. No major road or rail transport routes are listed within the area that would be impacted by flood flows from this site. The City of Parramatta Council has recently endorsed the Update of Parramatta Floodplain Risk Management Plans (Molino Stewart, 2021) and supporting documents the Parramatta CBD Flood Evacuation Assessment (Molino Stewart, 2021a) and the Horizontal Evacuation Pilot Study (SJB Architects, 2017). According to the Parramatta CBD Flood Evacuation Assessment, Great Western Highway, Church Street, Harris Street, Pennant Hills Road and Victoria Road were considered as evacuation routes leading out of the Parramatta CBD. All the streets adjacent to the block within which this proposal would be situated are considered feeder routes to these evacuation routes. Mitigation measures outlined in the Construction Environmental Management Framework require ongoing engagement with relevant agencies to coordinate planning in order to limit these impacts.
(h) any impacts the development may have on the social and economic costs to the community as consequence of flooding	Refer Section 5.2.12

Table 5-6: Impacts on flood behaviour during operations at Parramatta metro station

Secretary's environmental assessment requirements for flooding	Response
Full range of flood events up to the PMF (taking into account sea level rise and storm intensity due to climate change) including:	Refer Section 3.1.4
(a) maps featuring flood prone lands, flood planning areas (areas below the flood planning level), hydraulic categorisation (flood ways and flood storage areas) and flood hazards;	Refer Appendix A – Baseline environment flood maps and Appendix B – "With Proposal" flood maps

(b) assessment of potential flood affectation of other properties, assets and infrastructure against the flood management objectives	For the 5% AEP climate change and 1% AEP climate change event: • The site would be affected by shallow ponding and flooding from direct rainfall on the site in these flood events, there would be no overland flows through the site • There would be minor reductions in flood level of up to approximately 0.04 metres in George Street and Smith Street as a result of minor redirection of discharge from the site compared to the baseline flooding • The duration of inundation would not alter appreciably • Given the shallow depths and isolated areas of flooding it is not expected that additional properties would be impacted. For the PMF event: • The site would be affected by flooding with a depth in excess of one metre. • Compared to the baseline scenario, the "with proposal" scenario would block a greater volume of stormwater from passing west to east through the site. However, it would allow more flow through the site from the south to the north. The redirection of flow from the baseline to "with proposal" scenario results in increases in flood level to the west of the site as outlined in (g) with reductions in flood level to the east. • Substantial inundation would be experienced across the Parramatta CBD during a PMF event without this proposal. The scale of impact as a result of this proposal is modest by comparison. It is not expected that additional buildings would be impacted where they were not previously • The duration of inundation would not alter appreciably Figure 5-2 indicates the 1% AEP climate change flood event impact of the proposal. Hydraulic impact maps included in Appendix C – Impact assessment flood maps show that the building at 100 George Street with the childcare centre would be marginally less impacted in the PMF event. Table below outlines the defining event for the design of station entry levels and shows the station design level relative to the flood level for the defining event. Flood protection measures (for example flood barriers to protect the station from inundation) would be required at this station as the design level would not be situated at a height

<table>
<tr><th>Secretary's environmental assessment requirements for flooding</th><th>Response</th></tr>
<tr><td></td><td>greater than or equal to the PMF level which is generally the defining event for this metro station. This would most likely be achieved with flood barriers incorporated into the design of the metro station and operated as part of the emergency management arrangements.
<table>
<tr><th>Location</th><th>Defining Event</th><th>Flood level (mAHD)</th><th>Design level (mAHD)</th></tr>
<tr><td>Church Street</td><td>PMF</td><td>12.41</td><td>10.50</td></tr>
<tr><td>Macquarie Lane</td><td>PMF</td><td>10.87</td><td>9.90</td></tr>
</table></td></tr>
<tr><td>(c) consistency (or inconsistency) with applicable Council floodplain risk and stormwater management plans and other similar initiatives</td><td>The City of Parramatta Council recently endorsed the Update of Parramatta Floodplain Risk Management Plans (Molino Stewart, 2021). Flood depths in the PMF event are indicated as being between one and two metres which is consistent with the mapping in Appendix A – Baseline environment flood maps for the same flood event. The City of Parramatta Council includes flood risk mapping online as part of their FloodSmart initiative. The mapping shows the site area as “Low Risk”, which notes flooding is extremely rare but when this happens flooding will cover a large area with dangerous water in many places. This is consistent with the mapping in Appendix A – Baseline environment flood maps where the 5% AEP climate change and 1% AEP climate change flood events cause local flooding only as the Parramatta River would not have broken its banks.</td></tr>
</table>

Secretary's environmental assessment requirements for flooding	Response
(d) compatibility with the flood hazard of the land	The site and surrounding streets are classified within the H1 hazard category for the 5% and 1% AEP climate change flood events, which is accepted as safe for people, vehicles and buildings. Access and evacuation routes are readily available via the adjacent streets though Smith Street is likely to have approximately 0.5 metres of water in the 1% AEP climate change flood event so it may be prudent to consider other routes. In the PMF event, the hazard on the site and surrounding streets continues to be characterised by the high hazard (H5 and H6) categories. The Parramatta metro station would be protected from inundation in the PMF event as outlined above in (b) which would provide shelter in place arrangements during extreme flood events as surrounding streets would be high hazard. Potential hazard to people and vehicles accessing the Parramatta metro station as flood protection measures operate would be managed through emergency response planning as required by mitigation measure EIS-HF 2.
(e) compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land	Most of the Parramatta CBD is within the floodplain of the Parramatta River and therefore could be considered flood storage as well as flood ways. Figure B-12 of Appendix B – "With Proposal" flood maps indicates extended sections of high hazard in surrounding streets for the PMF event which demonstrates the conveyance behaviour associated with a flood way. Widespread flooding across the Parramatta CBD would be a rare occurrence and with the measures outlined in (d) it is expected these hydraulic functions would be compatible with this proposal.
(f) the likelihood of erosion, siltation, destruction of riparian vegetation on riverbanks and watercourses	Flood and stormwater discharged from this site would enter the minor and major urban drainage system rather than directly entering nearby watercourses. Water quality measures would be employed as indicated in Section 6.2. Furthermore, as these catchments are very small compared to the total catchment of nearby watercourses indirect impacts are likely to be low.

Secretary's environmental assessment requirements for flooding	Response
g) impacts the development may have upon existing community emergency management arrangements for flooding.	The site is located within the Parramatta local Emergency Management Plan Area. No major road or rail transport routes are listed within the area that would be impacted by flood flows from this site. All the streets adjacent to the block within which this proposal would be situated are considered feeder routes to the evacuation routes outlined in the Parramatta CBD Flood Evacuation Assessment. However, the assessment concludes that safe vehicular evacuation would not be realistically achievable under any circumstances for the PMF event. Modelling of the PMF event suggests the following potential adverse impacts to existing emergency evacuation routes outlined in the Parramatta CBD Flood Evacuation Assessment: • Increased inundation in Church Street mostly up to approximately 0.1 metres, including almost a city block beyond George Street, with a section near Macquarie Street experiencing an increase in inundation up to approximately 0.15 metres • Increased inundation in Macquarie Street of up to approximately 0.17 metres near to the junction with Church Street • Increased inundation in George Street of up to approximately 0.13 metres between Red Cow and Horwood Place Mitigation measures EIS-HF 3 would ensure that impacts the proposal may have on existing emergency management arrangements are discussed with the NSW State Emergency Service and the City of Parramatta Council.
(h) any impacts the development may have on the social and economic costs to the community as consequence of flooding	Refer Section 5.2.12

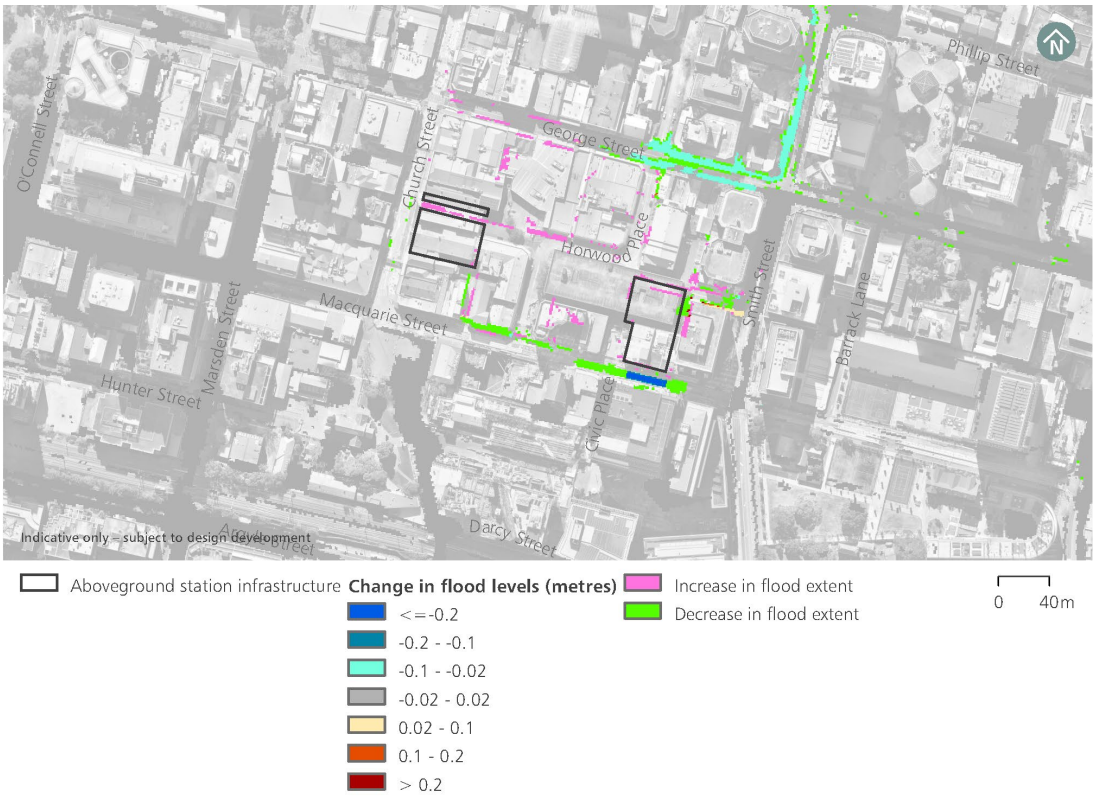

Figure 5-2 1% AEP climate change flood impact assessment map for Parramatta metro station

5.2.3 Sydney Olympic Park metro station

Construction phase flooding impacts (Table 5-7) and operation phase flooding impacts (Table 5-8) at Sydney Olympic Park metro station are described below in relation to the Secretary's environmental assessment requirements outlined in Table 1-1.

Table 5-7: Impacts on flood behaviour during construction at Sydney Olympic Park metro station

Secretary's environmental assessment requirements for flooding	Response
Full range of flood events up to the PMF (taking into account sea level rise and storm intensity due to climate change) including:	Refer Section 3.1.4
(a) maps featuring flood prone lands, flood planning areas (areas below the flood planning level), hydraulic categorisation (flood ways and flood storage areas) and flood hazards;	Refer Appendix A – Baseline environment flood maps

Secretary's environmental assessment requirements for flooding	Response
(b) assessment of potential flood affectation of other properties, assets and infrastructure against the flood management objectives	The baseline assessment is described in Section 4.3.7. Flood affectation as a result of construction of this proposal would have a similar risk profile to that outlined in the previous Sydney Metro West planning application. These works would include the following general impacts: • direct intense rainfall onto the site may cause nuisance flooding and drainage issues • flow of water into excavation areas to depth of approximately three metres. • continued potential interruption of overland flow paths from temporary construction site infrastructure and modifications to landforms • the potential interruption or diversion of existing flood routes away from the location of bunding or spoil within construction sites, resulting in a reduction of flood storage and an increased flood risk to adjacent sites • disruption of street kerb and gutter at construction site vehicle entry locations which may result in localised ponding • potential blocking of drainage networks through increased sedimentation of surface water. Mitigation measures implemented as part of the Construction Environment Management Framework would require that construction planning is compliant with the relevant requirements.
(c) consistency (or inconsistency) with applicable Council floodplain risk and stormwater management plans and other similar initiatives	The Sydney Olympic Park Authority has a policy entitled Stormwater Management and Water Sensitive Urban Design but no applicable floodplain risk management plans. The area is not subject to major overland or riverine flooding.

Secretary's environmental assessment requirements for flooding	Response
(d) compatibility with the flood hazard of the land	The site and surrounding streets are primarily classified within the H1 hazard in the 5% AEP climate change and 1% AEP climate change flood events which is accepted as safe for people, vehicles and buildings. Small, localised areas show higher velocity in Showground Road increase the hazard category to H2 to H5 for both flood events. Access and evacuation routes are readily available via the adjacent streets. In the PMF event, there are localised areas of H5 hazard in Herb Elliot Avenue and the width of Showground Road is H5. Evacuation from the site can be accessed via adjacent streets (only Showground Road would not be trafficable for its full width). However, due to the small catchment area and short critical storm duration this would likely only be affected for a short period of time.
(e) compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land	The site is not a conveyance or flood storage area in flood events up to the PMF event. Stormwater discharge from the site is via the underground stormwater network and adjacent streets.
(f) the likelihood of erosion, siltation, destruction of riparian vegetation on riverbanks and watercourses	Flood and stormwater discharged from this site would enter the minor and major urban drainage system rather than directly entering nearby watercourses. With implementation of the measures outlined in the Construction Environmental Management Framework it is expected that the likelihood of erosion, siltation, destruction of riparian vegetation on riverbanks and watercourses is very low.
g) impacts the development may have upon existing community emergency management arrangements for flooding.	The site is located within the South West Metropolitan Regional and Parramatta local Emergency Management Plan Areas. No major road or rail transport routes are listed within the plans that would be impacted by flood flows in the vicinity of the site. Measures outlined in the Construction Environmental Management Framework require ongoing engagement with relevant agencies to coordinate planning in order to limit these impacts.

Secretary's environmental assessment requirements for flooding	Response
(h) any impacts the development may have on the social and economic costs to the community as consequence of flooding	Refer Section 5.2.12

Table 5-8: Impacts on flood behaviour during operations at Sydney Olympic Park metro station

Secretary's environmental assessment requirements for flooding	Response
Full range of flood events up to the PMF (taking into account sea level rise and storm intensity due to climate change) including:	Refer Section 3.1.4
(a) maps featuring flood prone lands, flood planning areas (areas below the flood planning level), hydraulic categorisation (flood ways and flood storage areas) and flood hazards;	Refer Appendix A – Baseline environment flood maps and Appendix B – "With Proposal" flood maps

(b) assessment of potential flood affectation of other properties, assets and infrastructure against the flood management objectives	For the 5% AEP climate change and 1% AEP climate change flood events: • Generally, impacts would be contained within the Sydney Olympic Park metro station site • Flood depths across the site would be shallow with a maximum depth up to approximately 0.1 metres • The redirection of floodwater and on-site detention stormwater storage would result in slightly reduced flood levels within Herb Elliot Avenue at the north of the site and Figtree Drive to the south • There would be reduced discharge from overland flow across the site toward Olympic Boulevard • There would be no change in overall flood hazard within the site or adjacent streets compared to baseline assessment • Flood extents are not materially altered with slightly less extent of flooding on Herb Elliot Avenue and Figtree Driver reflecting the impact of the redirection of floodwater and on-site detention stormwater storage • Change in duration of inundation is negligible For the PMF event: • Generally, impacts would be contained within the Sydney Olympic Park metro station site • Flood depths across the site would be up to approximately 0.28 metres. • There would be increases in flood level of up to 0.11 metres on Herb Elliot Avenue with reductions of up to 0.16 metres on Figtree Drive. • There would be no change in overall flood hazard within the site or adjacent streets compared to baseline assessment • Flood extents are not substantially altered with slightly less extent of flooding on Herb Elliot Avenue and Figtree Driver reflecting the impact of the redirection of floodwater and on-site detention stormwater storage • Change in duration of inundation would be negligible

<table>
<tr><th>Secretary's environmental assessment requirements for flooding</th><th>Response</th></tr>
<tr><td></td><td>Figure 5-3 indicates the 1% AEP climate change flood event impact of the proposal. Further hydraulic impact assessment maps are located in Appendix C – Impact assessment flood maps. No private property impacts are expected in the 5% AEP climate change and 1% AEP climate change flood events and the PMF event. Apparent property impact suggested adjacent to the Pullman at Sydney Olympic Park is a modelling artifact associated with the placement of an inflow at a different point in the "with proposal" scenario than in the baseline case i.e. not an actual change in impact.

Table below outlines the defining event for the design of station entry levels and the station design level relative to the flood level for the defining event. Further design refinement (mitigation measure EIS-HF 1) would be carried out such that the design level of the station would be situated at a height at least equal to the 1% AEP climate change flood level plus freeboard which is the defining event for this metro station. Due to the nuisance nature of flooding at this site and owing to the location of the station within the catchment, 0.3 metres freeboard (rather than the typical freeboard of 0.5 metres) is considered adequate and would be adopted at this location.

<table>
<tr><th>Location</th><th>Defining Event</th><th>Flood level (mAHD)</th><th>Design level (mAHD)</th></tr>
<tr><td>Northern Station Entrance</td><td>1% AEP climate change with freeboard</td><td>21.79</td><td>22.0</td></tr>
<tr><td>Southern Station Entrance</td><td>1% AEP climate change with freeboard</td><td>21.81</td><td>22.0</td></tr>
</table>
</td></tr>
</table>

Secretary's environmental assessment requirements for flooding	Response
(c) consistency (or inconsistency) with applicable Council floodplain risk and stormwater management plans and other similar initiatives	The Sydney Olympic Park Authority has a policy entitled Stormwater Management and Water Sensitive Urban Design but no applicable floodplain risk management plans. The area is not subject to major overland or riverine flooding. The proposed works include landscaping and a new drainage system, including piped stormwater network and detention basins which would be consistent with the policy.
(d) compatibility with the flood hazard of the land	The site and surrounding streets are primarily classified within the H1 hazard in the 5% AEP climate change and 1% AEP climate change flood events which is accepted as safe for people, vehicles and buildings. Small, localised areas show higher velocity in Showground Road increase the hazard category to H2 to H5 for both flood events. Access and evacuation routes are readily available via the adjacent streets. In the PMF event, there are localised areas of H5 hazard in Herb Elliot Avenue and the width of Showground Road is H5. Evacuation is accessible via adjacent streets, with only Showground Road not being trafficable for the full width. However, due to the small catchment area and short critical storm duration this would likely only be affected for a short period of time. Hazard mapping indicates that hazard levels would generally be the same as presented for the baseline environment at areas surrounding the Sydney Olympic Park metro station site.
(e) compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land	The site is not a conveyance or flood storage area in flood events up to the PMF event. Stormwater discharge from the site is via the underground stormwater network and adjacent streets.

Secretary's environmental assessment requirements for flooding	Response
(f) the likelihood of erosion, siltation, destruction of riparian vegetation on riverbanks and watercourses	Flood and stormwater discharged from this site would enter the minor and major urban drainage system rather than directly entering nearby watercourses. Water quality measures would be employed as indicated in Section 6.2. Furthermore, as these catchments are very small compared to the total catchment of nearby watercourses indirect impacts are likely to be low.
g) impacts the development may have upon existing community emergency management arrangements for flooding.	The site is located within the South West Metropolitan Regional and Parramatta local Emergency Management Plan Areas. No major road or rail transport routes are listed within the plans that would be impacted by flood flows in the vicinity of the site. Vehicular access for emergency support vehicles to and from the NSW State Health Emergency Operations Centre may be affected by increased flooding of up to 0.11 metres in Herb Elliot Avenue in the PMF event. However, vehicle access to this centre is already affected during the PMF event. Mitigation measures EIS-HF 2 would require that impacts the proposal may have on existing emergency management arrangements are discussed with the NSW State Emergency Service and the City of Parramatta Council.
(h) any impacts the development may have on the social and economic costs to the community as consequence of flooding	Refer Section 5.2.12

Figure 5-3 1% AEP climate change flood impact assessment map for Sydney Olympic Park metro station

5.2.4 North Strathfield metro station

Construction phase flooding impacts (Table 5-9) and operation phase flooding impacts (Table 5-10) at North Strathfield metro station are described below in relation to the Secretary's environmental Assessment Requirements outlined in Table 1-1.

Table 5-9: Impacts on flood behaviour during construction at North Strathfield metro station

Secretary's environmental assessment requirements for flooding	Response
Full range of flood events up to the PMF (taking into account sea level rise and storm intensity due to climate change) including:	Refer Section 3.1.4
(a) maps featuring flood prone lands, flood planning areas (areas below the flood planning level), hydraulic categorisation (flood ways and flood storage areas) and flood hazards;	Refer Appendix A – Baseline environment flood maps

Secretary's environmental assessment requirements for flooding	Response
(b) assessment of potential flood affectation of other properties, assets and infrastructure against the flood management objectives	The baseline assessment is described in Section 4.4.7. Flood affectation as a result of construction of this proposal would have a similar risk profile to that of the previous Sydney Metro West planning application. This proposal may be subject to the following general impacts: • continued potential interruption of overland flow paths from temporary construction site infrastructure and modifications to landforms • the potential interruption or diversion of existing flood routes away from the location of bunding or spoil within construction sites, resulting in a reduction of flood storage and an increased flood risk to adjacent sites • disruption of street kerb and gutter at construction site vehicle entry locations which may result in localised ponding • potential blocking of drainage networks through increased sedimentation of surface water. This proposal includes additional construction footprint areas within the existing rail corridor to support construction and fit-out of a new aerial footbridge (to the north of the existing footbridge) to enable integration of this proposal with the existing Sydney Trains suburban network and to provide access to the existing station and North Strathfield metro station from the west of the rail corridor. It is expected that potential construction phase flooding impacts and impacts to drainage arrangements would be low and limited to the immediate area. Mitigation measures included in the Construction Environment Management Framework would require that construction planning manages potential construction phase flooding risk within the rail corridor and at other locations that form part of the North Strathfield metro station construction site.
(c) consistency (or inconsistency) with applicable Council floodplain risk and stormwater management plans and other similar initiatives	There is no applicable floodplain risk and stormwater management plan for the study area. The site is not within the Canada Bay Local Environmental Plan 2013 flood planning area. The area is not subject to major overland or riverine flooding.

Secretary's environmental assessment requirements for flooding	Response
(d) compatibility with the flood hazard of the land	The area adjacent to the site is primarily classified as H1 hazard in the 5% AEP climate change and 1% AEP climate change flood events. Along Queen Street there are localised H5 hazard areas due to elevated flow velocities in the kerb and gutter drainage. There are also elevated hazard areas up to H5 at the intersection of Wellbank and Queen Street which could affect access to and departure from the site. Construction activities are unlikely to cause significant variation in flood hazard categorisation. In the PMF event, the station construction site is expected to experience localised areas of H5 hazard category within the streets to the east of the site particularly where streets intersect with Queen Street. To the west of the station construction site the hazard increases up to H6, with high flood depth relating to floodwaters in the North Strathfield rail underpass adjacent to the existing station. Wellbank Street acts as an overland flow path during the PMF event with much of the area south of the station box and Wellbank Street having areas of H3 to H5 hazard. Access to and evacuation from the site in the PMF event would be available from the station construction site with adjacent streets having lower hazard particularly at the northern end. The support site (site office, amenities and storage area) would be likely to experience low to mid-range hazard flooding across most of the area. There are localised areas of high hazard (H5) which may also restrict access and evacuation from this site. Queen Street in the vicinity of Wellbank Street would be expected to experience discharge resulting in high hazard (H5) which would not be safe for pedestrians or vehicles. The hazard category in the downstream drainage channel increases to H6. Potential risk to construction areas which are not protected from flood inundation along with danger to people and vehicles accessing or working within the construction site would be managed as part of construction planning and would consider relevant measures outlined in the Construction Environmental Management Framework.

Secretary's environmental assessment requirements for flooding	Response
(e) compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land	The site is not a conveyance or flood storage area in flood events up to the PMF event with the exception of an area within the southern construction site which becomes flood storage in all flood events considered by this proposal due to the drainage arrangements of the flood protection barrier for the existing North Strathfield rail underpass. With the measures outlined in (d) it is expected that these hydraulic functions would be compatible with this proposal.
(f) the likelihood of erosion, siltation, destruction of riparian vegetation on riverbanks and watercourses	Flood and stormwater discharged from this site enter the minor and major urban drainage system rather than directly entering nearby watercourses. With implementation of measures outlined in the Construction Environmental Management Framework it is expected that the likelihood of erosion, siltation, destruction of riparian vegetation on riverbanks and watercourses is very low.
g) impacts the development may have upon existing community emergency management arrangements for flooding.	The site is located within the South West Metropolitan Regional Emergency Management Plan Area. No major road or rail transport routes are listed within the plan that would be impacted by flood flows in the vicinity of the site.
(h) any impacts the development may have on the social and economic costs to the community as consequence of flooding	Refer Section 5.2.12

Table 5-10: Impacts on flood behaviour during operations at North Strathfield metro station

Secretary's environmental assessment requirements for flooding	Response
Full range of flood events up to the PMF (taking into account sea level rise and storm intensity due to climate change) including:	Refer Section 3.1.4

Secretary's environmental assessment requirements for flooding	Response
(a) maps featuring flood prone lands, flood planning areas (areas below the flood planning level), hydraulic categorisation (flood ways and flood storage areas) and flood hazards;	Refer Appendix A – Baseline environment flood maps and Appendix B – "With Proposal" flood maps

(b) assessment of potential flood affectation of other properties, assets and infrastructure against the flood management objectives	For the 5% AEP climate change and 1% AEP climate change flood events: • Changes to the road levels in the vicinity of the intersection of Beronga Street and Queen Street as part of this proposal result in increases in water level within the kerb drainage and also cause minor increases of up to 0.1 metres within private properties. As part of further design development these private property impacts would look to be avoided. • On Queen Street along the eastern side of the proposed station, the changes to Queen Street have primarily reduced flood levels as a result of a lowered road surface. There are localised increases in flood level near the proposed station entrance. These minor increases are not considered an issue as they do not affect private property or impact trafficability of Queen Street. • At the south of the station, a public domain area has been incorporated into the design which has blocked a small portion of sheet flow that previously discharges through the gardens adjacent to Wellbank Street. This has resulted in increases in flood level on Queen Street and Wellbank Street of up to 0.2 metres approximately and private property impacts of up to 0.1 metres approximately in the 1% AEP climate change flood event. As part of further design development these private property impacts would look to be avoided. • Change in duration of inundation is negligible. For the PMF event • Hydraulic impacts on Queen Street near Beronga Street and Waratah Street are generally consistent with the 5% and 1% AEP climate change flood events. • The loss of flood storage at the south of the station results in increases in flood level of up to approximately 0.1 metres affecting a large area of the road and four private properties in the vicinity of Queen and Wellbank Streets as indicated on Figure B-23 of Appendix B – “With Proposal” flood maps • Change in duration of inundation is negligible This proposal includes a new aerial footbridge (to the north of the existing footbridge) to enable integration of this proposal with the existing Sydney Trains suburban network and to provide access to the existing station and North Strathfield metro station from the west of the rail corridor. It is expected that potential operation phase flooding impacts and impacts to drainage arrangements would be low and limited to the immediate area in all flood events. As part of design development, including for drainage infrastructure, consideration would be given to the flood risk at

<table>
<tr><th>Secretary's environmental assessment requirements for flooding</th><th>Response</th></tr>
<tr><td></td><td>all sites. Design development would include consideration of relevant best practice guidelines and include identification of measures to not worsen flood impacts on the community and on other property and infrastructure, up to and including the one per cent AEP flood event.

Figure 5-7 indicates the 1% AEP climate change flood event impact of the proposal. Further hydraulic impact assessment maps are located in Appendix C – Impact assessment flood maps.

Table below outlines the defining event for the design of station entry levels and the station design level relative to the flood level for the defining event. Further design refinement (mitigation measure EIS-HF 1) would be carried such that the design level of the station would be situated at a height at least equal to the 1% AEP climate change flood level plus freeboard which is the defining event for this metro station. Due to the nuisance nature of flooding at this site and owing to the location of the station within the catchment, 0.3 metres freeboard (rather than a typical freeboard of 0.5 metres) is considered adequate and would be adopted at this location.
<table>
<tr><th>Location</th><th>Defining Event</th><th>Flood level (mAHD)</th><th>Design level (mAHD)</th></tr>
<tr><td>Waratah Rd (Queen St)</td><td>1% AEP climate change with freeboard</td><td>21.64</td><td>21.80</td></tr>
<tr><td>Wellbank St (Queen St)</td><td>1% AEP climate change with freeboard</td><td>18.64</td><td>19.05</td></tr>
</table></td></tr>
<tr><td>(c) consistency (or inconsistency) with applicable Council floodplain risk and stormwater management plans and other similar initiatives</td><td>There is no applicable floodplain risk and stormwater management plan for the study area. The site is not within the Canada Bay Local Environmental Plan 2013 flood planning area.

The area is not subject to major overland or riverine flooding.</td></tr>
</table>

Secretary's environmental assessment requirements for flooding	Response
(d) compatibility with the flood hazard of the land	The area adjacent to the site is primarily classified as H1 hazard in the 5% and 1% AEP Climate change events. Along Queen Street there are localised H5 hazard areas due to elevated flow velocities in the kerb and gutter drainage. There are also elevated hazard areas up to H5 at the intersection of Wellbank and Queen Street which could affect access and evacuation routes. In the PMF event, the hazard along much of Queen Street is elevated to H5 category, with localised areas of H6 in Wellbank Street. It is expected with further design refinement that flows would be contained within the minor and major urban drainage system.
(e) compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land	The site is not a conveyance or flood storage area in flood events up to the PMF event with the exception of an area within the construction site where the site office and amenities are located which becomes flood storage due to the drainage arrangements of the flood protection barrier for the existing North Strathfield rail underpass. With the measures outlined in (d) it is expected that these hydraulic functions would be compatible with this proposal.
(f) the likelihood of erosion, siltation, destruction of riparian vegetation on riverbanks and watercourses	Flood and stormwater discharged from this site would enter the minor and major urban drainage system rather than directly entering nearby watercourses. Water quality measures would be employed as indicated in Section 6.2. Furthermore, as these catchments are very small compared to the total catchment of nearby watercourses indirect impacts are likely to be low.
g) impacts the development may have upon existing community emergency management arrangements for flooding.	The site is located within the South West Metropolitan Regional Emergency Management Plan Area. No major road or rail transport routes are listed within the plan that would be impacted by flood flows in the vicinity of the site.
(h) any impacts the development may have on the social and economic costs to the community as consequence of flooding	Refer Section 5.2.12

Figure 5-4 1% AEP climate change flood impact assessment map for North Strathfield metro station

5.2.5 Burwood North Station

Construction phase flooding impacts (Table 5-11) and operation phase flooding impacts (Table 5-12) at North Burwood Station are described below in relation to the Secretary's environmental assessment requirements outlined in Table 1-1.

Table 5-11: Impacts on flood behaviour during construction at Burwood North station

Secretary's environmental assessment requirements for flooding	Response
Full range of flood events up to the PMF (taking into account sea level rise and storm intensity due to climate change) including:	Refer Section 3.1.4

Secretary's environmental assessment requirements for flooding	Response
(a) maps featuring flood prone lands, flood planning areas (areas below the flood planning level), hydraulic categorisation (flood ways and flood storage areas) and flood hazards;	Refer Appendix A – Baseline environment flood maps
(b) assessment of potential flood affectation of other properties, assets and infrastructure against the flood management objectives	The baseline assessment is described in Section 4.5.7. Flood affectation as a result of construction of this proposal would have a similar risk profile to that outlined in the previous Sydney Metro West planning application. These works would include the following general impacts: • continued potential interruption of overland flow paths from temporary construction site infrastructure and modifications to landforms • the potential interruption or diversion of existing flood routes away from the location of bunding or spoil within construction sites, resulting in a reduction of flood storage and an increased flood risk to adjacent sites • disruption of street kerb and gutter at construction site vehicle entry locations which may result in localised ponding • potential blocking of drainage networks through increased sedimentation of surface water. Mitigation measures included in the Construction Environment Management Framework would require that construction planning manage the potential construction phase flooding risk at the Burwood North Station construction sites.
(c) consistency (or inconsistency) with applicable Council floodplain risk and stormwater management plans and other similar initiatives	There is no applicable floodplain risk or stormwater management plan for the study area. The northern construction site is not within the Canada Bay Local Environmental Plan 2013 flood planning area. The southern construction site is not within the Burwood Local Environmental Plan 2012 flood planning area. The Parramatta Road Corridor Flood Risk Assessment was undertaken for the City of Canada Bay Council. The mapping shows flooding consistent with the modelling undertaken as part of this assessment, with the sites being flood free and minor street flooding adjacent to the sites.

Secretary's environmental assessment requirements for flooding	Response
(d) compatibility with the flood hazard of the land	The area adjacent to the construction sites is primarily classified as H1 hazard in the 5% AEP climate change and 1% AEP climate change flood events with localised higher hazard areas up to H5 on Parramatta Road contained within kerb and gutter. It is expected that construction activities may cause minor variation to hazard categories but that flows would be contained within the kerb and gutter. In the PMF event there is more widespread H5 hazard within the streets adjacent to the site. This is generally contained within kerb and gutter except for Parramatta Road where intersections are also higher hazard as well as the overland flow path to the east. Potential risk to people and vehicles accessing the construction site would be managed through measures outlined in the Construction Environmental Management Framework.
(e) compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land	The sites are not a conveyance or flood storage area in flood events up to the PMF event. Stormwater discharge from the site is via the underground stormwater network and adjacent streets.
(f) the likelihood of erosion, siltation, destruction of riparian vegetation on riverbanks and watercourses	Flood and stormwater discharged from this site would enter the minor and major urban drainage system rather than directly entering nearby watercourses. With implementation of measures outlined in the Construction Environmental Management Framework it is expected that the likelihood of erosion, siltation, destruction of riparian vegetation on riverbanks and watercourses is very low.
g) impacts the development may have upon existing community emergency management arrangements for flooding.	The site is located within the South West Metropolitan Regional Emergency Management Plan Area. Parramatta Road, a listed transport route of the South West Metropolitan Regional Emergency Management Plan, is vulnerable in the PMF event due to the location of a major overland flow path which crosses just east of the station.
(h) any impacts the development may have on the social and economic costs to the community as consequence of flooding	Refer Section 5.2.12

Table 5-12: Impacts on flood behaviour during operations at Burwood North station

Secretary's environmental assessment requirements for flooding	Response
Full range of flood events up to the PMF (taking into account sea level rise and storm intensity due to climate change) including:	Refer Section 3.1.4
(a) maps featuring flood prone lands, flood planning areas (areas below the flood planning level), hydraulic categorisation (flood ways and flood storage areas) and flood hazards;	Refer Appendix A – Baseline environment flood maps and Appendix B – "With Proposal" flood maps

(b) assessment of potential flood affectation of other properties, assets and infrastructure against the flood management objectives	For the 5% AEP climate change and 1% AEP climate change flood events: • Increases to the flood extents particularly in Burwood Road, Burton and Loftus Street in the block containing the northern site are generally modelling artifacts associated with the road design around the precinct – Increased flood depths up to approximately 0.1 metres in Burwood Road south of Parramatta Road are generally a result of road design elements redirecting flows which would have previously drained into Parramatta Road. The design of the intersection is associated with this proposal. This results in a property on Burwood Road and Milton Street not previously affected in the 1% AEP climate change flood event potentially becoming flood affected – Increased flood depths and extent on Parramatta Road towards Loftus Street are primarily a result of the road design in Burwood Road and Loftus Street. These increases would be contained within the road – Some increases to flood depths in the kerb and gutter due to the proposal would be expected however the full extent of such increases in Parramatta Road is yet to be quantified owing to the redirection of flow associated with the road design • Change in duration of inundation is negligible. For the PMF event: • The flood behaviour outlined in the previous section for the 5% AEP climate change and 1% AEP climate change flood events applies but is more marked with wider flood extents in all roads around the precinct • Proposed road design in Burwood Road redirects flows into Burton Street which the modelling indicates would potentially adversely impact three properties • Change in duration of inundation is negligible. Figure 5-5 indicates the 1% AEP climate change flood event impact of the proposal. Further hydraulic impact assessment maps are located in Appendix C – Impact assessment flood maps. As part of design development, including for drainage infrastructure, consideration would be given to the flood risk at all sites. Design development would include consideration of relevant best practice guidelines and include identification of measures to not worsen flood impacts on the community and on

<table>
<tr><th>Secretary's environmental assessment requirements for flooding</th><th>Response</th></tr>
<tr><td></td><td>other property and infrastructure, up to and including the one per cent AEP flood event.

Table below outlines the defining event for the design of station entry levels and the station design level relative to the flood level for the defining event. The design level of the station would be situated at a height equal to the 1% AEP climate change flood level plus freeboard which is the defining event for this metro station. Due to the nuisance nature of flooding at this site and owing to the location of the station within the catchment, 0.3 metres freeboard (rather than the typical 0.5 metres freeboard) is considered adequate and would be adopted at this location.
<table>
<tr><th>Location</th><th>Defining Event</th><th>Flood level (mAHD)</th><th>Design level (mAHD)</th></tr>
<tr><td>Burwood Road south entrance</td><td>1% AEP climate change with freeboard</td><td>13.30</td><td>13.60</td></tr>
<tr><td>Burwood Road north entrance</td><td>1% AEP climate change with freeboard</td><td>17.35</td><td>17.75</td></tr>
</table></td></tr>
<tr><td>(c) consistency (or inconsistency) with applicable Council floodplain risk and stormwater management plans and other similar initiatives</td><td>There is no applicable floodplain risk and stormwater management plan for the study area. The northern construction site is not within the Canada Bay Local Environmental Plan 2013 flood planning area. The southern construction site is not within the Burwood Local Environmental Plan 2012 flood planning area. The Parramatta Road Corridor Flood Risk Assessment was undertaken for the City of Canada Bay Council. The mapping shows flooding consistent with the modelling undertaken as part of this assessment, with the sites being flood free and minor street flooding adjacent to the sites.</td></tr>
</table>

Secretary's environmental assessment requirements for flooding	Response
(d) compatibility with the flood hazard of the land	In the 5% AEP climate change flood event, streets surrounding the precinct typically experience H1 low hazard flows contained within the kerb and gutter except for areas in the vicinity of the intersections on Parramatta Road where shallow depths cover the road. There are isolated sections of H2 hazard category within kerb and gutter on Parramatta Road and Burwood Road south of Parramatta Road experiences up to H3 low hazard category within kerb and gutter. In the 1% AEP climate change flood event, a similar pattern occurs with isolated locations of H3 low hazard category occurring in kerb and gutter of Parramatta Road and more extensive H3 low hazard category occurring in the kerb and gutter of Burwood Road south of Parramatta Road. In the PMF event, all roads around the precinct are fully impacted with flows outside of the kerb and gutter at depth within Parramatta Road. H5 high hazard flows are expected within the kerb and gutter of Burton Street and Parramatta and Burwood Roads. It is expected with further design development that flows could be contained within the minor and major urban drainage system.
(e) compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land	The sites are not a conveyance or flood storage area in flood events up to the PMF event. Stormwater discharge from the sites is via the underground stormwater network and adjacent streets.
(f) the likelihood of erosion, siltation, destruction of riparian vegetation on riverbanks and watercourses	Flood and stormwater discharged from this site would enter the minor and major urban drainage system rather than directly entering nearby watercourses. Water quality measures would be employed as indicated in Section 6.2. Furthermore, as these catchments are very small compared to the total catchment of nearby watercourses indirect impacts are likely to be low.
g) impacts the development may have upon existing community emergency management arrangements for flooding.	The site is located within the South West Metropolitan Regional Emergency Management Plan Area. This proposal does not increase vulnerability of Parramatta Road, a listed transport route of the South West Metropolitan Regional Emergency Management Plan, during extreme flood events.

Secretary's environmental assessment requirements for flooding	Response
(h) any impacts the development may have on the social and economic costs to the community as consequence of flooding	Refer Section 5.2.12

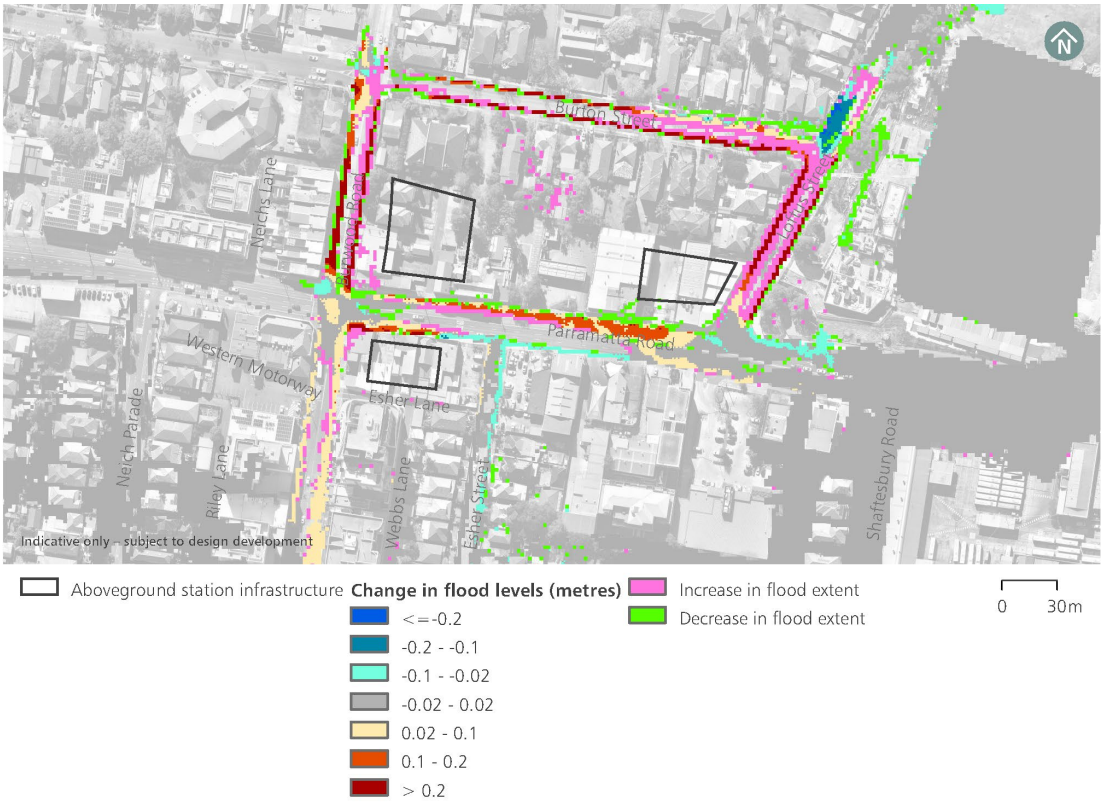

Figure 5-5 1% AEP climate change flood impact assessment map for Burwood North Station

5.2.6 Five Dock Station

Construction phase flooding impacts (Table 5-13) and operation phase flooding impacts (Table 5-14) at Five Dock Station are described below in relation to the Secretary's environmental assessment requirements outlined in Table 1-1.

Table 5-13: Impacts on flood behaviour during construction at Five Dock station

Secretary's environmental assessment requirements for flooding	Response
Full range of flood events up to the PMF (taking into account sea level rise and storm intensity due to climate change) including:	Refer Section 3.1.4
(a) maps featuring flood prone lands, flood planning areas (areas below the flood planning level), hydraulic categorisation (flood ways and flood storage areas) and flood hazards;	Refer Appendix A – Baseline environment flood maps
(b) assessment of potential flood affectation of other properties, assets and infrastructure against the flood management objectives	The baseline assessment is described in Section 4.6.7. Flood affectation as a result of construction of this proposal would have a similar risk profile to that of the previous Sydney Metro West planning application. These works would include the following general impacts: • continued potential interruption of overland flow paths from temporary construction site infrastructure and modifications to landforms • the potential interruption or diversion of existing flood routes away from the location of bunding or spoil within construction sites, resulting in a reduction of flood storage and an increased flood risk to adjacent sites • disruption of street kerb and gutter at construction site vehicle entry locations which may result in localised ponding • potential blocking of drainage networks through increased sedimentation of surface water. Mitigation measures implemented as part of the Construction Environment Management Framework would require that construction planning manage the potential construction phase flooding risk at the Five Dock Station construction sites.

Secretary's environmental assessment requirements for flooding	Response
(c) consistency (or inconsistency) with applicable Council floodplain risk and stormwater management plans and other similar initiatives	The area is not subject to major overland or riverine flooding. Therefore, no floodplain risk and stormwater management plan were available for the study area. The sites are not within the Canada Bay Local Environmental Plan 2013 flood planning area.
(d) compatibility with the flood hazard of the land	The site is primarily classified within the H1 hazard in the 5% AEP climate change and 1% AEP climate change flood events which is accepted as safe for people, vehicles and buildings. Small, localised areas with elevated flow velocities in East Street and Great North Road increase the hazard category to H5 in the 1% AEP climate change flood event. Access and evacuation routes are readily available via the adjacent streets. In the PMF event, the hazard along streets adjacent to the sites increases to H5 except for Second Avenue which continues to be low hazard. Potential hazard to people and vehicles accessing the site would need to be managed in rare and extreme flood events due to the high hazard in surrounding streets.
(e) compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land	The site is not a conveyance or flood storage area in flood events up to the PMF event. Stormwater discharge from the site is via the underground stormwater network and adjacent streets.
(f) the likelihood of erosion, siltation, destruction of riparian vegetation on riverbanks and watercourses	Flood and stormwater discharged from this site would enter the minor and major urban drainage system rather than directly entering nearby watercourses. With implementation of measures outlined in the Construction Environmental Management Framework it is expected that the likelihood of erosion, siltation, destruction of riparian vegetation on riverbanks and watercourses is very low.
g) impacts the development may have upon existing community emergency management arrangements for flooding.	The site is located within the South West Metropolitan Regional Emergency Management Plan Area. Parramatta Road, an identified transport route within the South West Metropolitan Regional Emergency Management Plan, is outside of the extent of influence of the proposal.

Secretary's environmental assessment requirements for flooding	Response
(h) any impacts the development may have on the social and economic costs to the community as consequence of flooding	Refer Section 5.2.12

Table 5-14: Impacts on flood behaviour during operations at Five Dock station

Secretary's environmental assessment requirements for flooding	Response
Full range of flood events up to the PMF (taking into account sea level rise and storm intensity due to climate change) including:	Refer Section 3.1.4
(a) maps featuring flood prone lands, flood planning areas (areas below the flood planning level), hydraulic categorisation (flood ways and flood storage areas) and flood hazards;	Refer Appendix A – Baseline environment flood maps and Appendix B – "With Proposal" flood maps

Secretary's environmental assessment requirements for flooding	Response
(b) assessment of potential flood affectation of other properties, assets and infrastructure against the flood management objectives	For the 5% AEP climate change and 1% AEP climate change flood events: • The proposal would result in negligible changes except in Great North Road where the changes reflect the road design of the proposal. • Great North Road would experience change in extent to flooding as the median strip would be removed and some increases in flood depth up to approximately 0.1 metres and isolated areas within the kerb and gutter would experience up to approximately 0.2 metres associated with relocation of the kerb and gutter. • No additional private properties would be impacted • Change in duration of inundation is negligible. For the PMF event: • There are minor increases in flood level on East Street of up to approximately 0.1 metres • As with the 5% climate change and 1% AEP climate change flood events, Great North Road would experience increases in flood depth up to approximately 0.1 metres and isolated areas within the kerb and gutter would experience up to approximately over 0.2 metres. This would be wider across the road but not noticeably greater extent along the road • No additional private properties would be impacted • Change in duration of inundation is negligible. Figure 5-7 indicates the 1% AEP climate change flood event impact of the proposal. Further hydraulic impact assessment maps are located in Appendix C – Impact assessment flood maps. Table below outlines the defining event for the design of station entry levels and the station design level relative to the flood level for the defining event. The design level of the station would be situated at a height equal to the 1% AEP climate change flood level plus freeboard which is the defining event for this metro station. Due to the nuisance nature of flooding at this site and owing to the location of the station within the catchment, 0.3 metres freeboard (rather than the typical 0.5 metres freeboard) is considered adequate and would be adopted.

<table>
<tr><th>Secretary's environmental assessment requirements for flooding</th><th colspan="4">Response</th></tr>
<tr><td rowspan="3"></td><td>Location</td><td>Defining Event</td><td>Flood level (mAHD)</td><td>Design level (mAHD)</td></tr>
<tr><td>Great North Road</td><td>1% AEP climate change with freeboard</td><td>19.70</td><td>20.25</td></tr>
<tr><td>Waterview Street</td><td>1% AEP climate change with freeboard</td><td>18.20</td><td>19.19</td></tr>
<tr><td>(c) consistency (or inconsistency) with applicable Council floodplain risk and stormwater management plans and other similar initiatives</td><td colspan="4">The area is not subject to major overland or riverine flooding. Therefore, no floodplain risk and stormwater management plan were available for the study area. The sites are not within the Canada Bay Local Environmental Plan 2013 flood planning area.</td></tr>
<tr><td>(d) compatibility with the flood hazard of the land</td><td colspan="4">The site is primarily classified within the H1 hazard in the 5% AEP climate change and 1% AEP climate change flood events which is accepted as safe for people, vehicles and buildings. Small, localised areas with elevated flow velocities in East Street and Great North Road increase the hazard category to H5 in the 1% AEP climate change flood event. Access and evacuation routes are readily available via the adjacent streets.

In the PMF event, the hazard along streets adjacent to the sites increases to H5 except for Second Avenue which continues to be low hazard. Five Dock Station would provide shelter in place arrangements during extreme flood events as surrounding streets would be high hazard.</td></tr>
<tr><td>(e) compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land</td><td colspan="4">The site is not a conveyance or flood storage area in flood events up to the PMF event. Stormwater discharge from the site is via the underground stormwater network and adjacent streets.</td></tr>
<tr><td>(f) the likelihood of erosion, siltation, destruction of riparian vegetation on riverbanks and watercourses</td><td colspan="4">Flood and stormwater discharged from this site would enter the minor and major urban drainage system rather than directly entering nearby watercourses. Water quality measures will be employed as indicated in Section 6.2. Furthermore, as these catchments are very small compared to the total catchment of nearby watercourses indirect impacts are likely to be low.</td></tr>
</table>

Secretary's environmental assessment requirements for flooding	Response
g) impacts the development may have upon existing community emergency management arrangements for flooding.	The site is located within the South West Metropolitan Regional Emergency Management Plan Area. Parramatta Road, an identified transport route within the South West Metropolitan Regional Emergency Management Plan, is outside of the extent of influence of the proposal.
(h) any impacts the development may have on the social and economic costs to the community as consequence of flooding	Refer Section 5.2.12

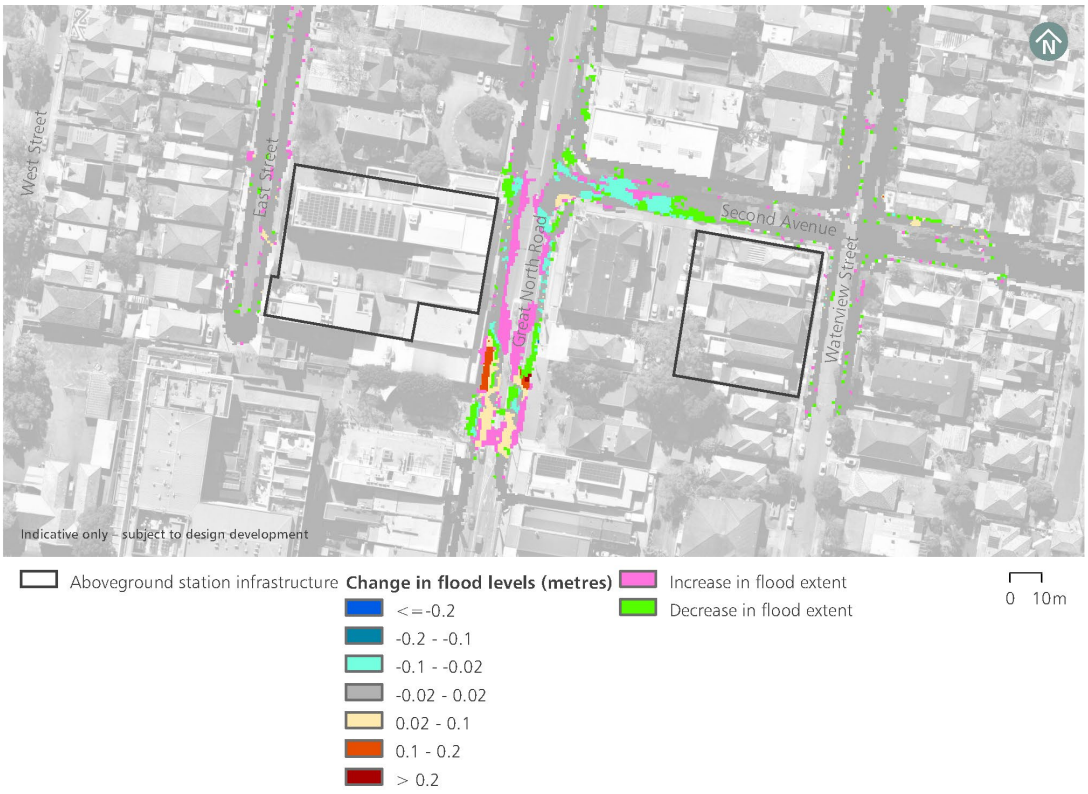

Figure 5-6 1% AEP climate change flood impact assessment map for Five Dock Station

5.2.7 The Bays Station

Construction phase flooding impacts (Table 5-15) and operation phase flooding impacts (Table 5-16) at The Bays Station are described below in relation to the Secretary's environmental assessment requirements outlined in Table 1-1.

Table 5-15: Impacts on flood behaviour during construction at The Bays station

Secretary's environmental assessment requirements for flooding	Response
Full range of flood events up to the PMF (taking into account sea level rise and storm intensity due to climate change) including:	Refer Section 3.1.4
(a) maps featuring flood prone lands, flood planning areas (areas below the flood planning level), hydraulic categorisation (flood ways and flood storage areas) and flood hazards;	Refer Appendix A – Baseline environment flood maps
(b) assessment of potential flood affectation of other properties, assets and infrastructure against the flood management objectives	The baseline assessment is described in Section 4.7.7. Flood affectation as a result of construction of this proposal would have a similar risk profile to that of the previous Sydney Metro West planning application. These works would include the following general impacts: • direct intense rainfall onto the site may cause nuisance flooding and drainage issues • continued potential interruption of overland flow paths from temporary construction site infrastructure and modifications to landforms • the potential interruption or diversion of existing flood routes away from the location of bunding or spoil within construction sites, resulting in a reduction of flood storage and an increased flood risk to adjacent sites • disruption of street kerb and gutter at construction site vehicle entry locations which may result in localised ponding • potential blocking of drainage networks through increased sedimentation of surface water. Mitigation measures implemented as part of the Construction Environment Management Framework would require that construction planning manage the potential construction phase flooding risk at The Bays Station construction site.

Secretary's environmental assessment requirements for flooding	Response
(c) consistency (or inconsistency) with applicable Council floodplain risk and stormwater management plans and other similar initiatives	Results are generally consistent with the Leichhardt Floodplain Risk Management Plan noting the hazard categorisation used in the plan is consistent with the Floodplain Development Manual rather than ARR2019.

Secretary's environmental assessment requirements for flooding	Response
(d) compatibility with the flood hazard of the land	In the 5% AEP climate change and 1% AEP climate change flood events the flood hazard within the site footprint is generally limited to H1, with small, localised ponding areas with greater depth having a higher hazard of H2 or H3. The area around the low-lying White Bay Power Station and on Robert Street to the north of the site is predominantly H3, due to the ponding water depth. In the PMF event the flood hazard within much of the site is increased to H4 hazard with Robert Street being predominantly H5 hazard with H6 on Mullens Street to the north of Robert Street. Access and evacuation on Robert Street would be limited in the 5% AEP climate change and 1% AEP climate change flood events due to the depth of ponding on Robert Street. There may be limited access to the site via Sommerville Road at the east of the site. In the PMF event, there are localised areas of high hazard (H5) on the site, particularly near the site access from Robert Street. There is also high hazard (H5) on the roads at the east of the site on Sommerville Road. In the PMF event there are additional areas around the proposed station with up to H3 hazard and the proposed overland flow path through the site increases to H5 hazard. Most of Robert Street is H5 hazard and would not be accessible to vehicles. The site would be isolated during a PMF event as hazards associated with access would be too high. Limited areas of the construction site would be protected from inundation as a result of work carried out under the previous Sydney Metro West planning application. Where that is not the case, proximity to H3 low hazard flows and greater within the construction site would require careful consideration of consequential risks and how they should be managed. Potential hazard to people and vehicles accessing the site would need to be managed in extreme flood events due to the high hazard.

Secretary's environmental assessment requirements for flooding	Response
(e) compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land	A major flow path for the catchment in which the proposal is located passes through the construction site. This presents risks to construction but with the measures outlined in (d) it is expected these hydraulic functions would be compatible with this proposal.
(f) the likelihood of erosion, siltation, destruction of riparian vegetation on riverbanks and watercourses	Flood and stormwater discharged from this site enter the minor and major urban drainage system rather than directly entering nearby watercourses. With implementation of measures outlined in the Construction Environmental Management Framework it is expected that the likelihood of erosion, siltation, destruction of riparian vegetation on riverbanks and watercourses is very low.
g) impacts the development may have upon existing community emergency management arrangements for flooding.	The site is located within the Sydney Metropolitan Regional Emergency Management Plan Area. Listed routes are outside of the area of influence by this proposal.
(h) any impacts the development may have on the social and economic costs to the community as consequence of flooding	Refer Section 5.2.12

Table 5-16: Impacts on flood behaviour during operations at The Bays station

Secretary's environmental assessment requirements for flooding	Response
Full range of flood events up to the PMF (taking into account sea level rise and storm intensity due to climate change) including:	Refer Section 3.1.4
(a) maps featuring flood prone lands, flood planning areas (areas below the flood planning level), hydraulic categorisation (flood ways and flood storage areas) and flood hazards;	Refer Appendix A – Baseline environment flood maps

(b) assessment of potential flood affectation of other properties, assets and infrastructure against the flood management objectives	For the 5% AEP climate change and 1% AEP climate change flood events: • A significant area of the proposed site would be raised above existing baseline levels based on the design. This results in increases in flood level within the site boundary due to the rain-on-grid modelling methodology adopted. This also results in newly flooded areas and areas that were previously flooded but are now flood free in these flood events. • An overland flow path, additional sub-surface drainage and a bund introduced as part of the proposal would result in a substantial reduction in the flood depth (up to approximately 0.5 metres) at the south of the White Bay Power station. • The proposed overland flow path and additional drainage infrastructure would also reduce flood levels on Robert Street by up to 0.10 metres and 0.09 metres in the 1% AEP climate change and 5% AEP climate change flood events, respectively • No additional private properties would be impacted • Change in duration of inundation is negligible. For the PMF event: • The existing Port Access Road acts as a level in the baseline scenario for the PMF event. The removal of this road and lowering of the area to the north of the station would result in widespread reductions in flood level across much of the site as it can more freely drain to White Bay • The proposed station design and realignment of the existing Port Access Road would also reduce flood levels (by up to approximately 0.35 metres) on Robert Street • No additional private properties would be impacted • Change in duration of inundation is negligible. Figure 5-7 indicates the 1% AEP climate change flood event impact of the proposal. Further hydraulic impact assessment maps are located in Appendix C – Impact assessment flood maps. Table below outlines the defining event for the design of station entry levels and the station design level relative to the flood level for the defining event. Further design refinement (mitigation measure EIS-HF 1) would be carried such that the design level of the station would be situated at a height at least equal to the 1% AEP climate

<table>
<tr><th>Secretary's environmental assessment requirements for flooding</th><th>Response</th></tr>
<tr><td></td><td>change flood level plus freeboard which is the defining event for this metro station.
<table>
<tr><th>Location</th><th>Defining Event</th><th>Flood level (mAHD)</th><th>Design level (mAHD)</th></tr>
<tr><td>Station Entrance</td><td>1% AEP climate change with freeboard</td><td>3.69</td><td>4.0</td></tr>
</table></td></tr>
<tr><td>(c) consistency (or inconsistency) with applicable Council floodplain risk and stormwater management plans and other similar initiatives</td><td>Results are generally consistent with the Leichhardt Floodplain Risk Management Plan noting the hazard categorisation used in the plan is consistent with the Floodplain Development Manual rather than ARR2019.</td></tr>
<tr><td>(d) compatibility with the flood hazard of the land</td><td>The site is predominantly H1 hazard up to the 1% AEP climate change flood event. There are areas with up to H3 and H4 hazard associated with the deep water ponding around White bay Power Station and the proposed overland flow channel through the site. On Robert Street, the hazard is up to H4 which would limit access and evacuation from the site.

In the PMF event there are additional areas around the proposed station with up to H3 hazard and the proposed overland flow path through the site increases to H5 hazard. Most of Robert Street is H5 hazard and would not be accessible to vehicles. Generally, the proposal reduces hazard categories within the site except for the flow path outlined in (e) with some minor reductions in areas outside of the proposal.

The Bays Station would be protected from inundation in the PMF event as outlined above in (b) which would provide shelter in place arrangements during extreme flood events as surrounding streets would be high hazard.</td></tr>
</table>

Secretary's environmental assessment requirements for flooding	Response
(e) compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land	A major flow path for the catchment in which the proposal is located passes through the site. This proposal seeks to enhance the hydraulic functions through the site by providing additional conveyance areas via the proposed sub-surface drainage and overland flow channel through the site. Figure B-46 of Appendix B – "With Proposal" flood maps indicate the location of the flow path relative to the proposal for the PMF event. This presents risks to people and vehicles but with the application of mitigation measures it is expected these hydraulic functions would be compatible with this proposal.
(f) the likelihood of erosion, siltation, destruction of riparian vegetation on riverbanks and watercourses	Flood and stormwater discharged from this site enter the minor and major urban drainage system rather than directly entering nearby watercourses. Water quality measures will be employed as indicated in Section 6.2. Furthermore, as these catchments are very small compared to the total catchment of nearby watercourses indirect impacts are likely to be low.
g) impacts the development may have upon existing community emergency management arrangements for flooding.	The site is located within the Sydney Metropolitan Regional Emergency Management Plan Area. Listed routes are outside of the area of influence by this proposal.
(h) any impacts the development may have on the social and economic costs to the community as consequence of flooding	Refer Section 5.2.12

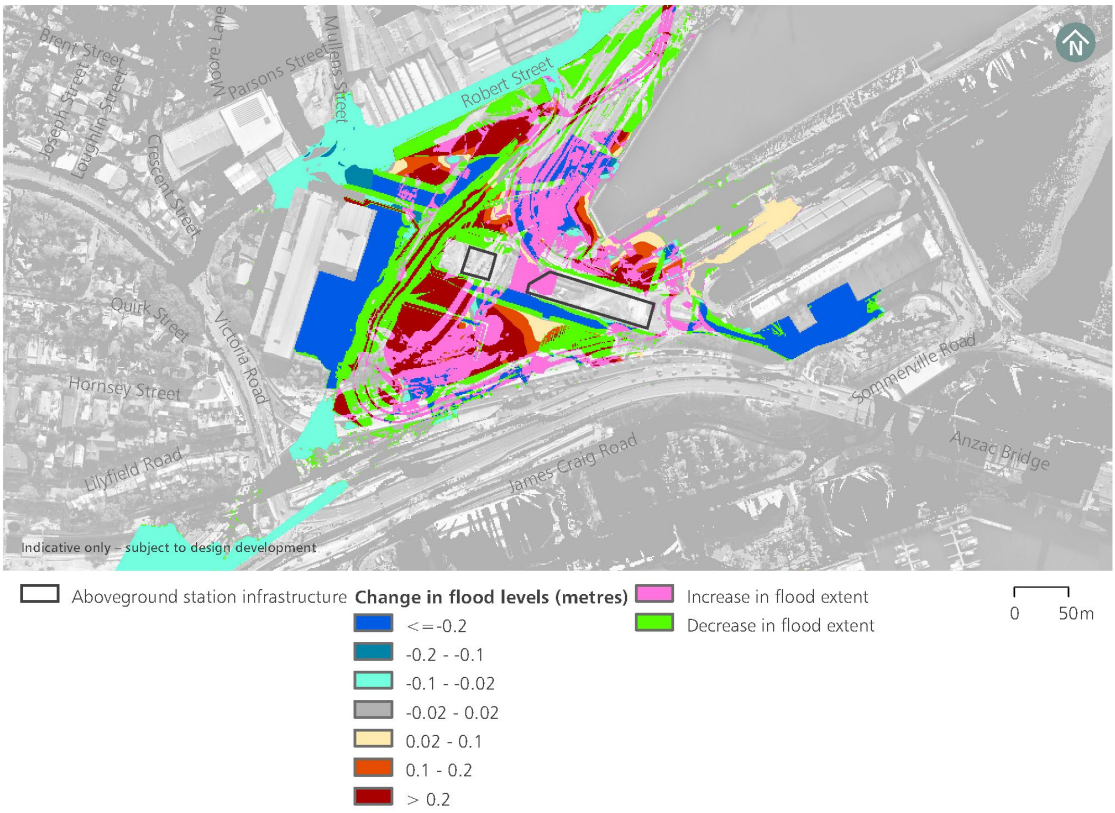

Figure 5-7 1% AEP climate change flood impact assessment map for The Bays Station

5.2.8 Pyrmont Station

Construction phase flooding impacts (Table 5-17) and operation phase flooding impacts (Table 5-18) at Pyrmont Station are described below in relation to the Secretary's environmental assessment requirements outlined in Table 1-1.

Table 5-17: Impacts on flood behaviour during construction at Pyrmont station

Secretary's environmental assessment requirements for flooding	Response
Full range of flood events up to the PMF (taking into account sea level rise and storm intensity due to climate change) including:	Refer Section 3.1.4
(a) maps featuring flood prone lands, flood planning areas (areas below the flood planning level), hydraulic categorisation (flood ways and flood storage areas) and flood hazards;	Refer Appendix A – Baseline environment flood maps

Secretary's environmental assessment requirements for flooding	Response
(b) assessment of potential flood affectation of other properties, assets and infrastructure against the flood management objectives	The baseline assessment is described in Section 4.8.7. Flood affectation as a result of the construction of this proposal would have a similar risk profile to that outlined in the previous Sydney Metro West planning application. These works would include the following general impacts: • continued potential interruption of overland flow paths from temporary construction site infrastructure and modifications to landforms • the potential interruption or diversion of existing flood routes away from the location of bunding or spoil within construction sites, resulting in a reduction of flood storage and an increased flood risk to adjacent sites • disruption of street kerb and gutter at construction site vehicle entry locations which may result in localised ponding • potential blocking of drainage networks through increased sedimentation of surface water. Mitigation measures implemented as part of the Construction Environment Management Framework would require that construction planning manage the potential construction phase flooding risk at the Pyrmont Station construction sites.
(c) consistency (or inconsistency) with applicable Council floodplain risk and stormwater management plans and other similar initiatives	Results are generally consistent with the Darling Harbour Catchment Floodplain Risk Management Plan – September 2016 noting the hazard categorisation used in the plan is consistent with the Floodplain Development Manual rather than ARR2019.

Secretary's environmental assessment requirements for flooding	Response
(d) compatibility with the flood hazard of the land	Large areas of these construction sites will be protected from inundation as a result of work carried out under the previous Sydney Metro West planning application. Where that is not the case, proximity to high hazard flows in adjacent roads would require careful consideration of consequential risks and how they should be managed. In the 5% AEP climate change and 1% AEP climate change flood events the hazard classification is generally H1 low hazard which is accepted as safe for people, vehicles and buildings. Access and evacuation routes are readily available via the adjacent streets. In the PMF event, Union and Pyrmont Streets and Pyrmont Bridge Road have large extents of H5 hazard category flows. This is mainly due to the road being a major flow path which has flow velocities up to 2m/s. Whilst the eastern construction site is not fully isolated by hazardous flows caution should be exercised. The western construction site is accessible from adjacent streets noting the nearby high hazard region downstream in Pyrmont Bridge Road. Potential risk to construction areas which are not protected from flood inundation along with danger to people and vehicles accessing or working within the construction site would be managed.
(e) compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land	Union and Edward Streets and approximately the lower half of Pyrmont Bridge Road are flood ways in the PMF event. This presents risks to construction but with the measures outlined in (d) it is expected these hydraulic functions would be compatible with this proposal.
(f) the likelihood of erosion, siltation, destruction of riparian vegetation on riverbanks and watercourses	Flood and stormwater discharged from this site enter the minor and major urban drainage system rather than directly entering nearby watercourses. With implementation of the measures outlined in the Construction Environmental Management Framework it is expected that the likelihood of erosion, siltation, destruction of riparian vegetation on riverbanks and watercourses is very low.

Secretary's environmental assessment requirements for flooding	Response
g) impacts the development may have upon existing community emergency management arrangements for flooding.	Sydney Metropolitan Emergency Management Plan November 2017, Sydney CBD Safety Subplan September 2019, Sydney & North Sydney CBD, Central Business Districts Evacuation Management Subplan 2015, City of Sydney Local Emergency Management Plan August 2021 and City of Sydney Council Flood Emergency Sub Plan December 2021 apply to this location. The City of Sydney Council Flood Emergency Sub Plan indicates that evacuation is the primary response strategy for people impacted by flooding. The Sydney North Sydney Central Business Districts Evacuation Management Subplan does not specifically list routes owing to the large number of people to coordinate. Potential impacts during construction would be managed through measures outlined in the Construction Environmental Management Framework.
(h) any impacts the development may have on the social and economic costs to the community as consequence of flooding	Refer Section 5.2.12

Table 5-18: Impacts on flood behaviour during operations at Pyrmont Station

Secretary's environmental assessment requirements for flooding	Response
Full range of flood events up to the PMF (taking into account sea level rise and storm intensity due to climate change) including:	Refer Section 3.1.4
(a) maps featuring flood prone lands, flood planning areas (areas below the flood planning level), hydraulic categorisation (flood ways and flood storage areas) and flood hazards;	Refer Appendix A – Baseline environment flood maps and Appendix B – "With Proposal" flood maps

<table>
<tr><th>Secretary's environmental assessment requirements for flooding</th><th>Response</th></tr>
<tr><td>(b) assessment of potential flood affectation of other properties, assets and infrastructure against the flood management objectives</td><td>
For the 5% AEP climate change and 1% AEP climate change flood events and the PMF event:

Hydraulic impact maps included in Appendix C – Impact assessment flood maps show that this proposal has limited localised impacts on existing flooding behaviour. Generally, there is no increase in afflux in all events due to the proposal with the following exceptions:

flood event modelling results indicate slight reduction in extent of flooding associated with minor differences in footprint size between the baseline and "with proposal" scenarios.
PMF event modelling suggests an afflux of up to approximately 0.05 metres on Union and Edward Street and Pyrmont Bridge Road at the perimeter of the metro station

No additional private properties are expected to be impacted
Change in duration of inundation is negligible.

Figure 5-8 indicates the 1% AEP climate change flood event impact of the proposal. Further hydraulic impact assessment maps are located in Appendix C – Impact assessment flood maps.

Table below outlines the defining event for the design of station entry levels and the station design level relative to the flood level for the defining event. Flood protection measures (for example flood barriers to protect the station from inundation) would be required at this station as the design level would not be situated at a height greater than or equal to the station1% AEP climate change flood level plus freeboard which is the defining event for this metro which is the defining event for this metro station. This would most likely be achieved with flood barriers incorporated into the design of the metro station and operated as part of the emergency management arrangements.
<table>
<tr><th>Location</th><th>Defining Event</th><th>Flood level (mAHD)</th><th>Design level (mAHD)</th></tr>
<tr><td>Pyrmont Bridge Road (Western Station Entrance)</td><td>1% AEP climate change with freeboard</td><td>14.97</td><td>14.7</td></tr>
</table>
</td></tr>
</table>

Secretary's environmental assessment requirements for flooding	Response			
	Union Street (Eastern Station Entrance)	1% AEP climate change with freeboard	8.57	9.03
(c) consistency (or inconsistency) with applicable Council floodplain risk and stormwater management plans and other similar initiatives	Results are generally consistent with the Darling Harbour Catchment Floodplain Risk Management Plan – September 2016 noting the hazard categorisation used in the plan is consistent with the Floodplain Development Manual rather than ARR2019.			
(d) compatibility with the flood hazard of the land	Hazard categories are largely unchanged. The Pyrmont Station would be protected from inundation in the PMF event as outlined above in (b) which would provide shelter in place arrangements during extreme flood events as surrounding streets would be high hazard. Potential hazard to people and vehicles accessing the metro station as flood barriers operate would be managed through emergency response planning. Mitigation measure EIS-HF 1 has been added to realise this requirement.			
(e) compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land	Union and Edward Streets and approximately the lower half of Pyrmont Bridge Road are flood ways in the PMF event. Figure B-48 of Appendix B – "With Proposal" flood maps indicate these locations relative to the proposal for the PMF event. The extended sections of high hazard in these streets for the PMF event demonstrates the conveyance behaviour associated with a flood way. This presents risks to people and vehicles but with the measures outlined in (d) it is expected these hydraulic functions would be compatible with this proposal.			
(f) the likelihood of erosion, siltation, destruction of riparian vegetation on riverbanks and watercourses	Flood and stormwater discharged from this site would enter the minor and major urban drainage system rather than directly entering nearby watercourses. Water quality measures would be employed as indicated in Section 6.2. Furthermore, as these catchments are very small compared to the total catchment of nearby watercourses indirect impacts are likely to be low.			

Secretary's environmental assessment requirements for flooding	Response
g) impacts the development may have upon existing community emergency management arrangements for flooding.	Sydney Metropolitan Emergency Management Plan November 2017, Sydney CBD Safety Subplan September 2019, Sydney & North Sydney CBD, Central Business Districts Evacuation Management Subplan 2015, City of Sydney Local Emergency Management Plan August 2021 and City of Sydney Council Flood Emergency Sub Plan December 2021 apply to this location. The City of Sydney Council Flood Emergency Sub Plan indicates that evacuation is the primary response strategy for people impacted by flooding. The City of Sydney Local Emergency Management Plan requires that transport agencies inform the State Emergency Services when their infrastructure is impacted by localised flooding. The Sydney North Sydney Central Business Districts Evacuation Management Subplan does not specifically list routes owing to the large number of people to coordinate. This site falls within sub precinct F. It is likely that this proposal would be involved in evacuation arrangements under this plan. Table 7-1 includes a mitigation measure to engage with relevant agencies to coordinate planning in order to limit these impacts.
(h) any impacts the development may have on the social and economic costs to the community as consequence of flooding	Refer Section 5.2.12

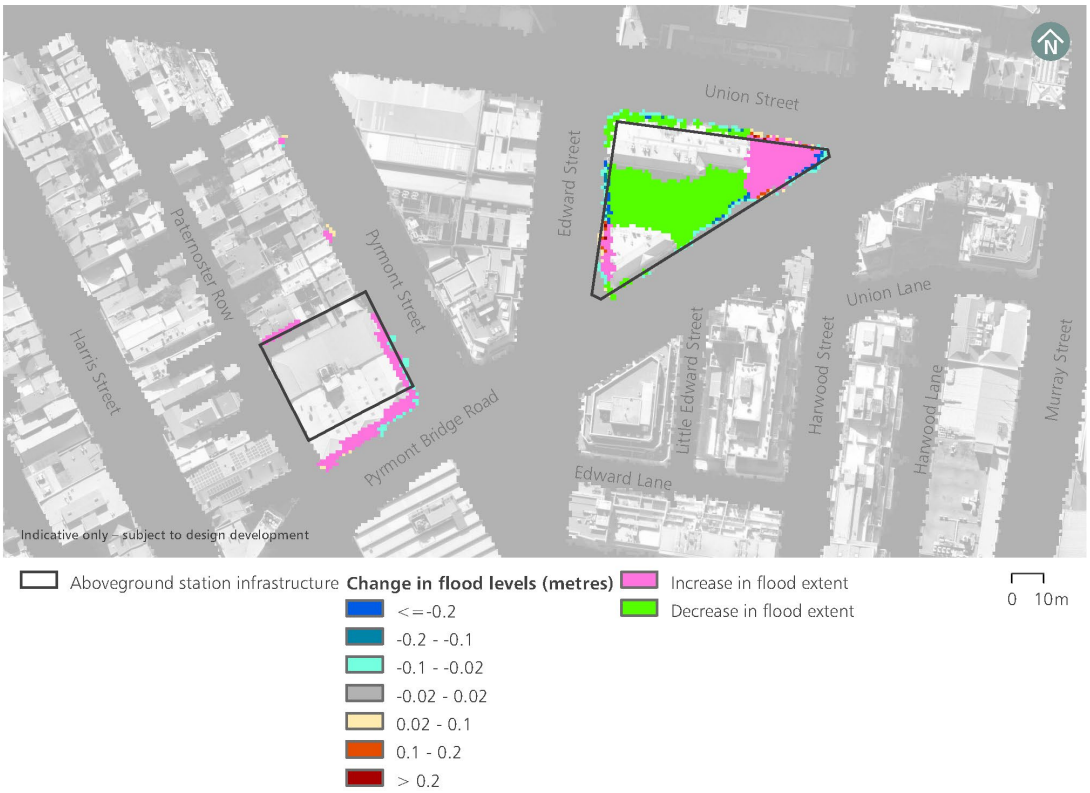

Figure 5-8 1% AEP climate change flood impact assessment map for Pyrmont Station

5.2.9 Hunter Street Station (Sydney CBD)

Construction phase flooding impacts (Table 5-19) and operation phase flooding impacts (Table 5-20) at Hunter Street Station (Sydney CBD) are described below in relation to the Secretary's environmental assessment requirements outlined in Table 1-1.

Table 5-19: Impacts on flood behaviour during construction at Hunter Street Station (Sydney CBD)

Secretary's environmental assessment requirements for flooding	Response
Full range of flood events up to the PMF (taking into account sea level rise and storm intensity due to climate change) including:	Refer Section 3.1.4
(a) maps featuring flood prone lands, flood planning areas (areas below the flood planning level), hydraulic categorisation (flood ways and flood storage areas) and flood hazards;	Refer Appendix A – Baseline environment flood maps

Secretary's environmental assessment requirements for flooding	Response
(b) assessment of potential flood affectation of other properties, assets and infrastructure against the flood management objectives	The baseline assessment is described in Section 4.9.7. Flood affectation as a result of construction of this proposal would have a similar risk profile to that outlined in the previous Sydney Metro West planning application. These works would include the following general impacts: • continued potential interruption of overland flow paths from temporary construction site infrastructure and modifications to landforms • the potential interruption or diversion of existing flood routes away from the location of bunding or spoil within construction sites, resulting in a reduction of flood storage and an increased flood risk to adjacent sites • disruption of street kerb and gutter at construction site vehicle entry locations which may result in localised ponding • potential blocking of drainage networks through increased sedimentation of surface water. Mitigation measures implemented as part of the Construction Environment Management Framework would require that construction planning manage the potential construction phase flooding risk at the Hunter Street Station (Sydney CBD) construction sites.
(c) consistency (or inconsistency) with applicable Council floodplain risk and stormwater management plans and other similar initiatives	Results are generally consistent with the City Area Catchment Floodplain Risk Management Plan noting the hazard categorisation used in the plan is consistent with the Floodplain Development Manual rather than ARR2019.

Secretary's environmental assessment requirements for flooding	Response
(d) compatibility with the flood hazard of the land	Large areas of these construction sites would be protected from inundation as a result of work carried out under the previous Sydney Metro West planning application. Where that is not the case, proximity to high hazard flows in adjacent roads would need to be managed. In the 5% AEP climate change and 1% AEP climate change flood events the hazard classification is generally H1 low hazard which is accepted as safe for people, vehicles and buildings. Access and evacuation routes are readily available via the adjacent streets with the exception of Hunter Street at the western site which experiences up to H5 high hazard category in the 1% AEP climate change flood event. In the PMF event, Hunter and George Street are H5 high hazard typically for their full width with isolated areas of H6 high hazard near the eastern construction site and more extensive sections of H6 high hazard in front of the western construction site. The western construction site would become isolated in rare and extreme flood events. Potential risk to construction areas which are not protected from flood inundation along with danger to people and vehicles accessing or working within the construction site would be managed.
(e) compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land	George Street and nearby Pitt Street are flood ways in all events considered. Hunter Street and various lanes off Pitt Street become flood ways in the PMF event. This presents risks to construction but with the application of measures it is expected these hydraulic functions would be compatible with this proposal.
(f) the likelihood of erosion, siltation, destruction of riparian vegetation on riverbanks and watercourses	Flood and stormwater discharged from this site enter the minor and major urban drainage system rather than directly entering nearby watercourses. With implementation of the measures outlined in the Construction Environmental Management Framework it is expected that the likelihood of erosion, siltation, destruction of riparian vegetation on riverbanks and watercourses is very low.

Secretary's environmental assessment requirements for flooding	Response
g) impacts the development may have upon existing community emergency management arrangements for flooding.	Sydney Metropolitan Emergency Management Plan November 2017, Sydney CBD Safety Subplan September 2019, Sydney & North Sydney CBD, Central Business Districts Evacuation Management Subplan 2015, City of Sydney Local Emergency Management Plan August 2021 and City of Sydney Council Flood Emergency Sub Plan December 2021 apply to this location. The City of Sydney Council Flood Emergency Sub Plan indicates that evacuation is the primary response strategy for people impacted by flooding. The Sydney North Sydney Central Business Districts Evacuation Management Subplan does not specifically list routes owing to the large number of people to coordinate. Potential impacts during construction would be managed through measures outlined in the Construction Environmental Management Framework.
(h) any impacts the development may have on the social and economic costs to the community as consequence of flooding	Refer Section 5.2.12

Table 5-20: Impacts on flood behaviour during operations at Hunter Street Station (Sydney CBD)

Secretary's environmental assessment requirements for flooding	Response
Full range of flood events up to the PMF (taking into account sea level rise and storm intensity due to climate change) including:	Refer Section 3.1.4
(a) maps featuring flood prone lands, flood planning areas (areas below the flood planning level), hydraulic categorisation (flood ways and flood storage areas) and flood hazards;	Refer Appendix A – Baseline environment flood maps and Appendix B – "With Proposal" flood maps

<table>
<tr><th>Secretary's environmental assessment requirements for flooding</th><th>Response</th></tr>
<tr><td>(b) assessment of potential flood affectation of other properties, assets and infrastructure against the flood management objectives</td><td>
For the 5% AEP climate change and 1% AEP climate change flood events and the PMF event:

Hydraulic impact maps included in Appendix C – Impact assessment flood maps show that the proposal has limited localised impacts on existing flooding behaviour. Generally, there is no increase in afflux in all events due to the proposal with the following exceptions:

5% AEP climate change flood event modelling results suggests an afflux of up to approximately 0.1 metres at Bligh Street. This is a modelling artifact caused due to interpolation within the modelled surface topography.
1% AEP climate change flood event modelling results indicate an afflux of up to approximately 0.08 metres In Hunter Street. This is localised and within the road.

No additional private properties would be impacted
Change in duration of inundation is negligible.

Figure 5-9 indicates the 1% AEP climate change flood event impact of the proposal. Further hydraulic impact assessment maps are located in Appendix C – Impact assessment flood maps.

Table below outlines the defining event for the design of station entry levels and the station design level relative to the flood level for the defining event. Flood protection measures (for example flood barriers to protect the station from inundation) would be required at this station as the design level would not be situated at a height greater than or equal to the station1% AEP climate change flood level plus freeboard which is generally the defining event for this metro which is the defining event for this metro station. This would most likely be achieved with flood barriers incorporated into the design of the metro station and operated as part of the emergency management arrangements.
<table>
<tr><th>Location</th><th>Defining Event</th><th>Flood level (mAHD)</th><th>Design level (mAHD)</th></tr>
<tr><td>George Street</td><td rowspan="3">1% AEP climate change with freeboard</td><td>13.75</td><td>13.50</td></tr>
<tr><td>O'Connell Street</td><td>12.15</td><td>12.40</td></tr>
<tr><td>Bligh Street</td><td>18.6</td><td>18.30</td></tr>
</table>
</td></tr>
</table>

Secretary's environmental assessment requirements for flooding	Response			
	Hunter Street (west)		10.0	9.5
(c) consistency (or inconsistency) with applicable Council floodplain risk and stormwater management plans and other similar initiatives	Results are generally consistent with the City Area Catchment Floodplain Risk Management Plan noting the hazard categorisation used in the plan is consistent with the Floodplain Development Manual rather than ARR2019.			
(d) compatibility with the flood hazard of the land	In the 5% AEP climate change and 1% AEP climate change flood events the hazard classification is generally H1 low hazard which is accepted as safe for people, vehicles and buildings. Access and evacuation routes are readily available via the adjacent streets with the exception of Hunter Street at the western site which experiences up to H5 high hazard category in the 1% AEP climate change flood event. In the PMF event, Hunter and George Street are H5 high hazard typically for their full width with isolated areas of H6 high hazard near the eastern site and more extensive sections of H6 high hazard in front of the western site. There would be a negligible difference in flood hazard compared with the baseline scenario. The Hunter Street Station (Sydney CBD) would be protected from inundation in the PMF event as outlined above in (b) which would provide shelter in place arrangements during extreme flood events as surrounding streets would be high hazard. Potential hazard to people and vehicles accessing the metro station as flood barriers operate would be managed through emergency response planning.			
(e) compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land	George Street and nearby Pitt Street are flood ways in all events considered. Hunter Street and various lanes off Pitt Street become flood ways in the PMF event. Figures B-52 and B-54 of Appendix B – "With Proposal" flood maps indicate these locations relative to the proposal for the 1% AEP climate change flood and PMF events. The extended sections of high hazard in these streets for the PMF event demonstrates the conveyance behaviour associated with a flood way. This presents risks to people and vehicles but with the application of measures it is expected these hydraulic functions would be compatible with this proposal.			

Secretary's environmental assessment requirements for flooding	Response
(f) the likelihood of erosion, siltation, destruction of riparian vegetation on riverbanks and watercourses	Flood and stormwater discharged from this site would enter the minor and major urban drainage system rather than directly entering nearby watercourses. Water quality measures will be employed as indicated in Section 6.2. Furthermore, as these catchments are very small compared to the total catchment of nearby watercourses indirect impacts are likely to be low.
g) impacts the development may have upon existing community emergency management arrangements for flooding.	Sydney Metropolitan Emergency Management Plan November 2017, Sydney CBD Safety Subplan September 2019, Sydney & North Sydney CBD, Central Business Districts Evacuation Management Subplan 2015, City of Sydney Local Emergency Management Plan August 2021 and City of Sydney Council Flood Emergency Sub Plan December 2021 apply to this location. The City of Sydney Council Flood Emergency Sub Plan indicates that evacuation is the primary response strategy for people impacted by flooding. The City of Sydney Local Emergency Management Plan requires that transport agencies inform the State Emergency Services when their infrastructure is impacted by localised flooding. The Sydney North Sydney Central Business Districts Evacuation Management Subplan does not specifically list routes owing to the large number of people to coordinate. This site falls within sub precinct C. It is likely that this proposal would be involved in evacuation arrangements under this plan. Table 7-1 includes a mitigation measure to engage with relevant agencies to coordinate planning in order to limit these impacts.
(h) any impacts the development may have on the social and economic costs to the community as consequence of flooding	Refer Section 5.2.12

Figure 5-9 1% AEP climate change flood event impact assessment map for Hunter Street Station (Sydney CBD)

5.2.10 Clyde stabling and maintenance facility and Rosehill services facility

Construction phase flooding impacts (Table 5-21) and operation phase flooding impacts (Table 5-22) at Clyde stabling and maintenance and Rosehill services facility are described below in relation to the Secretary's environmental assessment requirements outlined in Table 1-1.

Table 5-21: Impacts on flood behaviour during construction at Clyde stabling and maintenance facility and Rosehill services facility

Secretary's environmental assessment requirements for flooding	Response
Full range of flood events up to the PMF (taking into account sea level rise and storm intensity due to climate change) including:	Refer Section 4.10.7

Secretary's environmental assessment requirements for flooding	Response
(a) maps featuring flood prone lands, flood planning areas (areas below the flood planning level), hydraulic categorisation (flood ways and flood storage areas) and flood hazards;	Refer Section 4.10.7
(b) assessment of potential flood affectation of other properties, assets and infrastructure against the flood management objectives	The construction works associated with this proposal build upon the major earthworks undertaken as part of the previous Sydney Metro West planning application, as discussed in Section 4.10.1. No additional flooding assessment has been carried out for this site as this proposal considers no additional filling of the floodplain around the creeks and the scope of work for the rehabilitation of Duck Creek requires further definition prior to assessment of it's potential impact on flood levels. Once sufficiently detailed, the scope of rehabilitation work at Duck Creek would be incorporated into the flood model for assessment as part of further design development.
(c) consistency (or inconsistency) with applicable Council floodplain risk and stormwater management plans and other similar initiatives	This proposal is generally consistent with the Lower Parramatta River Floodplain Risk Management Study and Plan noting the hazard categorisation used in the plan is consistent with the Floodplain Development Manual rather than ARR2019.
(d) compatibility with the flood hazard of the land	As indicate in Section 4.10.7, the level of the earthen platform for the Clyde stabling and maintenance facility and the level to which the Rosehill services facility has been protected as part of the previous Sydney Metro West planning application provide immunity to this infrastructure in the PMF event which is compatible with the use of the land. Potential hazard to people and vehicles accessing the site would need to be managed as part of the construction planning as the surrounding area is vulnerable to flooding.
(e) compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land	This proposal is compatible with the hydraulic functions as they are generally above the PMF level excepting the works associated with the rehabilitation strategy and general surface drainage which would interface with Duck Creek.

Secretary's environmental assessment requirements for flooding	Response
(f) the likelihood of erosion, siltation, destruction of riparian vegetation on riverbanks and watercourses	Parts of Duck Creek and A'Becketts Creek that remain open channels would be rehabilitated and/or renaturalised. These works would improve the vegetation within the riparian zone and would be undertaken in a manner which minimises the likelihood of erosion and siltation. Potential impacts during construction would be managed through the implementation of measures outlined in the Construction Environmental Management Framework
g) impacts the development may have upon existing community emergency management arrangements for flooding.	The Parramatta Local Emergency Plan lists the M4 Motorway and Parramatta Road as major arterial routes. Drainage pathways from this site do not drain towards these routes and therefore there is no potential for this proposal to impact on those emergency management arrangements. Potential impacts during construction would be managed through the Construction Environmental Management Framework.
(h) any impacts the development may have on the social and economic costs to the community as consequence of flooding	Refer Section 5.2.12

Table 5-22: Impacts on flood behaviour during operations at Clyde stabling and maintenance facility and Rosehill services facility

Secretary's environmental assessment requirements for flooding	Response
Full range of flood events up to the PMF (taking into account sea level rise and storm intensity due to climate change) including:	Refer Section 4.10.7
(a) maps featuring flood prone lands, flood planning areas (areas below the flood planning level), hydraulic categorisation (flood ways and flood storage areas) and flood hazards;	Refer Section 4.10.7

Secretary's environmental assessment requirements for flooding	Response
(b) assessment of potential flood affectation of other properties, assets and infrastructure against the flood management objectives	The operation of this facility in this proposal and as outlined in Section 3.3 is not expected to introduce additional impacts to those that would have been resolved during construction.
(c) consistency (or inconsistency) with applicable Council floodplain risk and stormwater management plans and other similar initiatives	This proposal is generally consistent with the Lower Parramatta River Floodplain Risk Management Study and Plan noting the hazard categorisation used in the plan is consistent with the Floodplain Development Manual rather than ARR2019.
(d) compatibility with the flood hazard of the land	As indicated in Section 4.10.7, the level of the earthen platform for the Clyde stabling and maintenance facility and the level to which the Rosehill services facility has been protected as part of the previous Sydney Metro West planning application provides immunity in the PMF event which is compatible with the use of the land.
(e) compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land	This proposal is compatible with the hydraulic functions as they are generally above the PMF level.
(f) the likelihood of erosion, siltation, destruction of riparian vegetation on riverbanks and watercourses	Water quality measures would be employed as indicated in Section 6.2. Furthermore, as these catchments are very small compared to the total catchment of nearby watercourses indirect impacts are likely to be low.
g) impacts the development may have upon existing community emergency management arrangements for flooding.	The Parramatta Local Emergency Plan lists the M4 Motorway and Parramatta Road as major arterial routes. Drainage pathways from this site do not drain towards these routes and therefore there is no potential for the works in this proposal to impact on those emergency management arrangements.
(h) any impacts the development may have on the social and economic costs to the community as consequence of flooding	Refer Section 5.2.12

5.2.11 Cumulative impacts

Cumulative impacts result from the successive, incremental, or combined effects of an activity or project when added to other past, current, planned, or reasonably anticipated future impacts (Department of Planning and Environment, 2021). A qualitative assessment of the potential cumulative flood impacts of this stage with other proposed development has been carried out and a quantitative assessment has been carried out for the metro stations against the previous Sydney Metro West planning applications. The quantitative assessment compares the pre-development situation with the “with proposal” scenario of this proposal at each metro station. It does not reassess previous Sydney Metro West planning applications.

It is noted that major earthworks and civil construction works have been assessed as part of the previous Sydney Metro West planning applications. These previous Sydney Metro West planning applications also considered the potential cumulative impacts in the context of a range of other projects being undertaken or planned in the vicinity of the works associated with those proposals.

Projects where cumulative impacts have been considered for this proposal are described below.

Table 5-23: Cumulative flood impacts

Project name	Description	Cumulative impact assessment
Sydney Metro West - Major civil construction work between Westmead and the Bays	Sydney Metro West (the Concept) would involve the construction and operating of a metro rail line around 24 kilometres long between Westmead and Sydney CBD. Stage 1 (of the planning approval for Sydney Metro West) would involve major civil construction work between Westmead and The Bays. The Sydney Metro West Concept and major civil construction work for Sydney Metro West between Westmead and The Bays was approved on 11 March 2021.	Flood impact maps (Appendix E – Cumulative Assessment) have been prepared for the 5% AEP climate change and 1% AEP climate change flood events and the PMF event for Westmead metro station. As outlined in Section 5.2.1, mitigation measures have been introduced to ensure that impacts on other infrastructure and emergency management would be mitigated. With this measure, cumulative impacts are expected to be localised and would be contained within the minor and major urban drainage system.
		Flood impact maps (Appendix E – Cumulative Assessment) have been prepared for the 5% AEP climate change and 1% AEP climate change flood events and the PMF event. These maps indicate that there are potential cumulative impacts from the Parramatta metro station in the PMF event. Areas to the north east and east experience increased flooding generally up to approximately 0.2 metres with smaller areas experiencing impacts in excess of 0.2 metres including sections of the Civic Link. Areas to the north west, west, south west and south generally experience decreased flooding up to approximately 0.2 metres. This is due to the increased flow conveyance through the station compared with the pre-development conveyance of Horwood Place. The scale of impact is modest compared to the degree of impact these properties currently experience, with inundation in the PMF event already substantial. Cumulative impacts from flood events between the 1% AEP climate change flood event and the PMF event may also occur. Large scale evacuation by vehicle from the Parramatta CBD would be challenging as indicated in the Parramatta CBD Flood Evacuation Assessment. The Parramatta metro station has the potential to improve options for the evacuation of people from the Parramatta CBD until the activation of the flood barriers prevents further access to the Parramatta metro station. There may be other types of emergencies where these benefits can also be realised.

Project name	Description	Cumulative impact assessment
		Flood impact maps (Appendix E – Cumulative Assessment) have been prepared for the 5% AEP climate change and 1% AEP climate change flood events and the PMF event. These maps indicate that generally impacts are contained within the Sydney Olympic Park metro station, with the exception of shallow flooding on Herb Elliot Avenue near the junction with Showground Road and isolated areas of Figtree Drive mostly south west of the metro station. Kerb and gutter systems on Herb Elliot Avenue and Figtree Driver would experience increased flow depth of up to approximately 0.2 metres. It is expected that cumulative impacts would be minimal due to the shallow flood levels in Herb Elliot Avenue near Showground Road and the alternate route options for access to this area.
		Flood impact maps (Appendix E – Cumulative Assessment) have been prepared for the 5% AEP climate change and 1% AEP climate change flood events and the PMF event for North Strathfield metro station. As outlined in Section 5.2.4, a mitigation measure has been introduced to ensure that impacts on private properties not previously inundated would be mitigated. With this measure, cumulative impacts are expected to be localised and would be contained within the minor and major urban drainage system.
		Flood impact maps (Appendix E – Cumulative Assessment) have been prepared for the 5% AEP climate change and 1% AEP climate change flood events and the PMF event for Burwood North Station. As outlined in Section 5.2.5, a mitigation measure has been introduced to ensure that impacts on private properties not previously inundated would be mitigated. With this measure, cumulative impacts are expected to be localised and would be contained within the minor and major urban drainage system.
		Flood impact maps (Appendix E – Cumulative Assessment) have been prepared for the 5% AEP climate change and 1% AEP climate change flood events and the PMF event for Five Dock Station. Minor flood depth increases and flood extents in East Street and Great North Road for the flood events considered show as cumulative impacts however, these are owing to design road changes as part of this proposal. Consequently, cumulative impacts are expected to be localised and would be contained within the minor and major urban drainage system.

Project name	Description	Cumulative impact assessment
		Flood impact maps (Appendix E – Cumulative Assessment) have been prepared for the 5% AEP climate change and 1% AEP climate change flood events and the PMF event for The Bays Station. Cumulative impacts are within the proposal boundary with the exception of isolated increases at the eastern end Robert Street which are the result of modelling artifacts associated with the modelled surface topography. Therefore, it can be concluded that cumulative impacts are acceptable as they are contained within the proposal footprint and this proposal has resulted in improved hydraulic performance at Robert Street.
Sydney Metro West - Major civil construction works between Pyrmont and Sydney CBD	Stage 2 (of the planning approval process) includes all major civil construction work including station excavation and tunnelling between The Bays and Hunter Street Station (Sydney CBD). This proposal is yet to receive approval. There will be concurrent works at The Bays Station construction site between the fourth quarter of 2024 and the third quarter of 2025. Work associated with this project includes tunnelling eastwards to Sydney CBD and the use of The Bays Station construction site to support this activity. The Bays Station box will have been previously constructed as part of the Sydney Metro West - Major civil construction work between Westmead and the Bays.	Flood impact maps (Appendix E – Cumulative Assessment) have been prepared for the 5% AEP climate change and 1% AEP climate change flood events and the PMF event for Pyrmont Station: As outlined in Section 5.2.8, there are very limited localised cumulative impacts as a result of this proposal in all flood events that have been assessed so it can reasonably be considered as low impact. Large scale evacuation from the Sydney CBD would be difficult to achieve. The Pyrmont Station has the potential to contribute to improved evacuation from the Sydney CBD until the activation of the flood barriers at station entries prevents access. There may be other types of emergencies where these benefits can also be realised.
		Flood impact maps (Appendix E – Cumulative Assessment) have been prepared for the 5% AEP climate change and 1% AEP climate change flood events and the PMF event for Hunter Street Station (Sydney CBD). As outlined in Section 5.2.9, there are very limited localised cumulative impacts due to the proposal in the 1% AEP climate change flood event so it can reasonably be considered as low impact. Large scale evacuation from the Sydney CBD would be difficult to achieve. The Hunter Street Station (Sydney CBD) has the potential to contribute to improved evacuation from the Sydney CBD until the activation of the flood barriers at station entries prevents access. There may be other types of emergencies where these benefits can also be realised.

Project name	Description	Cumulative impact assessment
Sydney Metro City & Southwest (Chatswood to Sydenham)	The Sydney Metro City & Southwest Project, application number SSI-7400, were approved on 9 January 2017 with a number of subsequent modifications. The Chatswood to Sydenham component of Sydney Metro City & Southwest Project involves the construction and operation of a 15.5 km metro line from Chatswood, under Sydney Harbour and through Sydney's CBD out to Sydenham. This Proposal was not specifically considered in the cumulative assessment (Sydney Metro, 2016). The Hunter Street Station eastern construction site is 50 metres to the south-east of Martin Place Station. Hunter Street is a floodway from below the location of the Hunter Street Station eastern construction site to at least the intersection with Castlereagh Street (WMAwater, 2016b).	The development of the Martin Place Station does not cause increased flood levels at either of the Hunter Street Station (Sydney CBD) construction sites. However, there may be a potential impact on the Martin Place Station during construction as there would be a 10 metre rise of the adit connection to the Hunter Street Station (Sydney CBD) eastern construction site. This would be addressed through a mitigation measure from the previous Sydney Metro West planning application.

Project name	Description	Cumulative impact assessment
Western Harbour Tunnel and Warringah Freeway Upgrade	The Western Harbour Tunnel and Warringah Freeway Upgrade project form part of the Western Harbour Tunnel and Beaches Link Program and comprise a new motorway tunnel connection across Sydney Harbour, and an upgrade of the Warringah Freeway to integrate the new motorway infrastructure with the existing road network, with a connection to the Beaches Link and Gore Hill Freeway Connection project. This is an approved project with a construction period from 2023 until 2024.	Components of this proposal relevant to this assessment include construction activities at White Bay. However, it is not hydraulically connected to The Bays Station construction site therefore no cumulative impacts are expected in up to the 1% AEP flood event.
The new Sydney Fish Market	The project involves building a new Sydney Fish Market which will be set within an improved public domain including the creation of a waterfront promenade. The site is located at the head of Blackwattle Bay between Pyrmont Peninsula and Glebe Peninsula. This is an approved project with a construction period from 2020 until 2024.	The project is 1 kilometre to the south-east of The Bays construction site and 500 metres to the south-west of the Pyrmont Station construction sites. However, it is not hydraulically connected to either The Bays Station construction site or the Pyrmont Station construction sites therefore no cumulative impacts are expected in up to the 1% AEP flood event.

Project name	Description	Cumulative impact assessment
50-52 Phillip Street New Hotel (SSD)	This proposal involves the delivery of a new landmark hotel building in Sydney's CBD with approximately 330 rooms throughout the 47 storey development. Construction is likely to extend across 2.5 years and commencement of demolition and construction is not expected before 2023. This project is approximately 300 metres to the north-east of the Hunter Street Station (Sydney CBD) construction sites.	This project is located within a different sub-catchment of the same catchment draining to Circular Quay. In rare flood events this sub-catchment drains directly to Circular Quay via Phillip Street (WMAwater, 2016a). Consequently, cumulative impacts are not expected in up to the 1% AEP flood event.
One Sydney Harbour	One Sydney Harbour is a skyscraper complex under construction in Sydney which includes 808 apartments in three towers. The project is part of the major urban renewal precinct of Barangaroo.	The Hunter Street Station (Sydney CBD) construction site is 550 metres to the north-west. However, it is not hydraulically connected therefore no cumulative impacts are expected in up to the 1% AEP flood event.

Project name	Description	Cumulative impact assessment
Sydney Metro - Martin Place Over Station Development	The project includes two over station development commercial towers above the northern and southern entrances of the yet to be constructed Martin Place Metro Station. The Concept Proposal is intended to be delivered as a single, integrated project along with the delivery of rail, station, concourse infrastructure and public domain works associated with the Martin Place Metro Station. The construction of the different elements is likely to be staged so as not to interrupt the Metro construction program.	Although, the Hunter Street Station (Sydney CBD) construction site is 50 metres to the south-east, this project coincides with Martin Place Station as outlined earlier in this table. No additional cumulative impacts are expected as a result of this project in up to the 1% AEP flood event.

Project name	Description	Cumulative impact assessment
301 and 305 Kent Street Concept Hotel Development	"The proposal is a Concept SSDA submitted in accordance with Section 4.22 of the EP&A Act. The Concept SSDA seeks consent for: • The establishment of a building envelope up to a height of RL 96.2 metres • Use of the site as a hotel (with ancillary uses) • Pedestrian and vehicular access arrangements and • The provision of on-site bicycle and car parking. A future detailed SSDA (Stage 2 SSDA) will be lodged for the detailed design and construction of the development. The architectural reference scheme for the proposed development prepared by DBI Architects envisages a 29-storey hotel development on the site.	This project is located within a different sub-catchment of the city area catchment (WMAwater, 2016a). Consequently, cumulative impacts are not expected in up to the 1% AEP flood event.

Project name	Description	Cumulative impact assessment
Cockle Bay Wharf mixed use development	A SSDA was approved by the NSW Independent Planning Commission on 13 May 2019 for the Concept Proposal and Stage 1 works which include demolition works. The current proposal would include: • construction of a landbridge across part of the Western Distributor • the design, construction and use of a 43 storey mixed-use development • at least 6500 m2 of publicly accessible open space • site interface works • subdivision.	This project is located within a different sub-catchment of the city area and Darling Harbour catchments respectively (WMAwater, 2016a and WMAwater, 2016c). Consequently, cumulative impacts are not expected in up to the 1% AEP flood event.

Project name	Description	Cumulative impact assessment
Site 2A and Site 2B Australia Avenue, Sydney Olympic Park	The development comprises a State significant development application (SSDA) for the site including: • site preparation works including tree removal and excavation; • the construction of two buildings including a tower (approximately 45 storeys in height) that provides serviced apartments, plus a podium on Site 2A and a commercial building (approximately 12 storeys in height) on Site 2B; • six levels of basement accommodating car and bicycle parking; • construction of an extension to Dawn Fraser Avenue and a service lane; and • construction of a large activate public domain located in the frontage area between the proposed buildings and Australia Avenue	This project is outside the area of influence of the Sydney Olympic Park metro station and therefore cumulative impacts are not expected in up to the 1% AEP flood event.

Project name	Description	Cumulative impact assessment
Site 43/44, Sydney Olympic Park – Stage 1 and 2 (6 Australia Avenue and 2 Herb Elliot Avenue)	The project involves the staged development of two mixed-use buildings for commercial and retail spaces, associated basement car parking, landscaping and driveway access.	This project is outside the area of influence of the Sydney Olympic Park metro station and therefore cumulative impacts are not expected in up to the 1% AEP flood event.
Clyde Terminal Conversion Project	The project involves the removal of redundant crude oil refinery and import facilities at the Clyde Terminal and upgrade of existing facilities to allow for the receipt, storage and distribution of finished petroleum products. The project would result in a reduced operational footprint for the terminal.	This project is outside the area of influence of the construction and operation of the Clyde service and maintenance facility and the Rosehill services facility (as outlined in Section 3.3) and therefore cumulative impacts are not expected in up to the 1% AEP flood event.

Project name	Description	Cumulative impact assessment
Parramatta Leagues Club Hotel	The proposal involves the demolition of existing buildings and the construction of a 17-storey hotel building (plus a single level basement for services). The building would include accommodation, a café, pool, fitness/recreational uses and a function room ancillary to the hotel. Access is proposed from O'Connell Street to the south of the building (via an access road to the adjoining Parramatta Stadium). The proposal includes public domain works and service upgrades surrounding the building to integrate the building with the surrounding area and infrastructure.	This project is outside the area of influence of the Parramatta metro station and therefore cumulative impacts are not expected in up to the 1% AEP flood event.
Parramatta Light Rail	The Parramatta Light Rail will connect Westmead to Carlingford via the Parramatta CBD and Camellia with a two-way track spanning 12 kilometres. The route will link Parramatta's CBD and train station to the Westmead Health Precinct, Cumberland Hospital Precinct, CommBank Stadium, the Camellia Town Centre, the new science, technology and innovation museum Powerhouse Parramatta, the private and social housing redevelopment at Telopea, Rosehill Gardens Racecourse and three Western Sydney University campuses.	This project has been included in the assessment outlined in this technical paper as part of the baseline for the Parramatta metro station and therefore no further cumulative impacts are expected at this location. This project is outside the area of influence of the construction and operation of the Clyde service and maintenance facility and the Rosehill services facility (as outlined in Section 3.3) and therefore cumulative impacts from the Parramatta Light Rail stabling and maintenance facility at Camelia are not expected in up to the 1% AEP flood event.

5.2.12 Social and economic costs to the community

Based on the assessment of potential flooding impacts outlined earlier in Section 5, the potential flooding impacts that are expected to result from this proposal are generally considered to be minor except for Parramatta metro station where cumulative impacts would be expected in rare to extreme flood events.

Mitigation measures identified in Table 7-1 such as detailed construction planning and detailed design in accordance with best practice guidelines at all sites along with measures at specific sites are expected to result in minimal flood impacts (with the exception of Parramatta metro station) during construction and operations and the associated social and economic costs to the community are acceptable.

As discussed in Sections 5.2.2 and 5.2.11 there would be residual flooding impacts relating to the Parramatta metro station in the PMF event. Areas to the north east and east of Parramatta metro station experience increased flooding in the PMF event as a result of this proposal by generally up to approximately 0.2 metres with smaller areas experiencing impacts in excess of 0.2 metres including sections of the Civic Link. The scale of impact is modest compared to the degree of impact these properties would already experience in the current state, that is prior to work carried out under the previous Sydney Metro West planning application, as inundation in this area as a result of a PMF event would be significant.

Mitigation measure EIS-HF 3 in Table 7-1 makes provision for ongoing consultation to occur with State Emergency Services and the City of Parramatta Council in relation to potential impacts to existing community emergency management arrangements for flooding.

6 Water quantity and quality impact assessment

This chapter describes the construction and operational water quality impacts of this proposal on the existing environment within the study area. Content has been structured to cover the construction and operational phases of this proposal.

An additional section covers construction water use.

6.1 Water quality – construction

6.1.1 Surface water quality

The proposed works for tunnel fit-out and the construction of station and ancillary facilities between Westmead Station and Hunter Street Station (Sydney CBD) have the potential to result in impacts to the water quality of the waterways within this proposal area due to the release of pollutants. The following pollutants could be released directly, or conveyed by stormwater flow or wind, to nearby watercourses:

- Sediment from soil excavation, movement and storage and stormwater runoff through disturbed sites
- Chemicals, fuels and hydrocarbons from use, refuelling and maintenance of equipment and construction machinery
- Concrete slurry and wastewater – from mobile concrete batching plants
- Contaminants related to previous land uses or acid sulfate soils mobilised during civil works

Gross pollutants such as paper and plastic packaging and materials from material use on construction sites and general construction staff litter.

The likelihood and magnitude of impact would vary depending on the stage of construction, the area of disturbance and presence of high rainfall or wind weather events. Table 6-1 provides a description of the potential water quality impacts due to specific construction activities. Construction activities would be carried out in a highly modified and urban environment and would generally not be located within or near waterways (with the exception of the Clyde stabling and maintenance facility and Rosehill services facility construction site located adjacent to Duck and A'Beckett's Creek, and The Bays Station construction site located on White Bay). Refer to Section 4 for the watercourses, their description and distance from the construction sites relevant to this proposal.

Appropriate mitigation measures would be implemented to manage the potential impact of construction on the water quality of water courses within this proposal area, achieve NSW Water Quality Objectives, and reduce the impact to marine ecology. In accordance with a Construction Environmental Management Framework, soil and water mitigation and management measures, including progressive erosion and sediment control would be implemented at all construction sites, which would limit the impact of the construction works on water quality. Mitigation measures in Section 7 would be implemented to manage potential impacts to water quality which would be low and temporary, with no long-term impacts expected. The environmental management approach is detailed in Chapter 20 (Synthesis) of the Environmental Impact Statement.

Table 6-1 Potential construction impacts on water quality

Construction works	Potential impacts
General construction works	Although demolition would be minor during this stage of construction, demolition still has the potential to disturb and/or spread sources of pollutants (e.g. heavy metals, hydrocarbons, asbestos, solvents and per- and poly-fluoroalkyl) and generate soils and waste materials, which could be conveyed by wind or stormwater flow into the adjacent water body. This could result in elevated levels of pollution or increased turbidity. For this proposal, Westmead metro station construction site would require demolition of the existing concourse lift and temporary modification of the concourse supporting structure, and platform works are required at North Strathfield Station. Refer to 6.1.3 for a description of the potential impacts of constructions works.
Earthworks and stockpiling	Minor earthworks are required at Westmead metro station construction site, Sydney Olympic Park metro station construction site, North Strathfield metro station construction site and Five Docks Station construction site. Although earthworks would be minor during this stage of construction, earthworks (including stripping of topsoil, excavation, removal of existing paved areas, stockpiling and transport of materials) could result in temporary soil erosion and off-site movement of eroded sediments by wind and/or stormwater into receiving waterbodies. Refer to Section 6.1.5 for a description of the potential impacts of earthworks and stockpiling.
Accidental spills	Accidental spills or leaks of hydrocarbons could occur from the use, maintenance or re-fuelling of construction plant and equipment at construction sites, or from vehicle/truck incidents travelling to and from construction sites. Refer to Section 6.1.6 for a description of the potential impacts of accidental spills.
Disturbances of acid sulfate soils or contaminated land/ groundwater	Applicable to most sites including the basement excavation at the Parramatta metro station construction site, as a result of the disturbed land at the construction sites, potential disturbance of contaminated soils, groundwater, or acid sulfate soils during construction, demolition or earthwork activities could result in the mobilisation of contamination or acid sulfate soils by stormwater runoff and subsequent transportation to downstream watercourses, potentially increasing contaminant concentrations in the receiving environment. An assessment of existing groundwater quality indicated exceedances of iron and magnesium at the majority of monitoring sites for the 95 per cent aquatic protection levels in accordance with ANZG, 2018, and ANZECC, 2000 (Golder-Douglas, 2021). Other common exceedances included arsenic, cobalt, manganese and zinc.
Concrete activities	Concreting activities could result in the discharge of concrete dust, concrete slurries or washout water to downstream waterways. This could potentially increase the pH of downstream waterbodies which can be harmful to aquatic life. Concrete solids contained in the discharge also have the potential to cause increased turbidity.

6.1.2 Water treatment plant discharge

During the construction of this proposal works would result in wastewater being generated from the following sources:

- Water used in construction works and earthworks
- Groundwater ingress
- Rainfall runoff
- Machinery washdown runoff.

Releasing untreated wastewater could transport physical and chemical pollutants into waterways which would have ecological impacts to the receiving environment. As previously mentioned in Section 4, the watercourses relevant to this proposal are generally in poor condition and are representative of a heavily urbanised system (Sydney Metro, 2020) characterised by increased turbidity, lowered dissolved oxygen levels and increased nutrients.

To mitigate the impact of untreated wastewater, temporary construction water treatment plants would capture, treat, and discharge the water from general construction activities and water from construction activities that intercept groundwater. Due to the nature of the groundwater in this proposal, groundwater that is intercepted at construction sites may be contaminated with heavy metals, hydrocarbons, polychlorinated biphenyls, asbestos and pesticides before entering the water treatment process, as per Groundwater interactions and groundwater quality in Section 4. The water treatment plants would use clarifiers, tanks, filters and chemicals to treat the water to meet the requirements for discharge. The re-use of wastewater would be maximised during construction works (e.g. dust suppression) and any surplus treated wastewater would be discharged to the local stormwater system.

The water treatment plants would be designed so that wastewater is treated during construction and operation to a level that is compliant with the ANZG (2018) default guidelines for 95 per cent species protection and 99 per cent species protection for toxicants that bioaccumulate unless other discharge criteria are agreed with relevant authorities.

Table 6-2 provides an overview of the water treatment plant locations, indicative discharge volume, their discharge location and the receiving waterways. Indicative discharge volume during this proposal would vary depending on the construction works above and below the ground surface, and the amount of groundwater infiltrating into the tunnels.

Table 6-2 Construction wastewater treatment plants

Wastewater treatment plant location	Indicative capacity (litres per second)	Discharge location	Receiving waterbody	Distance from wastewater treatment plant (m)
Westmead metro station construction site	30	Local stormwater infrastructure	Domain Creek	250
Parramatta metro station construction site	15	Local stormwater infrastructure	Parramatta River	250
Clyde stabling and maintenance facility and Rosehill services facility construction site	30	Local stormwater infrastructure	Duck Creek and A'Becketts Creek	<100
Sydney Olympic Park metro station construction site	15	Local stormwater infrastructure	Haslams Creek	900
North Strathfield metro station construction sites	15	Local stormwater infrastructure	Powells Creek	400
Burwood North station construction sites	35	Local stormwater infrastructure	St Lukes Park Canal	500
Five Dock station construction sites	20	Local stormwater infrastructure	Iron Cove Creek	600
The Bays station construction site	30	Local stormwater infrastructure	White Bay	<100
Pyrmont station construction sites	30	Local stormwater infrastructure	Blackwattle Bay, Cockle Bay and Pyrmont Bay	150
Hunter Street station (Sydney CBD) construction sites	30	Local stormwater infrastructure	Circular Quay - Sydney Harbour	600

6.1.3 Impacts against the NSW Water Quality Objectives

The NSW Water Quality and River Flow Objectives (NSW Department of Environment, Climate Change and Water, 2006), as outlined in Section 3.2 have been developed to assist water quality planning, management and licencing procedures. These objectives are consistent with the ANZG (2018) trigger values and would be used as a guideline so that water quality discharge is maintained to a level that maintains or works towards improving surface water environments. Section 4 has identified the water quality conditions of the watercourses relevant to this proposal construction sites, as assessed against the ANZG guidelines. Common characteristics of these watercourses include:

- Low dissolved oxygen levels
- Elevated nutrient concentrations
- Elevated heavy metal concentrations
- High turbidity.

Table 6-3 outlines the water quality objectives relevant to this proposal and the potential impacts as a result of construction and operational activities.

Table 6-3 Assessment of potential construction impacts against Water Quality Objectives

Water quality objective	Indicators	Associated trigger values or criteria	Potential construction impacts
Aquatic ecosystems			
Maintaining or improving the ecological condition of waterbodies and their riparian zones over the long term	Total phosphorus	• Lowland Rivers - 25µg/L • Estuaries - 30µg/L	With the implementation of management measures, pollutant loading to the receiving waterways would be low with the possibility of better quality where existing water quality does not meet the ANZG (2018) guidelines. Therefore, there would be no impacts to the aquatic ecosystems of receiving waterways as a result of the construction works.
	Total nitrogen	• Lowland Rivers - 350µg/L • Estuaries - 300µg/L	
	Chlorophyll-a	• Lowland Rivers - 3µg/L • Estuaries - 4µg/L	
	Turbidity	• Lowland Rivers - 6-50 NTU • Estuaries - 0.5 - 10 NTU	
	Salinity (Electrical conductivity)	• Lowland Rivers – 125- 2200µS/cm	
	Dissolved oxygen	• Lowland Rivers - 85 - 110% • Estuaries - 80 - 100%	
	pH	• Lowland Rivers - 6.5 - 8.5 • Estuaries - 7.0 - 8.5	
	Chemical contaminants or toxicants	As per table 3.4.1 ANZECC/ ARMCANZ (2000) and ANZG (2018)	
	Temperature	As per table 3.3.1 ANZECC/ ARMCANZ (2000)	

Water quality objective	Indicators	Associated trigger values or criteria	Potential construction impacts
Visual amenity			
Maintaining the aesthetic quality of waters	Visual clarity and colour	• Natural visual clarity should not be reduced by more than 20%. • Natural hue of the water should not be changed by more than 10 points on the Munsell Scale. • The natural reflectance of the water should not be changed by more than 50%.	With the implementation of management measures, pollutant loading to the receiving waterways would be low with the possibly of better quality where existing water quality does not meet the ANZG (2018) guidelines. Therefore, there would be no impacts to the aquatic ecosystems of receiving waterways as a result of the construction works.
	Surface films and debris	• Oils and petrochemicals should not be noticeable as a visible film on the water, nor should they be detectable by odour. • Waters should be free from floating debris and litter.	
	Nuisance organisms	• Macrophytes, phytoplankton scums, filamentous algal mats, blue-green algae, sewage fungus and leeches should not be present in unsightly amounts.	

Primary contact recreation			
Maintaining or improving water quality for activities such as swimming in which there is a high probability of water being swallowed	Turbidity	• A 200 millimetre diameter black disc should be able to be sighted horizontally from a distance of more than 1.6 metres (approximately 6 NTU).	With the implementation of management measures, pollutant loading to the receiving waterways would be low and possibly of better quality where existing water quality does not meet the NHMRC (2008) guidelines. Primary contact recreation is not currently undertaken in the downstream waterways and watercourses, excepting White Bay, Parramatta River and Sydney harbour as outlined in Table 3-1. Construction works would not reduce the ability for the waterways to be used for primary contact recreation in the future.

	Enterococci	NHMRC (2008) microbial assessment based on 95th percentile of enterococci (cfu/100 mL): • Category A – Less than 40. No illness seen in most epidemiological studies • Category B – Between 41-200. Upper level is above the threshold of illness transmission reported in most studies. • Category C – Between 201-500. Represents a substantial elevation in the probability of adverse health outcomes. • Category D – Greater than 500. Above this level there may be a significant risk of high levels of illness transmission. ANZECC 2000 guidelines recommend: • Median over bathing season of < 35 enterococci per 100 mL (maximum number in any one sample: 60-100 organisms/100 mL).	
	Protozoans	Pathogenic free-living protozoans should be absent from bodies of fresh water. (Note, it is not necessary to analyse water for these pathogens unless temperature is greater than 24 degrees Celsius).	
	Algae & blue-green algae	NHMRC (2008) suitability for coastal and estuarine recreational water bodies should not contain: • ≥ 10 cells/mL *Karenia brevis* and/or have *Lyngbya majuscula* and/or *Pfiesteria* present in high numbers	
	pH	6.5-8.5	

	Temperature	16°-34 degrees Celsius	
	Chemical Contaminants	Waters containing chemicals that are either toxic or irritating to the skin or mucus membranes are unsuitable for recreation. Toxic substances should not exceed the concentrations provided in tables 5.2.3 and 5.2.4 of the ANZG (2018).	

Secondary contact recreation			
Maintaining or improving water quality for activities such as boating and wading, where there is a low probability of water being swallowed	Enterococci	Median bacterial content in fresh and marine waters of < 230 enterococci per 100 mL (maximum number in any one sample: 450-700 organisms/100 mL).	With the implementation of management measures, pollutant loading to the receiving waterways would be low with the possibility of better quality where existing water quality does not meet the NHMRC (2008) guidelines. Therefore, there would be no impacts to the aquatic ecosystems of receiving waterways as a result of the construction works.
	Algae & blue-green algae	< 15 000 cells/mL	
	Nuisance organisms	Large numbers of midges and aquatic worms are undesirable.	
	Chemical contaminants	Waters containing chemicals that are either toxic or irritating to the skin or mucous membranes are unsuitable for recreation. Toxic substances should not exceed values in tables 5.2.3 and 5.2.4 of the ANZECC 2000 Guidelines.	

Aquatic foods (cooked)			
Protecting water quality so that it is suitable for the production of aquatic foods for human consumption and aquaculture activities.	Algae & blue-green algae	No guideline is directly applicable, but toxins present in blue-green algae may accumulate in other aquatic organisms.	With the implementation of management measures, pollutant loading to the receiving waterways would be low with the possibly of better quality where existing water quality does not meet the ANZECC/ARMCANZ (2000) and ANZG (2018) guidelines. Note: At the time of developing the catchment water quality objectives, consumption of aquatic foods was nominated for protection. However due to contamination, particularly dioxins, current recommendations by the Department of Primary Industries is that no fish or crustaceans caught west of the Sydney Harbour Bridge should be eaten (Department of Primary Industries, n.d.).
	Faecal coliforms	Guideline in water for shellfish: The median faecal coliform concentration should not exceed 14 MPN/100mL; with no more than 10% of the samples exceeding 43 MPN/100 mL. Standard in edible tissue: Fish destined for human consumption should not exceed a limit of 2.3 MPN E Coli /g of flesh with a standard plate count of 100,000 organisms /g.	
	Toxicants	Metals: • Copper: less than 5µgm/L • Mercury: less than 1µgm/L • Zinc: less than 5µgm/L Organochlorines: • Chlordane: less than 0.004 µgm/L (saltwater production) • PCB's: less than 2 µgm/L	
	Physio-chemical indicators	Suspended solids: less than 40 micrograms per litre for saltwater production and less than 75 micrograms per litre for Brackish conditions. Temperature: less than 2 degrees Celsius change over one hour.	

6.1.4 Erosion and sedimentation

This proposal would require minor earthwork activities which could expose the ground/soils at station sites and the Clyde stabling and maintenance facility construction site which would include construction of the permanent station structures, fit out, above ground station facilities and the surrounding precincts. Works would also include installation, testing and commissioning of tunnel systems required to support the metro train operations. Some construction sites would require activities that may pose a higher risk of impact to water quality, including:

- Additional construction footprint areas (Sydney Olympic Park metro station, Westmead metro station, North Strathfield metro station and The Bays Station) – additional construction footprints at these locations would require additional clearing and exposure of soils including in areas adjacent to existing Sydney Trains stations and inside the operational rail corridor
- Select material placement and large areas of exposed soil (Clyde stabling and maintenance facility and Rosehill services facility)
- Additional earthwork activity (Sydney Olympic Park metro station, The Bays Station) – bulk earthworks and leveling of station sites would be required at Sydney Olympic Park metro station. Work at The Bays Station would include additional earthworks associated with public domain works including landscaping, road alignment and drainage infrastructure.

The earthwork activities described above and those in Table 5-1 may lead to export of sediment and the potential for increased erosion within and around waterways and slopes in these areas. These risks would be ongoing throughout the construction phase and would be highest at locations with a slope of greater than 2.5 per cent, that are near to waterways and frequently disturbed, and during high rainfall and wind activities. The construction sites with these slope characteristics include the Clyde stabling and maintenance facility construction site, North Strathfield metro station construction sites and The Bays Station construction site.

By increasing the amount of disturbed and exposed soil, surface water quality may be impacted through:

- Changes to surface water run-off due to clearing vegetation coverage. This may increase run-off volumes at both the temporary and long-term term scale
- Increased surface water run-off due to soil stabilisation earthworks. Soil stabilisation may result in change to the permeability of the natural soils
- Increased turbidity, lowered dissolved oxygen levels and increased nutrients in waterways
- Reduction in channel habitat from sediment transport and deposition.

Erosion and sediment control would focus on areas of surface disturbance, particularly near waterways including Clyde stabling and maintenance facility construction site, Sydney Olympic Park metro station construction site and The Bays Station construction site. These impacts would be adequately managed through the implementation of standard mitigation measures including progressive erosion and sediment controls, and on site management protocols within the Construction Environmental Management Framework. These controls would be used to manage and minimise risks of impacts to water quality.

6.1.5 Stockpiling and spoil handling

The construction of this proposal would generate minor amounts of spoil and other wastes, including vegetation, general construction and demolition waste and potentially excess spoil from excavations and earthworks, which would be temporarily stored in stockpiles. Through sediment movement, stockpiling of materials poses a risk to the water quality of receiving environments. This can impact the receiving aquatic environment through increased biological oxygen demand which may in turn decrease available dissolved oxygen, reduce visibility and light penetration and change the pH of receiving waters.

As described above, earthwork activities at Sydney Olympic Park metro station, Clyde stabling and maintenance facility and The Bays station may produce greater quantities of spoil and stockpiling of earthwork materials, potentially posing a greater impact to water quality. Spoil and other wastes would be minimised and reused where possible. Appropriate management measures including sediment fences, division drains and locating stockpiles away from surface water runoff, where practical, would be implemented to mitigate the impact of sediment movement.

6.1.6 Potential for spills and litter

The following activities may result in release of contaminants, oils, fuels, grease, chemicals and gross pollutants (including heavy metals, hydrocarbons and volatile organic compounds (VOCs)) into the waterways in and surrounding this proposal:

- Machinery and equipment operation, refuelling, maintenance and wash down
- Spills and failure of machinery
- Concrete batching, treatment and curing
- Disturbance of contaminated soils
- Inadequate management of chemicals, spoil, material stockpiles and litter from construction sites
- Litter generating activities from staff at office and construction areas.

Pollutants from these activities have the potential to impact the water quality of receiving waterways as contaminants are picked up in runoff and transported downstream. Mitigation and management measures would be implemented to reduce the potential release of chemicals from construction sites and into receiving waterways.

6.1.7 Cumulative impacts

Cumulative water quality impacts are not likely as the proposed construction site mitigation measures would be implemented and wastewater treated so that all discharges from the construction site would maintain the existing ambient water quality.

6.1.8 Construction water volumes

The table below outlines estimated daily water volumes for construction. It expected that water for construction will be sourced from a combination of potable and groundwater sources. Reusing groundwater will reduce the amount of treated water to be discharged from the construction water treatment plants at various sites. Information for the development of this table has been based on water use from prior Sydney Metro projects.

Table 6-4 Estimated construction water requirements

Activity	Quantity (kilolitres/day)	Water source
Site facilities	44	potable
Wheel washes	53	Reuse of groundwater supplemented by potable water where required
Dust suppression	168	Reuse of groundwater supplemented by potable water where required
Total	265	Reuse of groundwater supplemented by potable water where required

6.2 Water quality – operation

The operational phase of this proposal has the potential to impact and degrade the water quality of receiving waterways through the discharge of polluted water flows or airborne contaminants (e.g. particulate matter). Contaminants of concern during this phase include:

- Suspended and dissolved compounds in rainwater flows from impervious areas
- Gross pollutants such as litter from stations and ancillary facilities
- Chemical pollutants from trains along the line.

The most likely source of pollutants would be the concentrated flows resulting from newly impervious surfaces such as roofs and paved areas which can cause impacts to water quality of receiving waterways through increased pollutant loading and runoff volumes. Maintenance activities have the potential to generate considerable volumes of chemical pollutants, particularly at ancillary facilities such as the Clyde stabling and maintenance facility. Additionally, an increase in pedestrian and vehicle traffic would lead to increased pollution risk.

While it was noted in Section 4 of this report that the quality of the existing environment is heavily urbanised and, therefore, degraded, further impacts as a result of the operational phase may degrade the water quality further if appropriate mitigation and management measures are not implemented.

6.2.1 Water quality treatment

During the operation phase of this proposal, a water treatment plant would be located at the dive portal near the Clyde stabling and maintenance facility. This water treatment plant would treat the wastewater and groundwater ingress pumped from the stations, tunnels and other below ground facilities. The water treatment plant building would include chemical treatment tanks, water storage tanks, and filters which would be configured so that treated water does not negatively impact the water quality of the receiving waterbody. Discharges from the wastewater treatment plant would be monitored to achieve compliance with the discharge criteria and the performance outcomes outlined in Section 7.2, so that ambient water quality is not negatively impacted. As such, the impacts on the water quality of the receiving waterbodies, which include Duck Creek and A'Becketts Creek, would be negligible.

The wastewater treatment plants would be configured so that treated water is compliant with the NSW Water Quality and River Flow Objectives and ANZG guideline values, which would either maintain or improve the water quality waterways and the marine environment. Monitoring during the operation phase would be carried out to show compliance with the discharge criteria and, as such, the impacts on the water quality of the catchment would be negligible.

6.2.2 Stations and ancillary facilities

Station sites would, in some locations, result in increased impervious surfaces (station entrances public domain areas etc.) and increased vehicle and pedestrian traffic once operational. The change from a pervious to impervious environment would affect the type and volume of pollutants. Pollutants including litter, oil, sediments and chemicals from station cleaning activities and an increase in pedestrian traffic can impact waterways and the water quality if discharged into the environment.

Water Sensitive Urban Design features at stations and facilities would include gross pollutant traps, filter pits, grassed swales and bioretention trenches and raingardens that would treat stormwater runoff to required levels prior to discharge into the environment. Following onsite treatment, collected stormwater runoff at each station site and at the Rosehill services facility would be discharged into the local stormwater system, as identified in Table 6-2.

Maintenance activities such as the wash down and general maintenance of trains at the Clyde stabling and maintenance facility has the potential to generate pollutants. However, these activities would be carried out in covered buildings and wash down water would be collected in a separate system for treatment, thus avoiding any potential for such pollutants to enter the local drainage system.

6.2.3 Underground infrastructure

Existing groundwater could be mobilised by groundwater drawdown as a result of excavations associated with the tunnels, stations and ancillary infrastructure. Groundwater ingress to excavation voids along the alignment may be contaminated with heavy metals, hydrocarbons including total recoverable hydrocarbons (TRH), benzene, toluene, ethyl benzene and xylene (BTEX), polycyclic aromatic hydrocarbons (PAH), chlorinated hydrocarbons, volatile organic compounds (VOC) and phenol. It is estimated on average that during the operation of this proposal 584 kilolitres per day of groundwater would be collected as a result groundwater ingress and treated at the Clyde stabling and maintenance facility prior to discharge.

Underground sections of this proposal present a low risk of runoff given they are covered, and stormwater is captured at the station entrances and tunnel portals. However, pollutants like brake dust particulate matter, and hydrocarbons from operational activities in the tunnels may be generated and collected in the tunnel drainage system. Water captured as a result of stormwater entering the tunnel portal or ingress of contaminated groundwater would be pumped and treated at the water treatment plant at the Clyde stabling and maintenance facility before being discharged.

6.2.4 Erosion and sedimentation

During operation of this proposal, there remains the potential for erosion in recently disturbed areas. This risk would be higher during initial periods of landscaping and re-establishment of vegetation, particularly where soft landscaping is proposed, including open areas at station entrances and plazas, adjacent to disturbed areas and in areas where topsoil is settling, and vegetation is establishing. The majority of stations would undergo landscaping in and around the station precincts which present the greatest risk of sediment loads entering waterways through the stormwater system. Soil stabilisation work may be required at these stations following construction activities and severe storms, to prevent further erosion, topsoil loss or soil mitigation. Measures to manage erosion would be included in the Operational Environmental Management Plan.

6.2.5 Impacts on NSW Water Quality Objectives

During the operation phase of this proposal, the Water Quality and River Flow Objectives (NSW Department of Environment, Climate Change and Water, 2006) and the ANZG (2018) trigger values, as outlined in Section 3.2 would be used as a guideline so discharged water either maintains or improves the water quality of surface waterways and the marine environment. This requirement has been included as a mitigation measure in Section 7.2.

6.2.6 Cumulative impacts

Cumulative water quality impacts are not likely as the proposed station and ancillary facility mitigation measures would be implemented and wastewater treated so that all discharges would maintain the existing water quality.

7 Management and mitigation measures

7.1 Approach to the management and mitigation

Mitigation and management measures are proposed where appropriate to limit flooding and water quality impacts of this proposal on surrounding properties, in addition to limiting the risk of flooding on the construction sites and throughout operation. These are provided in Table 7-1. Mitigation measures have been identified in relation to operation of this proposal which would employ best practice methodologies from relevant guidelines outlined in Section 2.5 and consistent with the policy outcomes of Section 2.3. Residual risks are discussed further in Section 7.5.

7.2 Mitigation measures

Environmental management for this proposal would be undertaken through the environmental management approach as detailed in Chapter 20 (Synthesis) of the Environmental Impact Statement.

Potential hydrology, flooding and water quality impacts during construction of this proposal would be managed in accordance with Sydney Metro's Construction Environmental Management Framework (CEMF) (refer to Appendix F (Construction Environmental Management Framework) of this Environmental Impact Statement). The CEMF includes the development and implementation of water quality, stormwater and flooding measures as part of the management plans.

Additional mitigation measures have been identified to manage both construction and operation site specific impacts and these measures are presented Table 7-1.

Table 7-1: Summary of potential impacts and management measures

Reference	Impact	Mitigation measure	Applicable location(s)	Phase
EIS-HF 1	Flood protection	As part of design development, including for drainage infrastructure, consideration would be given to the flood risk at all sites. Design development would include consideration of relevant best practice guidelines and include: • identification of measures to not worsen flood impacts on the community and on other property and infrastructure, up to and including the one per cent Annual Exceedance Probability (AEP) flood event • Metro tunnels and other critical infrastructure would be protected from the Probable Maximum Flood (PMF), or the one per cent AEP flood level with an allowance for freeboard of 0.5 metres (whichever is greater) • provide flood protection for the nominated station or facility entry threshold level. Flood protection would be integrated into the architectural/urban design strategy for this proposal. Not worsen is defined as: • a maximum increase in flood levels of 50mm in a one per cent AEP flood event • a maximum increase in time of inundation of one hour in a one per cent AEP flood event • no increase in potential soil erosion and scouring from any increase in flow velocity in a one per cent AEP flood event.	All metro stations and facilities	Operations

Reference	Impact	Mitigation measure	Applicable location(s)	Phase
EIS-HF 2	Emergency management arrangements	Emergency management arrangements would be developed to manage flood risks to people and vehicles accessing stations and ancillary facilities. Egress arrangements would consider flood hazard in nearby streets particularly where active flood measures are employed. They would be designed so that the inclusion of flood barriers at relevant access points does not interfere with the egress strategy. Emergency management arrangements would also be integrated across this proposal and consider such matters as the relative degree of isolation of stations or ancillary facilities due to inundation by floodwaters.	All metro stations and facilities	Operations
EIS-HF 3	Residual impacts during operations	Ongoing consultation would occur with State Emergency Services and relevant councils in relation to potential impacts to existing community emergency management arrangements for flooding.	Westmead metro station, Parramatta metro station, Sydney Olympic Park metro station, Pyrmont Station, Hunter Street Station (Sydney CBD)	Operations
EIS-HF 4	Flooding behaviour impacts	Detailed construction planning for The Bays Station construction site would aim to minimise changes to existing levels in relation to potential impacts on flood behaviour, along the north-western side of the site adjacent to low-lying property, to minimise reduction in floodplain storage and blockage to local overland flow paths.	The Bays Station construction site	Construction
EIS-SSWQ1	Stormwater design	Water quality measures such as gross pollutant traps, bio-retention swales and Water Sensitive Urban Design features would be investigated during design development and implemented where feasible and reasonable.	All metro stations and facilities	Operation

Reference	Impact	Mitigation measure	Applicable location(s)	Phase
EIS-SSWQ2	Wastewater discharge	The water treatment plant would be designed so that wastewater is treated during operation to a level that is compliant with the ANZG (2018) default guidelines for 95 per cent species protection and 99 per cent species protection for toxicants that bioaccumulate unless other discharge criteria are agreed with relevant authorities.	Clyde stabling and maintenance facility	Operation
EIS-SSWQ3	Water quality monitoring	A surface water monitoring program would be implemented to observe any changes in surface water quality associated with operation of this proposal and inform appropriate management responses. The program would be developed in consultation with the EPA and relevant councils. Monitoring would occur at all waterbodies with the potential to be impacted. Water quality monitoring of all discharges from the operational water quality treatment plant would be undertaken be undertaken to confirm the ANZG guideline water quality trigger values are met.	Clyde stabling and maintenance facility	Operation

7.3 Interactions between mitigation measures

Mitigation measures in other chapters that are relevant to the management of potential impacts are outlined in Chapter 18.4 (Sustainability, climate change and greenhouse gas) which addresses sustainability and climate change consideration, Chapter 18.5 (Waste management and resource use) which addresses groundwater quality during construction and operations, Chapter 17.14 (Biodiversity) which addresses biodiversity in Duck Creek associated with the rehabilitation strategy and Chapter 20 (Synthesis) of the Environmental Impact Statement.

Together, these measures would minimise the potential impacts of this proposal. There are no mitigation measures identified in the assessment of other environmental aspects that are likely to affect the assessment of hydrology, flooding and water quality impacts.

7.4 Performance outcomes

Performance outcomes for Sydney Metro West were established as part of the concept assessment in the Sydney Metro West Environmental Impact Statement – Westmead to The Bays and Sydney CBD (Sydney Metro, 2020). The performance outcomes related to hydrology, flooding and water quality associated with this proposal are summarised in Table 7-2 below.

Table 7-2: Summary of hydrology, flooding and water quality performance outcomes

Operational performance outcomes	Construction performance outcomes
• The water quality criteria for water discharge, determined in consultation with NSW Environment Protection Authority, is met	• The discharge water quality requirements outlined in applicable environment protection licence(s) are met • Existing water quality of receiving surface watercourses is maintained
• Increases in flood levels are minimised, particularly within private properties, during events up to and including the one per cent annual exceedance probability • No additional private properties are affected by flood events up to and including the 1% annual exceedance probability • The potential for soil erosion and scouring is minimised for events up to and including a 1% annual exceedance probability event • Dedicated evacuation routes are not impacted in flood events up to and including the probable maximum flood • The performance of the downstream drainage network is maintained.	• Dedicated evacuation routes are not impacted in flood events up to and including the probable maximum flood.

Further detail regarding how this proposal would achieve the performance outcomes is provided in Chapter 20 (Synthesis) of the Environmental Impact Statement.

7.5 Residual impacts

Localised changes to overland flows associated with this proposal are generally limited in their scale to the immediate vicinity of this proposal's construction sites. Potential flooding and stormwater impact during construction and operation of this proposal have generally been addressed by the inclusion of mitigation measures to address issues that have arisen during the progression of design development along with the implementation of a Construction Environmental Management Framework.

Parramatta metro station is the exception as the residual flooding impacts of the PMF event are not limited to the immediate vicinity of the site during construction and would persist into operations.

Application of appropriate design standards and industry best practice, as well as mitigation measures throughout the life of the construction and operation of this proposal, would minimise impacts to the receiving waterbodies around this proposal.

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