NSW GOVERNMENT

Roads and Maritime Services

F6 Extension Stage 1

New M5 Motorway at Arncliffe to President Avenue at Kogarah

Environmental Impact Statement

Appendix L
Surface Water Technical Report

L

Volume 7

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Contents

Glossary of terms and abbreviations

Term	Definition
A	
Acid Sulfate Soils (ASS)	Naturally occurring soils, sediments or organic substrates (e.g. peat) that are formed under waterlogged conditions. These soils contain iron sulfide minerals (predominantly as the mineral pyrite) or their oxidation products. In an undisturbed state below the water table, acid sulfate soils are benign. However, if the soils are drained, excavated or exposed to air by a lowering of the water table, the sulfides react with oxygen to form sulfuric acid.
AEP	Annual Exceedance Probability
AHD	Australian Height Datum. The standard reference level used to express the relative height of various features. A height given in metres AHD is the height above sea level. Mean sea level is set as zero metres elevation.
Alluvial	Relating to, consisting of, or formed by sediment deposited by flowing water.
Alluvial material (alluvium)	Relatively recent deposits of sedimentary material within river/creek beds, floodplains, lakes or at the base of mountain slopes.
ANZECC	Australian and New Zealand Environment and Conservation Council.
Aquatic ecology	Flora and fauna that live in or on water for all or a substantial part of the life span (generally restricted to fresh/inland waters).
Aquifer	A groundwater bearing formation sufficiently permeable to transmit and yield groundwater or water bearing rock.
ARI	Average recurrence interval. An indicator used to describe the frequency of floods. The average period in years between the occurrences of a flood of a particular magnitude or greater. In a long period of say 1,000 years, a flood equivalent to or greater than a 100 year ARI event would occur 10 times. The 100 year ARI flood has a one per cent chance (i.e. a one-in-100 chance) of occurrence in any one year. Floods generated by runoff from the study catchments are referred to in terms of their ARI, for example the 100 year ARI flood.
B	
Batter	The constructed side slope of road embankments and cuttings usually expressed as a ratio of horizontal distance to a vertical height value of one e.g. 2H: 1V. A fill batter is where the road is above the existing surface on a filled embankment and refers to the sloping sides of the embankment. A cut batter is where the road is below the existing surface.
Bayside Council	The amalgamation of the former local government areas of Rockdale and Botany Bay proclaimed on 9 September 2016.
BBWQIP	Botany Bay and Catchment Water Quality Improvement Program.
Bedrock	Rock of a substantial thickness and extent underlying a relatively soft and variable surface.
Bioretention	Treatment process involving retention and filtration of stormwater through a filter media to remove contaminants and sediments.
BOD	Biological Oxygen Demand.
Box culvert	A culvert of rectangular cross section.
Bund	A small embankment designed to retain water.
C	
Catchment	The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
CEMP	Construction Environmental Management Plan. A site specific plan developed for the construction phase of the project to ensure that all contractors and sub-contractors comply with the environmental conditions of approval for the project and that the environmental risks are properly managed.

Term	Definition
Concept design	Initial functional layout of a road/road system or other infrastructure. Used to facilitate understanding of a project, establish feasibility and provide basis for estimating and to determine further investigations needed for detailed design.
Confluence	A point at which streams combine.
Construction ancillary facilities	Temporary facilities during construction that include, but are not limited to construction sites (civil and tunnel), sediment basins, temporary water treatment plants, pre-cast yards and material stockpiles, laydown areas, parking, maintenance workshops and offices.
CSWMP	Construction Soil and Water Management Plan.
CRC	Cooperative Research Centre.
Cul-de-sac	A street or road that is open for vehicular traffic at one end only.
Culvert	An enclosed channel for conveying water below a road.
Cumulative impacts	Impacts that, when considered together, have different and/or more substantial impacts than a single impact assessed on its own.
Cut-and-cover	A method of tunnel construction whereby the structure is built in an open excavation and subsequently covered.
Cutting	Formation resulting from the construction of the road below existing ground level, the material is cut out or excavated.
D	
DEC	NSW Department of Environment and Conservation (now OEH and the NSW EPA)
DECC	NSW Department of Environment and Climate Change (now OEH and the NSW EPA).
DECCW	NSW Department of Environment, Climate Change and Water (now OEH and the NSW EPA).
Detailed design	The phase of the project following concept design where the design is refined, and plans, specifications and estimates are produced. These typically include two dimensional and three dimensional models.
Dewatering	The removal of water from solid material or soil by wet classification, centrifugation, filtration or similar solid-liquid separation processes.
Discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving (e.g. metres per second [m/s]).
DLWC	NSW Department of Land and Water Conservation (now part of DPI).
DoP	NSW Department of Planning (now NSW Department of Planning and Environment).
DPE	NSW Department of Planning and Environment.
DP&I	NSW Department of Planning and Infrastructure (now NSW Department of Planning and Environment).
DPI	NSW Department of Primary Industries.
DPI (Water)	NSW Department of Primary Industries (Water), formerly the NSW Office of Water.
DPWS	NSW Department of Public Works and Services.
Drainage	Natural or artificial means for the interception and removal of surface or subsurface water.
Drawdown	Reduction in the height of the water table caused by changes in the local environment.
E	
Earthworks	All operations involved in loosening, excavating, placing, shaping and compacting soil or rock.
Ecosystem	A functional unit of energy transfer and nutrient cycling in a given place. It includes all relationships within the biotic community and between the biotic components of the system.
EIA	Effective Impervious Area.
EIS	Environmental Impact Statement.
Electrical conductivity	The measure of a material's ability to accommodate the transport of an electric charge.

Term	Definition
Embankment	An earthen structure where the road (or other infrastructure) subgrade level is above the natural surface.
Enabling works	Works which are required to enable the commencement of the main construction works.
Erosion	A natural process where wind or water detaches a soil particle and provides energy to move the particle.
Environmental assessment (process)	A specialised part of the decision-making process, where the environmental impact of a development or proposal or activity is considered in detail, together with other aspects of the development.
EP&A Act	Environmental Planning and Assessment Act 1979 NSW
EP&A Regulation	Environmental Planning and Assessment Regulation 2000 (NSW).
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth).
Ephemeral creek	A creek that only exists for a short duration of time following rainfall.
EPL	Environment Protection Licence under the Protection of the Environment Operations Act 1997 (NSW).
ESCP	Erosion and Sedimentation Control Plan.
F	
Feasible and reasonable	Consideration of best practice taking into account the benefit of proposed measures and their technological and associated operational application in the NSW and Australian context. 'Feasible' relates to engineering considerations and what is practical to build. 'Reasonable' relates to the application of judgement in arriving at a decision, taking into account mitigation benefits and cost of mitigation versus benefits provided, community expectations and nature and extent of potential improvements.
Fill	The material placed in an embankment.
Floodplain	Area of land which is inundated by floods up to and including the probable maximum flood event (i.e. flood prone land).
FM Act	Fisheries Management Act 1994 (NSW).
Footprint	The extent of direct impact that a development makes on the land.
FBA	Framework for Biodiversity Assessment
G	
Geomorphology	The study of shaping of the landscape by water, wind and other processes. Commonly used to describe the condition of streams as they are shaped by erosion and/or accretion of sediments.
GIS	Geographical Information System.
GPT	Gross pollutant trap.
Grade	Rate of longitudinal rise (or fall) with respect to the horizontal expressed as a percentage or ratio.
Groundwater	Water that is held in the rocks and soil beneath the earth's surface.
H	
ha	Hectare(s).
Hazard	A source of potential harm or a situation with a potential to cause loss of human life or damage to physical assets.
Habitat	The place where a species, population or ecological community lives (whether permanently, periodically or occasionally). Habitats are measurable and can be described by their flora and physical components.
Hydrology	The study of rainfall and surface water runoff processes.
I	
Impact	Influence or effect exerted by a project or other activity on the natural, built and community environment.

Term	Definition
Infiltration	The downward movement of water into soil and rock. It is largely governed by the structural condition of the soil, the nature of the soil surface (including presence of vegetation) and the antecedent moisture content of the soil.
Interchange	A grade separation of two or more roads with one or more interconnecting carriageways.
J	
K	
King Georges Road Interchange Upgrade	A component of the WestConnex program of works. Upgrade of the King Georges Road interchange between the M5 West and the M5 East at Beverly Hills, in preparation for the New M5 Motorway project (open to traffic).
kL	Kilolitres.
kL/day	Kilolitres per day.
km	Kilometres.
L	
L/s	Litres per second.
Leachate	Liquid that 'leaches' (drains) from a landfill.
LGA	Local government area.
M	
m	Metres
m/day	Metres per day
m^2	Square metres
m^3	Cubic metres
mg/L	Milligrams per litre
ML	Megalitres
ML/day	Megalitres per day
ML/year	Megalitres per year
M4 East	A component of the WestConnex program of works. Located from Homebush Bay Drive, Homebush to Parramatta Road and City West Link (Wattle Street) at Haberfield (under construction).
M4 Widening	A component of the WestConnex program of works. Located from Pitt Street, Parramatta to Homebush Bay Drive, Homebush (open to traffic).
M4-M5 Link	A component of the WestConnex program of works.
M5 East Motorway	Part of the M5 Motorway corridor. Located between Beverly Hills and Sydney Airport (General Holmes Drive).
M5 Motorway corridor	The M5 East Motorway and the M5 South West Motorway.
M5 South West Motorway	Part of the M5 Motorway corridor. Located between Prestons and Beverly Hills.
Mainline tunnels	Twin motorway tunnels (around three kilometres in length) between the New M5 Motorway at Arncliffe and President Avenue, Kogarah
MUS	Managing urban stormwater
Mean rainfall	The arithmetically averaged total amount of precipitation recorded during a calendar month or year.
Median	The central reservation which separates carriageways from traffic travelling in the opposite direction.
Methodology	The method for analysis and evaluation of the relevant subject matter.
microSiemens per centimetre (mS/cm)	A measure of electrical conductivity. Commonly used to measure the salinity of water.
Motorway	Fast, high volume controlled access roads. May be tolled or untolled.
MUSIC	Model for Urban Stormwater Improvement Conceptualisation.
N	

Term	Definition
New M5 Motorway	A component of the WestConnex program of works. Located from Kingsgrove to St Peters (under construction).
New M5 Motorway mainline tunnel stubs	Extensions of the New M5 Motorway mainline tunnel to a point underground at Arncliffe, being built as part of the New M5 Motorway project (to connect with the project).
New M5 Motorway mainline connection	The location where the project and the New M5 Motorway mainline tunnel stubs connect underground.
NSW EPA	NSW Environment Protection Authority.
NSW Water Quality and River Flow Objectives	The NSW Water Quality and River Flow Objectives (DECCW 2006) are consistent with the agreed national framework of the ANZECC Water Quality Guidelines and are primarily aimed at maintaining and improving water quality, for the purposes of supporting aquatic ecosystems, recreation and where applicable water supply and the production of aquatic foods suitable for consumption and aquaculture activities.
NSW RFOs	NSW River Flow Objectives. See also NSW Water Quality and River Flow Objectives.
NSW WQOs	NSW Water Quality Objectives. See also NSW Water Quality and River Flow Objectives.
NWQMS	National Water Quality Management Strategy.
O	
ODP	Operational discharge point
OEH	NSW Office of Environment and Heritage (formerly DECCW).
OEMP	Operational Environmental Management Plan
Off-ramp	A ramp by which one exits a limited-access highway/tunnel.
On-ramp	A ramp by which one enters a limited-access highway/tunnel.
Operational footprint	Areas to be directly impacted by the operational components of the project such as roadways, tunnels and associated facilities (e.g. motorway operations complex and ventilation facilities).
Outside shoulder	The area of pavement outside the traffic lanes that is closest to the 'slow' lane.
Overbridge	Bridge which conveys another road, rail or pedestrians over the described road.
P	
Parcel of land	Refers to an individual lot number (lot) and deposited plan (DP).
Pavement	The portion of a carriageway placed above the subgrade for the support of, and to form a running surface for vehicular traffic.
pH	Numeric scale ranging from zero to 14 used to specify the acidity or alkalinity of an aqueous solution. Solutions with a pH less than seven are acidic and solutions with a pH greater than seven are alkaline. Pure water has a pH of seven and is neutral.
POEO Act	Protection of the Environment Operations Act 1997 (NSW)
Pollutant	Any measured concentration of solid or liquid matter that is not naturally present in the environment.
Portals	The locations where a tunnel meets a surface road.
Probability	A statistical measure of the expected chance or likelihood of occurrence.
Project	The project would comprise a new multi-lane road between the New M5 Motorway at Arncliffe and President Avenue at Kogarah. The project would connect underground with the New M5 Motorway tunnel and to a new surface level intersection at President Avenue.
Project footprint	The land required to construct and operate the project. This includes permanent operational infrastructure (including the tunnels), and land required temporarily for construction.
Proprietary stormwater treatment device	Pre-fabricated device designed for removal of pollutants from stormwater. These are usually installed underground and connected to the pipe drainage network.
Publicly available	Available for inspection in hard copy and/or electronic format by a member of the general public (for example available on the project website).
Q	
R	

Term	Definition
RCBC	Reinforced concrete box culvert.
Revegetation	To revegetate an area by direct seeding with non-native species or cover crops and / or native species using manual or mechanical means such as hydromulching, straw mulching and tractor seeding.
Riparian	The part of the landscape adjoining rivers and streams that has a direct influence on the water and aquatic ecosystems within them.
Rising main	A pipe through which water from a pump is delivered to an elevated location.
Roads and Maritime	NSW Roads and Maritime Services.
RTA	NSW Roads and Traffic Authority. Now NSW Roads and Maritime Services.
Rockdale ventilation facility	A ventilation facility located in the Roads and Maritime depot off West Botany Street, Rockdale
Runoff	The part of the rainfall on a catchment which flows as surface discharge past a specified point.
RWQ	Recreational water quality
S	
Scour	The erosion of material by the action of flowing water.
Secretary's Environmental Assessment Requirements (SEARs)	Requirements and specifications for an environmental assessment prepared by the Planning Secretary under section 115Y of the Environmental Planning and Assessment Act 1979 (NSW).
Sediment	Material, both mineral and organic, that is being or has been moved from its site of origin by the action of wind, water or gravity and comes to rest either above or below water level.
Sensitive receptor/ receiver – biophysical	Refers to land uses, landforms and biological organisms that are less resilient (i.e. cannot easily adapt to change) to impacts including vulnerable ecological communities, threatened species and habitats.
Sensitive receptor/ receiver – socio-economic	Refers to land uses that are less resilient to impacts (i.e. cannot easily adapt to change) including educational, religious or health care facilities such as (not exclusive) childcare, day care, schools, tertiary education facilities (TAFE, college or university); churches, mosques, temples; aged care facilities, hospitals, and clinics (excludes commercial pharmacies).
Sedimentation	Deposition of sediment usually by water.
Sedimentation basins	A stormwater detention system that promotes the settling of sediments trough the reduction of flow velocities and temporary detention. Key elements include purpose designed inlet and outlet structures, settling pond and high flow, overflow structures.
Shared cycle and pedestrian pathways	Part of the project, comprising pathways for pedestrians and cyclists connecting Bestic Street to Civic Avenue, Kogarah
SMCMA	Sydney Metropolitan Catchment Management Authority.
SMD	Slightly to moderately disturbed
Socio-economic	Involving combination of social and economic matters.
SPL	Species protection level
Spoil	Surplus excavated material.
Staging	Refers to the division of the project into multiple contract packages for construction purposes, and/or the construction or operation of the overall project in discrete sections.
Stockpile	Temporarily stored materials such as soil, sand, gravel and spoil/waste.
Strata	Geological layers below the ground surface.
Study Area	The area of investigation determined by each of the technical specialist disciplines for the individual EIS studies. It may include part, or all, of the project footprint, with possible additional buffer zones.
Surface water	Water flowing or held in streams, rivers and other wetlands in the landscape.
Swale	A shallow, grass-lined drainage channel.
T	

Term	Definition
Terrestrial	Living or growing on land (i.e. terrestrial flora or fauna).
The Blue Book	Managing Urban Stormwater – Soils and Construction Volumes 1 and 2, NSW Government 2004 and 2006.
Threatened	As defined under the Threatened Species Conservation Act 1995 (NSW), a species, population or ecological community that is likely to become extinct or is in immediate danger of extinction.
Toxicity	The degree of danger posed by a substance to human, animal or plant life.
TN	Total Nitrogen
TP	Total Phosphorus
TPH	Total Petroleum Hydrocarbon.
TSS	Total Suspended Solids
Transverse drainage	Existing drainage lines (typically) that cross linear infrastructure such as roads. Synonym: cross drainage.
Tributary	A river or stream flowing into a larger river or lake.
TRH	Total recoverable hydrocarbons.
TSS	Total Suspended Solids.
Tunnel portal	The entrance/exit to the tunnel.
Tunnel stub	Driven tunnels constructed to connect to potential future motorway links.
Turbidity	A measure of light penetration through a water column containing particles of matter in suspension.
U	
Urban design	The process and product of designing human settlements, and their supporting infrastructure, in urban and rural environments.
V	
Ventilation facility	Facility for the mechanical removal of air from the mainline tunnels, or mechanical introduction of air into the tunnels.
W	
WAL	Water access licence.
Water Act 1912	Water Act 1912 (NSW)
WM Act	Water Management Act 2000 (NSW).
Waterway	Any flowing stream of water, whether natural or artificially regulated (not necessarily permanent).
WestConnex program of works	A 33 kilometre motorway linking Sydney's west and south-west with Sydney Airport and the Port Botany precinct. It includes the M4 Widening, King Georges Road Interchange Upgrade, M4 East, New M5 Motorway and the M4-M5 Link projects.
Wetland	Wetlands are areas of land that are wet by surface water or groundwater, or both, for long enough periods that the plants and animals in them are adapted to, and depend on, moist conditions for at least part of their lifecycle. They include areas that are inundated cyclically, intermittently or permanently with fresh, brackish or saline water, which is generally still or slow moving except in distributary channels such as tidal creeks which may have higher peak flows. Wetlands may be constructed for the purposes of removing pollutants from runoff.
WQPMP	Water Quality Plan and Monitoring Program.
WSUD	Water sensitive urban design.
X	
Y	
Z	

Executive summary

Introduction

NSW Roads and Maritime Services (Roads and Maritime) is seeking approval to construct and operate a new multi-lane road between the New M5 Motorway at Arncliffe and President Avenue at Kogarah.

This technical report presents the assessment of potential impacts on surface water quality, hydrology and geomorphology during construction and operation of the project. An assessment of potential flooding impacts associated with the project is presented in EIS **Appendix M** (Flooding technical report).

The project is located within the Bayside local government area about eight kilometres south west of the Sydney central business district. Project activities that would impact existing surface water resources would be undertaken within the Cooks River, Muddy Creek and Scarborough Ponds catchments, all of which form part of the greater catchment draining to Botany Bay. The catchments are highly urbanised and the waterways are typically highly modified and hard lined channels, with the exception of Scarborough Ponds which although highly modified comprises a chain of pond systems with relatively higher amenity value and habitat potential. Based on available data, existing water quality in all waterways is indicative of highly disturbed urbanised catchments.

Potential impacts

Construction impacts

During construction, the potential surface water quality, hydrology and geomorphology impacts would be associated with:

- Erosion of soils, sedimentation of waterways and exposure of contaminated soils, groundwater or acid sulfate soils
- Accidental leaks or spills of chemicals, fuels and oils from construction plant
- Direct disturbance of waterbodies, waterway beds and riparian areas, or increased scour due to increased discharge flow rates and volumes
- Discharge of poorly treated water during construction, which could potentially impact on water quality of receiving waterways.

The largest potential for adverse impacts relates to the disturbance of Rockdale Bicentennial Park Pond, and a range of specific measures, including design features, construction methods and monitoring, are proposed to minimise impacts at this location. These are described further below. Other potential impacts on surface water quality, hydrology and geomorphology during construction of the project are generally considered minor and manageable with the application of industry standard mitigation measures.

Operational impacts

During operation, potential surface water quality, hydrology and geomorphology impacts would be associated with:

- Discharges of treated tunnel wastewater
- Increases in impervious surfaces generating increased runoff and pollutant loads
- Accidental spills or leaks of fuels and/or oils from vehicle accidents or from operational plant and equipment
- Erosion of vegetated surfaces
- Scour at outlets to waterways.

The potential for additional cumulative impacts occurs due to the large number of infrastructure and development projects being undertaken within or in close proximity to the study area, including the WestConnex program of works (roads), Sydney Gateway (road), Sydney Metro (rail), future stages of the F6 Extension (road), Muddy Creek naturalisation (waterway) and local urban development. However, additional adverse surface water impacts are considered unlikely due to the cumulative impact of these projects.

Management of potential impacts

Construction phase

The Construction Environmental Management Plan (CEMP) will control potential surface water quality impacts during construction. A construction soil and water management plan including a water quality monitoring program will be prepared as part of the CEMP. Surface water runoff during construction will be managed in accordance with standard soil and water management practices, with a focus on erosion and sediment control, for major construction sites. Potentially contaminated water sourced primarily from groundwater ingress to the excavations will be collected and treated, prior to discharge to Muddy Creek and the Cooks River. Discharge criteria based on protection of the receiving waterways has been developed in accordance with relevant guidance and with consideration of the existing condition of and relevant objectives for these waterways, to inform design of the required water treatment plants.

Discharges of treated construction water would not have an impact on the geomorphology of affected waterways due to the proposed location of discharges and their relatively low volume compared to existing flow regimes. Specific localised mitigation measures are proposed to limit discharges into Scarborough Ponds, given the relatively higher sensitivity of this waterway than Muddy Creek, and where outlet scour protection and energy dissipation is required prior to release.

Works within or adjacent to waterways would be managed in accordance with the *Controlled Activities on Waterfront Land guidelines* (NSW Department of Primary Industries (DPI) 2012). Specific measures to manage short-term impacts associated with the construction of tunnels through Rockdale Bicentennial Park Pond via cut and cover methods include use of temporary barriers to isolate the work zone and prevent transport of sediment and pollutants from the construction zone into adjacent areas, and installation of a temporary diversion system to maintain hydrologic connectivity through the Pond throughout construction. Monitoring and an independent investigation will be undertaken after the restoration of the Pond to confirm that restoration works are undertaken appropriately.

Operational phase

Potential impacts to surface water quality during operation of the project, associated with treated tunnel water discharges, stormwater discharges and spills, are able to be mitigated by the design and with application of the proposed management measures.

Stormwater quality treatment systems will be implemented at President Avenue and the operational ancillary facilities, and designed with consideration to relevant catchment and waterway management plans. The pollutant loads associated with increases in imperviousness would be managed through a range of stormwater treatment measures such as gross pollutant traps, bioretention systems, vegetated swales and proprietary treatment devices. The current project design has been shown to meet relevant pollutant load reduction targets; however opportunities for further improvements to surface water quality in the vicinity of President Avenue have been identified for further investigation during detailed design.

Tunnel water will be pumped to a new water treatment plant at Arncliffe for treatment prior to discharge to the Cooks River. Assessment of the likely impact of the proposed discharge of treated water to the Cooks River shows that the adopted discharge criteria, consistent with the adjacent New M5 Motorway water treatment plant is suitable for the receiving waterway. Discharge volumes would also result in an insignificant increase in baseflows in the Cooks River and as such impacts to geomorphology are negligible.

Spill containment facilities will be provided at President Avenue and the tunnel sump. Spill management and emergency response procedures will also be documented in an Operational Environmental Management Plan (OEMP).

New discharge outlets would be designed with appropriate energy dissipation and scour protection measures.

Cumulative impacts

Due to the low risk of potential adverse cumulative impacts, no specific measures are warranted provided the proposed construction and operational phase management measures are implemented, maintained and monitored.

Conclusion

The project has the potential to impact on the surface water environment as a result of construction and operation activities, due to altered hydrology within the catchment, as well as the discharge of treated groundwater. The implementation of management measures would reduce or manage these impacts to an appropriate level.

1 Introduction

The project would comprise a new multi-lane road between the New M5 Motorway at Arncliffe and President Avenue at Kogarah. The project would connect underground with the New M5 Motorway tunnel and to a new surface level intersection at President Avenue, Kogarah. The project would allow commuters to travel north on the New M5 Motorway to St Peters Interchange or the M4-M5 Link.

1.1 Overview of the project

Key components of the project would include:

- An underground connection to the existing stub tunnels at the New M5 Motorway at Arncliffe
- Twin motorway tunnels (around four kilometres in length) between the New M5 Motorway at Arncliffe and President Avenue, Kogarah
- A tunnel portal and entry and exit ramps connecting the tunnels to a surface intersection with President Avenue
- Intersection improvements at the President Avenue / Princes Highway intersection
- Mainline tunnel stubs to allow for connections to future stages of the F6 Extension
- Shared cycle and pedestrian pathways connecting Bestic Street, Rockdale to Civic Avenue, Kogarah via Rockdale Bicentennial Park (including an on-road cycleway)
- An Operational Motorway Control Centre to be located off West Botany Street, Rockdale
- Ancillary infrastructure and operational facilities for signage (including electronic signage), ventilation structures and systems at Rockdale, fire and safety systems, and emergency evacuation and smoke extraction infrastructure
- A proposed permanent power supply connection from the Ausgrid Canterbury subtransmission substation
- Temporary construction ancillary facilities and temporary works to facilitate the construction of the project.

Once complete, the F6 Extension Stage 1 would improve connections and travel times between Sydney and the Princes Highway and enhance connections for residents and businesses within the broader regional area as well as promote and support economic development in areas to the south, such as Sutherland and the Illawarra.

Approval for the project is being sought under Part 5, Division 5.2 of the EP&A Act. Future stages of the F6 Extension would be subject to separate planning applications and assessments would be undertaken accordingly.

The configuration and design of the project will be further developed to take into consideration the outcomes of community and stakeholder engagement.

1.2 Project location

This project would be generally located within the Bayside local government area. The project commences about 8 kilometres south west of the Sydney central business district (CBD). The proposed President Avenue intersection would be located about 11 kilometres south east of the Sydney CBD.

1.3 Purpose of this report

This report has been prepared to address the Secretary's Environmental Assessment Requirements (SEARs) in relation to hydrology and surface water quality, for the preparation of an EIS for the project. The report presents the state of the existing surface water environment as a baseline and then identifies the potential impacts that may arise from the construction and operation of the project and measures to manage the potential impacts.

1.4 SEARs and Agency comments

Table 1-1 SEARs – Surface Water

Assessment requirements	Where addressed in this report
Water - Hydrology	
1. The Proponent must describe (and map) the existing hydrological regime for any surface and groundwater resource (including reliance by users, for ecological purposes and groundwater dependent ecosystems) likely to be impacted by the project, including stream orders, as per the FBA.	Refer to section 4.1 for a description of the existing hydrological regime for surface water resources. Refer to Appendix K of the EIS (Groundwater Technical Report) for groundwater resources, groundwater dependent ecosystems. Refer to Appendix H of the EIS (Biodiversity Development Assessment Report) for stream orders and reliance on surface water and groundwater resources for ecological purposes.
2. The Proponent must prepare a detailed water balance for ground and surface water including the proposed intake and discharge locations (including mapping of these locations),	Refer to section 5.1 for construction surface water balance and section 6.1 for operation surface water balance. Refer to Appendix K of the EIS (Groundwater Technical Report) for groundwater balance.
3. The Proponent must assess (and model if appropriate) the impact of the construction and operation of the project and any ancillary facilities (both built elements and discharges) on surface and groundwater hydrology in accordance with the current guidelines, including:	See responses for (a) to (j) below.
(a) natural processes within rivers, wetlands, estuaries and floodplains that affect the health of the fluvial, riparian and estuarine systems and landscape health (such as modified discharge volumes, durations and velocities), aquatic connectivity, water-dependent fauna and flora and access to habitat for spawning and refuge	Refer to sections 5.2.1, 5.2.2 and 5.2.3 for impacts to geomorphic and hydrological processes associated with discharges and waterway disturbance during construction. Refer to sections 6.2.1 and 6.2.2 for impacts to geomorphic and hydrological processes associated with discharges during operation associated with discharges and waterway disturbance. Refer to Appendix M of the EIS (Flooding Technical Report) for durations and velocities. Refer to Appendix H of the EIS (Biodiversity Development Assessment Report) for impacts to riparian corridors, aquatic connectivity, water-dependent fauna and flora and access to habitat.
(b) Impacts from any permanent and temporary interruption of groundwater flow, including the extent of drawdown, change in ground water levels, barriers to flows, implications for groundwater dependent on surface flows, ecosystems and species, groundwater users and potential for settlement	Refer to Appendix K of the EIS (Groundwater Technical Report).
(c) Changes to environmental water availability and flows	Refer to sections 5.2.1, 5.2.2 and 5.2.3 for how construction discharges and waterway disturbance would affect water availability and flow during construction.
(d) Direct or indirect increases in erosion, siltation, destruction of aquatic and riparian vegetation or a reduction in the stability of river banks or watercourses;	Refer sections 5.2.1, 5.2.2 and 5.2.3 for erosion, scour, siltation and bank stability impacts associated with discharges and waterway disturbance during construction. Refer to sections 6.2.1 and 6.2.2 for scour impacts associated with discharges during operation. Refer to Appendix H of the EIS (Biodiversity Development Assessment Report) for impacts to riparian vegetation.

Assessment requirements	Where addressed in this report
(e) 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 the existing stormwater systems where discharges are proposed through such systems or modifications are proposed to these systems	Refer to sections 8.1 and 8.2 for how impacts to hydrological attributes will be managed during construction and operation. Refer to Appendix M of the EIS (Flooding Technical Report) for how impacts to conveyance capacity of existing stormwater systems will be managed.
(f) Measures to mitigate the impacts of the proposal and manage the disposal of produced and incidental water; and	Refer to sections 8.1 and 8.2 for how impacts will be managed including disposal of water during construction and operation. Refer to Appendix M of the EIS (Flooding Technical Report) for impacts to the conveyance capacity of existing stormwater systems and how this will be managed.
4. The assessment must provide details of the final landform of the sites to be excavated or modified (e.g. portals and cut and cover works), including final void management and rehabilitation measures.	Refer to EIS Chapter 13 for urban design context and associated landscape and visual impact assessment.
5. The proposed must identify any requirements for baseline monitoring of hydrological attributes	Refer to section 8.1.3.
6. The assessment must include details of proposed surface and groundwater monitoring	Refer to section 8.1.5 for surface water quality monitoring and section 8.1.3 for monitoring of water levels within Rockdale Bicentennial Park Pond. Refer to Appendix K of the EIS (Groundwater Technical Report) for groundwater monitoring.
Water - Quality	
1. The Proponent must:	
(a) Describe the background conditions for any surface or groundwater resource likely to be affected by the development	Refer to sections 4.1 and 4.2 for surface waters. Refer to Appendix M of the EIS (Groundwater Technical Report) for groundwater resources
(b) State the ambient NSW Water Quality Objectives (NSW WQO) (as endorsed by the NSW Government {see www.environment.nsw.gov.au/ieo/index.htm]) and environmental values for the receiving waters (including groundwater where appropriate) relevant to the project and that represent the community's uses and values for those receiving waters, including the indicators and trigger values or criteria for the identified environmental values in accordance with the ANZECC (2000) Guidelines for Fresh and Marine Water Quality and/or local objectives, criteria or targets endorsed by the NSW Government;	Refer section 3.1.2 for NSW WQOs and section 3.1.4 for Botany Bay Water Quality Improvement Plan targets.

Assessment requirements	Where addressed in this report
(c) Identify and estimate the quality and quantity of all pollutants that may be introduced in the water cycle by source and discharge point and describe the nature and degree of impact that any discharge(s) may have on the receiving environment, including consideration of all pollutants that pose a risk of non-trivial harm to human health and the environment	The quality and quantity of groundwater pollutants which make up the majority of pollutant load during construction and operation has been estimated in sections 5.3.2 and 6.3.3 respectively. It is not practical to estimate the quality and quantity of pollutants from other sources in the tunnel and in surface water during construction. Measures are proposed to manage the potential impacts. Refer to section 6.3.2 for the quantity of the key stormwater pollutants being discharged during operation. It is not practical to estimate the quality and quantity of other pollutants in stormwater. Measures are proposed to manage the potential impacts.
(d) Identify the rainfall event that the water quality protection measures would be designed to treat;	Specifying a rainfall event for operational stormwater treatment measures is not appropriate. Operational measures are designed based on meeting relevant pollutant load reduction targets. Construction measures will be designed in accordance with the Blue Book. Refer to sections 8.1 and 8.2.
(e) Assess the significance of any identified impacts including consideration of the relevant ambient water quality outcomes	Refer sections 5.3 and 6.3 for assessment of surface water quality impacts during construction and operation including consideration of ambient water quality.
(f) Demonstrate how construction and operation of the project (including mitigating effects of proposed stormwater and wastewater management) would, to the extent that the project can influence, ensure that: - Where the NSW WQOs for receiving waters are currently being met they would continue to be protected; and - Where the NSW WQOs for receiving waters are not currently met, activities would work toward their achievement over time;	Refer to sections 5.3 and 6.3 for assessment of surface water quality impacts and sections 5.3.4 and 6.3.5 for their influence on the NSW WQOs.
(g) justify if required, why the WQOs cannot be maintained or achieved over time;	Refer to sections 5.3.4 and 6.3.5.
(h) demonstrate that all practical measures to avoid or minimise water pollution and protect human health and the environment form harm are investigated and implemented;	Refer to section 1 for proposed management measures.
(i) identify sensitive receiving environments (which may include wetlands / estuarine waters upstream and downstream of the project including their catchments) and develop a strategy to avoid or minimise impacts on these environments; and	The sensitivity of the receiving and downstream environments is assessed in section 4.5. Refer to section 8 for proposed management measures. These measures are considered to adequately manage potential impacts. A dedicated strategy to avoid or minimise impacts is not considered to be required.
(j) identify proposed monitoring locations, monitoring frequency and indicators of surface and groundwater quality.	Refer to section 8.2.7.
2. The assessment should consider the results of any current water quality studies, as available, in the project catchment.	A summary of water quality information sourced during the project is provided in section 4.2. The findings were considered in the assessment.

Assessment requirements	Where addressed in this report
3. The assessment should include concept designs for water quality treatment structures taking into account water sensitive urban design principles.	Refer to sections 2.3, 8.2.1 and Annexure B.
Soils	
The Proponent must verify the risk of acid sulfate soils (Class 1, 2, 3 or 4 on the Acid Sulfate Soil Risk Map) within, and in the area likely to be impacted by, the project	Refer to Appendix J of the EIS (Contamination Technical Report).
The Proponent must assess the impact of the project on acid sulfate soils (including impacts of acidic runoff offsite) in accordance with the current guidelines and detail the mitigation measures proposed to minimise impacts.	Refer to Appendix J of the EIS (Contamination Technical Report).
The Proponent must assess whether the land is likely to be contaminated and identify if remediation of the land is required, having regard to the ecological and human health risks posed by the contamination in the context of past, existing and future land uses. Where assessment and/or remediation is required, the Proponent must document how the assessment and/or remediation would be undertaken in accordance with current guidelines.	Refer to Appendix J of the EIS (Contamination Technical Report).
A baseline contamination assessment must be undertaken for filled land in the vicinity of the proposed cut and cover works near President Avenue. The Proponent must provide details of contamination characteristics and measures to manage this spoil, including spoil stockpile management, transport and disposal to avoid adverse impacts to land, water quality and sensitive receptors.	Refer to Appendix J of the EIS (Contamination Technical Report).
The Proponent must assess whether salinity is likely to be an issue and if so, determine the presence, extent and severity of soil salinity within the project area	Refer to sections 4.7 and 5.4.
The Proponent must assess the impacts of the project on soil salinity and how it may affect groundwater resources, hydrology and vegetation	Refer to sections 4.7 and 5.4 for impacts on soil salinity and impacts to hydrology. Refer to Appendix K of the EIS (Groundwater Technical Report) for impacts to groundwater. Refer to Appendix H of the EIS (Biodiversity Development Assessment Report) for impacts to vegetation.
The Proponent must assess the impacts on soil and land resources (including erosion risk or hazard). Particular attention must be given to soil erosion and sediment transport consistent with the practices and principles in the current guidelines	Refer to sections 4.7, 5.2.1, 5.2.3, 5.3.3, 5.4, 6.2 , 8.1.1 and 8.1.2
The Proponent must assess the impact of any disturbance of contaminated groundwater and the tunnels should be carefully designed so as not to exacerbate mobilisation of contaminated groundwater and/or prevent contaminated groundwater flow.	Refer to Appendix K of the EIS (Groundwater Technical Report).

Table 1-2 Agency comments – Surface Water

Agency	Agency comments	Where addressed in this report
DPI	The assessment of aquatic habitats must include opportunities for improvement including measures to reduce the potential for de-oxygenation of and increased nutrient inputs to waters and measures to control aquatic weeds within the Rockdale wetlands, both during construction and operation of facility.	Refer to section 6.3.2 and 8.2.2 for water quality improvements opportunities.
	The Proponent must provide full technical details and data for all surface and groundwater conceptual models and detailed quantitative modelling.	Refer to Annexure C and D for surface water modelling
	The Proponent must prepare a detailed water balance for ground and surface water including the proposed intake and discharge locations (including mapping of these locations), volume, frequency and duration for both the construction and operational phases of the project, and identify an adequate and secure water supply for the life of the project.	Refer to section 5.1 for construction surface water balance and section 6.1 for operation surface water balance. Refer to Appendix K of the EIS (Groundwater Technical Report) for groundwater balance.
	The Proponent must assess (and model if appropriate) the impact of the construction and operation of the project and any ancillary facilities (both built elements and discharges) on surface and groundwater hydrology in accordance with the current guidelines, including impacts from any permanent and temporary interruption of groundwater flow, including the extent of drawdown, change in ground water levels, barriers to flows, implications for groundwater dependent on surface flows, ecosystems and species, groundwater users and the potential for settlement. Impacts should be determined using a detailed groundwater model based on adequate baseline data (12 months minimum) and aquifer investigation including pump testing in high yield areas and packer testing, and monitoring across the entire F6 extension corridor.	Refer to Appendix K of the EIS (Groundwater Technical Report).
	The assessment must include details of proposed surface and groundwater monitoring for the life of the project, including a minimum of 12 months baseline monitoring. Long-term monitoring bores should be located to allow ongoing monitoring following completion of construction.	Refer to section 8.1.5 for surface water quality monitoring and section 8.1.3 for monitoring of water levels within Rockdale Bicentennial Park Pond. Refer to Appendix K of the EIS (Groundwater Technical Report) for groundwater monitoring.
Sydney Water	The proponent must obtain endorsement and/or approval from Sydney Water to ensure that the proposed project does not adversely impact on any existing water, wastewater or stormwater assets, or other Sydney Water asset, including any easement or property.	Refer to EIS Chapter 14 for how the project will affect and manage existing assets.
	Strict requirements for Sydney Water's stormwater assets (for certain types of development) may apply to this project. The proponent should ensure that satisfactory steps/measures been taken to protect existing stormwater assets, such as avoiding building over and/or adjacent to stormwater assets and building bridges over stormwater assets. The proponent should consider taking measures to minimise or eliminate potential flooding, degradation of water quality, and avoid adverse impacts on any heritage items	Refer to sections 5.3, 6.3 and 8 for water quality. Refer to Appendix M of the EIS (Flooding Technical Report) for flooding. Refer to EIS Chapter 14 for how the project will affect and manage existing assets.

1.5 Structure of this report

This technical report is structured as follows:

- **Section 1 – Introduction** – This chapter provides a brief overview of the outlines the project and presents the purpose of this report
- **Section 2 – The project** – This chapter provides an overview of the project
- **Section 3 – Assessment methodology** – This chapter describes the methodology employed for the Surface water technical report
- **Section 4 – Existing environment** – This chapter describes the surface water study area and its existing surface water conditions
- **Section 5 – Assessment of construction impacts** – This chapter describes the potential impacts on surface water resulting from the project during construction
- **Section 6 – Assessment of operational impacts** – This chapter describes the potential impacts to surface water resulting from the project during operation
- **Section 7 – Assessment of cumulative impacts** – This chapter describes the potential cumulative impacts to surface water resulting from the project and other key developments
- **Section 8 – Mitigation and management** – This chapter provides a summary of environmental mitigation, management and monitoring responsibilities in relation surface water management for the project.

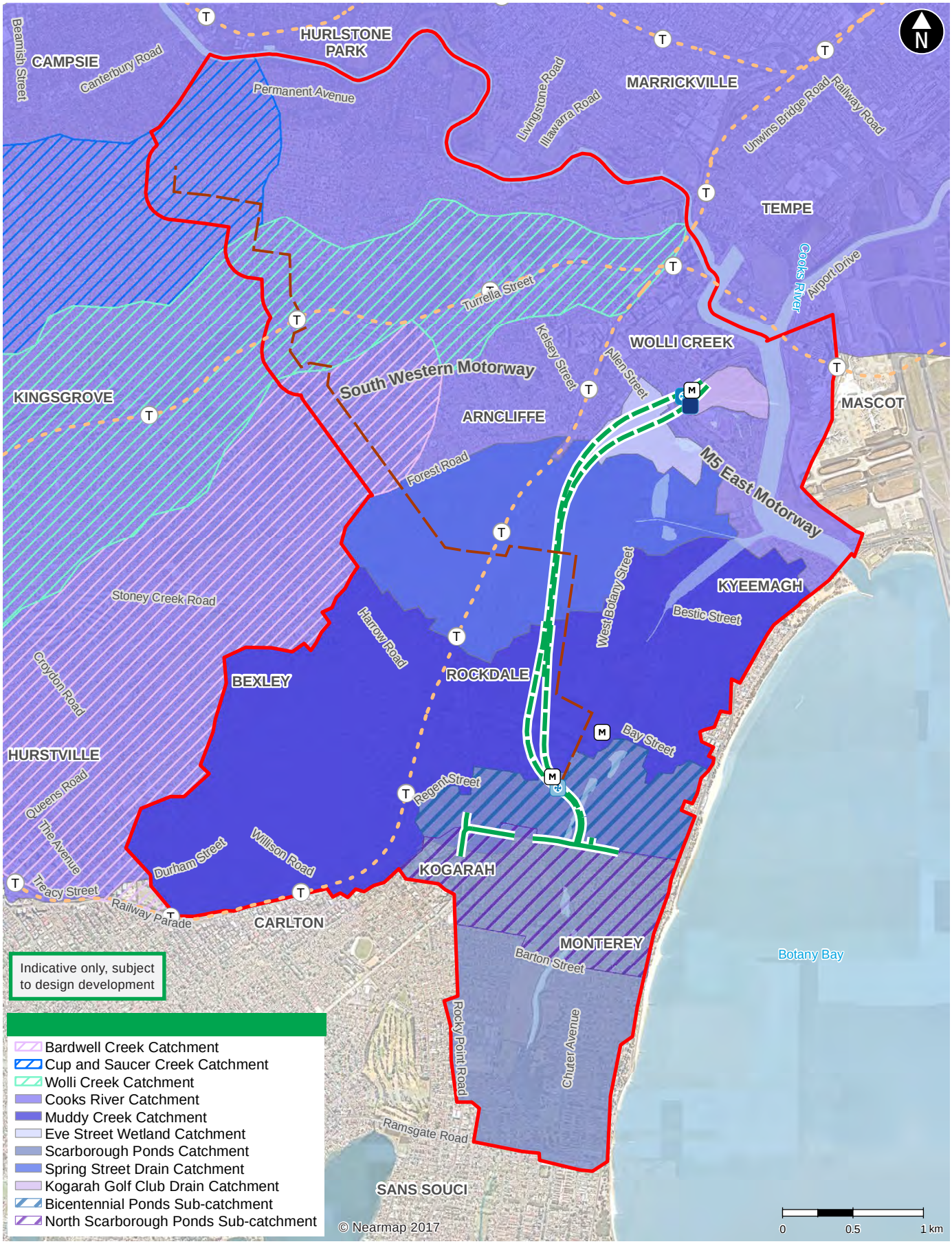
1.6 Surface water study area

The study area for the surface water assessment includes the project boundary, as well as areas where potential surface water impacts could occur as a result of construction or operation of the project. The study area is shown in **Figure 1-1**.

All project activities would lie within the following sub-catchments which form part of the larger Cooks River and Botany Bay catchments:

- Cooks River – the operational water treatment plant would discharge directly to the Cooks River
- Muddy Creek – the shared cycle and pedestrian pathways between Bestic Street and Bay Street is located within the Muddy Creek catchment, as is the proposed power supply connection. The tunnel also passes under Muddy Creek and its catchment
- Scarborough Ponds – the President Avenue intersection and associated ramps and portals, ancillary facilities at West Botany Street, various road adjustments, power supply connection, shared cycle and pedestrian pathways, water quality treatment systems and construction access decline are located within this catchment
- Spring Street Drain – the proposed power supply connection is located within this sub-catchment, and the tunnel passes beneath the catchment
- Eve Street Wetland - the tunnel passes beneath the catchment, there are no surface works within this sub-catchment
- Kogarah Golf Club Drain – runoff from a portion of the operational water treatment plant site would discharge to the Cooks River via this open drain that runs through the golf course
- Cup and Saucer Creek, Wolli Creek and Bardwell Creek – the proposed power supply connection is located within these sub-catchments.

The extent of the project activities within each of these catchments is discussed further in **section 4.1**.



LEGEND

- The project in tunnel
- The project on surface
- Permanent power supply line
- Surface water study area
- Water treatment facility
- Rockdale ventilation facility
- Motorway operations complex
- Arncliffe ventilation facility*
- * Under construction as part of the New M5 Motorway project
- Railway station
- Railway line
- Waterway
- Waterbody

Figure 1-1 Surface water study area

2 The Project

2.1 Project features

The project would comprise a new multi-lane underground road link between the New M5 Motorway and a surface intersection at President Avenue, Kogarah.

Key components of the project would include:

- Twin mainline tunnels. Each mainline tunnel would be around 2.5 kilometres in length, sized for three lanes of traffic, and line marked for two lanes as part of the project
- A tunnel-to-tunnel connection to the New M5 Motorway southern extension stub tunnels, including line marking of the New M5 Motorway tunnels from St Peters interchange to the New M5 Motorway stub-tunnels
- Entry and exit ramp tunnels about 1.5 kilometres long (making the tunnel four kilometres in length overall) and a tunnel portal connecting the mainline tunnels to the President Avenue intersection
- An intersection with President Avenue including entry and exit ramps and the widening and raising of President Avenue
- Upgrade of the President Avenue / Princes Highway intersection to improve intersection capacity
- Shared cycle and pedestrian pathways connecting Bestic Street, Brighton-Le-Sands to Civic Avenue, Kogarah (including an on-road cycleways)
- Three motorway operation complexes:
  - Arncliffe, including a water treatment plant, substation and fitout (mechanical and electrical) of a ventilation facility currently being constructed as part of the New M5 Motorway project
  - Rockdale (north), including a motorway control centre, deluge tanks, a workshop and an office
  - Rockdale (south), including a ventilation facility, substation and power supply.
- Reinstatement of Rockdale Bicentennial Park and recreational facilities
- In-tunnel ventilation systems including jet fans and ventilation ducts connecting to the ventilation facilities
- Drainage infrastructure to collect surface water and groundwater inflows for treatment
- Ancillary infrastructure for electronic tolling, traffic control and signage (both static and electronic signage)
- Emergency access and evacuation facilities (including pedestrian and vehicular cross and long passages); and fire and life safety systems
- New service utilities, and modifications and connections to existing service utilities
- A proposed permanent power supply connection from the Ausgrid Canterbury subtransmission substation, to Rockdale Motorway Operations Complex south. The power line would be constructed underground either by trenching or, where required, under-boring.

The project does not include ongoing motorway maintenance activities during operation or future upgrades to other intersections in the vicinity during operation. These works are permitted under separate existing approvals and / or are subject to separate assessment and approval in accordance with the EP&A Act.

The key features of the project are shown on **Figure 2-1**.

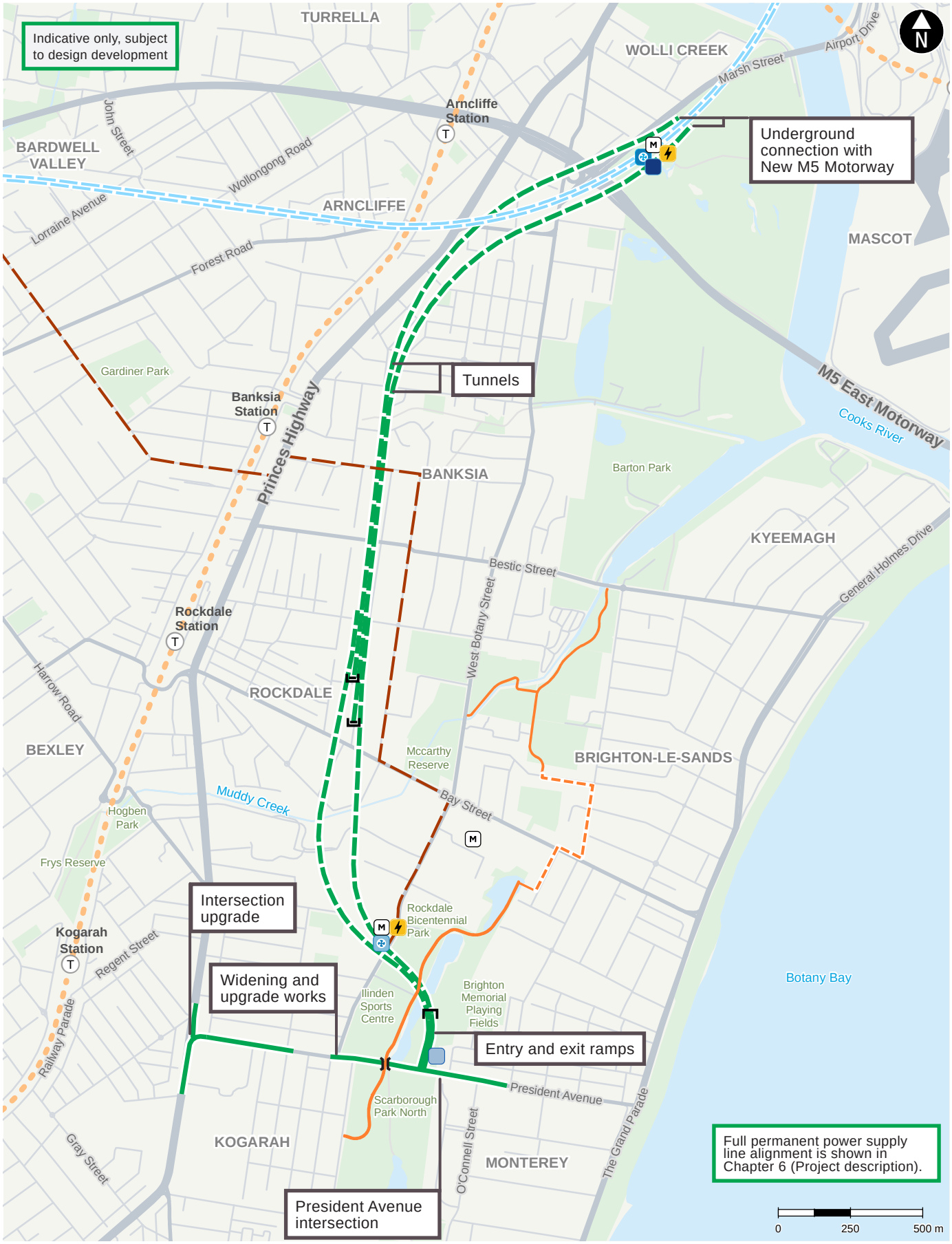


Figure 2-1 Project features

2.2 Construction

2.2.1 Construction activities

The proposed construction activities for the project would include:

- Preparatory investigations
- Site establishment and enabling work
- Tunnelling
- Surface earthworks and structures
- Construction of motorway operations complexes
- Drainage and construction of operational water management infrastructure
- Construction of the permanent power supply connection
- Road pavement works
- Finishing works.

These activities would generally be undertaken within the following construction ancillary facilities:

- Arncliffe construction ancillary facility (C1) at Arncliffe, within the Kogarah Golf Course currently being used for the construction of the New M5 Motorway
- Rockdale construction ancillary facility (C2) at Rockdale, within a Roads and Maritime depot at West Botany Street
- President Avenue construction ancillary facility (C3) at Rockdale, north and south of President Avenue within Rockdale Bicentennial Park and part of Scarborough Park North, and a site west of West Botany Street
- Shared cycle and pedestrian pathways construction ancillary facilities (C4 and C5) at Brighton-le-Sands, within the recreation area between West Botany Street and Francis Avenue, near Muddy Creek
- Princes Highway construction ancillary facility (C6), on the north-east corner of the President Avenue and Princes Highway intersection.

2.2.2 Construction boundary

The area required for project construction is referred to as the 'construction boundary'. This comprises the surface construction works area, and construction ancillary facilities (refer to **Figure 2-2**). Utility works to support the project would occur within and outside the construction boundary (refer to **Chapter 7** (Construction) of the EIS).

In addition to these works, the underground construction boundary (including mainline tunnel construction and temporary access tunnels) is also shown on **Figure 2-2**.

C1

- Tunnelling and spoil handling
- Construction of MOC1 (Water treatment plant, substation)
- Fitout, testing and commissioning of tunnels and MOC 1

C2

- Construction of the decline tunnel
- Tunnelling and spoil handling
- Pavement works for internal access road
- Construction of MOC2
- Reconfiguration of the site to enable ongoing/future use for maintenance activities

C3

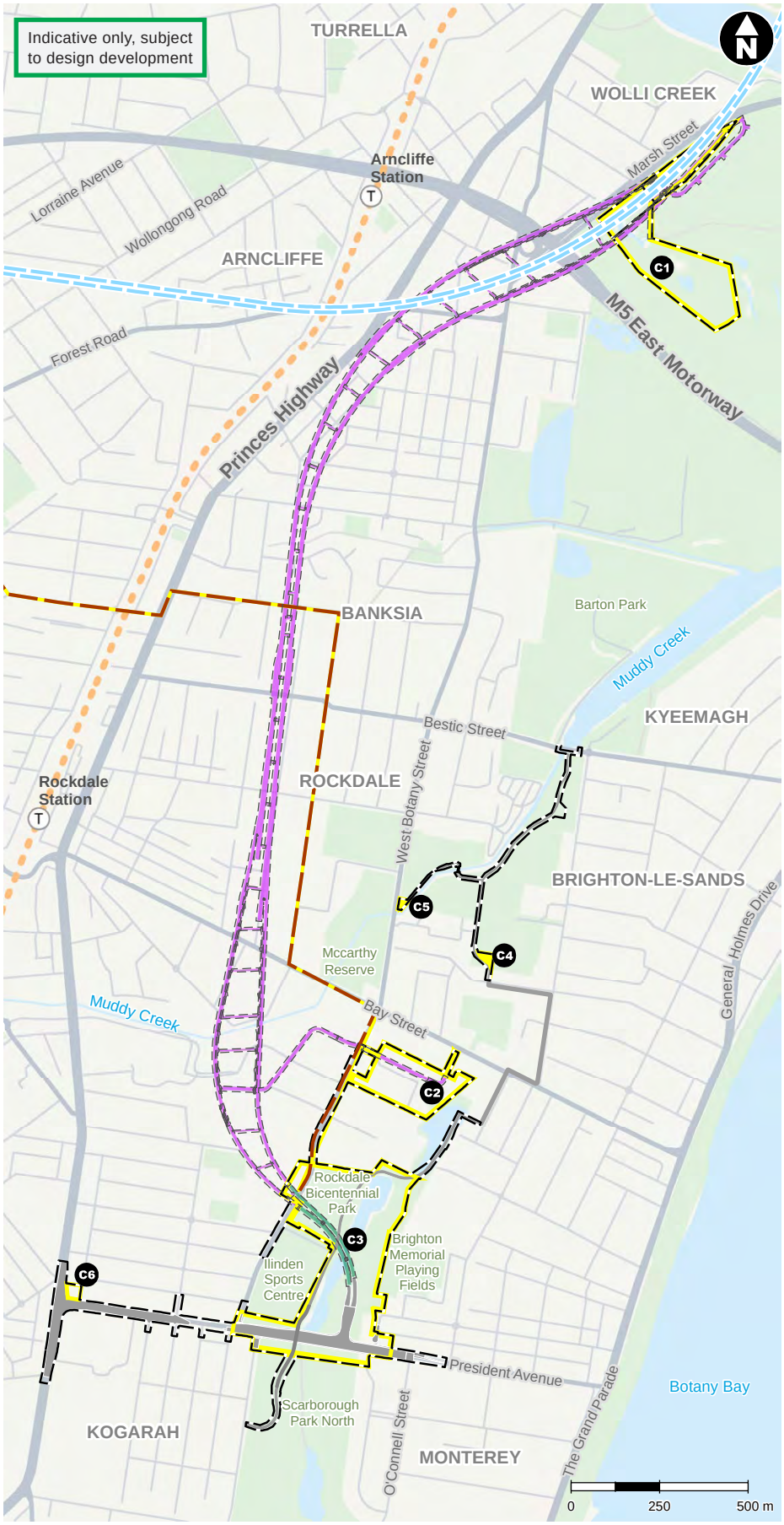
- Demolition of buildings and vegetation clearing and removal
- Relocation of utilities
- Temporary stockpiling of spoil and fill materials
- Management of any contaminated land, including acid sulphate soils
- Construction of cut-and-cover structures
- Construction of MOC3 (Rockdale ventilation facility and substation)
- President Avenue intersection upgrade works
- Construction of shared pedestrian and cyclist path and overpass

C4/C5

- Site establishment
- Vegetation clearing and removal, topsoil stripping areas and land-form shaping
- Temporary stockpiling of materials
- Construction of the shared pedestrian and cyclist path
- Finishing works including lighting, line marking and signage installation

C6

- Property adjustment and demolition
- Relocation of utilities, stormwater infrastructure, underground storage tanks and substation
- Laydown and parking of construction vehicles and equipment
- Reinstatement of site



LEGEND

- Surface works
- Construction boundary
- Cut-and-cover structures
- Underground construction
- Construction ancillary facility
- Permanent power supply line
- Permanent power supply construction route
- New M5 Tunnel
- Road
- Waterway
- Railway line
- Railway station
- Parks and recreation

Figure 2-2 Overview of construction boundary and construction ancillary facilities

2.2.3 Construction program

The project would be constructed over a period expected to be around four years, including commissioning which would occur concurrently with the final stages of construction (refer to **Figure 2-3**).

The project is expected to be completed towards the end of 2024.

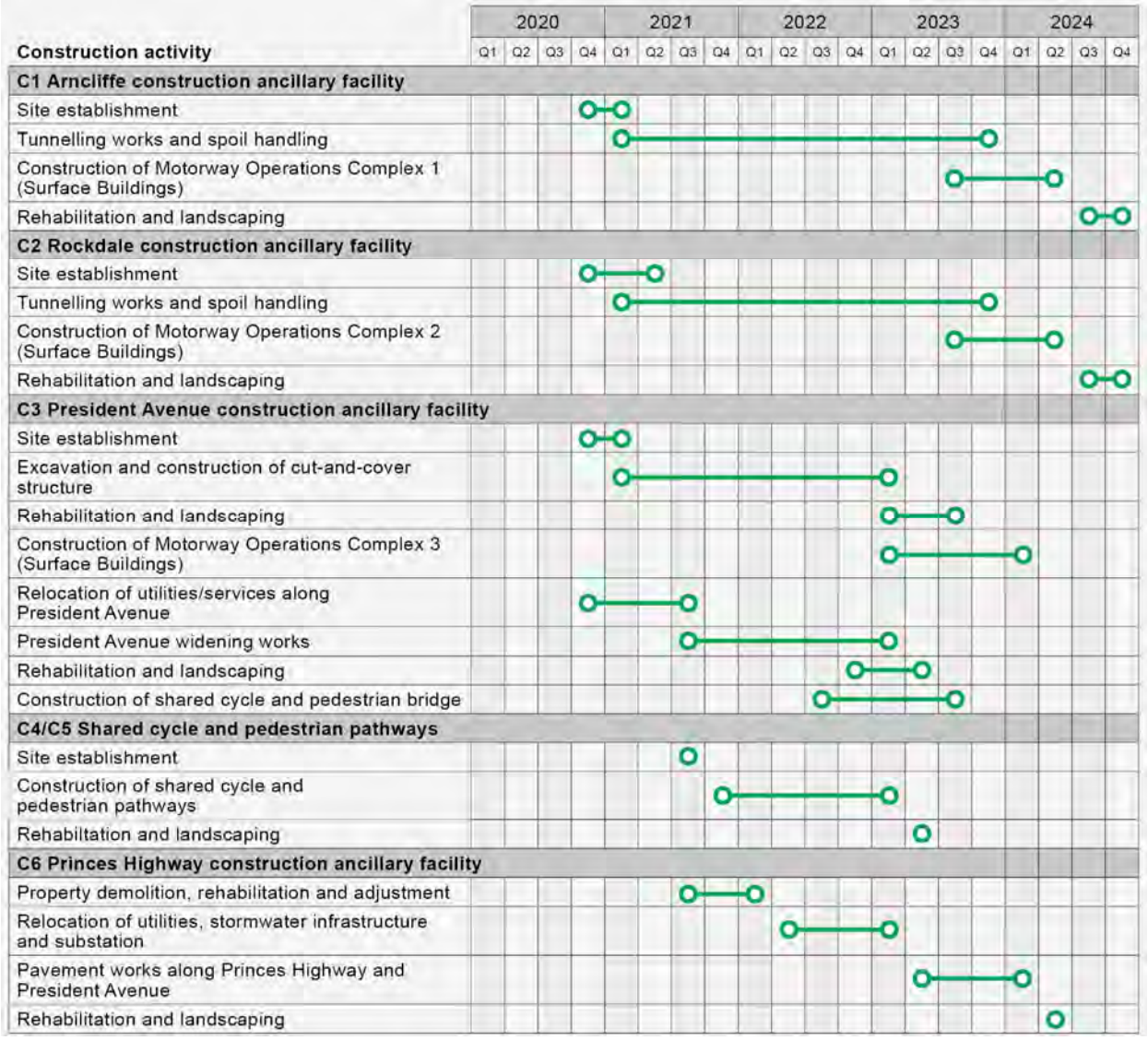


Figure 2-3 Indicative construction program

2.3 Other surface water specific project aspects

This section describes the specific aspects of the project which relate to surface water. This includes:

- Key groundwater and surface water management measures during construction
- Key surface and tunnel drainage and treatment elements during operation
- Key transverse drainage elements at President Avenue during operation.

A full description of the transverse drainage and flood mitigation features of the project is provided in **Appendix M** of the EIS (Flooding Technical Report).

The approach to surface water and tunnel water management during operation is shown in **Figure 2-4**. The proposed tunnel drainage concept and stormwater drainage concept at President Avenue are shown schematically in **Figure 2-5** and **Figure 2-6**, respectively. Indicative concepts for the water quality basin at President Avenue are provided in **Annexure B**. The key elements are described in **Table 2-1**.

Table 2-1 Project surface water specific project aspects

Component	Description
Construction	
Construction water treatment plants	• The Arncliffe and Rockdale construction ancillary facilities (C1 and C2) would each have a construction water treatment plant to treat groundwater inflows into the tunnel. • The President Avenue construction ancillary facility (C3) would also include a construction water treatment plant to treat groundwater that is extracted from the cut and cover structure during the excavation of the ramps at President Avenue.
Groundwater pre-treatment basins	• Each of the tunnel and civil construction sites would include a pre-treatment basin as part of the treatment train for groundwater, in conjunction with the construction water treatment plants.
Sediment basins for surface water	• Surface runoff from unsealed surfaces in President Avenue construction ancillary facility (C3) would be directed to sediment basins. The number location and size of the basins will depend on the stage of construction and arrangement of the works. It is likely that two basins, one either side of Rockdale Bicentennial Park pond would be installed to the north of President Avenue and one on the western side of the open channel to the south of President Avenue.
Operation – surface drainage	
Surface drainage and portal drainage at President Avenue	• A new pavement drainage system would be provided along President Avenue to accommodate the proposed road widening. • A new pavement drainage system would intercept runoff generated by direct rainfall at the President Avenue tunnel portal. Runoff from the tunnel portal would be diverted to temporary storage tanks and pump wells located beneath the carriageways. • Runoff from the tunnel portal at President Avenue would be pumped to a water quality basin for treatment prior to discharge into Rockdale Bicentennial Park Pond. • The stormwater drainage strategy assumes that runoff from the upgraded section of President Avenue and Princes Highway would discharge directly to either Rockdale Bicentennial Park Pond or the North Scarborough Pond on the basis that: – The upgrade of President Avenue represents a relatively minor increase in the overall imperviousness of the contributing catchment discharging to Scarborough Ponds – Opportunities for the treatment of stormwater runoff captured by new and upgraded pavement drainage systems along President Avenue are limited by both space constraints within the existing road corridor and the configuration of the existing road drainage system
Transverse drainage at President Avenue	• The existing 1800 x 900 box culvert that crosses President Avenue would be replaced with three 2700 x 1200 box culverts • In order to maintain the existing permanent water level in the Rockdale Bicentennial Park Pond upstream of President Avenue, the weir that is located upstream of the existing of the existing box culvert would be replaced with a similar arrangement at the inlet of the new box culvert • Re-grading and lowering ground levels to facilitate overland flow during major storm events or blockages.
Surface drainage for the operational Motorway Control Centre and Rockdale ventilation facility	• Requirements for management of stormwater runoff from the proposed Motorway Control Centre and Rockdale ventilation facility would be confirmed during detailed design. These would likely include: – a new pit and pipe drainage system to control runoff from hardstand and roof areas – a gross pollutant trap and spill containment tank to treat runoff and provide on-site management prior to discharge into the stormwater drainage network.

Component	Description
Tunnel drainage	• The tunnel drainage system has been designed to have a separate groundwater and surface water collection system • The tunnel groundwater collection system would capture groundwater ingress from the drained sections of the tunnel • The tunnel surface water collection system would capture: – Tunnel maintenance wash down water – Fire system (i.e. deluge) water – Water from an accidental rupture of a fire main or hydrant – Accidental spills of fuels or other chemicals carried by vehicles using the tunnel – Water transported into the tunnel by vehicles – Fire system testing water • All surface flows within the tunnel will be captured in pits before being drained via surface drainage pipes running longitudinally below the road surface to the tunnel sump. The surface flows would pass through trash and sediment screens and a spill containment chamber before discharging into a tunnel surface water storage chamber • Groundwater ingress would be captured in barrier drains provided on either side of the tunnels before being discharged via downpipes into groundwater drainage pipes running longitudinally below the road surface parallel with the surface drainage pipes. The groundwater flows will pass through sediment screens prior to discharge into a groundwater storage chamber • Groundwater and surface water flows captured in the separate storage chambers at the tunnel sump would be pumped via separate rising mains to a new operational water treatment plant at Arncliffe. The new water treatment plant would discharge to the Marsh Street road drainage network which ultimately discharges to the Cooks River • Groundwater and surface water flows captured in a short length of tunnel adjacent to the connection to the New M5 Motorway at Arncliffe will drain via gravity into the New M5 Motorway drainage system.
Operational water treatment plant	• A new operational water treatment plant would be provided at Arncliffe to treat tunnel groundwater. • Sources other than groundwater that are captured by the tunnel drainage system will be collected in one of the tunnel sumps. Water in the sump will be tested and a determination will be made whether it can be pumped to and discharged at surface (to the Cooks River via the water treatment plant), to sewer via a trade waste agreement, or will require removal directly from the sump by tanker for treatment and disposal offsite. • Stormwater runoff within the water treatment plant site would be managed as follows: – Potentially contaminated runoff to be captured and disposed to sewer via a trade waste agreement or removed by a liquid waste contractor and disposed of offsite at a licenced facility – a gross pollutant trap and spill containment facilities to treat runoff generated from other areas of the site prior to discharge into the stormwater drainage network.

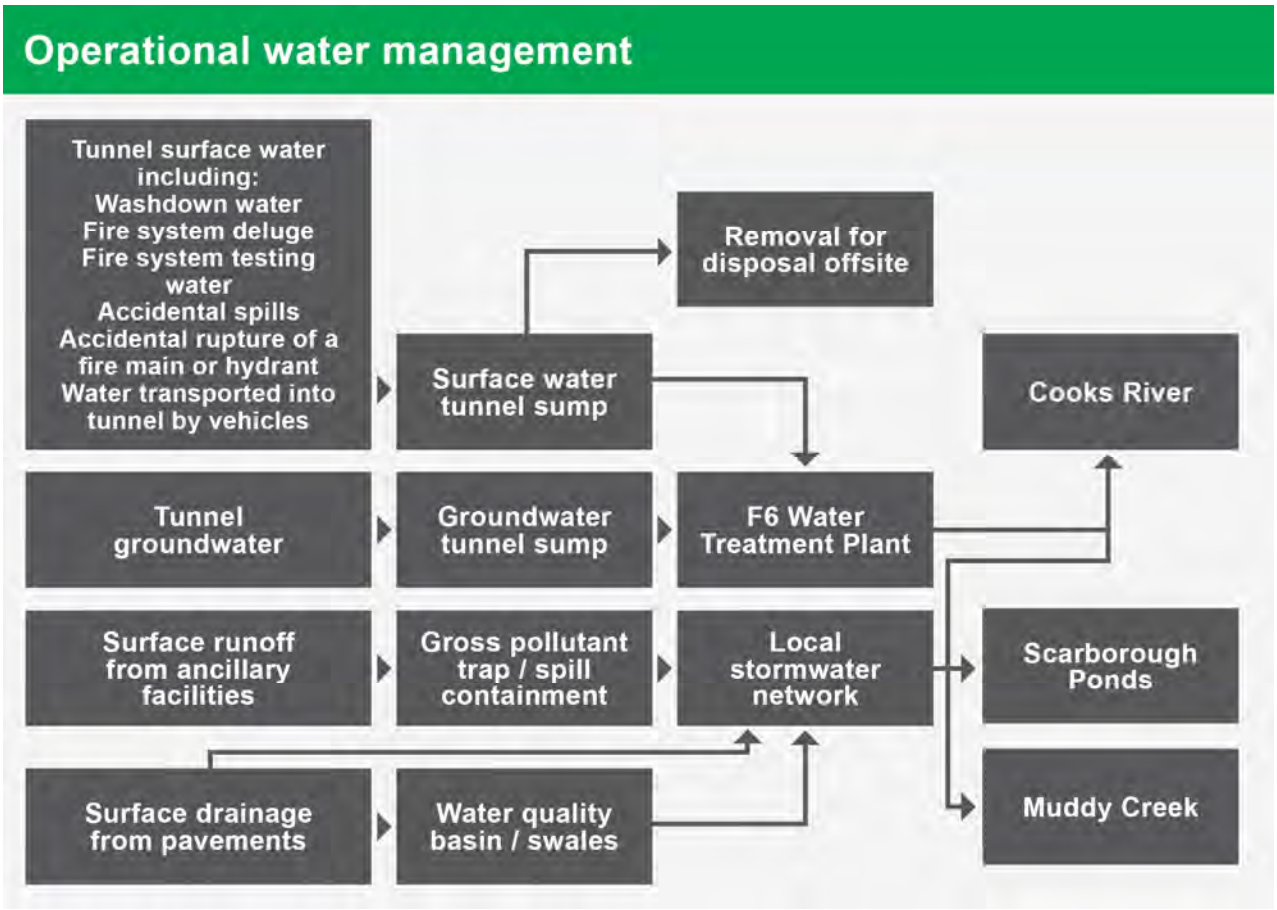


Figure 2-4 Operational water management

Figure 2-5 Tunnel drainage concept

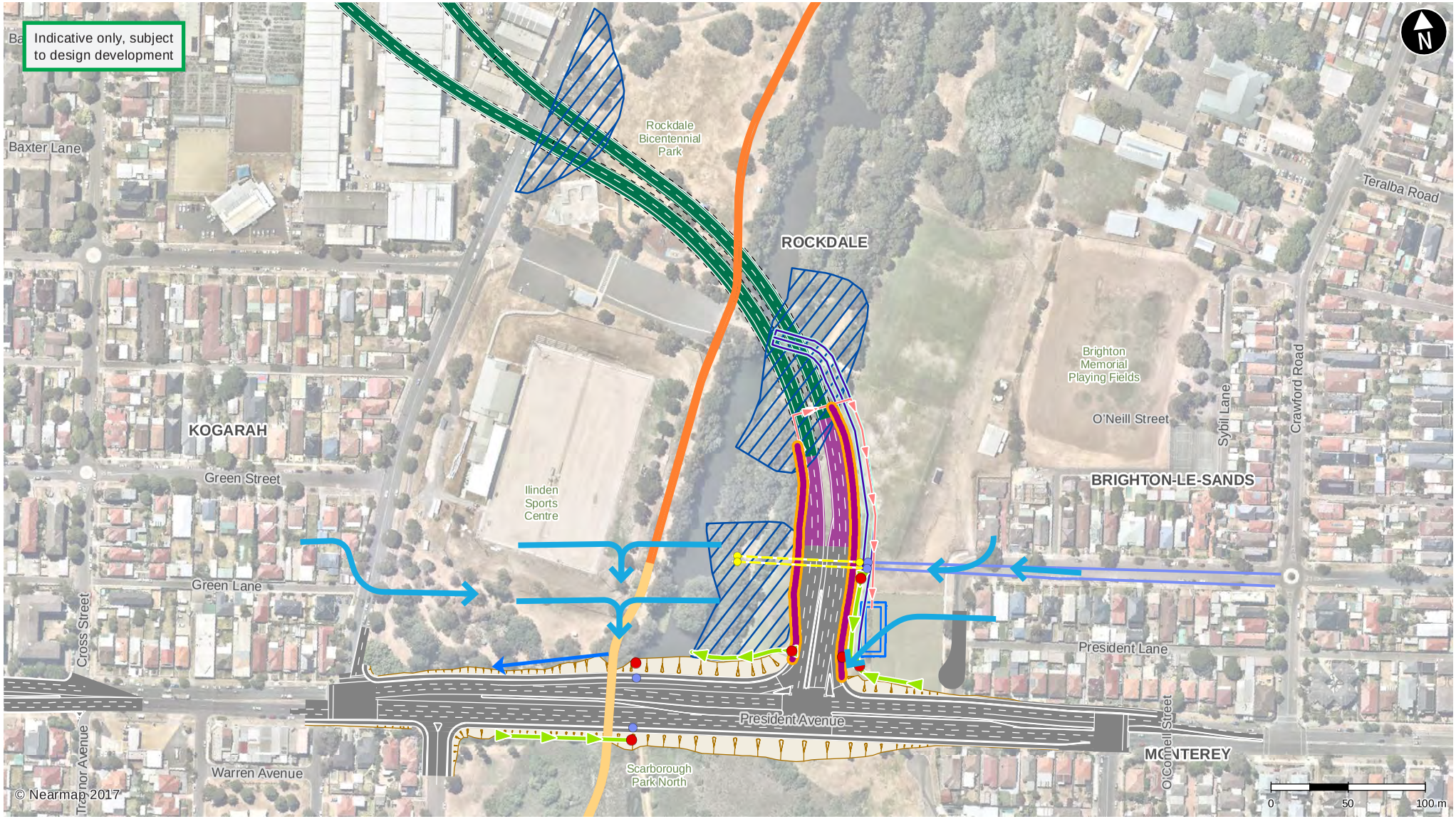


Figure 2-6 Stormwater drainage concept at President Avenue

3 Assessment methodology

3.1 Relevant guidelines and policies

3.1.1 Australian and New Zealand Guidelines for Fresh and Marine Water Quality

The *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC/ARMCANZ 2000) (commonly referred to as the 'ANZECC Water Quality Guidelines') form part of the National Water Quality Management Strategy and list a range of environmental values for water bodies. Different water quality criteria are set for the water bodies based on environmental values assigned to that water body. These values include consideration as to whether the water is to be used for drinking, recreation or according to ecological values. The ANZECC Water Quality Guidelines provide water quality criteria (scientifically-based benchmark values) for a wide range of parameters for each of these values. The ANZECC Water Quality Guidelines state that '*The Guidelines are not intended to be used as mandatory standards because there is significant uncertainty associated with the derivation and application of water quality guidelines*'. However, the guidelines provide a useful measure of risks to aquatic ecosystem health.

The ANZECC Water Quality Guidelines *'have not been designed for direct application in activities such as discharge consents, recycled water quality or stormwater quality, nor should they be used in this way. (The exception to this may be water quality in stormwater systems that are regarded as having some conservation value). They have been derived to apply to the ambient waters that receive effluent or stormwater discharges, and protect the environmental values they support'.*

The ANZECC Water Quality Guidelines are appropriate for the assessment of the existing ambient water quality of watercourses, water bodies, estuaries and marine water within the study area as discussed in **section 4.1**. They have also been used as a means of assessing the potential impacts of treated tunnel water discharges.

3.1.2 NSW Water Quality and River Flow Objectives

For each catchment in NSW, the state government has endorsed the community's environmental values for water, known as the NSW Water Quality Objectives. The NSW Water Quality Objectives (WQOs) (NSW Department of Environment, Climate Change and Water (DECCW) 2006) are consistent with the agreed national framework of the ANZECC Water Quality Guidelines and are '*primarily aimed at maintaining and improving water quality, for the purposes of supporting aquatic ecosystems, recreation and where applicable water supply and the production of aquatic foods suitable for consumption and aquaculture activities*' (DECCW 2006).

The NSW River Flow Objectives (RFOs) (DECCW 2006) are the agreed strategic goals for surface water flow management. They identify the key elements of the flow regime that protect river health and water quality for ecosystems and human uses.

The WQOs and RFOs have been developed for the Cooks River Catchment which includes land draining to Cooks River and Muddy Creek. The Georges River Catchment WQOs and RFOs also apply to lands which drain to Botany Bay including the water bodies which make up Scarborough Ponds.

The receiving waterway classification for waterways in the study area in accordance with DECCW (2006) is provided in **Table 3-1**. The WQOs and RFOs that were determined are provided in **Table 3-2**. The WQO key indicators which are considered to be relevant to the project and associated default trigger values as described in DECCW (2006) and ANZECC (2000) are provided in **Table 3-3**. The trigger values were established based on the following:

- As the receiving surface water environments are either estuarine (Cooks River, Muddy Creek, North Scarborough Pond) or located immediately upstream of estuarine environments (Rockdale Bicentennial Park Pond), the estuarine trigger value for physical and chemical stressors and the marine water trigger value for toxicants was considered to be appropriate for the protection of aquatic ecosystems

- The policy in NSW is that the level of protection applied to most waterways is the one suggested for slightly to moderately disturbed systems. A reduced level of protection may be appropriate for highly disturbed systems as a pragmatic short term goal, with the aim of eventually restoring the waterway to the status of a slightly to moderately disturbed system. As the ultimate objective is considered to be the slightly to moderately disturbed system, these trigger values have been adopted.

Table 3-1 Catchment and waterway classification

Receiving waterway / estuary	Relevant WQO and RFO catchment	Relevant waterway type classification
Cooks River	Cooks River Catchment	Estuaries
Muddy Creek north of Bestic Street	Cooks River Catchment	Estuaries
Muddy Creek south of Bestic Street	Cooks River Catchment	Waterways affected by urban development
Rockdale Bicentennial Park Pond	Georges River Catchment	Waterways affected by urban development
North Scarborough Pond	Georges River Catchment	Waterways affected by urban development

Table 3-2 NSW Water quality objectives and river flow objectives

Objective	Applicable catchments / waterway	Relevance to project
Water quality objectives		
Protect aquatic ecosystems - Estuarine	All waterways except Rockdale Bicentennial Park Pond	Treatment of surface water and groundwater discharges from construction compounds, road pavements and ancillary facilities. Direct disturbance of waterways.
Protect aquatic ecosystems - Freshwater	Rockdale Bicentennial Park Pond	Treatment of surface water and groundwater discharges from construction compounds, road pavements and ancillary facilities. Direct disturbance of waterways.
Visual amenity	All waterways	Treatment of surface water and groundwater discharges from construction compounds, road pavements and ancillary facilities. Direct disturbance of waterways.
Secondary contact recreation	All waterways	Treatment of surface water and groundwater discharges from construction compounds, road pavements and ancillary facilities.
Primary contact recreation	Cooks River, Muddy Creek north of Bestic Street, Rockdale Bicentennial Park Pond and Scarborough ponds	Treatment of surface water and groundwater discharges from construction compounds, road pavements and ancillary facilities.
Aquatic foods	Cooks River and Muddy Creek north of Bestic Street	Treatment of surface water and groundwater discharges from construction compounds, road pavements and ancillary facilities.
River flow objectives		
Protect important rises in water levels	All waterways	Refer to Appendix M of the EIS (Flooding Technical Report)
Maintain wetland and floodplain inundation	Rockdale Bicentennial Park Pond and Scarborough Ponds	Relevant to maintain, restore or mimic natural inundation and drying patterns for the semi-natural wetlands at Scarborough Ponds.
Maintain natural flow variability	All waterways	Adoption of water sensitive urban design techniques to reduce hydrological impacts of the project.
Maintain natural rates of change in water levels	All waterways	Adoption of water sensitive urban design techniques to reduce hydrological impacts of the project.
Minimise effects of weirs and other structures	All waterways	Maintaining hydraulic controls at President Avenue

Objective	Applicable catchments / waterway	Relevance to project
Maintain or rehabilitate estuarine processes and habitats	Cooks River, Muddy Creek north of Bestic Street and North Scarborough Pond	Protection of key fish habitat in the Cooks River and Muddy Creek

Table 3-3 NSW water quality objectives

Parameter	Protect aquatic ecosystems – Estuarine [2] (mg/L)	Protect aquatic ecosystems – Freshwater [4] (mg/L)	Visual Amenity	Secondary Recreation (mg/L)	Primary Recreation (mg/L)	Aquatic Foods (mg/L)
Total phosphorus	0.03	0.025	-	-	-	-
Total nitrogen	0.3	0.35	-	-	-	-
Chlorophyll-a	0.004	0.005	-	-	-	-
Turbidity	10	50 (NTU)	-	-	-	-
Salinity	-	125-2200 µS/cm				
pH	7.0-8.5	6.5-8.0	-	-	5 – 9.0	-
Temperature	Between 80%ile and 20%ile for reference site	Between 80%ile and 20%ile for reference site	-	-	15°C – 35°C for prolonged exposure	Less than 2°C change over one hour
Arsenic (III)	0.024[3]	0.024	-	-	-	-
Arsenic (V)	0.013[3]	0.013	-	-	-	-
Arsenic	Adopted as Arsenic (V) – 0.013	0.013		0.05	0.05	
Cadmium	0.0007	0.0002	-	0.005	0.005	-
Chromium (III)	0.0274	-	-	-	-	-
Chromium (VI)	0.0044	0.001	-	-	-	-
Chromium	Adopted as Cr(VI) – 0.0044	Adopted as Cr(VI) – 0.001	-	0.05	0.05	-
Copper	0.0013	0.0014	-	1	1	0.005
Iron	-	-	-	0.3	0.3	-
Lead	0.0044	0.0034	-	-	-	-
Manganese	1.9[3]	1.9	-	0.1	0.1	-
Mercury	Adopted as Mercury (inorganic) – 0.0001	Adopted as Mercury (inorganic) – 0.00006	-	0.001	0.001	0.001
Mercury (inorganic)	0.0001	0.00006	-	-	-	-
Nickel	0.007	0.011	-	-	-	-

Parameter	Protect aquatic ecosystems – Estuarine [2] (mg/L)	Protect aquatic ecosystems – Freshwater [4] (mg/L)	Visual Amenity	Secondary Recreation (mg/L)	Primary Recreation (mg/L)	Aquatic Foods (mg/L)
Zinc	0.015	0.008	-	5	5	0.005
Ammonia	0.91	0.90	-	0.01	0.01	-
Nitrate	0.7[3]	0.7	-	10	10	-
Nitrite	-	-	-	1	1	-
Benzene	0.5	0.95	-	0.01	0.01	-
o-xylene	0.35[3]	0.35	-	-	-	-
p-xylene	0.2[3]	0.2	-	-	-	-
Naphthalene	0.05	0.016	-	-	-	-
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%	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%	-	-
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	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	-	-

Parameter	Protect aquatic ecosystems – Estuarine [2] (mg/L)	Protect aquatic ecosystems – Freshwater [4] (mg/L)	Visual Amenity	Secondary Recreation (mg/L)	Primary Recreation (mg/L)	Aquatic Foods (mg/L)
Nuisance organisms	-		Macrophytes, phytoplankton scums, filamentous algal mats, blue-green algae, sewage fungus and leeches should not be present in unsightly amounts	-	Macrophytes, phytoplankton scums, filamentous algal mats, blue-green algae, sewage fungus and leeches should not be present in unsightly amounts	-
Algae and blue-green algae	-		-	< 15000 cells / mL	-	-

[1] Values in grey shading apply to the adopted WQO which is based on the minimum trigger value across the various WQOs. Values in blue shading apply to the adopted WQO for Rockdale Bicentennial Park only (freshwater system) where grey shading does not apply. Values in orange shading apply to the adopted WQO for the estuarine environments of Cooks River and Muddy Creek only where grey shading does not apply.
[2] Based on estuarine default trigger value for physical and chemical stressors and marine water slightly to moderately disturbed trigger value for toxicants
[3] No marine water trigger value available so freshwater slightly to moderately disturbed trigger value adopted
[4] Based on lowland rivers default trigger value for physical and chemical stressors and freshwater water slightly to moderately disturbed trigger value for toxicants

3.1.3 Managing Urban Stormwater – Soils and Construction

The *Managing Urban Stormwater (MUS) – Soils and Construction* series of handbooks are an element of the NSW Government's urban stormwater program specifically applicable to the construction phase of developments. These are aimed at providing guidance for managing soils in a manner that protects the health, ecology and amenity of urban streams, rivers estuaries and beaches through better management of stormwater quality.

The MUS handbooks were produced to provide guidelines, principles, and recommended minimum design standards for good management practice in erosion and sediment control during the construction of roads. Of particular relevance to the project are Volume 1, 4th Edition (Landcom 2004) (commonly known as The Blue Book 1) and Volume 2D, Main Road Construction (DECC 2008) (commonly known as The Blue Book 2).

3.1.4 Botany Bay and Catchment Water Quality Improvement Plan

Sydney Metropolitan Catchment Management Authority's (SMCMA) *Botany Bay and Catchment Water Quality Improvement Plan* (SMCMA 2011) (BBWQIP) is a contemporary plan designed specifically for the catchment of Botany Bay.

The plan is an agreed water quality improvement plan that builds on research and engagement undertaken as part of the BBWQIP, to provide direction for future land use and water quality management decisions in the Botany Bay catchment. The plan is aimed at Local, State and Federal Government agencies.

One of the primary objectives of the BBWQIP was to set targets for pollutant load reductions (in terms of total nitrogen, total phosphorus and suspended sediment) required to protect the condition of Botany Bay, its estuaries and waterways. The BBWQIP pollutant reduction targets are shown in **Table 3-4.**

Table 3-4 BBWQIP Pollutant Load Reduction Targets

Stormwater pollutant	Greenfield developments Large re-developments
Gross pollutants	90%
TSS	85%
TP	60%
TN	45%

Whilst the BBWQIP has not assigned pollutant load reduction targets for road infrastructure projects, it does recommend that the NSW Government ensures land / infrastructure / facilities under its control (including roads) minimise their negative impacts on water quality.

The project is situated within an existing urban area. The approach adopted in the project's stormwater management strategy to minimise negative impacts on water quality with consideration to the constraints of retrofitting stormwater treatment systems within an existing urban area, is to apply the targets to the increased (i.e. total new) road pavement footprint. This approach has been adopted on other road projects including the adjoining New M5 Motorway project.

3.1.5 Other policies and guidelines

Other polices and guidelines that apply to the project include:

- NSW State Rivers and Estuaries Policy (NSW Water Resources Council 1993)
- National Water Quality Management Strategy (ANZECC 2000)
- Guidelines for Design of Fish and Fauna Friendly Waterway Crossings (Fairfull and Witheridge 2003)
- Fish Passage Requirements for Waterway Crossings (Fairfull and Witheridge 2003)
- Controlled Activities – Guidelines for Riparian Corridors (NSW Office of Water 2011)
- Controlled Activities – Guidelines for Watercourse Crossings (NSW Office of Water 2010)
- Controlled Activities – Guidelines for In-stream Works (NSW Office of Water 2010)
- Controlled Activities – Guidelines for Laying Pipes and Cables in Watercourses (NSW Office of Water 2011)
- Controlled Activities – Guidelines for Outlet Structures (NSW Office of Water 2010)
- Managing Urban Stormwater: Council Handbook, Draft (NSW EPA 1981)
- Australian Rainfall and Runoff: A Guide to Flood Estimation, (ARR 2016) (Ball, Babister, Nathan, Weeks, Weinmann, Retallick, Testoni, 2016)
- Australian Runoff Quality (Institute of Engineers Australia 2006).

Relevant policies and guidelines of Roads and Maritime that also apply to the project include:

- Water Policy (NSW Roads and Traffic Authority (RTA) 1997)
- Roads and Maritime Services Code of Practice for Water Management (Roads and Maritime 1999)
- Stockpile Site Management Procedures (RTA 2001)
- Procedures for Selecting Treatment Strategies to Control Road Runoff (RTA 2003)
- Roads and Maritime Services Erosion and Sediment Management Procedure (Roads and Maritime 2008)
- Roads and Maritime Services Technical Guideline: Temporary Stormwater Drainage for Road Construction (Roads and Maritime 2011)
- Roads and Maritime Technical Guideline Environmental Management of Construction Site Dewatering (RTA 2011)

- Water sensitive urban design guideline, Applying water sensitive urban design principles to NSW transport projects (Roads and Maritime 2017).

Relevant Austroads guidelines that apply to the project include:

- AP-R180 Road Runoff and Drainage: Environmental Impacts and Management Options (Austroads 2011)
- AP-R232 Guidelines for Treatment of Stormwater Runoff from the Road Infrastructure (Austroads 2003)
- Guide to Road Design, Part 5: Drainage Design (Austroads 2013).

3.2 Key assumptions

The overall surface water assessment undertaken was based on the following key assumptions:

- For the purpose of assessing the impact of discharging treated groundwater to the Cooks River during operation, discharge concentrations were assumed to be equal to the New M5 Motorway water treatment plant discharge criteria (refer **Annexure F**)
- It is assumed the maximum tunnel water discharge rate during operation would be 1 L/s per any km for all project tunnels and cross passages and 2 L/s per any km for the construction access decline at Rockdale.

Further assumptions relating to water quality modelling undertaken as part of this assessment are described in later sections of this report and in relevant technical annexures.

3.3 Methodology

This section details the methodology adopted for this assessment, which has included:

- Undertaking a desktop review and analysis of existing information to determine potential receptors, characterisation of the existing environment and identifying potential issues
- A site inspection to confirm and supplement the findings of the desktop analysis and refine understanding of potential issues
- Assessment of potential construction and operational impacts related to hydrology, geomorphology, water quality and water quantity
- Identifying appropriate measures to mitigate potential impacts.

3.3.1 Desktop analysis

The existing surface water environment within the study area has been characterised and potential impacts have been identified through an initial desktop analysis of available information. The desktop analysis has included consideration of:

- Information and previous studies pertaining to surface water within the study area
- Other technical reports included in this EIS, including those relating to groundwater, flooding, contamination and biodiversity.

Data collection

Information on the existing water quality within the study area has been collected as described in **Table 3-5**.

Table 3-5 Water quality data

Data	Monitoring conducted
F6 Extension (Stage 1 - New M5 Motorway at Arncliffe to President Avenue at Kogarah) surface water quality monitoring program. Samples collected by AECOM between September and December 2017 (monitoring ongoing)	Two monitoring sites in Muddy Creek – total of 12 primary samples collected. One monitoring site in the North Scarborough Pond – total of 6 primary samples collected One monitoring site in the North Scarborough Pond – total of 6 primary samples collected
New M5 Motorway surface water quality monitoring program. Samples collected by AECOM between June 2015 and January 2016	Two monitoring sites (Site 3 and Site 4) in Cooks River including collection of 20 samples

Review of previous studies

A description of the existing environmental conditions within the study area has been developed via a review of a number of previous studies relevant to surface water. These studies were sourced from Bayside Council, Roads and Maritime and Sydney Motorway Corporation and are listed in **Table 3-6**.

Table 3-6 Previous studies

Relevance	Reference
Surface water quality, hydrology and natural processes	Bicentennial Park Wetland Concept Report, prepared for Rockdale City Council (Equatica 2011)
Surface water quality	Rockdale City Council Water Quality Study 1999 (Rockdale City Council 1999)
Surface water quality	Rockdale City Council Data Analysis – October 2007 to May 2008, prepared for Rockdale City Council, (Nalco 2008)
Surface water quality	City of Rockdale Water Quality Monitoring Study Report, prepared for Rockdale City Council, (Equatica 2014)
Surface water quality, hydrology and natural processes	Scarborough and Bicentennial Park Ponds – Water Quality Study and Management Plan, prepared for Rockdale City Council (Storm Consulting and the CRC for Freshwater Ecology 2005)
Surface water quality	Scarborough Ponds – Preliminary sediment study, report prepared for the Rockdale City Council (Albani, unknown date)
Surface water quality	Bayside Water Quality Monitoring and Management Review, Annual Report, 2016-17 (Bayside Council 2017)
Surface water quality	City of Rockdale Water Quality Monitoring Study – Part B: Appendices (Equatica 2014)
Surface water quality and quantity	New M5 Motorway Environmental Impact Statement, Appendix L, Technical Working paper: Surface Water (AECOM 2015)
Groundwater quality	F6 Extension – EIS and Concept Design Section A Phase 1: Groundwater Monitoring Boreholes (SMEC 2017)
Groundwater quality	F6 Northern Geotechnical Investigations – Draft Geotechnical Factual Report (SMEC 2018).

3.3.2 Assessment of potential construction impacts

The assessment of hydrological and geomorphological impacts during proposed construction works involved:

- Review of estimated surface water and groundwater use and development of a high level water balance to estimate construction discharge volumes. Annual and daily discharge volumes were estimated based on the construction ancillary facilities as a whole rather than at specific discharge locations within the facilities due to the conceptual nature of the current construction drainage arrangements
- Qualitative assessment of how construction discharges may impact the receiving environment

- Qualitative assessment of the effects of physical disturbance to the waterways during construction.

The assessment of surface water quality impacts during proposed construction works involved:

- Assessment of potential construction activities that could mobilise sediments and other pollutants into the surface water environment
- Review of existing policies and guidelines applicable to the management of water quality during construction
- Assessment of the potential impacts of proposed discharges of treated construction wastewater and surface water on the receiving environment. This included:
    - identification of potential pollutants of concern in surface water and a qualitative assessment of their potential impact, with consideration to the proposed water management systems and typical management practices adopted for road and tunnel projects consistent with standard industry practice.
    - the quality and quantity of pollutants in tunnel groundwater were estimated based on available groundwater quality data, the discharge criteria and estimated tunnel water discharge volumes during construction. Due to the high level of uncertainty in pollutant generation from other sources contributing to the construction tunnel water, pollutant quantities were not estimated for the other sources. Potential pollutants of concern were identified for consideration when identifying management measures. The discharge quality was assumed to be the lesser of the anticipated groundwater quality (refer **section 4.6**) and the respective discharge criteria (refer **Annexure F**)
    - qualitative assessment of the effect of the proposed discharge of treated construction water on the receiving environment.

3.3.3 Assessment of potential operational impacts

The assessment of hydrological and geomorphological impacts during operation involved:

- Water balance to estimate combined discharge volumes at key discharge locations including surface runoff and groundwater releases.
- Qualitative assessment of how operational discharges may impact the receiving environment with consideration to the sensitivity of the receiving waters.

The assessment of surface water quality impacts during operation involved:

- MUSIC modelling of the existing and proposed conditions to assess potential impacts on receiving waters associated with pollutant loads generated from pavement runoff and the performance of the proposed stormwater treatment system
- Box modelling to assess the impact of treated tunnel water discharges on ambient water quality within the Cooks River, with consideration to the proposed treatment plant and dilution and mixing which would occur in the river upon release
- Qualitative assessment of potential impacts associated with spills, including consideration of management practices.

A summary of the MUSIC modelling and Box modelling is provided below, with a full description and assumptions provided in **Annexure C** and **Annexure D** respectively.

MUSIC modelling

The MUSIC model was developed by the Cooperative Research Centre (CRC) for Catchment Hydrology (now eWater CRC) as a decision support system for the design of stormwater treatment devices, and is now considered the standard method for determining compliance with water quality targets within the stormwater industry. The MUSIC model meteorological template and pollutant generation parameters were based on the NSW MUSIC modelling guidelines (BMT WBM 2015).

The performance of the types of treatment devices likely to be used for stormwater quality treatment has been modelled and the results are presented in **section 6.3.2**. The type and design of specific stormwater treatment measures across the project would be further refined as part of detailed design.

Modelling undertaken for this assessment has required assumptions to be made regarding the size of catchments as well as the type, size and design of stormwater quality improvement devices. The results of the modelling should therefore be considered as estimates of the likely treatment performance that can be expected. Modelling would need to be revised during detailed design and this would be accompanied by a description of the treatment devices and any accompanying calculations including the assumptions.

A full description of the methodology and assumptions adopted for the MUSIC model are provided in **Annexure C**.

Box modelling

A box model was developed to simulate the mixing of treated discharges, from the new water treatment plant at Arncliffe, with the Cooks River.

The model incorporated tidal exchange, stormwater and operational water treatment plant discharge inputs. Stormwater inflows were estimated using MUSIC modelling for the upstream catchments. Operational water treatment plant discharges were assessed for the F6 tunnel groundwater flow and for the cumulative scenario of the project and New M5 Motorway tunnel groundwater contributions from the New M5 Motorway tunnel water treatment plant and project operational water treatment plant. The tidal exchange was calculated for mean tidal conditions.

Discharge concentrations were assumed to be the lesser quality of the baseline groundwater quality monitoring and the adopted discharge criteria. The water treatment plant discharge criteria adopted for both the project water treatment plant and New M5 Motorway water treatment plant has been based on the New M5 Motorway EIS Appendix N – Surface Water, *Appendix A – Water Quality Reference Criteria.*

Modelling undertaken for this assessment has required assumptions to be made regarding tidal conditions, channel bathymetry and the size and characteristics of catchment inflows. The results of the modelling should therefore be considered as estimates of the likely mixing that can be expected.

A full description of the methodology and assumptions adopted for the box model are provided in **Annexure D**.

4 Existing environment

4.1 Surface water hydrology

A description of the catchments, waterways and wetlands within the study area is provided in **section 4.1.1** to **section 4.1.5**. **Figure 4-1** shows the waterways, wetlands and surface water catchments.

4.1.1 Cooks River

The Cooks River catchment covers an area of around 10,000 hectares in southern and south western Sydney, discharging to Botany Bay at Mascot. The Cooks River flows for around 23 kilometres from Graf Park in Bankstown to Botany Bay at Kyeemagh (CRA 2013). The major tributaries of the Cooks River include Coxs Creek, Cup and Saucer Creek, Wolli Creek, Bardwell Creek, Alexandria Canal and Muddy Creek. Only Muddy Creek lies within the study area. The tidal limit of the Cooks River is estimated to be adjacent to Sando Reserve, Croydon Park (Manly Hydraulics Laboratory 2005).

The catchment was stripped of its natural vegetation during early European settlement and has been subject to long term anthropogenic development and degradation. The Cooks River catchment is highly urbanised and has a history of intensive land use ranging from residential to heavy industry. The majority of the reaches within the catchment are in a degraded ecological condition, with very little remaining bushland, and only a small amount of parkland (SMCMA 2011).

A number of authorities are responsible for the management of the Cooks River and its catchment, including the local councils located within the Cooks River catchment, the Local Land Services Board, the Environment Protection Agency and Sydney Water.

The landscape and natural function of the catchment and waterways has been impacted by urbanisation within the catchment and the density of the built environment. As a result, the majority of watercourses within the Cooks River catchment are anthropogenic channels. Generally the artificial modifications have included dredging, widening, re-alignment, filling and various forms of armouring such as concrete linings and rock revetments. The development of impervious surfaces within the catchment has increased the volume and rate of runoff, which has in turn necessitated flood mitigation measures primarily in the mid and upper catchment, and bank stabilisation works in the lower catchment (Earth Tech 2007).

Semi-natural channel morphology exists as small, laterally discontinuous reaches where the presence of bedrock have negated the need for channel stabilisation initiatives or the watercourse abuts natural floodplain or parkland. Partly confined and alluvial unconfined reaches exist in the lower catchment only in relatively low energy environments (Earth Tech 2007).

Within the catchment it is estimated that roughly 89 per cent of stormwater travels through a combination of pit and pipe networks, open concrete channels, metal sheet piled channels and rock armoured channels. Around 71 per cent of the stream reaches in the Cooks River catchment have no vegetation or are used for flood control (SMCMA 2011).

Most of the Cooks River bank was built between the late 1940s to the early 1950s as part of the river diversion and land reclamation works associated with the construction of the Sydney Airport. The mouth of the Cooks River was relocated 1.6 kilometres west to its current position during these works (PPK 1999). The Cooks River is almost uniformly 50 metres wide upstream of Cahill Park, Tempe where it widens to roughly 150 metres until its discharge through training walls into Botany Bay. The river in the study area is largely lined with stone/block revetments.

The project elements within the Cooks River catchment include:

- Northbound and southbound tunnels which connect via stub tunnels underground to the WestConnex New M5 Motorway project
- Ventilation tunnels which connect the tunnels to a surface ventilation facility on the site of the Kogarah Golf Course
- Operational tunnel water which would be pumped to a new water treatment plant at Arncliffe, with treated flows ultimately discharged to the Cooks River via the Marsh Street road drainage system. Stormwater generated within the water treatment plant site would be discharged to an existing unnamed watercourse running through the Kogarah Golf Club course ultimately discharging to the Cooks River.
- The Arncliffe construction ancillary facility (C1).

4.1.2 Muddy Creek

The Muddy Creek catchment covers an area of around 615 hectares. The catchment is highly urbanised and spans the LGA's of Bayside Council and Georges River Council including the suburbs of Hurstville, Allawah, Carlton, Kogarah, Bexley, Rockdale, Brighton-Le-Sands and Kyeemagh. Muddy Creek flows in a north-easterly direction, extending around 4.3 km from Forest Road in Hurstville to its confluence with the Cooks River. Its main tributary is the Spring Street Drain.

The upper portion of the catchment, west of the Eastern Suburbs and South Coast Railway Line, predominantly comprises low to medium density residential development. High density residential and commercial development is present along the major transport corridors, as well as the Rockdale Town Centre, while an industrial area is centred around West Botany Street and Lindsay Street. The majority of the catchment's open space areas are mainly located within the lower reaches of Muddy Creek.

The Muddy Creek channel has been highly modified as a result of urbanisation and consists of a series of concrete and brick lined channels and closed box culvert structures that extend from Willison Road in Carlton to Bestic Street in Kyeemagh. North (downstream) of Bestic Street the concrete lined channel discharges into an estuarine channel which runs through Barton Park to the Cooks River. A photograph of Muddy Creek is provided in **Annexure A**.

The shared cycle and pedestrian pathway between Bestic Street and Bay Street for pedestrians and cyclists is to be located within the Muddy Creek catchment. The proposed tunnel would also pass through the catchment. The construction water treatment plants for the Rockdale construction ancillary facility (C2) and the President Avenue construction ancillary facility (C3) would discharge to stormwater drainage ultimately draining to Muddy Creek.

4.1.3 Scarborough Ponds

Scarborough Ponds extends between Rockdale Bicentennial Park and Tonbridge Street reserve and comprises a series of three pond systems including Rockdale Bicentennial Park Pond, otherwise known as Rockdale Wetland, and the Northern and Southern Scarborough Ponds as shown in **Figure 4-1**.

The Scarborough Ponds catchment covers an area of around 400 hectares and extends between Bay Street in the north, Rocky Point Road in the west, Grand Parade in the east and Ramsgate Road in the south. The catchment spans across the Bayside Council LGA and Georges River Council LGA and includes the suburbs of Brighton-Le-Sands, Rockdale, Kogarah, Beverly Park, Monterey, Ramsgate and Ramsgate Beach.

The western and eastern sides of the catchment predominantly comprise medium density residential development with some industrial development situated around the northern edges of the Rockdale Bicentennial Park Pond. A large amount of open space also occurs within the central portion of the catchment adjacent to the ponds. Stormwater runoff from urbanised areas is conveyed by a pit and pipe network into Scarborough Ponds via a series of piped outlets.

The Rockdale Bicentennial Park Pond situated to the north of President Avenue is a highly modified, freshwater system. The Rockdale Bicentennial Park Pond is around 1.2 to 2.0 metres deep (Storm Consulting 2006) and functions as a stormwater detention system, habitat for birds and other species and as an asset for passive recreation (Equatica 2011). The Rockdale Bicentennial Park Pond is situated within a sandy aquifer and water levels are likely to be consistent with local groundwater levels during dry periods which groundwater monitoring indicates to be around 1 m AHD to 1.5 m AHD. Former landfills occur to the east and west of the Rockdale Bicentennial Park Pond, which may be resulting in groundwater of high nitrogen content leaching into the pond (Equatica 2011), refer **section 4.2.3** for further discussion on the water quality of the Rockdale Bicentennial Park Pond.

A site inspection of Rockdale Bicentennial Park Pond was undertaken on 18 December 2017. A large amount of duckweed was observed within the pond (refer Photograph 2 and 3 in **Annexure A**) which corresponds with reports of duckweed infestations (GHD 2017) occurring within Rockdale Bicentennial Park Pond and upper part of the Northern Scarborough Pond. Equatica (2011) and Storm Consulting (2006) also reported that seasonal algal blooms occur in the pond. Duckweed and algal growth is dependent on light, nutrients and temperature. It is likely that as aquatic weeds and algae die off and settle to the base of the pond the nutrients and organic matter would be stored with the potential to be released back into the water column, particularly during anaerobic conditions. Equatica (2011) indicated that an algal bloom occurred in Spring of 2010 following a duckweed die off event, likely the result of increased light energy combined with a spike in oxidised nitrogen released from the decaying duckweed. Higher salinity levels in the downstream areas of Northern Scarborough Pond and the Southern Scarborough Pond are likely to prevent infestations occurring due to duckweed not tolerating higher levels of salinity (GHD 2017). Bayside Council have installed a Floating Wetland (refer Photograph 4 in **Annexure A**), which would provide some nutrient stripping function, within the flow path to the west of the island in the southern part of Rockdale Bicentennial Park Pond. A trash rack is also installed on the stormwater outlet located downstream of the Rockdale Bicentennial Park car park.

The Rockdale Bicentennial Park Pond is separated from the Northern Scarborough Pond by a 1.8 metre by 0.9 metre box culvert beneath President Avenue. A weir controls water levels within the Rockdale Bicentennial Park Pond, before flowing into the culvert (refer Photograph 5 in **Annexure A**). The culvert discharges into an open channel immediately downstream of President Avenue (refer Photograph 6 in **Annexure A**), which includes a floating boom and litter trap to collect floating litter and plants prior to discharges to the Northern Scarborough Pond.

The Northern Scarborough Pond is tidally affected and stratification between the freshwater and saline water occurs (Storm Consulting 2006). Bayside Council have installed mechanical aerators in the Northern Scarborough Pond and Southern Scarborough Pond to mix the stratified surface water and deeper water layers in order to increase aeration and dissolved oxygen. The Northern Scarborough Pond drains to the Southern Scarborough Pond (SS Pond) via five 1050 mm diameter culverts beneath Barton Road.

The Southern Scarborough Pond forms a tidal creek at its southern end which provides important habitat for fish in Botany Bay (Storm Consulting 2006). Three 1350 mm diameter pipes connect the southern end of the ponds to Walmer Street and outlet into Botany Bay at the eastern end of Florence Street (Lyall and Associates 2017). The pipes allow tidal exchange with Botany Bay as well as a modified access route for fish and invertebrates (Storm Consulting 2006). Salinity monitoring has indicated that the Southern Scarborough Pond is permanently stratified with varying depths of freshwater flowing across the surface and high salinity water at the base of the pond (Storm Consulting 2006). A mechanical aerator is also located within this pond.

Fishkill events are known to have occurred in 2004 and 2016. Storm Consulting (2005) concluded that it was highly likely that the 2004 event, characterized by depleted oxygen and strong odours, occurred due to mixing of bottom layers in the ponds with surface water. The likely causes of the mixing were identified as strong winds in the week and days preceding the event and high stormwater inflows in the weeks prior (GHD 2017) and that it was unlikely that the mechanical aerators would have been the sole cause of the fish kill and odour event. However, when run at full power, the aerators could potentially generate a local plume of bottom water, exacerbating the release of odours and mixing of highly turbid and dirty water at the base of the pond with water at the surface. The 2016 event was investigated by the EPA who concluded that anoxic conditions, coupled with other undesirable effects, caused by an inversion of the water body are likely to have caused the fish kill and that it was not related to catchment runoff or an industrial or sewage discharge (GHD 2017).

The following project elements are located within the Scarborough Ponds catchment:

- Tunnel portals with entry and exit ramps connecting the F6 Extension Stage 1 (New M5 Motorway at Arncliffe to President Avenue at Kogarah) tunnels with President Avenue
- Widening and raising of President Avenue between Oakdale Avenue and O'Connell Street to accommodate the new connection
- Rockdale Motorway Operations Complex (north) (MOC2) which would house the Operational Motorway Control Centre, car parking, deluge tanks, workshop, office, bulky equipment store, pump station and pump room and a work yard
- Rockdale Motorway Operations Complex (south) (MOC3) which would house the Rockdale Ventilation Facility and an electrical substation

- Network adjustments at the Princes Highway/ President Avenue intersection to provide additional southbound left turn and northbound right turn lanes onto President Avenue
- Shared cycle and pedestrian pathway between Bay Street and Civic Avenue for pedestrians and cyclists
- Operational water quality basin in the south-eastern corner of Rockdale Bicentennial Park which would discharge to Rockdale Bicentennial Park Pond
- Construction access decline, deluge system and maintenance depot near West Botany Street.

No construction works or operational facilities would be located within the Southern Scarborough Pond sub-catchment. Therefore the receiving waters are considered to be Rockdale Bicentennial Park Pond and North Scarborough Pond with the Southern Scarborough Pond being a downstream sensitive environment.

4.1.4 Spring Street Drain

The Spring Street Drain sub-catchment is located within the Bayside Council LGA and covers an area of around 257 hectares including the suburbs of Arncliffe, Banksia and Rockdale. The Spring Street Drain is a concrete lined channel which flows easterly for around 1.3 kilometres, from Short Street in Banksia to its confluence with Muddy Creek.

A sub-branch of the Spring Street Drain runs in a north-easterly direction and joins the main channel around 160 metres upstream of West Botany Street. This sub-branch comprises a series of channel and culvert reaches, ending in a concrete lined channel where it discharges into Spring Street Drain (Lyall and Associates 2017).

The mainline tunnel would cross underneath the Spring Street Drain. No surface works are proposed within the catchment other than trenching required for installation of the proposed power supply connection. As the project would have minimal and temporary disturbance only at surface, surface water impacts within this catchment have not been considered any further.

4.1.5 Eve Street Wetland

Eve Street Wetland is located on the southern side of the M5 Motorway within the suburb of Arncliffe in the Bayside Council LGA. Its catchment covers an area of around 28 hectares and drains westerly, extending from the Princes Highway at Arncliffe to the Eve Street Wetland (Lyall and Associates 2017).

The catchment is predominantly low to medium density residential development with some areas of open space in its lower reaches. Stormwater runoff from urbanised areas is conveyed by a pit and pipe network into Eve Street Wetland. Flows that surcharge the Eve Street Wetland are conveyed via a vegetated channel in an easterly direction under the bridged section of the M5 Motorway, prior to discharging into the Cooks River (Lyall and Associates 2017).

The mainline tunnel would cross beneath the Eve Street Wetland catchment. No surface works are proposed within the catchment. As the project would not impact the waterway or catchment at surface, surface water impacts within this catchment have not been considered any further.

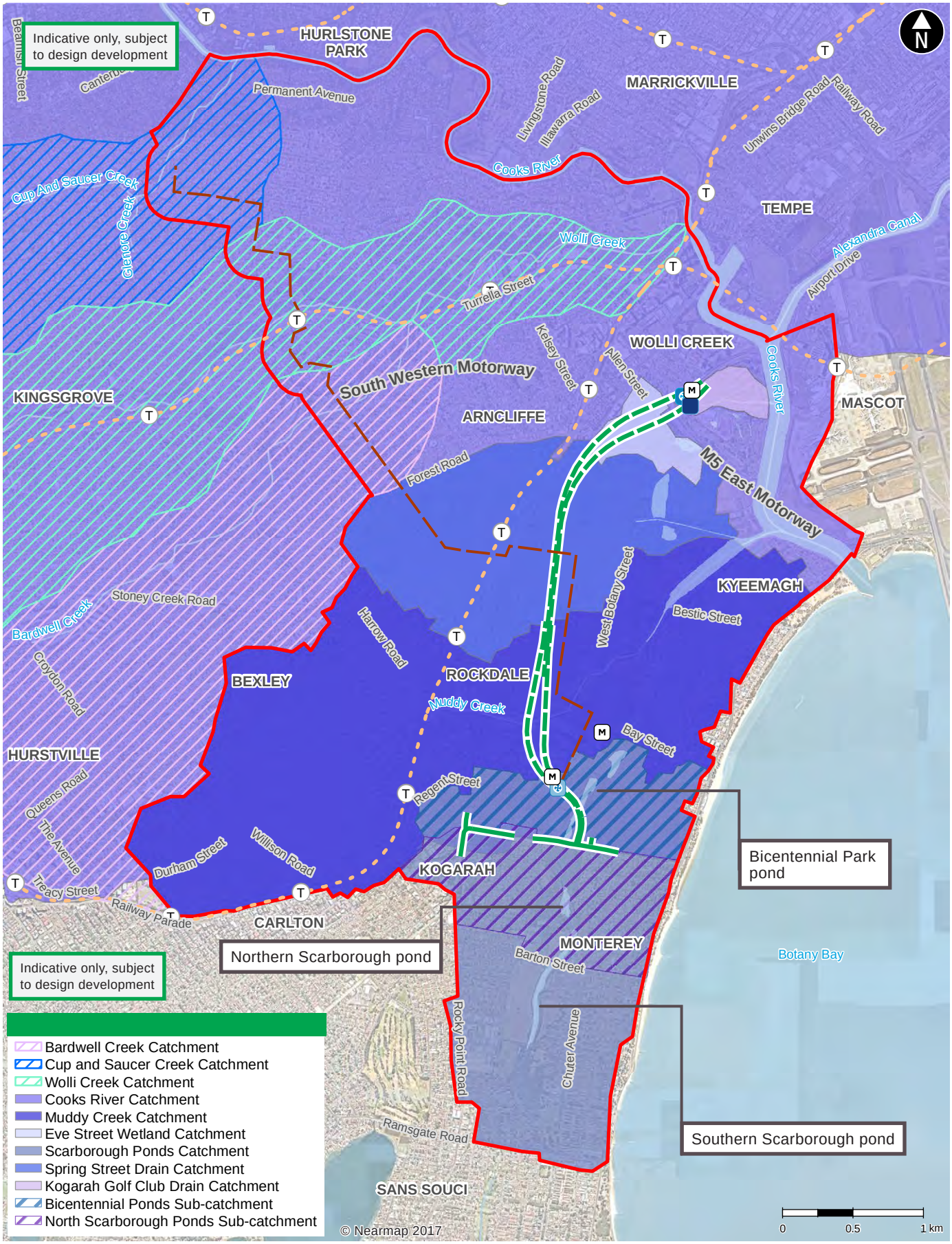
4.1.6 Kogarah Golf Club drain

An unnamed watercourse runs easterly through the Kogarah Golf Club course. The drain, hereby referred to as the Kogarah Golf Club drain, is an artificial, tidally affected watercourse. Its catchment is around 15 hectares receiving runoff from the southern portion of the golf course.

A portion of the stormwater runoff generated within the project operational water treatment plant site (refer **section 2.3**) would be discharged to the drain.

4.1.7 Other waterways

The proposed power supply connection between the Ausgrid Canterbury subtransmission substation and the Rockdale Motorway Operations Complex south runs through the catchments of Cup and Saucer Creek, Wolli Creek, Bardwell Creek, Spring Street Drain, Muddy Creek and Rockdale Bicentennial Park Pond. Due to the minor nature of the proposed power supply works, the existing surface water environment west of the Spring Street Drain catchment has not been characterised in detail.



LEGEND

- The project in tunnel
- The project on surface
- Permanent power supply line
- Surface water study area
- Water treatment facility
- Rockdale ventilation facility
- Motorway operations complex
- Arncliffe ventilation facility*
- * Under construction as part of the New M5 Motorway project
- Railway station
- Railway line
- Waterway
- Waterbody

Figure 4-1 Surface water hydrology

4.2 Surface water quality

A review of water quality reports and data (refer **section 3.3.1**) was undertaken to gain an appreciation of water quality conditions within the receiving waterways including the Cooks River, Muddy Creek and Scarborough Ponds.

A statistical summary of the monitoring results is provided in **Annexure E**. The findings of the desktop review of surface water quality is summarised in **sections 4.2.1** to **4.2.3**.

4.2.1 Cooks River

Surface water quality monitoring was undertaken within the Cooks River as part of the WestConnex New M5 Motorway project (AECOM 2015). Two monitoring points (Site 3 and Site 4) are around 170 metres upstream and one kilometre downstream respectively of the proposed operational water treatment plant discharge location (refer **Figure 4-2**).

Median concentrations for total nitrogen, total phosphorus, reactive phosphorus, cadmium, chromium, copper, lead and zinc were above ANZECC (2000) slightly to moderately disturbed (SMD) trigger levels with nitrate, arsenic, mercury and nickel also exceeding on some occasions. It is noted that the limit of reporting for cadmium, copper and chromium was set above the SMD trigger level on some occasions. Median lead concentrations were also above the ANZECC (2000) 80% species protection level (80% SPL) with zinc, mercury and copper also exceeding the respective criteria on some occasions. Zinc consistently exceeded the aquatic foods criteria. Median concentrations of ammonia exceeded the ANZECC (2000) recreational water quality (RWQ) criteria with iron also exceeding the respective criteria on some occasions. The results are indicative of a highly disturbed urban waterway.

4.2.2 Muddy Creek

Surface water quality monitoring was undertaken as part of the project (SW1 and SW2) within Muddy Creek (refer **Figure 4-2**). Median concentrations of total nitrogen, total phosphorus, reactive phosphorus, copper and zinc exceeded SMD trigger levels with lead, nitrate and ammonia also exceeding on some occasions. Median zinc concentrations exceeded the aquatic foods criteria and zinc, copper, lead and ammonia concentrations were also above the 80% SPL on some occasions. Median ammonia concentrations exceeded the RWQ criteria, with iron also exceeding the RWQ criteria on some occasions. Zinc consistently exceeded the aquatic foods criteria. The pH was below the SMD low range level on one occasion at SW1. The results are indicative of a highly disturbed urban waterway.

4.2.3 Scarborough Ponds

Surface water quality monitoring was undertaken at Rockdale Bicentennial Park Pond (SW3) and the Northern Scarborough Pond (SW4) as part of the project. In Rockdale Bicentennial Park Pond, median concentrations of ammonia, total nitrogen, total phosphorus, reactive phosphorus, copper and zinc exceeded SMD freshwater trigger levels with chromium, nitrate and lead also exceeding on some occasions. Iron and manganese concentrations also exceeded the RWQ criteria. Ammonia, copper, lead and zinc concentrations exceeded the 80% SPL for freshwater systems on some occasions. All iron concentrations exceeded the RWQ criteria as did the median ammonia concentrations. In Northern Scarborough Ponds, median concentrations of total nitrogen, total phosphorus, copper and zinc exceeded the SMD estuarine/marine trigger levels with copper and lead also exceeding the 80% SPL on some occasions. All ammonia concentrations exceeded the RWQ criteria and iron concentrations exceeded the RWQ criteria on some occasions. The pH was outside the SMD range on some occasions.

Some of the total nitrogen concentrations were higher than levels typical of urban stormwater inflows indicating the elevated levels are likely to be related to another source. Equatica (2011) indicated that the elevated nitrogen levels in the Rockdale Bicentennial Park Pond were likely to be attributable groundwater inflows affected by residual waste within a landfill located adjacent to the Rockdale Bicentennial Park Pond.

Within the Northern Scarborough Pond, median concentrations of total nitrogen, total phosphorus, copper and zinc exceeded the SMD estuarine/marine water trigger levels with copper and lead also exceeding the 80% SPL on some occasions. All ammonia concentrations exceeded the RWQ criteria and iron concentrations exceeded the RWQ criteria on some occasions. The pH was outside the SMD range on some occasions.

Water quality monitoring was conducted by GHD in 2016 to 2017 on behalf of Bayside Council, Equatica in 2012 to 2013 on behalf of the former Rockdale City Council and in 1999 by Rockdale City Council. The key findings in relation to water quality within the receiving waters of Rockdale Bicentennial Park Pond and Northern Scarborough Pond are summarised in **Table 4-1**, **Table 4-2** and **Table 4-3**. The results are indicative of a highly disturbed urban waterway.

Figure 4-2 Surface water monitoring locations

Table 4-1 Summary of key findings of Rockdale Bicentennial Park and North Scarborough Pond water quality monitoring 2016 to 2017 (GHD 2017)

Parameter	Key findings
pH	Occasionally outside the slightly to moderately disturbed (SMD) ANZECC (2000) guideline criteria and generally consistent through the vertical profile.
Temperature	Ranged between 13ºC to 29ºC with freshwater sites in Rockdale Bicentennial Park Pond and 13ºC to 29ºC in Northern Scarborough Pond. No evidence of thermal stratification along the vertical water column even during summer months.
Salinity	Low salinity (280 to 727µS/cm) recorded in Rockdale Bicentennial Park Pond. Brackish to saline conditions (5,946 to 52,819 µS/cm) observed in Northern Scarborough Pond. Results showed that saltwater intrusion and strong tidal flows influence Northern Scarborough Pond with freshwater conditions occurring in Rockdale Bicentennial Park Pond.
Dissolved Oxygen	Median dissolved oxygen (DO) concentrations were outside the SMD guideline low level (ANZECC 2000) at all Rockdale Bicentennial Park Pond and Northern Scarborough Pond sites, although DO declined with depth, with DO in surface samples often within the guideline.
Turbidity	Turbidity was highly variable ranging between 1.5 and 1140 NTU in Rockdale Bicentennial Park Pond and 2.4 and 687 in Northern Scarborough Pond.
Nutrients	Very high levels of ammonia (up to 10.6 mg/L) were recorded in Rockdale Bicentennial Park Pond with high levels also recorded in Northern Scarborough Pond (up to 2mg/L). Very high total nitrogen (TN) concentrations (up to 11 mg/L) were recorded in Rockdale Bicentennial Park Pond and in Northern Scarborough Pond (6.6mg/L). All results were above the SMD guideline criteria. Median total phosphorus (TP) and reactive phosphorus concentrations were above SMD guideline criteria at Rockdale Bicentennial Park Pond and Northern Scarborough pond with very high TP (0.46 mg/L) and reactive phosphorus (0.24mg/L) recorded in the Rockdale Bicentennial Park Pond.
Sulfur and sulphides	Concentrations of dissolved sulfides were very low. Elemental sulphur occurred in quite high concentrations in Northern Scarborough Pond but low in Rockdale Bicentennial Park Pond.

Table 4-2 Summary of key findings of Rockdale Bicentennial Park Pond water quality monitoring 2013 to 2014 (Equatica 2014)

Parameter	Key findings
Turbidity	Low turbidity levels recorded (mean of 5.1NTU).
Nutrients	Very high levels of total nitrogen (mean concentrations of 6mg/L), thought to be entering ponds from adjacent landfill. High levels of nitrogen were shown to be lower after runoff events indicating dilution was occurring. Elevated mean TP concentration (0.36mg/L). The high TN concentrations were relatively consistent with historical monitoring (TN mean concentration was 6.9 mg/L in 1999, 7.0mg/L in 2007, 9.3 mg/L in 2010 and 6.6 mg/L in 2012).
Heavy metals	Most heavy metal concentrations were relatively low compared to respective ANZECC (2000) criteria. One sample exceeded ANZECC (2000) 80% protection level for copper. One sample exceeded ANZECC (2000) 95% protection level for zinc.

Table 4-3 Summary of key findings of Rockdale Bicentennial Park Pond water quality monitoring 1999 (Rockdale City Council 1999)

Parameter	Key findings
Dissolved oxygen	Low dissolved oxygen levels, ranging between 3.5 and 13.1 mg/L, likely due to the breakdown of organic matter and poor oxygenation due to the lack of water movement and mixing.
Nutrients	Elevated levels of TN with mean concentration of 6.9 mg/L. Elevated levels of TP with concentrations ranging between 0.04 and 0.19 mg/L.
Heavy metals	Most heavy metal concentrations were relatively low

A sediment study prepared by A.D. Albani, on behalf of the former Rockdale City Council reported elevated levels of heavy metals (zinc, lead and arsenic) in sediments in Scarborough Ponds. GHD (2017) also reported the occurrence of high levels of zinc and lead as well as nutrients including carbon in the Rockdale Bicentennial Park Pond. Further discussion on sediment contamination is provided in **Appendix J** of the EIS (Contamination Technical Report).

4.3 Surface water resources

4.3.1 Water supply

The study area is highly urbanised and has access to water utility services. There are no known locations where water is extracted directly from the watercourses or wetlands within the study area for domestic, agriculture or industrial uses. However, stormwater is captured from rooves and surfaces within the urban landscape for the purposes of irrigation, domestic non-potable uses and for construction and operational activities.

The project is located within an area covered by the *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources*. This Plan includes rules for protecting the environment, extractions, managing licence holders' water accounts, and water trading in the plan area (DPI 2016).

The project does not propose to extract any surface water directly from the local waterways, although some surface water collected within the construction compounds may be reused for construction activities. Under Schedule 5, Part 1, clause 2 of the *Water Management (General) Regulation 2011* (NSW), roads authorities are exempt from the requirement to hold a water access licence to take water for road construction and road maintenance.

4.3.2 Environmental flows and water variability

Urbanisation within the study area has resulted in increases in impervious surfaces which generates more runoff than previously occurred naturally. In addition, leaking water utilities and landscape irrigation may also lead to unnatural permanent flows in some instances. This leads to problems with waterway health (e.g. stream stability).

In line with the NSW RFOs to maintain natural flow variability (refer **Table 3-1** and **Table 3-2** there is a need within the urban catchments in the study area to reduce runoff volumes where possible. Conversely, there is limited application for the protection of natural low flows / environmental flows within the study area.

Cooks River, Muddy Creek and the Northern and Southern Scarborough Ponds are tidally affected, (refer **section 4.1**). Scarborough Ponds, including Rockdale Bicentennial Park, and the Northern and Southern Scarborough Ponds, is located within a sand aquifer with groundwater inflows into the ponds occurring (refer **section 4.1.3**).

4.4 Riparian corridors

Existing riparian vegetation has been identified and assessed within **Appendix H** of the EIS (Biodiversity Development Assessment Report). A summary of the riparian vegetation is provided in **Table 4-4**.

Table 4-4 Summary of riparian vegetation

Surface water feature	Description of riparian vegetation
Rockdale Bicentennial Park Pond	Dense cover of native trees with scattered shrubs and groundcovers. Dense weeds such as Lantana camara (Lantana) and Erythrina crista-galli (Cockspur Coral Tree) occurred in patches
Open channel between President Avenue and Northern Scarborough Pond	A dense reedland of Typha orientalis (Typha) and Phragmites australis (Common Reed) extended westward of the channel, whilst the eastern bank supported scattered Casuarina glauca (She Oak) trees
Muddy Creek upstream of Bestic Street	Saltmarsh and mangroves present. High impact weeds included Juncus acutus (Sharp Rush) at the southern extent of the saltmarsh. Vegetation within drainage lines entering Muddy Creek included a narrow mangrove forest originating from a stormwater culvert at Cairnsfoot Special School. The other was west of the football field, comprised of mown lawn and reeds (Phragmites australis)
Cooks River near Kogarah Golf course	No mangrove or saltmarsh have established

4.5 Sensitivity of receiving environments

A summary and assessment of the sensitivity of the receiving environments (including estuarine and marine environments downstream) to hydrological and water quality impacts associated with the project is provided within **Table 4-5**.

The chain of ponds which make up Scarborough Ponds are considered to be of moderate sensitivity due to having good ecological habitat despite being highly modified systems. Botany Bay is considered to be a moderately sensitive downstream environment considering its high conservation value and significant tidal exchange. Cooks River and Muddy Creek are considered to be of low sensitivity due to their limited ecological habitat and significant tidal exchange.

Table 4-5 Sensitivity of receiving environments

Surface water feature	Description of surface water feature in study area	Condition	Sensitivity
Receiving environments			
Lower Cooks River	Estuarine, anthropogenic banks, poor water quality, limited riparian vegetation in reach within study area, key fish habitat, some recreational use.	Highly disturbed	Low
Muddy Creek	Estuarine, anthropogenic channel, poor water quality, limited riparian vegetation, some ecological value in estuarine reach, some recreational use.	Highly disturbed	Low
Rockdale Bicentennial Park Pond	Freshwater, modified open water body, poor water quality with tendency for algal blooms, provides ecological habitat and passive recreational use	Highly disturbed	Moderate
Northern Scarborough Ponds	Tidally influenced, modified open water body, poor water quality, provides ecological habitat and passive recreational use	Highly disturbed	Moderate
Downstream environments			
Southern Scarborough Ponds	Tidally influenced, modified open water body, provides ecological habitat and passive recreational use	Highly disturbed	Moderate
Botany Bay	Estuarine, largely unmodified, good water quality, high ecological value, high recreational value.	High conservation value	Moderate

4.6 Groundwater quality

Groundwater quality monitoring data was reviewed to gain an understanding of the likely quality of groundwater inflows into the tunnel during construction and operation. The locations of the monitoring wells used to inform tunnel groundwater quality are shown in **Figure 4-3**.

Monitoring data was separated into two zones as described as follows:

- Wells within Hawkesbury Sandstone, Alluvium and Botany Sands to the north west of Rockdale Bicentennial Park adjacent to the tunnel alignment. The summary of this data is designated as 'tunnel' groundwater in **Table 4-6** and considered to be an estimate of the average quality of groundwater which may enter the bored tunnel sections during construction and the tunnel during operation
- Wells within Botany Sands within Rockdale Bicentennial Park. The summary of this data is described as 'Rockdale Bicentennial Park' groundwater in **Table 4-6** and considered to be an estimate of the average quality of groundwater which may enter the cut and cover tunnel works during construction. The tunnel is assumed to be sealed through this area during operation.

Table 4-6 Summary of groundwater quality

Parameter	WQOs[1]	Tunnel groundwater Mean (mg/L)	Tunnel groundwater Upper bound (mg/L)	Rockdale Bicentennial Park groundwater Mean (mg/L)	Bicentennial Park groundwater Upper Bound (mg/L)
Arsenic	0.013	0.004	0.010	0.012	0.021
Cadmium	0.0007	0.00005	0.00007	0.00015	0.00020
Chromium (III + VI)	0.0044	0.0005	0.0005	0.0010	0.0014
Copper	0.0013	0.0005	0.0005	0.0010	0.0013
Iron	0.3	6.9	13.7	27.7	44.1
Lead	0.0044	0.0005	0.0005	0.0049	0.0075
Manganese	0.1	0.28	0.37	0.49	0.63
Mercury	0.0001	0.000025	0.000025	0.000025	0.000025
Nickel	0.007	0.0034	0.0051	0.0062	0.0074
Zinc	0.005	0.013	0.022	0.047	0.065
Total Nitrogen	0.3	2.5	3.7	52.7	85.1
Total Phosphate	0.03 [2]	0.15	0.25	0.008	0.012
Ammonia	0.01	0.99	1.6	40.2	65.3

[1] Refer Table 3-3

[2] Total Phosphorus SMD trigger level adopted

[3] Grey shading indicates concentration is elevated in relation to WQO

LEGEND

- The project in tunnel
- The project on surface
- F6 Monitoring well location
- Monitoring well location RMS, 2015
- Monitoring well location AECOM, 2017
- Monitoring well location SMEC, 2018
- Test Pit location SMEC, 2018
- Railway station
- Railway line

Figure 4-3 Groundwater mointoring locations used to inform tunnel groundwater quality assessment

Table 4-6 indicates that groundwater entering the tunnelling works (outside Rockdale Bicentennial Park) may contain elevated concentrations (compared to the NSW WQOs) of iron, manganese, zinc, total nitrogen, total phosphate and ammonia. Groundwater entering tunnelling works within Rockdale Bicentennial Park Pond may contain elevated levels of arsenic, iron, lead, manganese, nickel, zinc, total nitrogen and ammonia. Whilst not included in **Table 4-6**, various hydrocarbons were also detected at low concentrations in the wells on some occasions. Full details of the groundwater quality monitoring is provided in **Appendix K** of the EIS (Groundwater Technical Report). Further groundwater quality monitoring and assessment will be undertaken during detailed design to improve the characterisation of tunnel groundwater quality and inform the design of water treatment facilities.

4.7 Soils

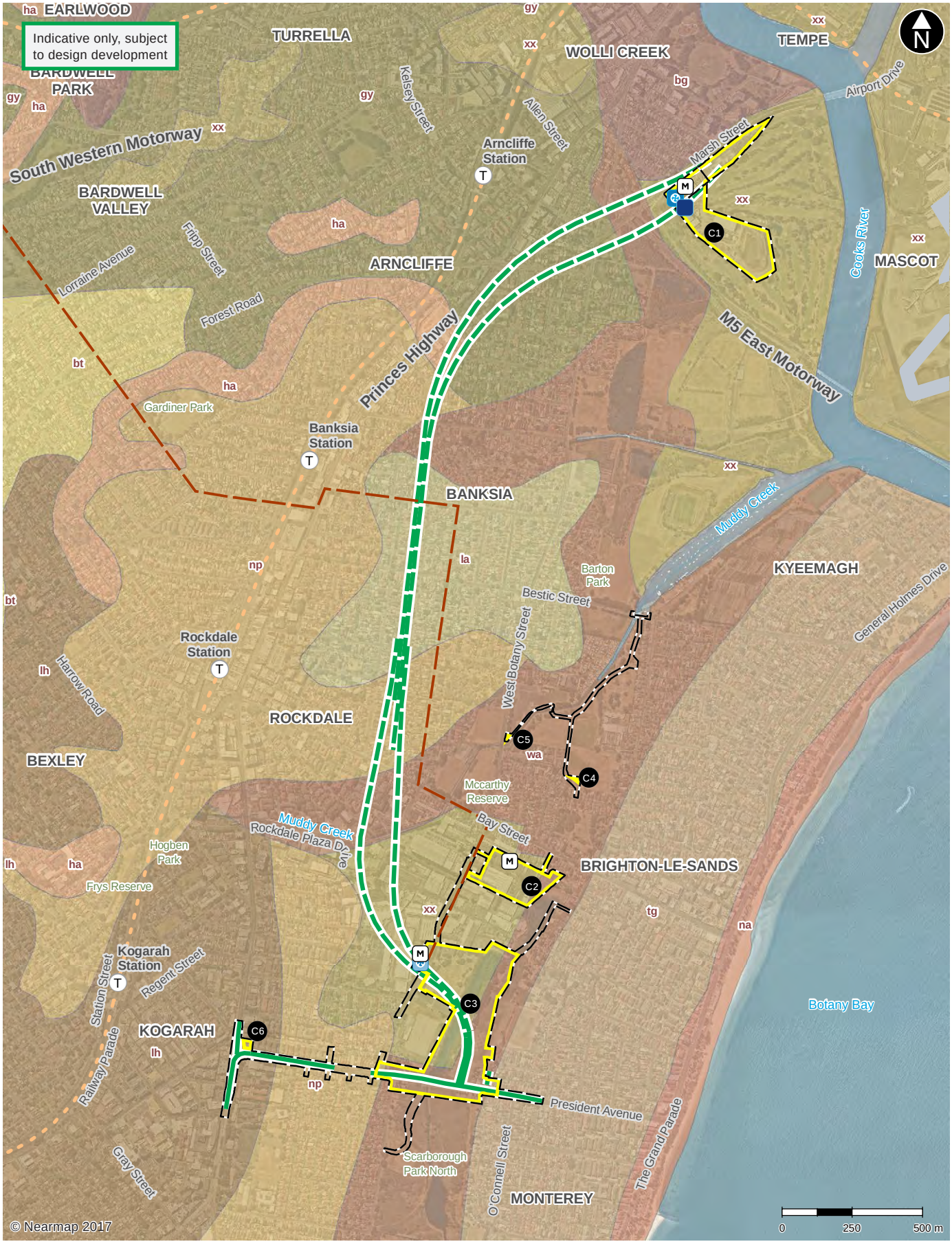
4.7.1 Soil landscapes

The Soil Landscapes of the Sydney 1:100,000 Sheet 9130 (NSW Department of Conservation and Land Management 1989) indicates that the project boundary is underlain by seven soil landscapes. These are shown in **Figure 4-4**. Characteristics of the soil landscapes, as well as their potential for erosion are summarised in **Table 4-7**.

Table 4-7 Soil landscapes

Soil landscape	Characteristics	Erosion potential	Sediment type
Tuggerah (tg1 to tg6)	Occurs on gently undulating to rolling coastal dunefields. Soils comprise loamy sand, sand and clayey sands	Low erodibility as soils consist of highly permeable, coarse sand grains, however lack of cohesion makes them susceptible to concentrated flows. Low to moderate erosion hazard for non-concentrated flows. Very high to extreme erosion hazard for concentrated flows.	Type C
Warriewood (wa1 to wa6)	Occur on level to gently undulating swales, depressions and infilled lagoons on quaternary sands. Soils comprise loamy sand, sand and peat (silt loam or silty clay loam) Market gardening at Kyeemagh occurs	Low to very low erodibility. Relatively stable and consist of well drained stable coarse sands or coarse sand grains weakly held together by organic matter or iron compounds The erosion hazard for non-concentrated flows is low. The erosion hazard for concentrated flows is moderate to high and for wind erosion is low to moderate. Ground surface within project boundary is generally stabilised due to urban development.	Type C
Newport (np1 to np6)	Occur on gently undulating plains to rolling rises of Holocene sands mantling other soil material or bedrock. Soils comprise sand, sandy loam, clayey sand and loamy sand	Soils range from having low erodibility (np 4 and np 5) to being moderately erodible (np1, np2, np3 and np6). Erosion hazard for non-concentrated flows is generally high but ranges from high to extreme. Erosion hazard for concentrated flows and wind is high. Ground surface within project boundary is generally stabilised due to urban development.	Type C

Soil landscape	Characteristics	Erosion potential	Sediment type
Lambert (la1 to la6)	Occur on undulating to rolling low hills on Hawkesbury Sandstone Soils comprise loamy sand, sandy loam, sandy clay loam, clayey sand and weathered sandstone	Soil materials are low (la5, la6) to moderately erodible. The soil erosion hazard for non-concentrated flows is usually very high but ranges from low to extreme. The soil erosion hazard from concentrated flow is extreme	Type C (Type D for Clays)
Gymea (gy1 to gy4)	Occurs on undulating to rolling rises and low hills on Hawkesbury Sandstone Soils comprise loamy sand, sandy loam, clayey sand, sandy clay loam, sandy clay and light clay	Very low (gy1 and gy2), moderately (gy3) and highly erodible (gy4) soils. Erosion hazard for non-concentrated flows is generally high to very high but can range from moderate to extreme. Soil erosion hazard for concentrated flows is high to extreme.	Type C (Type D for Clays)
Disturbed Terrain (xx1 to xx4)	Terrain extensively disturbed by human activity, including complete disturbance, removal or burial of soil. Variable relief and slopes Variable soils.	Erodibility and erosion hazard is variable.	-
Hawkesbury (ha1)	Occur on rugged, rolling to very steep hills on Hawkesbury Sandstone. Soils include sand, sandy loam, clayey sand, sandy clay loam and medium clay	Low (ha1) to moderate (ha2, ha3) erodibility. Erosion hazard for non-concentrated flows is generally very high and ranges from moderate to extreme. The soil erosion hazard for concentrated flows is extreme.	Variable Type C, D and F



LEGEND

- The project in tunnel
- The project on surface
- Construction boundary
- Construction ancillary facility
- Permanent power supply line
- Railway line
- Railway station
- Water treatment facility
- Rockdale ventilation facility
- Motorway operations complex
- Arncliffe ventilation facility*

* Under construction as part of the New M5 Motorway project

- bg - Birrong
- bt - Blacktown
- gy - Gymea
- ha - Hawkesbury
- la - Lambert
- lh - Lucas heights
- np - Newport
- na - Narrabeen
- tg - Tuggerah
- wa - Warriewood
- xx - Disturbed

Figure 4-4 Soil landscapes

4.7.2 Contaminated soils

The presence of contaminated soils has been assessed within **Appendix J** of the EIS (Contamination Technical Report), which should be referred to for further details and proposed management measures.

4.7.3 Soil salinity

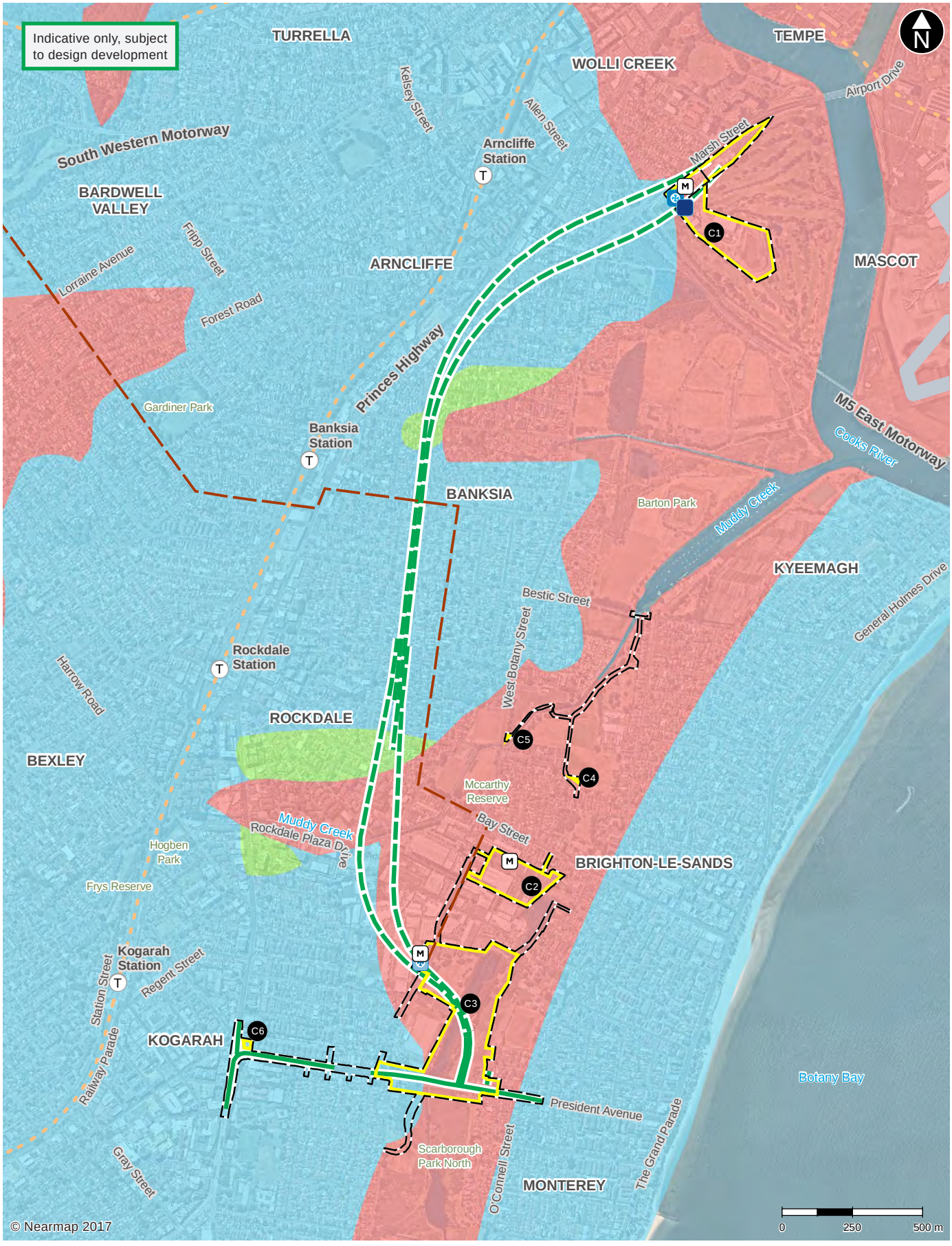
Salinity is an important variable in landscape systems and is often a determining factor in the capacity of the landscape to absorb change. It can impact on landscapes, namely land salinisation (salts stored in the soil profile are mobilised by water movement), in-stream salt load and in-stream salt concentration (DPI 2013).

Localised soil salinity is reported to occur within the Tuggerah (tg3 and tg5) and Disturbed Terrain (xx4) soil landscapes (Chapman *et al* 1989).

The risk of salinity impacts can be increased by clearing vegetation, irrigation or other activities that can lead to a rise in the groundwater table.

A map showing the broad salinity hazard distribution across the Sydney Metropolitan Catchment Management Authority Area (SMCMA) as developed as part of the Catchment Action Plan for the SMCMA area (DPI 2013). The hazard mapping in relation to the project boundary is shown in **Figure 4-5**.

Parts of the project boundary are located within areas depicted as having a very high salinity hazard based on the Sydney Hazard for Catchment Action Plan Update map (DPI 2013). The remainder of the project boundary is located within areas of very low salinity hazard (DPI 2013).



LEGEND

- The project in tunnel
- The project on surface
- Construction boundary
- Construction ancillary facility
- Permanent power supply line
- Water treatment facility
- Rockdale ventilation facility
- Motorway operations complex
- Arncliffe ventilation facility*
- * Under construction as part of the New M5 Motorway project
- Very High
- Low
- Very Low
- Railway station
- Railway line

Figure 4-5 Salinity hazard

5 Assessment of construction impacts

This chapter identifies and assesses the potential construction phase impacts to the hydrology, geomorphology, natural processes and water quality of surface waters. A water balance was undertaken focussing on water intake from surface water resources and the volume, frequency and duration of discharges to surface waters (including outputs from a combination of sources) which may impact the surface water environment. The potential impacts have been assessed with consideration to relevant components of the design which were developed to manage impacts to surface waters.

The following sections include:

- The water balance for the construction phase in **section 5.1**
- **Section 5.2** identifies and assesses potential impacts to surface water hydrology, geomorphology and natural processes
- **Section 5.3** identifies and assesses potential impacts to surface water quality
- **Section 5.4** identifies and assesses potential impacts to soil in relation to erosion and salinity.

5.1 Surface water balance

A water balance was conducted to estimate the annual volumes of surface water and groundwater that would be used and discharged during construction of the project. The water balance for each construction ancillary facility is summarised in **Table 5-1**. **Table 5-2** provides the estimated volumes of water that would be discharged during construction from each facility.

Table 5-1 Construction surface water balance

Construction Ancillary Facility	Surface Water inputs (ML/year)	Groundwater inputs (ML/year)	Groundwater / Surface Water losses following reuse (ML/year)	Total discharge volume (ML/year)
C1	37	193	1	229
C2	37	84	2	119
C3	140	Variable – 265 typical [1]	5	400
C4	0.9	0	negligible	0.9
C5	0.6	0	negligible	0.6
C6	1.8	0	negligible	1.8

[1] Based on daily discharge volume during periods where dewatering of cut and cover tunnel works required.

Table 5-2 Construction daily discharge volumes

Construction ancillary facility	Daily discharge volume (ML/day)
C1	0.6
C2	Variable - 0.9 typical, up to 1.4 short term rate [1]
C3	Variable – 0.8 typical, up to 2.0 short term rate [1]
C4	0.0025
C5	0.0017
C6	0.0049

[1] Based on daily discharge volume during periods where dewatering of cut and cover tunnel works required.

It is noted that groundwater discharge volumes estimated for the President Avenue construction ancillary facility (C3) reflect what is considered to be generally an upper bound of potential inflows as a result of dewatering of cut and cover tunnel works. Construction methods, staging and sequencing will require further consideration during detailed design to ensure that inflows are maintained at manageable levels within the constraints of the construction site.

Figure 5-1 shows the likely approach to surface water and tunnel water management during construction, whilst **Figure 5-2** shows the construction discharge locations.

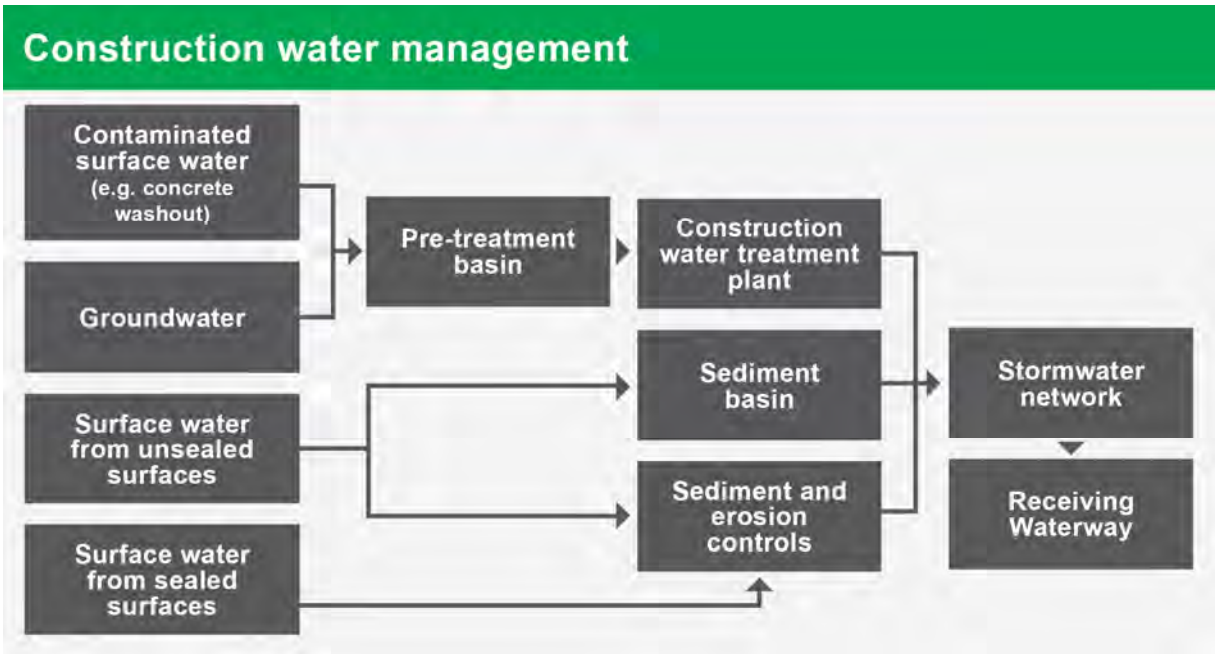


Figure 5-1 Surface water and tunnel water management during construction

LEGEND

- The project in tunnel
- The project on surface
- Surface water discharge location
- Construction water discharge location
- Surface and construction water discharge location
- Water treatment facility
- Rockdale ventilation facility
- Motorway operations complex
- Railway line
- Railway station
- Arncliffe ventilation facility*

* Under construction as part of the New M5 Motorway project

Figure 5-2 Construction discharge locations

5.2 Surface water hydrology and geomorphology

5.2.1 Potential impacts

The potential construction impacts to surface water hydrology and geomorphology are listed in **Table 5-3**. The impacts either relate to discharges or disturbance / interference with the waterways during construction. An assessment of the potential impacts in relation to these factors is provided in **sections 5.2.2** to **5.2.3**.

Table 5-3 Potential construction impacts to surface water hydrology, geomorphology and natural processes

Potential impact	Affected surface waters
Increase in baseflow rate to receiving waterways due to continuous discharge from construction water treatment plants	Scarborough Ponds Muddy Creek Cooks River
Potential for sediment to be scoured and mobilised where stormwater or wastewater is discharged directly to receiving waterways or discharge volumes are significantly increased	Rockdale Bicentennial Park Pond Northern Scarborough Pond Cooks River
Impacts to the hydrological and geomorphic processes within Scarborough Ponds due to construction activities associated with President Avenue intersection and shared pedestrian and cyclist path	Rockdale Bicentennial Park Pond Northern Scarborough Pond
Disturbance of Scarborough Ponds bed and banks and increased erosion and sedimentation during construction of surface works at President Avenue and the construction of main tunnel, ventilation tunnel and shared pedestrian and cyclist path	Rockdale Bicentennial Park Pond Northern Scarborough Pond
Disturbance of waterways during installation of the proposed power supply connection	Wolli Creek, Bardwell Creek, Muddy Creek
Disturbance of stormwater quality control devices including trash rack and floating wetlands in Rockdale Bicentennial Park Pond	Rockdale Bicentennial Park Pond

5.2.2 Discharges

During construction, treated groundwater and surface water would be discharged to the surface water environment from each of the construction ancillary facilities as shown in **Figure 5-2**. The discharge volumes are provided in **Table 5-2**. A comparison between the discharge volumes and daily flows within the waterways is provided in **Table 5-4**.

Table 5-4 Assessment of discharge impacts during construction

Location	Estimated mean daily flow	Estimated tidal inflow per tidal cycle
Northern Scarborough Pond	3 ML/day	< 6 ML/day
Muddy Creek	13 ML/day	76 ML/day
Cooks River	230 ML/day	2170 ML/day
C1	0.6 ML/day	Not applicable
C2	0.9 ML/day typical, up to 1.4 ML/day short term rate[1]	Not applicable
C3	0.8 ML/day up to 2.0 ML/day short term rate[1]	Not applicable
C4	0.0025 ML/.day	Not applicable
C5	0.0017 ML/day	Not applicable
C6	0.0049 ML/day	Not applicable

[1] Based on daily discharge volume during periods where dewatering of cut and cover tunnel works required.

During dry periods, water levels in the Rockdale Bicentennial Park Pond are controlled by local groundwater levels and the Rockdale Bicentennial Park Pond weir. Therefore an increased inflow from construction discharges are unlikely to significantly affect the water level within the pond with the additional flow discharging over the weir and being conveyed to the Northern Scarborough Pond.

The increase in flow would likely have a minor impact on water levels within the Northern Scarborough Pond. The additional flow may increase flushing through the system which may temporarily alter stratification conditions during construction.

Due to the relatively higher sensitivity of Northern Scarborough Pond and with consideration to the estimated discharge volumes when compared to daily flows and tidal exchange within that waterway, the continuous discharges from the construction water treatment plant at the Rockdale construction ancillary facility (C2) will instead be directed via stormwater drainage to the less sensitive Muddy Creek. Whilst volumes associated with dewatering of excavations and groundwater inflows at the President Avenue construction ancillary facility (C3), prior to sealing of the base of the cut and cover structure, are likely to be relatively minor, there is potential for short term higher inflows to occur if rock fractures are intercepted. To manage this risk, it is assumed discharges from the construction water treatment plant at the President Avenue construction ancillary facility (C3) are also directed to Muddy Creek.

Connection works in West Botany Street would be required to facilitate a pumped connection to stormwater drainage towards Muddy Creek and siting of the water treatment plant in the north west portion of the President Avenue construction ancillary facility (C3). Surface water discharges from the President Avenue construction ancillary facility (C3) will continue to be directed to Rockdale Bicentennial Park Pond and Northern Scarborough Pond.

Appropriate dissipation and scour protection from construction discharges would be provided to unlined systems such as Rockdale Bicentennial Park pond and Northern Scarborough Pond. No protection would be required for construction discharges which ultimately discharge to the concrete channel of Muddy Creek.

Discharges from the Shared cycle and pedestrian pathways construction ancillary facilities (C4 and C5) would be minor only due to their relatively small footprint, with negligible hydrologic impact. There is no change in the impervious area for the Princes Highway construction ancillary facility (C6) footprint; therefore discharges would not change from existing conditions. Minor discharges from other localised road and power supply connection works with a relatively small footprint would also have negligible hydrologic impact due to the existing surfaces at these locations being primarily impervious.

5.2.3 Waterway disturbance

Construction activities at the President Avenue construction ancillary facility (C3) will result in the direct disturbance of a large proportion of the Rockdale Bicentennial Park Pond and a small portion of the open channel south of President Avenue (which drains to the Northern Scarborough Pond).

Diaphragm walls would be installed from the surface to form a water tight wall prior to the cut and cover excavation works commencing for the construction of the ramps and portals. The Rockdale Bicentennial Park Pond bed and banks inside the diaphragm walls would be dewatered and excavated and require complete restoration following construction. A temporary diversion channel would be provided within the Rockdale Bicentennial Park Pond to divert water flows around the disturbance footprint during construction, as described in **Appendix M** of the EIS (Flooding Technical Report). Measures to manage hydrologic connectivity during dry / low flow conditions are provided in **section 8.1.7**.

The cut and cover tunnel excavation works would not commence within the pond until management measures such as a coffer dam (refer **section 8.1.7**) and the water tight diaphragm wall had been installed. Therefore, with the proposed diversion channel providing hydrologic connectivity within the pond and a continuous groundwater inflow, the cut and cover tunnel construction and associated dewatering is considered to pose a negligible impact to flows through the Rockdale Bicentennial Park Pond. Impacts to water levels within areas of the Rockdale Bicentennial Park Pond outside the construction footprint are also likely to be negligible.

Hydrologic connectivity and the hydraulic control between the Rockdale Bicentennial Park Pond and Northern Scarborough Pond may be disrupted during the works to widen President Avenue. Temporary measures to drain storm flows between the Rockdale Bicentennial Park Pond and Northern Scarborough Pond would be required throughout construction. Refer to **Appendix M** of the EIS (Flooding Technical Report) for details of proposed management measures.

Whilst the Rockdale Bicentennial Park Ponds bed and banks would be significantly disturbed within the coffer dam/diaphragm wall, and its surface area would be reduced, around 90% of the Rockdale Bicentennial Park Pond surface area would be retained throughout construction. Therefore geomorphic processes such as sedimentation of suspended solids conveyed in stormwater runoff would continue to occur.

The stormwater outlet (and its trash rack) adjacent to the Rockdale Bicentennial Park Pond footbridge is located within the cut and cover zone. The stormwater pipe would be diverted around the cut and cover structure and the trash rack relocated or replaced. The floating wetland is unlikely to be directly disturbed as a result of the construction works, but would need to be protected and maintained during construction.

The pond would eventually be restored following completion of the tunnelling and shared cycle and pedestrian pathway works. Potential opportunities to incorporate improvements to the Rockdale Bicentennial Park Pond system as part of the restoration works are described in **section 8.2.1**.

A small portion of the open channel south of President Avenue would be filled in as part of the widening of President Avenue. However this would not result in any adverse impacts to the channel's hydraulic or hydrologic function, albeit slightly reducing its length. Potential water quality impacts associated with disturbance and mobilisation of sediment are assessed in **section 5.3.3**.

The proposed powerline would cross the catchments of Cup and Saucer Creek, Wolli Creek, Bardwell Creek, Spring Street Drain and Muddy Creek. Where the powerline corridor crosses the watercourses of Wolli Creek, Bardwell Creek and Muddy Creek, it would be installed in a conduit attached to existing bridges. The proposed powerline corridor alignment would be finalised during detailed design with the alignment realigned around (or bored under) sensitive environmental features including Bardwell Creek where there is no existing bridge to attach a conduit to. With implementation of the proposed management measures, refer **section 8.1.7**, impacts to waterway bed and banks are considered to be negligible.

5.3 Surface water quality

5.3.1 Potential impacts

The potential impacts to surface water quality during construction are outlined in **Table 5-5**.

Table 5-5 Potential impacts to surface water quality during construction

Construction activity / source of pollutants	Pollutants of concern	Potential impact	Receiving waterways
Impacts to ambient water quality as a result of poorly treated discharges from the construction water treatment plants	Heavy metals, pH, oil and grease, sediment, ammonia, nutrients	Increased turbidity, lower dissolved oxygen levels and nutrients Increases in toxicant concentration Increased alkalinity	Rockdale Bicentennial Park Pond Northern Scarborough Pond Cooks River
Erosion and mobilisation of exposed soils from open cuts, batter slopes and stockpiles by stormwater runoff and wind, leading to sedimentation of receiving waterways	Sediment, nutrients, contaminants, gross pollutants	Increased turbidity, lower dissolved oxygen levels and nutrients which could lead to algal blooms and aquatic weed growth Increases in toxicant concentration Reduced visual amenity (visible gross pollutants)	Rockdale Bicentennial Park Pond Northern Scarborough Pond Cooks River Muddy Creek
Dust, litter and other pollutants associated with building materials and demolition waste being mobilised by wind and stormwater runoff into waterways	Sediment, gross pollutants	Reduced visual amenity (visible gross pollutants)	Rockdale Bicentennial Park Pond Northern Scarborough Pond Cooks River Muddy Creek

Construction activity / source of pollutants	Pollutants of concern	Potential impact	Receiving waterways
Leakage or spills of petroleum hydrocarbons, oils and greases from machinery, equipment or plant or during refuelling of plant could potentially result in pollutants being conveyed to downstream waterways	Hydrocarbons, oil and grease, hydraulic fluids, other hazardous chemicals	Oil sheen on water surface and increases in toxicant concentration which could lead to fish kills and other undesirable impacts	Rockdale Bicentennial Park Pond Northern Scarborough Pond Cooks River Muddy Creek
Wash-down water from construction plant washing being discharged into waterways	Petroleum hydrocarbons, oil and grease, hydraulic fluids, pH, heavy metals	Oil sheen on water surface and increases toxicant concentration which could lead to fish kills and other undesirable impacts	Rockdale Bicentennial Park Pond Northern Scarborough Pond Cooks River
Concrete washout water being discharged into waterways	High pH, chromium	Increases in alkalinity and toxicant concentration which could lead to fish kills and other undesirable impacts	Rockdale Bicentennial Park Pond Northern Scarborough Pond Cooks River
Increase in alkalinity in waterways due to transport of chemicals used in treatment and curing of concrete and mobilisation of concrete dust to waterways through wind, runoff	High pH	Increases in alkalinity of waterways which could lead to fish kills and other undesirable impacts	Rockdale Bicentennial Park Pond Northern Scarborough Pond Cooks River
Mobilisation of sediment into local stormwater drainage network via vehicles transferring soil to roads adjacent to construction sites	Sediment, heavy metals, nutrients	Increased turbidity, lower dissolved oxygen levels and nutrients Increases in toxicant concentration	Rockdale Bicentennial Park Pond Northern Scarborough Pond Cooks River
Soil and bank erosion and mobilisation of sediments into receiving waterways during the direct disturbance of waterway bed and/or banks as a result of earthworks and construction of instream structures	Sediment, nutrients and heavy metals stored in bed sediments	Increased turbidity, lower dissolved oxygen levels, increased nutrients which may exacerbate aquatic weed growth and algal blooms, increased toxicant concentrations	Rockdale Bicentennial Park Pond Northern Scarborough Pond
Impacts to ambient water quality as a result of poorly treated dewatered groundwater from powerline trench	Sediment, heavy metals, oil and grease	Oil sheen on water surface and increases toxicant concentration which could lead to fish kills and other undesirable impacts	Cup and Saucer Creek, Wolli Creek, Bardwell Creek, Spring Street Drain, Muddy Creek, Rockdale Bicentennial Park Pond
Impacts to salinity in receiving waterways due to treated construction wastewater discharges	Salinity	Changes in salinity concentration	Rockdale Bicentennial Park Pond Northern Scarborough Pond, Muddy Creek, Cooks River

Management and mitigation measures (as described in **section 8.1**) would be required to reduce the potential for surface water quality impacts arising during construction.

An assessment of the residual water quality impact from treated construction wastewater and treated construction surface water is provided in **section 5.3.2**. An assessment of the residual water quality impact from direct disturbance of waterways is provided in **section 5.3.3**.

A discussion of the combined residual impact on water quality and how the project would influence the NSW water quality objectives during construction is provided in **section 5.3.4**.

5.3.2 Construction discharges

Construction wastewater

During construction, the wastewater generated from the following construction zones / activities is considered to be 'construction wastewater' and would be captured, tested and treated at a construction water treatment plant (if required) prior to reuse, discharge, or disposal offsite if required. Construction wastewater would be generated from the following sources:

- Tunnelling works
- Surface works which intercept groundwater
- Any areas within the site compound which are identified during construction to be of high risk of generating contaminated surface waters (e.g. vehicle refuelling areas, chemical and fuel storage areas, concrete washout areas, vehicle wash-down areas).

The construction tunnelling works would result in large volumes of wastewater being generated from the following sources:

- Groundwater ingress
- Rainfall runoff in excavated tunnel portals and ventilation shafts
- Dust suppression water
- Wash down runoff
- Concrete washout.

A high proportion of the water generated from tunnelling would be collected from groundwater seepage. Natural groundwater quality along the alignment is spatially and temporally variable. The groundwater quality review undertaken for this assessment (**section 4.6**) indicates that groundwater inflows into the tunnel works would likely contain elevated levels of chromium, iron, nickel, zinc, total nitrogen, total phosphate and ammonia. Groundwater inflows into the cut and cover construction works in Rockdale Bicentennial Park before the base is lined are likely to contain elevated concentrations of arsenic, iron, lead, nickel, zinc, total nitrogen and ammonia.

The use of chemicals in the treatment and curing process of concrete as well as the concrete dust itself could result in the tunnelling wastewater having an increased alkalinity.

Rainfall runoff in excavated tunnel portals and ventilation shafts may account for loading of atmospheric pollutants such as nitrogen into the tunnel wastewater; however the loads are likely to be negligible in comparison to the respective loading from groundwater inflows.

Wastewater from vehicle refuelling areas and fuel storage areas would captured within bunded areas, tested and then either treated within the construction water treatment plant or discharged at a licensed facility.

Wastewater generated by dewatering activities during trenching of the proposed powerline will be managed in accordance with Managing Urban Stormwater Soils and Construction, Volume 2A Installation of services (DECC, 2008a) to minimise potential impacts to downstream waterways.

The discharge criteria for the pollutants of concern during construction is provided in **section 8.1.6**. Due to the high variability of water quality and discharge volumes during construction, it is not possible to accurately estimate the quantity of pollutants being discharged from each treatment plant. However, a high level estimate is provided in **Table 5-6**, with discharge locations shown in **Figure 5-2**. The assumptions for this estimate are described in **section 3.3.2**.

Table 5-6 Estimate of construction wastewater pollutant quantities at discharge locations

Pollutant	Arncliffe (C1) Groundwater discharge (DP1) (kg/yr)	Rockdale (C2) Groundwater discharge (DP2) (kg/yr)	President Avenue (C3) discharge (DP3) (kg/yr)
Arsenic	1.9	3.0	3.2
Cadmium	0.01	0.02	0.03
Chromium (III + VI)	0.1	0.2	0.2
Copper	0.1	0.2	0.2

Pollutant	Arncliffe (C1) Groundwater discharge (DP1) (kg/yr)	Rockdale (C2) Groundwater discharge (DP2) (kg/yr)	President Avenue (C3) discharge (DP3) (kg/yr)
Iron	57.5	88.6	45
Lead	0.1	0.2	1.1
Manganese	71	109	95
Mercury	0.005	0.007	0.004
Nickel	1.0	1.5	1.1
Zinc	4.2	6.5	6.5
Total Nitrogen	192	649	330
Total Phosphate	38	74	1.8
Ammonia	307	472	255
Salinity	442700	681900	346800

The discharge volumes (refer 5.1) are negligible compared to tidal inflows in Muddy Creek and Cooks River which would mix and dilute treated discharges. Provided the treatment measures achieve the recommended discharge criteria, impacts to toxicant and nutrient levels within Muddy Creek and Cooks River are considered to be negligible.

Discharge of fresh to brackish treated groundwater to the estuarine waters of Muddy Creek and the Cooks River are likely to provide a freshening effect to waters within the immediate vicinity of the outlet, which would be similar to the effect of fresh stormwater discharges occurring at the outlet. The freshening affect would diminish within close proximity of the outlet as mixing occurs.

Indicative discharge volumes from C3 are likely to be of a similar order of magnitude to tidal inflows in Northern Scarborough Pond. Provided the treatment measures achieve the recommended discharge criteria, impacts to toxicant and nutrient levels within Scarborough Ponds are considered to be negligible if discharges are directed to Scarborough Ponds. Discharge of treated construction wastewater to Scarborough Ponds would increase the daily freshwater inflow to Northern Scarborough Ponds. This would alter the stratified salinity profile (refer section 4.2.3) within the Northern Scarborough ponds in a similar way to intermittent fresh stormwater flows, although the impact would be continuous during construction. Given the receiving environment regularly receives fresh stormwater inflows, the temporary impact to the salinity profile during construction is unlikely to adversely impact the waterway.

Further details of the proposed treatment is provided in **section 8.1.6**.

Surface water

Surface runoff from areas not designated to be managed as 'construction wastewater' is hereby referred to as surface water. Surface water would be managed in accordance with Managing Urban Stormwater – Soils and Construction, Volume 1 (Landcom 2004) and Volume 2D (DECCW 2008), commonly referred to as the 'Blue Book' (refer to **sections 8.1.1** and **8.1.2**).

The quality and quantity of the pollutants generated within these areas would be variable and subject to the soil profile, phase of works, extent of disturbance, extent of pavement and roofs, construction activities and climatic influences (e.g. rainfall).

The key pollutants of concern from unsealed construction areas would be sediment (i.e. TSS), oil and grease and pH. The proposed construction discharge criteria for pH, TSS and oil and grease for the project has been set in line with typical license conditions for road projects (refer **section 8.1.6**). Other pollutants (such as nutrients) may also be bound to the sediment or present in dissolved form. Their concentrations would be variable but providing appropriate erosion and sediment controls are implemented, they are considered to pose a low risk to the surface water environment and human health during the construction phase of the project.

The tunnelling construction ancillary facilities would be paved at the commencement of the project. Onsite management measures in line with the Blue Book would be implemented, to reduce the risk of pollutants impacting runoff or being released to the stormwater drainage system. The key pollutants of concern would be sediment and oil and grease from spills and machinery leaks.

Due to the high variability of water quality and discharge volumes, it is not possible to estimate the quality or quantity of all pollutants being discharged in surface water from each of the construction ancillary facilities.

Providing the management measures are implemented during construction and the discharge criteria is achieved, short term impacts are expected to be manageable. With the measures in place, the pollutant load being discharged from the project will be minor compared to the pollutant load being discharged to the receiving waterways from the wider catchment and with consideration to the tidal flushing effect which will occur within the estuarine receiving environments impacts on receiving water quality are considered to be negligible.

5.3.3 Waterway disturbance

Significant disturbance of Rockdale Bicentennial Park Pond would occur as result of construction of the cut and cover tunnel at President Avenue. Minor disturbance would also occur to the open channel immediately downstream of President Avenue (which discharges to the Northern Scarborough Pond) during construction of the batter slopes associated with the raising of President Avenue and installation of the new culvert under President Avenue. The proposed utilities corridor and shared cycle and pedestrian pathway viaduct would also be constructed within proximity to the Northern Scarborough Pond, but are not proposed to directly disturb its banks.

The disturbance to the bed and banks of the Rockdale Bicentennial Park Pond and open channel would significantly increase the turbidity within the Rockdale Bicentennial Park Pond and open channel within the disturbance footprint temporarily during construction. If not properly managed, disturbance of the Rockdale Bicentennial Park Pond and open channel has the potential to result in erosion and mobilisation of bed and bank sediments downstream. These sediments could potentially contain toxicants and elevated nutrients.

Measures to manage potential impacts associated with erosion and mobilisation of sediments within Rockdale Bicentennial Park Pond, North Scarborough Pond or downstream are provided in **sections 8.1.2** and **8.1.7**. Procedures for management of potentially contaminated sediments are provided in **Appendix J** of the EIS (Contamination Technical Report).

Detrimental processes such as aquatic weed growth and algal blooms which occur in the Rockdale Bicentennial Park Pond are likely to continue within the sections of the pond that remain undisturbed during construction. If not appropriately managed, mobilisation of sediments of high nutrient content could potentially exacerbate the aquatic weed growth and algal blooms.

Provided the proposed management measures are implemented, disturbed sediment would be retained within the disturbance footprint during construction. Impacts to ambient water quality within the open channel (south of President Avenue) and Northern Scarborough Pond downstream of the disturbance footprint are therefore likely to be negligible during construction.

Restoration of the Rockdale Bicentennial Park Pond would be undertaken following completion of the tunnel works. Potential opportunities to incorporate improvements to the Rockdale Bicentennial Park Pond system as part of the restoration are described in **section 8.2.1**.

Construction of new stormwater outlets are proposed as shown in **Figure 6-1**. Disturbance of sediments could temporarily impact on water quality within proximity to new stormwater discharge points until settling occurs. Due to the minor disturbance that would occur, impacts to ambient water quality are likely to be negligible and temporary with any localised increase in turbidity only occurring until settlement occurs.

5.3.4 Impact on NSW Water Quality Objectives

The proposed management measures, including sediment and erosion control, treatment of construction wastewater and diversion of construction wastewater to the less sensitive environment of Muddy Creek (where feasible), aim to minimise pollutant loading of the receiving waterways during construction and avoid pollutant loading (where feasible) to Scarborough Ponds. With the implementation of the management measures, pollutant loading to the receiving waterways is considered to be minor compared to pollutant loading from the wider respective catchments and with consideration to the tidal flushing that would also occur within the estuarine environments it is considered that the project is unlikely to have a material impact on ambient water quality within the receiving waterways. Therefore the project is likely to have a negligible influence on whether the NSW WQOs are protected (if currently met) or achieved (if currently not met) during the construction phase.

5.4 Soil erosion and salinity

Areas of very high potential for salinity as well as other areas which may have residual saline soils present occur within the project boundary, as shown in **Figure 4-5**.

Salinity impacts occur when salts naturally present in soil or groundwater are mobilised and accumulate to a level that damages the natural and built environment. In urban areas, changes to the natural water balance as a result of removal of deep rooted vegetation, irrigation, leaking pipes and increased groundwater recharge can lead to rises in groundwater which can mobilise and concentrate salts. This can damage infrastructure and buildings and impact water quality and vegetation.

Salinity impacts could potentially occur during construction of the project as a result of soil disturbance during earthworks and through changes in groundwater levels during tunnelling.

Measures to manage potential soil salinity impacts are provided in **section 8.1.4**. With the proposed management measures in place potential impacts associated with disturbance of saline soils are considered to be negligible.

Potential salinity impacts associated with groundwater are assessed in **Appendix K** of the EIS (Groundwater Technical Report). Potential salinity impacts associated with biodiversity are assessed in **Appendix H** of the EIS (Biodiversity Development Assessment Report).

6 Assessment of operational impacts

6.1 Surface water balance

The project does not propose to extract surface water directly from any of the unregulated water sources within the study area during its operation.

A surface water balance was undertaken to estimate the operational impacts of the project to the annual volume of flow discharged to the surface water environment as a result of modified surface runoff and treated tunnel water discharges. A summary of the surface water balance for existing and operational conditions is provided in **Table 6-1** and **Table 6-2**. The proposed operational discharge points (ODPs) are shown in **Figure 6-1**.

Table 6-1 Existing conditions surface water balance

Discharge point	Rainfall (ML / year)	Losses (ML / year)	Stormwater runoff volume (ML / year)	Treated tunnel groundwater discharge volume (ML / year)	Total discharge volume (ML / year)
ODP1	137.8	40.2	97.6	0.0	97.6
ODP2	61.1	25.2	35.9	0.0	35.9
ODP3	60.5	23.9	36.6	0.0	36.6
ODP4	169.6	72.3	97.4	0.0	97.4
ODP5	48.0	11.3	36.7 [1]	901.9 [2]	938.6
ODP6	47.1	4.2	42.8	0.0	42.8
ODP7	4.9	0.4	4.4	0.0	4.4
ODP8	21.7	17.6	4.1	0.0	4.1

[1] From existing New M5 Motorway Arncliffe construction compound

[2] From New M5 Motorway water treatment plant once operational

Table 6-2 Design operational conditions surface water balance

Discharge point	Rainfall (ML / year)	Losses (ML / year)	Stormwater runoff volume (ML / year)	Treated tunnel groundwater discharge volume (ML / year)	Total discharge volume (ML / year)	Impact to discharge volume (ML / year)
ODP1	137.8	38.7	99.1	0.0	99.1	1.6
ODP2	61.1	19.8	41.3	0.0	41.3	5.4
ODP3	60.5	23.8	36.6	0.0	36.6	0.0
ODP4	169.6	66.6	103.1	0.0	103.1	5.7
ODP5	1.3	0.1	1.2	1204.7 [1]	1205.9	268.3
ODP6	47.1	4.2	42.8	0.0	42.8	0.0
ODP7	4.9	0.4	4.4	0.0	4.4	0.0
ODP8	55.0	32.4	22.6	0.0	22.6	18.5

[1] Cumulative discharge of New M5 Motorway water treatment plant and F6 water treatment plant

LEGEND

- The project in tunnel
- The project on surface
- Stormwater discharge location
- Tunnel Water discharge location and Stormwater discharge location
- Water treatment facility
- Rockdale ventilation facility
- Motorway operations complex
- Operational WTP ultimate discharge location
- Railway line
- Railway station
- Arncliffe ventilation facility*
- * Under construction as part of the New M5 Motorway project

Figure 6-1 Operational discharge points

6.2 Surface water hydrology and geomorphology

6.2.1 Potential impacts

The potential impacts to surface water hydrologic and geomorphic processes are summarised in **Table 6-3**.

Table 6-3 Potential operational impacts to surface water hydrology and geomorphology

Potential Impact	Affected waterways
Increase in baseflow rate to Cooks River due to continuous discharge from operational water treatment plant	Cooks River
Increase in stormwater runoff volume	Rockdale Bicentennial Park Pond Northern Scarborough Pond Cooks River
Potential for sediment to be scoured and mobilised where stormwater or wastewater is discharged directly to receiving waterways at new discharge locations or where discharge volumes are significantly increased at existing discharge locations	Cooks River Rockdale Bicentennial Park Pond Northern Scarborough Pond
Impacts to the hydrological regime as a result of modifications to hydraulic controls and infilling to widen President Avenue	Rockdale Bicentennial Park Pond Northern Scarborough Pond

Management and mitigation measures (as described in **section 8.2**) would be required to reduce the potential for surface water hydrology and geomorphic impacts arising during operation. An assessment of the residual impacts as a result of operational discharges and interferences in the hydrologic and hydraulic regime is provided in **section 6.2.2**.

6.2.2 Assessment of impacts

Treated flows from the operational water treatment plant would increase the total flow discharged to the Kogarah Golf Club drain and to the Cooks River downstream. Tides dominate the flow regime within the Cooks River at this location, therefore impacts to flow and water levels within the Cooks River would be negligible.

The project would slightly increase the imperviousness in affected catchments, generating an increase in stormwater runoff volumes to Rockdale Bicentennial Park Pond and Northern Scarborough Pond by 7.0 ML / year and 5.7 ML / year respectively, with a total runoff volume increase to the Scarborough Ponds system of 12.7 ML / year. A surface water balance was undertaken for the total catchment upstream of President Avenue. The results indicate that the annual stormwater runoff volume at President Avenue would be around 765 ML/year. Therefore runoff volumes are likely to increase by about two per cent at President Avenue, which is considered to pose a negligible impact on the hydrological regime of Rockdale Bicentennial Park Pond and the Northern Scarborough Pond.

The existing weir controlling water levels within Rockdale Bicentennial Park Pond would be replicated during restoration of Rockdale Bicentennial Park Pond. The restoration works would also be designed with consideration to the hydrologic and geomorphic function of Rockdale Bicentennial Park Pond.

Around 550 square metres of Rockdale Bicentennial Park Pond would be filled in to widen President Avenue, which is approximately three per cent of the existing pond footprint. Considering the minor loss of volume and given water levels are controlled by the weir, impacts to water levels within Rockdale Bicentennial Park Pond as a result of the loss in volume are likely to be negligible. The minor reduction in the length (around 11 metres) of the estuarine open channel downstream of President Avenue as a result of the widening of President Avenue would result in a negligible loss in volume to the Scarborough Ponds system and is therefore considered to pose a negligible impact on its hydrologic function.

Runoff volumes to the unnamed drain through the golf course are likely to increase by around 16.5 ML/year as a result of the project and 10.3 ML/year compared to conditions before New M5 Motorway construction activities commenced (i.e. prior to the New M5 Motorway Arncliffe construction compound portion of the catchment being diverted to the Marsh Street road drainage system). Compared to pre New M5 Motorway conditions, annual runoff volumes are likely to increase by 100% at the upstream extent of the drain and 20% at the downstream extent. Some bank erosion may occur as a result of the additional runoff volumes during more frequent events within unlined sections of the drain, although the presence of tidal water is likely to mitigate this risk during the upper tidal range. The potential for erosion is therefore considered to range between minor within the upstream extent to negligible within the downstream extent.

Appropriate dissipation and scour protection measures will be provided at discharge locations to prevent scour within the waterways.

Measures to manage potential bank erosion impacts within the unnamed golf course drain (such as, for example rainwater harvesting and WSUD measures with extended detention (e.g. bioretention) or bank stabilisation techniques) will be investigated further during detailed design once the volume of runoff which is captured onsite (for disposal via a trade waste agreement or removal by liquid waste contractor) and resulting stormwater discharge volumes are further refined.

With consideration to the above, impacts to the hydrologic and geomorphic processes, environmental water availability and flow would be negligible during operation.

6.3 Surface water quality

6.3.1 Potential operational impacts

The potential impacts to surface water quality during operation of the project are summarised in **Table 6-4**.

Table 6-4 Potential operational impacts to surface water quality

Source of pollutants	Pollutants of concern	Potential Impact	Receiving waterways
Poorly treated tunnel groundwater discharge from the operational water treatment plant	Heavy metals, TSS, pH, nutrients	Increased turbidity, lower dissolved oxygen levels and nutrients Increases in toxicant concentration Increased alkalinity	Cooks River
Poorly treated tunnel surface water discharge from the operational water treatment plant	TSS, nutrients, heavy metals, oil and grease, pH	Increased turbidity, lower dissolved oxygen levels and nutrients Increases in toxicant concentration Increased alkalinity	Cooks River
Untreated stormwater from new impervious surfaces not conveyed to treatment systems	Gross pollutants, TSS, nutrients, heavy metals, oil and grease	Increased turbidity, lower dissolved oxygen levels and nutrients Increases in toxicant concentration Increased alkalinity Reduction in visual amenity	Rockdale Bicentennial Park Pond Northern Scarborough Pond Cooks River
Spill events	Oil and grease and various hazardous fuels and chemicals that may be transported by vehicles	Increases in toxicant concentration	Cooks River Rockdale Bicentennial Park Pond Northern Scarborough Pond

Management and mitigation measures (as described in **section 8.2**) would be required to reduce the potential for surface water quality impacts to occur during operation. An assessment of the residual water quality impacts associated with stormwater (runoff at surface), tunnel water and from spill events is provided in **sections 6.3.2**, **6.3.3** and **6.3.4** respectively.

A discussion of the combined residual impact on water quality and how the project would influence the NSW water quality objectives during operation is provided in **section 6.3.5**.

6.3.2 Stormwater quality

The project includes sections of aboveground roadway, and interchanges with existing surface roads, and subsurface road tunnels. New surface roadway exposed to direct rainfall is proposed at the intersection of President Avenue and Princes Highway. The tunnel ramps at President Avenue will also generate a minor amount of surface runoff which would be captured and pumped to the surface for treatment.

Increases in impervious area (such as road pavement) exposed to direct rainfall will contribute to an increase in runoff volume and pollutant mobilisation. Runoff from road pavement would typically contain pollutants such as sediments, nutrients, oils and greases and heavy metals, from atmospheric deposition, vehicle leaks, operational wear, road wear or spills of materials on the road as described in **Table 6-5**. These pollutants could potentially impact on water quality when discharged to receiving waterways.

Table 6-5 Key pollutants of concern in typical road runoff

Pollutant	Sources
Litter / gross pollutants	Soil, litter, vegetation
Suspended solids	Vehicles, bitumen wear, atmosphere, maintenance
Nitrogen	Atmosphere
Phosphorus	Atmosphere
Biological oxygen demand and chemical oxygen demand	Soil, litter, vegetation
Lead	Leaded petrol, tyre wear, lubricating oil and grease, bearing wear
Zinc	Tyre wear, motor oil, grease
Iron	Auto body rust, steel highway structures, engine parts
Copper	Plating, bearing / brushing / brake wear, engine parts, insecticides
Cadmium	Tyre wear, insecticide application
Chromium	Metal plating, moving engine parts, brake lining wear
Nickel	Fuels, oils, metal plating, brushing wear, brake lining wear, asphalt
Manganese	Moving engine parts
Oil and grease	Spills, lubricants, antifreeze, and hydraulic fluids, asphalt, polycyclic aromatic hydrocarbons (PAH), petroleum hydrocarbons

A preliminary stormwater drainage strategy (base case) including treatment measures was developed for the project (refer **section 2.3**), and would be finalised during detailed design.

The final selection and design of treatments would consider the sensitivity of the environment, changes in imperviousness as a result of the project, environmental, operational and hydraulic constraints and the BBWQIP.

Current industry practice is to assess the performance of stormwater treatment systems in managing pollutants by modelling the generation and treatment of Total Suspended Solids (TSS), Total Nitrogen (TN) and Total Phosphorus (TP) using the MUSIC modelling software.

MUSIC modelling was undertaken for the project to assess the performance of the proposed preliminary stormwater drainage strategy and identify further opportunities for water quality improvement. Full details of the MUSIC modelling assessment are provided in **Annexure C**. The MUSIC modelling results are shown in **Table 6-7**. The MUSIC modelling indicates that when incorporating the treatment benefits of diverting the upstream residential catchment on O'Neill Street into a proposed grassed swale, the pollutant load reduction targets (refer **Table 6-6**) for the total increase in pavement footprint associated with the project would be achieved (refer to **Table 6-7**). The modelling also indicates that compared to existing conditions, there would be a negligible annual increase in TN load while TSS and TP loads would be reduced.

MUSIC modelling has demonstrated that the preliminary stormwater drainage strategy exceeds the stormwater pollutant load reduction targets when taking account the treatment of the diverted residential external catchment. Stormwater is therefore considered to be managed in line with current industry practice.

The treatment strategy would be finalised at detailed design and consider opportunities for water quality improvements.

Table 6-6 Pollutant load reduction targets

Pollutants	Total additional load from new pavements (kg/year)	Pollutant load reduction target (%)	Target pollutant load reduction (kg/year)
TSS	4340	85	3689
TP	8.1	60	4.8
TN	35.3	45	15.9

Table 6-7 Stormwater treatment scenario results

	Pollutant Load Reduction (kg/year)	Pollutant load reduction (%)
TSS	6800	157
TP	8.7	108
TN	17	48

To assess the impact of the discharges at President Avenue, the predicted load impacts for TSS, TP and TN were compared with an estimate of the pollutant loads for the wider catchment. A range of loads for the wider catchment were assessed based on the assumption that between 0% and 25% of the catchment is currently treated to BBWQIP pollutant load reduction targets (refer **Annexure C**). The results are shown in **Table 6-8**. The results indicate that the residual impact to water quality within the Scarborough Ponds would be negligible with the potential for a small benefit in terms of annual TSS and TP load reduction.

Table 6-8 Stormwater treatment scenario results

	Pollutant Load Impact as a result of the project (kg/year)	Assumed load from wider catchment (kg/year)	Pollutant Load Impact (%)
TSS	-2460	105000 to 82700	-2.3 to -3.0%
TP	-0.62	208 to 175	-0.3 to -0.4%
TN	+18.3	1690 to 1500	1.1 to 1.2%

The Operational Motorway Control Centre and Ventilation facility at West Botany Street, Rockdale and the new water treatment facility at Arncliffe would incorporate treatment facilities to manage potential impacts associated with stormwater runoff, as described in **section 2.3**. The treatment facilities would capture pollutants such as sediments and hydrocarbons. With consideration to the size of the catchments (and associated pollutant load) of the waterways downstream of these facilities, including Muddy Creek, Rockdale Bicentennial Park Pond and the Cooks River, the residual impact is considered to be negligible.

An assessment of impacts associated with tunnel water discharges is provided in **section 6.3.3**.

6.3.3 Tunnel water quality

The tunnels will require drainage infrastructure to capture two separate drainage streams, the first to collect groundwater ingress (tunnel groundwater) and a second to collect stormwater ingress at portals, spills, maintenance wash-down water, fire suppressant deluge and other potential water ingress events.

The two tunnel drainage streams are expected to produce flows containing a variety of pollutants. The pre-treatment water quality of each drainage stream is expected to vary considerably, and consequently it is likely that the two drainage streams would need to be collected and treated separately as follows:

- Tunnel groundwater would be captured and pumped to a new operational water treatment plant at Arncliffe
- Tunnel surface water would be captured in the sump where it would undergo some treatment (sediment and free oil screening). The water would be tested and a determination made whether it can be:
    - pumped to surface and treated at the operational water treatment plant (if of suitable quality for the treatment plant to treat)
    - pumped to surface and discharged without further treatment
    - will require removal directly from the sump by tanker for treatment and disposal offsite.

Tunnel groundwater

The discharge criteria for the new operational water treatment plant is summarised in **section 8.2.4** with the full list of trigger levels provided in **Annexure F**. The adopted discharge criteria is consistent with the New M5 Motorway discharge criteria.

The groundwater quality review (refer **section 4.6**) indicates that F6 Extension Stage 1 tunnel groundwater would likely contain concentrations of iron, total nitrogen and ammonia which are elevated in relation to the adopted discharge criteria. The anticipated manganese concentration, whilst below the discharge criteria, is significantly elevated in comparison to ambient water quality within the Cooks River.

A “box model” (refer **section 3.3.2** and **Annexure D**) was developed to assess how the quality and quantity of pollutants associated with treated releases from the operational water treatment plant would impact the Cooks River for two scenarios:

- Scenario 1 – F6 Extension Stage 1 treated tunnel water discharges (9.6 L/s flow)
- Scenario 2 – Cumulative discharge of F6 Extension Stage 1 + New M5 Motorway + M4M5 Link treated tunnel water (38.2 L/s)

The findings are summarised below in **Table 6-9** and **Table 6-10**. Full details of the assumptions applied within the assessment are provided in **Annexure D**.

Table 6-9 Scenario 1 – F6 Extension Stage 1 discharge only

Pollutants	Baseline Cooks River water quality (mg/L)	Tunnel groundwater quality (mg/L)	Water treatment plant discharge criteria (mg/L)	Assumed discharge quality (mg/L)	Assumed daily discharge load (kg)	Final Cooks River Water Quality (mg/L)	Impact (%)
Arsenic	0.005	0.01	0.14	0.01	0.008	0.0050	0.1%
Cadmium	0.0013	0.00007	0.036	0.00007	0.0001	0.0013	-0.1%
Chromium (III+VI)	0.0013	0.0005	0.085	0.0005	0.0004	0.0013	-0.0%
Copper	0.005	0.0005	0.008	0.0005	0.0004	0.0049	-0.1%
Iron	0.225	13.7	0.3[1]	0.3	0.25	0.225	0.1%
Lead	0.0265	0.0005	0.012	0.0005	0.0004	0.026	-0.1%
Manganese	0.005	0.4	3.6	0.4	0.3	0.0056	9.8%
Mercury	0.00005	0.00003	0.0014	0.00003	0.00002	0.00005	-0.1%
Nickel	0.0005	0.005	0.56	0.005	0.004	0.0005	1.3%
Zinc	0.025	0.02	0.043	0.02	0.02	0.005	-0.0%
Nitrogen (Total)	0.50	4.8	1	1	0.8	0.50	0.1%
Ammonia	0.27	1.6	1.7	1.6	1.3	0.27	0.4%
Phosphorus (Total)	0.05	0.2 [2]	0.2	0.2	0.17	0.05	0.4%
Salinity	25090	2310 - 14430[3]	-	2310 – 14430[3]	1916-11969	25059 - 25075	-0.12% to -0.06%

Bold values indicate where treatment likely required to achieve discharge criteria

[1] Recreational water quality trigger value adopted for iron in the absence of relevant discharge criteria for New M5 Motorway.

[2] Assumed to be equivalent to total phosphate for the purposes of this assessment

[3] Range of salinity assessed to account for increased potential salinity due to groundwater drawdown. Lower bound equates to average salinity in local groundwater, upper bound is maximum recorded salinity in local groundwater.

Table 6-10 Scenario 2 – F6 Extension Stage 1 + New M5 Motorway

Pollutants	Baseline Cooks River Water Quality	Tunnel groundwater quality	Water treatment plant discharge criteria	Assumed Discharge Quality	Assumed daily discharge load (kg)	New Cooks River Water Quality	Impact (%)
Arsenic	0.005	0.02	0.14	0.02	0.06	0.0051	1.4%
Cadmium	0.0013	0.0007	0.036	0.0007	0.002	0.0013	-0.3%
Chromium (III+VI)	0.0013	0.002	0.085	0.002	0.007	0.0013	0.4%
Copper	0.005	0.002	0.008	0.002	0.007	0.0050	-0.3%
Iron	0.225	3.5	0.3 [1]	0.3	0.99	0.23	0.2%
Lead	0.0265	0.002	0.012	0.002	0.005	0.026	-0.5%
Manganese	0.005	0.7	3.6	0.7	2.2	0.0085	69.8%
Mercury	0.00005	0.00009	0.0014	0.00009	0.0003	0.00005	0.4%
Nickel	0.0005	0.005	0.56	0.005	0.017	0.00052	4.9%
Zinc	0.025	0.048	0.043	0.04	0.14	0.025	0.4%
Nitrogen (Total)	0.50	4.8	1.0	1.0	3.3	0.50	0.6%
Ammonia	0.27	5.2	1.7	1.7	5.6	0.28	2.6%
Phosphorus (Total)	0.05	0.2 [2]	0.2	0.2	0.66	0.05	1.6%
Salinity	25090	2310 - 14430[3]	-	2310 – 14430[3]	7624-47625	24967-25032	-0.5% to -0.2%

Bold values indicate where treatment likely required to achieve discharge criteria

[1] Recreational water quality trigger value adopted for iron in the absence of relevant discharge criteria for New M5 Motorway.

[2] No available phosphorus tunnel groundwater quality so phosphate concentration used.

[3] Range of salinity assessed to account for increased potential salinity due to groundwater drawdown. Lower bound equates to average salinity in local groundwater, upper bound is maximum recorded salinity in local groundwater.

The results indicate that impacts to ambient water quality within the Cooks River would be negligible with the exception of manganese for Scenario 2 (refer **Table 6-10**).

The adopted manganese concentration is likely to be conservative as some manganese would likely be removed during the primary sedimentation process. In any case, the resultant water quality (0.009 mg/L) is still below both the ANZECC (2000) SMD criteria (3.6 mg/L) and recreational water quality criteria (0.1 mg/L) for manganese, so no detrimental impacts as a result of the slight increase in concentration are likely to occur.

Iron, total nitrogen and ammonia treatment would likely be required to achieve the adopted discharge criteria. The assumed zinc concentration in tunnel groundwater was only slightly above the proposed discharge criteria for Scenario 2 (refer **Table 6-10**). The benefits of treatment are considered to be negligible, therefore further investigation at detailed design would be required to determine whether zinc treatment is warranted.

Treated tunnel water discharges are likely to be fresher than the estuarine receiving waters in the Cooks River with groundwater drawdown at the tunnel potentially leading to an increase in tunnel water salinity over time (refer **Appendix K** of the EIS, Groundwater Technical Report). The tunnel discharges are likely to provide a freshening effect to waters within the immediate vicinity of the outlet, which would be similar to the effect of fresh stormwater discharges occurring at the outlet. The freshening affect would diminish within close proximity of the outlet as mixing occurs. The freshening affect is also likely to diminish at the outlet overtime as tunnel water salinity increases. The box model indicates that impacts to ambient water quality within the Cooks River would be negligible due to the mixing and regular flushing of the system with the impact shown to diminish as tunnel water salinity increases.

Tunnel surface water

The volume and quality of tunnel surface water would be highly variable. Surface water discharge volumes to the Cooks River would therefore also be highly variable with some highly polluted surface water potentially removed for treatment and disposal elsewhere (refer **section 6.3.3**). It is therefore not practical to assess the quantity of pollutants which could potentially be discharged. Tunnel surface water discharges would be intermittent and the quality would be consistent with the discharge criteria for the Cooks River (refer to **section 8.2.4** and **Annexure F**). Therefore impacts as a result of tunnel surface water discharges to the Cooks River would be negligible.

6.3.4 Spills

Spills of oils, lubricants, hydraulic fluids and chemicals could potentially occur during the operation of the project due to vehicle or plant and equipment leakages or a vehicle crash. Any contaminant spill within the project boundary has the potential to pollute downstream waterways, as a result of being conveyed to waterways via the stormwater network. The severity of the potential impact depends on the magnitude and/or location of the spill in relation to sensitive receptors, emergency response procedures and/or management controls implemented on site, and the nature of the receiving environment.

The preliminary stormwater drainage strategy and tunnel drainage strategy (refer **section 2.3** identified the need for spill containment facilities at the following locations:

- President Avenue water quality basin
- Mainline tunnel sump
- Ancillary facilities at West Botany Street
- New operational water treatment plant at Arncliffe.

The proposed spill containment facilities would manage the potential risks to an acceptable level. Impacts to Scarborough Ponds and Cooks River as a result of spills are therefore likely to be negligible.

6.3.5 Impact on NSW Water Quality Objectives

Scarborough Ponds

Runoff from President Avenue, the Princes Highway, the Ventilation at West Botany Street and potentially a portion of the Operational Motorway Control Centre at West Botany Street will drain to Scarborough Ponds (Rockdale Bicentennial Park Pond or Northern Scarborough Pond). It has been demonstrated that the preliminary stormwater drainage strategy and proposed management measures (refer **section 8.2.1**) would minimise impacts to ambient water quality within Scarborough Ponds such that impacts to Scarborough Ponds are likely to be negligible. A small benefit is predicted to occur in terms of a reduction in TSS and TP loading.

Existing water quality within the Scarborough Ponds does not currently meet the NSW Water Quality Objectives.

Opportunities for the project to provide further stormwater quality improvements and to work towards achievement of the NSW WQOs for Scarborough Ponds are available for further consideration during detailed design. This could be achieved by treating existing pavements and/or incorporating measures to remove nutrients within Rockdale Bicentennial Park Pond as part of the restoration of the pond (refer **section 8.2.2**).

Cooks River

Treated flows from the operational water treatment plant and stormwater runoff from that facility would increase the volume of water discharged into the Cooks River. Whilst it is unlikely that the project would have a beneficial impact on ambient water quality when increasing discharge volumes, the proposed treatment facilities would minimise the impact by treating groundwater to a quality suitable for discharge to the Cooks River and minimising stormwater pollutant loading by providing stormwater management measures (**refer section 2.3**). As discussed in **section 6.3.2** and **6.3.3**, impacts to ambient water quality are likely to be negligible. Therefore the project is considered to have a negligible influence on stakeholder goals to achieve the NSW WQOs for the Cooks River over time.

Muddy Creek

Runoff from a portion of the shared cycle and pedestrian pathway and potentially a portion of the Operational Motorway Control Centre at West Botany Street will ultimately discharge to Muddy Creek during operation of the project. With implementation of the preliminary stormwater drainage strategy (refer **section 2.3**) and proposed management measures (refer to **section 8.2.1**), pollutant loading from the Operational Motorway Control Centre and shared cycle and pedestrian pathway would be negligible. Therefore the project is considered to have a negligible influence on stakeholder goals to achieve the NSW WQOs for the Cooks River over time.

7 Assessment of cumulative impacts

7.1 WestConnex

The following WestConnex EIS documents were reviewed in assessing potential cumulative surface water impacts with the project:

- Kings Georges Road Intersection Upgrade Environmental Impact Statement, Appendix L, Flooding and drainage investigation (Lyall and Associates August 2014)
- M4 Widening Environmental Impact Statement (SMEC 2014)
- M4 East Environmental Impact Statement, Appendix Q, Surface Water: Flooding and Drainage (Lyall and Associates 2015a)
- M4 East Environmental Impact Statement, Appendix O, Technical Working paper: Soil and water quality assessment (GHD 2015)
- New M5 Motorway Environmental Impact Statement, Appendix N, Technical Working paper: Surface Water (AECOM 2015)
- New M5 Motorway Environmental Impact Statement, Appendix P, Technical Working paper: Flooding (Lyall and Associates 2015b).

7.1.1 New M5 Motorway and M4-M5 Link

The Cooks River is a common receptor for the New M5 Motorway and the project with Botany Bay being a common sensitive downstream receptor. Whilst there is no common direct surface water receptors for the M4M5 Link and the project during construction or operation, the Cooks River is a downstream receptor for the M4M5 Link project.

The impacts of the New M5 Motorway and M4M5 Link project on surface water were assessed as part of the New M5 Motorway EIS and M4M5 Link EIS. Management measures were identified to mitigate surface water impacts for both the construction and operational phases.

The tunnelling construction works for New M5 Motorway are due for completion in 2019 with the F6 Extension Stage 1 likely to commence in 2020. As construction discharges would not occur at the same time for these two projects, cumulative impacts during construction associated with increased flows and pollutant loading are unlikely to occur.

Construction of the project is likely to overlap with the M4M5 Link construction over the period 2018 to 2022. Discharges from the M4M5 Link Campbell Road construction compound in St Peters would be discharged to Alexandra Canal which is upstream of the Cooks River. The expected combined flow ultimately being discharged to the Cooks River system from the project Arncliffe construction ancillary facility (0.6 ML/day) and M4M5 Link Campbell Road construction compound (1.2 ML/day) is 1.8 ML/day. Given the Cooks River is an estuarine system influenced by tidal flushing with a large upstream catchment (around 10,500 hectares), the increase in flow is considered to be negligible compared to the mean flow and tidal exchange within the Cooks River. Discharges from construction water treatment plants would be required to achieve discharge criteria such that releases would be of suitable quality for discharge to the receiving environment. Therefore, cumulative impacts to water quality and the hydrological regime within the Cooks River due to these two projects would be negligible during construction.

During operation the project, tunnel water would be treated at a new water treatment plant at Arncliffe. Tunnel water from the New M5 Motorway and a small portion of the M4M5 Link project would be pumped to the adjacent New M5 Motorway treatment plant at Arncliffe. This will increase the total flow and pollutant load being discharged to the Cooks River. The approved discharge criteria for the New M5 Motorway project would be adopted for the additional flows contributed by the F6 Extension Stage 1 project. With regard to the estuarine receiving environment and tidal flushing that occurs at the discharge point, and providing management measures are implemented, maintained and monitored for both projects, the cumulative impacts associated with operational discharges to the Cooks River are considered to pose a minimal impact to water quality within the Cooks River.

Runoff volumes to the Kogarah Golf Club drain are likely to increase as a result of additional impervious area associated with the New M5 motorway operation complex and the project operational water treatment plant as discussed in **section 6.2**. This could potentially lead to some minor erosion within unlined sections of the upstream section of the Kogarah Golf Club drain. Implementation of scour protection measures (for example, rainwater harvesting and WSUD measures with extended detention or infiltration upstream of the drain) would manage potential impacts. This would be investigated further during detailed design once the detailed management of runoff at the project water treatment plant site has been confirmed.

The New M5 Motorway EIS indicates that the proposed New M5 Motorway stormwater treatment systems would provide a net benefit to the Cooks River in terms of stormwater pollutant loading for TSS, TP and TN during its operation. Potential opportunities to reduce stormwater pollutant loading to Scarborough Ponds as part of the project have also been identified. Therefore the cumulative impact of the two projects in terms of stormwater pollutant loading to the downstream sensitive environment of Botany Bay could be beneficial but negligible in the context of the larger Botany Bay catchment. Given the Cooks River and Botany Bay are large estuarine systems, increases in stormwater runoff volume as a result of the increased imperviousness associated with the New M5 Motorway, M4M5 Link and the project are considered to pose a negligible impact to the Cooks River hydrological regime.

7.1.2 M4 East

The M4 East project has no common surface water receptors with the project and as such cumulative impacts are unlikely to occur.

7.1.3 M4 Widening

The M4 Widening project has no common surface water receptors with the project and as such cumulative impacts are unlikely to occur.

7.1.4 King Georges Road Interchange Upgrade

The King Georges Road interchange upgrade project has no common surface water receptors with the project but has two common sensitive downstream receptors, the Cooks River and Botany Bay. Cumulative impacts are unlikely to occur to the sensitive downstream receptors provided that the proposed management measures are implemented, maintained and monitored.

7.1.5 Summary

Based on a review of the respective EIS documents for the approved New M5 Motorway, M4M5 Link, M4 East, M4 Widening and King Georges Road interchange upgrade projects of the WestConnex scheme, it is considered unlikely that the project would have a significant cumulative impact on receiving water receptors or sensitive environments provided the proposed surface water management measures are implemented, maintained and monitored.

Therefore, with due consideration of the proposed management measures to be implemented as part of the project (refer to **section 8**), there are minimal adverse cumulative surface water impacts anticipated with the WestConnex projects. The residual risk to common receptors and sensitive environments downstream would be low provided the proposed surface water management measures are implemented, maintained and monitored.

7.2 Sydney Gateway

A surface water impact assessment is not yet available for the Sydney Gateway project therefore the cumulative impact with the F6 Extension Stage 1 project is unable to be fully assessed at this stage. The Cooks River could potentially be a common receptor to both projects, with Botany Bay likely to be a common sensitive downstream receptor. It is assumed that potential surface water impacts for the Sydney Gateway project would be managed in accordance with relevant legislation and guidelines, and that potential cumulative impacts with the F6 Extension Stage 1 project would be assessed in any future EIS prepared for the Sydney Gateway.

7.3 Sydney Metro (Sydenham to Bankstown)

The Sydney Metro City and South West Sydenham to Bankstown upgrade rail corridor would run through the Cooks River catchment, a surface receptor for the project. Potential cumulative surface water impacts could affect the Cooks River and downstream sensitive environments (Cooks River and Botany Bay). The *Sydney Metro City and Southwest Sydenham to Bankstown upgrade Environmental Impact Statement* (Transport for NSW 2017) states that it is expected that with the appropriate mitigation measures in place, residual surface water impacts during construction and operation of that project are likely to be negligible. Providing the environmental management measures for the project are implemented, maintained and monitored, the cumulative impact to the Cooks River and the downstream sensitive receptor of Botany Bay are likely to be minimal.

7.4 F6 Extension (President Avenue to Loftus)

As potential future stages of the F6 Extension are not yet committed, and no surface water impact assessment has been undertaken for those potential future stages, potential cumulative impacts with the F6 Extension Stage 1 project is unable to be fully assessed at this time. If the potential future stages of the project go ahead, Scarborough Ponds could potentially be a common receptor and Botany Bay could be a common sensitive downstream receptor. The key potential cumulative impacts are considered to be increases in pollutant loading during construction and operation and increases in runoff volumes during operation. It is assumed that surface water impacts for potential future stages of the F6 Extension would be assessed cumulatively with the Arncliffe to President Avenue, Kogarah project and would be managed in accordance with relevant legislation and guidelines.

Providing the project and potential future stages of the F6 Extension implement, maintain and monitor appropriate surface water management measures, the cumulative impacts to the common receptors are likely to be minimal, with the potential for some beneficial impacts if opportunities identified as part of the project to improve the water quality of Rockdale Bicentennial Park pond are implemented.

7.5 Local residential development

The local major residential development proposed within proximity to the project includes the Bayside West Precincts of Arncliffe, Banksia and Cooks Cove, development at Wolli Creek and also within the Turrella precinct. In terms of common surface water receptors with the project, Cooks River and Botany Bay are downstream of all of these urban developments, and Muddy Creek downstream of the Banksia precinct. The key potential cumulative impacts are considered to be increases in pollutant loading during construction and post development and increases in runoff volumes post development.

Whilst environmental assessments have not been prepared for the various urban development projects, it is assumed that local councils would impose development conditions to ensure erosion and sediment controls are implemented during construction in accordance with the principles of the Blue Book (Landcom 2004) and that pollutant load reduction targets in accordance with the BBWQIP would be set for the developed sites. Therefore, providing the proposed project environmental management measures are implemented, maintained and monitored, the cumulative impacts to water quality with common receiving and downstream receptors are likely to be minimal.

Given the common receptors of Muddy Creek and Cooks River are estuarine, anthropogenic environments, and given the existing urbanised nature of the development zones, the cumulative increase in runoff volumes associated with the urban development is likely to pose a negligible impact to hydrology or erosion within the waterways.

7.6 Muddy Creek naturalisation

Sydney Water has prepared a concept design for the naturalisation of Muddy Creek between West Botany Street and Bestic Street. The concept design proposes replacement of the existing concrete channel with rock banks, planted with native species, a sandstone block low flow channel and replacement of the existing channel base with new concrete. Other potential opportunities shown within the concept design include saltmarsh zones, a wetland for treating stormwater flows and an outdoor education area. The timing of the works is currently unknown.

Whilst no environmental assessment has been reviewed for the Muddy Creek naturalisation project it is assumed that surface water construction impacts would be managed in accordance with relevant legislation and guidelines, particularly to limit potential mobilisation of sediments downstream during earthworks in the channel. Whilst water quality and hydrological benefits of the naturalisation works are likely to be negligible, the works are likely to result in ecological improvements to the waterway.

The project shared cycle and pedestrian pathways currently conflicts with sections of salt marsh and riparian restoration proposed as part of the Muddy Creek naturalisation concept design.

Providing the proposed project environmental management measures are implemented, maintained and monitored, the cumulative impacts to water quality within Muddy Creek and Cooks River downstream are likely to be negligible. Consultation with Sydney Water would be required during detailed design so that the shared cycle and pedestrian pathway alignment is cognisant of the Muddy Creek naturalisation works.

8 Management of impacts

8.1 Management of construction impacts

8.1.1 Soil and water management plan

A Construction Soil and Water Management Plan (CSWMP) will be prepared for the project. The plan will include the measures that will be implemented to manage and monitor potential surface water quality impacts during construction. The CSWMP will be developed in accordance with the principles and requirements in Managing Urban Stormwater – Soils and Construction, Volume 1 (the 'Blue Book') (Landcom, 2004), Volume 2A (DECCW, 2008a) and Volume 2D (DECCW 2008b).

8.1.2 Erosion and sediment control plan

Erosion and Sediment Control Plans (ESCPs) will be prepared for all work sites in accordance with the Blue Book (Landcom 2004). ESCPs will be implemented in advance of site disturbance and will be updated as required as the work progresses. A soil conservation specialist would be engaged for the duration of construction to provide advice regarding erosion and sediment control.

The ESCP will include but not be limited to the following controls:

- Surface runoff from unpaved surfaces generated during construction will be captured (for example in sediment basins or low point sumps), tested (and treated if required) prior to reuse or discharge under a site specific arrangement, so as to prevent sediment being carried into adjacent waterways or stormwater
- The design, construction and management of any sediment sumps/basins to capture surface runoff and sediment during the construction phase will be in accordance with the Blue Book (Landcom 2004). The number, location and size of these basins/sumps will be confirmed during detailed design and in accordance with the requirements of the relevant Environment Protection Licence
- Internal construction traffic will be restricted to access tracks and where practicable sealed parking areas, delineated (for example through fencing) before the start of construction and maintained until construction is complete, so as to minimise erosion potential of the site and sediment being carried into adjacent waterways or stormwater
- Erosion and sediment controls will be implemented prior to soil disturbance. Lateral flow (i.e. stormwater) will be managed to avoid flow over exposed soils to minimise erosion and impacts to water quality
- The extent of ground disturbance and exposed soil will be minimised to the greatest extent practicable to minimise the potential for erosion
- Disturbed ground and exposed soils will be temporarily stabilised prior to extended periods of site inactivity to minimise the potential for erosion
- Disturbed ground and exposed soils will be permanently stabilised and proposed landscaped areas will be suitably profiled and vegetated as soon as possible following disturbance to minimise the potential for erosion
- Rainfall forecasts will be monitored daily and the site managed to minimise the impact of heavy rainfall and flood events and avoid erosion and sedimentation of adjacent waterways or stormwater
- Sealed surfaces will be provided within construction ancillary facilities where possible to minimise erosion
- Controls to minimise mobilisation of dirt onto roads will be implemented including, for example, wheel wash or rumble grid systems installed at site exit points
- A soil conservation specialist will be contracted to supervise construction involving excavation in 'high risk' areas, in accordance with the Roads and Maritime Erosion and Sedimentation Management Procedure
- Procedures and protocols to manage potentially contaminated fill, soil and bedrock, acid sulfate soils and extracted groundwater will be detailed in the CEMP

- Procedures and controls will be implemented for the management of sediment and hydrologic disturbance within waterways including Rockdale Bicentennial Park Pond and Northern Scarborough Pond to minimise potential impacts on aquatic ecology and habitat
- Procedures and controls to manage sediment and erosion control during the installation of services in accordance with DECC (2008a)
- Procedures and controls to manage dewatering of drainage and service trenches in accordance with DECC (2008a)
- Works within waterfront land will be managed in accordance with the *Controlled Activities on Waterfront Land Guidelines* (DPI 2012), refer **section 8.1.7**.

Indicative discharge criteria for surface water releases are provided in **Table 8-1**. This will be finalised based on relevant project environment protection license and approval conditions. Refer to **section 8.1.6** for discharge criteria for construction water treatment plants.

Table 8-1 Construction surface water discharge criteria

Parameter	Discharge criteria
pH	6.5-8.5
Oil and Grease	No visible oil and grease
Total Suspended Solids	<50 mg/L

8.1.3 Rockdale Bicentennial Park Pond monitoring

Monitoring will be conducted within Rockdale Bicentennial Park Pond and surrounds to improve the characterisation of baseline conditions, to monitor and identify hydrological impacts to Rockdale Bicentennial Park Pond during construction of the project, and to inform the investigation of opportunities for improvement works as part of the proposed restoration of the Pond (refer **section 8.2.2**):

- Continuous (automated) surface water level monitoring of Rockdale Bicentennial Park Pond will be conducted for a period of 12 months prior to the commencement of the cut and cover construction works and during construction works which directly disturb Rockdale Bicentennial Park Pond, or as otherwise required by future conditions of approval. Monitoring to be conducted within proximity to the outlet weir to facilitate estimates of surface water flow over the weir during dry conditions
- Continuous (automated) groundwater level monitoring will be conducted for a period of 12 months prior to the cut and cover tunnel works and during construction works which directly disturb Rockdale Bicentennial Park Pond or as otherwise required by future conditions of approval, to inform an improved understanding of pond hydrology and surface water / groundwater interactions and inform restoration design
- Groundwater quality monitoring will be conducted monthly at the locations nominated in **Annexure G** for the same analysis as the wider project groundwater quality monitoring program (refer **Appendix K** of the EIS, Groundwater technical report) to inform the opportunities for improvement works. Monitoring will be conducted for a period of 12 months prior to construction or as otherwise required by future conditions of approval
- Surface water quality monitoring will be undertaken as detailed in **section 8.1.5**.

8.1.4 Saline soil management

Prior to ground disturbance in areas of potential soil salinity (refer **section 4.7.3**), testing would be carried out to confirm the presence of saline soils. If saline soils are encountered, they would be managed in accordance with *Site Investigations for Urban Salinity* (DLWC 2002).

8.1.5 Water quality monitoring

A program to monitor potential surface water quality impacts of the project will be developed and included in the CSWMP. The program will include the water quality monitoring parameters and the monitoring locations identified in **Annexure G**. Water quality reference criteria have also been developed to assess potential impacts. In accordance with ANZECC (2000), water quality reference criteria will be updated as additional data becomes available prior to construction.

The surface water quality monitoring program will commence prior to any ground disturbance for the project, so as to establish appropriate baseline conditions. The program will continue for the duration of construction, as well as for a minimum of three years following the completion of construction or until the affected waterways are certified by a suitably qualified and experienced independent expert as being of acceptable condition (or as otherwise required by any project conditions of approval).

Samples would be taken monthly, and will be undertaken during a range of wet and dry conditions, where possible. This would include upstream (control) and downstream measurement locations. Additional monitoring locations may be required as part of the CSWMP.

8.1.6 Construction water treatment facilities

Temporary construction water treatment plants will be designed to treat construction wastewater including:

- Tunnel groundwater ingress
- Rainfall runoff in tunnel portal and ventilation shaft construction areas
- Heat and dust suppression water
- Wash down runoff.

Wastewater from concrete washout, fuel and chemical storage areas and refuelling areas will be tested and disposed of at a licensed waste management facility.

Construction wastewater discharge locations are shown in **Figure 5-2**. The proposed discharge criteria for the pollutants of concern for treated construction wastewater are listed in detail in **Annexure F** and summarised in **Table 8-2**. Where feasible and reasonable, construction wastewater will be discharged to Muddy Creek or the Cooks River to protect the more sensitive environment of Scarborough Ponds.

Where feasible and reasonable, construction wastewater will be treated such that discharge concentrations would be equal to or less than the discharge criteria set for the receiving waterways (refer **Annexure F**). The criteria have been developed in accordance with ANZECC (2000) and with consideration to the NSW WQOs. The justification for adopting the proposed discharge criteria is discussed further in **Annexure F**.

Table 8-2 Construction water treatment plant discharge criteria

Receiving waters	Environment	Toxicants	Nutrients	Oil and grease	pH	Turbidity	EC
Cooks River	Highly disturbed system with significant tidal exchange	Marine Water 80% species protection level	80 %ile of reference sites	No visible oil and grease	Between 20%ile and 80%ile of reference site	80 %ile of reference site	NA (estuarine waters)
Muddy Creek	Highly disturbed system with tidal exchange	Marine Water 80% species protection level	80 %ile of reference sites	No visible oil and grease	Between 20%ile and 80%ile of reference site	80 %ile of reference site	NA (estuarine waters)
Rockdale Bicentennial Park Pond	Highly disturbed system Freshwater and limited assimilative capacity for nutrients with high potential for algal blooms	Freshwater slightly to moderately disturbed protection level	Freshwater slightly to moderately disturbed trigger level	No visible oil and grease	Between 20%ile and 80%ile of reference site	10 NTU	80%ile of reference site

Receiving waters	Environment	Toxicants	Nutrients	Oil and grease	pH	Turbidity	EC
Northern Scarborough Pond	Highly disturbed system Limited tidal exchange and limited assimilative capacity for nutrients with high potential for algal blooms	Marine Water slightly to moderately disturbed protection level	Estuarine slightly to moderately disturbed trigger level	No visible oil and grease	Between 20%ile and 80%ile of reference site	10 NTU	NA (estuarine waters)

The design of the construction water treatment plants will be undertaken during detailed design. The treatment facilities may consist of:

- Primary settling tanks / ponds to remove sand and silt sediment fractions as well as oil and grease
- pH balance/metals oxidation tank with primary flocculation
- Secondary flocculation tank
- Clarifiers to remove sediment and residual oil
- Sediment dewatering processes
- More advanced treatment such as, for example, reverse osmosis or ion exchange for releases to Scarborough Ponds to treat the higher nutrient concentrations likely to occur in groundwater, and potentially to remove salinity where Rockdale Bicentennial Park Pond is the receiving environment
- Inline process and discharge turbidity and pH monitoring with diversion valves to divert out of specification water for retreatment.

8.1.7 Activities on waterfront land

All works within watercourses or on waterfront land will be managed in accordance with the *Controlled Activities on Waterfront Land* guidelines (DPI 2012).

The WM Act defines waterfront land as the bed of any river, lake or estuary and any land within 40 metres of the river banks, lake shore or estuary mean high water mark.

Specific measures to manage impacts associated with the construction of the cut and cover structure through Rockdale Bicentennial Park Pond are as follows:

- A temporary barrier (such as, for example, a cofferdam) would be required upstream and downstream of the proposed cut and cover construction zone through Rockdale Bicentennial Park Pond to isolate the works from the rest of the pond and prevent mobilisation of sediment and pollutants from the construction zone into adjacent areas. Water within the construction zone will be treated by the construction water treatment plant (refer **section 8.1.6**).
- Additional controls (such as, for example, silt curtains or similar) will be installed to manage sediment mobilised during installation of the temporary barriers
- Hydrologic connectivity through Rockdale Bicentennial Park Pond will be retained (for example by a diversion channel or equivalent connecting structure). Design of the upstream hydraulic control level (for example, for the channel or equivalent connecting structure) will be informed by baseline surface water and groundwater level monitoring (refer **section 8.1.3**) to maintain hydrologic connectivity and water levels across the pond during low flow / dry conditions.

The proposed power supply corridor alignment would be finalised during detailed design. The corridor will be realigned around (or bored under) sensitive environmental features, including Bardwell Creek.

8.1.8 Water reuse

A Water Reuse Strategy for the construction and operational phases of the project will be developed during detailed design, and will outline the construction and operational water requirements and potential water sources to supply the water demand.

8.1.9 Contaminated runoff and spills

The following measures will be implemented to manage spills of contaminated fluids:

- Areas for the storage of fuels, chemicals and other hazardous materials will be located as far away as feasible and reasonable from drainage channels; outside the 20 year ARI event, and on an impervious, bunded area
- Areas for the storage of fuels, chemicals and other hazardous materials will be secured and bunded to levels in accordance with the NSW EPA guidelines
- Spills or contaminated runoff will be captured and disposed of at a licensed facility where necessary
- Activities such as re-fuelling, wash down and preparation of construction materials will be undertaken in designated and bunded areas to prevent spills or leaks of fuels/oils or other hazardous onsite construction material moving offsite and/or into adjacent stormwater or waterways
- Potential discharges from construction sites (such as accidental construction spills or leaks) will be managed through the installation of (for example) sumps / basins (primarily designed for sediment capture but with capacity to contain the nominated spill volume) constructed in accordance with Managing Urban Stormwater – Soils and Construction, Volume 2D (Landcom 2004). Captured contaminants resulting from spills or leaks will be treated and disposed of at a licensed facility where necessary
- Soil which has been contaminated with fuel, oils or other chemicals will be appropriately classified and disposed offsite at a licensed facility.

8.1.10 Minimising impacts to sensitive receiving environments

No highly sensitive receiving environments were identified (refer **section 4.5**). All measures listed above are applicable to minimising impacts to the low and moderately sensitive receiving environments.

The following design components and management measures are specifically applicable to minimising impacts to the moderately sensitive receiving environments of Rockdale Bicentennial Park Pond and Northern Scarborough Pond:

- All erosion and sediment controls installed upstream of Rockdale Bicentennial Park Pond and Northern Scarborough Pond (refer **section 8.1.2**)
- Surface water level and groundwater quality and level sampling at Rockdale Bicentennial Park Pond (refer **section 8.1.3**).
- Surface water quality monitoring in Rockdale Bicentennial Park Pond and Northern Scarborough Pond (refer **section 8.1.5**)
- Construction water treatment facilities and redirection of treated flows to Muddy Creek where feasible (refer **section 8.1.6**)
- Sediment controls either side of cut and cover tunnel across Rockdale Bicentennial Park Pond (refer **section 8.1.9**)
- Retention of hydrologic connectivity during construction in Rockdale Bicentennial Park Pond (refer **section 8.1.7**)
- Contaminated runoff and spill management at C2, C3 and C4 (refer **section 8.1.9**)

8.2 Management of operational impacts

8.2.1 Stormwater management

A stormwater management strategy for the capture, treatment and disposal of stormwater runoff from new road pavements was developed for the project as described in **section 2.3**.

To achieve the pollutant load reduction targets for the project, the proposed stormwater management strategy that has been developed for the project will be implemented, which includes the following treatment measures for the operation of the project at the President Avenue intersection:

- A biofiltration water quality basin to treat runoff from the tunnel portals at President Avenue
- Re-establishment of a grass swale adjacent and south of President Avenue
- New grass swales to convey runoff from batter slopes to Rockdale Bicentennial Park Pond
- New grass swale to convey diverted residential runoff to Rockdale Bicentennial Park Pond.

The water quality basin which incorporates biofiltration and swales are commonly used water sensitive urban design (WSUD) systems. They take into account WSUD principles by using vegetation and soil media to attenuate, filter and treat runoff prior to release to surface waters.

The final selection and design of the stormwater treatment measures will be undertaken during detailed design, supported by additional MUSIC modelling as the design progresses.

Potential for implementation of additional treatment measures within the project footprint will be investigated during detailed design, where feasible and reasonable, to provide a beneficial impact on water quality within Scarborough Ponds (and thereby provide a contribution to achieving the NSW WQOs over time). This investigation will explore opportunities to treat the existing pavements and incorporate passive treatments within the Rockdale Bicentennial Park Pond (as described in **section 8.2.2**).

Stormwater treatment of other (non-road pavement) project elements will include:

- Landscaped areas will be suitably profiled, vegetated and stabilised to control erosion
- Passive treatment of stormwater from the shared cycle and pedestrian pathway pavement. This could include diverting stormwater to a grass or vegetated buffer adjacent to the pavement or through use of a permeable pavement system
- Incorporation of rainwater harvesting and proprietary devices to treat runoff from ancillary buildings and pavement where feasible and reasonable.

The above passive treatment and rainwater harvesting measures take into account WSUD principles by replicating a natural system through infiltration and reuse respectively to reduce runoff volumes.

The need for incorporation of WSUD measures with extended detention and / or infiltration or bank stabilisation techniques to manage potential bank erosion within the unnamed golf course drain will be investigated during detailed design.

8.2.2 Rockdale Bicentennial Park Pond stormwater quality assets

The existing floating wetlands within the Rockdale Bicentennial Park Pond will be retained, protected and maintained during construction.

The existing stormwater outlet located adjacent to the Rockdale Bicentennial Park Pond footbridge and within the cut and cover corridor will be relocated during construction. The trash rack on the existing outlet will be relocated to the new outlet or replaced with an equivalent device.

8.2.3 Rockdale Bicentennial Park Pond restoration

The Rockdale Bicentennial Park Pond weir at President Avenue will be replaced with a similar arrangement and weir crest level to the existing structure to maintain the existing permanent water level and existing level of protection to saline water intrusion from Northern Scarborough Pond.

As part of the restoration of Rockdale Bicentennial Park Pond, and in consultation with Bayside Council and other relevant stakeholders identified within the conditions of approval, opportunities to incorporate improvement measures to the pond to provide additional treatment of surface water and shallow groundwater to assist nutrient removal will be investigated. This may include investigation of:

- The incorporation of opportunistic macrophyte zones and appropriate treatments within the wetland zones disturbed by the project during construction
- Solar powered aeration devices to aerate the water column and maintain more consistent dissolved oxygen conditions within deeper zones to reduce algal bloom conditions
- Solar powered water circulation facilities to push water through macrophyte benches and eliminate stagnant areas and aquatic weed and algal growth
- Passive treatment of shallow groundwater within a sub-surface wetland system upstream of Rockdale Bicentennial Park Pond if groundwater and surface water level monitoring (refer **section 8.1.3**) indicate groundwater inflows to be a significant contributor of pollutants to the pond.

Due to the interaction between surface water and surrounding groundwater at Rockdale Bicentennial Park Pond, a surface water and groundwater monitoring regime within the Rockdale Bicentennial Park Pond and surrounds will be undertaken to inform the investigation, as described in **section 8.2.6**.

8.2.4 Tunnel water treatment facilities

Tunnel groundwater inflows during operation of the project will be pumped to a new water treatment plant at Arncliffe for treatment and disposal. The water treatment plant will be designed such that effluent will be of suitable quality for discharge to the receiving environment. The adopted F6 Extension Stage 1 discharge criteria are consistent with the New M5 Motorway approval conditions and agreed discharge criteria to the Cooks River.

Trigger levels for the Cooks River were provided within the New M5 Motorway EIS Technical Working Paper: Surface Water, Appendix N (AECOM 2015). A summary of the New M5 Motorway discharge criteria is provided in **Table 8-3**. Full details are provided in **Annexure F**.

Table 8-3 Operational water treatment plant – water quality discharge criteria

Receiving waters	Toxicants	Nutrients	pH	Turbidity
Cooks River	ANZECC (2000) 80% species protection level for estuarine waters	80 percentile of reference data as determined by New M5 Motorway project	Range between 20 and 80 percentile of reference data as determined by New M5 Motorway project	80 percentile of reference data as determined by New M5 Motorway project.

8.2.5 Spill controls

Spill containment facilities are proposed within the sediment basin at President Avenue and the tunnel sump. Spill containment facilities will also be provided as part of on-site management at the President Avenue construction ancillary facility (C3) and operational water treatment plant facility. The final design of the spill containment facilities would be determined during detailed design.

Spill management and emergency response procedures would be documented in an OEMP.

8.2.6 Rockdale Bicentennial Park Pond monitoring

Continuous (automated) monitoring of water levels at Rockdale Bicentennial Park Pond would be conducted following the completion of construction for a period of 12 months (or as otherwise required by future conditions of approval).

The findings of the pre and post construction water level monitoring and relevant water quality monitoring (refer **section 8.1.4** and **section 8.2.7**) would be reviewed as part of an investigation by a suitably qualified and experienced independent expert to certify that the Rockdale Bicentennial Park Pond has been restored to an acceptable level in terms of its hydrology and water quality, including a review of how water quality within the downstream waters may have been affected by the restoration works.

8.2.7 Water quality monitoring

A program to monitor potential surface water quality impacts due to the project will be developed and included in the OEMP. The program will include the water quality monitoring parameters and the monitoring locations identified in **Annexure G**. Water quality reference criteria for assessing potential impacts within the receiving waters have also been provided within **Annexure F**. The water quality reference criteria will be updated and finalised during the preparation of the CSWMP to enable additional pre-construction monitoring results to be incorporated.

The monitoring program would continue for a minimum of three years following the completion of construction or until the affected waterways are certified by a suitably qualified and experienced independent expert as being of acceptable condition (or as otherwise required by any project conditions of approval).

8.2.8 Minimising impacts to sensitive receiving environments

No highly sensitive receiving environments were identified (refer **section 4.5**). All measures listed are applicable to minimising impacts to the receiving environments.

The following design components and management measures are specifically applicable to minimising impacts to the moderately sensitive receiving environments of Rockdale Bicentennial Park Pond and Northern Scarborough Pond:

- Swales and water quality basin at President Avenue upstream of Rockdale Bicentennial Park Pond (refer **section 8.2.1**)
- Spill containment facilities within the water quality basin at President Avenue and within the Ventilation facility and Operational Motorway Control Centre at Rockdale upstream of the Rockdale Bicentennial Park Pond (refer **section 8.2.5**)
- Investigation into opportunities to provide improvement measures to Rockdale Bicentennial Park Pond (refer **section 8.2.3**)
- Water level monitoring as part of restoration of Rockdale Bicentennial Park Pond (refer **section 8.2.6**)
- Water quality monitoring in Rockdale Bicentennial Park Pond and North Scarborough Ponds (refer **section 8.2.7**).

8.3 Management of cumulative impacts

With due consideration of the proposed management measures to be implemented as part of the project as discussed in **sections 8.1** and **8.2**, there are minimal adverse cumulative surface water impacts anticipated. The residual risk to common receptors and sensitive environments downstream would be low provided the proposed management measures are implemented, maintained and monitored.

9 Conclusion

9.1 Surface water hydrology, geomorphology and water resources

Potential impacts to the surface water hydrology and geomorphology during construction of the project as a result of discharges of surface water and construction wastewater and disturbances to waterways are considered to be confined to the construction footprint with application of the proposed management measures. Treated construction wastewater will be discharged to the highly disturbed, less sensitive, estuarine environments of Muddy Creek and the Cooks River and discharges to the more sensitive waterways of Rockdale Bicentennial Park Pond and Northern Scarborough Pond would be limited to intermittent surface water releases where feasible. Potential scour impacts at construction discharge locations will be controlled through implementation of dissipation and scour protection measures where appropriate. Hydrologic connectivity within Rockdale Bicentennial Park Pond will be retained during the construction of the cut and cover tunnel.

Residual impacts to surface water flows and water levels during dry conditions and after frequent rainfall events in Scarborough Ponds, Muddy Creek and the Cooks River are considered to be negligible during the operation of the project. Potential scour impacts at discharge locations will be controlled through implementation of dissipation and scour protection measures. Monitoring and an independent investigation will be undertaken after the restoration of the Rockdale Bicentennial Park Pond to certify that Rockdale Bicentennial Park Pond restoration works are undertaken appropriately.

9.2 Surface water quality

Quantitative and qualitative assessments for all pollutants that pose a risk of non-trivial harm to human health and the environment were undertaken.

Potential impacts to surface water quality during construction of the project, associated with discharges of surface water and construction wastewater and disturbances to waterways, are considered to be manageable with application of the proposed management measures.

The CEMP will control potential surface water quality impacts during construction. Construction water treatment plants will be established during the construction phase to treat water to a quality suitable for discharge to the environment.

A CSWMP will be prepared as part of the overall CEMP. The CSWMP will set out how soil and water would be managed during construction. A Water Quality Monitoring Program will be prepared and implemented to monitor, identify and mitigate impacts on surface water quality during construction and operation. A surface water and groundwater level monitoring program for Rockdale Bicentennial Park Pond will also be implemented to inform the restoration works and monitor, identify and mitigate impacts.

Potential impacts to surface water quality during operation of the project, associated with treated tunnel water discharges, stormwater discharges and spills, are able to be mitigated by the proposed design and with application of the proposed management measures.

Stormwater quality treatment systems will be implemented at President Avenue and the operational ancillary facilities, and tunnel water will be pumped to a new water treatment plant at Arncliffe. Spill containment facilities will be provided at President Avenue and the tunnel sump. Spill management and emergency response procedures will also be documented in an OEMP. Opportunities for improvements to surface water quality have been identified for further investigation during detailed design.

10 References

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Annexure A – Photographs

Photograph 1 – Cooks River upstream of Southern and Western Suburbs Ocean Outfall Sewer (SWSOOS) crossing

Photograph 2 - Muddy Creek channel downstream of West Botany Street

Photograph 3 – Rockdale Bicentennial Park Pond

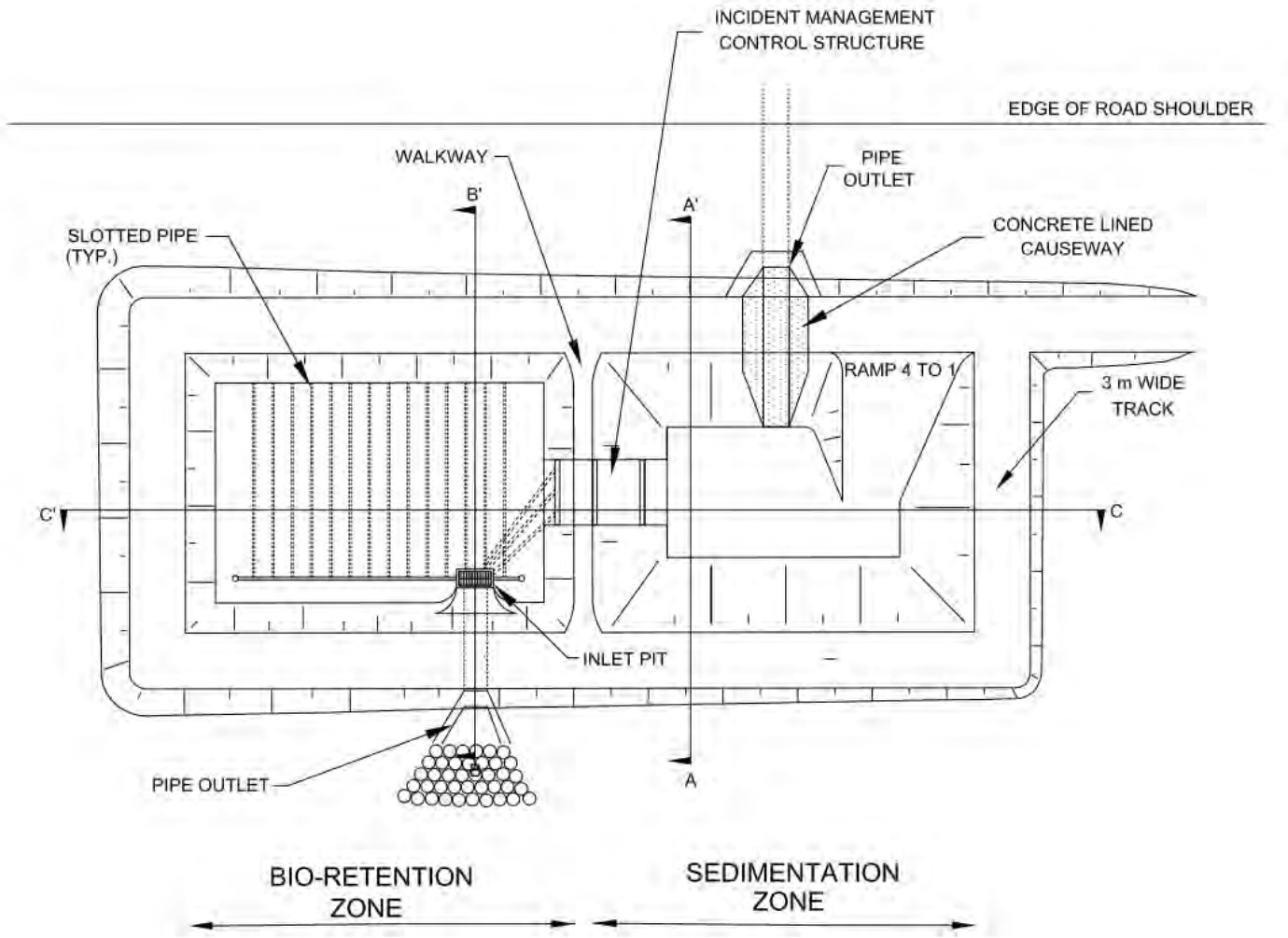
Photograph 4 – Rockdale Bicentennial Park Pond

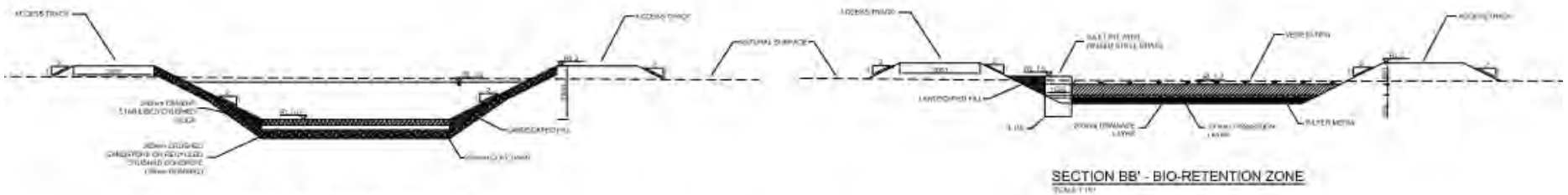
Photograph 5 – Floating wetland in Rockdale Bicentennial Park Pond

Photograph 6 – Rockdale Bicentennial Park Pond Weir at President Avenue

Photograph 7 – Open channel between President Avenue and North Scarborough Pond

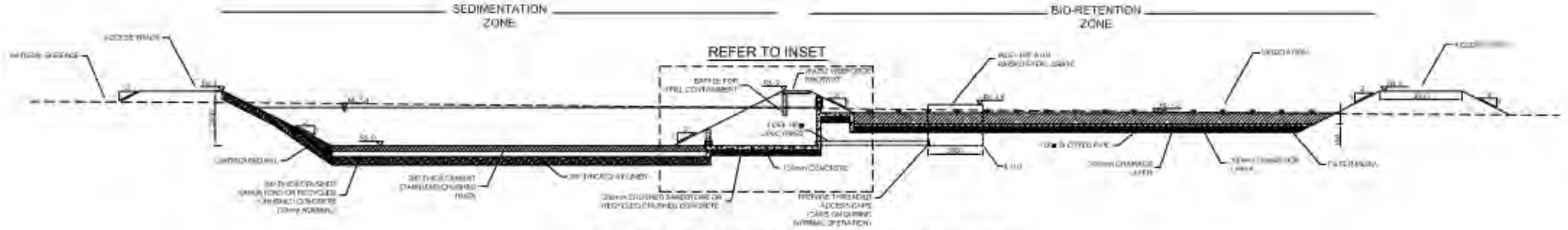
Annexure B – Concepts for water quality basin at Presidents Avenue



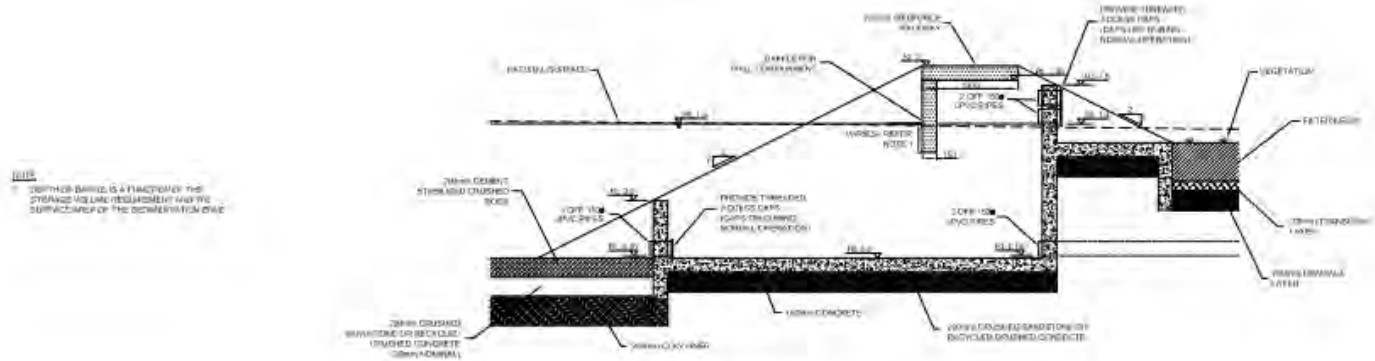


SECTION AA' - SEDIMENTATION ZONE

SECTION BB' - BIO-RETENTION ZONE



SECTION CC' - SEDIMENTATION AND BIO-RETENTION ZONES



INSET - INCIDENT MANAGEMENT CONTROL STRUCTURE

Annexure C – MUSIC Modelling

MUSIC modelling at President Avenue

The adopted stormwater quality targets for treatment of road runoff were based on the BBWQIP mean annual pollutant load reduction targets for urban development. Project specific targets were determined by applying the BBWQIP mean annual pollutant load reduction target percentages to the pollutant load generated by the additional pavement footprint resulting from the project, refer **Table 10-1**.

The project would result in around 1.44 hectares of additional pavement including portals and the road widening along President Avenue and the Princes Highway.

The catchments and their treatment nodes were modelled using the MUSIC software and the results were compared to the targets set for the additional pavement area as described above. As runoff discharging to the proposed project stormwater treatment systems and discharge points would be from external catchments, upstream of the project boundary, the external catchments were accounted for within the model. Any pollutant load reduction achieved by treating the external catchments was therefore also accounted for when assessing the performance of the stormwater treatment systems.

Table 10-1 Pollutant reduction target calculation

Pollutant	BBWQIP Mean annual pollutant load reduction target (%)	Pollutant load generated from increased pavement footprint (kg/yr)	Pollutant load Reduction Target [1] (kg/yr)
TSS	85	4340	3689
TP	60	8.1	4.8
TN	45	35.3	15.9

[1] Equates to the pollutant load reduction target (%) multiplied by the increased pollutant load (kg/yr)

The modelled catchments are shown in **Figure 10-1**. The modelled catchment areas and proposed treatment systems are provided in **Table 10-2**. Whilst accounted for when estimating the increase in pollutant load, as no treatment systems are proposed, the road widenings outside the President Avenue Centre catchment (refer to **Figure 10-1**) were not modelled. The ancillary facilities at West Botany Street were also not modelled in MUSIC as there would be no change in impervious area at these sites. Stormwater within the water treatment plant facility at Arncliffe would be managed as described in **section 2.3** and as such, stormwater quality for the water treatment plant was not assessed in MUSIC.

Table 10-2 Stormwater catchments

Catchment	Area (ha)	Existing Treatment	Base Case
President Avenue West	10.78	None	None
President Avenue Centre	1.18	None	None
President Avenue South	4.73	None	None
President Avenue North	3.6	None	None
Portals	0.65	None	Sedimentation Basin and Bioretention
O'Neill St Wider Catchment	12.62	None	Grassed swale

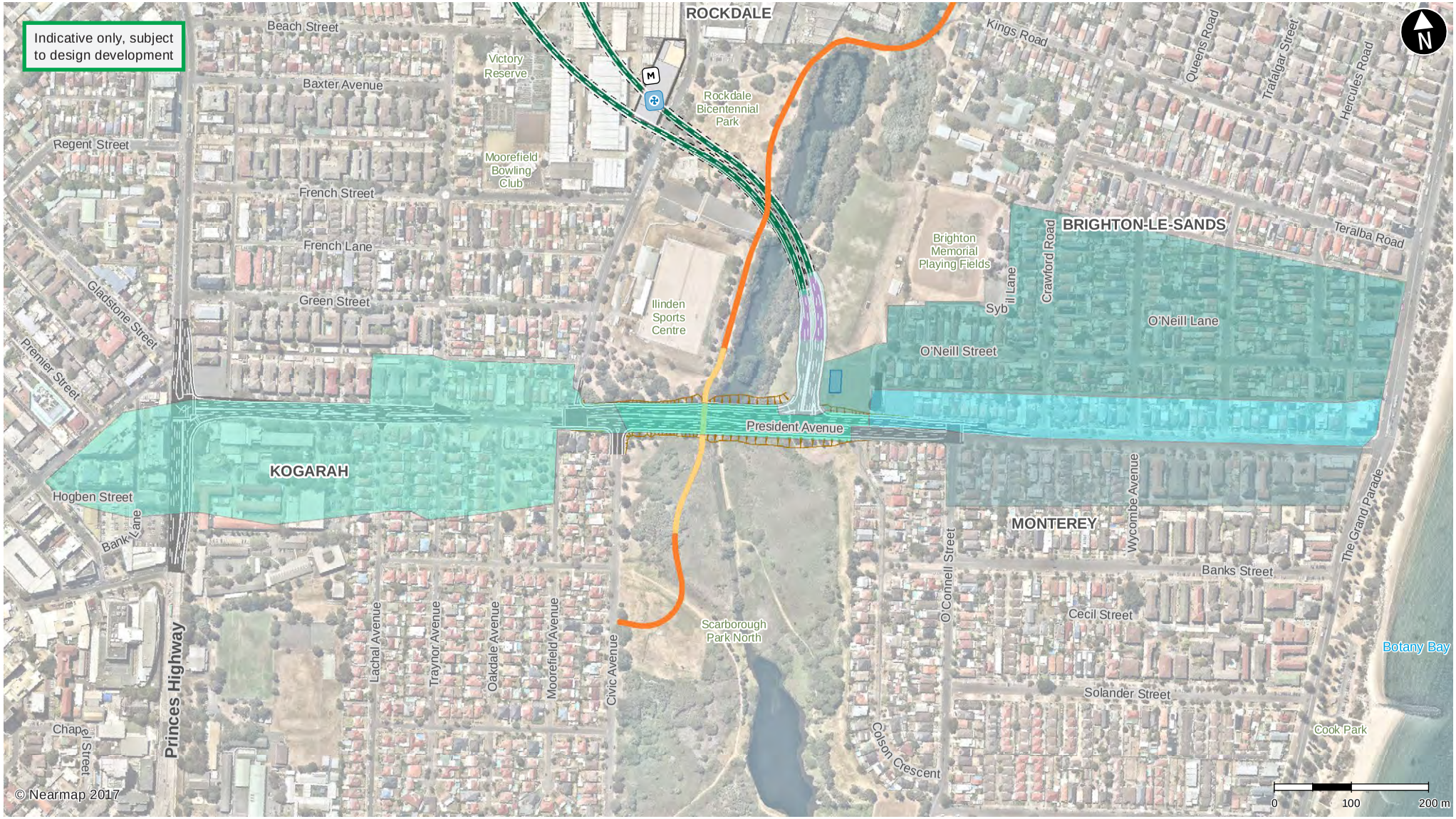


Figure 10-1 MUSIC Modelling catchments

MUSIC modelling for broader catchment upstream of President Avenue

The catchment extent for assessing pollutant loads upstream of President Avenue including the entire Rockdale Bicentennial Park Pond catchment is provided in Figure 10-2.

A total catchment area of 116.5 hectares was applied in the Model with an effective impervious area of 42%. Two scenarios were modelled assuming 0% treatment and 25% treatment respectively of the upstream catchment. A generic node was applied to the catchment to treat 25% of the catchment to meet BBWQIP pollutant load reduction targets. The 25% treatment assumption is considered to be conservative given much of the development in the area pre-dates the BBWQIP and other WSUD initiatives.

Figure 10-2 Extent of broader catchment upstream of President Avenue

MUSIC modelling inputs

The MUSIC modelling parameter inputs are provided in **Table 10-3** to **Table 10-7**. The parameters have been selected based on relevant values documented within the NSW MUSIC Modelling Guidelines (BMT WBM 2015).

Rainfall time series was selected as 5/1/1962 to 31/12/1966 for Observatory Hill with a mean annual rainfall of 1279 mm.

Table 10-3 Effective impervious area

Zoning/ Surface Type	EIA Factor	Source
Sealed Road	1 x Total Surface Area	Table 5-2
Residential	0.6 x Total Impervious Area	Table 5-3

Table 10-4 Default rainfall threshold values (RT)

Zoning/ Surface Type	RT (mm)	Source
Sealed Road	1.5	Table 5-4
Residential	1	Table 5-4

Table 10-5 Pervious area rainfall-runoff parameters

Soil Texture	Soil Storage Capacity (mm)	Field Capacity (mm)	Infiltration Capacity Coefficient "a" (mm/d)	Infiltration Capacity Coefficient "b"	Daily Recharge Rate (%)	Daily Baseflow Rate (%)	Daily Deep Seepage Rate (%)
Clayey Sand	107	75	250	1.3	60%	45%	0%

Table 10-6 Base flow concentration parameters

Zoning/ Surface Type	Total Suspended Solids (mg/L-log10)		Total Phosphorus (mg/L-log10)		Total Nitrogen (mg/L-log10)	
	Mean	Std dev	Mean	Std dev	Mean	Std dev
Residential	1.20	0.17	-0.85	0.19	0.11	0.12
Sealed Road	1.20	0.17	-0.85	0.19	0.11	0.12

Table 10-7 Storm flow concentration parameters for NSW

Zoning/ Surface Type	Total Suspended Solids (mg/L-log10)		Total Phosphorus (mg/L-log10)		Total Nitrogen (mg/L-log10)	
	Mean	Std dev	Mean	Std dev	Mean	Std dev
Residential	2.15	0.32	-0.60	0.25	0.30	0.19
Sealed Road	2.43	0.32	-0.30	0.25	0.34	0.19

Annexure D – Box model

Approach

A box model of the Cooks River was developed to assess the impact of treated tunnel water discharges to the Cooks River with consideration to the proposed treatment plant and dilution and mixing which would occur upon release.

In this model, the Cooks River has been schematised into three control volumes whereby the main process of mixing is tidal exchange. This mixing is assumed to be uniform and effective. The model is split in three to further understand the spatial variations that occur across the water body. For each box, stormwater concentrations, groundwater concentrations, and inflows have been averaged over time, with Botany Bay having constant water quality as a boundary condition. With these assumptions, an iterative scheme over many tidal cycles has been created to estimate the final water body concentrations at each box for a selection of analytes at three locations. In this annexure, the hydrology of Cooks River is introduced first, followed by a description of the box model.

The inputs to the box model are described as follows. The results are presented in **section 6.3.3**.

Hydrology

A high level continuous rainfall runoff model of the Cooks River catchment has been developed to estimate average stormwater and baseflow inputs to the Cooks River. The model was developed using the MUSIC software. An overview of the box model extent can be seen in **Figure 10-5**. Refer to **Annexure C** for MUSIC modelling assumptions. The MUSIC model catchment inputs are provided in **Table 10-8**.

Table 10-8 MUSIC model Cooks River catchment inputs

Parameter	Upstream	Middle	Downstream
Catchment Area (ha)	8942	144	1031
Effective Impervious Area (%)	47	28	40

From the MUSIC model, a median flow was calculated for each catchment and used to evaluate the volume of stormwater (V_{sw}) at each time step.

Figure 10-3 Box Model Sub-catchments

Box model

A box model simulates the average state of a system through mass balancing and is used to evaluate heterogeneities in the system. A summary of the water balance and mass balance components of the model is provided below.

The box consists of a flood (V_{ft}) and ebb (V_{et}) component. The proposed outlet for tunnel groundwater (V_{gw}) is introduced in the middle box model, allowing upstream and downstream influences to be observed with each tidal cycle. As a whole, the water balance of Cooks River is determined using a simple box model and is expressed in discrete time steps:

$$\frac{dV}{dt} = V_0 + V_{ft} - V_{et} + V_{sw} + V_{gw} = 0 \qquad \text{(over many tidal cycles)}$$
$$V_{et} = V_{ft} + V_{sw} + V_{gw}$$

As the main exchange of mixing is tidal exchange, the tidal prism (V_{ft}) is calculated using mean high tide (MHW) and mean low tide (MLW) values with (V_0) representing the volume of the box at mean low water. Tidal heights were obtained from Manly Hydraulics Lab (2012), and using bathymetric data the flood tide volumes were calculated as follows:

As the main exchange of mixing is tidal exchange, the tidal prism (V_{ft}) is calculated using mean high tide (MHW) and mean low tide (MLW) values with (V_0) representing the volume of the box at mean low water. Tidal heights were obtained from Manly Hydraulics Lab (2012), and using bathymetric data the flood tide volumes were calculated as follows:

$$V_{ft} = V_{MHW} - V_{MLW}$$

Since the change in volume over time is assumed to reach zero, change in concentration can be calculated through mass balance equations.

As water propagates upstream due to the tidal process, there is an exchange of residual concentration (C_{i-1}) based on the previous box or bay (C_{bay}) providing model continuity, refer to **Figure 10-5** These have been calculated using the mass balance equations in **Figure 10-4** for the flood and ebb tides respectively.

Figure 10-4 Mass balance calculations for the flood and ebb components of each box

Flood Tide	**Ebb Tide**
At t=0, $C_i=C_{bay}$ $V_{sw} = t \times Q_{sw}$ $M_i = V_{mid} \times C_{i-1}$ $M_{ft} = V_{ft} \times C_{i-1}$ $M_{sw} = V_{sw} \times C_{sw}$ $M_{gw} = V_{gw} \times C_{gw}$ $C_{i(full)} = \frac{M_{sw} + M_{ft} + M_i + M_{gw}}{V_{sw} + V_{ft} + V_i + V_{gw}}$	$V_{sw} = t \times Q_{sw}$ $M_i = V_i \times C_{i-1}$ $M_{sw} = V_{sw} \times C_{sw}$ $M_{gw} = V_{gw} \times C_{gw}$ $M_{et} = \frac{M_{et}}{C_{us}}$ $C_i = \frac{M_{sw} + M_i + M_{gw} + M_{ft} - M_{et}}{V_{us}}$

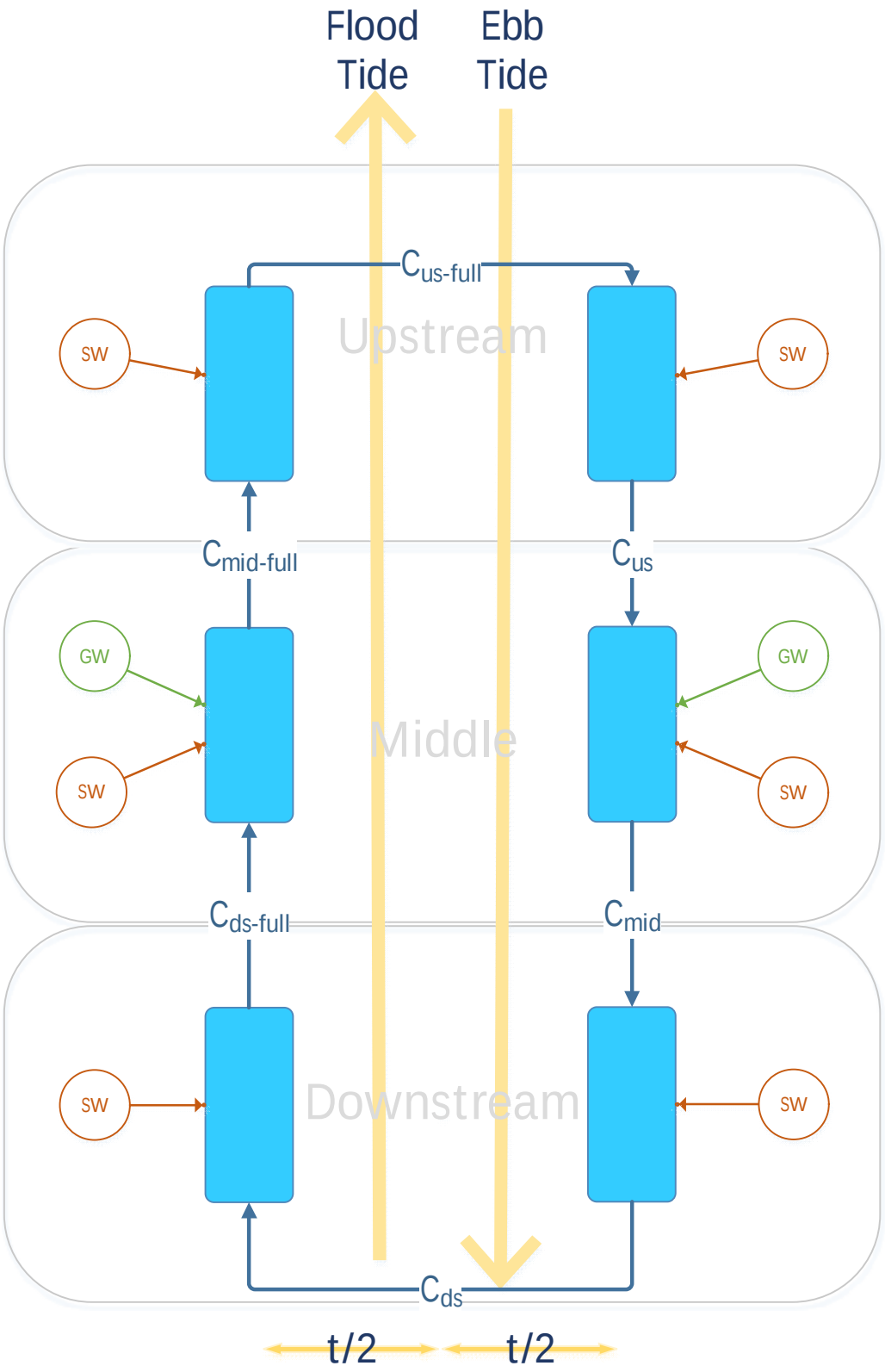


Figure 10-5 Schematisation of Cooks River Box Model

Treated discharge assumptions

Water quality inputs to the Box model were developed as per Table 10-9. Two scenarios were modelled:

- Scenario 1 – F6 Extension Stage 1 treated tunnel water discharges (9.6 L/s Flow)
- Scenario 2 – Cumulative discharge of F6 Extension Stage 1 + New M5 Motorway + M4M5 Link treated tunnel water (38.2 L/s)

Table 10-9 Water quality inputs to box model

Parameter	Method
Tunnel groundwater quality for F6 Extension Stage 1	Based on upper bound (assumed to be mean plus one standard deviation) groundwater quality as described in section 4.6
Tunnel groundwater quality for New M5 Motorway + F6 Extension Stage 1	Based on flow weighted concentration for F6 + New M5 Motorway. New M5 Motorway concentration based on groundwater quality monitoring reported in the MOC3 – Arncliffe Motorway Operations Complex – Water Treatment and Discharge, Design Report, for WestConnex New M5 Motorway, prepared for CPB Dragados Samsung Joint Venture (AJJV 2017)
Discharge concentration	Lesser of New M5 Motorway discharge criteria and indicative tunnel water quality
Surface water quality	Based on median Cooks River water quality for Site 3 and Site 4, refer Annexure E

References

BMT WBM 2010, Draft Music Modelling Guidelines for New South Wales, (for Sydney Metropolitan Catchment Authority), August 2010, Reference R.B17048.001.01

BMT WBM 2015, NSW Music Modelling Guidelines, (for Greater Sydney Local Land Services), August 2015, Reference R.B17048.001.05

MHL 2012, OEH NSW Tidal Planes Analysis, 1990-2010 Harmonic Analysis, (for NSW Office of Environment and Heritage), October 2012, Reference MHL2053

Annexure E – Water Quality Monitoring

Geophysical parameters

F6 Extension monitoring program (AECOM 2017) - SW1 - Muddy Creek – Geochemical results

Parameter	DO (mg/L)	EC (µS/cm)	pH	Redox (mV) - sensor reading	Redox (mV)	Temperature (°C)	Turbidity (NTU)
Estuarine ANZECC SMD Criteria	-	-	7.0 - 8.5		-	-	50
20%ile	3.4	25577	7.1	114.7	319.7	14.4	1.2
50%ile	4.8	40732	7.5	146.9	351.9	19.4	5.0
80%ile	6.1	45532	7.8	206.8	411.8	21.5	7.9
Min	2.4	5407	6.1	51.0	256.0	12.3	0.1
Max	6.6	49276	7.9	255.8	460.8	23.4	15.5
Mean	4.7	35873	7.4	153.3	358.3	18.4	4.9
Number of Samples	19	19	19	19	19	19	15

Note: samples taken between 6 Sept 17 to 11 Sept 18

F6 Extension monitoring program (AECOM 2017) – SW2 - Muddy Creek – Geochemical results

Parameter	DO (mg/L)	EC (µS/cm)	pH	Redox (mV) - sensor reading	Redox (mV)	Temperature (°C)	Turbidity (NTU)
Estuarine ANZECC SMD Criteria	-	-	7.0 - 8.5		-	-	50
20%ile	4.5	1805	7.6	111.7	316.7	16.4	3.4
50%ile	6.4	37056	7.8	141.0	346.0	19.8	4.9
80%ile	9.8	46901	7.9	200.9	405.9	23.0	6.4
Min	3.6	356	7.2	62.4	267.4	12.6	-0.1
Max	13.6	48577	9.0	230.1	435.1	27.5	30.8
Mean	7.3	28890	7.8	147.5	352.5	19.9	6.5
Number of Samples	19	18	19	19	19	19	15

Note: samples taken between 6 Sept 17 to 11 Sept 18

F6 Extension monitoring program (AECOM 2017) – SW3 - Rockdale Bicentennial Park Pond (Rockdale Wetlands) - Geochemical results

Parameter	DO (mg/L)	EC (µS/cm)	pH	Redox (mV) - sensor reading	Redox (mV)	Temperature (°C)	Turbidity (NTU)
Lowland River ANZECC SMD Criteria	-	125 - 2200	6.5 - 8.5		-	-	50
20%ile	1.7	257	7.4	72.3	277.3	14.6	5.3
50%ile	2.6	376	7.5	126.9	331.9	19.6	9.0
80%ile	7.2	482	7.9	164.4	369.4	23.4	13.4
Min	1.1	8	5.5	55.0	260.0	10.1	1.4
Max	9.9	715	9.1	1070.0	1275.0	27.7	30.7
Mean	4.0	376	7.6	172.4	377.4	19.2	10.3
Number of Samples	19	18	19	19	19	19	15

Note: samples taken between6 Sept 17 to 11 Sept 18

F6 Extension monitoring program (AECOM 2017) – SW4 – North Scarborough Pond - Geochemical results

Parameter	DO (mg/L)	EC (µS/cm)	pH	Redox (mV) - sensor reading	Redox (mV)	Temperature (°C)	Turbidity (NTU)
Estuarine ANZECC SMD Criteria	-	-	7.0 - 8.5		-	-	50
20%ile	5.6	20663	7.4	81.5	286.5	15.6	1.3
50%ile	8.4	30540	7.7	153.0	358.0	20.9	4.5
80%ile	10.4	39763	8.1	179.6	384.6	25.2	8.9
Min	3.0	5140	6.6	-221.5	-16.5	12.3	-3.5
Max	14.4	46656	8.6	1760.0	1965.0	28.6	16.0
Mean	8.2	30034	7.7	198.7	403.7	20.5	5.3
Number of Samples	19	19	19	19	19	19	15

Note: samples taken between 6 Sept 17 to 11 Sept 18

Analytical parameters

able 10-10 F6 Extension monitoring program (AECOM 2017) - SW1 - Muddy Creek – Summary of analytical results

	Inorganics												Metals									
	Ammonia (as N)	Ferrous Iron	Kjeldahl Nitrogen Total	Nitrate (as N)	Nitrite (as N)	Nitrogen (Total Oxidised)	Nitrogen (Total)	Nitrate & Nitrite (as N)	Phosphate total (P)	Phosphorus	Total Phosphorus (P) [F]	Reactive Phosphorus as P	Arsenic	Cadmium	Chromium (III+VI)	Copper	Iron	Lead	Manganese	Mercury	Nickel	Zinc
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
ANZECC (2000) Ecosystems Marine Water (99%)	0.5			0.017 [C]									0.0008 [A]	0.0007	0.00014 [D]	0.0003	ID	0.0022	1.2 [B]	0.0001 [E]	0.007	0.007
ANZECC (2000) Ecosystems Marine Water (95%)	0.91			0.7 [C]			0.3 [G]				0.03 [G]	0.005 [G]	0.013 [A]	0.0055	0.0044 [D]	0.0013	ID	0.0044	1.9 [B]	0.0004 [E]	0.07	0.015
ANZECC (2000) Ecosystems Marine Water (90%)	1.2			3.4 [C]									0.042 [A]	0.014	0.02 [D]	0.003	ID	0.0066	2.5 [B]	0.0007 [E]	0.2	0.023
ANZECC (2000) Ecosystems Marine Water (80%)	1.7			17 [C]									0.14 [A]	0.036	0.085 [D]	0.008	ID	0.012	3.6 [B]	0.0014 [E]	0.56	0.043
ANZECC (2000) Recreational Water Quality Guideline Values	0.01			10	1								0.05	0.005	0.05	1	0.3	0.05	0.1	0.001	0.1	5
NSW Water Quality Objective	0.01			0.7	1		0.3				0.03	0.005	0.013	0.0007	0.0044	0.0013	0.3	0.0044	0.1	0.0001	0.007	0.005 [H]
Number of Samples	8	17	12	10	19	10	19	9	0	19	19	13	19	19	19	19	19	19	19	17	19	19
20%ile	0.23	0.025	0.25	0.10	0.010	0.11	0.50	0.2	-	0.03	0.03	0.005	0.0017	0.0001	0.00025	0.0020	0.17	0.0016	0.014	0.00002	0.0006	0.018
50%ile	0.79	0.025	0.60	0.20	0.030	0.23	1.20	0.5	-	0.07	0.07	0.030	0.0018	0.0001	0.00060	0.0040	0.25	0.0029	0.020	0.00002	0.0009	0.026
80%ile	**2.80**	0.035	1.02	0.42	0.060	0.45	2.50	0.63	-	0.15	0.15	0.064	0.0022	0.0001	0.00100	**0.0090**	0.55	0.0055	0.038	0.00002	0.0012	**0.056**
Min	0.21	0.025	0.25	0.09	0.005	0.09	0.25	0	-	0.03	0.03	0.005	0.0015	0.0001	0.00025	0.0005	0.13	0.0002	0.007	0.00002	0.0003	0.011
Max	0.81	0.130	2.00	0.73	0.040	0.76	2.40	0	-	0.33	0.33	0.090	0.0025	0.0001	0.00170	**0.0120**	0.65	**0.0145**	0.045	0.00005	0.0014	**0.075**
Mean	1.24	0.035	0.68	0.27	0.037	0.29	1.61	0.54	-	0.10	0.10	0.037	0.0020	0.0001	0.00068	0.0052	0.32	0.0040	0.023	0.00002	0.0009	0.034

Notes:

Samples taken between 6/09/2017 – 11/09/2018

mg/L = milligrams per litre

ANZECC = Australian and New Zealand Environment Conservation Council

Values in grey shading are the trigger values applying to typical slightly-moderately disturbed systems
Values in orange shading are values that exceed the Water Quality Objective
Values in **bold** indicate exceedance of the ANZECC (2000) 80% species protection level
NSW Water Quality Objective taken as smaller value between recreational water quality criteria and slightly-moderately disturbed values with the exception of zinc, where the aquatic foods objective was adopted

ID = insufficient data

A = Arsenic trigger values based on Freshwater Ecosystems and taken as AsV

B = Manganese trigger values based on Freshwater Ecosystems

C = Nitrate trigger values based on Freshwater Ecosystems

D = Chromium trigger values taken as CrVI

E = Mercury trigger values based on Mercury (Inorganic)

F = Total Phosphorus (P) result taken as higher value between phosphate total and phosphorus
G = trigger values for physical and chemical stressors for estuarine slightly disturbed ecosystems
H = Aquatic foods trigger value for zinc

Where values were below the Limit of Recording (LOR), a value of LOR/2 was adopted

Table 10-11 F6 Extension monitoring program (AECOM 2017) - SW2 - Muddy Creek – Summary of analytical results

	Inorganics												Metals									
	Ammonia (as N)	Ferrous Iron	Kjeldahl Nitrogen Total	Nitrate (as N)	Nitrite (as N)	Nitrogen (Total Oxidised)	Nitrogen (Total)	Nitrate & Nitrite (as N)	Phosphate total (P)	Phosphorus	Total Phosphorus (P) [F]	Reactive Phosphorus as P	Arsenic	Cadmium	Chromium (III+VI)	Copper	Iron	Lead	Manganese	Mercury	Nickel	Zinc
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
ANZECC (2000) Marine Water (99%)	0.5			0.017 [C]									0.0008 [A]	0.0007	0.00014 [D]	0.0003	ID	0.0022	1.2 [B]	0.0001 [E]	0.007	0.007
ANZECC (2000) Marine Water (95%)	0.91			0.7 [C]			0.3 [G]				0.03 [G]	0.005 [G]	0.013 [A]	0.0055	0.0044 [D]	0.0013	ID	0.0044	1.9 [B]	0.0004 [E]	0.07	0.015
ANZECC (2000) Marine Water (90%)	1.2			3.4 [C]									0.042 [A]	0.014	0.02 [D]	0.003	ID	0.0066	2.5 [B]	0.0007 [E]	0.2	0.023
ANZECC (2000) Marine Water (80%)	1.7			17 [C]									0.14 [A]	0.036	0.085 [D]	0.008	ID	0.012	3.6 [B]	0.0014 [E]	0.56	0.043
ANZECC (2000) Recreational Water Quality Guideline Values	0.01			10	1								0.05	0.005	0.05	1	0.3	0.05	0.1	0.001	0.1	5
NSW Water Quality Objective	0.01			0.7	1		0.3				0.03	0.005	0.013	0.0007	0.0044	0.0013	0.3	0.0044	0.1	0.0001	0.007	0.005 [H]
Number of Samples	8	16	12	10	19	10	19	10	1	19	19	13	19	19	19	19	19	19	19	17	19	19
20%ile	0.14	0.025	0.25	0.07	0.010	0.07	0.25	0.254	-	0.06	0.06	0.009	0.0014	0.0001	0.00025	0.0020	0.20	0.0011	0.014	0.00002	0.0006	0.015
50%ile	0.37	0.025	0.50	0.16	0.030	0.18	1.00	0.46	0.34	0.10	0.10	0.020	0.0019	0.0001	0.00060	0.0040	0.32	0.0016	0.021	0.00002	0.0010	0.027
80%ile	1.68	0.046	1.04	0.84	0.060	0.88	2.20	1.158	-	0.26	0.32	0.072	0.0022	0.0001	0.00180	**0.0140**	0.66	**0.0099**	0.038	0.00002	0.0016	**0.079**
Min	0.11	0.025	0.25	0.03	0.005	0.04	0.25	0.04	0.34	0.03	0.03	0.005	0.0011	0.0001	0.00025	0.0005	0.17	0.0002	0.006	0.00002	0.0003	0.011
Max	**4.49**	0.100	1.20	1.25	0.160	1.29	7.40	1.61	0.34	0.54	0.54	0.110	0.0032	0.0001	0.00350	**0.0640**	3.24	**0.0324**	0.058	0.00005	0.0045	**0.257**
Mean	0.92	0.035	0.61	0.35	0.045	0.37	1.57	0.70	0.34	0.16	0.17	0.037	0.0019	0.0001	0.00097	**0.0097**	0.62	0.0050	0.025	0.00002	0.0012	**0.051**

Notes:

Samples taken between 6/09/2017 – 11/09/2018

mg/L = milligrams per litre

ANZECC = Australian and New Zealand Environment Conservation Council

Values in grey shading are the trigger values applying to typical slightly-moderately disturbed systems
Values in orange shading are values that exceed the Water Quality Objective
Values in **bold** indicate exceedance of the ANZECC (2000) 80% species protection level
NSW Water Quality Objective taken as smaller value between recreational water quality criteria and slightly-moderately disturbed values with the exception of zinc, where the aquatic foods objective was adopted

ID = insufficient data

A = Arsenic trigger values based on Freshwater Ecosystems and taken as AsV

B = Manganese trigger values based on Freshwater Ecosystems

C = Nitrate trigger values based on Freshwater Ecosystems

D = Chromium trigger values taken as CrVI

E = Mercury trigger values based on Mercury (Inorganic)

F = Total Phosphorus (P) result taken as higher value between phosphate total and phosphorus
G = trigger values for physical and chemical stressors for estuarine slightly disturbed ecosystems
H = Aquatic foods trigger value for zinc

Where values were below the Limit of Recording (LOR), a value of LOR/2 was adopted

Table 10-12 F6 Extension monitoring program (AECOM 2017) - SW3 – Rockdale Bicentennial Park Pond (Rockdale Wetland) – Summary of analytical results

	Inorganics												Metals									
	Ammonia (as N)	Ferrous Iron	Kjeldahl Nitrogen Total	Nitrate (as N)	Nitrite (as N)	Nitrogen (Total Oxidised)	Nitrogen (Total)	Nitrate & Nitrite (as N)	Phosphate total (P)	Phosphorus	Total Phosphorus (P) [F]	Reactive Phosphorus as P	Arsenic	Cadmium	Chromium (III+VI)	Copper	Iron	Lead	Manganese	Mercury	Nickel	Zinc
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
ANZECC (2000) Freshwater (99%)	0.32			0.017 [C]									0.0008 [A]	0.00006	0.00001 [D]	0.001	ID	0.001	1.2 [B]	0.00006 [E]	0.008	0.0024
ANZECC (2000) Freshwater (95%)	0.9			0.7 [C]			0.5 [G]				0.05 [G]	0.02 [G]	0.013 [A]	0.0002	0.001 [D]	0.0014	ID	0.0034	1.9 [B]	0.0006 [E]	0.011	0.008
ANZECC (2000) Freshwater (90%)	1.43			3.4 [C]									0.042 [A]	0.0004	0.006 [D]	0.0018	ID	0.0056	2.5 [B]	0.0019 [E]	0.013	0.015
ANZECC (2000) Freshwater (80%)	2.3			17 [C]									0.14 [A]	0.0008	0.004 [D]	0.0025	ID	0.0094	3.6 [B]	0.0054 [E]	0.017	0.031
ANZECC (2000) Recreational Water Quality Guideline Values	0.01			10	1								0.05	0.005	0.05	1	0.3	0.05	0.1	0.001	0.1	5
NSW Water Quality Objective	0.01			0.7	1		0.3				0.05	0.02	0.013	0.0002	0.001	0.0014	0.3	0.0044	0.1	0.00006	0.011	0.008
Number of Samples	8	11	10	11	19	10	19	12	3	19	19	13	19	19	19	19	18	19	19	17	19	19
20%ile	0.26	0.088	1.12	0.01	0.005	0.01	1.50	0.07	-	0.21	0.21	0.028	0.0009	0.00003	0.00040	0.0020	0.67	0.0019	0.048	0.00002	0.0008	0.012
50%ile	1.24	0.160	1.70	0.05	0.020	0.09	3.00	0.2	0.41	0.34	0.37	0.110	0.0011	0.00010	0.00080	**0.0046**	0.90	0.0039	0.091	0.00002	0.0011	0.031
80%ile	**3.03**	0.366	4.60	0.33	0.040	0.35	5.40	0.252	-	0.50	0.50	0.334	0.0019	0.00020	0.00290	**0.0140**	2.39	**0.0180**	0.144	0.00002	0.0027	**0.111**
Min	0.08	0.025	0.80	0.01	0.005	0.01	0.80	0.02	0.36	0.16	0.16	0.005	0.0008	0.00003	0.00025	0.0010	0.52	0.0007	0.038	0.00002	0.0006	0.009
Max	**4.12**	0.410	5.30	1.10	0.170	1.27	6.10	0.34	0.5	1.43	1.43	0.370	0.0058	**0.00119**	**0.00920**	**0.0542**	8.89	**0.1560**	0.229	0.00005	0.0149	**0.691**
Mean	1.59	0.199	2.49	0.19	0.034	0.24	3.13	0.18	0.42	0.40	0.41	0.141	0.0016	0.00016	0.00179	**0.0102**	1.86	**0.0162**	0.099	0.00002	0.0022	**0.090**

Notes:

Samples taken between 6/09/2017 – 11/09/2018

mg/L = milligrams per litre

ANZECC = Australian and New Zealand Environment Conservation Council

Values in grey shading are the trigger values applying to typical slightly-moderately disturbed systems

Values in orange shading are values that exceed the Water Quality Objective

Water Quality Objective taken as smaller value between Recreational Water Quality Guideline and slightly-moderately disturbed values with the exception of zinc, where the aquatic foods objective was adopted

Values in **bold** are values that exceed the ANZECC (2000) 80% species protection level

ID = insufficient data

C = Nitrate water quality values based on Freshwater Ecosystems

D = Chromium water quality values taken as CrVI

E = Mercury water quality values based on Mercury (Inorganic)

F = Total Phosphorus (P) taken as higher value between phosphate total and phosphorus

G = trigger values for physical and chemical stressors for slightly disturbed ecosystems for lowland rivers

Where values were below the Limit of Recording (LOR), a value of LOR/2 was adopted

Table 10-13 F6 Extension monitoring program (AECOM 2017) - SW4 – North Scarborough Pond – Summary of Analytical results

	Inorganics												Metals									
	Ammonia (as N)	Ferrous Iron	Kjeldahl Nitrogen Total	Nitrate (as N)	Nitrite (as N)	Nitrogen (Total Oxidised)	Nitrogen (Total)	Nitrate & Nitrite (as N)	Phosphate total (P)	Phosphorus	Total Phosphorus (P) [F]	Reactive Phosphorus as P	Arsenic	Cadmium	Chromium (III+VI)	Copper	Iron	Lead	Manganese	Mercury	Nickel	Zinc
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
ANZECC (2000) Marine Water (99%)	0.5			0.017									0.0008 [A]	0.00006	0.00014 [D]	0.0003	ID	0.0022	1.2 [B]	0.0001 [E]	0.007	0.007
ANZECC (2000) Marine Water (95%)	0.91			0.7			0.3 [G]				0.03 [G]	0.005 [G]	0.013 [A]	0.0002	0.0044 [D]	0.0013	ID	0.0044	1.9 [B]	0.0004 [E]	0.07	0.015
ANZECC (2000) Marine Water (90%)	1.2			3.4									0.042 [A]	0.0004	0.02 [D]	0.003	ID	0.0066	2.5 [B]	0.0007 [E]	0.2	0.023
ANZECC (2000) Marine Water (80%)	1.7			17									0.14 [A]	0.0008	0.085 [D]	0.008	ID	0.012	3.6 [B]	0.0014 [E]	0.56	0.043
ANZECC (2000) Recreational Water Quality Guideline Values	0.01			10	1								0.05	0.005	0.05	1	0.3	0.05	0.1	0.001	0.1	5
NSW Water Quality Objective	0.01			0.7	1		0.3				0.03	0.005	0.013	0.0002	0.0044	0.0013	0.3	0.0044	0.1	0.0001	0.007	0.015
Number of Samples	8	14	11	11	19	10	19	9	0	19	10	13	19	19	19	19	19	19	19	17	19	19
20%ile	0.09	0.025	0.35	0.01	0.005	0.01	0.70	0.02	-	0.03	0.03	0.005	0.0012	0.0001	0.00025	0.0005	0.14	0.0006	0.015	0.00002	0.0003	0.006
50%ile	0.15	0.025	0.80	0.06	0.005	0.09	1.30	0.15	-	0.07	0.08	0.005	0.0016	0.0001	0.00025	0.0020	0.23	0.0016	0.024	0.00002	0.0007	0.018
80%ile	0.63	0.080	1.30	0.31	0.020	0.34	1.90	0.51	-	0.13	0.14	0.042	0.0026	0.0001	0.00110	0.0050	0.34	0.0027	0.042	0.00002	0.0011	0.032
Min	0.06	0.025	0.25	0.01	0.005	0.01	0.25	0	-	0.01	0.01	0.005	0.0012	0.0001	0.00025	0.0005	0.10	0.0003	0.008	0.00002	0.0003	0.003
Max	0.17	0.250	4.90	0.53	0.020	0.53	5.20	0	-	0.58	0.58	0.050	0.0030	0.0001	0.00280	**0.0190**	1.36	**0.0145**	0.049	0.00005	0.0022	**0.079**
Mean	0.32	0.053	1.14	0.14	0.012	0.16	1.46	0.40	-	0.10	0.12	0.015	0.0019	0.0001	0.00069	0.0036	0.35	0.0027	0.029	0.00002	0.0008	0.023

Notes:

Samples taken between 6/09/2017 – 11/09/2018

mg/L = milligrams per litre

ANZECC = Australian and New Zealand Environment Conservation Council

Values in grey shading are the trigger values applying to typical slightly-moderately disturbed systems
Values in orange shading are values that exceed the Water Quality Objective
Values in **bold** indicate exceedance of the ANZECC (2000) 80% species protection level

NSW Water Quality Objective taken as smaller value between recreational water quality criteria and slightly-moderately disturbed values

ID = insufficient data

A = Arsenic trigger values based on Freshwater Ecosystems and taken as AsV

B = Manganese trigger values based on Freshwater Ecosystems

C = Nitrate trigger values based on Freshwater Ecosystems

D = Chromium trigger values taken as CrVI

E = Mercury trigger values based on Mercury (Inorganic)

F = Total Phosphorus (P) result taken as higher value between phosphate total and phosphorus

G = trigger values for physical and chemical stressors for estuarine slightly disturbed ecosystems

Where values were below the Limit of Recording (LOR), a value of LOR/2 was adopted

Table 10-14 New M5 Motorway monitoring program (AECOM 2016) - Site 3 and Site 4 – Cooks River – Summary of Analytical results

	Inorganics											Metals									
	Ferrous Iron	Kjeldahl Nitrogen Total	Nitrate (as N)	Nitrite (as N)	Nitrogen (Total Oxidised)	Nitrogen (Total)	Ammonia (as N)	Phosphate total (P)	Phosphorus	Total Phosphorus (P) [F]	Reactive Phosphorus as P	Arsenic	Cadmium	Chromium (III+VI)	Copper	Iron	Lead	Manganese	Mercury	Nickel	Zinc
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
ANZECC (2000) Ecosystems Marine Water (99%)			0.017 [C]				0.5					0.0008 [A]	0.00006	0.00014 [D]	0.0003	ID	0.0022	1.2 [B]	0.0001 [E]	0.007	0.007
ANZECC (2000) Ecosystems Marine Water (95%)			0.7 [C]			0.3 [G]	0.91			0.03 [G]	0.005 [G]	0.013 [A]	0.0002	0.0044 [D]	0.0013	ID	0.0044	1.9 [B]	0.0004 [E]	0.07	0.015
ANZECC (2000) Ecosystems Marine Water (90%)			3.4 [C]				1.2					0.042 [A]	0.0004	0.02 [D]	0.003	ID	0.0066	2.5 [B]	0.0007 [E]	0.2	0.023
ANZECC (2000) Ecosystems Marine Water (80%)			17 [C]				1.7					0.14 [A]	0.0008	0.085 [D]	0.008	ID	0.012	3.6 [B]	0.0014 [E]	0.56	0.043
ANZECC (2000) Recreational Water Quality Guideline Values			10	1			0.01					0.05	0.005	0.05	1	0.3	0.05	0.1	0.001	0.1	5
NSW Water Quality Objective			0.7	1		0.3	0.01			0.03	0.005	0.013	0.0002	0.0044	0.0013	0.3	0.0044	0.1	0.0001	0.007	0.005 [H]
Number of Samples	20	20	20	20	20	20	2	0	20	0	20	20	20	20	20	20	20	20	20	20	20
20%ile	0.025	0.12	0.09	0.005	0.09	0.25	-	-	0.005	0.005	0.012	0.005	0.0005	0.0005	0.0050	0.005	0.0050	0.005	0.00005	0.00005	0.025
50%ile	0.05	0.3	0.135	0.005	0.135	0.5	0.27	-	0.05	0.05	0.04	0.005	0.00125	0.0013	0.0050	0.225	**0.0265**	0.005	0.00005	0.00050	0.025
80%ile	0.23	0.8	0.206	0.005	0.206	1.08	-	-	0.11	0.11	0.13	0.026	0.005	0.0050	0.0050	0.552	**0.25**	0.0196	**0.0098**	0.00500	0.026
Min	0.025	0.1	0.005	0.005	0.005	0.1	0.24	-	0.0005	0.0005	0.005	0.002	0.00005	0.0001	0.0005	0.001	0.0010	0.005	0.00005	0.00005	0.010
Max	0.85	1.2	4.43	0.01	4.43	4.7	0.3	-	0.39	0.39	0.31	0.050	0.0055	0.0220	**0.1070**	1.74	**0.25**	0.049	**0.023**	0.01600	**0.120**
Mean	0.1278	0.44	0.3838	0.00525	0.38425	0.8	0.27	-	0.073	0.073	0.07525	0.013	0.0026	0.0034	**0.0102**	0.2836	**0.10**	0.01275	**0.0044**	0.00287	0.034

Notes:

Samples taken between 30/06/2015 – 28/01/2016

mg/L = milligrams per litre

ANZECC = Australian and New Zealand Environment Conservation Council

Values in grey shading are the trigger values applying to typical slightly-moderately disturbed systems
Values in orange shading are values that exceed the Water Quality Objective
Values in **bold** indicate exceedance of the ANZECC (2000) 80% species protection level
NSW Water Quality Objective taken as smaller value between recreational water quality criteria and slightly-moderately disturbed values with the exception of zinc, where the aquatic foods objective was adopted

ID = insufficient data

A = Arsenic trigger values based on Freshwater Ecosystems and taken as AsV

B = Manganese trigger values based on Freshwater Ecosystems

C = Nitrate trigger values based on Freshwater Ecosystems

D = Chromium trigger values taken as CrVI

E = Mercury trigger values based on Mercury (Inorganic)

F = Total Phosphorus (P) result taken as higher value between phosphate total and phosphorus
G = trigger values for physical and chemical stressors for estuarine slightly disturbed ecosystems
H = Aquatic foods trigger value for zinc

Where values were below the Limit of Recording (LOR), a value of LOR/2 was adopted

Annexure F - Water quality discharge criteria

Introduction

The project corridor and proposed discharge locations span the catchments of the Cooks River, Muddy Creek and the Scarborough Ponds system including the North Scarborough Pond and Rockdale Bicentennial Park Pond.

The Australian and New Zealand Environment Conservation Council (ANZECC) provide guidelines for the protection of ambient water quality of the rivers. The ANZECC Guidelines for Fresh and Marine Water Quality (ANZECC, 2000) provide a framework for determining guideline trigger values for an aquatic system.

Although the trigger values determined using ANZECC (2000) are applicable to ambient water quality, rather than discharge water quality, they are considered to represent the best available basis for setting discharge concentration limits for the project's construction and operational water treatment plant discharges. The trigger values are not applicable to stormwater discharges including construction surface water and operational stormwater.

Application of the ANZECC (2000) guidelines to discharge criteria

The proposed discharge criteria have been developed with consideration to ANZECC (2000) and the NSW WQOs. Key considerations are provided below:

- *"The ANZECC (2000) guidelines have not been designed for direct application in activities such as discharge consents, recycled water quality or stormwater quality, nor should they be used in this way. They have been derived to apply to the ambient waters that receive effluent or stormwater discharges, and protect the environment values they support" (ANZECC 2000, Section 2.2.1.9).*
- *"The NSW WQOs are not intended to be applied directly as regulatory criteria, limits or conditions but are one factor to be considered by industry, the community, planning authorities or regulators when making decisions affecting the future of a waterway" (Using the ANZECC guidelines and water quality objectives in NSW, NSW Department of Environment and Conservation, 2006)*
- *"The policy in NSW is that the level of protection applied to most waterways is the one suggested for 'slightly to moderately disturbed systems, in a highly disturbed waterway, a reduced level of protection may be appropriate as a pragmatic short-term goal, with the aim of eventually restoring it to the status of a slightly to moderately disturbed. However, it is not acceptable to allow poor environmental management or water pollution, simply because a waterway is currently degraded." (Using the ANZECC guidelines and water quality objectives in NSW, NSW Department of Environment and Conservation, 2006)*
- *"The policy in NSW is that the level of protection applied to most waterways is the one suggested for 'slightly to moderately disturbed systems, in a highly disturbed waterway, a reduced level of protection may be appropriate as a pragmatic short-term goal, with the aim of eventually restoring it to the status of a slightly to moderately disturbed. However, it is not acceptable to allow poor environmental management or water pollution, simply because a waterway is currently degraded." (Using the ANZECC guidelines and water quality objectives in NSW, NSW Department of Environment and Conservation, 2006)*
- The guiding principles for the NSW WQOs (which have been reflected within the SEARs) are that:
  - *"Where the environmental values are being achieved in a waterway, they should be protected" (DEC, 2006)*
  - *"Where the environmental values are not being achieved in a waterway, all activities should work towards their achievement over time" (DEC, 2006)*

Although ANZECC (2000) was not designed for the purpose of setting discharge criteria (as described above), the trigger values developed using the ANZECC (2000) framework are considered to represent the best available guidelines for establishing criteria for construction and operational water treatment plant discharges. Other factors would need to be considered during detailed design to determine whether the discharge criteria can be feasibly and reasonably achieved, including operational constraints and/or practicalities and any associated environmental impacts with providing additional treatment, such as for example, excess waste production.

The waterways that are receiving environments for the construction and operational water treatment plant discharges from the project are highly disturbed ecosystems, which cannot feasibly be returned to a 'slightly to moderately disturbed' condition.

In such cases, the ANZECC (2000) recommends that suitable trigger levels for physical and chemical water quality trigger values can be either:

- Compliant with the ANZECC (2000) default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems. Trigger values are used to assess risk of adverse effects due to nutrients, biodegradable organic matter and pH in various ecosystem types (ANZECC 2000, Table 3.3.2 on p96).
- Trigger values derived from a local reference data set for physical and chemical stressors where the quality of discharge should not exceed the relevant 80th and/or 20th percentile values.

For toxicants (such as heavy metals or organic chemical compounds), a reference data set is not needed (see Table 3.4.1. in ANZECC 2000). The water quality requirements should be consistent with an appropriate percent protection level for marine water ecosystems, i.e. the percentage of species that are expected to be protected if water quality meets or exceeds this criterion (ANZECC, 2000).

Development of discharge criteria

The basis for selection of discharge criteria for the water treatment plants for each of the receiving waterways is summarised in **Table 10-15** and **Table 10-16**.

Based on sampling conducted at Site 3 and 4 during the New M5 Motorway water quality monitoring program (AECOM 2016), median water quality within the Cooks River exceeds the NSW WQOs for total nitrogen, reactive phosphorus, copper, lead and zinc.

Based on sampling conducted at SW1 and SW2 during the F6 Extension water quality monitoring program (AECOM 2018), median water quality within Muddy Creek exceeds the NSW WQOs for total nitrogen, total phosphorus, reactive phosphorus, copper and zinc. It is considered that both the Cooks River and Muddy Creek cannot feasibly be returned to a slightly to moderately disturbed ecosystem (including the channel form, processes, ecology and water quality) although water quality may be improved in the medium to long term to achieve the NSW WQOs.

When considering the significant dilution and mixing which would occur in the estuarine environment of Muddy Creek and Cooks River, an 80 per cent species protection level is considered to be appropriate for adoption as discharge criteria for toxicants. This is consistent with the criteria adopted and approved for the New M5 Motorway water treatment plant and is considered to be appropriate for maintaining ambient water quality during construction.

The potential impacts associated with the permanent operational water treatment plant discharges to the Cooks River were assessed in a box model; refer **Annexure D**, including a sensitivity assessment of the impact if the NSW WQOs were achieved for the receiving waterway. The findings of this assessment indicate that the proposed discharge criteria would have a negligible influence on receiving water quality at present and if the NSW WQOs are achieved in the medium to long term.

Due to its higher ecological sensitivity and limited tidal exchange, the ANZECC (2000) slightly to moderately disturbed species protection level (95 percent species protection for the majority of toxicants excluding those which bio-accumulate, whereby a 99 per cent species protection level is recommended) was adopted as the toxicant discharge criteria for construction water treatment plant releases to Rockdale Bicentennial Park Pond and Northern Scarborough Pond.

The proposed discharge criteria are provided in **Table 10-17**.

Table 10-15 Waterway condition

Waterway	System Type	Relevant discharge
Lower Cooks River	Highly disturbed estuarine system with significant tidal exchange	Operational water treatment plant and Construction water treatment plant
Muddy Creek	Highly disturbed estuarine system with tidal exchange.	Construction water treatment plant
North Scarborough Pond	Highly disturbed estuarine system with limited tidal exchange	Construction water treatment plant
Rockdale Bicentennial Park Pond	Highly disturbed freshwater system	Construction water treatment plant

Table 10-16 Approach to setting discharge criteria

Waterway	Data used to develop	Detailed design update requirements
Lower Cooks River	Based the New M5 Motorway EIS Appendix N – Surface Water, Appendix A – Water Quality Reference Criteria (AECOM, 2015). The criteria was developed based on the 80 percent species protection level for toxicants and 2 reference sites for pH, TN, TP, turbidity and temperature including 40 samples taken between December 2007 and June 2015	Any updates to the discharge criteria developed as part of the New M5 Motorway detailed design to be incorporated into F6 Extension Stage 1 criteria for releases to the Cooks River.
Muddy Creek	Based on the Cooks River water quality reference criteria documented in the New M5 Motorway EIS Appendix N – Surface Water, Appendix A – Water Quality Reference Criteria (AECOM, 2015) as described above.	-
North Scarborough Pond	ANZECC (2000) slightly to moderately disturbed species protection level for toxicants. Temperature criteria were based on monitoring conducted as part of the project at one site, SW4 between September and December 2017 including 6 samples. Due to limited range of pH values from monitoring data, slightly to moderately disturbed criteria for pH adopted.	Discharge criteria for temperature to be updated based on continued baseline monitoring.
Rockdale Bicentennial Park Pond	ANZECC (2000) slightly to moderately disturbed species protection level for toxicants. Temperature criteria were based on monitoring conducted as part of the project including at two sites, SW3 between September and December 2017 including 6 samples. Due to limited range of pH values from monitoring data, slightly to moderately disturbed criteria for pH adopted.	Discharge criteria for temperature to be updated based on continued baseline monitoring.

Table 10-17 Proposed discharge criteria

Parameter	Units	Lower Cooks River[1]	Muddy Creek	North Scarborough Pond	Bicentennial Park Pond
Arsenic (As III)	µg/L	360 [2]	360 [2]	24	24
Arsenic (As V)	µg/L	140 [2]	140 [2]	13	13
Cadmium	µg/L	36	36	0.7	0.7
Chromium (III)	µg/L	90.6	90.6	27.4	27.4
Chromium (VI)	µg/L	85	85	4.4	4.4
Copper	µg/L	8	8	1.3	1.3
Iron	µg/L	300 [3]	300 [3]	300 [3]	300 [3]
Lead	µg/L	12	12	4.4	4.4
Manganese	µg/L	3,600 [2]	3,600 [2]	1,900 [2]	1,900 [2]
Mercury (inorganic)	µg/L	1.4	1.4	0.1	0.1
Nickel	µg/L	560	560	7	7
Zinc	µg/L	43	43	15	15
Ammonia	µg/L	1700	1700	910	910
Nitrate	µg/L	17000 [2]	17000 [2]	700	700
Total Nitrogen	mg/L	1.0 [6]	1.0 [6]	0.3	0.3
Total Phosphorus	mg/L	0.2 [6]	0.2 [6]	0.03	0.03
Oil and grease	-	No visible oil and grease	No visible oil and grease	No visible oil and grease	No visible oil and grease
pH	-	7.0 – 8.5 [4]	7.0-8.5 [4]	7.0-8.5 [4]	7.0-8.5 [4]
Turbidity	NTU	15 [6]	11 [6]	10	10
Electrical Conductivity	µS/cm	Not applicable, estuarine environment	Not applicable, estuarine environment	Not applicable, estuarine environment	694
Temperature	°C	15 - 23 [6]	15 – 23 [6]	10 - 27	19 - 25

[1] Adopted from WestConnex New M5 Motorway EIS Appendix N – Technical Working Paper (Surface Water) – Appendix A, Water Quality Reference Criteria (AECOM, 2015) for Lower Cooks River marine water trigger values

[2] Freshwater trigger value adopted as no marine water trigger value available

[3] ANZECC (2000) recreational water quality trigger value adopted as no aquatic ecosystem protection level available

[4] ANZECC (2000) slightly to moderately disturbed default trigger value for estuaries adopted

[5] Shaded values should be updated at the completion of baseline water quality monitoring program.

[6] Adopted from WestConnex New M5 Motorway EIS Appendix N – Technical Working Paper (Surface Water) – Appendix A, Water Quality Reference Criteria (AECOM, 2015) for Lower Cooks River reference condition estuarine trigger values

Annexure G - Water Quality Monitoring Program

Table 10-18 Surface water quality monitoring parameters

In situ field parameters	Analytical sampling
Temperature (˚C) Dissolved Oxygen (mg/L) Electrical Conductivity (µS/cm) Reduction-Oxidation Potential (Redox)(mV) pH Turbidity (NTU)	Organics TRH (C6-C40) BTEXN – Benzene, Toluene, Ethylbenzene, Xylene and Naphthalene Nutrients - Total Nitrogen, TKN, NOx, NO2, NO3, Total Phosphorus and Filterable Reactive Phosphorus 8 Metals (Cu, Cr, As, Ni, Zn, Pb, Hg, Ni) and Manganese (total metals) Ferrous Iron, Total Iron Ammonia

Table 10-19 Surface water quality monitoring parameters

Reference	Watercourse	Latitude	Longitude
SW1	Muddy Creek	-33.948103	151.155223
SW2	Muddy Creek	-33.953478	151.149715
SW3	Rockdale Bicentennial Park Pond	-33.963233	151.145942
SW4	North Scarborough Pond	-33.970507	151.145190
Site 3	Cooks River	-33.933284	151.159560
Site 4	Cooks River	-33.943436	151.159990

Table 10-20 Rockdale Bicentennial Park groundwater quality monitoring locations

Reference	Northing	Easting
BH1143	6240513	328596
BH1303	6240470	328710
BH1212	6240367	328750
BH1121a	6240132	328691
TP1303	6240301	328711
TP1307	6240350	328727
TP1308	6240406	328669
TP1309	6240487	328577
TP1310	6240489	328627

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