WestConnex

Australian Government
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NSW GOVERNMENT

M4-M5 Link

Environmental Impact Statement

August 2017

Appendices Q to S

Volume 2H

Since finalisation of the Environmental Impact Statement, the project has been declared by Ministerial Order to be State significant infrastructure and critical State significant infrastructure under sections 115U (4) and 115V of the *Environmental Planning and Assessment Act 1979*. The Ministerial Order also amended Schedule 5 of *State Environmental Planning Policy (State and Regional Development) 2011*. The project remains subject to assessment under Part 5.1 of the *Environmental Planning and Assessment Act 1979* and requires the approval of the Minister for Planning.

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Arabic

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Hindi

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www.westconnex.com.au/yourlanguage व (हिन्दी) स इ
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दुभाषयिा सेवा ो **131 450** र फ़ोन करें।

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Volume 2H

Appendices

Q ..... Technical working paper: Surface water and flooding
R ..... Technical working paper: Contamination
S ..... Technical working paper: Biodiversity

WestConnex

Appendix Q

Technical working paper: Surface water and flooding

WestConnex

Roads and Maritime Services

WestConnex – M4-M5 Link

Technical working paper: Surface water and flooding

August 2017

Client: Roads and Maritime Services

ABN: 76 236 371 088

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Glossary of terms and abbreviations

Term	Definition
A	
Acid Sulfate Soils	Naturally occurring soils, sediments or organic substrates (eg 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. The probability of a rainfall or flood event exceeding a nominated level in a year. For example, a one per cent AEP is the probability of an event exceeding a nominated level in 100 years
Afflux	An increase in water level resulting from obstacles in the flow path
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
AR&R	Australian Rainfall & Runoff
ARI	Average recurrence interval. An indicator used to describe the frequency of floods. The average period in years between the occurrence 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 eg 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
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
Biota	All organisms in a given area (including flora and fauna), considered as a unit
BOD	Biological Oxygen Demand
BoM	Bureau of Meteorology
Box culvert	A culvert of rectangular cross section
Bund	A small embankment designed to retain water
BTEX	Benzene, toluene, ethylbenzene and xylenes
C	
Campbell Road civil and tunnel site	A construction ancillary facility for the M4-M5 Link project at St Peters

Term	Definition
Campbell Road ventilation facility	Ventilation supply and exhaust facilities, axial fans, ventilation outlets and ventilation tunnels. Located at St Peters, within the St Peters interchange site
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
CBD	Central business district
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
Climate change	A change in the state of the climate that can be identified (eg by statistical tests) by changes in the mean and/or variability of its properties, and that persists for an extended period of time, typically decades or longer (CSIRO and BoM 2015)
Climate projection	A climate projection is the simulated response of the climate system to a scenario of future emission or concentration of greenhouse gases and aerosols, generally derived using climate models. Climate projections are distinguished from climate predictions by their dependence on the emission/concentration/radiative forcing scenario used, which in turn is based on assumptions concerning, for example, future socio-economic and technological developments that may or may not be realised (CSIRO and BoM 2015)
CMA	Catchment Management Authority
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
CDS	CPB Contractors, Dragados, Samsung Joint Venture (CDS). Contractor responsible for the New M5 Project
CSJ	CPB Contractors, Samsung, John Holland Joint Venture (CSJ). Contractor responsible for the M4 East Project
CSWMP	Construction Soil and Water Management Plan
CRC	Cooks River catchment
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	
Darley Road civil and tunnel site	A construction ancillary facility for the M4-M5 Link project at Leichhardt
DCP	Development Control Plan
DEC	NSW Department of Environment and Conservation (now OEH and the NSW EPA)
DECC	NSW Department of Environment and Climate Change (now OEH and NSW EPA)

Term	Definition
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.
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 (eg 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)
DP&E	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
DRAINS	A stormwater drainage system design and analysis program for estimating water flows. It is a successor to the ILSAX program which has been widely used for urban stormwater system design and analysis
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
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
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
Extreme rainfall	There is no consistent global definition for extreme rainfall. It can be defined by either relative rainfall at a location (amount relative to averages), or absolute rainfall amounts (eg over 100 millimetres in a single day). In this report, an extreme rainfall event is defined as the wettest day in 20 years

Term	Definition
F	
Feasible and reasonable	Consideration of standard or good 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
Flash flooding	Flooding which is sudden and unexpected. It is often caused by sudden local or nearby heavy rainfall. It is often defined as flooding which peaks within six hours of the rain event
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami
Flood immunity	Relates to the level at which a particular structure would be clear of a certain flood event
Flood planning level (FPL)	The combinations of flood levels and freeboards selected for floodplain risk management purposes, as determined in flood studies and floodplain risk management studies and plans
Flood prone land	Land susceptible to flooding by the probable maximum flood. Note that the flood prone land is also known as flood liable land
Flood storage area	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. It is necessary to investigate a range of flood sizes before defining flood storage areas
Floodplain	Area of land which is inundated by floods up to and including the probable maximum flood event (ie flood prone land)
FMS	Flood mitigation strategy
Floodplain Risk Management Plan	A management plan developed in accordance with the principles and guidelines in the NSW Floodplain development manual (NSW Department of Infrastructure, Planning and Natural Resources 2005). Usually includes both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives
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
Freeboard	A factor of safety typically used in relation to the setting of floor levels, levee or crest levels. It is usually expressed as the difference in height between the adopted FPL and the peak height of the flood used to determine the flood planning level. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the floodplain, such as wave action, localised hydraulic behaviour and impacts that are specific event related, such as levee and embankment settlement, and other effects such as 'greenhouse' and climate change. Freeboard is included in the Flood Planning Level
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

Term	Definition
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.
Groundwater dependent ecosystem (GDE)	Refers to communities of plants, animals and other organisms whose extent and life process are dependent on groundwater, such as wetlands and vegetation on coastal sand dunes
H	
ha	Hectare(s)
Haberfield civil and tunnel site/ Haberfield civil site	Construction ancillary facilities for the M4-M5 Link project located at the Wattle Street interchange
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	
IFD	Intensity-Frequency-Duration
Impact	Influence or effect exerted by a project or other activity on the natural, built and community environment
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
Inner West Council	The amalgamation of the former local government areas of Ashfield, Leichhardt and Marrickville, proclaimed on 12 May 2016
Interchange	A grade separation of two or more roads with one or more interconnecting carriageways
Iron Cove Link	Around one kilometre of twin tunnels that would connect Victoria Road near the eastern abutment of Iron Cove Bridge and Anzac Bridge
Iron Cove Link civil site	A construction ancillary facility for the M4-M5 Link project located at Rozelle
Iron Cove Link ventilation facility	Ventilation supply and exhaust facilities, axial fans, ventilation outlets and ventilation tunnels. Located at Rozelle
IPCC	Intergovernmental Panel on Climate Change
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 project
kL	Kilolitres
kL/day	Kilolitres per day
L	
L/s/km	Litres per second per kilometre
Leachate	Liquid that 'leaches' (drains) from a landfill
LGA	Local government area
LiDAR	Light Detection and Ranging
LLS	Local Land Services
Localised flooding	Localised flooding occurs when components of the drainage system are undersized or blocked and cannot accommodate the incoming overland surface flows, resulting in the flooding of a localised area
M	
M	Metres
m/day	Metres per day

Term	Definition
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 Motorway/project	A component of the WestConnex program of works. Extension of the M4 Motorway in tunnels between Homebush and Haberfield via Concord. Includes provision for a future connection to the M4-M5 Link at the Wattle Street interchange
M4 East mainline tunnel stubs	Eastbound and westbound extensions of the M4 East mainline tunnel being built as part of the M4 East project (to connect with the M4-M5 Link)
M4 East mainline connection	The underground connection between the M4-M5 Link mainline tunnels and the M4 East mainline stub tunnels
M4 Widening	A component of the WestConnex program of works. Widening of the existing M4 Motorway from Parramatta to Homebush
M4-M5 Link	The project which is the subject of this EIS. 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	The M4-M5 Link mainline tunnels connecting with the M4 East Motorway at Haberfield and the New M5 Motorway at St Peters
Mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam
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
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	
New M5 Motorway/project	A component of the WestConnex program of works. Located from Kingsgrove to St Peters (under construction)
New M5 mainline stub tunnels	Northbound and southbound extensions of the New M5 mainline tunnel being built as part of the New M5 project (to connect with the M4-M5 Link)
New M5 mainline connection	The underground connection between the M4-M5 Link mainline tunnels and the New M5 mainline stub tunnels
Northcote Street civil site	A construction ancillary facility for the M4-M5 Link project located at Haberfield
NSW EPA	NSW Environment Protection Authority
NSW State Flood Plan	A plan that deals specifically with flooding and is a sub-plan of an EMPLAN. Flood Sub Plans describe agreed roles, responsibilities, functions, actions and management arrangements for the conduct of flood operations and for preparing for them. They are prepared at State, Region and Local Government levels

Term	Definition
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 WQOs	NSW Water Quality Objectives. See also NSW Water Quality and River Flow Objectives
NWQMS	National Water Quality Management Strategy
O	
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
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.
Overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam
P	
Parcel of land	Refers to an individual lot number (lot) and deposited plan (DP)
Parramatta Road corridor	The Parramatta Road corridor is the area from Parramatta CBD to Sydney CBD, generally between the Main Western Rail line in the south and the Parramatta River to the north
Parramatta Road East civil site	A construction ancillary facility for the M4-M5 Link project at Haberfield
Parramatta Road ventilation facility	A ventilation facility located on the south-eastern corner of the Parramatta Road/Wattle Street intersection (referred to as the Eastern ventilation facility in the M4 East project EIS). The facility is being built as part of the M4 East project. As part of the M4-M5 Link project, fitout works would be carried out on a section of this facility
Parramatta Road West civil and tunnel site	A construction ancillary facility for the M4-M5 Link project at Ashfield
Pavement	The portion of a carriageway placed above the subgrade for the support of, and to form a running surface for vehicular traffic
Peak discharge	The maximum discharge occurring during a flood event
Peak flood level	The maximum water level occurring during a flood event
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
PMF	Probable Maximum Flood. The flood that occur as a result of the probable maximum precipitation on a study catchment. The probable maximum flood is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The probable maximum flood defines the extent of flood prone land (ie the floodplain)

Term	Definition
Portal	The entry and/or exit to a tunnel
Project	A new multi-lane road link between the M4 East Motorway at Haberfield and the New M5 Motorway at St Peters. The project would also include an interchange at Lilyfield and Rozelle (the Rozelle interchange) and a tunnel connection between Anzac Bridge and Victoria Road, east of Iron Cove Bridge (Iron Cove Link). In addition, construction of tunnels, ramps and associated infrastructure to provide connections to the proposed future Western Harbour Tunnel and Beaches Link project would be carried out at the Rozelle interchange
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)
Pyrmont Bridge Road tunnel site	A construction ancillary facility for the M4-M5 Link project at Annandale
Q	
R	
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
Rozelle civil and tunnel site	A construction ancillary facility for the M4-M5 Link project located at Lilyfield and Rozelle
Rozelle interchange	A new interchange at Lilyfield and Rozelle that would connect the M4-M5 Link mainline tunnels with City West Link, Anzac Bridge, the Iron Cove Link and the proposed future Western Harbour Tunnel and Beaches Link
Rozelle Rail Yards	The Rozelle Rail Yards is bound by City West Link to the south, Lilyfield Road to the north, Balmain Road to the west, and White Bay to the east. Note that the project only occupies part of the Rozelle Rail Yards site
Rozelle Rail Yards site management works	The preparation of a project site prior to construction commencement. It may include the installation of fencing, temporary site offices, signage, and erosion and sediment controls; and involve the delineation of equipment laydown, material stockpile, spoil transfer, and waste management areas
Rozelle ventilation facility	Ventilation supply and exhaust facilities, axial fans, ventilation outlets and ventilation tunnels. Located at the Rozelle Rail Yards, the ventilation supply facility is located at the Rozelle West motorway operations complex and a ventilation exhaust facility at the Rozelle East motorway operations complex
Runoff	The part of the rainfall on a catchment which flows as surface discharge past a specified point
S	
Scour	The erosion of material by the action of flowing water
SEARs	Secretary's Environmental Assessment Requirements Requirements and specifications for an environmental assessment prepared by the Secretary of the NSW Department of Planning and Environment under section 115Y of the *Environmental Planning and Assessment Act 1979* (NSW)

Term	Definition
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
Sedimentation	Deposition of sediment usually by water
Sedimentation basin	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
Sensitive receiver/receptor	Includes residences, educational institutions (including preschools, schools, universities, TAFE colleges), health care facilities (including nursing homes, hospitals), religious facilities (including churches), child care centres, passive recreation areas (including outdoor grounds used for teaching), active recreation areas (including parks and sports grounds), commercial premises (including film and television studios, research facilities, entertainment spaces, temporary accommodation such as caravan parks and camping grounds, restaurants, office premises, retail spaces and industrial premises)
SES	NSW State Emergency Service
SHPRC	Sydney Harbour and Parramatta River Catchment
SHWQIP	Sydney Harbour Water Quality Improvement Plan
SMC	Sydney Motorway Corporation
SMCMA	Sydney Metropolitan Catchment Management Authority
Socio-economic	Involving combination of social and economic matters
Spoil	Surplus excavated material
St Peters interchange	A component of the New M5 project, located at the former Alexandria Landfill site at St Peters. Approved and under construction as part of the New M5 project. Additional construction works proposed as part of the M4-M5 Link project
St Peters motorway operations complex	New M5 motorway operations complex located near the western corner of the St Peters interchange, adjacent to the Prince Highway/Canal Road intersection. Contains operational ancillary infrastructure that is required for operation of the project
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
Strahler stream ordering process	A stream classification system where waterways are given an 'order' according to the number of additional tributaries associated with each waterway. This is used as a measure of system complexity and therefore the potential for fish habitat to be present. Flow paths at the top of a catchment are assigned the number one
Strata	Geological layers below the ground surface
Stream order	A classification system which assigns an 'order' to waterways according to the number of additional tributaries associated with each waterway, to provide a measure of system complexity
Surface road widening works	Located between the M5 East Motorway, east of King Georges Road and the new tunnel portals
Surface water	Water flowing or held in streams, rivers and other wetlands in the landscape
Swale	A shallow, grass-lined drainage channel
T	
Terrestrial	Living or growing on land (i.e. terrestrial flora or fauna)
Thalweg	The lowest point along the length of a stream bed
The Blue Book	*Managing Urban Stormwater – Soils and Construction* Volumes 1 and 2, NSW Government 2004 and 2006

Term	Definition
The Crescent civil site	A construction ancillary facility for the M4-M5 Link project located at Annandale
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.
TPH	Total Petroleum Hydrocarbon
Transverse drainage	Existing drainage lines (typically) that cross linear infrastructure such as roads
Tributary	A river or stream flowing into a larger river or lake
TRH	Total recoverable hydrocarbons
TSS	Total Suspended Solids
TUFLOW	A 1D/2D finite difference numerical model that simulates hydrodynamic behaviour in rivers, floodplain and urban drainage environments
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. May comprise one or more ventilation outlets
Victoria Road civil site	A construction ancillary facility for the M4-M5 Link project located at Rozelle
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)
Wattle Street civil and tunnel site	A construction ancillary facility for the M4-M5 Link project located at Haberfield
Wattle Street interchange	An interchange to connect Wattle Street (City West Link) with the M4 East and the M4-M5 Link tunnels. Approved and under construction as part of the M4 East project. Additional construction works proposed as part of the M4-M5 Link project
WestConnex program of works	A program of works that includes the M4 Widening, King Georges Road Interchange Upgrade, M4 East, New M5 and 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
WQIP	Water Quality Improvement Plan
WQPMP	Water Quality Plan and Monitoring Program
WSUD	Water sensitive urban design
WTP	Water treatment plant
X	
Y	
Z	

Executive summary

NSW Roads and Maritime Services (Roads and Maritime) is seeking approval to construct and operate the WestConnex M4-M5 Link, which would comprise:

- About 7.5 kilometres of twin motorway tunnels (that is, two mainline tunnels located side-by-side) between the M4 East at Haberfield and the New M5 at St Peters
- An underground connection between the mainline tunnels and the Wattle Street interchange at Haberfield. The Wattle Street interchange is being constructed as part of the WestConnex M4 East project
- An underground connection between the mainline tunnels and the St Peters interchange. The St Peters interchange is being built as part of the WestConnex New M5 project
- A new interchange at Lilyfield and Rozelle (the Rozelle interchange) that would include dive structures and tunnel portals to connect the mainline tunnels to the surface road network at City West Link and Victoria Road/Anzac Bridge
- Construction of connections to the proposed future Western Harbour Tunnel and Beaches Link project as part of the Rozelle interchange
- A new tunnel connection between the Rozelle interchange and Victoria Road at the eastern abutment of Iron Cove Bridge (the Iron Cove Link)
- A dive structure and tunnels portals on Victoria Road at Rozelle, east of Iron Cove Bridge
- Upgrades and improvements to the surface road network at Lilyfield and Rozelle
- Ventilation facilities at the Rozelle interchange, Iron Cove tunnel portals and the St Peters interchange.

This technical working paper presents the assessment of potential impacts during construction and operation of the project on surface water including flooding, drainage, water quality, water quantity and geomorphology. The majority of the project footprint is located within the Sydney Harbour and Parramatta River catchment (SHPRC) with the southern portion within proximity to the St Peters interchange located within the Cooks River catchment (CRC). The predominant waterways within the SHPRC traversed or affected by the project footprint include Hawthorne Canal, Whites Creek, Rozelle Bay, Johnstons Creek as well as Dobroyd Canal (also known as Iron Cove Creek) and Easton Park drain. Dobroyd Canal and Hawthorne Canal discharge to Iron Cove while Whites Creek, Johnstons Creek and Easton Park drain discharge to Rozelle Bay. Alexandra Canal is the main waterway downstream of the project footprint within the CRC. The catchments are highly urbanised and the waterways are all artificial, hard lined stormwater channels, with the exception of Alexandra Canal which has an unlined base and hard lined banks. Existing water quality in all waterways was indicative of a highly urbanised catchment.

The investigation undertaken for the M4-M5 Link project found that the local stormwater drainage systems that control runoff from these catchments are of limited capacity. As a result, the project corridor is presently impacted by both main stream flooding and overland flows. **Section 4.4** of this report provides a brief description of the existing flood behaviour at each of the main surface features of the project. This takes into consideration the works currently undertaken as part of the M4 East and New M5 projects which adjoin the M4-M5 Link. **Table 4-1** provides a summary of the existing flood risk, based on available flood information.

Construction impacts

The majority of the construction ancillary facilities assessed in the environmental impact statement (EIS) would be affected by either main stream or overland flows. Flood related impacts during construction could include:

- Inundation of excavated tunnels
- Damage to facilities, infrastructure, equipment, stockpiles and downstream sensitive areas caused by inundation from floodwaters

- Increased risk of flooding of adjacent areas due to temporary loss of floodplain storage (resulting in displacement of water) or impacts on the conveyance of floodwaters.

The likelihood of flooding and a summary of the potential impacts of construction sites and associated construction activities on flood risk is provided in **Table 5-1** in **section 5.2**. The assessment found that a number of the construction ancillary facilities would be affected by flooding during relatively frequent storms events. In particular, the Rozelle civil and tunnel site (C5) is affected by both mainstream flooding from Whites Creek and major overland flows through the Rozelle Rail Yards.

Construction activities also have the potential to exacerbate flooding conditions in adjacent developments. This arises due to the need to locate temporary measures on the floodplain outside the road footprint. A preliminary investigation was undertaken to assess the potential construction impacts on the characteristics of flooding. The key findings of the investigation are also summarised in **Table 5-1**.

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 and groundwater
- Accidental leaks or spills of chemicals, fuels and oils during construction
- Direct disturbance of waterway channel 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.

Potential impacts on surface water quality, geomorphology and hydrology during construction of the project are considered minor and manageable with the application of standard mitigation measures.

Operational impacts

If unmanaged, inundation of the project by floodwater during its operation has the potential to cause damage to infrastructure; impact on the safe operation of the motorway tunnels and pose a safety risk to road users and motorway operations staff. The project also has the potential to exacerbate flooding and drainage conditions in adjacent developments.

An assessment was undertaken of the flood risk to the project in its operational phase, as well as the impact it would have on the characteristics of flooding in adjacent development. **Section 6.2.1** provides an overview of the operational flood risks at the main project surface features. The assessment has shown that the Rozelle interchange, Iron Cove Link and Darley Road site are partially located within the Probable Maximum Flood (PMF) flood extent, which has the potential to impact on the interchange and tunnel portals.

A recommended level of flood protection to each project element has been identified with due consideration of the consequences of flooding in accordance with the *NSW Floodplain Development Manual* (NSW Department of Infrastructure, Planning and Natural Resources 2005) and current Roads and Maritime standards. The design criterion is to prevent flooding of the portals for events up to the PMF or the 100 year Average Recurrence Interval (ARI) event plus 0.5 metres freeboard (whichever is greater).

The investigation found that once constructed, the project would have only a minor impact on flooding behaviour in adjacent developments for storms with ARI's up to 100 years. While it will be necessary to undertake further design development during detailed design aimed at further reducing the residual impacts of the project on flooding behaviour, it is concluded that the minor nature of the changes in flooding patterns attributable to the project would not have a significant impact on the future development potential of land located outside the project footprint.

Potential impacts of future climate change on flooding

Future climate change could lead to sea level rise and potential increase in rainfall intensity and frequency. This could affect flood behaviour over the life of the project. An assessment of the potential

impact of climate change on flood behaviour in the vicinity of the M4-M5 Link project has therefore been undertaken, in accordance with the NSW Office of Environment and Heritage's (OEH) *Floodplain Risk Management Guideline – Practical Considerations of Climate Change* (NSW Department of Environment and Climate Change (DECC) 2007) and current best practice. **Section 6.2.2** provides an overview of the climate change scenarios that were assessed, considering different combinations of design storm rainfalls and sea level conditions under 2050 and 2100 conditions.

The investigation found that changes in the flood behaviour under future climate change conditions would not lead to a significant increase in the flood risk to the project. **Section 6.2.2** summarises the potential impact future climate change could have on peak flood levels at key locations along the project corridor.

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

- 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
- Discharges of treated tunnel wastewater
- Poor erosion protection treatments within the proposed naturalised sections of Whites Creek.

Management of potential impacts

The assessment of flood impacts associated with the project has provided an understanding of the scale and nature of the flood risk to the project infrastructure and its operation, as well as the risks for the surrounding environment. The layouts of the different interchanges have been influenced by flood risk and drainage considerations. A range of potential flood mitigation measures which would reduce/manage the flood impacts during the project's operational phase is provided in **section 8.1.3**.

A Flood Mitigation Strategy (FMS) would be prepared for flood prone or flood affected land within the project footprint prior to construction, to demonstrate that the existing flooding characteristics would not be exacerbated as a consequence of the project. The FMS would identify flood risks to the project and adjoining areas, design and mitigation measures that would be implemented to protect proposed operations and not worsen existing flood characteristics and required drainage system upgrades.

Bridge crossings over existing waterways and proposed drainage channels would be designed for the underside of bridge structure to be above the peak 100 year ARI design flood level. All entry points into the tunnels would be designed so that they are located above the peak level of the PMF or the 100 year ARI design flood plus 0.50 metres, whichever is greater. The same hydrological standard would be applied to tunnel ancillary facilities such as tunnel ventilation and emergency response facilities, electrical substations and water treatment plants where the ingress of floodwaters would also have the potential to flood the tunnels.

Further impact assessments based on the detailed design would be undertaken to determine the ability of the receiving drainage systems to effectively convey drainage discharges from the project once operational.

During the construction phase, some of the works would occur within the extent of various flood event magnitudes as outlined in **section 5.2**. Flood management plans would be developed prior to construction as part of the Construction Environmental Management Plan (CEMP), to guide the design of construction ancillary facilities and thereby minimise potential impacts of flooding. This would be in line with minimising risk to the surrounding environment.

Further assessment of the construction of ancillary facilities and measures to manage flooding onsite and mitigate flood impacts during construction would be undertaken during detailed design. A range of potential flood mitigation measures which would reduce/manage the impact of construction activities on flooding behaviour are set out in **Table 8-1**.

The CEMP would control potential surface water quality impacts during construction. A Construction Soil and Water Management Plan (CSWMP) including a water quality monitoring program would be prepared as part of the CEMP, construction water treatment plants would be established during the construction phase to treat water to a quality suitable for discharge to the environment. 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).

Suitable treatment devices would be provided to treat stormwater runoff from impervious surfaces that result from the project. The final design of treatment facilities would be undertaken during detailed design including investigation of potential opportunities to achieve annual stormwater pollutant load reduction targets through the treatment of external catchments.

Operational water quality monitoring would be conducted for three years post-construction or as otherwise required by project conditions of approval.

An assessment of risk of spills on the motorway, with emphasis placed on the receiving environment, would be undertaken. If warranted in areas of higher sensitivity, such as upstream of Rozelle Bay and Iron Cove, containment facilities would be provided. This would be determined during detailed design. Spill management and emergency response procedures would also be documented in an Operational Environmental Management Plan (OEMP). Proposed landscaped areas would be suitably profiled, vegetated and stabilised to control erosion.

New discharge outlets would be designed with appropriate energy dissipation and scour protection measures. The presence and suitability of energy dissipation and scour protection measures at existing outlets would also be assessed during detailed design and appropriate improvements incorporated as required.

Water treatment plants would be permanently established at Rozelle interchange and Darley Road, Leichhardt to treat tunnel groundwater inflows as well as discharges collected via the tunnel drainage system and sump. Treated water would be discharged at a rate of up to 22 litres per second into the Rozelle Bay and 23 litres per second to Hawthorne Canal. The tunnel operational water treatment facilities would be designed such that effluent will be of suitable quality for discharge to the receiving environment with consideration to the characteristics of the discharge and receiving waterbody, any operational constraints or practicalities and associated environmental impacts, Australian and New Zealand Environment and Conservation Council (ANZECC) (2000) and relevant NSW Water Quality Objectives (NSW WQOs).

The proposed constructed wetland at Rozelle will provide ‘polishing’ treatment to the treated groundwater flows. As no constructed wetland is proposed at Darley Road, opportunities to incorporate other forms of nutrient treatment within the plant at Darley Road will be investigated during detailed design.

Minor increases in storm flow to Rozelle Bay, Whites Creek, White Bay, Iron Cove, Alexandra Canal and Hawthorne Canal associated with an increase in impervious surface and the increase in base flow to Hawthorne Canal and Rozelle Bay associated with treated tunnel flows are considered to pose a negligible impact on the natural flow variability of the tidal waterways. Naturalisation works on Whites Creek would incorporate surface treatments which provide suitable erosion protection once constructed and established.

Conclusion

The project has the potential to impact on the surface water environment as a result of construction and operation activities, 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

NSW Roads and Maritime Services (Roads and Maritime) is seeking approval to construct and operate the WestConnex M4-M5 Link (the project), which would comprise a new multi-lane road link between the M4 East Motorway at Haberfield and the New M5 Motorway at St Peters. The project would also include an interchange at Lilyfield and Rozelle (the Rozelle interchange) and a tunnel connection between Anzac Bridge and Victoria Road, east of Iron Cove Bridge (Iron Cove Link). In addition, construction of tunnels, ramps and associated infrastructure to provide connections to the proposed future Western Harbour Tunnel and Beaches Link project would be carried out at the Rozelle interchange.

Together with the other components of the WestConnex program of works and the proposed future Sydney Gateway, the project would facilitate improved connections between western Sydney, Sydney Airport and Port Botany and south and south-western Sydney, as well as better connectivity between the important economic centres along Sydney's Global Economic Corridor and local communities.

Approval is being sought under Part 5.1 of the *Environmental Planning and Assessment Act 1979* (NSW) (EP&A Act) for the project. A request has been made for the NSW Minister for Planning to specifically declare the project to be State significant infrastructure and also critical State significant infrastructure. An environmental impact statement (EIS) is therefore required.

1.1 Overview of WestConnex and related projects

The M4-M5 Link is part of the WestConnex program of works. Separate planning applications and assessments have been completed for each of the approved WestConnex projects. Roads and Maritime has commissioned Sydney Motorway Corporation (SMC) to deliver WestConnex, on behalf of the NSW Government. However, Roads and Maritime is the proponent for the project.

In addition to linking to other WestConnex projects, the M4-M5 Link would provide connections to the proposed future Western Harbour Tunnel and Beaches Link, the Sydney Gateway (via the St Peters interchange) and the F6 Extension (via the New M5).

The WestConnex program of works, as well as related projects, are shown in **Figure 1-1** and described in **Table 1-1**.

Table 1-1 WestConnex and related projects

Project	Description	Status
WestConnex program of works		
M4 Widening	Widening of the existing M4 Motorway from Parramatta to Homebush.	Planning approval under the EP&A Act granted on 21 December 2014. Open to traffic.
M4 East	Extension of the M4 Motorway in tunnels between Homebush and Haberfield via Concord. Includes provision for a future connection to the M4-M5 Link at the Wattle Street interchange.	Planning approval under the EP&A Act granted on 11 February 2016. Under construction.
King Georges Road Interchange Upgrade	Upgrade of the King Georges Road interchange between the M5 West and the M5 East at Beverly Hills, in preparation for the New M5 project.	Planning approval under the EP&A Act granted on 3 March 2015. Open to traffic.
New M5	Duplication of the M5 East from King Georges Road in Beverly Hills with tunnels from Kingsgrove to a new interchange at St Peters. The St Peters interchange allows for connections to the proposed future Sydney Gateway project and an underground connection to the M4-M5 Link. The New M5 tunnels also include provision for a future connection to the proposed future F6 Extension.	Planning approval under the EP&A Act granted on 20 April 2016. Commonwealth approval under the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) granted on 11 July 2016. Under construction.

Project	Description	Status
M4-M5 Link (the project)	Tunnels connecting to the M4 East at Haberfield (via the Wattle Street interchange) and the New M5 at St Peters (via the St Peters interchange), a new interchange at Rozelle and a link to Victoria Road (the Iron Cove Link). The Rozelle interchange also includes ramps and tunnels for connections to the proposed future Western Harbour Tunnel and Beaches Link project.	The subject of this EIS.
Related projects		
Sydney Gateway	A high-capacity connection between the St Peters interchange (under construction as part of the New M5 project) and the Sydney Airport and Port Botany precinct.	Planning underway by Roads and Maritime and subject to separate environmental assessment and approval.
Western Harbour Tunnel and Beaches Link	The Western Harbour Tunnel component would connect to the M4-M5 Link at the Rozelle interchange, cross underneath Sydney Harbour between the Birchgrove and Waverton areas, and connect with the Warringah Freeway at North Sydney. The Beaches Link component would comprise a tunnel that would connect to the Warringah Freeway, cross underneath Middle Harbour and connect with the Burnt Bridge Creek Deviation at Balgowlah and Wakehurst Parkway at Seaforth. It would also involve the duplication of the Wakehurst Parkway between Seaforth and Frenchs Forest.	Planning underway by Roads and Maritime and subject to separate environmental assessment and approval.
F6 Extension	A proposed motorway link between the New M5 at Arncliffe and the existing M1 Princes Highway at Loftus, generally along the alignment known as the F6 corridor.	Planning underway by Roads and Maritime and subject to separate environmental assessment and approval.

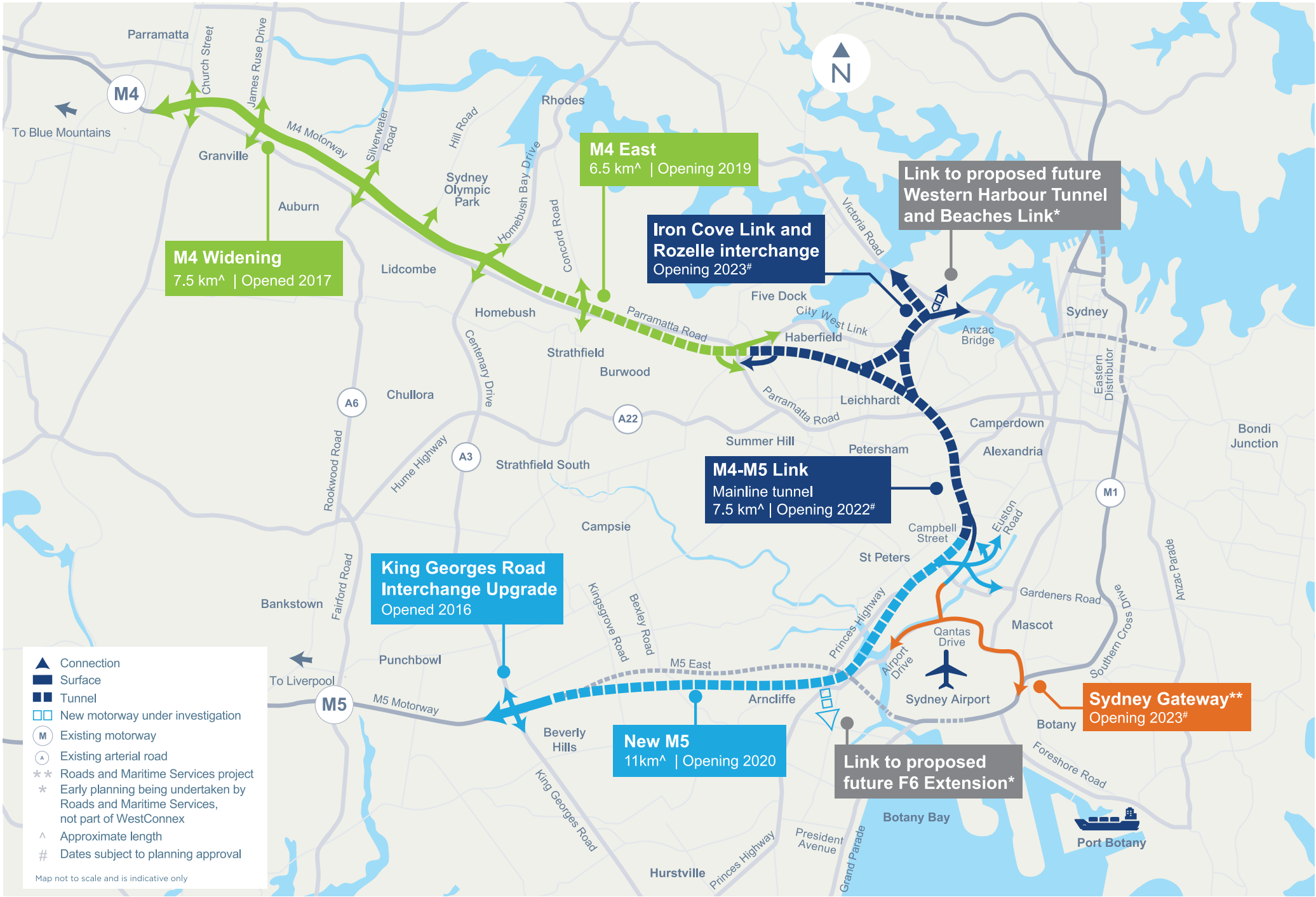


Figure 1-1 Overview of WestConnex and related projects

1.2 Purpose of this report

This report has been prepared to address the Secretary's Environmental Assessment Requirements (SEARs) in relation to hydrology, surface water quality and flooding, for the preparation of an EIS for the project. The report presents the state of the existing surface water and flooding 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.

1.3 SEARs and agency comments

Table 1-2 How SEARs have been addressed in this report

	Key issue SEARs	Section where addressed in this report
10. Water - Hydrology		
The environmental values of nearby, connected and affected water sources, groundwater and dependent ecological systems including estuarine and marine water (if applicable) are maintained (where values are achieved) or improved and maintained (where values are not achieved).	1. The Proponent must describe (and map) the existing hydrological regime for any surface and groundwater resource (including reliance by users and for ecological purposes) likely to be impacted by the project, including stream orders, as per the FBA.	See **section 4.1** for the existing hydrological regime for surface water resource. Refer **Appendix T** (Technical working paper: Groundwater) of the EIS for discussion regarding groundwater resource. Refer to **Chapter 18** (Biodiversity) for further consideration of the Framework for Biodiversity Assessment (FBA).
	2. The Proponent must prepare a detailed water balance for ground and surface water including the proposed intake and discharge locations, volume, frequency and duration for both the construction and operational phases of the project.	See **sections 2.4.1, 5.2.1, 5.2.2** and **6.3** for surface water balance. Refer **Appendix T** (Technical working paper: Groundwater) of the EIS for groundwater inflow predictions.
	3. The Proponent must assess (and model if appropriate) the impact of the construction and operation of the project and any ancillary facilities (both built elements and discharges) on surface and groundwater hydrology in accordance with the current guidelines, including:	
	(a) natural processes within rivers, wetlands, estuaries, marine waters and floodplains that affect the health of the fluvial, riparian, estuarine or marine system and landscape health (such as modified discharge volumes, durations and velocities), aquatic connectivity and access to habitat for spawning and refuge;	See **sections 4.1, 4.2, 4.6, 4.9, 5.2, 5.4** and **6.2.4** for surface water. Refer **Appendix T** (Technical working paper: Groundwater) of the EIS for groundwater hydrology. Refer **Appendix S** (Technical working paper: Biodiversity) of the EIS for impacts on aquatic habitat.

	Key issue SEARs	Section where addressed in this report
	(b) impacts from any permanent and temporary interruption of groundwater flow, including the extent of drawdown, barriers to flows, implications for groundwater dependent surface flows, ecosystems and species, groundwater users and the potential for settlement;	Refer to **Appendix T** (Technical working paper: Groundwater) of the EIS for impacts on groundwater and **Appendix S** (Technical working paper: Biodiversity) of the EIS for impacts on groundwater dependant ecosystems and species.
	(c) changes to environmental water availability and flows, both regulated/licensed and unregulated/rules-based sources;	See **sections 2.4.1, 5.1, 5.2.2** and **6.2.4**.
	(d) direct or indirect increases in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses;	See **sections 4.2, 4.9**, **5.2.2**, **5.3.2**, **6.2.4**, **6.3.5**, **8** and **Appendix S** (Technical working paper: Biodiversity) of the EIS.
	(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 existing stormwater systems where discharges are proposed through such systems; and	See **sections 4.2, 5.2.2** and **6.2.4** and **8**.
	(f) water take (direct or passive) from all surface and groundwater sources with estimates of annual volumes during construction and operation.	See **sections 2.4.1** , **5.1** and **6.1** for surface water. Refer to **Appendix T** (Technical working paper: Groundwater) of the EIS for groundwater.
	4. The Proponent must identify any requirements for baseline monitoring of hydrological attributes.	No monitoring of hydrological attributes in surface water bodies was considered to be required for the project given that no surface water extraction from the urban waterways would be undertaken and with consideration to the artificial nature of the receiving waterways. Refer to **Appendix T** (Technical working paper: Groundwater) of the EIS.
	5. The assessment must include details of proposed surface and groundwater monitoring.	For proposed surface water monitoring, see **sections 4.5** and **8.2**. For proposed groundwater monitoring, refer to **Appendix T** (Technical working paper:

	Key issue SEARs	Section where addressed in this report
		Groundwater) of the EIS.
	6. The proposed tunnels should be designed to prevent drainage of alluvium in the palaeochannels.	Refer to **Appendix T** (Technical working paper: Groundwater) of the EIS.
11. Water - Quality		
The project is designed, constructed and operated to protect the NSW Water Quality Objectives where they are currently being achieved, and contribute towards achievement of the Water Quality Objectives over time where they are currently not being achieved, including downstream of the project to the extent of the project impact including estuarine and marine waters (if applicable).	1. The Proponent must:	
	(a) state the ambient NSW Water Quality Objectives (NSW WQO) and environmental values for the receiving waters relevant to the project, including the indicators and associated trigger values or criteria for the identified environmental values;	**Section 3.2.2**.
	(b) identify and estimate the quality and quantity of all pollutants that may be introduced into 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 quantity of stormwater pollutants has been assessed in **section 6.3**. Tunnel pollutant discharges are assessed in **section 6.3**. Other potential pollutants of concern have been listed. Refer to **sections 4.10, 5.3** and **6.3**. Residual impacts to water quality are discussed in **sections 8.2.2** and **8.2.4**.
	(c) identify the rainfall event that the water quality protection measures will be designed to cope with;	Operational measures are designed based on pollutant load reduction (rather than a rainfall event). Construction measures will be designed in accordance with the Blue Book. See **section 8.2**.
	(d) assess the significance of any identified impacts including consideration of the relevant ambient water quality outcomes;	**Sections 5.3, 6.3** and **8.2** Residual impacts to water quality are discussed in **sections 8.2.2** and **8.2.4**.
	(e) demonstrate how construction and operation of the project will, to the extent that the project can influence, ensure that:	
	- where the NSW WQOs for receiving waters are currently being met they will continue to be protected; and	**Sections 8.2.2** and **8.2.4**.
	- where the NSW WQOs are not currently being met, activities will not worsen water quality and, where reasonably practicable, work toward their achievement over time;	**Sections 8.2.2** and **8.2.4**.
	(f) justify, if required, why the WQOs cannot be maintained or achieved over time;	**Sections 8.2.2** and **8.2.4**.

	Key issue SEARs	Section where addressed in this report
	(g) demonstrate that all practical measures to avoid or minimise water pollution and protect human health and the environment from harm are investigated and implemented;	**Sections 2.4** and **8.2.** A review of tunnel treatment options is provided in **Annexure H**.
	(h) identify sensitive receiving environments (which may include estuarine and marine waters downstream) and develop a strategy to avoid or minimise impacts on these environments; and	**Sections 2.4, 4.1, 4.6** and **8**.
	(i) identify proposed monitoring locations, monitoring frequency and indicators of surface and groundwater quality.	**Sections 4.5** and **8.2**.
	2. The assessment should consider the results of any current water quality studies, as available, in the project catchment.	**Section 4.5**.
12. Flooding		
The project minimises adverse impacts on existing flooding characteristics. Construction and operation of the project avoids or minimises the risk of, and adverse impacts from, infrastructure flooding, flooding hazards, or dam failure.	1. The Proponent must assess and (model where required) the impacts on flood behaviour during construction and operation for a full range of flood events up to the probable maximum flood (taking into account sea level rise and storm intensity due to climate change) including:	**Sections 6.2.1, 6.2.2** and **Annexure C**.
	(a) how the tunnel entries and cut-and-cover sections of the tunnels would be protected from flooding during construction works;	**Sections 5.2, 6.2** and **8.1.2**.
	(b) any detrimental increases in the potential flood affectation of the project infrastructure and other properties, assets and infrastructure;	**Sections 5.2, 6.2** and **8.1.2**.
	(c) consistency (or inconsistency) with applicable Council floodplain risk management plans;	**Sections 3.2.9**, **4.4.1** and **6.2**.
	(d) compatibility with the flood hazard of the land;	**Sections 4.4.1, 6.2** and **8.1**.
	(e) compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land;	**Sections 4.4.1** and **6.2**.
	(f) whether there will be adverse effect to beneficial inundation of the floodplain environment, on, or adjacent to or downstream of the site;	**Sections 5.2** and **6.2**.
	(g) downstream velocity and scour potential;	**Section 6.2**.
	(h) impacts the development may have upon existing community emergency management arrangements for flooding. These matters must be discussed with the State Emergency Services and Council;	**Section 6.2** and **8.1.1**.

	Key issue SEARs	Section where addressed in this report
	(i) any impacts the development may have on the social and economic costs to the community as consequence of flooding;	See **section 6.2.1**
	(j) whether there will be direct or indirect increase in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses; and	See **sections 4.2, 5.2.1, 5.2.2 6.2.4** and **6.3**.
	(k) any mitigation measures required to offset potential flood risks attributable to the project.	See **Sections 6.2** and **8.1**.
	2. The assessment should take into consideration any flood studies undertaken by local government councils, as available.	See **Sections 3.4** and **4.4.1**.
	Other issue SEARs	
13. Soils		
The environmental values of land, including soils, subsoils and landforms, are protected. Risks arising from the disturbance and excavation of land and disposal of soil are minimised, including disturbance to acid sulfate soils and site contamination.	2. 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 potential impacts.	Refer to **Appendix R** (Technical working paper: Contamination) of the EIS, **Appendix T** (Technical working paper: Groundwater) of the EIS and **sections 4.10, 5.3, 6.3** and **8**.
16. Waste		
All wastes generated during the construction and operation of the project are effectively stored, handled, treated, reused, recycled and/or disposed of lawfully and in a manner that protects environmental values.	2. The Proponent must assess potential environmental impacts from the excavation, handling, storage on site and transport of the waste particularly with relation to sediment/leachate control, noise and dust.	See **sections 5.3** and **6.3**. Refer to **Appendix I** (Technical working paper: Air quality) of the EIS and **Appendix J** (Technical working paper: Noise and vibration) of the EIS.

Table 1-3 How agency comments have been addressed in this report

Agency letters	
Inner West Council	
Requirement	**Section where addressed in EIS**
Reference should also be made to various water quality studies currently underway, most particularly studies being prepared by NSW Urban Growth.	**Section 4.5**.
As the project drains to two significant areas of Sydney Harbour (Iron Cove and White Bay/Blackwattle Bay) it is essential that attention be paid to all phases of the project (construction, early operation and continued operation) including emergency situations (eg spills in or adjacent to the site) and that the project should aim to both.	**Sections 2.4, 5.3, 6.3** and **8.2**.

Agency letters	
Reference should specifically be made to Council's recent Flood Study which provides detailed information on existing flood behaviour across the entire LGA. In addition, Council is currently preparing a Flood Risk Management Study and Plan for the entire LGA incorporating flood management and mitigation measures which may in some cases impact on or overlap with the proposed works.	**Section 4.4.1**.
Ashfield Council	
Requirement	**Section where addressed in EIS**
The SEARs should also specify a requirement for the EIS to address cumulative impacts of the proposal across all major issues – traffic, noise, vibration, social, health, visual, heritage, biodiversity, environmental, climate change, flooding and water quality.	**Section 7** for flooding and water quality cumulative impacts.
Department of Primary Industries (Water)	
Requirement	**Section where addressed in EIS**
The SSI report notes Johnstons Creek and Whites Creek traverse the project corridor (section 4.8.1, page 56) and palaeochannels are associated with these creeks (section 4.7.1, page 52). The proposed tunnels should be designed to prevent drainage of alluvium in the palaeochannels.	Refer to **Appendix T** (Technical working paper: Groundwater) of the EIS.
The SSI report notes construction of the project has the potential for disturbance of contaminated soils (section 4.7.2, page 55). The disturbance of contaminated groundwater is another potential soil, water and contamination-related impact that should be addressed.	Refer to EIS **Appendix R** (Technical working paper: Contamination) of the EIS and **Appendix T** (Technical working paper: Groundwater) of the EIS. **Sections 2.4, 5.3, 6.3** and **8.2**.
Water licensing requirements: The SSI report indicates water resources are required during construction, particularly during tunnelling and groundwater may also be used (see section 4.10.1, page 63). Under Schedule 5, Part 1, clause 2 of the Water Management (General) Regulation 2011, roads authorities are exempt from the requirement to hold a water access licence for water required for road construction and road maintenance. While Roads and Martime is currently exempt from requiring a licence for this water during construction, arrangements for the licensing requirements are currently being finalised between Roads and Martime and DPI Water. The proponent is requested to continue liaising with DPI Water to ensure that any licensing requirements are met.	Not relevant for assessment purposes. Refer **Appendix T** (Technical working paper: Groundwater) of the EIS.
Hawthorne Canal and Rozelle Bay are important key fish habitat within or adjacent to the project boundary. DPI Fisheries recommends that the project is designed to minimise the following potential impacts to these waterways: · Erosion and sedimentation impacts during construction · Operational water quality impacts · Direct impacts to aquatic habitats, such as saltmarsh are avoided or minimised.	**Sections 2.4** and **8.2**.
Marrickville Council	
Requirement	**Section where addressed in EIS**
Stormwater and groundwater treatments should be detailed in the context of both local biodiversity and water quality	**Sections 6.3** and **8.2**. Refer to **Appendix S** (Technical

Agency letters	
objectives. The impact of changes to the permeability of surfaces should also be detailed.	working paper: Biodiversity) of the EIS.
Council is working with a number of regional councils in improving the water quality and environmental health of the Cooks River and Parramatta River. A comprehensive assessment will be needed to evaluate the water quality issues and surface water contamination risks during construction and at operation stages.	**Sections 2.4, 5.3, 6.3** and **8.2**.
NSW OEH	
Requirement	**Section where addressed in EIS**
The EIS must assess the impacts of the proposed project on flood behaviour, including: · Any impacts the development may have on the social and economic costs to the community as a consequence of flooding · Whether there will be direct or indirect increase in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses.	**Sections 4.2, 5.3, 6.2** and **8.2**.
The EIS should ensure the use of the latest data from Local Councils' relevant flood studies. It is prudent to consult with Ashfield, Leichhardt, Marrickville and City of Sydney Councils to ensure the latest flood data is used.	**Section 4.4.1**.
The EIS must map the following features relevant to flooding within the vicinity of the project, as described in the Floodplain Development Manual 2005 (NSW Government 2005) including: · Flood prone land · Flood planning area – the area below the flood planning level (ie the area below the 1 in 100 year flood level plus an identified freeboard) · Hydraulic categorisation (floodway and flood storage areas).	**Sections 4.4.1** and **6.2.1**.
The EIS must describe the flood assessment and modelling undertaken in determining the design flood levels for events, including as a minimum the 1 in 10 year, 1 in 100 year flood levels and the probable maximum flood (PMF), or an equivalent extreme event.	**Section 6.2.1** and **Annexure C.**
The EIS must model the effect of the proposed project (including earthworks) on the flood behaviour under the following scenarios: · Current flood behaviour for a range of design events as identified above. · The 1 in 200 and 1 in 500 year flood events as proxies for assessing sensitivity to an increase in rainfall intensity of flood producing rainfall events due to climate change.	**Section 6.2.1**. For climate change assessment see **section 6.2.2**.
The EIS should ensure that the tunnel entries and cut and cover sections of the tunnels would be protected from flooding during construction works, considering both mainstream flooding and local overland flow paths. The EIS should identify appropriate mitigation measures such as physical barriers for further assessment in the detailed design prior to construction.	**Section 8.1**.

Agency letters	
The EIS should ensure that in the operational stage the proposed tunnel's dive structure, dilation structures and systems, fire and safety systems, emergency evacuation and key extraction infrastructure would be protected up to the PMF level or the 100 year ARI flood level plus 0.5 metres freeboard, whichever is greater, considering both mainstream flooding and local overland flow paths.	**Section 6.2.1**.
Modelling in the EIS must consider and document: · The impact of the project on existing flood behaviour for a full range of flood events including up to the PMF · The impact of the project on flood behaviour resulting in detrimental changes in potential flood affection of other properties, assets or infrastructure. This may include redirection of flow, flow velocities, flood levels, hazards and hydraulic categories Impacts of earthworks and stockpiles within the flood prone land up to the PMF level · The assessment should be based on an understanding of cumulative flood impacts of construction and operational phase. Whether appropriate mitigation measures required to offset potential flood risk arise from the project. Proposed mitigation work should be modelled and assessed on the overall catchment basis in order to ensure it fits its purpose and meets the criteria of the relevant Council where it is located.	**Sections 5.2, 6.2.1, 7** and **8.1**.

1.4 Study area

The study area for the surface water and flooding assessment includes the project's surface footprint, as well as areas where potential surface water and flooding impacts could occur as a result of construction or operation of the project.

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

- Dobroyd Canal (Iron Cove Creek) – the section of the project within this catchment includes the Wattle Street interchange and construction ancillary facilities at Haberfield (Option A) and Ashfield and Haberfield (Option B)
- Hawthorne Canal – project surface features include the Darley Road civil and tunnel site, which remains as an access point to the tunnel
- Whites Creek – a portion of the Rozelle interchange and associated local roads
- Easton Park drain – project surface features include the Rozelle interchange and Rozelle civil and tunnel site
- Rozelle Bay – the Rozelle civil and tunnel site, Rozelle interchange and associated roads
- Whites Bay – a portion of the Victoria Road works are located in the Whites Bay catchment
- Iron Cove – the Iron Cove Link is located within an area that drains to Iron Cove
- Johnstons Creek – The Pyrmont Bridge Road tunnel site is located within the catchment of Johnstons Creek
- Alexandra Canal – St Peters interchange and the Campbell Road civil and tunnel site is located within its catchment.

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

1.5 Structure of this report

This technical working paper is structured as follows:

- Chapter 1 – Introduction – This chapter provides a brief overview of the outlines the project and presents the purpose of this report
- Chapter 2 – The project – This chapter provides an overview of the project
- Chapter 3 – Assessment methodology – This chapter describes the methodology employed for the Technical Working Paper – Surface water and flooding assessment
- Chapter 4 – Existing environment – This chapter describes the surface water study area and its existing surface water and flooding conditions
- Chapter 5 – Assessment of construction impacts – This chapter describes the potential impacts on surface water and flooding resulting from the project during construction
- Chapter 6 – Assessment of operational impacts – This chapter describes the potential impacts to surface water and flooding resulting from the project during operation
- Chapter 7 – Assessment of cumulative impacts – This chapter describes the potential cumulative impacts to surface water and flooding resulting from the project and other key developments
- Chapter 8 – Mitigation and management – This chapter provides a summary of environmental mitigation, management and monitoring responsibilities in relation surface water management and flooding mitigation for the project
- Chapter 9 – Conclusion
- Chapter 10 – References
- Annexure A – Photographs
- Annexure B – Water Quality Data Summary
- Annexure C – Flood Model Development
- Annexure D – Step by Step Flood Risk Assessment
- Annexure E – Water Quality Monitoring Program
- Annexure F – Stormwater Quality Modelling Catchments
- Annexure G – NSW Water Quality Objectives – Indicators and Criteria
- Annexure H – Tunnel water treatment plant options review.

2 The project

2.1 Project location

The project would be generally located within the City of Sydney and Inner West local government areas (LGAs). The project is located about two to seven kilometres south, southwest and west of the Sydney central business district (CBD) and would cross the suburbs of Ashfield, Haberfield, Leichhardt, Lilyfield, Rozelle, Annandale, Stanmore, Camperdown, Newtown and St Peters. The local context of the project is shown in **Figure 2-1**.

2.2 Overview of the project

Key components of the project are shown in **Figure 2-1** and would include:

- Twin mainline motorway tunnels between the M4 East at Haberfield and the New M5 at St Peters. Each tunnel would be around 7.5 kilometres long and would generally accommodate up to four lanes of traffic in each direction
- Connections of the mainline tunnels to the M4 East project, comprising:
  - A tunnel-to-tunnel connection to the M4 East mainline stub tunnels east of Parramatta Road near Alt Street at Haberfield
  - Entry and exit ramp connections between the mainline tunnels and the Wattle Street interchange at Haberfield (which is currently being constructed as part of the M4 East project)
  - Minor physical integration works with the surface road network at the Wattle Street interchange including road pavement and line marking
- Connections of the mainline tunnels to the New M5 project, comprising:
  - A tunnel-to-tunnel connection to the New M5 mainline stub tunnels north of the Princes Highway near the intersection of Mary Street and Bakers Lane at St Peters
  - Entry and exit ramp connections between the mainline tunnels and the St Peters interchange at St Peters (which is currently being constructed as part of the New M5 project)
  - Minor physical integration works with the surface road network at the St Peters interchange including road pavement and line marking
- An underground interchange at Leichhardt and Annandale (the Inner West subsurface interchange) that would link the mainline tunnels with the Rozelle interchange and the Iron Cove Link (see below)
- A new interchange at Lilyfield and Rozelle (the Rozelle interchange) that would connect the M4-M5 Link mainline tunnels with:
  - City West Link
  - Anzac Bridge
  - The Iron Cove Link (see below)
  - The proposed future Western Harbour Tunnel and Beaches Link
- Construction of connections to the proposed future Western Harbour Tunnel and Beaches Link project as part of the Rozelle interchange, including:
  - Tunnels that would allow for underground mainline connections between the M4 East and New M5 motorways and the proposed future Western Harbour Tunnel and Beaches Link (via the M4-M5 Link mainline tunnels)
  - A dive structure and tunnel portals within the Rozelle Rail Yards, north of the City West Link / The Crescent intersection
  - Entry and exit ramps that would extend north underground from the tunnel portals in the

Rozelle Rail Yards to join the mainline connections to the proposed future Western Harbour Tunnel and Beaches Link

- A ventilation outlet and ancillary facilities as part of the Rozelle ventilation facility (see below)

· Twin tunnels that would connect Victoria Road near the eastern abutment of Iron Cove Bridge and Anzac Bridge (the Iron Cove Link). Underground entry and exit ramps would also provide a tunnel connection between the Iron Cove Link and the New M5 / St Peters interchange (via the M4-M5 Link mainline tunnels)

· The Rozelle surface works, including:

- Realigning The Crescent at Annandale, including a new bridge over Whites Creek and modifications to the intersection with City West Link

- A new intersection on City West Link around 300 metres west of the realigned position of The Crescent, which would provide a connection to and from the New M5/St Peters interchange (via the M4-M5 Link mainline tunnels)

- Widening and improvement works to the channel and bank of Whites Creek between the light rail bridge and Rozelle Bay at Annandale, to manage flooding and drainage for the surface road network

- Reconstructing the intersection of The Crescent and Victoria Road at Rozelle, including construction of a new bridge at Victoria Road

- New and upgraded pedestrian and cyclist infrastructure

- Landscaping, including the provision of new open space within the Rozelle Rail Yards

· The Iron Cove Link surface works, including:

- Dive structures and tunnel portals between the westbound and eastbound Victoria Road carriageways, to connect Victoria Road east of Iron Cove Bridge with the Iron Cove Link

- Realignment of the westbound (southern) carriageway of Victoria Road between Springside Street and the eastern abutment of Iron Cove Bridge

- Modifications to the existing intersections between Victoria Road and Terry, Clubb, Toelle and Callan streets

- Landscaping and the establishment of pedestrian and cycle infrastructure

· Five motorway operations complexes; one at Leichhardt (MOC1), three at Rozelle (Rozelle West (MOC2), Rozelle East (MOC3) and Iron Cove Link (MOC4)), and one at St Peters (MOC5). The types of facilities that would be contained within the motorway operations complexes would include substations, water treatment plants, ventilation facilities and outlets, offices, on-site storage and parking for employees

· Tunnel ventilation systems, including ventilation supply and exhaust facilities, axial fans, ventilation outlets and ventilation tunnels

· Three new ventilation facilities, including:

- The Rozelle ventilation facility at Rozelle

- The Iron Cove Link ventilation facility at Rozelle

- The Campbell Road ventilation facility at St Peters

· Fitout (mechanical and electrical) of part of the Parramatta Road ventilation facility at Haberfield (which is currently being constructed as part of M4 East project) for use by the M4-M5 Link project

· Drainage infrastructure to collect surface and groundwater for treatment at dedicated facilities. Water treatment would occur at

- Two operational water treatment facilities (at Leichhardt and Rozelle)

- The constructed wetland within the Rozelle Rail Yards

- A bioretention facility for stormwater runoff within the informal car park at King George Park at

Rozelle (adjacent to Manning Street). A section of the existing informal car park would also be upgraded, including sealing the car park surface and landscaping

- Treated water would flow back to existing watercourses via new, upgraded and existing infrastructure
- Ancillary infrastructure and operational facilities for electronic tolling and traffic control and signage (including electronic signage)
- Emergency access and evacuation facilities, including pedestrian and vehicular cross and long passages and fire and life safety systems
- Utility works, including protection and/or adjustment of existing utilities, removal of redundant utilities and installation of new utilities. A Utilities Management Strategy has been prepared for the project that identifies management options for utilities, including relocation or adjustment. Refer to **Appendix F** (Utilities Management Strategy) of the EIS.

The project does not include:

- Site management works at the Rozelle Rail Yards. These works were separately assessed and determined by Roads and Maritime through a Review of Environmental Factors under Part 5 of the EP&A Act (refer to **Chapter 2** (Assessment process) of the EIS)
- Ongoing motorway maintenance activities during operation
- Operation of the components of the Rozelle interchange which are the tunnels, ramps and associated infrastructure being constructed to provide connections to the proposed future Western Harbour Tunnel and Beaches Link project.

Temporary construction ancillary facilities and temporary works to facilitate the construction of the project would also be required.

2.2.1 Staged construction and opening of the project

It is anticipated the project would be constructed and opened to traffic in two stages (as shown in **Figure 2-1**).

Stage 1 would include:

- Construction of the mainline tunnels between the M4 East at Haberfield and the New M5 at St Peters, stub tunnels to the Rozelle interchange (at the Inner West subsurface interchange) and ancillary infrastructure at the Darley Road motorway operations complex (MOC1) and Campbell Road motorway operations complex (MOC5)
- These works are anticipated to commence in 2018 with the mainline tunnels open to traffic in 2022. At the completion of Stage 1, the mainline tunnels would operate with two traffic lanes in each direction. This would increase to generally four lanes at the completion of Stage 2, when the full project is operational.

Stage 2 would include:

- Construction of the Rozelle interchange and Iron Cove Link including:
  - Connections to the stub tunnels at the Inner West subsurface interchange (built during Stage 1)
  - Ancillary infrastructure at the Rozelle West motorway operations complex (MOC2), Rozelle East motorway operations complex (MOC3) and Iron Cove Link motorway operations complex (MOC4)
  - Connections to the surface road network at Lilyfield and Rozelle
  - Construction of tunnels, ramps and associated infrastructure as part of the Rozelle interchange to provide connections to the proposed future Western Harbour Tunnel and Beaches Link project
- Stage 2 works are expected to commence in 2019 with these components of the project open to traffic in 2023.

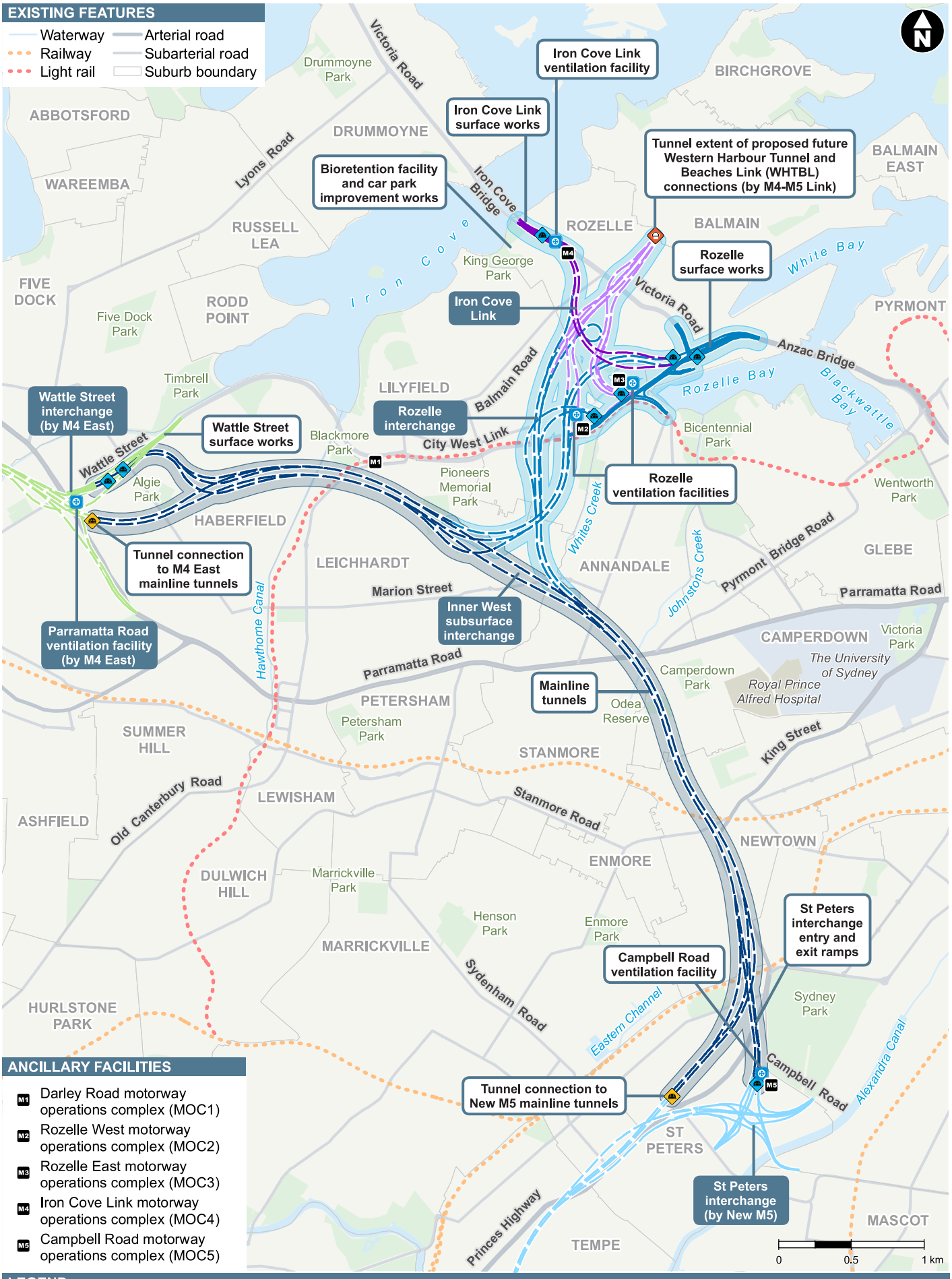


Figure 2-1 Overview of the project

2.3 Construction activities

An overview of the key construction features of the project is shown in **Figure 2-2** and would generally include:

- Enabling and temporary works, including provision of construction power and water supply, ancillary site establishment including establishment of acoustic sheds and construction hoarding, demolition works, property adjustments and public and active transport modifications (if required)
- Construction of the road tunnels, interchanges, intersections and roadside infrastructure
- Haulage of spoil generated during tunnelling and excavation activities
- Fitout of the road tunnels and support infrastructure, including ventilation and emergency response systems
- Construction and fitout of the motorway operations complexes and other ancillary operations buildings
- Realignment, modification or replacement of surface roads, bridges and underpasses
- Implementation of environmental management and pollution control facilities for the project.

A more detailed overview of construction activities is provided in **Table 2-1**.

Table 2-1 Overview of construction activities

Component	Typical activities
Site establishment and enabling works	· Vegetation clearing and removal · Utility works · Traffic management measures · Install safety and environmental controls · Install site fencing and hoarding · Establish temporary noise attenuation measures · Demolish buildings and structures · Carry out site clearing · Heritage salvage or conservation works (if required) · Establish construction ancillary facilities and access · Establish acoustic sheds · Supply utilities (including construction power) to construction facilities · Establish temporary pedestrian and cyclist diversions
Tunnelling	· Construct temporary access tunnels · Excavation of mainline tunnels, entry and exit ramps and associated tunnelled infrastructure and install ground support · Spoil management and haulage · Finishing works in tunnel and provision of permanent tunnel services · Test plant and equipment
Surface earthworks and structures	· Vegetation clearing and removal · Topsoil stripping · Excavate new cut and fill areas · Construct dive and cut-and-cover tunnel structures · Install stabilisation and excavation support (retention systems) such as sheet pile walls, diaphragm walls and secant pile walls (where required) · Construct required retaining structures · Excavate new road levels
Bridge works	· Construct piers and abutments · Construct headstock · Construct bridge deck, slabs and girders · Demolish and remove redundant bridges
Drainage	· Construct new pits and pipes · Construct new groundwater drainage system

Component	Typical activities
	· Connect drainage to existing network · Construct sumps in tunnels as required · Construct water quality basins, constructed wetland and bioretention facility and basin · Construct drainage channels · Construct spill containment basin · Construct onsite detention tanks · Adjustments to existing drainage infrastructure where impacted · Carry out widening and naturalisation of a section of Whites Creek · Demolish and remove redundant drainage
Pavement	· Lay select layers and base · Lay road pavement surfacing · Construct pavement drainage
Operational ancillary facilities	· Install ventilation systems and facilities · Construct water treatment facilities · Construct fire pump rooms and install water tanks · Test and commission plant and equipment · Construct electrical substations to supply permanent power to the project
Finishing works	· Line mark to new road surfaces · Erect directional and other signage and other roadside furniture such as street lighting · Erect toll gantries and other control systems · Construct pedestrian and cycle paths · Carry out earthworks at disturbed areas to establish the finished landform · Carry out landscaping · Closure and backfill of temporary access tunnels (except where these are to be used for inspection and/or maintenance purposes) · Site demobilisation and preparation of the site for a future use

Twelve construction ancillary facilities are described in this EIS (as listed below). To assist in informing the development of a construction methodology that would manage constructability constraints and the need for construction to occur in a safe and efficient manner, while minimising impacts on local communities, the environment, and users of the surrounding road and other transport networks, two possible combinations of construction ancillary facilities at Haberfield and Ashfield have been assessed in this EIS. The construction ancillary facilities that comprise these options have been grouped together in this EIS and are denoted by the suffix a (for Option A) or b (for Option B).

The construction ancillary facilities required to support construction of the project include:

- Construction ancillary facilities at Haberfield (Option A), comprising:
  - Wattle Street civil and tunnel site (C1a)
  - Haberfield civil and tunnel site (C2a)
  - Northcote Street civil site (C3a)
- Construction ancillary facilities at Ashfield and Haberfield (Option B), comprising:
  - Parramatta Road West civil and tunnel site (C1b)
  - Haberfield civil site (C2b)
  - Parramatta Road East civil site (C3b)
- Darley Road civil and tunnel site (C4)
- Rozelle civil and tunnel site (C5)
- The Crescent civil site (C6)
- Victoria Road civil site (C7)

- Iron Cove Link civil site (C8)
- Pyrmont Bridge Road tunnel site (C9)
- Campbell Road civil and tunnel site (C10).

The number, location and layout of construction ancillary facilities would be finalised as part of detailed construction planning during detailed design and would meet the environmental performance outcomes stated in the EIS and the Submissions and Preferred Infrastructure Report and satisfy criteria identified in any relevant conditions of approval.

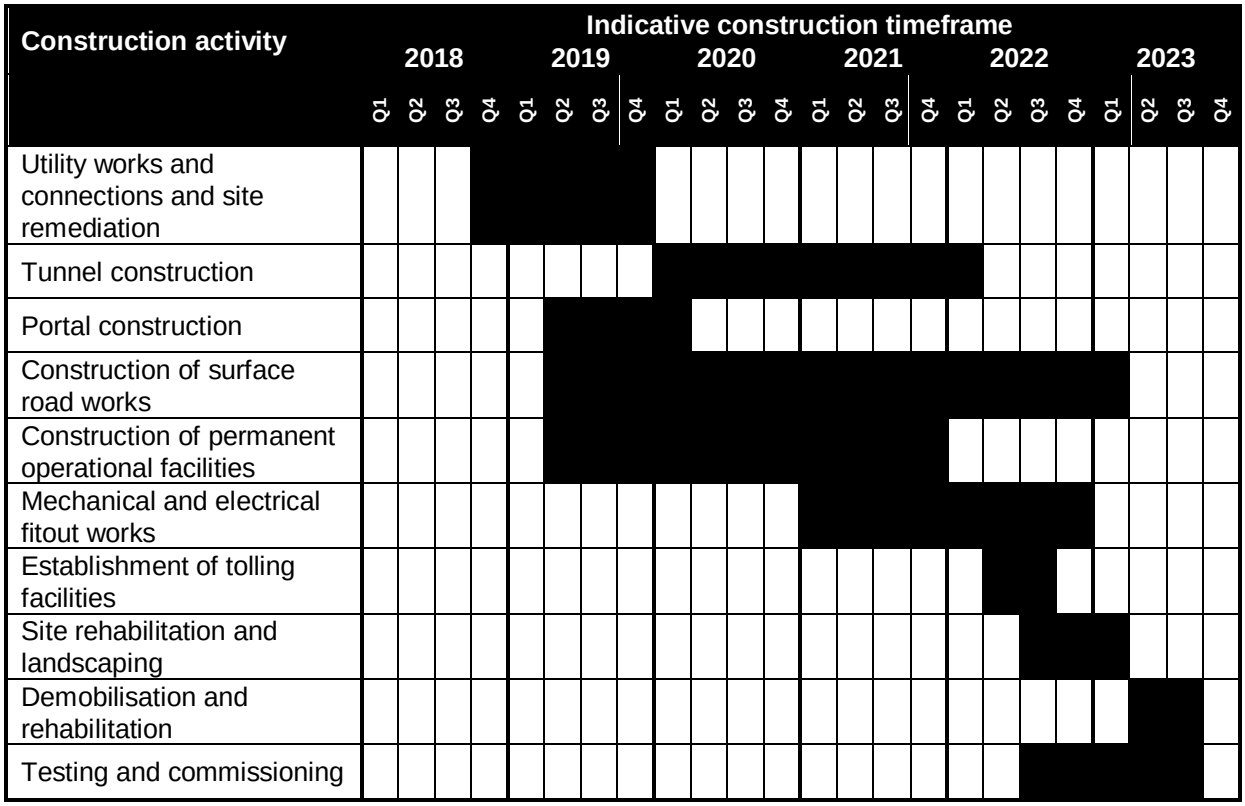
The construction ancillary facilities would be used for a mix of civil surface works, tunnelling support, construction workforce parking and administrative purposes. Wherever possible, construction sites would be co-located with the operational footprint to minimise property acquisition and temporary disruption. The layout and access arrangements for the construction ancillary facilities are based on the concept design only and would be confirmed and refined in response to submissions received during the exhibition of the EIS and during detailed design.

2.3.1 Construction program

The total period of construction works for the project is expected to be around five years, with commissioning occurring concurrently with the final stages of construction. An indicative construction program is shown in **Table 2-2**.

Table 2-2 Indicative construction program

Construction activity	Indicative construction timeframe																							
	2018				2019				2020				2021				2022				2023			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Mainline tunnels																								
Site establishment and establishment of construction ancillary facilities			■	■	■	■	■	■	■	■														
Utility works and connections			■	■	■	■	■																	
Tunnel construction				■	■	■	■	■	■	■	■	■	■											
Portal construction				■	■	■	■	■																
Construction of permanent operational facilities												■	■	■	■	■								
Mechanical and electrical fitout works													■	■	■	■								
Establishment of tolling facilities															■	■								
Site rehabilitation and landscaping																■	■	■	■					
Surface road works																	■	■	■					
Demobilisation and rehabilitation																			■					
Testing and commissioning																■	■	■	■					
Rozelle interchange and Iron Cove Link																								
Site establishment and establishment of construction ancillary facilities				■	■	■	■	■																


Construction activity
Indicative construction timeframe
2018
2019
2020
2021
2022
2023
Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4
Utility works and connections and site remediation
Tunnel construction
Portal construction
Construction of surface road works
Construction of permanent operational facilities
Mechanical and electrical fitout works
Establishment of tolling facilities
Site rehabilitation and landscaping
Demobilisation and rehabilitation
Testing and commissioning

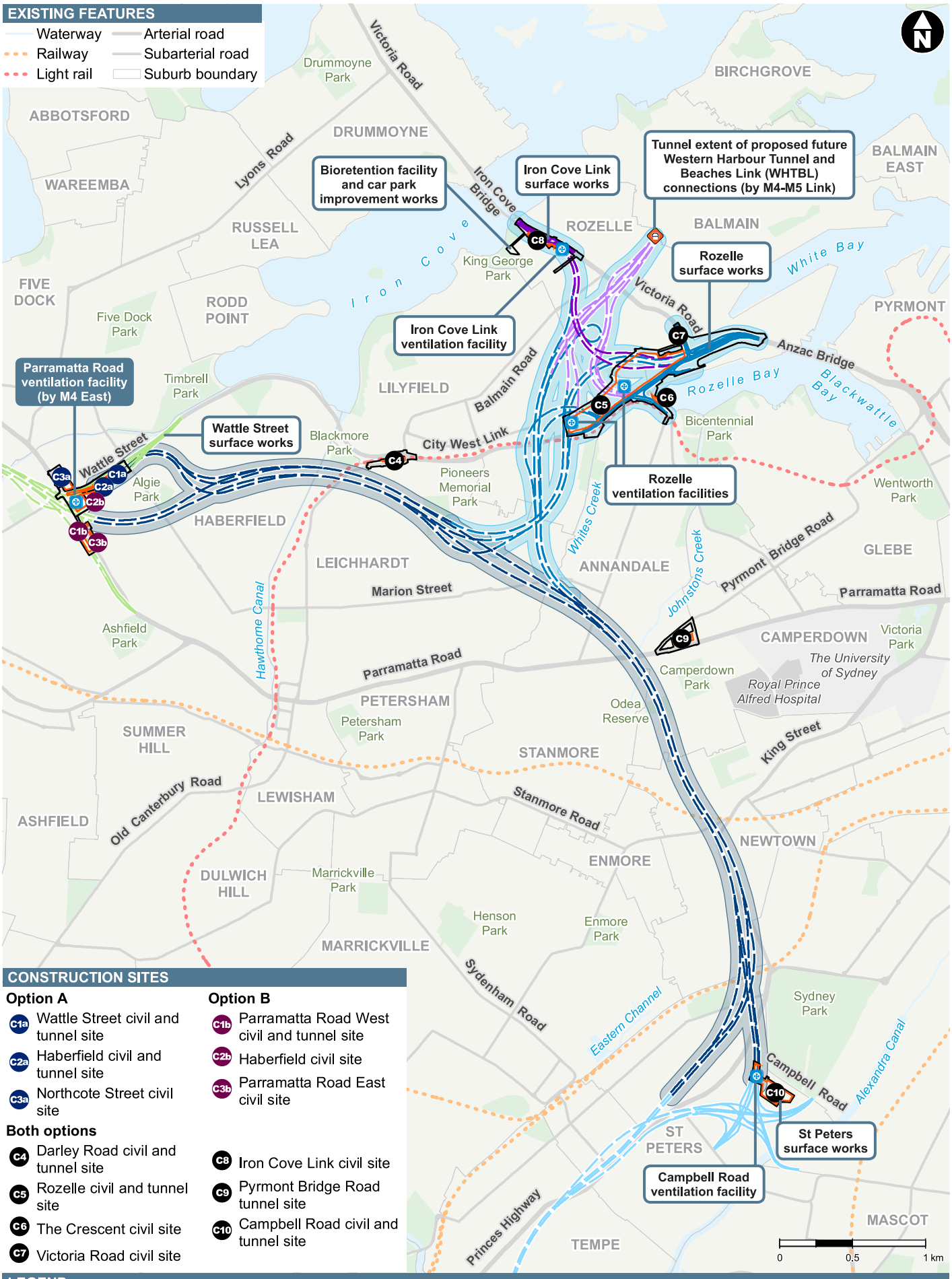


Figure 2-2 Overview of project footprint and ancillary facilities

2.4 Other project specific aspects

This section describes the specific aspects of the project related to surface water and flooding that are proposed in the current design. The potential impacts of the development during the construction and operational phases were considered during the design process and are described in detail in **section 5** and **section 5.4** of this report, additional mitigation measures as well as a recommended water quality monitoring programme to be considered and further developed during the detailed design of the project are described in **section 8**.

2.4.1 Construction

Water use

The total volume of water required during construction of the project is estimated to be around 900 megalitres. The use of non-potable water would be preferred over potable water where possible.

Non-potable water demands include:

- Surface activities such as dust suppression, wheel washing and plant washing
- Underground activities such as road header dust suppression, rock bolting and plant washdown.

Stormwater and other non-potable sources such as treated tunnel groundwater and treated 'dirty' construction water would be reused for non-potable water demands during construction. It is not proposed that surface water would be extracted from the local urban waterways.

The extent to which non-potable water sources can be used would be variable and governed by workplace health and safety considerations, economic feasibility, the functional specifications of the design and the availability and quality of non-potable water.

An estimate of daily stormwater and treated tunnel groundwater usage is provided in **Table 2-3**.

Table 2-3 Indicative stormwater and groundwater daily construction use

Site	Rainwater / stormwater reuse		Treated Groundwater Use	
	Daily (kL/day)	Annual (kL/year)	Daily (kL/day)	Annual (kL/year)
C1a – Wattle Street civil and tunnel site	2	730	250	91250
C2a – Haberfield civil and tunnel site	1	365	0	0
C3a – Northcote Street civil site	0	0	0	0
C1b – Parramatta Road West civil and tunnel site	2	730	250	91250
C2b – Haberfield civil site	1	365	0	0
C3b – Parramatta Road East civil site	1	365	0	0
C4 – Darley Road civil and tunnel site	1	365	50	18250
C5 – Rozelle civil and tunnel site	3	1095	370	135050
C6 – The Crescent civil site	1	365	0	0
C7 – Victoria Road civil site	1	365	0	0
C8 – Iron Cove civil site	1	365	50	18250
C9 – Pyrmont Bridge Road tunnel site	1	730	25	9125
C10 – Campbell Road civil and tunnel site	1	365	100	36500

Construction wastewater management

Construction wastewater (including stormwater, groundwater and construction water) would be generated from all temporary construction ancillary facilities (see **section 2.4.1**) with the exception of the Northcote Street civil site which would be used for parking and construction support only.

Civil construction sites such as Victoria Road would incorporate contoured embankments and surface drains to channel water to sedimentation basins for treatment and reuse on site, for dust suppression and wheel washes, for example.

The total volume of wastewater generated during construction would vary according to construction activities taking place, the amount of groundwater infiltrating into the tunnel, and the length of the tunnel that has been excavated. Indicative daily volumes of wastewater at each site and associated indicative discharge points are shown in **Table 2-4**.

Table 2-4 Indicative construction wastewater volumes and discharge points

Site	Daily discharge (kL/day)	Discharge points
C1a – Wattle Street civil and tunnel site	Managed by Haberfield civil and tunnel site	Managed by Haberfield civil and tunnel site
C2a – Haberfield civil and tunnel site	1200	Discharging to a stormwater pipe under Parramatta Road that connects to Dobroyd Canal
C3a – Northcote Street civil site	Managed by Haberfield civil and tunnel site	Managed by Haberfield civil and tunnel site
C1b – Parramatta Road West civil and tunnel site	1200	Discharging to a stormwater pipe under Parramatta Road that connects to Dobroyd Canal
C2b – Haberfield civil site	Managed by Parramatta Road West civil and tunnel site	Discharging to a stormwater pipe under Parramatta Road that connects to Dobroyd Canal
C3b – Parramatta Road East civil site	Managed by Parramatta Road West civil and tunnel site	Discharging to a stormwater pipe under Parramatta Road that connects to Dobroyd Canal
C4 – Darley Road civil and tunnel site	700	Existing drainage system draining to Hawthorne Canal
C5 – Rozelle civil and tunnel site	2400	Existing drainage system at City West Link draining to Rozelle Bay Easton Park drain discharging to Rozelle Bay
C6 – The Crescent civil site	10	Existing drainage system at City West Link draining to Rozelle Bay
C7 – Victoria Road civil site	200	Existing drainage system at Victoria Road draining to White Bay
C8 – Iron Cove civil site	300	Existing drainage system at Victoria Road draining to Iron Cove
C9 – Pyrmont Bridge Road tunnel site	1200	Discharging to a stormwater pipe under Parramatta Road which discharges to Johnstons Creek
C10 – Campbell Road civil and tunnel site	1200	Discharging to a stormwater pipe that connects into Alexandra Canal

Spoil management

Spoil stockpiles would be contained by roller doors between the cut and cover ramps and tunnel section at Wattle Street, and within acoustic sheds at all other temporary construction ancillary facilities where spoil would be stockpiled (including Haberfield, Darley Road, Rozelle, Pyrmont Bridge Road and Campbell Road). The roller doors/acoustic sheds would minimise potential for transport of spoil sediments by both wind and rain.

Flood risk

The indicative layouts of the temporary construction ancillary facilities have taken into consideration the flood risk posed to the land. This includes identifying opportunities to provide set-back from areas at risk of flooding or considering locating uses considered more vulnerable to flooding, such as stockpile areas, storage of chemicals, tunnel dives and deep excavations, away from areas of highest risk, where feasible.

2.4.2 Operation

Portal drainage

Tunnel portals would be designed to ensure immunity from the greater of the PMF or 100 year average recurrence interval (ARI) event plus 0.5 metres freeboard. Where the portals lie within the PMF extent, this would be achieved by appropriate flood protection measures.

Where open surface roadways grade toward portal openings, the pavement drainage system at tunnel entrances would be sized to capture and drain runoff generated by the local catchment in events up to the PMF.

Surface roadway drainage, gravity outfalls and treatment

Surface roads would be drained by gravity to appropriate discharge locations. This may be in the form of an outfall discharge or a connection to an existing drainage network. Some form of stormwater treatment would be provided prior to discharge/connection where feasible and practicable.

Due to the constrained or heavily urbanised nature of the interface between the project works and surrounding areas there may not be opportunity to install treatment devices within individual surface catchments. In these highly constrained areas good practice treatment techniques such as inline pollution control measures would be deployed where feasible and practical. However, consideration would also be given to other Water Sensitive Urban Design (WSUD) measures such as wetlands, swales and bioretention where feasible including the proposed constructed wetland and bioretention systems at Rozelle and the proposed bioretention basin located within King George Park. The design of such stormwater quality treatment measures would be undertaken and finalised during detailed design. The stormwater quality objectives are presented in **section 3.2.11** and a preliminary assessment of the types of stormwater treatment devices which could potentially be implemented and their performance is provided in **section 6.3**. The proposed drainage and treatment facilities are shown in **Figure 2-3** to **Figure 2-5**. Indicative operational stormwater discharge locations are provided in **Figure 2-6**.

Tunnel drainage and treatment

Tunnel drainage infrastructure would be designed to accommodate a combination of water ingress events including groundwater ingress, stormwater ingress at portals, tunnel wash-down water, fire suppressant deluge or fire main rupture and spillage of flammable and other hazardous materials. Separate sumps would be provided at tunnel sags, one to collect groundwater ingress and one to collect the other potential water sources. During operation, the two tunnel drainage streams from the mainline would either be pumped via rising mains to a water treatment plant at Darley Road in Leichhardt with treated flows ultimately discharged to Hawthorne Canal.

During operation, tunnel drainage for Rozelle would be pumped to an operational water treatment plant at Rozelle interchange, with treated flows ultimately being discharged to Rozelle Bay.

Tunnel drainage from about one kilometre of the northbound and 600 metres southbound tunnel would be captured by the New M5 drainage system and conveyed to the New M5 operational water treatment plant at Arncliffe which ultimately drains to the Cooks River.

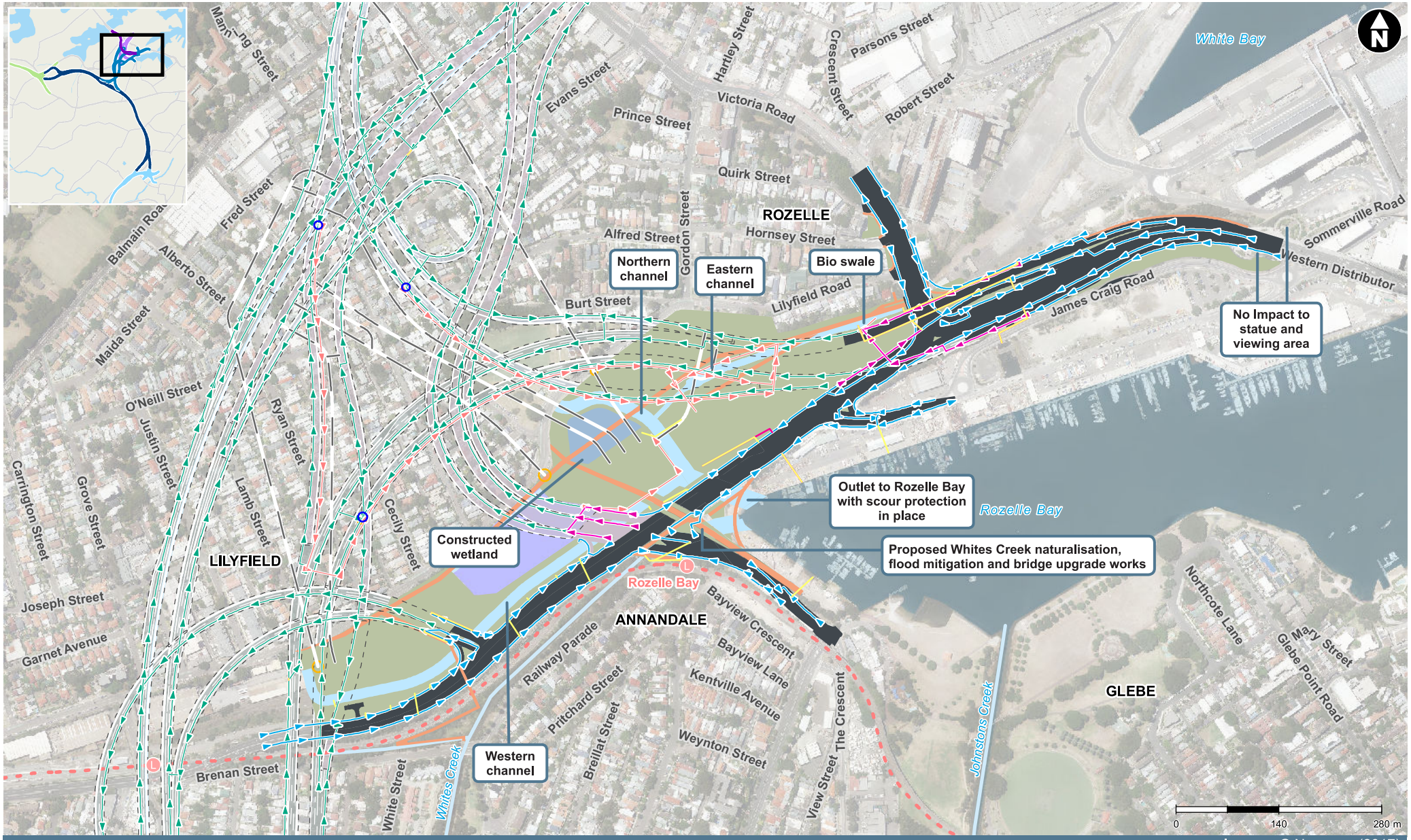
The tunnels are designed to restrict groundwater inflow to below one litre per second per kilometre. Therefore, groundwater inflow is expected to be up to around 23 litres per second for the mainline tunnel and 22 litres per second for the Rozelle tunnels. The second drainage system would incorporate pumping infrastructure to pump out other potential water ingress sources as listed previously, via rising mains, at a rate of around five to 30 litres per second to enable sumps to be emptied in around one day.

The two tunnel drainage streams are expected to produce flows containing a variety of different pollutants that require some form of treatment before discharge. The level of treatment to be provided by each plant would need to reflect the groundwater conditions, which would be informed by knowledge of adjoining tunnel projects (M4 East and New M5) and the M4-M5 Link groundwater monitoring. Groundwater conditions are discussed in **section 4.11**. The proposed operational water treatment plant discharge criteria are provided in **section 8.2**. The design of the operational water treatment plant would be developed and finalised during detailed design. A review and multi-criteria analysis of the various treatment options is provided within **Annexure H**. The review indicates that when considering a range of factors, primary sedimentation is likely to be the most appropriate groundwater treatment process. This option reflects the accepted groundwater treatment process strategies for other transport and power tunnel infrastructure in Sydney.

Treated flows from the Rozelle water treatment plant would be discharged to a constructed wetland within the Rozelle Rail Yards. This would afford some 'polishing' of the effluent, helping to remove a proportion of the residual dissolved constituents such as nitrogen and phosphorus not removed by the operational water treatment plant. Indicative operational water treatment plant discharge points are provided in **Figure 2-6**.

Flood risk

The layout of the operational sites has taken into consideration the flood risk posed to the sites and how to manage these risks, as appropriate, in accordance with relevant standards and guidelines. This has meant that mitigation measures are already included as part of the project as a consequence of the evolution of the concept and reference design.



LEGEND

Existing features
- Waterway
- Light rail

M4-M5 Link surface works
- Surface road
- Shared path
- Land subject to UDLP
- Drainage channel
- Constructed wetland
- Proposed future WHTBL construction area

M4-M5 Link tunnels
- Proposed future WHTBL (civil construction only)
- Rozelle interchange tunnel
- Iron Cove Link tunnel

Drainage
- Rising main
- Surface drainage path
- Portal drainage path
- Tunnel drainage path
- Sump
- Ventilation tunnel drainage path

Figure 2-3 Rozelle Rail Yards drainage schematic

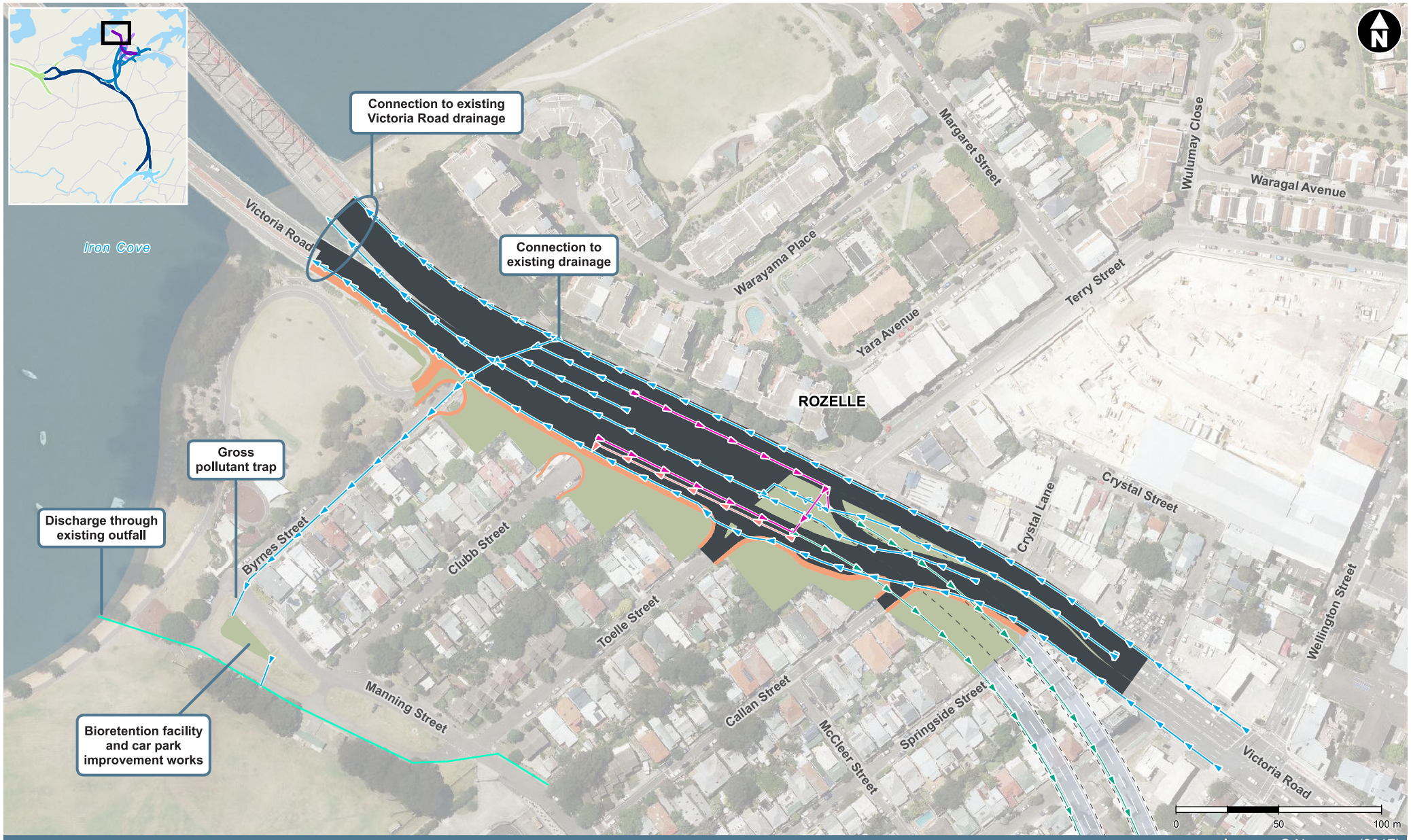


Figure 2-4 Iron Cove Link drainage schematic

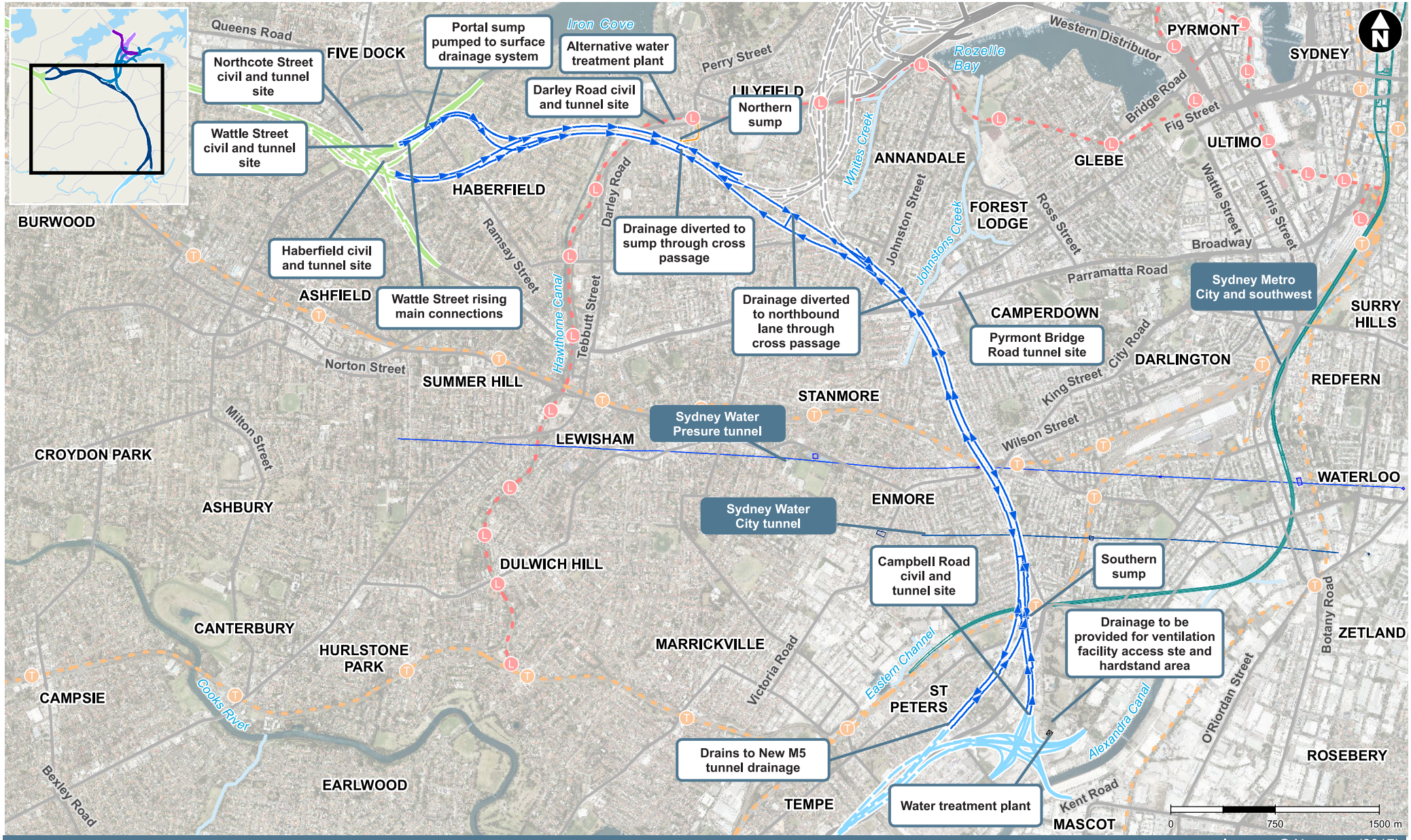


Figure 2-5 Mainline tunnel works drainage schematic

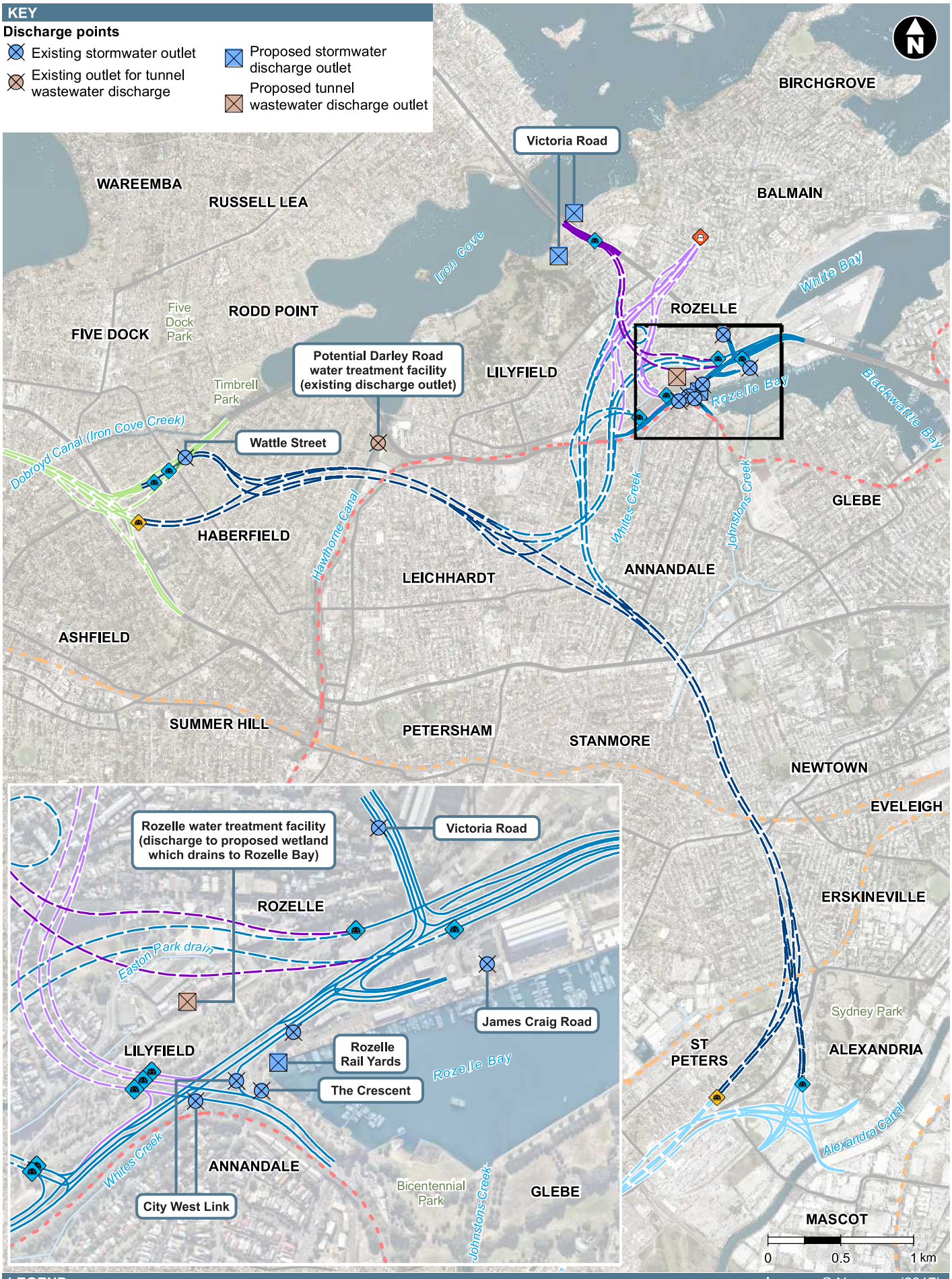


Figure 2-6 Indicative operational discharge points

3 Assessment methodology

3.1 Relevant legislation

3.1.1 Water Act 1912 (NSW) and Water Management Act 2000 (NSW)

The *Water Act 1912* (NSW) and the *Water Management Act 2000* (NSW) (WM Act) are the two key pieces of legislation for the management of water in NSW and contain provisions for the licensing of water capture and use. The *Water Act 1912* (NSW) is being progressively phased out and replaced by the WM Act but some provisions are still in force. The *Water Management Amendment Act 2014* (NSW) amends the WM Act in relation to planning, licensing and compliance aspects.

The objective of the WM Act is the sustainable and integrated management of the state's water for the benefit of both present and future generations. The WM Act recognises the need to allocate and provide water for the environmental health of our rivers and groundwater systems, while also providing licence holders with more secure access to water and greater opportunities to trade water through the separation of water licences from land. The main tool the WM Act provides for managing the state's water resources are water sharing plans. These are used to set out the rules for the sharing of water in a particular water source between water users and the environment and rules for the trading of water in a particular water source. See **section 4.1** for details of human and environmental values/uses of the waterways.

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). Rules relevant for the waterways within the study area, which includes the hydrological catchment of Parramatta River up to the mangrove limit and hydrological catchment of the Cooks River and Botany Bay up to the mangrove limit are listed in **Table 3-1**.

Water access licences (WALs) entitle licence holders to specified shares in the available water within a particular water management area or water source and to take water at specified times, rates or circumstances from specified areas or locations. However, the project does not propose to extract any surface water from local urban waterways. Therefore, Water Sharing Plan rules as documented below do not apply.

In any case, 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.

In response to the SEARs, DPI stated that *'while Roads and Maritime is currently exempt from requiring a licence for this water during construction, arrangements for the licensing requirements are currently being finalised between Roads and Maritime and DPI Water*'.

Table 3-1 Water Sharing Plan rules

Rules	Lower Parramatta River management zone[1]	Cooks River and Botany Bay management zone[2]
Access rules		
Environmental Flow Protection Rule	Pumping is not permitted when there is no visible flow at the pump site	Pumping is not permitted when there is no visible flow at the pump site
Trading rules		
INTO management zone	Trading into the zone is not permitted if the trade will increase the total licensed entitlement of the zone	Not permitted
WITHIN management zone	Permitted subject to assessment	Permitted subject to assessment
Conversion to High Flow Access licence	Not permitted	Not permitted

Notes:

[1] Includes the hydrological catchment of Parramatta River to the mangrove limit excluding the Upper Parramatta River Management Zone.

[2] Includes the hydrological catchment of Cooks River and Botany Bay up to the mangrove limit excluding the Georges River Management Zone.

3.1.2 Other legislation

Other legislation that applies to the project that is relevant to this report includes:

- EP&A Act
- *Protection of the Environment Operations Act 1997* (NSW) (POEO Act)
- *Fisheries Management Act 1994* (NSW) (FM Act)
- Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005.

3.2 Relevant guidelines and policies

3.2.1 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 (baseflow) water quality of watercourses in proximity to the project as discussed in **section 4.1**.

3.2.2 NSW Water Quality and River Flow Objectives

The *NSW Water Quality and River Flow Objectives* (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 Water Quality and River Flow Objectives have been developed for the CRC and SHPRC. The receiving waterway classification for waterways in the study area in accordance with DECCW (2006) is provided in **Table 3-2**. The water quality and river flow objectives that were determined are shown in **Table 3-3**. The associated water quality indicators and criteria as detailed in DECCW (2006) are provided within **Annexure G**.

Table 3-2 Receiving waterway catchment and classification

Receiving waterway within study area	Catchment	Classification of waterway with respect to NSW Water Quality and River Flow Objectives
Dobroyd Canal	SHPRC	Waterways affected by urban development
Hawthorne Canal	SHPRC	Waterways affected by urban development
Whites Creek	SHPRC	Waterways affected by urban development
Easton Park drain	SHPRC	Waterways affected by urban development
Johnstons Creek	SHPRC	Waterways affected by urban development
Alexandra Canal	CRC	Partially Waterways affected by urban development and partially Estuaries
Rozelle Bay	SHPRC	Lower Estuary
Iron Cove	SHPRC	Upper Estuary

Table 3-3 NSW water quality and river flow objectives relevant to project

Objective	Applicable catchments / waterway	Where covered in this report
Water quality objectives		
Protect aquatic ecosystems	Waterways affected by urban development in SHPRC Upper estuary in SHPRC Lower estuary in SHPRC Estuaries in CRC	**Sections 2.4** and **8.2**.
Protect visual amenity	Waterways affected by urban development in SHPRC Upper estuary in SHPRC Lower estuary in SHPRC Estuaries in CRC	**Sections 2.4** and **8.2**
Protect secondary contact recreation	Waterways affected by urban development in SHPRC Upper estuary in SHPRC	**Sections 2.4** and **8.2**

Objective	Applicable catchments / waterway	Where covered in this report
	Lower estuary in SHPRC Estuaries in CRC – for achievement within 5 years	
Protect primary contact recreation	Waterways affected by urban development in SHPRC – for achievement in 10 years or more Upper estuary in SHPRC Lower estuary in SHPRC Estuaries in CRC – for achievement in 10 years or more	**Sections 2.4** and **8.2**
Aquatic foods (to be cooked before eating)	Upper estuary in SHPRC Lower estuary in SHPRC Estuaries in CRC – for achievement in 5 to 10 years	**Sections 2.4** and **8.2**.
River flow objectives		
Protect pools in dry times	Urban waterways in SHPRC	Not Applicable – limited application to catchment or hard lined waterways and no surface water extraction from waterways or natural wetlands is proposed. See **section 4.2** for details.
Protect natural low flows	Urban waterways in SHPRC	Not Applicable – all urban waterways in study area are hard lined with limited habitat. See **section 4.2** for details.
Protect important rises in water levels	Estuaries in CRC	See **sections 5.2, 6.2** and **8.1**.
Maintain wetland and floodplain inundation	Waterways affected by urban development in SHPRC Upper estuary in SHPRC Lower estuary in SHPRC	See **sections 5.2, 6.2** and **8.1**.
Mimic natural drying in temporary waterways	Waterways affected by urban development in SHPRC	Not Applicable - urban waterways in study area are hard lined with limited habitat. See **section 4.2** for details.
Maintain natural flow variability	Waterways affected by urban development in SHPRC Estuaries in CRC	**Sections 4.2** and **5.2.2**.
Maintain natural rates of change in water levels	Waterways affected by urban development in SHPRC Estuaries in CRC	**Sections 5.2, 6.2** and **sections 2.4** and **8.2**.
Manage groundwater for ecosystems	Upper estuary in SHPRC	Refer to **Appendix T** (Technical working paper: Groundwater) of the EIS.
Minimise effects of weirs and other structures	Waterways affected by urban development in SHPRC Upper estuary in SHPRC Lower estuary in SHPRC Estuaries in CRC	Not Applicable - no weirs or fish barriers are proposed as part of the project.
Maintain or	Upper estuary in SHPRC	**Section 8.2**.

Objective	Applicable catchments / waterway	Where covered in this report
rehabilitate estuarine processes and habitats	Lower estuary in SHPRC Estuaries in CRC	

3.2.3 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).

3.2.4 Sydney Harbour Water Quality Improvement Plan

The *Sydney Harbour Water Quality Improvement Plan* (Greater Sydney Local Land Services 2015) (SHWQIP) was developed by Greater Sydney Local Land Services, NSW OEH and Local Government in coordination with a range of stakeholders. The SHWQIP provides a coordinated management framework for the local councils, state government agencies and federal government agencies that have a stake in improving the future health of Sydney Harbour and its catchments. This plan applies to the greater portion of the study area which ultimately drains to Sydney Harbour.

The main objective of the SHWQIP '*is to identify threats to water quality in the Harbour and its tributaries and to set targets for pollutant load reductions (in terms of total nitrogen, total phosphorus, suspended sediment and pathogens) required to protect the condition and values of the Sydney Harbour, its tributaries, estuaries and waterways. The WQIP is designed to give focus and direction to water quality policy development and on-ground implementation throughout the Sydney Harbour catchment'.*

While the SHWQIP does not include pollutant reduction targets for individual developments, catchment load and estuary condition targets have been developed for sub-catchments and LGAs using feasible scenario options for both the management of stormwater and improvements in sewer outflow performance. These targets are based on the following scenario including assumptions of feasible change/actions:

- WSUD incorporated into 70 per cent of infill developments
- WSUD retrofitted into 10 per cent of existing urban areas
- Improving sewer overflow performance to limit overflows to no more than 40 events in 10 years.

The targets are designed to provide direction to change rather than being prescriptive of the exact management actions that should be undertaken to achieve these goals. It is acknowledged that different scenarios to that assumed above could also achieve the targets. The targets for the City of Sydney LGA and the former LGAs of Leichhardt, Ashfield and Marrickville are outlined in **Table 3-4**. Targets for some of the Sydney Harbour sub-catchments within the study area are provided in **Table 3-5**. No targets are available for Rozelle Bay.

Table 3-4 Load targets by LGA based on 70% WSUD to infill redevelopment, 10% retrofit to existing urban areas and capping sewer overflows to no more than 40 in 10 years

Stormwater pollutant	LGA reduction target			
	Leichhardt	Sydney	Ashfield	Marrickville
Total suspended solids (TSS)	21%	35%	24%	15%
Total phosphorus (TP)	17%	28%	20%	13%
Total Nitrogen (TN)	12%	19%	13%	9%
Enterococci	18%	30%	21%	14%
Faecal coliforms	20%	34%	23%	15%

Table 3-5 Load targets by sub-catchment based on 70% WSUD to infill redevelopment, 10% retrofit to existing urban areas and capping sewer overflows to no more than 40 in 10 years

Stormwater pollutant	LGA reduction target				
	Dobroyd Canal	Hawthorne Canal	Whites Creek	Johnstons Creek	Iron Cove
Total suspended solids (TSS)	26%	22%	29%	14%	11%
Total phosphorus (TP)	21%	18%	24%	12%	9%
Total Nitrogen (TN)	15%	12%	16%	8%	6%
Enterococci	24%	20%	26%	12%	10%
Faecal coliforms	25%	21%	27%	13%	11%

As the targets are based on LGA or sub-catchment scale management actions, they are not considered appropriate for use in terms of the project's stormwater treatment design. However, the proposed incorporation of stormwater treatment measures within the project's drainage network is considered to be consistent with the principles of the SHWQIP (ie implementing WSUD / stormwater treatment measures within infill development/existing urban areas).

3.2.5 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) is a contemporary plan designed specifically for the catchment of Botany Bay. The CRC is a sub-catchment of the larger Botany Bay catchment hence this plan applies to parts of the study area near to the St Peters interchange that are within the Alexandra Canal catchment and drain to the Cooks River.

The main objective of the *Botany Bay and Catchment Water Quality Improvement Plan* (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 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. A primary objective of the BBWQIP is to establish stormwater pollution reduction targets for all new development and re-development within the Botany Bay catchment to protect the condition of the bay, its estuaries and waterways. These pollutant reduction targets are shown in **Table 3-6**.

Table 3-6 Stormwater reduction targets recommended for urban development in the Botany Bay catchments

Stormwater pollutant	Reduction target	
	Greenfield developments Large re-developments	Multi-unit dwellings, commercial and industrial developments, small re-developments
Gross pollutants	90%	90%
TSS	85%	80%
TP	60%	55%
TN	45%	40%

3.2.6 Floodplain Development Manual

The *Floodplain Development Manual* (NSW Government 2005) incorporates the NSW Government's Flood Prone Land Policy, the primary objectives of which are to reduce the impact of flooding and flood liability on owners and occupiers of flood prone property. Additionally, it is also intended to reduce public and private losses resulting from floods, whilst also recognising the benefits of use, occupation and development of flood prone land.

The *Floodplain Development Manual* forms the NSW Government's primary technical guidance for the development of sustainable strategies to support human occupation and use of the floodplain. It also promotes strategic consideration of key issues including safety to people, management of potential damage to property and infrastructure, and management of cumulative development impacts. Importantly, the *Floodplain Development Manual* promotes the concept that proposed developments be treated on their merit rather than through the imposition of rigid and prescriptive criteria. This means that each project needs to be assessed on a case by case basis and that there is no single solution or standard that should be applied to all projects. The overall benefits and impacts of a project should be taken into consideration when development is proposed in flood affected areas.

3.2.7 Planning directions and guidelines on flooding

In January 2007 the NSW Department of Planning issued Planning circular PS 07-003 *New guideline and changes to section 117 direction and Environmental Planning and Assessment Regulation on flood prone land*. This provided an overview of its new guideline to the *Floodplain Development Manual* and provided advice on a package of changes concerning flood-related development controls for residential development on land above the 100 year ARI flood and up to the PMF.

The *Guideline on Development Controls on Low Flood Risk Areas* confirmed that unless there are exceptional circumstances, councils should adopt the 100 year ARI flood as the basis for deriving the Flood Planning Level (FPL) for residential development. In proposing a case for exceptional circumstances, a council would need to demonstrate that a different flood planning levels was required for the management of residential development due to local flood behaviour, flood history, associated flood hazards or a particular historic flood. The guideline also notes that, unless there are exceptional circumstances, councils should not impose flood related development controls on residential development on land above the residential FPL (low flood risk areas). However, the guideline does acknowledge that controls may need to apply to critical infrastructure and consideration be given to evacuation routes and vulnerable developments in areas above the 100 year ARI flood. This has been taken into consideration when setting the hydrologic standards for various items of the project infrastructure as set out in **section 3.4.4**.

In July 2007 the NSW Minister for Planning issued a list of directions to local councils under section 117(2) of the EP&A Act Direction 4.3 – Flood Prone Land applies to all councils that contain flood prone land within their LGA.

The assessment of the potential impacts that the project would have on existing flood risk and also the future development potential of flood affected land outside the project footprint is shown in **sections 5.2** and **6.2**. The assessment includes the impacts of storms with ARI's up to

100 years in the case of residential type development (and by default commercial and industrial type development) and storm ARI's greater than 100 years in the case of critical infrastructure (such as hospitals) and vulnerable developments (such as aged care facilities).

3.2.8 Floodplain Risk Management Guideline – Practical Considerations of Climate Change

The *Floodplain Risk Management Guideline – Practical Consideration of Climate Change* (DECC 2007) was prepared to assist Councils in the preparation and implementation of their Floodplain Risk Management (FRM) plans.

The guideline recommends that sensitivity analyses should be undertaken based on increased rainfall intensities of between 10 and 30 per cent. Under present day climatic conditions, increasing the 100 year ARI design rainfall intensities by 10 per cent would produce about a 200 year ARI flood; and increasing those rainfalls by 30 per cent would produce about a 500 year ARI flood. On current projections, the increase in rainfall within the design life of the project is likely to be around 10 per cent, with the higher value of 30 per cent representing an upper limit. Given that finished road levels for the project generally lie above the upper envelope of 100 year ARI flooding, the impact on flood behaviour of a 10 per cent increase in 100 year ARI design rainfall intensities was assessed as part of this investigation.

Many of the watercourses within the study area are tidally influenced, therefore climate change in terms of potential sea level rise is a relevant consideration. Climate change is expected to impact sea levels and rainfall intensities, both of which may have significant influence on flood behaviour at specific locations. DECC 2007 states that the Intergovernmental Panel on Climate Change (IPCC) 2007 trends indicate that average global sea level rise (not including ice flow melt) may be between 0.18 to 0.59 metres by between 2090 and 2100. Adding to this, the ice flow melt uncertainty of up to 0.2 metres gives an adjusted global range of 0.18 to 0.79 metres. IPCC 2007 and recent CSIRO modelling indicate that mean sea levels along the NSW coast are expected to rise by more than the global mean. Combining the relevant global and local information indicates that sea level rise on the NSW coast is expected to be in the range of 0.18 to 0.91 metres by between 2090 and 2100 (DECC 2007).

In 2009 the NSW Government released its *Sea Level Rise Policy Statement* (NSW Government, 2009) which supported adaptation to projected sea level rise impacts. The policy statement included sea level rise planning benchmarks for use in assessing potential impacts of projected sea level rise in coastal areas, including flood risk and coastal hazard assessment. These benchmarks were a projected rise in sea level (relative to 1990 mean sea level) of 0.4 metres by 2050 and 0.9 metres by 2100, based on work carried out by the Intergovernmental Panel on Climate Change and CSIRO. In its *Flood Risk Management Guide: Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments* (DECCW 2010), the NSW Government recommended that these benchmark rises should be used to assess the sensitivity of flood behaviour to future sea level rise.

In 2012 the NSW Government announced its Stage 1 Coastal Management Reforms (NSW Government 2012). As part of these reforms, the NSW Government no longer recommends state-wide sea level rise benchmarks, with local councils now having the flexibility to consider local conditions when determining local future hazards.

In the absence of a formal State Government policy on sea level rise benchmarks, the previously recommended rises in sea level of 0.4 metres by 2050 and 0.9 metres by 2100 have been adopted for assessing the impact future climate change could have on flooding conditions in the vicinity of the project. The key findings of the assessment are set out in **section 6.2**.

3.2.9 Local council requirements for flooding

The majority of the project and its surface operational features are located in the Inner West Council LGA (formerly Ashfield, Leichhardt and Marrickville Councils) with a small length of sub-surface tunnel encroaching into the City of Sydney LGA.

The Local Environment Plans for each of the Councils state that the FPL for residential development is in all cases equal to the peak 100 year ARI flood level plus 0.5 metres freeboard for properties

subject to mainstream flooding. The approach is consistent with the NSW Government's Guideline on Development Controls on Low Flood Risk Areas.

The Development Control Plans that support the Local Environment Plans identify that some of the surface features of the project are located within areas designated as Flood Control Lots, which are areas that have been identified as having the potential to be flood affected. The Rozelle interchange, Darley Road civil and tunnel site and Pyrmont Bridge tunnel site are identified as Flood Control Lots.

The Inner West Council is currently working toward formation of a Floodplain Risk Management Committee for the new Council. This would address management of the hazards associated with flooding and mitigation of the amount of flooding at or through properties. The Plan would address flood management issues within the former Leichhardt LGA as identified in the *Leichhardt Flood Study* (Cardno 2014). In the absence of a floodplain risk management plan, the assessment of flood behaviour (existing and future) has therefore been based on the flood study.

3.2.10 Other policies and guidelines

Other polices and guidelines that apply to the project include:

- *NSW State Rivers and Estuaries Policy* (NSW Water Resources Council1993)
- *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 (Institute of Engineers Australia 2001; AR&R)
- Australian Runoff Quality (Institute of Engineers Australia 2006; ARQ)
- *Guideline on Development Controls on Low Flood Risk Areas* (NSW Government 2007)
- The Estimation of Probable Maximum Precipitation in Australia: Generalised Short- Duration Method (Bureau of Meteorology (BoM 2003)
- Derivation of the NSW Government's Sea Level Rise Planning Benchmarks. Technical Note (DECCW 2009)
- *Coastal Planning Guideline – Adapting to Sea Level Rise* (NSW Department of Planning 2010)
- *Coastal Risk Management Guideline – Incorporating Sea Level Rise Benchmarks in Coastal Risk Assessments* (NSW Department of Planning 2010)
- *Flood Risk Management Guide: Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments* (DECCW 2010).

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)
- *Draft Technical Guide for Climate Change Adaptation for the State Road Network* (Roads and Maritime 2016).

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).

3.2.11 Project stormwater quality objectives

The stormwater treatment design will be developed with consideration to the SHPRC water quality objectives (DECCW 2006) which are primarily aimed at maintaining or improving water quality within Sydney Harbour and the Parramatta River estuary. There are no M4-M5 Link treatment facilities proposed within catchments draining to the Cooks River.

To facilitate this objective, the stormwater treatment design for the project is will adopt the following mean annual pollutant load reduction targets where practical and space is available:

- 85 per cent reduction in the mean annual load of Total Suspended Solids (TSS)
- 65 per cent reduction in the mean annual load of Total Phosphorous (TP)
- 45 per cent reduction in the mean annual load of Total Nitrogen (TN)
- 90 per cent reduction in the mean annual load of Gross Pollutants >5 millimetres (GP).

In some instances, due to the highly constrained urban environment, there may not be opportunity to install treatment devices within individual surface catchments and achieve the pollutant load reduction targets. In these highly constrained areas good practice treatment techniques would be deployed where feasible and practical.

3.3 Key assumptions

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

- In order to undertake stormwater quality Model for Urban Stormwater Improvement Conceptualisation (MUSIC) modelling, assumptions were made with regards to the size of catchments and the size, type and location of permanent water quality treatment devices as detailed in **section 3.4.3**
- Groundwater inflows to the tunnel drainage system were assumed to be similar quality to that previously documented within the New M5 and M4 East EIS documents due to the similar geology and land use traversed by the project. Where elevated levels of other parameters have been identified in the groundwater sampling program undertaken to date for the project, these have also been considered in the assessment.

3.4 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, characterise the existing environment and identify potential issues

- A field assessment 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 flooding, drainage, hydrology, geomorphology, water supply and water quality
- Identifying appropriate measures to mitigate potential impacts.

3.4.1 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. This included previous flooding and surface water studies that have been used to inform the EIS undertaken for the M4 East and New M5 projects
- Other Technical Working Papers included in this EIS, including those relating to groundwater, contamination and biodiversity.

Data collection

Information on the existing environmental conditions within the study area has been collected from the following sources:

- Inner West Council (formerly Leichhardt, Ashfield, Marrickville) and City of Sydney Council
- Roads and Maritime, SMC, UrbanGrowth NSW, Sydney Water Corporation and Transport for NSW (CBD and South East Light Rail).

Review of previous studies

A number of previous studies into various aspects of surface water and flooding in the study area have been reviewed as listed in **Table 3-7**.

Table 3-7 Previous studies

Relevance	Reference
Surface water, flooding and drainage	Whites Creek Catchment Management Study (Sydney Water 1990)
	Johnstons Creek SWC55 Capacity Assessment (Sydney Water 1995)
	Hawthorne Canal Flood Study, Final Draft (Ashfield and Marrickville Councils 2013a, WMAwater)
	Dobroyd Canal Flood Study, Final Draft (Ashfield and Burwood Councils 2013b, WMAwater)
	Johnstons Creek Catchment Flood Study (City of Sydney Council 2015, WMAwater)
	Leichhardt Flood Study (Leichhardt Council 2014, Cardno)
	Alexandra Canal Catchment Flood Study (City of Sydney Council 2014, Cardno)
	M4 East EIS, Appendix Q, Surface Water: Flooding and Drainage (Lyall and Associates 2015a)
	New M5 Environmental Impact Statement, Appendix P, Technical Working paper: Flooding (Lyall and Associates 2015b)
	St Peters Interchange and Local Road Upgrades Flood Modelling, Hydrology Model Development Report, Substantial Detailed Design, Rev D, Doc No. M5N-AJV-TER-100-114-HY-1499, 24/06/2016 (CPB Contractors, Dragados, Samsung Joint Venture (CDS) 2016a)
	St Peters Interchange and Local Road Upgrades Drainage Drawings set, M5N-AJV-DWG-900-300-DR Final Design, M5N-AJV-DWG-700-300-DR (FD) (CDS 2016b)
	M4 East - Design and Construct, Technical Report – Hydrology and Flooding, Project Wide, Final Design, Doc No. M4E-AEH-TR-00-120-053001_D_00, 15/09/2016 (CPB Contractors, Samsung, John Holland Joint Venture (CSJ) 2016a)
	M4 East - Design and Construct, Technical Report – Flood Mitigation Strategy, Project Wide – Permanent Works, Final Design, Doc No. M4E-AEH-TR-00-120-100001_D_00, 23/06/2016 (CSJ 2016b)
Water quality	Source of heavy metals in sediments of the Port Jackson estuary, Australia (Birch and Taylor 1999)
	Catchment condition as a major control on the quality of receiving basin sediments (Sydney Harbour, Australia) (Birch and McCready 2008)
	Leichhardt State of the Environment Report, 2009-2010
	Assessment of water quality and treatment options in Johnstons Creek, Whites Creek, Hawthorne Canal and Balmain catchments. (Beck 2010)
	Field and modelling investigations of fresh-water plume behaviour in response to infrequent high-precipitation events, Sydney Estuary, Australia. (Lee, Birch and Lemckert 2010)
	Metals, nutrients and total suspended solids discharged during different flow conditions in highly urbanised catchments (Beck and

Relevance	Reference
	Birch, 2010)
	Pollution in Sydney Harbour: sewage, toxic chemicals and microplastics. Briefing Paper No 03/2015 (Montoya, 2015)
	M4 East Environmental Impact Statement, Appendix O, Technical Working paper: Soil and water quality assessment (GHD, 2015)
	Baseline assessment of ecological structure and environmental condition at the Bays Precinct (Bugnot, A.B., Mayer-Pinto, M., Johnston, E.L., Coleman, R.A., Morris, R. L., and Dafforn, K.A. 2016)
Waterways	Sydney Light Rail Extension – Stage 1 – Inner West Extension Environmental Assessment (Parsons Brinckerhoff 2010)
	Sydney Water heritage search tool www.sydneywater.com.au

Review of baseline data

A number of sources provided data for the purpose of this assessment. These include:

- Details of trunk drainage assets operated by Sydney Water
- Details of pit and pipe stormwater drainage provided by Inner West Council and City of Sydney Council. Data included locations of pits and pipes
- Light Detection and Ranging (LIDAR) topographic survey
- Survey of Rozelle Rail Yards
- Aerial imagery
- Water quality monitoring data provided by SMC from the New M5 and M4 East projects and by UrbanGrowth NSW for The Bays Precinct project.

3.4.2 Field assessment

The purpose of the site visits was to visually assess the locations of the proposed surface elements of the project and the current state of surface water receptors and potential pathways to the receptors. Field inspections were made on three separate occasions, as shown in **Table 3-8**.

Table 3-8 Summary of site visits

Date	Area visited	Waterbodies visited	Outcomes
18 May 2016	St Peters, Rozelle Rail Yards, Wattle Street, Darley Street, Pyrmont Bridge Road	Dobroyd Canal, Hawthorne Canal, Easton Park drain, Whites Creek, Rozelle Bay, Johnstons Creek, Alexandra Canal	Inspection of waterways
12 July 2016	Rozelle Rail Yards	Whites Creek, Easton Park drain, Rozelle Bay	Inspection of waterways and drainage infrastructure
5 September 2016	Rozelle Rail Yards and Victoria Road	Whites Creek, Easton Park drain, Rozelle Bay, Iron Cove	Inspection of waterways and drainage infrastructure

3.4.3 Assessment of potential impacts

Water quality 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 the quality and volume of proposed discharges of treated construction water on the receiving environment.

Water quality during operation

MUSIC modelling of the existing and proposed conditions was undertaken to assess potential impacts on receiving waters associated with pollutant loads generated from pavement runoff and the performance of the proposed treatment system.

The MUSIC model was developed by the Cooperative Research Centre 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 used was based on the NSW MUSIC modelling guidelines for the meteorological template and pollutant generation parameters.

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.

The following assumptions were made for the purposes of developing the pre-construction MUSIC model scenario:

- Hydrological and pollutant parameters were selected in accordance with the NSW MUSIC modelling guidelines (Sydney Metropolitan Catchment Management Authority 2010)
- Climate data for Sydney Meteorological Office weather station for the period 1962 to 1966 was selected as recommended in the NSW MUSIC modelling guidelines (Sydney Metropolitan Catchment Management Authority 2010)
- A catchment area equivalent to the proposed development pavement drainage catchment was modelled, using separate sub-catchments for each existing land use type
- Gross Pollutant Traps (GPTs) were assumed to be installed upstream of Iron Cove on Victoria Road heading south and northbound. The GPTs were modelled in accordance with the NSW MUSIC modelling guidelines with a high flow bypass equivalent to the three month ARI for the pavement catchment being assessed.

The following assumptions were made for the purposes of developing the post-construction MUSIC model scenario:

- Hydrological and pollutant parameters were selected in accordance with the NSW MUSIC modelling guidelines
- Surface runoff from the road surfaces of Victoria Road to Anzac Bridge east bound ramps, a portion of City West Link, a portion of Victoria Road, portals for the future proposed Western Harbour Tunnel ramp and M4 ramps to Anzac Bridge, and the Rozelle ancillary infrastructure facilities were assumed to be treated by either the constructed wetland or one of the proposed bioretention systems at Rozelle
- Surface runoff from a portion of Iron Cove Link including a portion of the Victoria road northbound, the Victoria Road southbound, and the Victoria Road portals were assumed to be treated by the bioretention basin within King George Park
- Other areas including The Crescent bridge, a portion of City West Link east bound and west bound, James Craig Road, the proposed New M5 ramps, a portion of the upgraded section of Victoria Road at Rozelle, a portion of the upgraded section of Victoria Road at Iron Cove Link and portals at Wattle Street were assumed to be constrained and treated by proprietary devices including a GPT and a hydrodynamic separator. The GPTs were modelled as per the existing conditions modelling approach. Hydrodynamic separators were modelled conservatively assuming a 33 per cent reduction in performance to a proprietary hydrodynamic separator MUSIC node
- The constructed wetland was modelled as an ephemeral wetland with no permanent pool to account for the groundwater flows (associated with tunnel ingress) which would be passing through the wetland permanent pool
- Assumed pervious public open space areas and indicative shared pathways within these areas were not incorporated within the model.

Annexure F provides full details of the catchments modelling in MUSIC.

Proposed discharges of treated tunnel water were qualitatively assessed for potential impacts on Hawthorne Canal, Whites Creek and Rozelle Bay associated with the quality of water discharge. This considered groundwater inflow quality at other tunnel water treatment plants in Sydney, groundwater quality data collected for the project and the characteristics of the two tunnel drainage streams (groundwater being a continuous flow and the other water ingress events being discontinuous flows), (see **section 2.4.2**). The finalisation of the design of the treatment plant and discharge quality criteria will be undertaken during detailed design and will be informed by ongoing groundwater quality monitoring.

Flooding

A staged approach was undertaken to determine the level of assessment required to establish:

- The flood risk posed to the surface features of the M4-M5 Link
- The potential impact of the development on surrounding properties
- Mitigation measures required to protect sensitive infrastructure.

This enabled the assessments to be tailored to individual sites and targeted towards the locations considered to be at greatest risk of flooding. The level of assessment required was determined as a consequence of the following considerations:

- Existing flood risk information
- Identifying risk to the sites and mechanisms of flooding
- Determining flood risk to the project and potential impacts of the development to surrounding areas.

Where sites were identified as being at high risk of flooding, the process followed enabled consideration of flood risk in the design of the layout of the interchanges and construction sites.

This included identifying opportunities to:

- Provide easements from areas identified at risk of flooding in order to maintain existing flowpaths
- Locate land uses across the study area based on the vulnerability to flooding. For example, locating car parks in areas of a site considered at high risk of flooding and placing tunnel ramps away from areas of flooding.

The process for establishing flood risk and the level of assessment required was determined by following the steps in **Figure 3-1**. All surface features within the study area associated with the proposed M4-M5 Link project (interchanges and construction sites) were assessed through this process. For details of the step by step process see **Annexure D**. A summary of this assessment is provided in **sections 5.2** and **6.2**.

It is noted that SEARs 12.1 (f) refers to ‘adverse effect on beneficial inundation’. Beneficial inundation is considered to be more applicable to a rural agricultural environment. Therefore, in the context of this EIS, considering that the project is located in a highly urbanised environment, the flood assessment has considered adverse effects on general flooding behaviour on, or adjacent to the site.

Quantitative assessment

For locations where a quantitative assessment was required, the following was undertaken:

- Development of new hydrologic and hydraulic flood models
- Running the flood models identifying flood behaviour under present day (pre-project) conditions for the 10 year and 100 year ARI events, as well as the PMF
- Assessment of the potential impact the project would have on flooding characteristics during construction and operation

- Assessment of the impact a partial blockage of major hydraulic structures due to floating debris would have on flood behaviour under post-construction conditions
- Assessment of the impact that future climate change would have on flood behaviour under post-construction conditions.

The 10 year ARI, 100 year ARI and PMF design events were chosen for the quantitative assessment as they represent a range of different flood events from more frequent (ie 10 year ARI) to extreme event (ie PMF). Further detail on the methodology adopted for locations that required a quantitative assessment is provided in **Annexure C**.

Process for establishing flood risk and the level of assessment required

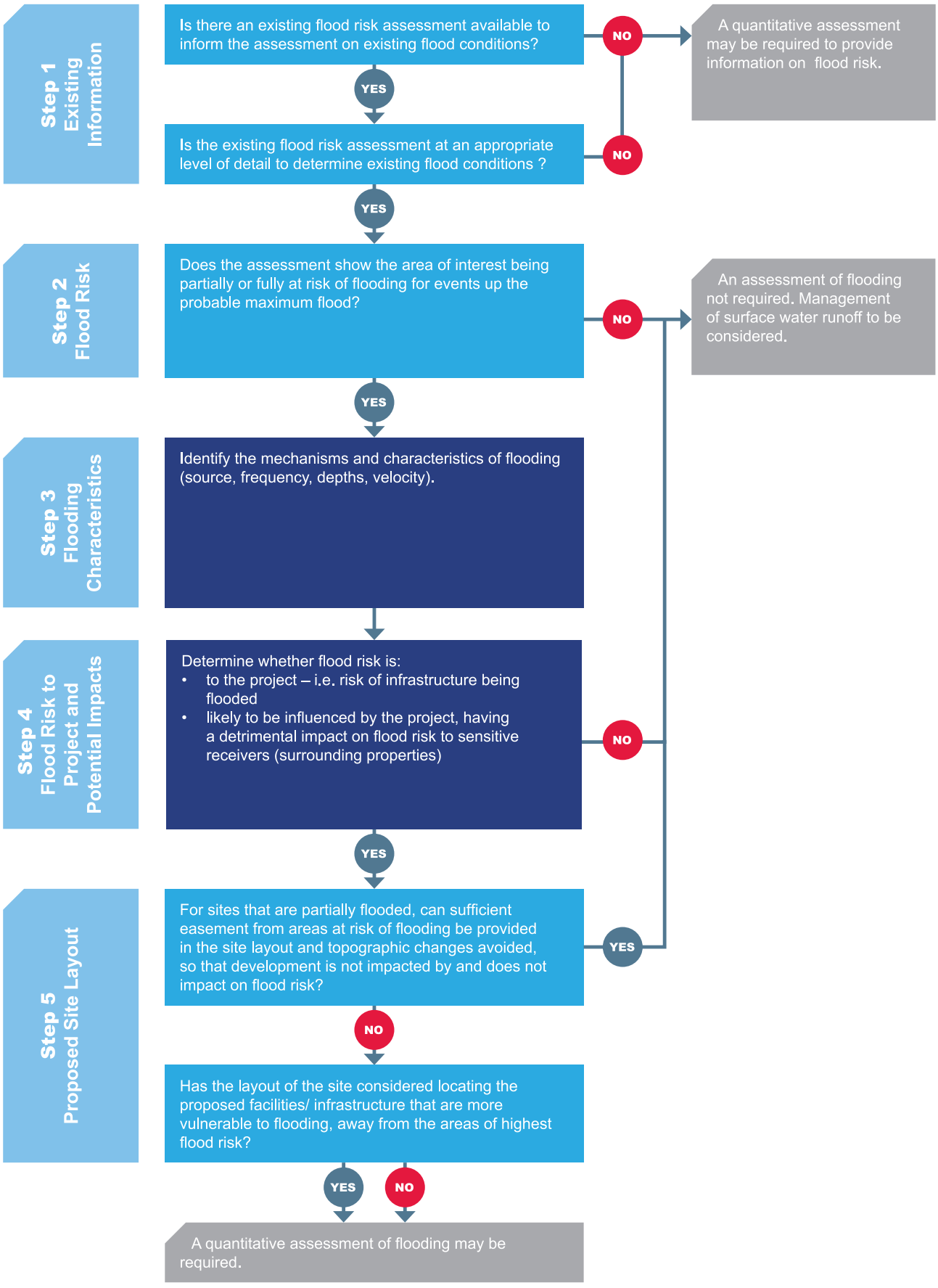


Figure 3-1 Flood risk assessment decision process (AECOM 2017)

3.4.4 Hydrologic standards

The standards adopted in the assessment of transverse drainage and flood mitigation measures were established in accordance with the *Floodplain Development Manual* and current Roads and Maritime standards. The hydrologic standards adopted are based on matching the level of protection to the risk and consequence of flooding and are outlined in **Table 3-9**.

Table 3-9 Hydrologic standards

Project infrastructure	**Standards**
Tunnel portals and ancillary facilities (ventilation facility, water treatment plants)	Located above the PMF level or the 100 year ARI flood level plus 0.5 metres freeboard (whichever is greater).
Emergency response facilities (motorway control centre, fire water tank, pump buildings)	Located above the PMF level or the 100 year ARI flood level plus 0.5 metres freeboard (whichever is greater).
Modifications to existing road network	Modifications to existing roads at their point of connection to the project are to be configured such that the existing level of flood immunity is maintained. Temporary modifications to existing roads during the construction staging will maintain the existing level of flood immunity where feasible, taking the duration of the construction stages into consideration.
Impacts on existing development	**Standards**
Operational	100 year ARI flood standard is to be adopted in the assessment of measures which are required to mitigate any adverse flooding impacts attributable to the project. Changes in flood behaviour under PMF conditions would also be assessed in order to identify impacts on critical infrastructure and significant changes in flood hazard resulting from the project.
Construction	Construction-related flood risks and impacts need to be evaluated in the context of the construction period in order to set requirements that are commensurate to the period of time that the risk exposure occurs. To this end, this report identifies the risks and potential impacts associated with construction activities and the site so that informed decisions on the flood criteria to be set as part of the flood risk management plan for the construction of the project can be made.

4 Existing environment

4.1 Catchments and watercourses

The project footprint is located within the SHPRC and the CRC. The majority of the study area is located within the Sydney Harbour catchment, which covers an area of around 484 square kilometres including its main tributary the Parramatta River. The southern portion of the project footprint, within proximity to the St Peters interchange is located within the CRC. The CRC covers an area of around 100 km^2 in southern Sydney and discharges to Botany Bay at Mascot.

The predominant waterways within the SHPRC traversed or affected by the project footprint include Hawthorne Canal, Whites Creek, Johnstons Creek as well as Dobroyd Canal (also known as Iron Cove Creek) and Easton Park drain. Dobroyd Canal and Hawthorne Canal discharge to Iron Cove while Whites Creek, Johnstons Creek and Easton Park drain discharge to Rozelle Bay.

The channels of Dobroyd Canal, Hawthorne Canal, Whites Creek and Johnstons Creek are considered to be of historical significance as they are four of a group of similar channels which were the earliest purpose built stormwater drains to be constructed in Sydney (Sydney Water 2014).

Alexandra Canal is the main waterway downstream of the project footprint within the CRC. Alexandra Canal is one of only two navigable canals built in NSW and is characterised by its controlled route, defined edges and sandstone embankment walls. The canal is considered to be of high historic, aesthetic and technical/research significance (Sydney Water 2014).

Rozelle Bay, Iron Cove, White Bay, Alexandra Canal and downstream portions of Dobroyd Canal and Hawthorne Canal have been mapped as Key Fish Habitat, as defined in the *Fisheries Policy and Guidelines for Fish Habitat Conservation and Management* (update 2013) (Fairfull 2013). The project's receiving waters are marine environments which include the intertidal and subtidal ecosystem of the harbour and its estuarine tributaries. Further details of the aquatic habitat and species present within the waterways are provided within **Appendix S** (Technical working paper: Biodiversity) of the EIS.

The stream order, based on the Strahler System for each waterway is provided in the following sections. The stream order was assessed based on the Framework for Biodiversity Assessment (FBA).

Uses of the waterways within the study area include recreational users (including swimming, boating and aesthetics), commercial activities (commercial shipping and tourism) and as an ecological resource. Commercial fishing in Sydney Harbour, Parramatta River and other connected tidal waterways has been banned since 2006 as a precautionary measure due to elevated levels of dioxins in some fish and seafood. Recreational fishing is still allowed but fishers are urged to follow dietary advice on the consumption of seafood. There is very limited extraction of fresh water, or reuse of stormwater within the SHPRC (DECCW 2006) and no known freshwater extractions occur downstream of the construction and operational surface water discharge points.

Figure 4-1 shows the waterways and associated catchments within the study area, which are traversed or downstream of the project footprint. Photographs of the key waterways are shown in **Annexure A**. The locations of the photographs are shown in **Figure 4-2**.

4.1.1 Dobroyd Canal

Dobroyd Canal drains parts of the inner west suburbs of Ashfield, Burwood, Haberfield, Croydon, Drummoyne and Canterbury and discharges into Iron Cove (Cardno Lawson Treloar 2008). The Dobroyd Canal catchment is fully urbanised with an area of around 800 hectares. The canal comprises an open channel between Iron Cove and the intersection of Carshalton and Norton Streets with underground branches extending upstream (**Annexure A** – Photo 1). Dobroyd Canal is a first order stream and is mapped as Key Fish Habitat downstream of Ramsay Street, Haberfield.

This waterway runs parallel to the Wattle Street interchange and the proposed tunnel portal of the M4-M5 Link. The Wattle Street civil and tunnel site (C1a), Haberfield civil and tunnel site (C2a)/Haberfield civil site (C2b), Northcote Street civil site (C3a), Parramatta Road West civil and tunnel site (C1b) and

Parramatta Road East civil site (C3b) are located within the Dobroyd Canal catchment (see **Figure 4-1**). The Wattle Street interchange will drain to Dobroyd Canal during operation.

4.1.2 Hawthorne Canal

Hawthorne Canal starts in Lewisham and flows into Iron Cove at Dobroyd Point. The canal's catchment is around 670 hectares and is heavily urbanised (PB 2010). Sydney Water Corporation owns the canal. It was originally a natural waterway known as Long Cove Creek but has since been straightened and given artificial banks. The channel is generally constructed from unreinforced concrete with the base of the channel comprising paved brick for a section upstream of Parramatta Road (Sydney Water 2014). The main channel is tidal to upstream of Parramatta Road and the channel width varies from around two metres in upper areas to 22 metres at its confluence with Iron Cove (WMAwater 2013). Hawthorne Canal is a first order stream and is mapped as Key Fish Habitat downstream of approximately Marion Street, Leichhardt.

The proposed M4-M5 Link tunnel alignment crosses beneath Hawthorne Canal adjacent to Hawthorne Parade, around 300 metres upstream of Iron Cove. The proposed operational water treatment plant at Darley Road, Leichhardt, would discharge to Hawthorne Canal. The Darley Road civil and tunnel site (C4) is located within the catchment.

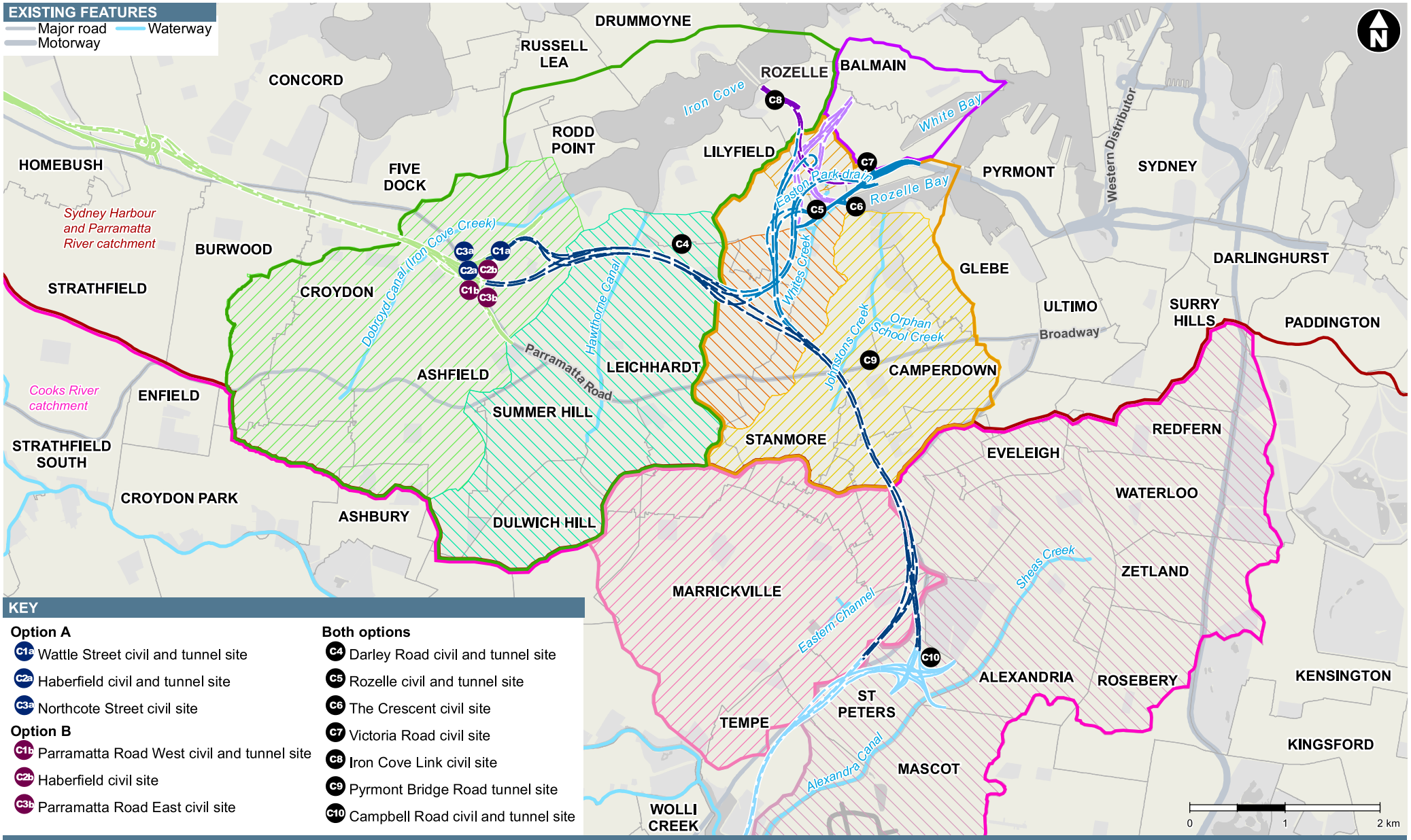


Figure 4-1 Catchments and waterways within study area

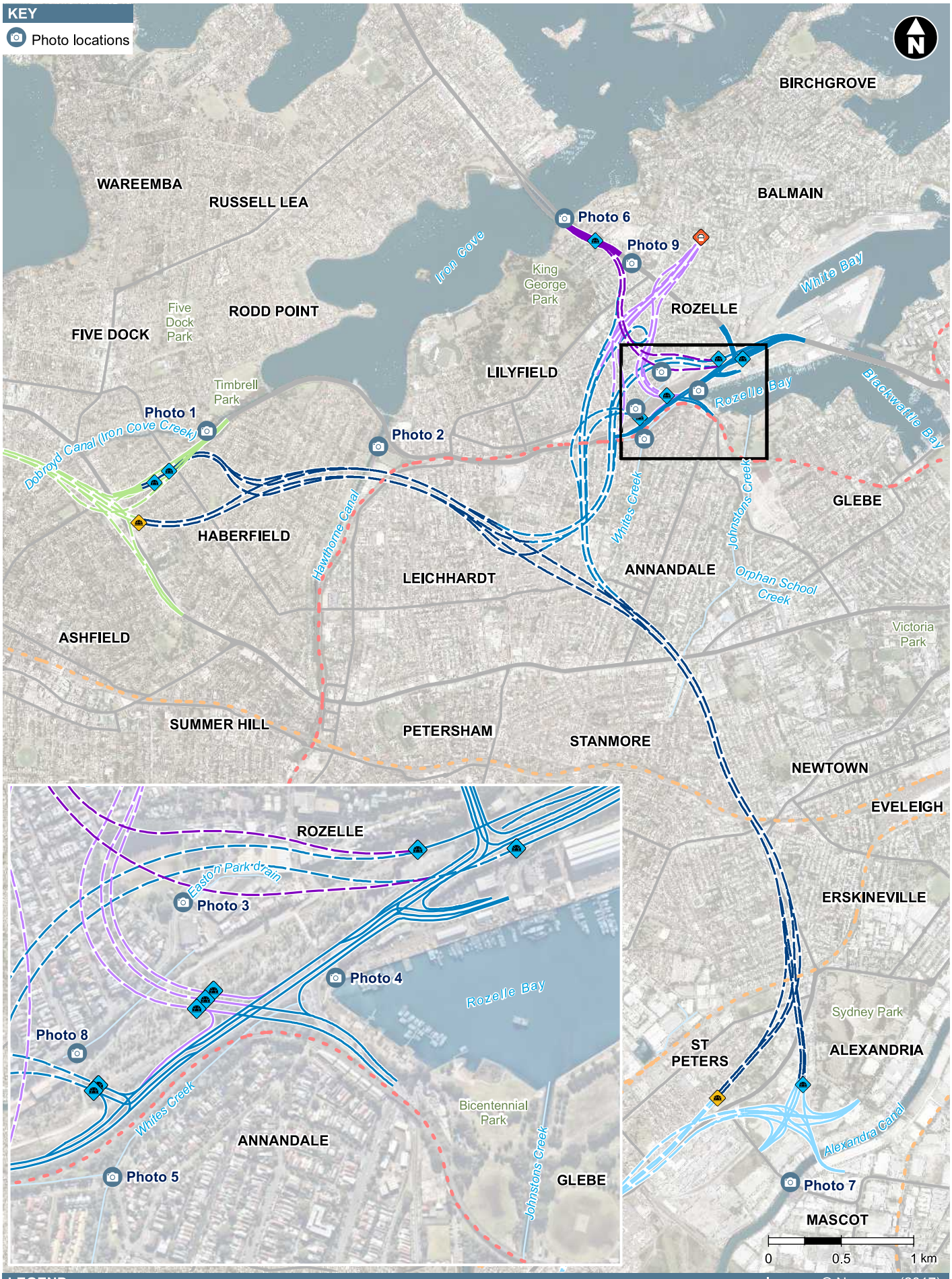


Figure 4-2 Location of photographs

4.1.3 Whites Creek

Whites Creek is a brick and concrete-lined channel that flows through the suburbs of Leichhardt and Marrickville, discharging to Rozelle Bay (**Annexure A** – Photo 5). The Whites Creek catchment is heavily urbanised and comprises an area of around 262 hectares. Originally a natural watercourse, the Whites Creek stormwater channel was constructed progressively during the period 1898 to 1938. The channel varies between circular and covered sections in the upper reach and open channel sections in the lower reach.

The lower reach of Whites Creek is located to the south of the proposed Rozelle interchange and associated road upgrades. Proposed works in this area include the redevelopment of City West Link and The Crescent intersection, raising the level of sections of these roads, the construction of new culverts into Rozelle Bay, in addition to upgrade and widening of the existing bridge structure that crosses Whites Creek at The Crescent. Whites Creek is a first order stream. The Crescent civil site (C6) is located at the confluence between Whites Creek and Rozelle Bay.

4.1.4 Easton Park drain

Easton Park drain, running between Denison Street adjacent to Easton Park and Rozelle Bay, conveys runoff from a heavily urbanised catchment of around 55 hectares within the suburb of Rozelle. The drain originates from a series of stormwater networks that discharge into a brick-lined, open channel south of Lilyfield Road (**Annexure A** – Photo 3). The open channel section passing through the industrial area between Lilyfield Road and the Rozelle Rail Yards is around 175 metres long. It discharges into a culvert that runs underneath the Rozelle Rail Yards and outlets into Rozelle Bay, to the east of the intersection of City West Link and The Crescent (**Annexure A** – Photo 3). Observations of the outfall suggest that discharges from the culvert are influenced by tidal fluctuations in Rozelle Bay (**Annexure A** – Photo 4).

Easton Park drain passes through the proposed Rozelle interchange, from Lilyfield Road in the north to Rozelle Bay in the south. Easton Park drain is a first order stream. It is proposed to divert Easton Park drain into a new channel to convey flows through Rozelle Rail Yards, with the former Easton Park drain decommissioned. An upsized culvert would be provided to discharge flows into Rozelle Bay.

4.1.5 Johnstons Creek

The Johnstons Creek catchment is heavily urbanised being situated within the suburbs of Glebe, Annandale, Petersham and Newtown, immediately west of Sydney CBD and comprises a total area of around 460 hectares (WMAwater 2014). Originally a natural watercourse discharging to Rozelle Bay, Johnstons Creek was converted into a stormwater channel in the 1890s. The channel consists of a wide open concrete section at the Rozelle Bay end and brick walls further upstream.

The proposed M4-M5 Link mainline tunnel traverses beneath Johnstons Creek adjacent to Bridge Road, Stanmore, south of Parramatta Road. At this point, Johnstons Creek is a first order stream. The Pyrmont Bridge Road tunnel site (C9) is located within the Johnstons Creek catchment.

4.1.6 Rozelle Bay

The Rozelle Bay catchment is highly urbanised and comprises a total area of around 857 hectares. Rozelle Bay is located between the suburbs of Glebe, Annandale, Lilyfield and Rozelle with flow inputs from Whites Creek, Johnstons Creek and Easton Park drain. The foreshore is actively used for recreational fishing and the bay houses private recreation craft, NSW patrol vessels and maritime industries including the Sydney Heritage Fleet located on the western shore of Rozelle Bay. Rozelle Bay is classified as W1 Maritime Waters in the Sydney Regional Environmental Plan (Sydney Harbour Catchment) (NSW Government 2005). Rozelle Bay is mapped as Key Fish Habitat and is an estuarine environment.

Rozelle Bay is a receiving waterbody for discharge from the operational water treatment plant at Rozelle and runoff from the proposed Rozelle interchange and associated road upgrades. A new outlet would be constructed within Rozelle Bay to receive the flows from the Rozelle interchange. The Rozelle civil and tunnel site (C5) is located within the Rozelle Bay catchment. The Victoria Road civil site (C7) is located on the boundary of the Rozelle Bay and White Bay catchments.

4.1.7 Iron Cove

The Iron Cove catchment, a bay within the Parramatta River estuary, is highly urbanised and comprises a total area of around 2,011 hectares (**Annexure A**– Photo 6). Dobroyd Canal (Iron Cove Creek) and Hawthorne Canal discharge into Iron Cove.

Iron Cove is classified as W5 Water Recreation in the Sydney Regional Environmental Plan (Sydney Harbour Catchment) (NSW Government 2005). The Sydney Regional Environmental Plan also identifies some waters adjacent to the Iron Cove foreshore as Wetlands Protection Area. Iron Cove has been mapped as Key Fish Habitat.

A portion of the proposed road upgrades (ie the widening of a section of Victoria Road) associated with Iron Cove Link will drain into Iron Cove, either utilising existing outlets or a new direct drainage outlet. Iron Cove is a second order stream. The Iron Cove civil site (C8) and proposed bioretention basin and car park improvement works in Manning Street within King George Park are located within the Iron Cove catchment.

4.1.8 White Bay

The White Bay catchment is highly urbanised and comprises a total area of around 163 hectares. White Bay is surrounded by the suburbs of Balmain and Rozelle with White Bay wharf and White Bay Cruise Terminal to the north and Glebe Island to the south. White Bay wharf is one of only two deep-water wharves west of the Sydney Harbour Bridge. It is used for a variety of port uses, including bulk vessel loading and vessel repairs. The White Bay Cruise Terminal is Sydney's second cruise terminal to the Overseas Passenger Terminal at Circular Quay. The former White Bay power station is located around 260 metres west of White Bay. Glebe Island is a strategic deep-water port actively used for deep-water wharfage, including bulk vessel and unloading.

White Bay is classified as W1 Maritime Waters in the Sydney Regional Environmental Plan (Sydney Harbour Catchment) (NSW Government 2005). White Bay is mapped as Key Fish Habitat and is an estuarine environment.

The Victoria Road civil site (C7) is located on the boundary of the White Bay and Rozelle Bay catchments. A portion of the proposed Victoria Road upgrade between Hornsby Street and Robert Street could potentially drain via an existing or new connection to White Bay.

4.1.9 Alexandra Canal

The Alexandra Canal catchment (including Sheas Creek) has an area of around 23 square kilometres and takes in the suburbs of Alexandria, Rosebery, Erskineville, Beaconsfield, Zetland, Waterloo, Redfern, Newtown, Eveleigh, Surry Hills and Moore Park. The catchment is heavily altered, predominantly covered by commercial, industrial and residential development with a small amount of parkland such as Sydney Park and Moore Park.

Alexandra Canal is a constructed canal, originally a natural watercourse named Sheas Creek. It flows into the Cooks River near the north-western corner of Sydney Airport. Dredging and canalisation of Sheas Creek started in the 1880s to make the creek navigable in order to attract industries to the area. By 1896 the creek was excavated by about three metres and spoil was used to fill banks by up to 1.8 m to reclaim the low lying wetland areas surrounding the creek. The canal was substantially complete by 1900. As it was originally built for navigation by boat for transportation purposes, it is much larger than technically required to convey stormwater from the catchment area draining to it. Due to its size, in relation to its inflows as well as tidal action, the canal accumulates sediment. Dredging to remove sediment build up was regularly undertaken up to the 1950's. By that time, road and rail had made boat navigation in the canal superfluous for goods transportation. The last major works on the canal, including backfilling and dredging, were carried out in the 1970's when the north-south runway for Sydney Airport was built (DPWS 2004). The contaminated sediments within the canal have been declared a remediation site by the NSW EPA.

The proposed M4-M5 Link underground connection to the St Peters interchange and ventilation facility are located in the catchment of Alexandra Canal. The Campbell Road civil and tunnel site (C10) is located within the Alexandra Canal catchment. Alexandra Canal is a second order stream within the vicinity of St Peters interchange (**Annexure A**– Photo 7).

4.1.10 Eastern Channel

The Eastern Channel catchment includes the suburbs of Tempe, Sydenham, Enmore and Newtown and is around 776 hectares in area. The catchment is heavily urbanised and altered by a relatively even mix of commercial and residential property. The catchment has a very small proportion of open space in the form of recreational parklands.

The Eastern Channel runs along the Sydenham to Tempe railway line, discharging into the Cooks River. The channel conveys stormwater as a concrete-lined trapezoidal-shaped open channel. The main open section is around 2.3 kilometres in length from near Murray Street, Marrickville to its confluence with the Cooks River adjacent to Tempe Station. Part of the channel is tidal due to its connectivity with the Cooks River.

The proposed M4-M5 Link mainline tunnel runs through the Eastern Channel catchment. However, no surface works or discharges, surface operational facilities or surface carriageways are proposed within the catchment, and as such the project is not expected to impact the channel. No further assessment of the Eastern Channel in relation to surface water and flooding impacts has been undertaken.

4.2 Geomorphology

The urban waterways within the study area are all artificial, hard lined (e.g. concrete channel, piped channel, brick channel, underground concrete channel) stormwater channels, with the exception of Alexandra Canal which has an unlined base and hard lined banks. The characteristics of the watercourses in the study area are outlined in **section 4.1**. The geomorphic characteristics of the watercourses reflect their urban and anthropogenic nature. Sea walls have been constructed around Rozelle Bay and White Bay where development occurs up to the shoreline, with boat vessel moorings also occurring within the bays. The Iron Cove shoreline comprises a mixture of sea wall and vegetated zones with parkland and residential development occurring adjacent to the shoreline.

Given the characteristics of the majority of watercourses and subsequent lack of potential for lateral or vertical adjustment, further detailed assessment of potential geomorphological impacts on the urban waterways associated with the project is not considered necessary. This includes assessment of erosion and creek health impacts due to increased runoff volumes, frequency and flow rates associated with an increase in impervious area. Potential for scour and sediment loading at discharge points within the receiving bays has been considered in **sections 5.2.1** and **6.3**. The potential for an increase in discharge volume to increase the disturbance of contaminated sediments in Alexandra Canal is discussed in **section 6.3**. Potential impacts to Whites Creek as a result of the construction of the proposed bridge are discussed in **sections 5.2** and **5.3.2**.

4.2.1 Creek renewal/naturalisation works

Sydney Water is currently investigating potential opportunities for naturalisation within a section of Johnstons Creek and Whites Creek in Annandale. A concept design has been developed for the Whites Creek naturalisation project. Naturalisation at Whites Creek includes the replacement of deteriorating concrete banks and low flow channel with a combination of rocks, native plants and sandstone blocks or concrete. No concept design is currently available for Johnstons Creek.

The Sydney Water naturalisation works on Whites Creek would be located adjacent to Railway Parade and Hutchinson to the south of the Rozelle interchange, and are scheduled for construction in the 2017 financial year. The project would similarly incorporate channel naturalisation works extending from The Crescent back to Railway Parade, adopting a similar philosophy regarding surface treatments to integrate with Sydney Water's naturalisation works.

The potential works on Johnstons Creek proposed by Sydney Water extend from Rozelle Bay to 20 metres south of The Crescent. The construction schedule for the works on Johnstons Creek is currently not known.

4.3 Drainage

Due to the extensive urban nature of the study area, there is a dense network of stormwater drainage which conveys stormwater flows for the smaller storm events. This network manages stormwater

flows predominantly from the roads and impervious areas of the catchments before discharging into the local waterways and canals. Dobroyd Canal, Hawthorne Canal, Easton Park drain, Whites Creek, Johnstons Creek and Alexandra Canal all receive inputs from the stormwater network. In larger storm events when the capacity of the existing drainage system is exceeded, runoff follows overland paths to these waterways and canals.

The Rozelle Rail Yards site is an area that has little known formal drainage other than:

- The Easton Park drain and associated drains in the north of the site
- An open channel running west to east along the base of the rock wall to the south of Lilyfield Road, between Denison Street and Cecily Street. The channel discharges into a culvert underneath 92-94 Lilyfield Road. It is likely that this drain discharges into the Easton Park drain
- A small number of pits and pipes found throughout the site.

The existing drainage infrastructure on the Rozelle Rail Yards is likely to be of relatively poor condition as a consequence of age and a lack of maintenance since the site ceased as an active rail facility in the late 1990s. The Easton Park drain is the only known discharge point from the northern section of the site. From the limited drainage information available, it is expected that rainfall and runoff from the site would generally drain through a combination of infiltration, evaporation and the local drainage network (condition unknown). Observations made by SMC personnel on site following rainfall has been that water pools across the site including at the stormwater pits adjacent to (east of) the existing workshop in the southwest corner.

There are some Sydney Water and Council road drainage assets in the vicinity of the Rozelle Rail Yards, some of which connect into the Easton Park drain system. The catchment to the northwest of the proposed Rozelle interchange is connected to Whites Creek via a brick arch culvert which passes underneath the CBD and South East Light Rail site and the light rail line. This provides a sub-surface connection between Whites Creek and a catchment north of Lilyfield Road.

At Iron Cove, there is an Inner West Council stormwater drainage system serving the existing road network to the southeast and east of the proposed Iron Cove Link. The drainage network on Victoria Road is reported to generally consist of 300 millimetre to 450 millimetre diameter pipes.

To the south of the Darley Road site, an Inner West Council stormwater drainage system serves the road network. The drainage network on Darley Road is reported as 2.4 metre diameter pipes receiving surface water inputs from drainage to the east and to the south.

It is expected that the age or quality of some of these existing stormwater drainage assets is commensurate with the age of the buildings and houses in the area and therefore, some of the assets are potentially nearing, at or beyond the end of their design life. The stormwater network is owned by Sydney Water and Inner West and City of Sydney councils.

There are numerous drainage networks to be crossed by the proposed road alignment. This is of particular relevance for those areas of the project footprint where the proposed road works are at or near the surface ie the western and southern ends of the project, interchanges, cut-and-cover sections and tunnel portals.

4.4 Hydrology and flooding

As discussed in **section 4.1**, the project footprint is located within a number of catchments including Dobroyd Canal, Hawthorne Canal, Whites Creek, Johnsons Creek and Alexandra Canal.

Land within the study area (see **section 1.4**) is predominantly of urbanised nature with small pockets of open space frequently located along some of the watercourses. Development within the study area is typically well established with a high proportion of residential and commercial land use.

Flood risk in the study area has increased since the onset of urbanisation, as a consequence of:

- Development occurring prior to the installation of road drainage systems in the 1900s
- Development occurring in overland flowpaths or in localised topographic depressions and encroaching into floodplains, reducing storage capacity

- Culverting and channelisation of watercourses increasing the speed of water travelling through the system
- Increases in the area of impermeable land resulting in increased runoff during rainfall events.

This means that the watercourse flow rates and water levels respond more quickly to rainfall events, due to reduced storage and infiltration capability within the catchments.

4.4.1 Existing flood behaviour

A summary of the existing flood conditions at the surface features during the operational phase of the M4-M5 Link project is presented in **Table 4-1**. This is based on a review of existing flood risk assessments and identifies if further quantitative assessment is required to assess flood risk and impacts of the development. Flood risk associated with the construction ancillary facilities is discussed in **section 5.2**.

Wattle Street interchange

The Wattle Street interchange (M4 East project) is located in the catchment of Dobroyd Canal. Due to the interface of the M4-M5 Link project with the M4 East project and timing for completion of construction of these projects, the 'existing' flood conditions at the Wattle Street interchange has been taken to be represented by the post-construction situation for the M4 East project. This is because the existing flooding conditions at this location, which will incorporate flood mitigation measures that also afford protection to the M4-M5 Link project, will change post-development of the M4 East project.

The western section of the interchange is not affected by creek flooding, only by localised stormwater runoff. Mitigation measures, such as local piped drainage systems, an on-site detention basin and an overland flowpath have been implemented in the M4 East project design to capture local runoff upstream and connect into the new interchange drainage system. Excess flows in events greater than the 100 year ARI up to the PMF will be diverted around the western tunnel portal towards Parramatta Road. The eastern end of the interchange is affected by flooding from Dobroyd Canal. The road crest for the eastern tunnel portal has been located above the PMF level to prevent flooding of the tunnel portals. The tunnel ventilation facility at the Wattle Street interchange (Parramatta Road ventilation facility) is also protected from flooding in events up to the PMF.

For the Wattle Street interchange, the mitigation measures provided by the preceding construction of the M4 East project means that the risk of flooding to the M4-M5 Link project from a PMF is considered to be low. As the design surface layout or levels of the interchange will not change as a consequence of the M4-M5 Link project, the impact of the development is considered to be negligible and no additional mitigation measures are necessary at this location. Therefore, a quantitative assessment of impacts at this location is not required.

St Peters interchange

The St Peters interchange (New M5 project) is located in the catchment of Alexandra Canal. Due to the interface of the M4-M5 Link project with the New M5 project, and timing for completion of construction of this project, the 'existing' flood conditions at the St Peters interchange has been taken to be represented by the post-construction situation for the New M5 project. This is because the existing flooding conditions at this location will change post-development of the New M5 project.

The St Peters interchange is generally not affected by flooding from Alexandra Canal and only the area around the intersection of Campbell Road and Burrows Road is flood affected in events up to the 100 year ARI. Critical infrastructure such as the motorway operations complexes is generally located above PMF level, including the tunnel ventilation facility at the interchange.

The design of the New M5 project is providing enabling works for the M4-M5 Link construction site within the St Peters interchange, including provision of flood mitigation measures. For the St Peters interchange the mitigation measures provided by the preceding construction of the New M5 project means that the risk of flooding to the M4-M5 Link project from a PMF is considered to be low. Therefore, the impact of the project on flood risk is considered to be negligible and no additional mitigation measures are necessary for the M4-M5 Link at this location. Therefore a quantitative assessment of impacts at this location is not required.

Rozelle interchange

The Rozelle interchange is located within and adjacent to the Rozelle Rail Yards in the catchment of Rozelle Bay and Whites Creek. The Rozelle Rail Yards is comprised of reclaimed land located within a disused rail cutting. The site spans a topographic low with levels ranging from around two metres AHD (Australian Height Datum) to seven metres AHD. The site is bound by excavated, near-vertical rock walls up to eight metres high along the northern boundary and a fill embankment in the southwest section adjacent to City West Link (see **Annexure A** – Photo 8). Sub-catchments draining to Rozelle civil and tunnel site are shown in **Figure 4-2**.

Two watercourses are located within this section of the study area:

- Easton Park drain
- Whites Creek.

The 'Easton Park drain' drains a heavily urbanised catchment of around 55 hectares to the north of the Rozelle Rail Yards and discharges to Rozelle Bay through a combination of stormwater pipes, lined open channel and culverted reaches. Once it has passed under Lilyfield Road the drain is an open concrete lined section for a distance of around 170 metres through the Industrial Estate on Lilyfield Road. It then flows into a culvert passing under the Rozelle Rail Yards before discharging to Rozelle Bay just east of the intersection of City West Link and The Crescent. Observations of the outfall suggest that discharges from the culvert are influenced by tidal fluctuations in water level in Rozelle Bay.

Whites Creek is located to the south of both the Rozelle Rail Yards and City West Link. The watercourse drains a dense urban catchment area of around 262 hectares originating approximately 1.9 kilometre southwest of the Rozelle Rail Yards. The upstream section of the creek is conveyed within a culverted system, owned by Sydney Water, flowing in a north easterly direction before discharging into an open channel in Annandale. Downstream near the Rozelle interchange, Whites Creek is a brick and concrete lined open channel approximately nine metres wide which is spanned by a number of road and rail crossings in proximity to the Rozelle Rail Yards. The creek discharges into Rozelle Bay immediately east of The Crescent and is also tidally influenced.

The flood study undertaken by Leichhardt Council (Cardno 2014) suggests that the existing drainage system surcharges in the five year ARI storm event and that overland flooding occurs along the line of Whites Creek as well as the connecting ‘tributaries’.

Although the existence of a direct surface water connection between the Rozelle Rail Yards and Whites Creek has not been established, there are potential indirect surface pathways. This includes the adjacent CBD and South East Light Rail Rozelle maintenance depot to the west of the Rozelle Rail Yards, which includes the Inner West Light Rail line. The CBD and South East Light Rail line passes underneath City West Link roadway and may present a pathway for surface water to exchange between the Rozelle Rail Yards area and a drain that discharges into Whites Creek. Another pathway relates to surface water potentially flowing across City West Link and into the lower reaches of Whites Creek near The Crescent or vice versa.

Rozelle Bay is a harbour embayment located approximately 65 metres south of the Rozelle Rail Yards. The bay is tidal and receives urban runoff from the suburbs of Rozelle, Lilyfield, Annandale, Glebe and Forest Lodge. On average the bay experiences two tidal cycles a day with a mean high water springs level of 0.69 metres AHD and mean low water spring level of -0.64 metres AHD reported for Port Jackson.

The *Leichhardt Flood Study* (Cardno 2014), commissioned by the former Leichhardt Council, suggests that a significant area of the Rozelle Rail Yards would be inundated with floodwater in the five year ARI event, with localised depths of over 0.5 metres on Lilyfield Road near Easton Park. A larger area would be inundated during the 100 year ARI event with depths of up to one metre on Lilyfield Road. Flooding along Whites Creek is fairly confined to the main channel, but there are breakout areas mainly along the right bank, affecting properties along Railway Parade in particular. Both The Crescent and City West Link have 100 year ARI flood immunity from creek flooding under

existing conditions in the vicinity of the study area. Some ponding occurs on these roads due to localised pavement runoff.

The flood extent and depth maps suggest that the Rozelle Rail Yards acts as a storage area for floodwater. The site of the proposed Rozelle interchange is classed as a flood control lot in the Leichhardt Development Control Plan 2013 (DCP 2013 Part E, Leichhardt Municipal Council). As the site is below the FPL and located in flood prone land (potentially impacted by the PMF), it is considered to be at high risk of flooding. A quantitative assessment of flood risk was therefore undertaken.

The results of the flood modelling of existing conditions shows that the Rozelle Rail Yards is subject to surface water inputs through both piped drainage discharges and overland flow, from a number of external catchments to the north and west. More details on the flood model development are provided in **Annexure C**.

As the Rozelle Rail Yards is within a topographic low, it receives runoff from relatively steep contributing catchments to the north and west. This, combined with the limited capacity of the local drainage network, means that the existing site functions as a floodway for overland flow and provides a significant area for floodwater storage. Floodways are areas of the floodplain where a significant discharge of water occurs during floods. They are areas that, even if only partially blocked, would cause a significant redistribution of flood flow or a significant increase in flood levels.

The Rozelle Rail Yards has minimal known formal flow conveyance other than through the Easton Park drain. The main surface outlet from the site is at a low point on City West Link, where excess floodwater spills over the road and discharges into Rozelle Bay. However, the overtopping of City West Link currently only occurs in relatively large, infrequent flood events greater than the 100 year ARI.

The existing flood conditions for the 10 and 100 year ARI design events and PMF are shown in **Figure 4-4, Figure 4-5** and **Figure 4-6**. The figures highlight the Rozelle Rail Yards currently providing a large area of surface water storage during these events. Modelled flood depths for the 10 and 100 year ARI design events are generally less than one metre across the site. During the PMF event, depths across the site reach over 1.5 metres at the low point near the intersection with The Crescent. Areas of higher ground along City West Link at the southern boundary of the site and along Lilyfield Road to the northeast are outside of the PMF flood extent.

Flow velocities across the site during flood events are generally low. For example, in the 100 year ARI event, peak flow velocities are less than 0.5 metres per second across the majority of the site, and typically less than 0.2 metres per second (see **Figure 4-7**). Zones of faster moving floodwaters up to approximately two metres per second occur in the vicinity of the existing workshop in the southwest corner of the site.

Flood hazards according to the *Floodplain Development Manual* (NSW Government 2005) are shown in **Figure 4-8** for the 100 year ARI. Easton Park drain and Whites Creek, as well as its overbank areas including sections of Railway Parade, are considered high flood hazard zones. This is consistent with the *Leichhardt Flood Study*. The Rozelle Rail Yard is generally a low flood hazard area, with the exception of a small area near Victoria Road.

The Rozelle Rail Yards is generally not subject to flooding from Whites Creek, as the Sydney Light Rail line and City West Link provide physical barriers to flow. However, during the PMF Whites Creek overtops the road at The Crescent and flows in an easterly direction along City West Link, merging the floodwaters from the Rozelle Rail Yards and Whites Creek.

Iron Cove Link

The proposed Iron Cove Link is located on Victoria Road within the catchment of Iron Cove. The area slopes from the southeast (around 24 metres AHD) to the northwest (16 metres AHD) towards Iron Cove Bridge. The closest waterway in proximity to Iron Cove Link is Iron Cove, located to the northwest of the proposed interchange. Sub-catchments draining to the Iron Cove Link civil site are shown in **Figure 4-9**.

The existing flood conditions for the 10 and 100 year ARI design events and PMF are shown in **Figure 4-10, Figure 4-11** and **Figure 4-12**. Maximum water depths of less than 0.25 metres are

found on Victoria Road in the area of the proposed Iron Cove Link, with the deeper water generally found on the northern carriageway. During the PMF event, depths across the site reach 0.3 metres near the intersection with Terry Street.

Flow velocities across the site during flood events reach up to 2.0 and 2.5 metres per second for the 10 year and 100 year ARI events respectively **(Figure 4-13**). This is due to the topographic levels along Victoria Road dropping towards Iron Cove Bridge. Flood hazards for the 100 year ARI are shown in **Figure 4-14**. The hazards associated with main overland flow paths are predominantly medium hazard, however, there are localised areas of high hazard on the northern carriageway of Victoria Road. This is consistent with the *Leichhardt Flood Study*.

An assessment of flood risk posed to the Iron Cove Link was undertaken by comparing the location of the portals to the PMF flood extents presented in the Leichhardt Flood Study report and model results (2014). This location is subject to runoff generated in the small catchment to the north and east and conveyed along the roads, mainly Victoria Road and Crystal Street. The site is not identified as a flood control lot in the Leichhardt Development Control Plan 2013.

The flood mapping suggests that the Iron Cove Link portals may be at risk of inundation from overland flow paths on Victoria Road during the PMF event. The water flows in a north-westerly direction along Victoria Road towards Iron Cove Bridge. The median traffic barrier along Victoria Road provides an obstruction to overland flows and deflects floodwaters towards Iron Cove bridge (see **Annexure A** – Photo 9).

Darley Road

The Darley Road civil and tunnel site (C4), where the operational water treatment plant (WTP) for the M4-M5 Link may be located, is situated south of City West Link in the catchment of Hawthorne Canal. The site is situated in an area covered by two flood studies, the *Hawthorne Canal Flood Study* (WMAwater 2013) commissioned by Ashfield and Marrickville councils (now Inner West Council), and the *Leichhardt Flood Study*. The site slopes east to west with ground levels dropping from around 12 to four metres AHD. The eastern side of the Darley Road site sits higher than the CBD and Inner West Light Rail line to the north, with levels dropping by approximately eight metres in its western extent and sitting lower than the rail line. Sub-catchments draining to Darley Road civil and tunnel site are shown in **Figure 4-15**.

The existing flood conditions for the 10 and 100 year ARI design events and PMF are shown in **Figure 4-16** and **Figure 4-17**. The *Hawthorne Canal Flood Study* shows that the Darley Road site is located on the fringe of the 100 year ARI flood extent. However, the majority of the site may be inundated in a PMF, particularly the western half of the site, with depths of up to 0.5 metres within the site and up to one metre around the intersection of Darley Road and Charles Street. The *Leichhardt Flood Study* identified that part of the Darley Road civil and tunnel site (C4) may be subject to flooding during the PMF to similar depths. The site is identified as a flood control lot in the Leichhardt Development Control Plan 2013.

The site itself has a limited catchment area and the presence of low walls on the eastern side of the site reduces the potential for runoff to enter from higher ground near City West Link, deflecting it onto Darley Road and around to the south of the site.

During the PMF event, the north east section of the site is subject to flooding as a consequence of water spilling onto the site from the Light Rail Station platform area. The western section, which is the lowest part of the site, is inundated by floodwater during the PMF event as a consequence of water spilling from the Inner West Light Rail line as well as from water that collects at the topographic low point near the junction of Darley Road and Charles Street.

Localised inundation depths of less than 0.2 metres are expected for the 10 year ARI event. Maximum depths on the western section of the site are around 0.8 metres for the PMF event (see **Figure 4-18**).

The velocity of water through the site is generally less than 0.1 metres per second except on the steeper areas where water flows from Darley Road onto the site. Velocities on Darley Road are estimated to be up to 1.5 metres per second along the kerb line (see **Figure 4-19**).

Flood hazards in the vicinity of the site are generally low, but medium to high hazards are estimated along the north-eastern boundary with the light rail line (see **Figure 4-20**).

Pyrmont Bridge Road

The Pyrmont Bridge Road tunnel site (C9) is located near the top of the Johnstons Creek catchment. There is only a small catchment draining to the site but the dense existing building development means that all runoff is channelled along Bignell Lane. Water ponds at the low point on Bignell Lane, where the local drainage system connects to the road drainage system on Pyrmont Bridge Road, before draining towards Johnstons Creek. The *Leichhardt Flood Study* identified flood depths generally between 0.1 metres and 0.2 metres along Bignell Lane in the 100 year ARI event and up to one metre at the low point on Bignell Lane. Given the small catchment size, the relatively high flood depths are a result of the confined overland flowpath.

During construction, the existing buildings on the site will be demolished and replaced with facilities of a smaller footprint, which would allow for less concentrated overland flows paths and would also reduce the potential to displace water and impact surrounding properties. With appropriate site drainage to manage runoff at the Pyrmont Bridge Road tunnel site, the risk of flooding to the site from overland flow is considered to be low. Measures would include a combination of temporary piped drainage, open drains and swales, overland flow paths and sedimentation and erosion control measures.

Table 4-1 M4-M5 Link operational surface features and existing flood risk

Project surface feature	Catchment(s)	Existing flood risk assessment	Existing flood risk review	Further assessment required
Wattle Street interchange	Dobroyd Canal	M4 East EIS (Roads and Maritime 2015a) M4 East Final Design (CSJ 2016a, b)	· M4-M5 Link portals and cut and cover sections of the tunnel have been constructed as part of the M4 East project · M4 East project has designed raised road crests at the entry to the tunnels above the PMF level · The M4 East ventilation facility at Walker Avenue (Parramatta Road ventilation facility) has been designed to be flood protected in design storm events up to the PMF, by providing bunds and walls around the site and local drainage systems to direct stormwater runoff away from critical buildings. · The M4-M5 Link project will not change the M4 East design surface layout or levels; therefore, it is considered that the: - Risk of flooding to the M4-M5 Link tunnel structure in a PMF event is low - M4-M5 Link project will not have an impact on flood risk to surrounding properties at this location · Therefore, no further mitigation measures are considered to be required beyond that provided by the M4 East project.	No
Rozelle interchange	Easton Park drain, Rozelle Bay, Whites Creek	Leichhardt Flood Study (Cardno 2014a)	· The Rozelle Rail Yards is subject to extensive flooding in the 5 year ARI event · Limited information available from the Leichhardt study on flood depths at the Rozelle Rail Yards and the potential risk to project (inundation of portals) · The project has the potential to displace water and impact on flood risk to surrounding properties at this location · A replacement bridge structure is proposed over Whites Creek at The Crescent · Critical project infrastructure such as the Rozelle interchange motorway operations complexes (MOC2 and MOC3) and tunnel ventilation facility are located at the Rozelle Rail Yards.	Yes
Iron Cove Link	Iron Cove	Leichhardt Flood Study (Cardno 2014a)	· An overland flowpath is present on Victoria Road for the 5 year ARI event · Floodwater depths of up to 0.3 metres for the PMF and peak flow velocities between 2-3 metres per second for PMF	Yes

Project surface feature	Catchment(s)	Existing flood risk assessment	Existing flood risk review	Further assessment required
			· Potential risk to project (inundation of portals and flooding of the Iron Cove Link motorway operations complex (MOC4)) · Potential for project to displace water and impact on flood risk to surrounding properties at this location.	
St Peters interchange	Alexandra Canal	M5 EIS (Roads and Maritime 2015b) New M5, Substantial Detailed Design report, Rev D, (CDS 2016a)	· The tunnel stubs for the M4-M5 Link and New M5 project have been constructed as part of the New M5 project · Mitigation measures for the New M5 project include a bund around the perimeter of the interchange and upgrades to the local drainage network around the interchange · The M4-M5 Link portals would be at low risk of flooding as they are protected from the PMF by the measures provided by the New M5 project · The New M5 tunnel ventilation facility (St Peters ventilation facility) has been designed to be above the PMF event · The M4-M5 Link tunnel ventilation facility (Campbell Road motorway operations complex (MOC5)) is proposed to be located above the tunnel portal and would therefore also be flood protected up to the PMF event · The M4-M5 Link project would not change surface levels or layout outside of the perimeter flood bund and therefore will not have a detrimental impact on flood risk to surrounding properties at this location · No further mitigation is required in addition to that provided as part of the New M5 project at this location.	No
Darley Road	Hawthorne Canal	Hawthorne Canal Flood Study (WMAwater 2013), Leichhardt Flood Study (Cardno 2014a)	· Localised ponded water on the north-eastern side of the site for 20 year ARI event · Flood water depths up to 0.8 metres during the PMF event · Potential risk to project (inundation of portals and Darley Road motorway operations complex (MOC1)) · Potential to displace water and impact on flood risk to surrounding properties at this location.	Yes

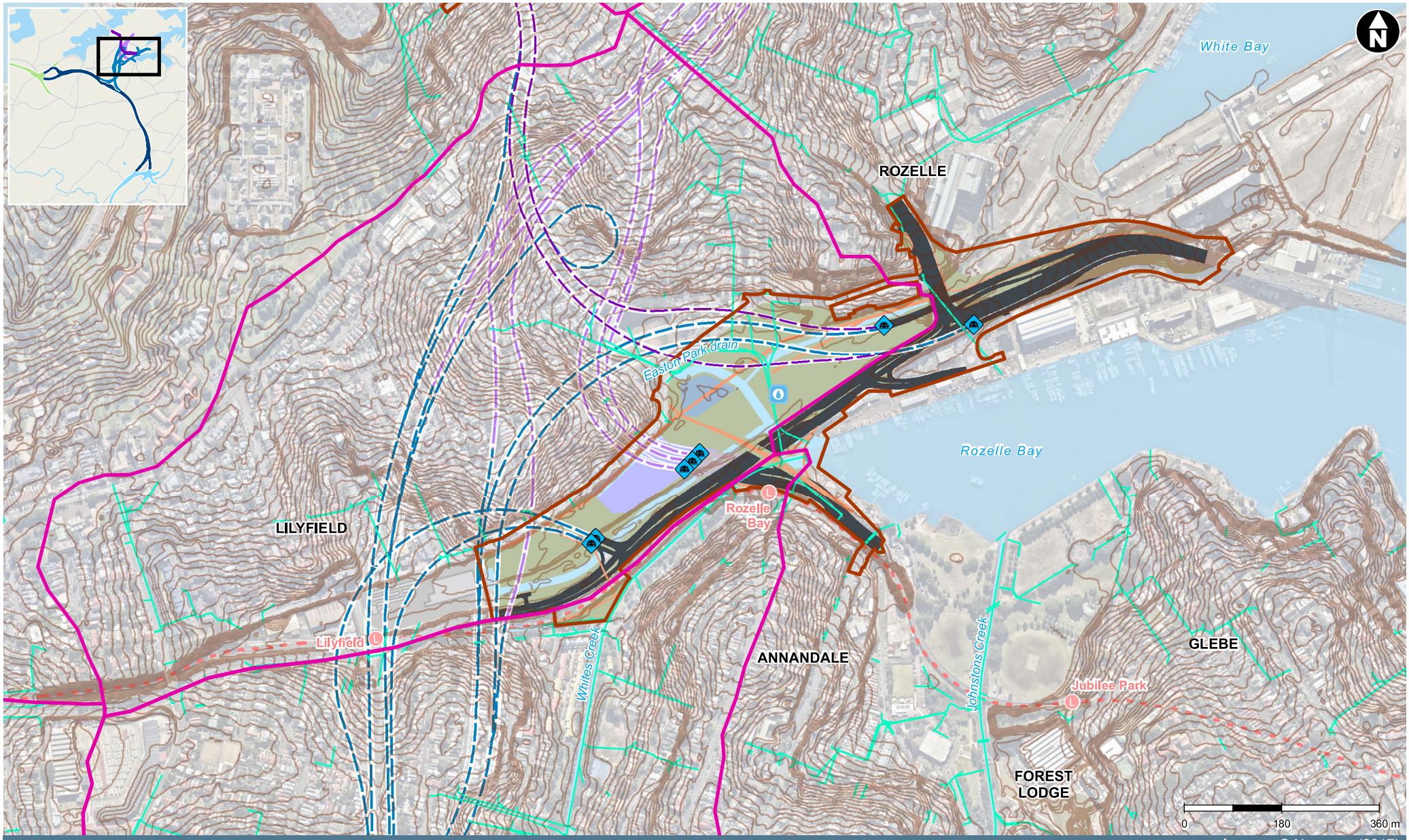


Figure 4-3 Subcatchment draining to Rozelle civil and tunnel site

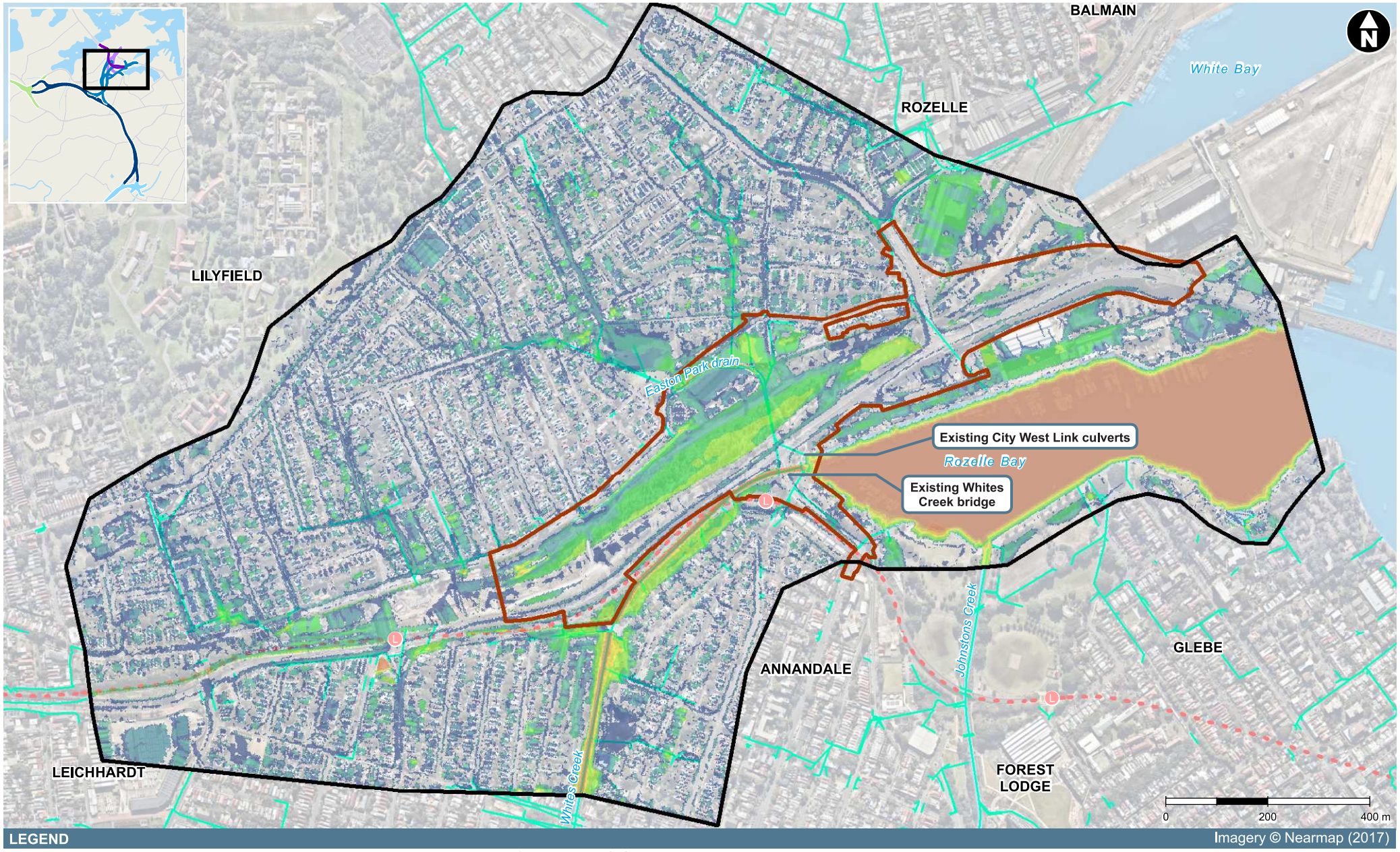


Figure 4-4 Present day flood behaviour – Rozelle interchange - peak flood depths (10 year ARI)

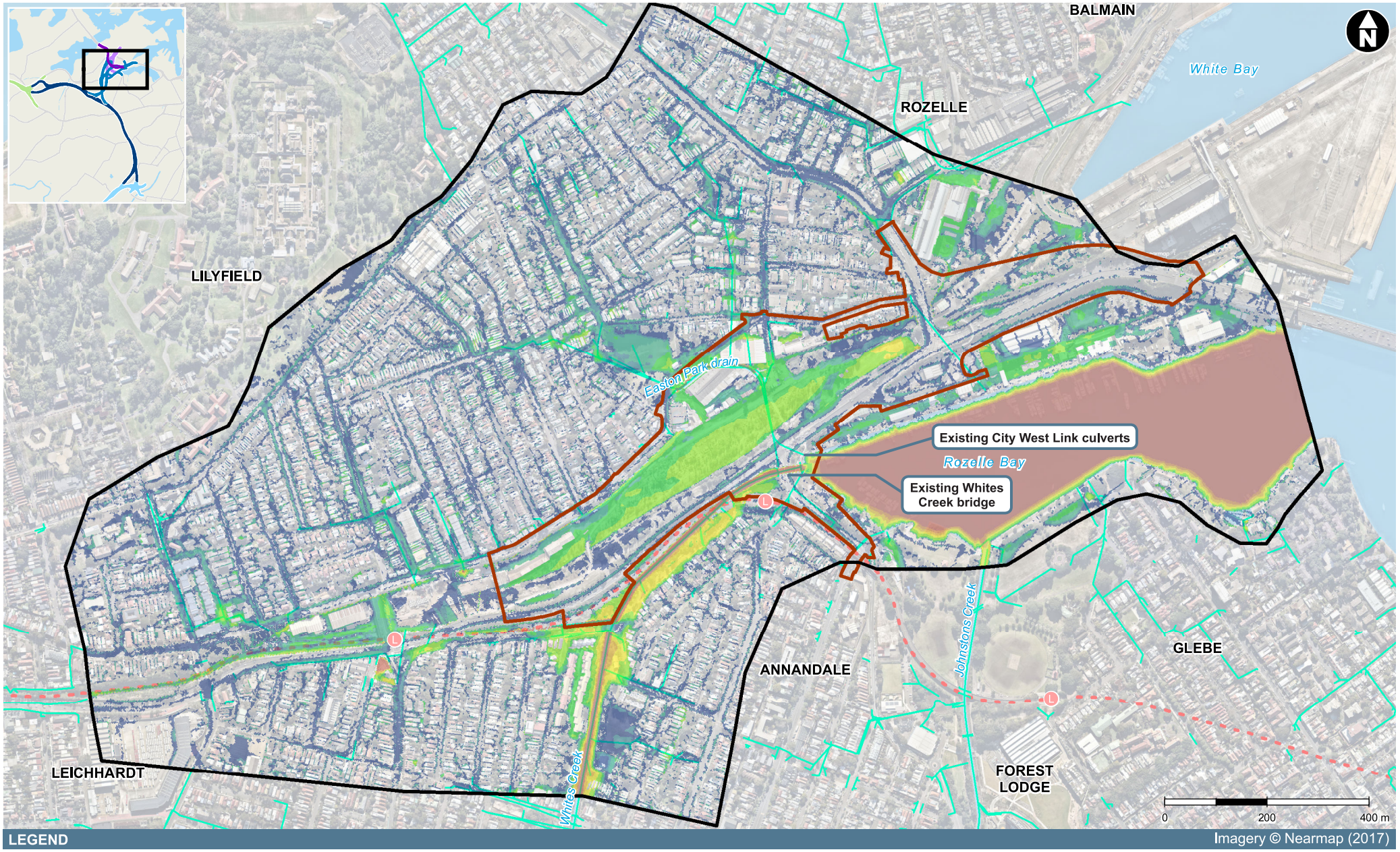


Figure 4-5 Present day flood behaviour – Rozelle interchange - peak flood depths (100 year ARI)