M1 Princes Motorway

Mount Ousley interchange

NSW Roads and Maritime

Water Quality Assessment

Rev 04

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M1 Princes Motorway
Mt Ousley interchange upgrade

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Water Quality Assessment

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Contents

1. Introduction

1.1 Proposal background

Jacobs has been appointed by Roads and Maritime Services to undertake the concept design and environmental assessment for the upgrade of the M1 Princes Motorway Interchange at the base of Mount Ousley.

The M1 Princes Motorway is the primary road link between Sydney and the Illawarra with average daily traffic of more than 50,000 vehicles per day using this link at the base of Mount Ousley near Wollongong. Heavy vehicles represent up to 15% of total daily vehicle movements. The Princes Motorway and Mount Ousley Road currently experience heavy traffic congestion particularly during weekday, weekend and holiday peaks. The intersection of these two roads is the only location on the Princes Motorway between Waterfall and Albion Park Rail (a distance of about 60 kilometres) where vehicles turning right to access the motorway need to give way to oncoming motorway traffic. In addition to poor road network performance, 56 crashes were recorded near the intersection during the five year period between July 2011 and June 2016 (inclusive). Of the 56 crashes, one crash resulted in one fatality and four injuries, and 25 were injury crashes resulting in 28 injuries. The two most common crash types were intersection and rear end crashes.

The southbound carriageway of the motorway has a sign-posted speed limit of 80 kilometres per hour for light vehicles and 40 kilometres per hour for heavy vehicles (trucks and buses). This speed differential creates conflicts between light and heavy vehicles as faster moving light vehicles (travelling in the median lane) are required to cut across groups of slower moving heavy vehicles (travelling in the kerbside lane) to access the exit at Mount Ousley Road, which is the primary access from the north to the Wollongong CBD and surrounding suburbs. Conflicting interactions between light and heavy vehicles create road safety risks as well as contributing to flow breakdowns (stop-start or acceleration and braking) conditions, thus affecting the efficiency of the network in this area. In turn, this reduces the efficiency of access to nearby destinations, such as the Wollongong CBD and University of Wollongong.

Further south on the motorway, the southbound morning traffic queue from University Avenue is observed to extend back toward the motorway with vehicles largely bound for the university. This also creates flow breakdown on the motorway with associated increased risk of vehicle crashes as vehicles intending to exit to University Avenue slow down on the through lanes of the motorway. Modelling shows that in the future years, these queues will regularly extend back onto the motorway in peak hours and past the Mount Ousley Road intersection blocking access into Wollongong.

Additionally, the M1 Princes Motorway creates a barrier for safe pedestrian and cyclist movements between the University of Wollongong and suburbs to the north. Within three kilometres of the university, 23 percent of students live to the north of the campus however only four percent of people who walk to the university come from suburbs to the north.

1.2 The proposal

The proposal is situated at the base of the Illawarra escarpment at Mount Ousley, where the M1 Princes Motorway enters Wollongong via an existing at-grade intersection with Mount Ousley Road. The main features of the proposal, as shown in **Figure 1-1** include:

- An overpass from Mount Ousley Road to allow northbound traffic to safely access the M1 Princes Motorway
- A dedicated heavy vehicle bypass lane, to separate heavy vehicles from general southbound traffic on the M1 Princes Motorway and light vehicles exiting at Mount Ousley Road
- A dedicated southbound heavy vehicle exit ramp to Mount Ousley Road, to separate heavy and light vehicles exiting the M1 Princes Motorway to Mount Ousley Road
- A new entry to the University of Wollongong from the M1 Princes Motorway, for both northbound and southbound vehicles, via a new overpass from Mount Ousley Road and a new (northbound) motorway exit ramp
- A new exit from the University of Wollongong to the M1 Princes Motorway northbound, and to Mount Ousley Road via the new overpass

- New roundabouts at Mount Ousley Road, servicing the new entrance to the University of Wollongong and for vehicles exiting the Motorway (from northbound and southbound lanes) at Mount Ousley Road
- A new southbound service road, which would replace the existing southbound access from the M1 Princes Motorway to University Avenue
- Two new heavy vehicle safety ramps
- A new pedestrian and cyclist bridge over Mount Ousley Road and the M1 Princes Motorway, and a new shared path connecting suburbs to the north with the University of Wollongong and the TAFE Illawarra Wollongong campus
- Upgrades to the existing pedestrian bridge over the M1 Princes Motorway at Northfields Avenue, comprising modifications to the bridge span and the eastern access ramp
- A new commuter car park, relocated to the southern side of the M1 Princes Motorway, with additional formalised parking spaces
- New noise walls along the M1 Princes Motorway, between the motorway and nearby residential areas
- New noise walls along Mount Ousley Road, between the M1 Princes Motorway interchange and Gaynor Avenue.

The proposal extends on the motorway from about 450 metres west to just over 1,000 metres south of the existing intersection with Mt Ousley Road, and about 650 metres east on Mt Ousley Road between the M1 Princes Motorway and Gaynor Avenue, as shown in **Figure 1-1**. The overall footprint of the proposed interchange extends north of Mt Ousley Road up to the southern edge of Dumfries Avenue, and into the land occupied by the University of Wollongong on the southern side. The proposed works extend south along the M1 Princes Motorway corridor as far as the University Avenue interchange and overpass. Along the eastern side, the proposal's footprint would encroach into a narrow strip of land occupied by the Illawarra TAFE campus. In addition, an existing parcel of Roads and Maritime owned land bounded by the M1 Princes Motorway, Mount Ousley Road, Gowan Brae Avenue and the Illawarra TAFE campus, would be temporarily used as a site construction compound which may be converted into a permanent traffic incident response unit.

1.3 Scope of this report

This working paper provides an assessment of surface water quality within the proposal area. The potential water quality impacts associated with the construction and operation of the proposal are identified and discussed with the provision of mitigation measures to address the potential impacts. Recommendations are also made regarding monitoring activities to be undertaken to assess the impacts of the proposal during construction and operation.

Impact mitigation measures during the construction phase of the proposal include the development of a Soil and Water Management Plan (SWMP), with erosion and sediment controls being used at the source, such as sedimentation basins. The proposed locations and approximate sizing of temporary sedimentation basins will be provided as part of the detailed design. Impact mitigation during the operational phase involves permanent water quality features such as vegetated swales and spill basins. The location and size of these permanent water quality control features are provided in this report for the entire length of the proposal.

The assessment of existing conditions has been made using existing water quality data and literature. The assessment of existing water quality in the waterways is in accordance with default trigger values for slightly to moderately disturbed aquatic ecosystems outlined in the Australian and New Zealand guidelines for fresh and marine water (ANZECC/ARMCANZ 2000).

1.4 Report structure

This working paper is structured as follows:

- Chapter 1 – Proposal background and description
- Chapter 2 - A description of the methodology used for the assessment and an outline of the water quality objectives
- Chapter 3 - An overview of the existing environment
- Chapter 4 - An assessment of potential impacts from the construction and operation of the proposal on water quality within the proposal area.
- Chapter 5 – Potential mitigation measures including a conceptual erosion and sediment control design strategy for key water quality control requirements for the construction and operational phases of the proposal.
- Chapter 6 – Conclusion.

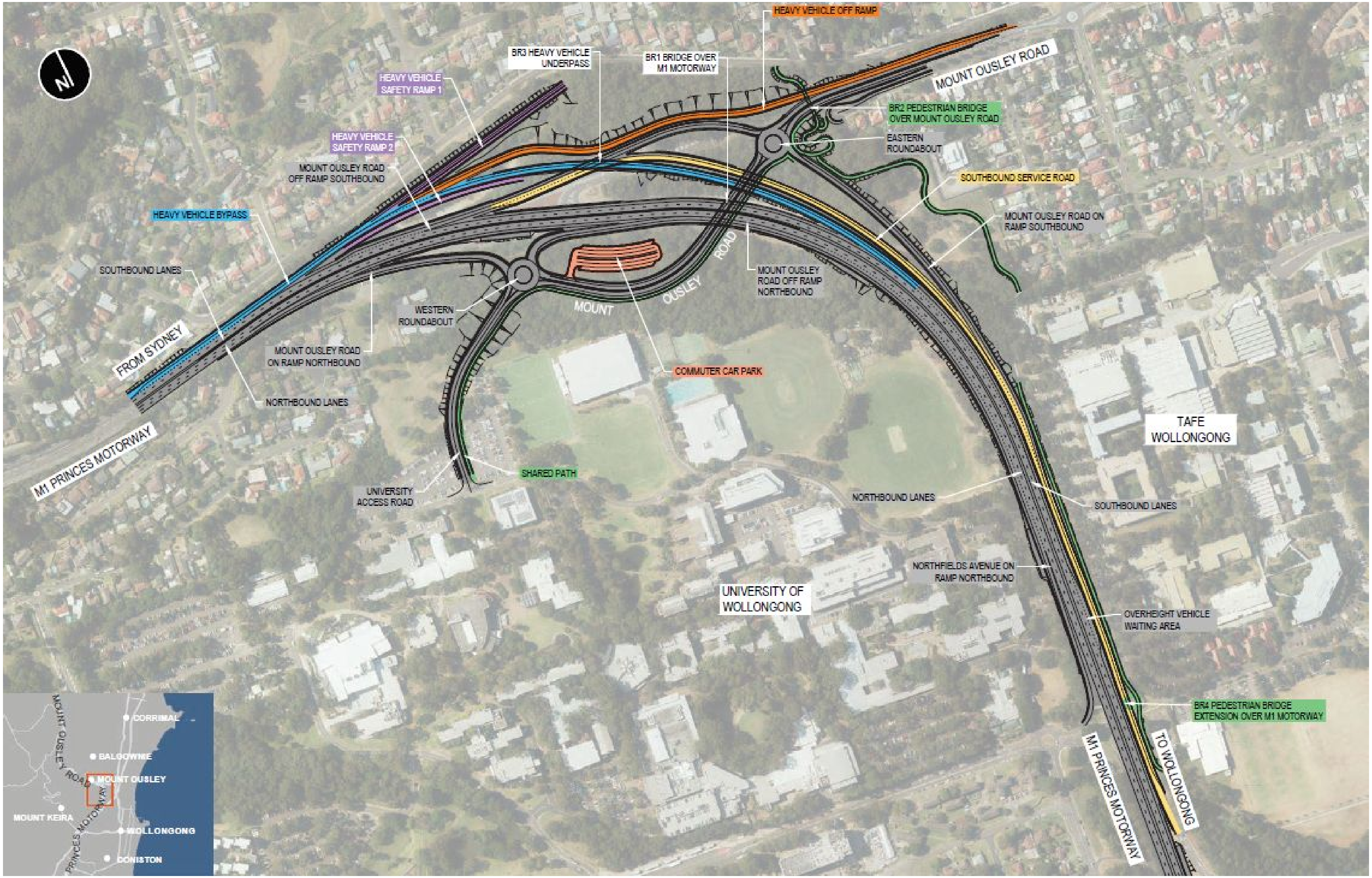

Figure 1-1 The proposal

2. Methodology

Assessment of likely and potential impacts of the proposal on surface water quality during construction and operation has included:

- Review of existing literature relating to the proposal, available water quality data and existing conditions using available non-proposal literature to obtain background information on catchment history and land use to aid in interpreting the existing conditions
- Assessment of the impact of construction activities on water quality with reference to the ANZECC/ARMCANZ (2000) water quality guidelines for protection of the relevant environmental values of aquatic ecosystems and visual amenity
- Review of water quality treatment measures that could be used to mitigate the impact of construction on water quality, following the principles of Managing Urban Stormwater–Soils and Construction Volume 1 (Landcom 2004) and Volume 2D (DECC 2008)
- Review of water quality treatment measures that could be used to mitigate the impact of the operation of the proposal on water quality following the principle of Procedure for Selecting Treatment Strategies to Control Road Runoff (RTA 2003), Roads and Maritime Water Policy (RTA 1997) and Roads and Maritime Code of Practice, Water Management (RTA 1999).

2.1 Requirements and guidelines

There are a number of guidelines and management procedures relevant to the assessment of surface water quality. These guidelines and procedures have been used to determine existing water conditions along the proposal and identify the appropriate water quality management and mitigations measures for implementation during the construction and operational phases of the proposal.

2.1.1 Statutory requirements

The following NSW legislation and statutory requirements apply to the water quality assessment work:

- Protection of the Environment Operations Act 1997 (POEO Act)
- Protection of the Environment Administration Act 1991
- Local Government Act 1993
- NSW Fisheries Management Act 1994
- Water Management Act 2000
- The State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011 (the SEPP)
- Water Management (General) Regulation 2011.

2.1.2 Water quality guidelines

The water quality guidelines and objectives applicable to the protection of the nominated environmental values that will be applied in the assessment of surface water quality are presented in Table 2-1. For the protection of aquatic ecosystems in this region, the ANZECC/ARMCANZ (2000) default trigger values for physical and chemical stressors for ‘South-East Australian slightly to moderately disturbed lowland rivers’ have been applied. Recommended limits for metals are in accordance with ANZECC/ARMCANZ (2000) trigger values for toxicants for the protection of 95% of freshwater aquatic species.

Table 2-1 – Water quality guidelines

Indicator	Freshwater	Estuarine
Conductivity (µs/cm)	125-1200	No Guideline
pH	6.5-8.5	7-8.5
Dissolved oxygen (% saturation)	85-110	80-110
Suspended Solids (mg/L)	<50	<50
Ammonia (µg/L)	<20	<15
Oxidised nitrogen (µg/L)	<40	<15
Total nitrogen (µg/L)	<350	<300
Total Kjeldahl Nitrogen (TKN) (µg/L)	<310	<285
Total Phosphorus (µg/L)	<25	<30
Copper (µg/L)	<1.4	<1.3*
Zinc (µg/L)	<8	<15*
Lead (µg/L)	<3.4	<4.4*
Manganese (µg/L)	<1900	No guideline
Arsenic (µg/L)	<13	No guideline
Cadmium (µg/L)	<0.2	<5.5*
Chromium** (µg/L)	<1	<1*
Nickel (µg/L)	<11	<70*
Mercury (µg/L)	<0.6	<0.4*
Aluminium (µg/L)	<55	No guideline

2.1.3 Construction phase mitigation guidelines

The following design guidelines and management procedures are relevant in identifying the appropriate water quality management and mitigation measures to be implemented during the construction phase of the proposal:

- NSW DECC (2008), Managing Urban Stormwater-Volume 2D Main Road Construction, NSW Department of Environment, Climate Change and Water (known as the Blue Book Volume 2): Sydney.
- Landcom (2004), Managing Urban Stormwater- Soils and Construction, Volume 1, 4th Edition (known as the Blue Book Volume 1): Sydney.
- RTA (2003b), Road Design Guideline: Section 8 Erosion and Sediment, Roads and Traffic Authority of NSW: Sydney.
- RTA (2003d), Guideline for Construction Water Quality Monitoring, Roads and Traffic Authority of NSW: Sydney.
- RTA (2009), Erosion and Sediment Management Procedure, Oct 2009, Roads and Traffic Authority of NSW: Sydney.
- RTA (1999), Code of Practice for Water Management - Road Development and Management, Roads and Traffic Authority of NSW: Sydney.
- Roads and Maritime (2012), Environmental Direction: Management of Tannins from Vegetation Mulch, Roads and Maritime Services: Sydney.
- RTA (2005), Guidelines for the Management of Acid Sulphate Materials: Acid Sulphate Soils, Acid Sulphate Rock and Monosulfidic Black Ooze, Roads and Traffic Authority of NSW: Sydney.
- RTA (2001), Stockpile Site Management Procedures, Roads and Traffic Authority of NSW: Sydney.

- Roads and Maritime (2011), Technical Guideline: Temporary Stormwater Drainage for Road Construction, Roads and Maritime Services: Sydney.
- Roads and Maritime (2011), Technical Guideline – Environmental Management of Construction Site Dewatering, Roads and Maritime Services: Sydney.

These guidelines seek to minimise land degradation and water pollution from road construction sites in NSW. The guidelines have been used to identify appropriate management procedures during construction works and physical controls to minimise erosion and to prevent sediment moving off site during the construction phase.

2.1.4 Operational phase mitigation guidelines

The following design guidelines and management procedures are relevant in identifying the appropriate water quality management and mitigation measures to be implemented during the operational phase of the proposal:

- RTA (2003a), Procedures for Selecting Treatment Strategies to Control Road Runoff, Roads and Traffic Authority of NSW: Sydney.
- RTA (1999), RTA Code of Practice for Water Management, Roads and Traffic Authority of NSW: Sydney.
- RTA (1997), RTA Water Policy, Roads and Traffic Authority of NSW, Sydney.
- EPA (1997), Managing Urban Stormwater: Council Handbook, NSW Environmental Protection Authority: Sydney.
- Austroads (2001), Road Runoff and Drainage: Environmental Impacts and Management Options, Austroads AP-R180.
- Austroads (2003), Guidelines for Treatment of Stormwater Runoff from the Road Infrastructure, Austroads AP-R232.
- Austroads (2010), Guide to Road Design, Part 5: Drainage Design, Austroads: Sydney.
- DECCW (2007), Managing Urban Stormwater, Environmental Targets Consultation Draft, Department of Environment, Climate Change and Water: Sydney.
- VicRoads (2011), Integrated Water Management Guidelines, VicRoads: Melbourne.

The objective of these documents is to provide guidance on water management practices, water quality and quantity, and water conservation issues related to the design, operation and maintenance of the roads and traffic system. This is in order to protect waterways and water quality where practicable and feasible. They provide guidance on the process of designing permanent water quality treatment in a consistent and practicable manner. The design for the proposal would address the sensitivity of receiving waters and local environment along the proposal alignment.

2.2 Water quality objectives

Current surface water quality in the proposal area potentially does not meet existing guidelines and trigger values for protecting nominated environmental values. Irrespective of the current condition of waterways, the proposal should not further degrade water quality. As such the key objective of the proposal is to minimise the potential impacts on downstream receiving waters, so that the proposal changes the existing water regime by the smallest amount practicable. This objective is consistent with *the Roads and Maritime's Water Policy 1997* (RTA, 1997) and *Code of Practice for Water Management 1999* (RTA, 1999).

Roads and Maritime approach to water quality management is to provide operational water quality control measures for the following sensitive receiving waters:

(i) Class 1 or Class 2 fish habitat waterways (in accordance with the DPI guideline *"Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings (2003)*";

(ii) Any waterway that discharges into SEPP 14 wetlands that are located within 500 metres of the project;

(iii) Any waterway that discharges to waters that are used for the purposes of human consumption and located within 500 metres of the project;

(iv) Any water sensitive threatened species habitat, endangered ecological communities, or other identified areas of biodiversity conservation significance.

None of the above sensitive receiving environments are located within the study area.

An additional water quality objective is to contain any accidental spill of hydrocarbons that may occur within the proposal area. The target is to provide a basin that would contain a spill of up to 40m^3. Following a desktop assessment to determine the risks associated with the upgraded road layout and profile, it has been decided to provide spill basins at the three main pavement discharge locations on the basis of the high traffic volume, the proportion of heavy vehicles, the vertical profile steepness and the horizontal geometry. Refer to Section 4.2.2.

3. Existing environment

3.1 Proposal area

The proposal is located approximately 135 kilometres south of Sydney, at the junction of Mount Ousley Road and the M1 Princes Motorway, approximately 3 kilometres north-west of Wollongong CBD (**Figure 1-1**). The proposal is situated within the Wollongong City Council local government area. The broader study area consists primarily of low to medium density housing and Wollongong University. Downstream of the proposal area, the catchment contains residential, industrial and commercial developments.

The proposal area is situated on the foothills of the Illawarra escarpment which lies to the west. The Illawarra escarpment, ranges from 250 to 500 m above sea level and is generally responsible for creating an east/west rainfall gradient across the area. During storm events the creeks and drainage lines experience high velocity flows, which carry large amounts of erosional materials down the steep escarpment slopes into the coastal creeks and lagoon downstream (WBM 2006). Riparian vegetation is limited and highly modified within the proposal area, providing minimal bank stability from erosion.

Fairy Lagoon is an Intermittently Closed and Open Lake or Lagoon (ICOLL) located downstream of the proposal Area. Fairy Lagoon's entrance is usually closed, naturally discharging only when the catchment flows are sufficient to breach the sand berm at the entrance. Pollutants transported into Fairy Lagoon are likely to be retained within for much longer than they would be in a more open system or estuarine channel which receives greater tidal flushing.

3.1.1 Waterways and Catchments

Two minor freshwater, tributaries occur within the study area, a tributary of Cabbage Tree creek to the north, and a tributary of Fairy Creek to the south. The Fairy Creek and Cabbage Tree Creek catchment covers a combined area of 2076 ha (Wollongong City Council, 2010). The upper reaches of Fairy and Cabbage Tree Creeks are highly branched and pass primarily through residential areas with limited riparian vegetation. Downstream of the study area, the two creeks join midway into the catchment, to the west of an industrial area to form Fairy Lagoon approximately 1 kilometre downstream. The tidal limit of Fairy Creek is 100m upstream of Flinders Street Bridge, whilst within Cabbage Tree Creek the tidal limit is 20m downstream from Montague Street Bridge.

3.1.2 Key fish habitats

Two watercourses occur within the study area, a tributary of Fairy Creek and a tributary of Cabbage Tree Creek. Both tributaries are not identified as key fish habitat based on DPI (2007) mapping. Site investigations have also confirmed no key fish habitat is present based upon the *Department of Primary Industries Policy and Guidelines for Fish Habitat Conservation and Management* (DPI 2013). Both watercourses are impacted, minor first and second order streams, with limited water and instream aquatic habitat. No threatened or protected fish species are expected to occur.

3.1.3 Sensitive receiving environments

Sensitive receiving environments have been identified using aquatic habitat as an indicator, which was assessed against the NSW *Department of Primary Industries Policy and Guidelines for Fish Habitat Conservation and Management* (2013) and Fish Passage Requirements for Waterway Crossings (Fairfull & Witheridge 2003). Sensitive receiving environments are identified based on the following considerations:

- Key Fish Habitat
- Groundwater and surface water dependant TSC listed vegetation communities, EPBC listed saltmarsh communities
- SEPP and RAMSAR Wetlands
- Drinking water catchment

- Areas that contribute to aquaculture and commercial fishing.

No watercourses within the study area have been defined as a sensitive receiving environment.

Activities and decisions made upstream affect water quality downstream, particularly the cumulative impacts of nutrients and sediments. Fairy Lagoon is the downstream receiving environment to the proposal area. The water quality within Fairy Lagoon is integrally linked to the level of pollutants that are discharged, and tidal flushing of the lagoon, to dispose of these pollutants before they become problematic. Catchment runoff can result in elevated nutrient levels and subsequent algal blooms, which are undesirable given the proximity to popular recreation areas surrounding Fairy Lagoon. Fairy Lagoon is artificially opened in accordance with the Fairy Lagoon Entrance Management Policy (Cardno Lawson Treloar 2007), which has a trigger level set at 1.6 m AHD. Seagrass beds (*Zostera Capricorni* and *Ruppia spp.*) occur in small scattered patches near the southern shore of Fairy Lagoon, and there are isolated wetlands surrounding Fairy Lagoon. Fairy Lagoon is defined a Type 2 – Moderately Sensitive Key Fish Habitat NSW *Department of Primary Industries Policy and Guidelines for Fish Habitat Conservation and Management* (2013) due to the isolated patches of seagrass and the Lagoons artificial opening by council.

3.2 Environmental Values

Environmental values are particular values or uses of the environment that are important for a healthy ecosystem or for public benefit or health. They are values that require protection from the effects of pollution and waste discharges (ANZECC/ARMCANZ 2000). The Office of Environment and Heritage (OEH) have nominated a number of environmental values for the Illawarra Catchment and relevant indicators and guideline levels which are used in protecting the environmental value (DECCW 2006).

There are a number of recognised environmental values, and for the purposes of this assessment those relevant include:

- Aquatic ecosystems
- Visual amenity
- Primary and secondary contact recreation.

3.2.1 Aquatic Ecosystems

The most relevant environmental value for the purposes of this assessment is aquatic ecosystems. Aquatic ecosystems comprise the animals, plants and micro-organisms that live in water and the physical and chemical environment in which they interact. Aquatic ecosystems have historically been impacted upon by multiple pressures including changes in flow regime, modification and destruction of key habitats, development and poor water quality.

Aquatic ecosystems can range from freshwater to marine and comprise the animals, plants and micro-organisms that live in water and the physical and chemical environment in which they interact. Aquatic ecosystems have been impacted upon by multiple pressures including changes in flow regime, modification and destruction of key habitats, development and poor water quality. There are a number of naturally occurring physical and chemical stressors that can cause degradation of aquatic ecosystems and for the purposes of this assessment include nutrients, dissolved oxygen, pH, metals, salinity and turbidity (suspended solids). These are discussed below.

- Nutrients in aquatic environments promote the growth of algae and increase turbidity which in turn reduces light and may affect plant growth. Generally excessive nutrient inputs lead to excessive algal growth and formation of nuisance blooms. Nutrients consist of nitrogen (including total nitrogen, oxidised nitrogen and ammonia) and phosphorus (including total phosphorus and filterable reactive phosphorus (FRP)).
  - **Total Nitrogen** is a measure of all the nitrogen species found in a water body including oxidised nitrogen, ammonia and total organic nitrogen).

- **Oxidised Nitrogen** represents the level of free nitrogen within the water column that is readily available to plants. Excessive concentrations of oxidised nitrogen concentrations can promote algal growth.
- **Ammonia** is the most reduced form of inorganic nitrogen available, and is preferentially utilised by plants and aquatic micro-organisms. The main sources of ammonia in aquatic ecosystems are from human and animal wastes and that which is released by bacteria during the decomposition of organic material.
- **Total Phosphorus** is a measure of both biologically available species (known as filterable reactive phosphorus) and the unavailable species. There are two forms of dissolved phosphorus in the water body, organic phosphorus produced from the decay of plant and animal material and inorganic orthophosphates, which are released through breakdown of rock and transported into the waterbody.
- **Filterable Reactive Phosphorus** is a measure of orthophosphates which is the readily available biological component of total phosphorus. Concentrations of FRP within a waterbody can be influenced by variations in pH, oxygen levels and turbidity.
- **Total Kjeldahl Nitrogen** is the total concentration of organic nitrogen and ammonia. An abundance of nutrients in the water leads to excess plant growth and eventually to eutrophication.

- **pH** is a measure of the acidity or alkalinity of a waterbody. Changes in pH can impact the ability of aquatic organisms to maintain basic functions such as respiration. pH also controls the bioavailability of metals, nutrients and other organic molecules. Potential sources of changes to pH include changes in the level of organic matter within the system, agricultural runoff from low pH soils (eg acid sulphate soils (ASS)) and changes in salinity.
- **Turbidity** is a measure of the optical clarity of a water body which is important in characterising the health of a waterbody. Changes in the availability of light can affect the distribution of animals and potentially alter the chemical characteristics of the waterbody. Suspended solids from runoff or land disturbance can result in increased turbidity, thereby reducing light penetration, modification of physical habitat and smothering of biota thereby impacting on aquatic ecosystems.
- **Dissolved oxygen** (per cent saturation and milligrams per litre (mg/L)) is a measure of the amount of oxygen dissolved in water. Dissolved oxygen is vital for many forms of estuarine biota including native fish, and is also vital for the functioning of healthy aquatic ecosystems.

Metals occur naturally at trace levels in the environment. This category includes the elements arsenic, cadmium, copper, chromium, iron, lead, manganese, mercury, nickel, selenium and zinc. Organisms require varying amounts of some of these metals for various biological functions. However, excessive levels can be toxic and can enter the food chain through bioaccumulation. Heavy metals can be present in the dissolved form or bound to sediment particles. Potential sources of metals include urban stormwater such as runoff from roads, industrial waste discharges and sewage treatment plant effluent.

3.2.2 Visual Amenity

The aesthetic appearance of a waterbody is an important aspect with respect to recreation. As such the water should be free from noticeable pollution, floating debris, oil, scum and other matter. Substances that produce objectionable colour, odour, taste or turbidity and substances and conditions that produce undesirable aquatic life should not be apparent (NHMRC 2008). The key aesthetic indicators are transparency, odour and colour. These have been considered in the assessment of existing water quality and potential impacts as a result of the proposal.

3.2.3 Primary and Secondary Contact Recreation

Recreational activities downstream of the study area are highly valued by the community in the study area and therefore the protection of the water for recreational use is necessary. There are two main categories of recreational water use; primary contact and secondary contact recreation. Primary contact recreation implies direct contact with the water via bodily immersion or submersion with a high potential for ingestion. Activities classified as primary contact recreation include swimming, diving and water skiing. Secondary contact recreation implies some direct contact with the water will be made but where ingestion is unlikely such as the activities of boating, fishing and wading. Bacteriological indicators are used to assess the suitability of water for recreation.

3.3 Existing Water Quality

The water quality in Fairy Creek is largely influenced by urban development. Fairy Creek is typically subjected to high velocity flows from the steep escarpment down towards the coastal plains. The watercourses within the proposal area boundaries are classified as freshwater, however further downstream the receiving environment is classified as estuarine (**Figure 3-1**). Limited water quality data is available within the proposal area, with the most recent relevant water quality data collected by Wollongong City Council. Monitoring was undertaken on a monthly basis from August 2002 to March 2006 at three locations, Fairy Creek immediately downstream of the proposal (Site 22), Fairy Creek – upstream of the proposal (Site 23) and within the downstream receiving environment, Fairy Lagoon (Site 21) (**Figure 3-1**).

Water quality within Fairy Creek was reflective of the urbanised catchment with high nutrient concentrations observed at both freshwater sites (Site 23 & Sites 22). The median total phosphorus, total nitrogen and ammonia (as NH_4) concentrations were above the ANZECC/ARMCANZ (2000) recommended guidelines. Dissolved oxygen (DO) was low within Fairy Creek, with DO outside the recommended guideline (85-110% saturation) at Site 23 (67.4% saturation) and Site 22 (70.5% saturation). Within the upstream Fairy Creek site (Site 23), metal concentrations were low, with all parameters within the recommended guidelines. However, downstream at Site 22, the median concentrations of copper (4 µg/L) and zinc (19 µg/L) exceeded the recommended guidelines of 1.4 µg/L and 8 µg/L respectively.

Downstream within Fairy Creek Lagoon (Site 21), nutrient concentrations remained high, reflecting the limited tidal flushing which occurs within the ICOLL. Total nitrogen, TKN and ammonia exceeded the recommended guidelines. Copper and zinc concentrations remained elevated, however only copper (5 µg/L) exceeded the more conservative estuarine guidelines (1.3 µg/L).

Overall the historic water quality in the proposal area indicates slightly eutrophic conditions with low oxygen and high nutrients. These conditions are likely due to the high nutrient and sediment inflows from the upstream catchment. Generally the aquatic ecosystems are considered impacted due to the elevated nutrient concentrations. It is likely that water quality conditions have changed since the monitoring was last undertaken in 2006, as catchment land uses have changed and urbanisation has continued to develop within the Proposal area.

Table 3-1 Median Wollongong City Council Monthly Water Quality Monitoring (2002-2006)

Parameter	Site 23 (upstream)	Site 22 (downstream)	Freshwater ANZECC/ARMCANZ (2000) Guidelines	Site 21 (Fairy Creek Lagoon)	Estuarine ANZECC/ARMCANZ (2000) Guidelines
pH	7.72	7.94	6.5-8	7.61	7-8.5
Conductivity µs/cm	266.9	614	125-2200	21496	#
Dissolved Oxygen (% sat)	**67.4**	**70.5**	85-110	98	80-110
Suspended Solids (mg/L)	3	#	50	11	50
Total Phosphorus (mg/L)	**0.03**	**0.065**	0.025	0.0295	0.03
Total Nitrogen (mg/L)	**0.4**	**0.42**	0.35	**0.38**	0.3
Total Kjeldahl Nitrogen (TKN) (mg/L)	0.21	**0.34**	0.31	**0.37**	0.285
Ammonia* mg/L	**0.02**	**0.03**	0.015	**0.04**	0.015
Copper (µg/L)	0.1	**4**	1.4	**5**	1.3
Zinc (µg/L)	7	**19**	8	14.5	15

Parameter	Site 23 (upstream)	Site 22 (downstream)	Freshwater ANZECC/ARMCANZ (2000) Guidelines	Site 21 (Fairy Creek Lagoon)	Estuarine ANZECC/ARMCANZ (2000) Guidelines
Lead (µg/L)	1	1	3.4	1	4.4
Manganese (µg/L)	57	115	1900	91.5	#
Arsenic (µg/L)	0.5	1	13	1.5	#
Total Iron (µg/L)	271	177.25	#	125	#
Cadmium (µg/L)	0.05	#	0.2	0.1	5.5
Chromium** (µg/L)	0.5	#	1	0.5	1
Nickel (µg/L)	0.5	#	11	3	70
Mercury (µg/L)	0.05	#	0.6	0.05	0.4
Aluminium (µg/L)	30	#	55	35	na

*Note: **Bold** text denotes exceedence of guidelines*

** Ammonia is assumed to be* NH_4

***More conservative ANZECC/ARMCANZ Guidelines for Chromium VI have been assumed.*

 # No data

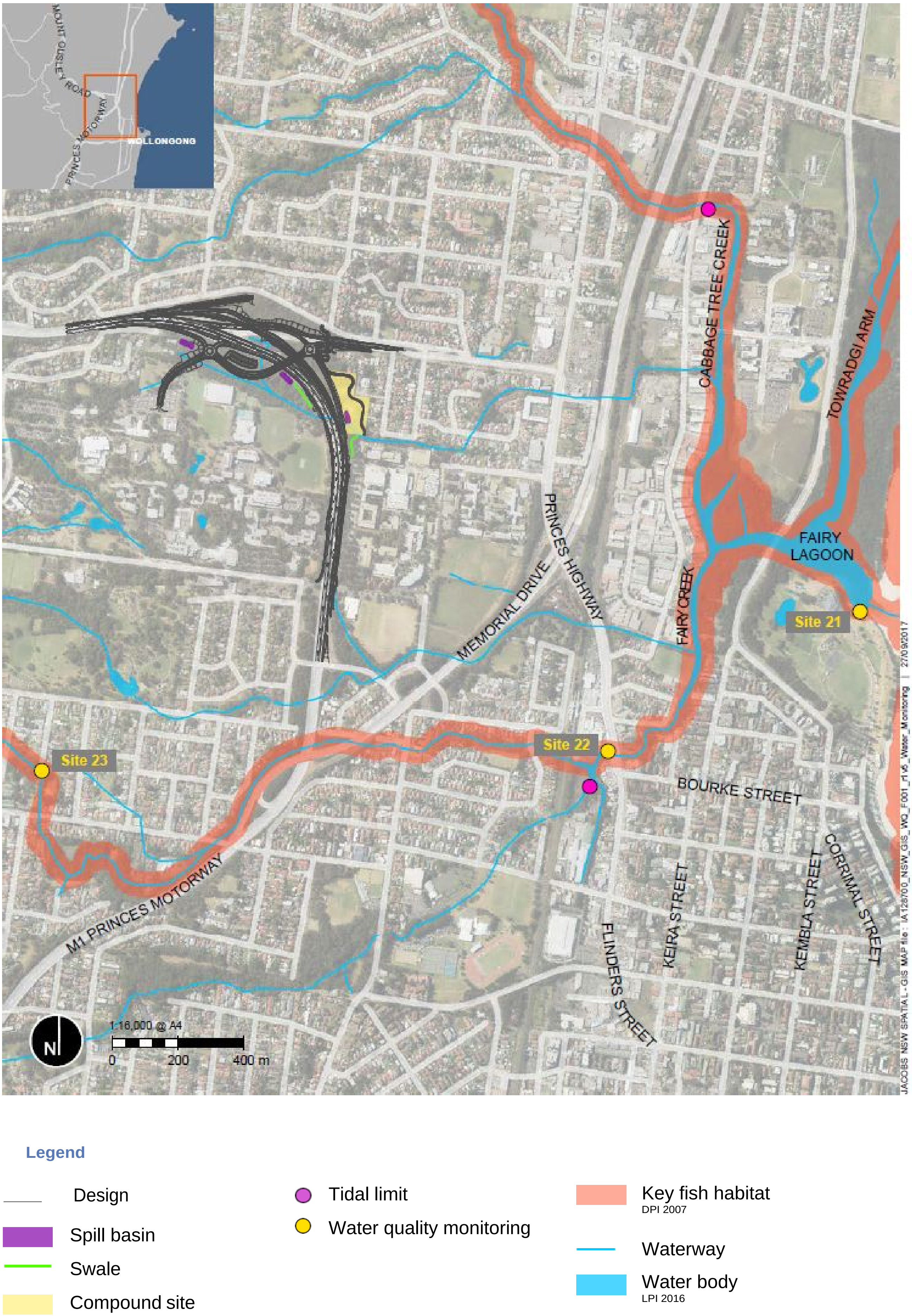

Figure 3-1 Water Quality Monitoring Locations

4. Assessment of impacts

4.1 Construction impacts

The construction phase of the proposal presents a risk to further degradation of downstream water quality if management measures are not implemented, monitored and maintained throughout the construction phase. If unmitigated, the highest risk to water quality would occur through the following construction activities:

1) General construction works that occur upstream of the tributaries of Cabbage Tree Creek and Fairy Creek.
2) The proposal would require traversing both tributaries of Cabbage Tree Creek and Fairy Creek. Watercourse crossings would be designed and constructed to minimise impacts on natural flow regimes and to not present any barriers.
3) Disturbance/mobilisation of sediment associated with general earthworks including vegetation removal, stripping of topsoil and filling particularly when these sites are located close to waterways. Removal of vegetation and/or filling (generally minor) is proposed at several locations on the proposal. Loose fill has the potential to be eroded during rainfall events by runoff, thereby increasing the potential for mass movements of soils and sedimentation of the abovementioned waterways where filling is proposed. This has the potential to smother vegetation and change the soil surface characteristics and habitat of adjacent areas.
4) Vegetation clearing and subsequent rainfall and erosion from construction in areas comprising of fine silt and clay can result in siltation of downstream watercourses and storages.
5) Dewatering activities during construction may mobilise sediments and contaminants, and increase the turbidity of the receiving environments along the proposal, potentially having an adverse impact on water quality if not appropriately managed.
6) Ancillary facilities to support construction would be required at one location (see **Figure 3-1**). The ancillary facility would include construction compounds, stockpile areas, material and waste storage areas including spoil stockpiles and other waste materials, and sediment basins. The final type, location and number of ancillary facilities would be determined by the construction contractor.
7) Stockpile sites may be used to temporarily store excess spoil and wastes such as concrete from demolition before their reuse on-site or disposal off-site. As stockpile sites present the potential for sediment-laden runoff to wash offsite into the storm water systems and receiving environment, any stockpile site would include environmental protection measures such as sediment controls and hoardings to minimise impacts on sensitive receivers from dust and receiving waters from erosion and sedimentation and waste contamination. Stockpile sites would be established and managed in accordance with *Roads and Maritime Stockpile Site Management Guideline* (Roads and Maritime, 2015).
8) Construction activities adjacent to waterways could introduce contaminants such as oil or grease and disturb contaminated sediments, potentially having an adverse impact on water quality.
9) Relocation and protection of utilities including potential dewatering of potable water from watermains. Relocation of utilities would involve soil disturbance by trenching and underboring. The disturbance of soil by machinery could increase the potential for soil erosion. Potable water is chlorinated, which has the potential to impact on downstream water quality. This has the potential to impact aquatic biodiversity if not managed appropriately.
10) Increased sediment loads and organic matter from exposed soil during site disturbance and movement of construction vehicles, particularly following rainfall events. This can result in elevated turbidity levels and increased levels of nutrients, metals and other pollutants in downstream waterways in close proximity to the construction works. Increased sedimentation has the potential to smother aquatic life and affect the ecosystems of downstream waterways which would potentially impact on downstream users such as commercial and recreational users.

Provided safeguards and management measures are implemented, the proposal would be unlikely to contribute significant amounts of sediment and organic matter to the immediate waterways. Waterways in the proposal area have been described as generally low flow with disconnected pools, or ephemeral. Therefore, impacts are likely to be localised and to occur under high flow conditions. Impacts on the downstream environment would be negligible. Overall, potential impacts on surface water quality during construction are considered minor and manageable with the application of standard mitigation measures (as detailed in **Section 5**).

4.1.1 Chronic and acute water quality impacts

Water quality impacts from construction are also discussed below in terms of chronic (or day to day) impacts and acute impacts (which result from a one-off severe event). Water quality during construction is proposed to be managed primarily through sediment basins and other measures such as local erosion and sediment controls. Sediment basins have been designed in accordance with the Blue Book with key criteria considered including the catchment area draining into the sediment basin, percentage of cut and fill in sub-catchment and other relevant design parameters.

Chronic impacts to water quality are expected to be minimal as sediment basins have been designed for the 80th percentile, 5 day rainfall depth for most basins. Upstream of sensitive receiving environments, the Blue Book (Table 6-1 Vol 2D) requires that the 85th percentile be used for construction projects with a duration of more than 6 months. It should be noted however that larger storm events could result in overtopping of basins and the potential deposition of sediment and associated pollutants into receiving waterways.

Risks of acute water quality impacts during construction would primarily be related to spills or leaks of fuel/oil from machinery due to accidents or negligence. Three sediment basins are proposed throughout the proposal area, each being an appropriate size to capture spills of this nature. The likelihood of impacts to waterways is therefore minimised. Additionally, onsite and offsite diversion drains, sediment fences, spill procedures, spill kits and erosion controls at the source would provide additional protection of waterways. Refer to **Section 5** for specific construction mitigation measures for the proposal.

4.2 Operational impacts

During the operational phase of the proposal, roads would be sealed, embankments landscaped and cuts stabilised. Typically, no exposed topsoil would remain in the proposal area during operation. Hence, risks would no longer be associated with sediment loading but would instead be associated with pollutants from atmospheric deposition, vehicles and motorists.

4.2.1 General impacts

Once the proposal is complete and becomes operational, the main risk to water quality would be surface runoff from an increase in impervious surfaces and the concentration of runoff via drains and kerbs. This can result in the build-up of contaminants on road surfaces, median areas, rest areas and roadside corridors in dry weather which, during rainfall events, can be transported to surrounding watercourses or infiltrate into the groundwater system. The generation of additional pollutants is directly attributable to the increased road surface area and the associated increases in future vehicle traffic.

The most important pollutants of concern relating to road runoff include:

- Sediments derived from pavement surface wear and atmospheric deposition
- Heavy metals attached to particles washed off the paved surface
- Oil and grease and other hydrocarbon products
- Litter from the road corridor
- Nutrients such as nitrogen and phosphorus (organic compounds) from biological matter and from natural atmospheric deposition of fine soil particles.

The emphasis in stormwater quality management for road runoff includes managing the export of suspended solids and associated contaminants – namely heavy metals, nutrients, hydrocarbons and organic compounds (Austroads, 2001). Pollutants such as nutrients, heavy metals and hydrocarbons are usually attached to fine sediments (RTA, 2003). Trapping suspended solids is therefore the primary focus of the water quality management strategy for the operational phase of the proposal.

4.2.2 Accidental Spills

The risk of accidental spillage of hazardous materials such as petroleum hydrocarbons is present along any operational road corridor. Without satisfactory means of containment, contaminant spills could pass rapidly into the proposal's drainage system and impact downstream ecosystems. Accidental spills of chemicals or petrol in road accidents can cause severe damage to the ecology of waterways and therefore environmental protection would be required. A desktop risk assessment has been undertaken to assess the need for spill containment basins, taking into consideration the road geometry (horizontal and vertical alignments), the high traffic volumes, the proportion of heavy vehicles, the steepness of the vertical profile and the location of the project at the base of a steep gradient. The results of this assessment indicated that three locations would require spill containment. The spill basins would need to contain a spill of 40 m^3 (double tanker). The overall volume of each spill basin would be less than 100 m^3. These three locations coincided with locations where temporary sediment basins for the construction phase only are required. These three locations are shown in **Figure 3-1.**

5. Proposed mitigation measures

The potential impacts on water quality as a result of the proposal would be minimised by implementing adequate temporary and permanent water quality controls for the construction and operational phases respectively.

5.1 Construction stage

5.1.1 Surface water controls

The Construction Environmental Management Plan (CEMP) would include a Surface Water Management Plan (SWMP), which would be applicable to all activities during the construction phases of the proposal. The SWMP would ensure any water collected from the worksites during construction would be treated and discharged in accordance with *The Blue Book – Managing Urban Stormwater* (Landcom, 2004) and the Roads and Maritime (2011) *Technical Guideline – Environmental Management of Construction Site Dewatering* to avoid any potential contamination or local stormwater impacts. The SWMP would specify the requirements for source controls (such as sediment fences and bunding of chemical storage areas). Where piling, concreting, earthworks, scour protection or other works are required within or adjacent to a waterway, a silt barrier such as a boom, bund or curtain would be installed either downstream of the work site and/or around the piles themselves prior to the commencement of works.

An Emergency Spill Plan would be developed and incorporated into the CEMP, which would include measures to avoid spillages of fuels, chemicals, and fluids into any waterways. The storage, handling and use of the materials would be carried out in accordance with the *Occupational Health and Safety Act 2000* and SafeWork NSW's Storage and Handling of Dangerous Goods Code of Practice (Workcover, 2005). Procedures would include:

- All fuels, chemicals, and liquids would be stored at least 50 metres away from any waterways or drainage lines and would be stored in an impervious bunded area within the compound site
- Bunded areas for refuelling and washdown
- Sediment basins with sufficient storage capacity to capture spills
- Spill kits
- Training requirements of staff.
- Details of the proposed erosion and sediment controls including proposed sediment basins for the construction phase will be included in the Erosion and Sediment Management Report (ESMR).

5.1.2 Water quality monitoring

A water quality inspection procedure would be developed for inclusion in the SWMP. The procedure would be established prior to construction to assess compliance with the identified WQO's and enable potential impacts to water quality to be identified, controlled and reported. Water quality inspections would require regular visual inspection of drainage channels and surface waters near the worksites, particularly after periods of rainfall to monitor sediment runoff, erosion, waste (e.g. litter and oil) and debris. Should visual inspection indicate a potential impact to water quality, the on-site environmental officer will be notified for immediate corrective action and to conduct further water quality monitoring as specified in the SWMP.

5.2 Operational stage

5.2.1 Water quality controls

Even though permanent water quality controls such as water quality basins are not required, two water quality swales have been proposed to provide some water quality treatment. The proposed locations of these two swales) are presented in **Table 5-1**.

Table 5-1 Permanent water quality controls – Swales and spill basins

Name	Chainage (m)	Catchment area (ha)	Swale length (m)	Spill basin Volume (m3)
S79700	79,640 - 79,730	0.17	83 m	n/a
S79880	79840 - 79880	1.05	66 m	n/a
SB79260R	79,260	n/a	n/a	80 m3
SB79600R	79,600	n/a	n/a	80 m3
SB79760L	79,760	n/a	n/a	80 m3

n/a= not applicable

6. Conclusion

Waterways within the proposal area are minor tributaries of Cabbage Tree Creek and Fairy Creek which discharge into Fairy Creek Lagoon. The waterways are ephemeral, and typically receive high velocity flows from the steep escarpment down towards the coastal plain. Historical water quality in the proposal area indicates slightly eutrophic conditions with low oxygen and high nutrients. These conditions are likely due to the high nutrient and sediment inflows from the upstream catchment.

During construction, the key potential impacts to water quality are sedimentation and runoff, and accidental spills or releases of pollutants. The greatest risks to surface water arise from the site compound, spoil placement, and during vegetation removal. The potential impact on receiving waterways during construction would generally be mitigated through erosion and sediment controls including appropriately sized temporary sediment basins in accordance with the requirements of the *Blue Book*. A Surface Water Management Plan would be prepared as part of the Construction Environmental Management Plan prior to the commencement of construction. The Plan would detail measures for reducing the incidence of sediment, litter and chemical pollution reaching Fairy Creek and Cabbage Tree Creek during the construction phase. Waste storage and management procedures would also be developed and implemented during construction to ensure appropriate waste storage, transport and disposal, in particular in relation to the proposed ancillary facility. Additionally, water quality inspections would be undertaken during the construction of the proposal. This will ensure there is no further degradation in water quality or impact on the nominated environmental values during construction and operational phases.

Operation of the proposal could potentially impact water quality through emissions from vehicles, and has the potential to generate increased pollutant loads into the receiving waterways at areas that were previously pervious. Operational impacts are likely to be minimal if adequate water quality swales are adopted throughout the proposal. Water quality treatment measures such as those listed on **Table 5-1** of this report would be implemented to minimise the potential water quality impacts of the proposal.

Given the ephemeral nature of these waterways, the poor water quality, and small volume of flows in these streams and creeks, they are unlikely to impact on the downstream larger creeks and rivers to which they discharge. As such any changes in water quality are likely to be localised and not affect downstream users, particularly commercial and recreational users of Fairy Creek Lagoon.

7. References

ANZECC/ARMCANZ (2000) *National Water Quality Management Strategy Australian and New Zealand Guidelines for Fresh and Marine Water Quality.* Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand.

Cardno Lawson Treloar (Pty Ltd) (2007) Fairy Lagoon Entrance Management Policy. Report Prepared for Wollongong City Council.

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