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NSW GOVERNMENT

M1 Pacific Motorway extension to Raymond Terrace

Environmental impact statement – Chapter 11: Surface water and groundwater quality

Transport for NSW | July 2021

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11. Surface water and groundwater quality

This chapter describes the potential surface water and groundwater quality impacts that may be generated by the construction and operation of the project and presents the approach to the management of these impacts.

The desired performance outcomes for the project relating to surface water and groundwater quality, as outlined in the SEARs, are to:

- Ensure 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
- Ensure that 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).

Table 11-1 outlines the SEARs that relate to surface water and groundwater quality and identifies where they are addressed in this EIS. The full assessment of surface water and groundwater quality impacts is provided in the Surface Water and Groundwater Quality Working Paper (**Appendix K**).

Table 11-1 SEARs (surface water and groundwater quality)

Secretary's requirement	Where addressed
8. Water – Quality	
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;	NSW Water Quality Objectives (NSW WQOs), associated trigger values and nominated environmental values for receiving waterways and wetlands relevant to the project are presented in **Section 11.2.4**.
(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;	Pollutants that may be introduced into the water cycle by source and discharge point during construction, and their impacts to human health and the environment are discussed in **Section 11.4.2**. Estimated loads during operation and how they relate to WQOs are discussed in **Section 11.4.3**. Pollutants that may pose a risk to human health or the environment that may be introduced into the water cycle by source and discharge point during operation are discussed in **Section 11.4.3**.
(c) identify the rainfall event that the water quality protection measures will be designed to cope with;	**Section 11.4.2** identifies the rainfall event for which the water quality protection measures have been designed. Temporary sediment basin and permanent water quality basin sizing is provided in the Surface Water and Groundwater Quality Working Paper (**Appendix K**).

Secretary's requirement	Where addressed
(d) assess the significance of any identified impacts including consideration of the relevant ambient water quality outcomes;	Existing surface water quality of receiving waterways is described in **Section 11.3.1**. Identified impacts to surface water quality from construction, including impacts to water quality outcomes, are discussed in **Section 11.4.2**. Identified impacts to surface water quality from operation, including impacts to water quality outcomes, are discussed in **Section 11.4.3**.
(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 − where the NSW WQOs are not currently being met, activities will work toward their achievement over time;	The NSW WQOs refer to the ANZG (2018) and other guidelines to assess compliance as further detailed in **Section 11.2**. Existing surface water quality and compliance with ANZG (2018) Water Quality Guideline values are discussed in **Section 11.3.1**. Water quality controls and management measures to protect water quality objectives are described in **Section 11.4.2**, **Section 11.4.3** and **Section 11.5**. The project's influence on meeting objectives during construction and operation is discussed in **Section 11.4.2** and **Section 11.4.3**.
(f) justify, if required, why the WQOs cannot be maintained or achieved over time;	Discussion about maintaining or achieving WQOs over time is provided in **Section 11.4.2** and **Section 11.4.3**.
(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;	Construction and operational impacts on surface water and groundwater quality are discussed in **Section 11.4.2** and **Section 11.4.3** respectively. Avoidance of impacts to surface water and groundwater quality is discussed in **Section 11.4.1**. Water quality controls and management measures to protect human health and the environment are described in **Section 11.4.2**, **Section 11.4.3** and **Section 11.5**.
(h) identify sensitive receiving environments (including estuarine and marine waters downstream and the Tomago Sandbeds Catchment Area) and develop a strategy to avoid or minimise impacts on these environments; and	The method for identifying sensitive receiving environments (SREs) is provided in **Section 11.2.2.** SREs (including the Tomago Sandbeds Catchment Area) are discussed in **Section 11.3.3**. Water quality controls and management measures for protecting SREs are discussed in **Section 11.4.2**, **Section 11.4.3** and **Section 11.5**.
(i) identify proposed monitoring locations, monitoring frequency and indicators of surface and groundwater quality.	Proposed water monitoring locations are shown in **Figure 11-1** and discussed in **Section 11.5.1**. Water quality monitoring frequency and indicators details are provided in **Section 11.5.1**.
2. The assessment should consider the results of any current water quality studies, as available, in the project catchment.	Existing surface water quality in the surface water and groundwater study area is discussed in **Section 11.3.1** and **Section 11.3.2** respectively. Further discussion of the existing surface water and groundwater quality, including the literature sources reviewed and existing surface water quality data, is provided in the Surface Water and Groundwater Quality Working Paper (**Appendix K**).

Secretary’s requirement	Where addressed
6. Soils	
5. The Proponent must assess the impacts of the project on soil salinity and how it may affect groundwater resources and hydrology.	Soil salinity impacts to surface water and groundwater quality during construction and operation are discussed in **Section 11.4.2** and **Section 11.4.3**. **Chapter 16** (soils and contamination) assesses the impacts of the project on soil salinity. Soil salinity risks in the vicinity of the project are discussed in **Section 16.3.4**.

11.1 Policy and planning setting

The surface water and groundwater quality assessment was prepared to assess the potential impacts of the project in accordance with the following relevant legislation and guidelines:

- Legislation:
  - *Environment Protection and Biodiversity Conservation Act 1999*
  - *Environmental Planning and Assessment Act 1979*
  - *Protection of the Environment Operations Act 1997*
  - *Water Management Act 2000* and *Water Act 1912*
  - *Fisheries Management Act 1994*
  - *Hunter Water Act 1991.*
- Plans and policies:
  - State Environmental Planning Policy (Coastal Management) 2018
  - NSW Aquifer Interference Policy (DPI 2012)
  - NSW Wetlands Policy
  - NSW State Rivers and Estuaries Policy.
- Guidelines:
  - Approved Methods for Sampling and Analysis of Water Pollutants in NSW (DECC 2008)
  - National Water Quality Management Strategy (Australian Government 2018)
  - NSW Water Quality and River Flow Objectives (DECCW 2006)
  - Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018)
  - Australian Drinking Water Guidelines (NHMRC 2011)
  - Managing Urban Stormwater (Volume 1 and 2) (Landcom 2004) (DECC 2008)
  - Guidelines for Controlled Activities on Waterfront Land.

Further detail on the above legislation, policies, and guidelines, and how they apply to the project, is provided in the Surface Water and Groundwater Quality Working Paper (**Appendix K**).

11.2 Assessment methodology

The assessment of surface water and groundwater quality involved:

- Carrying out a desktop review and analysis to characterise the existing environment and identify waterway and aquifer-specific risks
- Site visits and water quality monitoring to support and enhance the findings of the desktop analysis and refine the understanding of impacts (refer to **Section 11.2.3**)
- Identification and mapping of SREs (such as wetlands, marine parks and groundwater dependent ecosystems)

- Developing a numerical groundwater model to assess groundwater interaction during construction and operation of the project
- Analysis of existing water quality data from a variety of stakeholders, including Hunter Water Corporation, the former Office of Environment and Heritage (OEH, now EES Group), Australian Rail Track Corporation (ARTC), the Australian Bureau of Meteorology (BoM) and Transport (refer to **Section 11.2.5**)
- Assessing impacts from construction and operation of the project on water quality with reference to the ANZG (2018) Water Quality Guidelines, with regard to the relevant water quality objectives and environmental values as identified in the DECCW (2006) NSW Water Quality and River Flow Objectives and with reference to the minimal impact considerations of the NSW AIP (refer to **Section 11.2.6**)
- Qualitatively assessing cumulative water quality impacts by identifying major project(s) with a construction program that is likely to overlap with the project construction and/or is within the same catchment
- Identifying appropriate treatment measures to mitigate the impacts to surface water and groundwater quality resulting from project construction and operation.

Further detail on the methodology is provided in the following sections and in the Surface Water and Groundwater Quality Working Paper (**Appendix K**).

11.2.1 Study areas

The surface water study area is the area up to 500 metres from the construction and operation footprints. In addition, the Hunter Wetlands Ramsar site at Kooragang Nature Reserve has been included in the assessment despite its location outside of the nominated study area as it is a sensitive and nationally important wetland located downstream of the project on the Hunter River (about 5.1 kilometres downstream of the construction footprint).

The groundwater study area is defined as being two kilometres from the construction footprint. This area was adopted to include surrounding registered groundwater users, including the Tomago Sandbeds borefield.

The same study areas for this assessment were used in the hydrology and flooding assessment, and are shown on **Figure 10-1**.

11.2.2 Identification of sensitive receiving environments

SREs are environments that have a high conservation or community value or support ecosystems/human uses of water that are particularly sensitive to pollution or degradation of water quality. SREs relevant to the water quality assessment were identified based on the following considerations:

- Presence of Key Fish Habitat (KFH) based on NSW Fisheries KFH maps (DPI 2007)
- Presence of threatened aquatic species listed under the *Fisheries Management Act 1994* (FM Act) and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Likelihood of presence is based on threatened species distribution mapping (DPI 2016) and database searches including the Protected Matters Search Tool (DAWE, 2020), BioNet Atlas records (DPIE 2020) and Atlas of Living Australia (ALA) records (ALA 2020)
- Aquatic habitat field assessment (in accordance with the requirements of DPI (2013))
- Waterway classification (Fairfull and Witheridge 2003)
- Groundwater and surface water dependent vegetation and fauna communities listed under the BC Act and EPBC Act
- Proximity to a drinking water catchment
- Proximity to protected areas including Ramsar listed wetlands and National Parks
- Proximity to recreational swimming areas.

Areas mapped as ‘Coastal Wetlands’ under the Coastal Management SEPP that are within the construction footprint and immediately adjacent have been considered within this assessment to be SREs due to their environmental sensitivity.

SREs are described in **Section 11.3.3**.

11.2.3 Site investigations and monitoring

Project specific water quality monitoring was conducted as part of the surface water and groundwater quality impact assessment to supplement water quality data provided by external stakeholders.

Surface water quality monitoring

Surface water quality monitoring for the project was carried out in accordance with the Approved Methods for Sampling and Analysis of Water Pollutants in NSW (DEC 2008). Site visits were carried out to monitor surface water quality at representative sites and to visually assess the conditions of the waterways traversed by or in close proximity to the project.

Twenty-one monitoring locations were selected with monitoring generally carried out at the project crossing or downstream of discharge locations (as shown in **Figure 11-1**). Sampling was carried out between 2018 and 2020, with further water quality monitoring currently ongoing. The results of ongoing monitoring would be considered during the detailed design stage of the project. Monitoring dates and data are presented in the Surface Water and Groundwater Quality Working Paper (**Appendix K**).

Water quality sampling was carried out where sufficient water was present. In situ measurements were collected for temperature, electrical conductivity, salinity, oxygen reduction potential (ORP), pH, turbidity, and dissolved oxygen. For each parameter measured in situ, three replicate measurements were recorded and the average (arithmetic mean) of the measures reported. The following grab samples were collected at each site and sent to the laboratory for analysis:

- Total suspended solids (TSS)
- Turbidity
- Dissolved metals (arsenic, cadmium, chromium, copper, nickel, lead, zinc, and mercury)
- Oxidised nitrogen (NO_x)
- Total Kjeldahl Nitrogen (TKN)
- Total nitrogen (TN)
- Total phosphorus (TP)
- Enterococci.

Groundwater quality monitoring

Groundwater quality monitoring for the project was carried out in accordance with DEC (2008), the Guideline for Construction Water Quality Monitoring (RTA 2003) and the National Water Quality Management Strategy – Australian Guidelines for Water Quality Monitoring and Reporting (ANZECC 2000).

The project has a groundwater monitoring bore network consisting of a total of 20 monitoring bores at 13 locations, comprising six single and seven paired (one deep and one shallow) installations (as shown in **Figure 11-1**). In general, three groundwater quality monitoring rounds were completed at each piezometer between September 2016 and 2017. Monitoring dates and data are presented in the Surface Water and Groundwater Quality Working Paper (**Appendix K**).

Parameters measured in situ included electrical conductivity (EC), pH, temperature, ORP and dissolved oxygen. Parameters measured through laboratory analysis included:

- Major ions and cations
- Dissolved heavy metals
- Total dissolved solids
- Nutrients
- Fluoride
- Faecal coliforms.

11.2.4 Identification of water quality criteria

Surface water criteria

Water quality objectives (WQOs) were identified for waterways within the surface water study area using NSW water quality objectives (DECCW 2006). The relevant water quality objectives endorsed within the surface water study area are provided in **Table 11-2**. The waterways within the surface water study area and their allocated category are described in **Table 11-3**, with WQOs that apply to waterway categories provided in **Figure 11-1**.

Table 11-2 NSW Water quality objectives (DGV's) for waterway categories

Category	Environmental value										
	Aquatic ecosystems	**Visual amenity**	**Secondary contact recreation**	**Primary contact recreation**	**Livestock water supply**	**Irrigation water supply**	**Homestead water supply**	**Drinking water at point of supply- disinfection only**	**Drinking water at point of supply – clarification and disinfection**	**Drinking water at point of supply – groundwater**	**Aquatic foods (cooked)**
Estuaries: being dominated by saline conditions, estuary has hydraulic and water quality characteristic, and potential problems, that are often very different from those of freshwater systems	X	X	X	X							X
Town water supply sub catchments: streams or groundwater aquifers typically feed into a town's water supply	X	X								X	
Waterways affected by urban development: waterways within urban areas that are often substantially modified and generally carry poor quality stormwater	X	X	X	X							
National Parks, Nature Reserves and State Forests: streams mainly in forested areas including national parks or state forests	X	X	X	X							

Table 11-3 Assigned categories for waterways in the study area from DECCW mapping

Waterway	Category
Purgatory Creek	Estuaries
Hunter River	Estuaries
Windeyers Creek	Estuaries^
Hexham Swamp	National Parks, Nature Reserves and State Forest
Hunter River (at Raymond Terrace)	Waterways affected by urban development
Grahamstown Drain	Waterways affected by urban development
Tomago Sandbeds	Town water supply sub catchment / aquifers

^ whilst DECCW classify Windeyers Creek as estuarine, for the purposes of this assessment it has been considered as a ‘lowland river’ based on the absence of tidal influences in the upper reaches due to the presence of artificial barriers. As such, relevant WQO and Default Guideline Values (DGVs) applicable to this ‘lowland river’ have been applied for Windeyers Creek.

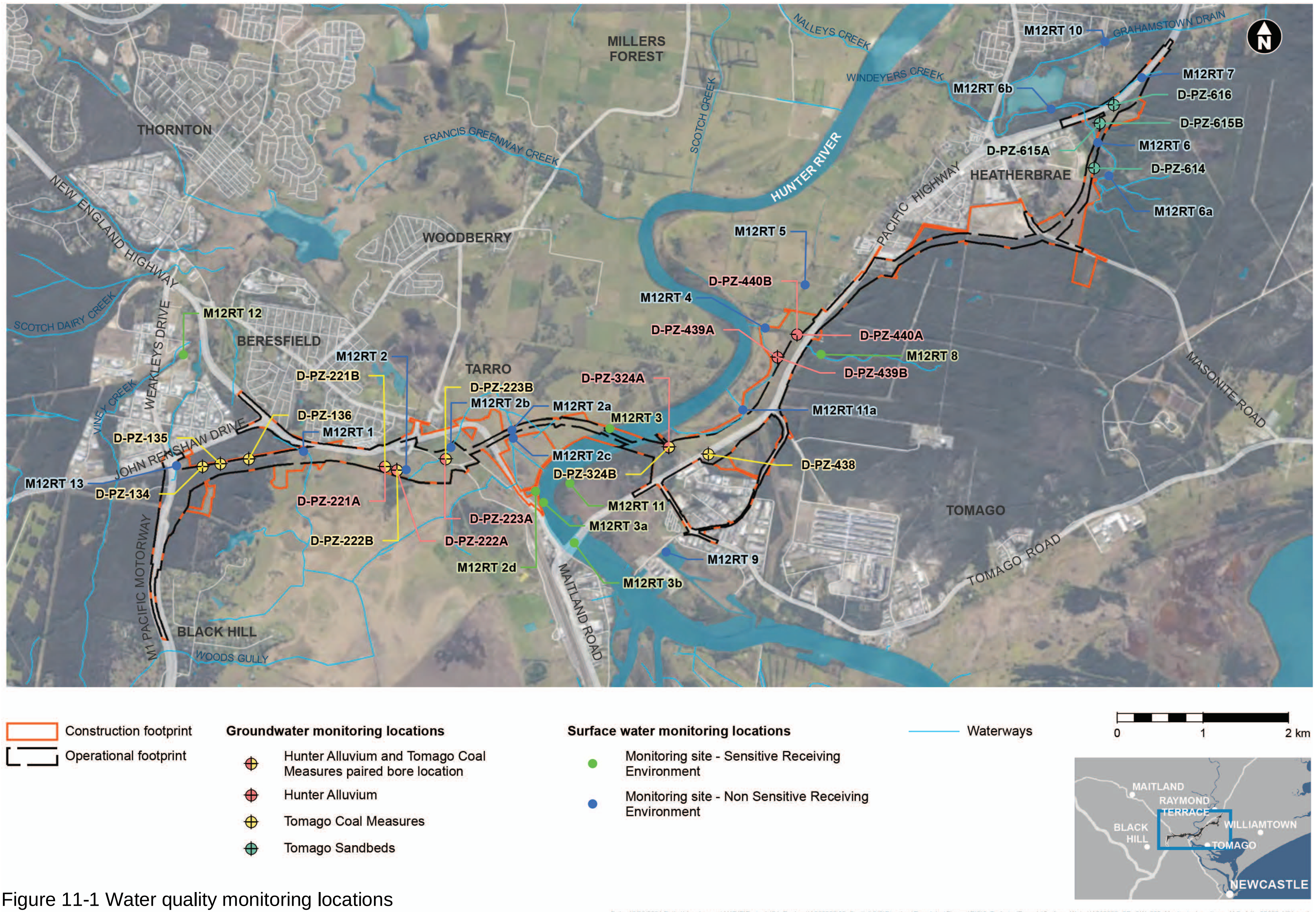

Figure 11-1 Water quality monitoring locations

Default guideline values (DGVs), which are nominated for water quality indicators that are associated with the WQOs, have been identified from relevant guidelines (ANZG 2018; NHMRC 2008; DECCW 2006). These DGVs are the recommended values for protecting the WQOs irrespective of existing water quality and river flow conditions in the study area. Key water quality indicators and related DGV have been nominated for each WQO and are presented in **Table 11-4**. The project's surface water quality performance has been assessed against these DGVs.

Table 11-4 Water quality indicators and associated default guideline values for water quality objectives nominated to waterways within the surface water study area

Water quality objective	Indicator	Default guideline value	
		Lowland rivers	Estuaries and marine
Aquatic ecosystems: maintaining or improving the ecological condition of waterbodies and their riparian zones over the long term	Total phosphorus	0.025mg/L	0.030mg/L
	Filterable reactive phosphorus	0.02mg/L	0.005mg/L
	Total nitrogen	0.35mg/L	0.3mg/L
	Ammonium	0.02mg/L	0.015mg/L
	Oxidised nitrogen	0.04mg/L	0.015mg/L
	Chlorophyll-a	0.003mg/L	0.004mg/L
	pH	6.5 – 8.5	7 – 8.5
	Turbidity	6 – 50 Nephelometric Turbidity Units (NTU)	0.5 – 10 NTU
	Dissolved oxygen	85 – 110%	80 – 110%
	Electrical conductivity	200 – 300 micro Siemens per centimetre (µS/cm)	N/A
	Chemical contaminants or toxicants	As per ANZG (2018)	As per ANZG (2018)
Visual amenity – aesthetic qualities of waters	Visual clarity and colour	Natural visual clarity should not be reduced by more than 20%. Natural hue of water should not be changed by more than 10 points on the Munsell Scale. The natural reflectance of the water should not be changed by more than 50%.	
	Surface films and debris	Oils and petrochemicals should not be noticeable as a visible film on the water, nor should they be detectable by odour. Waters should be free from floating debris and matter.	
	Nuisance organisms	Macrophytes, phytoplankton scums, filamentous algal mats, blue-green algae, sewage fungus and leeches should not be present in unsightly amounts.	
Secondary contact recreation – maintaining or improving water quality for activities such as boating and wading, where there is a low probability of	Faecal coliforms, enterococci, algae, and blue-green algae	Median over bathing season of <230 enterococci per 100mL (maximum number in any one sample: 450-700 organisms/100mL) Median over bathing season of <1000 faecal coliforms per 100mL, with 4 out of 5 samples <4000/100mL Algae: <15000 cells/mL.	
	Nuisance organisms	As per the visual amenity guidelines Large numbers of midges and aquatic worms are undesirable.	

Water quality objective	Indicator	Default guideline value	
		Lowland rivers	Estuaries and marine
water being swallowed	Chemical contaminants	Waters containing chemicals that are either toxic or irritating to the skin or mucous membranes are unsuitable for recreation. Toxic substances should not exceed values in Table 9.3 of NHMRC (2008) Guidelines.	
	Visual clarity and colour	As per the visual amenity guidelines.	
	Surface films	As per the visual amenity guidelines.	
Primary contact recreation – maintaining or improving water quality for activities such as swimming where there is a high probability of water being swallowed	Faecal coliforms, enterococci, algae, and blue-green algae	Median over bathing season of <35 enterococci per 100mL (maximum number in any one sample: 60 – 100 organisms/100mL) Median over bathing season of <150 faecal coliforms per 100mL, with 4 out of 5 samples <600/100mL Algae: <15000 cells/mL.	
	Protozoans	Pathogenic free-living protozoans should be absent from bodies of fresh water.	
	Chemical contaminants	Waters containing chemicals that are either toxic or irritating to the skin or mucus membranes are unsuitable for recreation. Toxic substances should not exceed values in Table 9.2 of NHMRC (2008) guidelines.	
	Visual clarity and colour	As per the visual amenity guidelines.	
	Temperature	15°– 35°C for prolonged exposure	
Aquatic foods (cooked) – refers to protecting water quality so that it is suitable for production of aquatic foods for human consumption and aquaculture activities	Algae and blue-green algae	No guidelines are directly applicable, but toxins present in blue-green algae may accumulated in other aquatic organisms.	
	Faecal coliforms	Guideline in water for shellfish: The median faecal coliform concentration should not exceed 14 Most Probable Number (MPN)/100mL; with no more than 10 per cent of the samples exceeding 43 MPN/100mL. Standard in edible tissue: Fish destined for human consumption should not exceed a limit of 2.3 MPN E Coli/g of flesh with a standard plate count of 100,000 organisms/g.	
	Toxicants (as applied to aquaculture activities)	Metals: Copper: less than 0.005mg/L Mercury: less than 0.001mg/L Zinc: less than 0.005mg/L. Organochlorines: Chlordane: less than 0.004mg/L (saltwater production) PCBs: less than 0.002mg/L.	
	Physico-chemical indicators (as applied to aquaculture activities)	Suspended solids: less than 40mg/L (freshwater), 10mg/L (marine) Temperature: less than 2°C change over one hour.	

Groundwater

Groundwater quality criteria adopted for the project include:

- The NSW AIP (2012) beneficial use categories for in situ groundwater
- The Australian Drinking Water Guidelines (ADWG) for groundwater specifically within the Tomago Sandbeds Catchment Area
- Corresponding surface water quality criteria where groundwater would be extracted and discharged.

These criteria have been adopted for each groundwater source as described in **Table 11-5**. The water quality indicators and DGVs for groundwater sources are provided in **Table 11-4**.

Table 11-5 Groundwater sources in groundwater study area and adopted categories

Groundwater source	In situ category	Discharge category^
Hunter Alluvium (Hunter floodplain)	Beneficial use criteria – industrial water	Estuarine
Tomago Coal Measures	Beneficial use criteria – industrial water	Lowland River
Tomago Sandbeds	Beneficial use criteria – aquatic ecosystems / drinking water	Lowland River

^ for discharge categories classified as estuarine, the DGVs for toxicants in marine water apply. For discharge categories classified as lowland river, the DGVs for toxicants in freshwater apply

11.2.5 Data analysis

Water quality data used in this report is sourced from a variety of stakeholders including Hunter Water Corporation, Environment, Energy and Science (EES) Group (formerly OEH), ARTC, Bureau of Meteorology (BoM) and Transport. Each organisation has its own monitoring objectives for their monitoring and as such, data is variable throughout the catchment, spatially and temporarily and also vary in the types of indicators that are monitored. Some organisations have routine monitoring programs, while others only monitor water quality for specific projects. Further detail on the data used for the surface water and groundwater quality assessment is provided in the Surface Water and Groundwater Quality Working Paper (**Appendix K**).

Surface water

The data used to inform the surface water quality assessment is generally from 2011 onwards and is considered most representative of contemporary water quality. No minimum number of results was applied to the dataset due to a shortage in data. The location of monitoring sites is shown on **Figure 11-1**.

Data was analysed to determine water quality criteria exceedances for each site, and involved:

- Collating water quality data into a spreadsheet
- Calculating summary statistics for each site including number of samples, mean, median, maximum, and minimum value and the number and percentage of samples outside the guideline range
- Reporting compliance of the data using colour coded symbols for each of the different nominated WQOs, with respect to the percentage of samples that achieved WQOs. Colours and rating for compliance are outlined in **Table 11-6**.

Table 11-6 Compliance against water quality objectives

Per cent compliance	Colour and rating
75.1% – 100%	Good
50.1% – 75%	Fair
25.1% – 50%	Poor
0 – 25%	Very poor
Insufficient data	N/A

Non-compliance was determined when any single WQO indicator failed to meet the relevant guideline value.

Groundwater

For groundwater, five Hunter Water Corporation bores installed within the Tomago Sandbeds Catchment Area were used to inform the groundwater assessment. While not specifically located within the groundwater study area, the data are considered representative of the Tomago Sandbeds aquifer and drinking water resource within the study area.

Three rounds of groundwater quality sampling results from between August and September 2013 were available for each bore. In addition, available groundwater salinity data from the BOM's (2020) Australian Groundwater Explorer was reviewed to assess existing bore water salinity.

11.2.6 Impact assessment methodology

The assessment methodology for potential construction and operational impacts relating to surface water and groundwater quality are detailed in the sections below. Flows from Hunter River tributaries within the study area are controlled by floodgates, and therefore sediment and associated contaminants would likely be deposited in the disturbed waterways upstream of the floodgates and not reach the Hunter River.

Construction impacts

The assessment of potential impacts to surface water quality during construction involved:

- Identification of unmitigated risks to surface water quality from the construction activities (as described in **Section 5.4**)
- Identification of impacts to downstream waterways and SREs
- Assessment of impacts to the nominated WQOs of aquatic ecosystems, visual amenity, primary and secondary contact recreation and aquatic foods (cooked) with consideration to the criteria described in **Section 11.2.4**
- Assessment of construction related impacts and changes in water quality to the receiving environment
- A dilution assessment to estimate the reduction in TSS concentrations from temporary sediment basin discharges into the Hunter River at the Hunter Estuary Wetlands Ramsar site downstream of the project. Flow from all other waterways within the study area are controlled by floodgates and therefore it is unlikely that any construction discharges to these waterways would reach the Hunter River
- Calculation of TSS annual average loads and maximum TSS discharges from temporary sediment basins during controlled and overflow conditions and assessment against WQOs for turbidity
- Identification of water quality treatment measures to mitigate the impacts of construction in accordance with ANZG (2018).

Assessment of impacts to groundwater quality during construction involved:

- Identification of unmitigated risks to groundwater quality from the construction activities (as described in **Section 5.4**)
- Identification of impacts to downstream users and SREs
- Assessment of impacts to groundwater quality within the Tomago Sandbeds Catchment Area
- Assessment of impacts to the relevant beneficial use of groundwater with consideration of the NSW AIP minimal impact considerations
- Identification of water quality treatment measures and other environmental management measures to mitigate the impacts.

Operational impacts

Assessment of potential impacts to surface water quality during operation involved:

- Assessment of operation impacts to water quality to receiving environments
- Identification of unmitigated risks to surface water quality from project operation
- Identification of impacts to downstream waterways and SREs
- Assessment of increased pollutant loading at each of the SREs or downstream waterways by considering the increase in impervious surfaces within each of their catchments
- Modelling of surface water pollutant loads and stormwater runoff discharges from the operational project
- Comparison of modelled pollutant loading and mean concentrations to existing water quality and the criteria described in **Section 11.2.4**
- Estimation of permanent water quality basin discharge concentrations of TSS, TN and TP at the Hunter Estuary Wetlands Ramsar site downstream of the Hunter River
- Identification of water quality controls to treat project runoff
- Identification of appropriate treatment measures to mitigate the residual impact of project operation.

Assessment of impacts to groundwater quality during operation involved:

- Identification of unmitigated risks to groundwater quality from project operation
- Identification of impacts to downstream users and SREs
- Assessment of impacts to groundwater quality within the Tomago Sandbeds Catchment Area
- Assessment of impacts to the relevant beneficial use of groundwater with consideration to the NSW AIP
- Identification of water quality treatment measures and other environmental management measures to mitigate impacts.

11.3 Existing environment

An overview of the catchment, topography and climate of the surface water and groundwater study areas is described in **Section 10.3**.

11.3.1 Existing surface water quality

Waterways and wetlands within the surface water study area are shown in **Figure 10-4**.

Table 11-7 summarises the existing water quality compliance with the ANZG (2018) Water Quality Guidelines default guideline values for the protection of aquatic ecosystems for slightly to moderately disturbed ecosystems (95 per cent level of species protection). These values are recommended thresholds. If an indicator or indicators fall outside of the threshold(s), it assumes that the environmental value is not being protected or requires further assessment.

The protection of the aquatic ecosystems WQO provides the most conservative water quality criteria of all nominated WQOs (for indicators relevant to the proposed work). Therefore, by meeting the protection of aquatic ecosystems, all other relevant values will be protected. Further detail of existing surface water quality is provided in **Table 11-8**.

Table 11-7 Summary of existing water quality compliance with recommended ANZG (2018) thresholds for aquatic ecosystems

Waterway/wetland	**Description of existing water quality (with reference to aquatic ecosystem values)**	
	Wet	**Dry**
Viney Creek	Very poor	Very poor
Glenrowan Creek	Very poor	Very poor
Purgatory Creek	Very poor	Very poor
Hexham Swamp Nature Reserve	Poor	Poor
Mid Site Channel	N/A – no wet weather samples	Very poor
Hunter River main stream	Poor	Very poor
Hunter River Drain	Very poor	Very poor
Hunter River wetland	Very poor	Very poor
Drainage canal, Old Punt Road	Very poor	Very poor
Unnamed Coastal Wetland	N/A – no wet weather samples	Very poor
Windeyers Creek	Very poor	Very poor
Grahamstown Drain	Very poor	Very poor

Table 11-8 Summary of existing water quality compliance with recommended ANZG (2018) thresholds for other relevant values

<table>
<tr><th rowspan="2">Waterway / wetland</th><th colspan="5">Compliance with ANZG (2018) guideline values</th></tr>
<tr><th>Aquatic ecosystems</th><th>Visual amenity</th><th>Primary contact recreation</th><th>Secondary contact recreation</th><th>Aquatic foods (cooked)</th></tr>
<tr><td>Viney Creek</td><td>Currently not being protected (very poor during both dry and wet weather) due to:
• Nutrient concentrations, electrical conductivity and turbidity were higher than the DGVs
• Dissolved oxygen levels were lower than the DGV range
• Apart from zinc, all other metals were below DGVs</td><td>Currently not being protected due to:
• Murky, stagnant, odorous water with limited transparency during dry weather
• Turbid with oily sheens during dry weather</td><td>Currently not being protected due to:
• Median enterococci exceed the recommended threshold</td><td>Currently not being protected due to:
• Median enterococci exceed the recommended threshold</td><td>-</td></tr>
<tr><td>Glenrowan Creek</td><td>Currently not being protected (very poor during both dry and wet weather) due to:
• pH, turbidity, and electrical conductivity met the DGV
• Metal concentrations were low and compliant with DGVs, with the exception of copper and zinc, which exceeded DGVs
• Total nitrogen concentrations and total phosphorus concentrations were higher than DGVs
• Dissolved oxygen levels were lower than the DGV range</td><td>Currently not being protected due to:
• Presence of floating debris and nuisance organisms such as algae and aquatic weeds
• Translucent brown water during dry conditions
• Murky, cloudy water following rainfall</td><td>Currently not being protected due to:
• Median enterococci exceed the recommended threshold.</td><td>Currently being protected</td><td>-</td></tr>
</table>

Waterway / wetland	Compliance with ANZG (2018) guideline values				
	Aquatic ecosystems	**Visual amenity**	**Primary contact recreation**	**Secondary contact recreation**	**Aquatic foods (cooked)**
Purgatory Creek	Currently not being protected (very poor during both wet and dry weather) due to: • Median nutrients and turbidity exceed DGVs • Total nitrogen and turbidity during dry weather considerably higher than the DGV • Both pH and dissolved oxygen levels, were very poor at the most upstream site but improved at the downstream site • Mercury, lead, and cadmium were the only metals to remain below the DGVs during dry weather • Median zinc, copper and nickel concentrations exceeded DGVs.	Currently not being protected due to: • Thick, turbid, brown stagnant water, often covered in aquatic weeds and algae, at the most upstream sites • Brown, slightly turbid and algae affected water with some transparency at other sites downstream	Currently not being protected due to: • Median enterococci exceed the recommended threshold	Currently not being protected	Currently not being protected due to: • Elevated zinc levels • TSS and dissolved oxygen did not meet DGVs.
Hexham Swamp Nature Reserve	There has been no current monitoring of Hexham Swamp Nature Reserve, with the only data available from August and September 2011 (Parsons Brinkerhoff 2012). Currently not being protected (poor during both dry and wet weather) due to: • pH and dissolved oxygen outside acceptable limits and elevated nutrients • At the time of sampling, the swamp was mildly acidic and dissolved oxygen levels were variable with both anoxic and supersaturated levels recorded • Ammonia, total nitrogen, total phosphorus, and filterable reactive phosphorus exceeded the guideline limit.	-	-	-	-

Waterway / wetland	Compliance with ANZG (2018) guideline values				
	Aquatic ecosystems	**Visual amenity**	**Primary contact recreation**	**Secondary contact recreation**	**Aquatic foods (cooked)**
Mid Site Channel	Currently not being protected (very poor during dry weather) due to: • Elevated nutrients and turbidity • Exceeds TP and TN concentrations • Metal concentrations were generally low with the exception of zinc, nickel and copper, which were recorded in elevated concentrations on occasion.	-	-	-	Currently not being protected due to: • Elevated TSS and zinc concentrations.
Hunter River main stream	Currently not being protected (poor or very poor at all sites except Newcastle Harbour where the water quality is improved by tidal flushing) due to: • Elevated TN, TP, turbidity, and chlorophyll-a • Metal concentrations were recorded as generally low, with the exception of copper and zinc which exceeded DGVs • Dissolved oxygen levels did not meet DGV • pH levels were within acceptable ranges.	Currently not being protected due to: • Brown and turbid water with an oily sheen • Surface water frothing during wet weather	Currently not being protected	Currently being protected	Currently not being protected due to: • Elevated TSS and zinc concentrations.
Hunter River Drain	Currently not being protected (very poor during both dry and wet weather) due to: • Turbidity and dissolved oxygen concentrations were outside DGVs • Total nitrogen and total phosphorus exceed DGVs • pH, cadmium, chromium, lead, and mercury levels met DGVs.	Currently not being protected due to: • Brown muddy turbid water and oily sheens	-	-	-
Hunter River wetland	Currently not being protected (very poor during both dry and wet weather) due to: • TN, TP, pH, dissolved oxygen, and median were outside DGVs • Metal concentrations were low at the time of sampling, all meeting the relevant species protection limit DGVs with the exception of zinc.	-	-	-	-

<table>
<tr><th rowspan="2">Waterway / wetland</th><th colspan="5">Compliance with ANZG (2018) guideline values</th></tr>
<tr><th>Aquatic ecosystems</th><th>Visual amenity</th><th>Primary contact recreation</th><th>Secondary contact recreation</th><th>Aquatic foods (cooked)</th></tr>
<tr><td>Drainage canal, Old Punt Road</td><td>Currently not being protected (very poor during both dry and wet weather) due to:
• pH, dissolved oxygen, turbidity, nutrient levels were outside DGVs
• Concentrations of all metals except copper were outside DGVs.</td><td>Currently not being protected due to:
• Turbid brown water
• Water more turbid and oily following rainfall</td><td>Currently not being protected</td><td>Currently being protected</td><td>Currently not being protected due to:
• Elevated TSS and zinc concentrations
• Dissolved oxygen outside DGV.</td></tr>
<tr><td>Unnamed Coastal Wetland</td><td>Currently not being protected (very poor during wet weather) due to:
• Dissolved oxygen, turbidity, TP, and TN were outside DGVs
• Zinc and copper concentrations were outside DGVs.</td><td>Currently partially protected:
• Brown, transparent water
• Oily surface containing nuisance scums</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Windeyers Creek</td><td>Currently not being protected (very poor during both dry and wet weather) due to:
• TP, total and oxidised nitrogen, pH, and dissolved oxygen were outside DGVs
• Zinc concentrations were outside DGV
• Concentrations of arsenic, cadmium, nickel, and mercury were within DGVs
• Turbidity and electrical conductivity generally met their respective DGVs.</td><td>Currently not being protected due to:
• Oily films on surface
• Surface covering of duckweed
• Odour present</td><td>Currently not being protected due to:
• Median enterococci exceed the recommended threshold.</td><td>Currently not being protected due to:
• Median enterococci exceed the recommended threshold.</td><td>Currently not being protected due to:
• Elevated TSS and zinc concentrations
• Dissolved oxygen outside DGV.</td></tr>
<tr><td>Grahamstown Drain</td><td>Currently not being protected (very poor during both dry and wet weather) due to:
• Elevated concentrations of TP and TN
• Dissolved oxygen, pH, concentrations were outside DGVs
• Concentrations of chromium and zinc were outside the DGVs.</td><td>Currently not being protected due to:
• Milky white surface water
• Containing iron bacteria</td><td>Currently not being protected due to:
• Median enterococci exceed the recommended threshold.</td><td>Currently not being protected due to:
• Median enterococci exceed the recommended threshold.</td><td>-</td></tr>
</table>

11.3.2 Existing groundwater quality

The groundwater systems within the ground water study area are shown on **Figure 10-6**.

Details of groundwater monitoring bores installed for the project and further results from those monitoring bores are described in the Surface Water and Groundwater Quality Working Paper (**Appendix K**).

Table 11-9 summarises the existing water quality compliance with the ANZG (2018) Water Quality Guidelines default guideline values for the protection of aquatic ecosystems for slightly to moderately disturbed ecosystems (95 per cent level of species protection), as outlined in **Table 11-5**. These values are recommended thresholds. If an indicator or indicators fall outside of the threshold(s), it assumes that the environmental value is not being protected.

Table 11-9 Summary of existing water quality comparison against ANZG (2018) DGVs for aquatic ecosystems

Groundwater System	Description of water quality (with reference to aquatic ecosystem values)
Hunter Alluvium	Poor (Estuarine)
Tomago Sandbeds	Very poor (Lowland river)
Tomago Coal Measures	Very poor (Lowland river)

Groundwater systems and existing groundwater quality within the groundwater study area are described in **Table 11-10**.

Table 11-10 Groundwater systems and existing groundwater quality

Groundwater system	Description	Existing groundwater quality
Hunter Alluvium	• The Hunter River floodplain and its associated alluvial groundwater systems form a regional groundwater sink for the Hunter Valley. • Groundwater levels are typically very shallow (0.2 to 2.4m below ground level) and often discharge to surface water. Wetlands and associated waterways on the floodplain are also expected to receive groundwater contribution.	• Existing groundwater quality is typically brackish to saline. pH values are typically mildly acidic. • Existing water quality samples are not compliant with relevant WQOs as they exceed estuarine/marine DGVs and estuarine physical and chemical stressors.
Tomago Sandbeds	• The Tomago Sandbeds are used for public drinking water supply by Hunter Water Corporation. • Groundwater levels are typically 1.6 to 2.7m below ground level. Some recharge to groundwater is likely during periods of elevated rainfall and runoff.	• Existing groundwater quality is typically fresh. pH values are typically mildly to moderately acidic. • Existing water quality samples are not compliant with WQO as they exceed freshwater DGVs and lowland river physical and chemical stressors. • Existing water quality samples comply with WQOs for drinking water guidelines.

Groundwater system	Description	Existing groundwater quality
Tomago Coal Measures	• Hardrock groundwater systems within the groundwater study area occur within the Permian Tomago Coal Measures. • Groundwater levels are typically 6.3 to 16.8m below ground level at Black Hill, with a potentiometric level of 0.3m above ground level at Tarro. • When flowing, waterways and surface drainages are typically sources of groundwater recharge. Wetlands, including the Hunter River wetland, are maintained by drainage from the aquifers or are windows to the water table where the water table is locally at a higher elevation than ground level.	• Existing groundwater quality is typically mildly brackish to saline. pH values are typically mildly to moderately acidic. • Existing water quality samples are not compliant with relevant WQOs as they exceed for freshwater DGVs and lowland river physical and chemical stressors.

Groundwater contamination from acid sulphate soils (ASS), acid rock and salinity is further discussed in **Chapter 16** (soils and contamination). In addition to potential for acid sulfate soils and soil salinity risk areas, key areas of potential contamination are noted in the following sections.

Former mineral sands processing facility

A former mineral sands processing facility is located within the construction footprint in Tomago. The facility is decommissioned, however the site retains pre-existing contamination in soil and groundwater. Investigations have found localised distribution of naturally occurring radioactive materials (NORM) with areas of elevated dose rates relative to surrounds identified on the site surface and at depth. However, concentrations of NORM in both surface water and groundwater were found to comply with all relevant guidelines for drinking water or guidelines for use of the water for livestock or irrigation. Concentrations of metals (cadmium, dissolved copper, dissolved nickel, and dissolved zinc) were also detected in surface water and groundwater that exceeded investigation levels (ANZG (2018) fresh water guidelines for 95 per cent ecosystem protection).

To ensure that the contaminants identified at the site are controlled to an acceptable level that limits harm to human health and the environment and to facilitate the overlying motorway project, Transport will remediate the former mineral sands processing facility site during construction of the project.

Transport will remediate the site in accordance with the Remediation Action Plan described in **Chapter 16** (soils and contamination). The Remediation Action Plan will address contamination risks and issues associated with NORM, metals and minor hydrocarbon contamination at the site, including areas where metals impacted soils may be interacting with surface water and approved by a NSW EPA accredited site auditor

Further information of potential contamination is provided in **Chapter 16** (soils and contamination).

Per- and poly-fluoroalkyl substances (PFAS)

The EPA is currently investigating potential PFAS contamination at two sites; Heatherbrae Total Fire Solutions and Our Lady of Lourdes Primary School, Tarro. Groundwater modelling for the project shows groundwater flows away from the project that decreases the potential for PFAS occurrence at project.

Predicted groundwater drawdown from temporary construction dewatering for the project (refer to **Chapter 10** (hydrology and flooding) is not predicted to interact with the areas of known or potential PFAS contamination. Contaminated groundwater from these sites is therefore considered unlikely to reach the project, and the project activities are not anticipated to influence or capture potential contaminant migration.

11.3.3 Sensitive receiving environments

A SRE is defined as one that has a high conservation or community value or supports ecosystems or water for human use and is particularly sensitive to pollution and/or degradation of water quality.

SREs identified in the surface water and groundwater quality assessment are summarised in **Table 11-11**.

Table 11-11 Description of SREs and reasons for determination

SRE	Description	Reason for determination
Tomago Sandbeds Catchment Area	• The Tomago Sandbeds Catchment Area is a designated 'Special Area' in the *Hunter Water Act 1991* and is protected as a public drinking water supply by the Hunter Water Corporation. The Tomago Sandbeds are operated as a backup to Grahamstown Dam, and can provide up to 20 per cent of the Lower Hunter's drinking water • The aquifer is predominantly comprised of fine sand, typically around 20m deep and receives direct recharge from rainfall. Water levels are generally relatively shallow.	• Due to the highly permeable nature of the Tomago Sandbeds and shallow depth to water, the aquifer is vulnerable to contamination and therefore is considered an SRE.
Groundwater users	• 303 existing registered bores are within the groundwater study area, with five located within the construction footprint itself.	• Due to distance from the project and potential risk of groundwater contamination, groundwater users are considered SREs.
Hunter River	• The Hunter River is a ninth order major river and an open, wave dominated barrier estuary in its lower reaches (where the project is located). • Despite the physical condition and water quality of the Hunter River within the surface water study area being generally poor and reflective of the urban, agricultural and industrial land uses within the catchment, the waterway is classified as "Type 1 – Major KFH'. • Hunter River is additionally accessed as fish grounds for the Estuary Prawn Trawl Fishery and there are oyster leases downstream near Stockton Bridge. • Hunter River is utilised for secondary contact recreation, for activities such as waterskiing, fishing and boating.	• Due to the environmental and human uses of the waterway, the Hunter River is considered an SRE.
Hunter Estuary Wetland Ramsar site	• Kooragang Nature Reserve, which is located 5.1km directly downstream from the project where the new viaduct crosses the Hunter River, forms part of the nationally important wetland the Hunter Estuary Wetlands Ramsar site. • The Hunter Wetlands Centre Australia in Shortland is located a minimum distance of about 3.8km south of the construction footprint. However due to the substantial distance from the project and several hydrological barriers which obstruct project discharges from reaching the Ramsar site area (rail embankment at the northern boundary of Hexham Swamp Nature Reserve and floodgates on Ironbark Creek), the	• Despite being a significant distance downstream, there is a potential direct flow path from the project to Kooragang Nature Reserve therefore it is considered an SRE.

<table>
<tr><th>SRE</th><th>Description</th><th>Reason for determination</th></tr>
<tr><td></td><td>Hunter Wetland Centre in Shortland is not expected to be directly or indirectly impacted by the project.</td><td></td></tr>
<tr><td>Important wetlands</td><td>Six areas identified as Coastal wetlands under the Coastal Management SEPP are located within the surface water study area
Three are located within the construction footprint, these include:
– South of the existing New England Highway
– On the western banks of the Hunter River
– On the eastern bank of the Hunter River.
Three are located outside of the construction footprint but within the study area, these include:
– North of the project in Tarro, this wetland is commonly referred to as “Woodberry Swamp”
– In Tomago, on the southern side of Masonite Road on the northern floodplain of the Hunter
– In Tomago, located south east on the northern floodplain of the North Channel Hunter River.
Although not classified under the Coastal Management SEPP, the Hunter River wetland is located within the Tomago Sandbeds Catchment Area and has significant wetland habitat features
All above mentioned wetlands are likely to be supported by groundwater discharge therefore are considered to be GDEs.</td><td>Due to these areas being either state-listed, protected wetlands or located on the Tomago Sandbeds Catchment Area, they are considered important wetlands and therefore are considered to be SREs.</td></tr>
<tr><td>GDEs</td><td>A number of known and potential GDEs were identified in the study area, these include:
– Aquatic GDEs: Floodplain wetlands (including Hexham Swamp Nature Reserve and surrounding wetlands, Hunter Wetlands National Park)
– High Potential Terrestrial GDEs: Coastal Floodplain Wetlands on the floodplain of Hunter River, Mangrove Swamps on the margins on the Hunter River and Coastal Dune Dry Sclerophyll Forests on the Tomago Sandbeds
– Moderate potential GDEs: Coastal Dune Dry Sclerophyll Forests on the Tomago Sandbeds.
It is noted that these potential and known GDEs coincide with the important wetlands outlined above.</td><td>These aquatic and terrestrial GDEs are sensitive to groundwater changes and are therefore considered SREs.</td></tr>
<tr><td>Key Fish Habitat</td><td>Based on aquatic habitat assessment, the following waterways and wetlands have been classified as Key Fish Habitat:
– Viney Creek: Type 2, Moderately sensitive KFH
– Purgatory Creek (downstream of the floodgates): Type 1, Highly sensitive KFH
– Hunter River: Type 1, Highly sensitive KFH
– Coastal Wetland (east of Hunter River): Type 1, Highly sensitive KFH.</td><td>Waterways that were deemed KFH are considered to have high conservation value therefore have been considered SREs.</td></tr>
</table>

11.4 Impact assessment

11.4.1 Impacts avoided and minimised

As described in **Chapter 4**, various alternatives to the project were considered as part of the project development process. This included the relocation of the Hunter River viaduct crossing (described in **Section 5.3.5**) to about 1.4 kilometres north of the original location and thereby minimising the overlap with the Hunter River floodplain. As a result of this change and other design developments, the project design would:

- Minimise the extent of the project located within the flood plain and its soft soils to limit ongoing complex surface water and groundwater interactions
- Avoid substantial water quality impacts arising from substantial increases in flooding behaviour, flows and afflux associated with a large embankment across the Hunter River floodplain
- Avoid permanent drawdown of the various groundwater resources during operation as a result of design interface lowering the groundwater.

Design of the project has further minimised surface water and groundwater quality impacts through:

- Applying a strategy to minimise impacts to the Tomago Sandbeds Catchment Area, including lining water quality controls in the Catchment Area during construction and operation to avoid infiltration of untreated water and ensure runoff is treated prior to discharge
- Minimising vegetation clearance and disturbance of previously undisturbed areas by placing the project within or adjacent to existing development corridors
- Minimising disturbance of sediments on the Hunter River floodplain by crossing the floodplain with a 2.6 kilometre viaduct instead of an embankment
- Construction water quality controls to reduce water quality impacts during construction, including impacts on SREs and downstream estuarine and marine waters
- Operational water quality controls (including permanent water quality basins and grassed swales) to reduce water quality impacts during operation, including impacts on SREs and downstream estuarine and marine waters
- Lining selected temporary sediment, permanent water quality basins and grassed swales with the potential to discharge water with elevated salinity into receiving environments.

11.4.2 Construction impacts

Construction of the project presents a risk of degradation of downstream surface water and groundwater quality if management measures are not implemented, monitored and maintained throughout the construction phase.

A strategy to minimise impacts to water quality during construction, and in particular to SREs, is to provide a combination of water quality treatment measures typically consisting of erosion control, sediment control, sediment capture and treatment. This strategy is supported by management measures to be implemented during construction as detailed in **Section 11.5**.

Construction phase impacts to surface water and groundwater are discussed in the sections below.

Surface water quality

Construction activities which are considered to be the highest risk to water quality are:

- Bridge work: Involving instream work, including dredging, piling, as well as construction and use of temporary instream work platforms, bridges and wharfs, vegetation clearing in creek riparian zones, concrete work, steel work and dewatering. Bridges which are proposed to be constructed over or within proximity of waterway and wetlands include:
  - A 2.6 kilometre viaduct over Hunter River and areas classified as Coastal Wetlands (Coastal Management SEPP)
  - Bridge across minor waterways including Glenrowan Creek (B02) and Windeyers Creek (B11)
  - A bridge within proximity of the Hunter River wetland (B09).
- Drainage work: Including excavation and soft soil compaction, vegetation clearing on the streambed and banks, instream work, including streambed levelling for installation of culverts and temporary creek diversions, installation of drainage pipes and pits, construction of table drains and swales, and dewatering.

Other construction activities with the potential to impact specific waterways include but are not limited to:

- Site establishment and access tracks: Involving movement and use of vehicles across exposed earth, excavation, vegetation clearing and mulching, and transport of materials to and from site
- Ancillary facilities: Activities occurring at ancillary facilities include movement and use of vehicles across exposed earth, stockpiling, vegetation clearing and mulching, batching plants, crushing plants, precast facilities, transport of materials to and from site and establishment of water quality controls (temporary sediment basins and permanent water quality basins)
- Earthworks: Activities including cut and fill of existing soils importing materials to work area, and stockpiling soils and treatment of soils
- Excavation and relocation of utilities: Utilities would need to be relocated, adjusted, or protected where they may be affected by project construction, particularly in areas where ground disturbance is required
- Waterway adjustments: Involving excavation, vegetation clearing in creek riparian zones, and instream work, including streambed levelling for installation of culverts and new channel alignments
- Construction discharges and dewatering: Involving dewatering of excavations and as a result of soil consolidation activities
- Site restoration: Restoration and landscaping of disturbed areas (including ancillary facilities and construction access roads) where required.

Waterways and wetlands with the potential to be impacted by these construction activities are described in **Table 11-12**.

Table 11-12 Waterways and wetlands with the potential to be impacted by construction activities

Waterway or wetland	Construction activities								
	Bridge work	Drainage work	Site establishment and access tracks	Ancillary facilities	Earthworks	Excavation and relocation of utilities	Waterway adjustment	Construction discharges and dewatering	Site restoration
Tributary of Viney Creek			✓	✓	✓	✓	✓	✓	✓
Glenrowan Creek and wetland near the twin bridge (B02) between Black Hill and Tarro	✓		✓	✓	✓	✓		✓	✓
Unnamed Coastal Wetland (Coastal Management SEPP) south of New England Highway		✓	✓	✓	✓	✓		✓	✓
Purgatory Creek	✓	✓	✓	✓	✓	✓	✓	✓	✓
Hunter River	✓	✓	✓	✓				✓	✓
Unnamed Coastal Wetland (Coastal Management SEPP) east of Hunter River	✓	✓	✓	✓	✓			✓	✓
Hunter River wetland	✓	✓	✓	✓	✓		✓	✓	
Tomago Sandbeds (near Masonite Road)		✓	✓	✓	✓	✓	✓		✓
Windeyers Creek	✓	✓	✓	✓	✓			✓	✓
Tributary of Windeyers Creek		✓	✓	✓	✓	✓		✓	✓

The construction activities described above may result in release of pollutants described in **Table 11-13**. Work within waterways (comprising bridge work, drainage work and waterway adjustments) is considered to be the construction activity with the highest risk, as it would be carried out in a dynamic and fluid setting with minimal buffer area for control.

Pollutant-specific impacts are described in the sections that follow.

Table 11-13 Pollutants relating to construction activities and general impacts on surface water quality

Pollutant	Potential source of pollutant from construction activities
Sediment	• Instream work, including dredging and piling, streambed levelling for installation of culverts and temporary creek diversions • Vegetation clearing in waterways and riparian zones • Movement and use of vehicles across exposed earth • Cut and fill earthworks • Excavation • Transport of materials to and from site • Relocation of utilities, including under boring and trenching • Stockpiling • Waterway adjustments • Dewatering temporary sediment basins • Site restoration including landscaping.
Sulfuric acid	Disturbance of ASS from: • Excavation • Dredging • ASS treatment.
Salt	Disturbance of saline soils from: • Excavation • Cut and fill earthworks • Dewatering.
Concrete waste	• Release of concrete liquid by-products with high pH from concrete installation or batching plants/precast facilities.
Oils and fuels	Release of oils and fuels from: • Vehicle movements • Spills and leaks from construction plant and equipment • Dewatering temporary sediment basins.
Heavy metals, polyaromatic hydrocarbons (PAHs) and other hydrocarbons	Release or exposure of heavy metals and PAHs from: • Asphalt works (batching, transport, laying, milling) • Contaminated site remediation • Concrete works • Vegetation clearing and mulching • Spills.
Tannin leachate	Release of tannin leachate from: • Mulching and stockpiling of cleared vegetation.
Dust and litter	Release of dust and litter during: • Earthworks • Material transport • Stockpiling • Concrete work • Rock crushing and blasting • Demolition • Use of construction sites by construction workers.

Erosion and sedimentation

Erosion and sedimentation can result in increased turbidity and poor water clarity. This can impact visual amenity and could potentially leading smothering of aquatic ecosystems due to clogging fish gills or decrease trophic interactions due to reduced visibility. Mobilised sediments may contain elevated concentrations of metals and other contaminants, which can negatively impact aquatic life.

Sediments may also contain high concentrations of nutrients which can lead to algal blooms and result in reduced light penetration that limits the growth of aquatic and estuarine vegetation. Algal blooms may also result in a reduction of dissolved oxygen content of the water which can lead to the creation of 'dead zones' where aquatic life cannot survive.

While highly erodible soils are generally not located within the construction footprint, there would still be a risk of erosion and sedimentation from the activities presented in **Table 11-14**.

Table 11-14 Construction impacts on erosion and sedimentation

Activity	Erosion / sedimentation risk
Instream work, including dredging and piling, streambed levelling and alteration of banks for installation of culverts and temporary creek diversions	Carrying out instream works would result in disturbance of sediment during piling or dredging activities, or may destabilise the streambed and river banks when altering channel structure. This may result in potential sedimentation of downstream environment which can cause increased turbidity that can be detrimental to aquatic life, result in algal blooms and can reduce visual amenity.
Vegetation clearing in waterways and the riparian zone (comprising bridge work, drainage work and waterway adjustments)	Vegetation clearing within and near waterways may result in mobilisation of instream sediments, destabilisation of riverbanks and potential bank collapse, and/or erosion of exposed top soils via wind or runoff. Mobilised soils or sediments may result in increased turbidity within waterways which can be detrimental to aquatic life, result in algal blooms and can reduce visual amenity.
Cut and fill earthworks	Cut and fill earthworks are required along the main alignment due to the undulating topography. In areas of cut, there would be a risk of erosion and sedimentation from destabilisation of the landform. In areas of fill, soils and landform could become eroded during rainfall events, resulting in sedimentation of downstream waterways through mass movement of soils. There would be a risk of erosion and sedimentation from destabilisation at the large cut proposed at Black Hill and from smaller cuts at the Tomago interchange. Areas of fill around Purgatory Creek, Hunter River Drain and tributary to the Hunter River Drain also pose a risk to downstream water quality during rainfall events.
Excavation	Excavation could transport loose sediment to downstream waterways if able to mobilise via wind and runoff. Excavation would be required for establishing access tracks, road construction activities, piling activities, building bridge abutments, constructing drainage infrastructure, and adjusting waterway channel alignments along the entirety of the project.
Movement and use of heavy vehicles across exposed earth	Operation of heavy machinery can disturb soils, particularly in areas where vegetation has been removed or topsoil has been stripped. This increases the potential for erosion and sedimentation in downstream receiving environments, particularly those near access tracks, ancillary facilities, and construction areas where vehicles, plant and equipment would be used.
Transport of materials to and from site	Excavated material, as well as material brought to site to be used in construction, would need to be transported to and from site via access tracks which has the potential to be lost from the vehicle if not appropriately secured. This could result in sedimentation to downstream waterways if able to mobilise via wind or runoff. Material transport poses the highest risk to waterways that are near or crossed by access tracks and waterways in proximity to ancillary facilities or construction sites.

Activity	Erosion / sedimentation risk
Stockpiling	Excavated material would require stockpiling before being crushed and reused or transported off site. High rainfall events and high winds during construction can erode stockpiled areas and disturbed areas with exposed soils. This can result in increased turbidity, lower dissolved oxygen and increased nutrients which may exacerbate algal blooms and aquatic weed growth. Stockpiles are proposed at all ancillary facilities within the project construction footprint.
Relocation of utilities	A number of utilities are located within the construction footprint and may need to be relocated, adjusted, or protected where they may be impacted by project construction, particularly where excavation would be required. Relocation would involve soil disturbance from trenching and underboring, and disturbance of soil by machinery could increase the potential for soil erosion.
Construction dewatering and discharges	Dewatering discharge from construction (either from excavations or wick drains) can result in water that may be turbid. This water would be directed into temporary construction treatment controls to minimise impacts.
Site restoration	Minor earthworks are required during landscaping and site restoration activities that could result in the erosion of disturbed soils that have not yet stabilised, with potential for sediment to be transported downstream by wind or runoff. Impacts associated with landscaping and site restoration would be temporary as stabilisation and revegetation would act to prevent future soil erosion.

While sediment-laden runoff and pollutants from erosion and sedimentation may temporarily reduce downstream water quality, they would be unlikely to cause major or long term impacts to the overall condition of the surrounding waterway, as erosion and sedimentation would be managed with the implementation of erosion and sediment controls described in **Section 11.5** and **Chapter 5**).

Sulfuric acid

Sulfuric acid can be generated from the exposure of ASS to air and may mobilise to waterways and cause a decrease in pH which can be harmful to aquatic life. Vegetation clearing, excavation, dredging, piling, general ground disturbance and streambed levelling can result in moderate water quality impacts due to the potential to disturb ASS and mobilise poor water quality to downstream waterways. ASS is further discussed in **Chapter 16** (soils and contamination). The waterways at risk of being impacted by disturbance of ASS are the Hunter River and Windeyers Creek due to the excavation required for bridge construction, and Purgatory Creek due to disturbance for creek adjustment. Of lower risk are the Viney Creek tributary, unnamed tributaries, and drainage canals.

Inappropriate management of ASS could result in sulphuric acid and heavy metals being transferred to downstream waterways following rainfall, directly impacting aquatic life and water supply quality. With the implementation of the environmental management measures described in **Section 11.5** and **Section 16.5**, acid sulfate soil disturbance would not be likely to result in a significant impact to water quality.

Salts

Saline soils present a risk to downstream waterways if they are exposed and leach high concentrations of salt into runoff. Saline soils can alter the salinity of waterways which can alter instream biodiversity and ecosystem function. However, the risk of this occurring as a result of construction of the project is considered low as the receiving environment has habituated to catchment geology and salt impacted surface water flows. Surface water quality controls and management measures would be implemented to minimise the development of excessive saline water flows. Saline soils are further discussed in **Chapter 16** (soils and contamination).

Concrete waste

Concrete work, including batching, pre-casting and in situ pouring, can result in concrete dust, concrete slurries or washout water entering downstream waters. Concrete by-products are alkaline and therefore could alter the pH of downstream watercourses and be harmful to aquatic life that is sensitive to changes in water quality.

The main areas at risk from mobilisation of concrete waste are waterways which are in proximity to ancillary facilities where concrete batch plants and precast facilities would be located. However, the risk of transportation of concrete waste to waterways is considered low as water quality controls and management measures would be implemented to ensure no runoff is mobilised downstream prior to being captured and treated in temporary sediment basins.

Oils, fuels, and polycyclic aromatic hydrocarbons

Mobilisation of oils and/or fuels from leaks and spills or from temporary sediment basin discharges may lead to the introduction of hydrocarbons and heavy metals into the waterways. This may be harmful to aquatic life and could reduce visual amenity.

Release or exposure of polycyclic aromatic hydrocarbons (PAH) from asphalt can be toxic to aquatic life. Dewatering of surface water features for the establishment of construction areas and access tracks may mobilise poor quality water with high toxicant concentrations, including PAH to downstream receiving environments.

Heavy metals have the potential to be introduced into waterways from construction activities if mobilised by wind or stormwater runoff. Potential sources include:

- Steel cuttings from steel works required for road and bridge construction
- Changes in physico-chemical conditions may trigger release of accumulated trace metals from mangroves
- Concrete waste may contain elevated concentrations of chromium
- Other heavy metals associated with waste materials from contaminated site remediation.

With the implementation of the environmental management measures described in **Section 11.5** and **Section 16.5**, the release or exposure of oils, fuels, and PAH, if managed correctly, would not be likely to result in a significant impact to water quality.

Tannin leachate

Tannins from mulching and stockpiling of cleared vegetation can cause dark coloured water to be discharged into downstream waterways. This could alter the instream pH and reduce visibility and light penetration in the water column. Tannins could also increase biochemical oxygen demand, which could decrease instream dissolved oxygen concentrations. This can impact on aquatic ecosystems and lead to fish kills.

The implementation of the environmental management measures described in **Section 11.5,** tannin leachate, if managed correctly, would not be likely to result in a significant impact to water quality.

Dust and litter

Dust generated from concrete work, rock crushing and blasting may contain heavy metals which could be harmful to aquatic life. Dust associated with demolition of buildings and infrastructure may contain contaminants such as concrete, asbestos, or other pollutants. These may be harmful to aquatic ecosystems if mobilised to downstream environments.

Mobilisation of litter to waterways may lead to the introduction of gross pollutants, hydrocarbons and heavy metals into the waterways which may be harmful to aquatic life and reduce visual amenity.

With the implementation of the environmental management measures described in **Section 11.5** and **Section 16.5**, the dust and litter, if managed correctly, are not likely to result in a significant impact to water quality.

Water quality impacts from temporary sediment basin discharge

Pollutants

Project construction would result in discharge of temporary sediment basins. Pollutants of most concern during construction are total suspended solids, oil, and grease.

The primary aim of the temporary sediment basins is to capture sediment as nutrients and metals are typically bound to sediments in a dissolved (and often harmful) state. By capturing sediments (and subsequently nutrients and toxicants) via the grassed swales and temporary sediment basins, the risk to downstream water quality would be reduced. Environmental impact of discharge from basins is of greatest concern where they discharge directly to the SREs of the Hunter River and the downstream Ramsar wetlands.

Treatment of these pollutants would be in accordance with typical pollution controls for road projects. As the primary aim of the temporary sediment basins would be to capture sediment, the basins would also capture nutrients and metals that are bound to sediments. By capturing sediments the risk to downstream water quality would be reduced. As described in **Section 5.4.11**, a total of 47 temporary sediment basins are proposed (shown in **Figure 5-25**). Temporary sediment basins would be sized in accordance with the requirements of Landcom (2004) and DECC (2008) to provide sufficient volume for settling and storage of sediments. Further information on the location and design of temporary sediment basins are provided in Surface Water and Groundwater Quality Working Paper (**Appendix K**).

As per 85th percentile Blue Book requirements for the area, the rainfall event criteria is 38.9 millimetres.

Total annual average TSS loads discharged from temporary sediment basins under controlled conditions is shown in **Table 11-15**. It is noted that the Hunter River would receive lower direct discharge loads than smaller waterways, such as Viney Creek, as these smaller waterways would have a greater number of basins discharging into them.

Table 11-15 Annual average TSS loads (kg/yr) discharged from sediment basins under controlled conditions

Locations	Controlled discharge from sediment basins
R1-Glenrowan Creek	584
R2-Purgatory Creek	209
R3-Hunter River drain	2734
R4-Windeyers Creek	2066
R5-Viney Creek	2974
R6-Hunter River	104
R7-Unnamed coastal wetland	209

Salinity

Thirty temporary sediment basins would interact with groundwater. For the majority of the basins, modelled electrical conductivity of discharge is similar to the receiving environment. However, there are a number of basins where modelled conductivity would exceed background concentrations and the ANZG (2018) guidelines.

Dewatering discharge from these basins would be into Glenrowan Creek and the tributary of Viney Creek and may impact on biota that cannot tolerate higher salinity. Four temporary sediment basins are recommended to be lined to avoid discharge of highly saline water (greater than 7500µS/cm). There is potential for slightly more saline water to be released into some waterways classified as lowland river, which may temporarily increase waterway salinity, however given the temporary nature of construction, this is not expected to impact on achieving the WQOs. Given this, the project is unlikely to have long term impacts on the salinity of the affected waterways and is not expected to have a significant impact on water quality during construction.

pH

ANZG (2018) Water Quality Guidelines recommended water quality discharges have a pH between 6.5 and 8.5 to ensure protection of lowland river aquatic ecosystems or between pH 7 and 8.5 for protection of estuarine aquatic ecosystems. The pH of water will be tested prior to discharge to confirm it falls within these limits so that there is no impact to the pH of downstream waterways.

Groundwater quality impacts

Construction activities that may cause groundwater quality impacts include:

- Temporary construction dewatering, which may result in dewatered discharge of unknown quality to be managed and also resulting in localised lowering of the water table with potential to oxidise acid sulphate soils or impact GDEs
- Mounding of water table associated with soft soil consolidation, resulting in potential for mobilisation of salts within soil profile
- Operation of unlined temporary sediment basins and potential to introduce contaminants into groundwater via a new migration pathway
- Mobilisation of areas of existing or potential groundwater contamination due to construction activities (refer to **Chapter 16** (soils and contamination)).

These impacts, as well as water quality impacts to the public drinking supply of the Tomago Sandbeds Catchment Area, are discussed in the following subsections.

Acid sulphate soil risk associated with construction dewatering

Temporary construction dewatering would be required where excavations occur below the water table. As described in **Chapter 10** (hydrology and flooding), shallow excavations (such as for culverts and minor utilities) are not anticipated to require substantial dewatering. Key activities that have been assessed as requiring more substantial dewatering include, but are not limited to, the following:

- Excavations for large utility work
- Excavation of temporary and permanent basins, including 36 proposed temporary sediment basins that require excavation below the water table
- Excavations for bridge and viaduct piers at four sites (including a tributary to Mid Site Channel in Tarro, the Hunter River viaduct, an overbridge at Tomago interchange and Windeyers Creek)
- Excavations for the Purgatory Creek adjustment.

Temporary construction dewatering could lower groundwater levels in areas of high ASS risk, exposing sulphide minerals in soil to oxygen, creating acidic conditions. This is especially relevant in the low lying floodplain areas next to the Hunter River in Tarro and Tomago and Windeyers Creek (refer to **Chapter 16** (soils and contamination)).

Predicted groundwater drawdown due to temporary construction dewatering are typically of limited extent and short duration. The rate of oxidation of sulphide minerals in soil is primarily controlled by rate of oxygen diffusion through the soil and the initial soil pH. Given the relatively short durations of dewatering, the typically low permeability of the high risk ASS materials and the elevated initial pH conditions, acid generation resulting from short term dewatering is expected to be minor. Any potential for oxidation is likely to be limited to oxidation within the exposed faces in the excavation, and the volume of acid generated is not expected to be significant. Acid sulphate soils are further discussed in **Chapter 16** (soils and contamination).

Soil salinity and acid sulphate soil risk from soft soil consolidation

Soft soil consolidation activities can change groundwater levels. Raised groundwater levels can increase soil salinity risk by mobilising salts accumulated in unsaturated soils, resulting in elevated shallow groundwater salinity. Lowered groundwater levels have potential to result in generation of ASS.

As discussed in **Section 10.5.2**, the use of surcharge embankments to facilitate soft soil consolidation for the project. Areas of groundwater level change across the groundwater study area include:

- Mounding (elevated groundwater levels up gradient of the surcharge embankment)
  - Tarro: Mounding would be minor in this area (0.2 metres). The degree of mounding is within seasonal fluctuations and is located in an area where there is frequent existing surface expression of groundwater. As such, the unsaturated zone would not be subject to salt accumulation and the rise in water level would have little effect from a salinity risk perspective
  - Tomago and Tomago Sandbeds: Mounding of up to 0.2 metres is predicted over most of the upstream area of consolidation, while the greatest magnitude of predicted mounding (up to 0.8 metres) is predicted within the highly permeable Tomago Sandbeds that are subject to frequent flushing by infiltrating rainfall. As such, the unsaturated zone is not subject to substantial salt accumulation and the rise in water level would have little effect from a salinity risk perspective. It is also noted that the level of mounding, at its highest point, would be about two metres below ground surface and as such is not expected to result in noticeable surface effects or impacts to other groundwater users.
- Shadowing (reduced groundwater levels down gradient of the surcharge embankment)
  - Tarro: Shadowing would be localised and negligible (less than 0.05 metres)
  - Tomago: Shadowing effects at the Tomago soft soil consolidation would be very localised and minor (less than 0.1 metre).
- Lowered groundwater water levels as a result of soft soil consolidation are predicted to be negligible and well within the range of seasonal groundwater fluctuation. Accordingly, there would be no significant risk of acid generation as a result of oxidation of PASS from groundwater shadowing.

Chapter 10 (hydrology and flooding) further discusses water levels and associated groundwater impacts associated with soft soil consolidation in this area.

Groundwater contamination risk from operation of unlined temporary sediment basins

Unlined temporary sediment basins that are excavated below the water table may potentially expose local groundwater to contaminants in the basin water. When full or partially full, water levels in the basins would be above that of the surrounding water table and the basins could act as temporary groundwater recharge points, dependant on local soil conditions. With runoff from the construction footprint entering the basins there would be potential for spills or contaminants to also enter the basin with subsequent migration to groundwater impacting on groundwater quality.

During construction, key risks from contaminants relate to hydrocarbon storage and the operation of mobile plant (leaks and spills). Hydrocarbon spills would be managed by site protocols and any spills would be cleaned up in the short term. In the event of any hydrocarbon spills substantial enough to impact a sediment basin, the spills would be obvious on the surface of the basins and rapid clean up based on site management protocols would be implemented to minimise the potential for groundwater contamination.

Non-spill related contaminants likely to enter the basin would be associated with suspended sediment. As sediment would settle out in the basin, the impact on groundwater is expected to be negligible.

Mobilisation of areas of existing or potential groundwater contamination

Construction dewatering and associated drawdown is not anticipated to interact with any of the areas of existing known contamination described in **Chapter 16** (soils and contamination). Drawdown is not predicted in areas of known contamination and is not predicted to encroach on areas of known contamination.

Impacts to Tomago Sandbeds Catchment Area

Eleven temporary sediment basins within the Tomago Sandbeds Catchment Area would be lined to avoid potential for any contamination to occur. As a result, no construction impacts to groundwater quality are anticipated within the Tomago Sandbeds Catchment Area.

Surface water reuse

Non-potable water would be required for a number of construction activities such as dust suppression and earthworks compaction. While water sources would be confirmed during detailed design, there is the potential to source this water from temporary sediment basins, which may comprise of surface runoff as well as groundwater. Water in temporary sediment basins may be acidic, saline, or turbid depending on its source. Where practicable, acidic water would be treated to reduce acidity, while turbid water would be treated through normal operation of the temporary sediment basins. However, highly saline water (greater than 7500µS/cm) would be reused in applications where there is minimal risk of harm to biodiversity, infrastructure, existing soils or entry into waterways (such as compaction of elevated formations, dust suppression etc) and where the salinity is commensurate with existing soil and groundwater conditions.

With the appropriate sizing of the temporary sediment basins to allow for treatment of runoff and implementation of other management measures (including sediment basin water quality checks prior to reuse), reuse of this water for construction activities would not pose a risk to downstream surface water and groundwater quality including any risks to ecosystem and human health.

Coastal Management Areas

The construction footprint is located within or near Coastal Management Areas as defined in the Coastal Management SEPP. These include areas classified as Coastal Wetland, Coastal Wetlands Proximity Area, Coastal Environment Area or Coastal Use Area. In accordance with the Coastal Management SEPP, work carried out within these areas should be designed to avoid, minimise, or mitigate any adverse impacts on the integrity and reliance of the biophysical, hydrological, or ecological environment of the wetland, adjacent wetland, coastal environment area or coastal use area.

The Coastal Management Areas that would be cleared for use during construction are presented in **Table 11-16**. The majority of the mapped 'Coastal Management Areas' which fall within the construction footprint have already been cleared for agricultural purposes, and any remnant wetland vegetation within the mapped areas is in poor condition (refer to **Chapter 9** (biodiversity)). The mapped areas are therefore not expected to function as important wetland environments and clearing of vegetation from these areas would not result in a significant impact to their ecological function, with the exception of the Unnamed Coastal Wetland which is located on the eastern bank of the Hunter River.

The unnamed Coastal Wetland is known to include a number of threatened ecological communities (TECs) and functions as an estuarine habitat. While clearing in this section is unlikely to significantly disrupt the ecological processes of the wetland, there is potential for changes to the local biophysical and hydrological conditions during construction due to increased risk of erosion of disturbed soils and potential for overland flow. The risk of these impacts is considered unlikely due to establishment of erosion and sediment controls prior to any clearing being carried out within the construction areas. Therefore, all potential sediment-laden runoff would be directed to temporary sediment basins prior to reaching any undisturbed sections of the wetland.

Overall, water quality impacts from construction activities on Coastal Management Areas would be unlikely following the implementation of management measures and controls detailed in **Section 11.5**. Further, ancillary facilities, instream work platforms and wharves would be rehabilitated as far as practicable prior to demobilisation.

Table 11-16 Coastal Management Areas (Coastal Management SEPP) that would be cleared or occupied for use during construction

Coastal Management Area category	Area to be cleared for use	Project features that would occupy the area
Coastal Wetlands	16.5ha	• Main alignment (western side of Hunter River) • Hunter River crossing (the viaduct) • Main alignment (eastern side of Hunter River) • Ancillary facility 10 (AS10) • Ancillary facility 11 (AS11)
Coastal Wetlands Proximity Area	28.3ha	• Main alignment (western side of Hunter River) • Ancillary facility 9 (AS9) • Hunter River crossing (the viaduct) • Main alignment (eastern side of Hunter River) • Ancillary facility 10 (AS10) • Ancillary facility 11 (AS11)
Coastal Use Area	46.8ha	• Ancillary facility 6 (AS6) • Ancillary facility 7 (AS7) • Ancillary facility 8 (AS8) • Ancillary facility 9 (AS9) • Hunter River crossing (the viaduct) • Ancillary facility 10 (AS10) • Ancillary facility 11 (AS11)
Coastal Environment Area	140ha	• Ancillary facility 6 (AS6) • Ancillary facility 7 (AS7) • Ancillary facility 8 (AS8) • Ancillary facility 9 (AS9) • Hunter River crossing (the viaduct) • Ancillary facility 10 (AS10) • Ancillary facility 11 (AS11) • Ancillary facility 13 (AS13)

Assessment of project construction discharges against WQOs

As discussed in **Table 11-13**, a number of pollutants associated with construction of the project have potential to impact on nominated WQOs for waterways within the surface water study area. The proposed management measures including erosion and sediment controls have been designed to primarily prevent or reduce erosion and sediment impacts during construction. Where erosion does occur, the secondary aim of the temporary sediment basins is to capture runoff as close to the source as practicable to minimise pollutants entering downstream waterways.

As discussed in **Section 11.3.1**, the current water quality of waterways in the study area is considered poor due to elevated turbidity, nutrients, low dissolved oxygen and often high levels of zinc and copper. The WQO for protection of aquatic ecosystems is currently not being achieved at any site, nor is the objective for aquatic foods (cooked) where applicable. The WQOs of visual amenity, primary contact recreation and secondary contact recreation were also not met for any of the waterways.

Pollutant loading into waterways from temporary sediment basin discharges has been calculated for turbidity and compared against the DGV for protection of aquatic ecosystems (refer to **Table 11-17**). Representative waterways have been assessed to verify if they comply with the relevant WQO DGV or, to determine if the outcomes of the project construction activities work towards their achievement over time. Proposed calculated turbidity that is lower than the ambient DGV is shaded dark green to highlight that the WQO of the receiving waterway is met and protected, and that discharge is not considered cause significant harm to the waterway. Proposed calculated turbidity that does not meet the DGV but is generally lower than the existing ambient median values (determined by onsite monitoring) is shaded light green as it is contributing to achievement of the WQO DGV of the receiving waterway over time, is generally an improvement on the existing ambient water quality and is unlikely to cause significant harm to the waterway. Proposed calculated turbidity that exceeds the WQO DGV and existing ambient water quality is shaded red and are discussed in **Table 11-8**.

A detailed summary of the project's impact on water quality objectives during construction is presented in **Table 11-18**. When the calculated project pollutant point loading from basin discharges is considered against the WQO DGV and/or compared with pollutant loading from the wider catchments, impacts to ambient water quality due to the project are unlikely to be significant.

Table 11-17 Comparisons of calculated turbidity discharged from sediment basins during construction against existing conditions and guideline values

Waterway	Ecosystem turbidity guideline values (NTU)	Existing median turbidity values (NTU) (Dry)	Existing range of turbidity values (NTU) (Dry)	Proposed calculated turbidity (NTU)	Further discussion required (refer to Table 11-8)
R1-Glenrowan Creek	6-50	17.2	5.8-57.7	33 Achieves WQO DGV	No
R2-Purgatory Creek	0.5-10	14.1 – 41.65	4-115	92	Yes
R3-Hunter River drain	0.5-10	20.82 – 55.63	6-551	82	Yes
R4-Windeyers Creek	6-50	6.57 – 39.53	5.01-71.2	12 Achieves WQO DGV	No
R5-Viney Creek	6-50	31.58	20-58	67	Yes
R6-Hunter River	0.5-10	37.3 – 66.03	18-776	48 Contributes towards achieving WQO over time	No
R7- Unnamed coastal wetland	0.5-10	25.75	9-33	48	Yes

Table 11-18 Project impact on water quality objectives during construction

Waterway	Relevant site specific WQO applied to the assessment					Assessment of project impact during construction
	Aquatic ecosystems	Visual amenity	Secondary contact recreation	Primary contact recreation	Aquatic foods (cooked)	
R1 – Glenrowan Creek (Lowland river)	✓	✓	✓	✓	N/A	The proposed quality of the construction water discharge from basins at this waterway complies with the turbidity DGV and continues to protect aquatic ecosystems WQO. Construction basin discharges are unlikely to have a significant impact on water quality. A brief discussion on the WQO is provided below. <u>Aquatic ecosystems</u>: Turbidity of discharges from temporary sediment basins to Glenrowan Creek will comply with the DGV for the protection of aquatic ecosystems (lowland river) WQO. Electrical conductivity (EC), however, is expected to be slightly elevated above the DGV for protection of lowland river aquatic ecosystems as the sediment basin may interact with the saline groundwater table in this location, causing discharges to not meet the WQO. The impact of the potentially slightly elevated EC is considered to be negligible as the existing receiving environment is disturbed (refer to **Table 11-8**) and is anticipated to be habituated to the existing inputs. Despite the discharges from the temporary sediment basins not meeting the DGV for EC, the temporary nature of the discharge is unlikely to reduce existing water quality or impact aquatic ecosystems over time. <u>Visual amenity</u>: Turbidity of discharges will comply with the DGV and hence protect visual amenity. Construction discharges are expected to meet the WQO for visual amenity as turbidity levels are expected to be below the DGV and therefore visual clarity is not expected to be reduced. <u>Primary and secondary contact</u>: Secondary contact is possible due to landowner access and ongoing asset maintenance, however primary contact is considered highly unlikely due to the nature of the waterway as a shallow drainage channel within grazing land. Construction discharges are not anticipated to generate or consolidate enterococci. Additionally, since the turbidity of the discharges will be low, algal blooms are not anticipated. Concentrations of metals and toxicants that are hazardous to human health are not expected as they would be bound to sediment captured within the sediment basin. As the project would not generate any additional enterococci and is not expected to produce excessive sediment, the project is not anticipated to impact on the achievement of the relevant WQO DGV.

Waterway	Relevant site specific WQO applied to the assessment					Assessment of project impact during construction
	Aquatic ecosystems	Visual amenity	Secondary contact recreation	Primary contact recreation	Aquatic foods (cooked)	
R2 – Purgatory Creek (Estuarine)	✓	✓	✓	✓	N/A	The proposed turbidity of the construction water discharge from basins at this waterway does not comply with the DGV or the median turbidity in the existing environment. Further assessment is provided below. The existing water quality and receiving environment at Purgatory Creek is presented in **Table 11-8** where it is shown to be highly disturbed. Ongoing maintenance (flood conveyance) and surrounding livestock grazing land uses are anticipated to result in ongoing impacts to water quality and the aquatic environment. The range of values identified during site monitoring (<115 NTU) display the disturbed and variable condition of the waterway. The impacts of the surrounding land use on water quality in Purgatory Creek are evident in the water quality measured to date (**Table 11-8**). Without changes in surrounding land use it is unlikely that Purgatory Creek will meet WQO's over time. Flood gates at the downstream end of the creek alter surface flows by containing flows within the creek channel and hence increase residence time to aid sediment settlement within the confines of the disturbed environment. The proposed turbidity is calculated to require a dilution of 2.2 to meet the existing median ambient water quality and it is assumed that discharge inputs would generally occur during/after rainfall events where catchment surface water would be adequate to provide sufficient dilution. It is noted that the proposed calculated turbidity is lower that the upper limit of the existing environment and following dilution, the short term construction discharge is anticipated to be generally in accordance with the existing surface water and is unlikely to significantly impact on the receiving disturbed environment. A brief discussion on the WQO is provided below. <u>Aquatic ecosystems</u>: Turbidity in Purgatory Creek will not meet the DGV for protection of aquatic ecosystems (estuarine), however existing conditions do not comply with the DGV for turbidity. Due to surrounding land use, Purgatory Creek is not likely to meet the WQO over time and the proposed discharges (temporary for construction discharges) are unlikely to have a significant impact to existing water quality or aquatic ecosystems over time. <u>Visual amenity</u>: Existing water quality in Purgatory Creek does not meet the WQO for visual amenity due to high turbidity that reduces visual clarity. As stated above, turbidity of discharges to Purgatory Creek from the temporary sediment basins are within the range of existing turbidity experienced within Purgatory Creek and all discharges

Waterway	Relevant site specific WQO applied to the assessment					Assessment of project impact during construction
	Aquatic ecosystems	Visual amenity	Secondary contact recreation	Primary contact recreation	Aquatic foods (cooked)	
						would be temporary in nature. Discharges are therefore not expected to result in further degradation of visual amenity. Primary and secondary contact: Secondary contact is possible due to landowner access and ongoing asset maintenance, however primary contact recreation is considered highly unlikely as it is a shallow modified drainage channel that is situated within private farmland. Construction discharges is not anticipated to generate or consolidate enterococci. Additionally, since the turbidity of the discharges will be low, algal blooms are not anticipated. Concentrations of metals and toxicants that are hazardous to human health are not expected as they would be bound to sediment captured within the sediment basin. As the project would not generate any additional enterococci and would not produce excessive sediment, the project is considered unlikely to have a significant impact to secondary contact values.
R3 – Hunter River Drain (Estuarine)	✓	✓	✓	✓	N/A	The existing water quality and receiving environment at Hunter River Drain (not a natural waterway) is presented in **Table 11-8** where it is shown to be highly disturbed (as per WQO supporting information). Ongoing maintenance (flood conveyance) and surrounding agricultural land uses are anticipated to result in ongoing impacts to water quality and aquatic environment impacts. The range of values identified during site monitoring (<551 NTU) display the disturbed and variable condition of the drain. Flood gates at the downstream end of the creek alter surface flows by containing low and medium flows within the creek channel and therefore increase residence time to aid sediment settlement within the confines of the disturbed environment. The proposed quality of the construction water discharge from basins at this waterway does not comply with the DGV or the median turbidity of the existing environment. The impacts of the surrounding land use on water quality in the Hunter River Drain are evident in the water quality measured to date (**Table 11-8**). Without changes in surrounding land use it is unlikely the Hunter River Drain will meet WQO's over time. The proposed turbidity is calculated to require a dilution of 1.5 to meet the existing median ambient water quality and it is assumed that discharges would generally occur during/after rainfall events where catchment surface water would be adequate to provide sufficient dilution.

Waterway	Relevant site specific WQO applied to the assessment					Assessment of project impact during construction
	Aquatic ecosystems	Visual amenity	Secondary contact recreation	Primary contact recreation	Aquatic foods (cooked)	
						It is noted that the proposed calculated turbidity is lower that the upper limit of the existing environment and following dilution, the short term construction discharge is anticipated to be generally in accordance with the existing surface water and is unlikely to significantly impact on the receiving disturbed environment. A discussion on the WQO is provided below. Aquatic ecosystems: Discharges from temporary sediment basins to Hunter River Drain will not meet the turbidity DGVs for protection of aquatic ecosystems (estuarine), however existing conditions within the waterway are often found to be highly turbid. Despite the sediment basin discharges not meeting DGVs, the temporary nature of the discharge is unlikely to reduce existing water quality or impact aquatic ecosystems over time. Visual amenity: Existing water quality in Hunter River Drain does not meet the WQO for visual amenity due to high turbidity levels that reduce visual clarity. Turbidity of discharges to Hunter River Drain from the temporary sediment basins are within the range of existing turbidity experienced within Hunter River Drain and discharges would be temporary in nature, therefore it is not expected to significantly impact visual amenity. Primary and secondary contact: Secondary contact is possible due to private land owner access and ongoing asset maintenance, however, primary contact is considered highly unlikely as it is a drainage channel that receives degraded runoff from a stud farm. Discharges from the temporary sediment basin would not contribute any bacterial constituents, however elevated turbidity would mean that the discharges could contain contaminants that could be hazardous to human health and therefore would continue to not meet these.
R4 – Windeyers Creek (Lowland river)	✓	✓	✓	✓	N/A	The proposed turbidity of the construction water discharge from basins at this waterway complies with the DGV and continues to protect WQOs. A brief discussion on the WQO is provided below. Aquatic ecosystems: Turbidity associated with discharge from temporary sediment basins to Windeyers Creek will comply with the DGV for the protection of aquatic ecosystems (lowland river) WQO. Contaminants such as heavy metals or toxicants which are bound to sediments are unlikely to be elevated in basin discharge due to deposition of sediments prior to discharge. The discharge into the aquatic environment is unlikely to have significant impact to the aquatic ecosystem.

Waterway	Relevant site specific WQO applied to the assessment					Assessment of project impact during construction
	Aquatic ecosystems	Visual amenity	Secondary contact recreation	Primary contact recreation	Aquatic foods (cooked)	
						Visual amenity: Proposed turbidity would meet the WQO for visual amenity as turbidity levels are expected to be below the DGV and therefore visual clarity is not expected to be reduced. Primary and secondary contact: Secondary contact is possible due to public access, although primary contact recreation is considered highly unlikely. WQO for primary and secondary contact would be met for recreation, as sediment basin discharges are not expected to generate bacteria (i.e. enterococci) that would result in the deterioration of recreational water quality. Additionally, since the turbidity of the waterway will be low, additional algal blooms are not anticipated.
R5 – Viney Creek (Lowland river)	✓	✓	✓	✓	N/A	The proposed turbidity at this waterway does not comply with the DGV or the median turbidity of the existing environment. Further assessment is provided below. The existing water quality and receiving environment at Viney Creek is presented in **Table 11-8** where it is shown to be disturbed and modified due to complete alteration for its passage through a light industrial precinct. Ongoing maintenance (flood conveyance) and surrounding light industrial land uses are anticipated to result in ongoing impacts to water quality and aquatic environment impacts. A dam constructed within the channel of the creek alter surface flows by containing low and medium flows within the dam, however the dam increases residence time to aid sediment settlement within the confines of the disturbed environment. The proposed turbidity is calculated to require a dilution of 1.3 to meet the existing median ambient water quality and it is assumed that discharges would generally occur during/after rainfall events where catchment surface water would be adequate to provide sufficient dilution. It is noted that the proposed turbidity is slightly higher that the upper limit of the existing environment however following dilution, the short term construction impact is anticipated to be generally in accordance with the existing surface water and is unlikely to significantly impact on the receiving disturbed environment. With the proposed attenuation, construction discharges would work towards achievement of the WQO DGV over time and are unlikely to have a significant impact on water quality.

Waterway	Relevant site specific WQO applied to the assessment					Assessment of project impact during construction
	Aquatic ecosystems	Visual amenity	Secondary contact recreation	Primary contact recreation	Aquatic foods (cooked)	
						Aquatic ecosystems: Proposed turbidity in Viney Creek is marginally higher that the ambient DGV, however the diluted turbidity would generally correspond with the existing water quality. The existing aquatic ecosystems are habituated to existing water quality and therefore the diluted discharges are unlikely to have significant impact to the aquatic ecosystem and would not hinder the long-term achievement of this WQO. Visual amenity: Turbidity would not meet the WQO, however the proposed turbidity is only slightly above the DGV and existing turbidity levels and therefore significant changes to the clarity of the waterway are not expected. Discharges are therefore not expected to hinder the long term achievement of the WQO. Primary and secondary contact: Secondary contact with the water is possible due to its accessibility by the public and its ongoing of maintenance for flood conveyance through the industrial area, however primary contact is unlikely due to shallow water and access limitation due to dense reed growth. Construction discharges are not anticipated to generate or consolidate enterococci, and as the modelled turbidity output is lower than the existing range, the project is unlikely to have a significant impact to secondary contact values.
R6 – Hunter River (Estuarine)	✓	✓	✓	✓	✓	The proposed turbidity at this waterway does not comply with the DGV, however calculated turbidity levels are generally lower than existing ambient turbidity levels. Hence the temporary sediment basin discharges are unlikely to have a significant impact on water quality and are working towards achieving the WQO over time. A discussion on the WQO is provided below. Aquatic ecosystems: The proposed turbidity is generally consistent with the existing background levels and with the high levels of dilution available in the tidal Hunter River, the minor volumes of temporary sediment basins discharges are unlikely to impact water quality in the Hunter River. As the aquatic ecosystems present within the river are habituated to the proposed discharge levels and are well under the existing range in the river (<776 NTU), the proposed discharges are unlikely to have a significant impact on the aquatic ecosystems of the Hunter River Visual amenity: The proposed turbidity of discharges to Hunter River are below the median value of turbidity experienced within the waterway and all discharges would be temporary in nature. Discharges are therefore expected to be working towards improving visual amenity.

Waterway	Relevant site specific WQO applied to the assessment					Assessment of project impact during construction
	Aquatic ecosystems	Visual amenity	Secondary contact recreation	Primary contact recreation	Aquatic foods (cooked)	
						Primary and secondary contact: The most probable primary recreational contact with water across the project will be in the Hunter River as it is infrequently used for water sports (skiing, paddling etc) Secondary contact is highly probable due to activities such as shore and boat fishing. The WQOs of primary and secondary contact recreation are currently not being met due to high turbidity and nutrient levels and suspended sediments may contain elevated concentrations of metals and toxicants that are hazardous to human health. Construction discharges would not contribute to conditions favouring the growth of or introducing bacteria (i.e. enterococci) to the waterway. Discharges therefore would work toward meeting these WQOs and improving existing conditions. Aquatic foods (cooked): The WQO of aquatic foods (cooked) is currently not being met due to elevated NTU and other contaminant levels above the DGV. The discharges from the temporary sediment basins would comply with the lowland river DGV. Additionally, due to the temporary nature of construction, the basin discharges are unlikely to hinder the long-term achievement of this WQO.
R7 – Unnamed coastal wetland (Estuarine)	✓	✓	✓	✓	N/A	The proposed turbidity at this waterway does not comply with the DGV and exceeds the existing median background levels. Further assessment is provided below. The existing water quality and receiving environment is presented in **Table 11-8**. Surrounding livestock grazing land uses are anticipated to result in ongoing impacts to water quality and the aquatic environment. The proposed turbidity calculated to require a dilution of 1.8 to meet the existing ambient water quality and it is assumed that discharges would generally occur during/after rainfall events where catchment surface water would be adequate to provide sufficient dilution. Additionally, the wetland is expected to receive ongoing groundwater inputs from the adjacent Hunter River and upgradient Tomago Sands aquifer and these inputs can also be expected to express as surface water in the channel resulting in further dilution. When the dilution factor is applied to the, the short duration discharges are unlikely to have a significant impact on the receiving aquatic ecosystem. A brief discussion on the WQO is provided below. Aquatic ecosystems: The wetland and channelised watercourse at the site reflects a wetland of low to moderate condition that is affected by livestock grazing, various underground and overhead utility installations and the flood

Waterway	Relevant site specific WQO applied to the assessment					Assessment of project impact during construction
	Aquatic ecosystems	Visual amenity	Secondary contact recreation	Primary contact recreation	Aquatic foods (cooked)	
						levee bank that separates the wetland form the adjacent Hunter River. The aquatic ecosystems at the site have become habituated to the modified conditions and are anticipated to be resilient to further modified inputs over the construction period. The site is expected to receive ongoing groundwater inputs from the adjacent Hunter River and upgradient Tomago Sands aquifer and these inputs can be expected to consistently resupply the channel with water for dilution. When the dilution factor is applied to the waterway inputs from temporary sediment basins are unlikely to have a significant impact on the receiving aquatic ecosystem and work towards meeting the water quality objectives over time. <u>Visual amenity</u>: Existing water quality of the unnamed tributary does not meet the estuarine WQO for visual amenity due to elevated turbidity that reduces visual clarity, Diluted turbidity is anticipated to be generally consistent with the range of turbidity experienced within the waterway and temporary in nature. Discharges are therefore not expected to degrade the waterway further than existing conditions and are expected to work towards meeting the lowland river WQO over time. <u>Primary and secondary contact</u>: Secondary contact with surface water is possible due to access to the site for asset maintenance. Primary contact is highly unlikely due to shallow water at the site Whilst construction discharges would not contribute to conditions conducive to the growth of bacteria (i.e. enterococci) in the waterway, discharges could contribute sediment and therefore toxicants that may result in WQO not being met.

Hunter Estuary Wetlands Ramsar site

Due to substantial distance from the project, it is expected that there would be no direct impacts to the Hunter Estuary Wetlands Ramsar site, comprising the Hunter Wetlands National Park at Kooragang Nature Reserve and the Hunter Wetland Centre at Shortland. However, there is potential for indirect impacts to the Kooragang Nature Reserve, located about 5.1 kilometres from the construction footprint, from construction discharges to the Hunter River. No pollution pathway is expected for the Hunter Wetland Centre at Shortland, therefore the following assessment only relates to the Hunter Estuary Ramsar Wetland at Kooragang Nature Reserve.

Potential indirect impacts to the Hunter Estuary Wetlands Ramsar site were considered in an assessment of significance required under the EPBC Act referral prepared for the project and described in the Biodiversity Assessment Report (**Appendix I**). Impacts to the Hunter Estuary Wetlands Ramsar site were not declared as part of the controlled action status identified for the project by the delegate for the Australian Minister for the Environment.

During construction of the project, three temporary sediment basins on the Hunter River could discharge directly into the river, travelling downstream to the Hunter Estuary Wetlands Ramsar site at Kooragang Nature Reserve. These basins have a direct flow path to the Hunter River (without obstruction by floodgates).

Dilution was modelled to estimate the concentrations of TSS that could be discharged from the three temporary sediment basins and transported downstream to the Hunter Estuary Wetlands Ramsar site at Kooragang Nature Reserve (refer to the Surface Water and Groundwater Quality Working Paper (**Appendix K**)). It is assumed that discharges from all other temporary sediment basins would not reach the Hunter River without dilution and treatment due to retention behind floodgates and therefore are not included in this assessment.

Dilution modelling found that the Hunter River generally provides sufficient dilution of the basin discharges into the Hunter River so that water flowing to the Hunter Estuary Wetlands Ramsar site at Kooragang Island meets the DGV for turbidity. As controlled discharges from temporary sediment basins would not contribute additional sediment to the wetland, it is expected that nutrient and toxicant concentrations would not materially increase as a result of discharges as these are typically bound to sediment. The WQO is met with the assistance of the dilution of the Hunter River and it is unlikely that the project will have a significant impact to the downstream Ramsar wetlands.

11.4.3 Operational impacts

Prior to the end of construction, disturbed areas would be stabilised with sealed operational surfaces, landscaping and in channel scour protection. Potential water quality impacts to waterways would therefore be limited to the accidental spills associated with vehicle accidents and road use, and stormwater runoff from new impervious surfaces.

The main strategy to minimise impacts to water quality during operation, in particular to SREs, is the provision of a water quality treatment sequence consisting of permanent water quality basins, and grassed swales (the controls are discussed further below). Rainfall runoff and accidental spills (such as petroleum hydrocarbons) within the footprint of the road would be treated and contained through these swales and water quality basins.

Operational surface water and groundwater quality impacts are discussed in the sections below.

Surface water quality from project operation

After construction, all temporary instream structures would be removed, scour protection and drainage would be installed where required, ancillary facilities would be rehabilitated, and disturbed soils would be stabilised. The main operation risks that could cause surface water quality impacts include:

- Accidental spills: Discharge of spills directly into waterways (should spill event happen on a bridge) or via runoff into the drainage system. Spills may include heavy metals, oils and/or fuels. This may result in transportation of dust, litter, or poor-quality runoff to downstream receiving environments from road use by vehicles or from car accidents
- Stormwater runoff: Untreated stormwater from impervious surfaces which are not conveyed to treatment systems. This may result in surface runoff that may cause erosion and sedimentation of downstream receiving environments, or may contain elevated levels of pollutants from new impervious surfaces which are not conveyed to treatment system
- Permanent water quality basin discharges: Discharges from permanent water quality basins following a rainfall event and dewatering of unlined basins with groundwater interaction which could result in elevated saline water being discharged to lowland river environments.

Waterways and wetlands that may be impacted by these operational risks are presented in **Table 11-19**. Further pollutant specific discussion is provided in the following sections.

Table 11-19 Operational water quality risks and waterways that may be impacted

Waterway or wetland	Operational risks		
	Accidental spill	Stormwater runoff	Permanent basin discharge of highly saline water
Tributary of Viney Creek	✓	✓	✓*
Glenrowan Creek and wetland near the twin bridge (B02) between Black Hill and Tarro	✓	✓	✓*
Unnamed Coastal Wetland (Coastal Management SEPP) south of New England Highway	✓	✓	
Purgatory Creek	✓	✓	
Hunter River	✓	✓	
Unnamed Coastal Wetland (Coastal Management SEPP) east of Hunter River	✓	✓	
Hunter River wetland	✓	✓	
Tomago Sandbeds (near Masonite Road)	✓^	✓	
Windeyers Creek	✓	✓	
Tributary of Windeyers Creek	✓	✓	

* These waterways/wetlands are considered lowland river environments that will receive saline discharge (<7500µS/cm). Windeyers Creek and Tributary of Windeyers Creek are not ticked for intrusion of elevated saline water, as indicative blends of water quality from basins are not saline.
^ The event of an accidental spill in this area is considered highly unlikely as all road pavements in the drinking water catchment areas drain to water quality basins which have spill containment of 30,000 litres and are lined.

Sediment

Sediment is most likely to be generated by the project during operation when surface runoff enters downstream receiving environments, causing erosion and sedimentation impacts. Sediment-laden runoff has the potential to temporarily reduce downstream water quality, particularly directly after a rainfall event. This would be unlikely to cause major or long term impacts to the overall condition of the surrounding waterways, as erosion and sedimentation would be managed with the implementation of erosion and sediment controls as detailed in **Section 11.4.2**.

Saline groundwater

During operation, 25 permanent water quality basins would interact with groundwater. Discharge from these basins following rainfall may result in the release of water that is more saline than the receiving environment during rainfall events. While permanent water quality basins are not subject to a dewatering regime, surface water runoff during and following rainfall may result in permanent water quality basins overtopping and discharging into receiving environments.

Risk of overflows that are more saline than the receiving environment would be most likely at basins which would discharge into Glenrowan Creek and the tributary of Viney Creek. These waterways are categorised as lowland river, and typically have lower salinity concentrations than groundwater. This discharge, if prolonged and regular, presents a risk to the long term health of these waterways. These, over time, may become more saline, and impact biota that are unable to tolerate higher salinities. However, discharge is expected to be limited to occasional rainfall events where basin capacity is exceeded. This is due to the design of the basin and gradually increasing impermeability of the basins caused by the settlement of fine particles sealing the basin and reducing the interaction between groundwater and surface water.

Potential impacts to surface water quality would be reduced through adequate project design and the implementation of management measures as discussed above and as detailed in **Section 11.4.2** and **Section 11.5**. Four basins that are considered the most likely to result in elevated saline water discharges (greater than 7,500µS/cm) have been recommended for lining to avoid groundwater ingress to the basins, reducing the potential for the release of highly saline water. As such, the risk of water quality impacts during operation would be low and would be manageable through proposed measures.

Heavy metals, oils, and fuels

During rainfall events, increased concentrations of heavy metals and hydrocarbons can be mobilised in runoff. Oils and fuels can also be mobilised from spill events or leaks. While mobilisation would be most likely during rainfall events, spills following vehicle accidents can still result in transportation of pollutants to downstream environments in dry weather. These pollutants (either directly transported to a waterway or attached to sediments) can damage the ecology of waterways and terrestrial ecosystems, they can be toxic to aquatic biota, result in fish kills and reduce visual amenity.

Stormwater quality management for road runoff includes managing the export of suspended solids and associated contaminants – namely heavy metals, nutrients, and organic compounds. Pollutants such as nutrients, heavy metals and hydrocarbons are usually attached to fine sediments. To minimise water quality impacts from additional stormwater runoff and spills, the project has been designed to include permanent water quality controls, including permanent water quality basins and vegetated swales as detailed in **Section 11.4.2**. Due to these controls, risk of potential changes to water quality within downstream waterways and wetlands would be minimised. Stormwater runoff from the project would not be expected to have a significant impact on water quality during operation.

There would be sufficient opportunity for any spill event to be contained near the project within the permanent water quality basins which include spill containment across the project. As such, potential risk of poor water quality mobilising to downstream waterways from spills would be negligible and would be sufficiently managed through proposed design and management measures.

Dust and litter

Project operation would generate litter and transport dust as part of road use by vehicles. Pollutants may result in increased levels of nutrients and toxicants which may be harmful to aquatic life and reduce visual amenity in receiving waterways and wetlands. With the implementation of the environmental management measures described in **Section 11.5**, dust and litter are not likely to result in a significant impact to water quality.

Water quality impacts from permanent water quality basins

Permanent water quality basins and grassed swales have been designed to minimise physical-chemical and toxicant levels from stormwater runoff from roads during operation. As described in **Section 5.3.9**, a total of 39 permanent water quality basins are proposed as shown in **Figure 5-1**. The volume and type of permanent water quality control basins are described in the Surface Water and Groundwater Quality Working Paper (**Appendix K**).

As with the temporary sediment basins, the permanent water quality basins would not be able to fully contain rainfall runoff from rainfall exceeding 38.9 millimetres, which is anticipated to happen about seven times per year for most basins except those which can only be partially emptied due to high groundwater levels. 25 of the permanent water quality basins proposed have the capacity to partially fill with groundwater. As the groundwater level would not be above the discharge water level of the basins, continuous drawdown and impact on the groundwater is not anticipated to occur. Four permanent water quality basins located within the Tomago Sandbeds Catchment Area are recommended to be lined, as well as four basins where elevated salinity discharge (i.e. more than 7500µS/cm) is expected to avoid contamination into the groundwater.

Grassed swales would also be implemented as described in **Section 5.3.9** to support the function of the permanent water quality basins. While swales alone may not achieve all of the water quality criteria for the project, the swales have allowed basin sizes to be reduced, therefore reducing the operational footprint. Grassed swales within the Tomago Sandbeds Catchment Area would be lined to avoid potential groundwater contamination.

As described in **Section 11.2.6**, TSS, TN and TP loads were derived at seven locations representative of receiving waterways and compared to the water quality indicators and associated DGVs shown in **Table 11-4**. Modelled residual annual pollutant loads for each receiving waterway are identified in **Table 11-20**. Lower loads discharged to the Hunter River are due to the smaller number of basins that have a direct connection to the Hunter River, where as smaller waterways such as Viney Creek receive a greater number of basin discharges.

Road pavement surface runoff is typically collected in the water quality basins and retained up until the next rainfall event when volume displacement occurs and the treated water leaves the basin. This process which is repeated provides hydraulic residence time for the collected runoff to start the treatment process of reducing concentrations and loads. TSS and particulate bound pollutants such as TP and heavy metals settle at the base of the basin and additional chemical and biological processes occur in the basin to reduce other pollutants such as TN.

Table 11-20 Average annual pollutant loads (kg/yr) discharged from water quality basins during operation under controlled conditions

Location	TSS	TN	TP
R1 – Glenrowan Creek	231	0.48	3.1
R2 – Purgatory Creek	2,200	4.47	28.4
R3 – Hunter River drain	2,260	4.11	22.7

Location	TSS	TN	TP
R4 – Purgatory Creek	2,270	5.39	39.2
R5 – Viney Creek	1,950	4.38	39.7
R6 – Hunter River	128	0.36	3.9
R7 – Unnamed coastal wetland	606	2.09	14.3

Operational groundwater quality impacts

Potential groundwater quality impacts during operation include:

- Permanent lowering of the water table and oxidation of PASS material
- Mounding of water table associated with soft soil consolidation, resulting in mobilisation of salts from the soil profile
- Operation of unlined permanent water quality basins and introduction of contaminants into groundwater via a new migration pathway.

These impacts, as well as water quality impacts to the public drinking supply of the Tomago Sandbeds Catchment Area, are discussed in the following subsections.

Acid sulphate soil risk associated with permanent lowering of the water table

No long term lowering of the water table is anticipated in association with operation of the project. Once temporary dewatering activities are completed, recovery of the water table at individual dewatering locations is expected to occur within the same time frame for which dewatering was carried out (typically two to 10 days). In the vicinity of the Purgatory Creek adjustment, no long term reduction in water levels in the vicinity of the adjusted channel is anticipated. Accordingly, project operation is not expected to result in the oxidation of PASS material.

Soil salinity risk from soft soil consolidation

The long term mounding of the water table due to the consolidation of soft soil during operation is commensurate with that predicted during construction, with minor mounding predicted at Tarro and more substantial mounding predicted at Tomago. As such, and similar to construction, no significant impacts with respect to groundwater quality or soil salinity risk are anticipated.

Groundwater contamination risk from operation of unlined water quality basins

Unlined permanent water quality basins that have been excavated below the water table could expose local groundwater to any contaminants in the basin water. When full or partially full, water levels in the basins would be above that of the surrounding water table and the basins would act as temporary groundwater recharge basins. With runoff from the operational footprint entering the basins there is a risk that spills or contaminants could also enter the basin with subsequent migration to groundwater that may impact on groundwater quality.

The design of the permanent water quality basins incorporates spill containment measures to account for potential spills and the prevention of accidental discharge or migration to groundwater. Hydrocarbon spills would separate to the surface of the basins, be released to the atmosphere through volatilisation, therefore minimising the potential for migration to groundwater. Most non-spill related contaminants likely to enter the basin would be associated with suspended sediment or road particulate in runoff water. These particulates would settle out in the water quality basin and impacts of these contaminants on groundwater is expected to be negligible. Given that unlined water quality basins would be generally located in areas of relatively low permeability soils, the potential for contaminant migration, and water quality impacts would be substantially reduced.

Impacts to Tomago Sandbeds Catchment Area

No impacts to water quality within the Tomago Sandbeds Catchment Area are anticipated as a result of project operation. As the project has been designed to minimise and avoid impacts to the Tomago Sandbeds Catchment Area through the capture and conveyance of runoff leading to lined water quality basins, the risk impact to groundwater contamination at the Tomago Sandbeds Catchment Area from the project is considered to be minimal.

Coastal Management Areas

The operational footprint would be smaller than the construction footprint, providing opportunities for revegetation in Coastal Management Areas in accordance with the project urban design and landscape strategy (refer to **Section 15.3**).

Table 11-21 Coastal Management Areas (Coastal Management SEPP) that would be cleared or occupied for use during operation

Coastal Management Area category	Area to be permanently occupied by operational footprint
Coastal Wetlands	16.2ha
Coastal Wetlands Proximity Area	22.6ha
Coastal Use Area	15.3ha
Coastal Environment Area	78.2ha

Considering the existing roads (New England Highway and Pacific Highway) which traverse the Coastal Management Areas (and which the main alignment generally follows) the permanent clearance of these areas for the project is not expected to substantially impact on the functionality or visual amenity of the wetlands more than is already occurring.

Only two areas of wetland and floodplain vegetation are required to be permanently cleared and occupied from areas classified as 'Coastal Wetland' in the operational footprint, including wetland vegetation within the unnamed Coastal Wetland (south of the existing New England Highway) and Freshwater wetland and floodplain vegetation within the unnamed Coastal Wetland (east of the Hunter River). This vegetation is in poor to moderate condition with most areas showing signs of previous disturbance (i.e. regrowth following clearing and grazing). Further information is presented in **Chapter 9** (biodiversity).

Project operation has the potential to directly and indirectly impact the water quality of Coastal Management Areas that are within the surface water study area. These impacts would be related to:

- Changes to local hydrology at Purgatory Creek: The headwaters of Purgatory Creek are situated in the Coastal Wetland south of New England Highway near Tarro. The permanent adjustment of Purgatory Creek has the potential to result in a change in local hydrology for the area which may lead to changes in water quality such as build-up of contaminants in the wetland environment due to reduced flow or barriers to flow and therefore less flushing. The risk of this impact is considered low, and not significant, however, as the project design has ensured the revised operational drainage from the wetland to Purgatory Creek is generally maintained
- Road runoff: Road runoff to permanent water quality basins and subsequent discharge to downstream environments has the potential to result in deposition of sediment in wetlands or may introduce elevated levels of hydrocarbons, metals, or other contaminants such as litter to the wetland environment. As the environment surrounding already experiences runoff from existing roads, the operation of the project is not expected to result in a substantial increase in volume of runoff flowing to the downstream environment. As such, road runoff from the project is not expected to have a significant impact on Coastal Management Areas during operation.

To further minimise impacts to wetlands, the project design has ensured wetland fragmentation is minimised as much as practicable, with the main alignment only permanently occupying fringe areas of the wetlands and only requiring clearance and occupation of a small amount of the wetland relative to its size. As such, the permanent occupation of the main alignment is not expected to result in any significant impacts to Coastal Wetland areas listed under the Coastal Management SEPP.

Potential impacts to the Coastal Management Areas during operation of the project would therefore be limited to indirect impacts which would be related to changes to local hydrology at Purgatory Creek and road runoff during project operation.

Assessment of project operational discharges against WQOs

As discussed in **Table 11-19**, a number of pollutants associated with operation of the project may affect performance against the WQOs of the project described in **Section 11.2.4**. As described in **Section 11.3**, the WQOs are not currently being met.

While an improvement to existing water quality is anticipated for some indicators at modelled locations, water quality remains unlikely to meet the ANZG (2018) Water Quality Guidelines and nominated objectives in the short term. **Table 11-22** provides the expected concentrations of key pollutants from permanent water quality basin discharges against the DGVs for protection of aquatic ecosystems and existing water quality. The modelled median concentrations proposed in the discharge were compared against the WQOs DGV and against the existing background median values.

Representative waterways have been assessed to verify if they comply with the relevant WQO DGV or, to determine if the outcomes of the project construction activities work towards their achievement over time.

Proposed modelled water quality that is lower than the ambient DGV is shaded dark green to highlight that the WQO is protected. The compliant water quality is considered unlikely to cause significant harm to the waterway and a brief discussion on the relevant default WQO(s) is provided below in **Table 11-23**.

Proposed modelled water quality that does not meet the DGV but is generally lower than the existing ambient median values (determined by onsite monitoring) is shaded light green as it would contribute to achievement of the WQO DGV over time. The water quality is generally an improvement on the existing ambient water quality and is unlikely to cause significant harm to the waterway and a brief discussion on the relevant default WQO(s) is provided below in **Table 11-23**.

Proposed modelled water quality that exceeds the WQO DGV and existing ambient water quality is shaded red in **Table 11-22**. These representative locations are assessed in further detail in **Table 11-23.**

A detailed summary of the project's impact on water quality objectives during operation is presented in **Table 11-23**. The operation of the project is not expected to impact on achieving the WQOs of primary and secondary contact recreation with the key indicators of concern relevant to these objectives being pathogens, algae and toxicants. This is because the operation of the project would not result in an increase in bacteriological indicators. Additionally, increased algal numbers are not anticipated as there would be a reduction in nutrients entering the water via project runoff. It would be expected that a corresponding decrease in toxicants would also be observed into downstream waterway which could have posed a risk to human health. Therefore, operation of the project does not pose a significant risk to human health and the environment (refer to the Surface Water and Groundwater Quality Working Paper (**Appendix K**) for further details).

Table 11-22 Comparison of modelling water quality during operation with existing water quality and project water quality objectives

Waterway classification	Indicator	DGV aquatic ecosystem	Existing median concentrations when dry	Existing range concentrations when dry	Modelled median value and comparison against aquatic ecosystems WQO	Further discussion required (refer to Table 11-23)
R1 – Glenrowan Creek (Lowland river)	Turbidity	6-50 NTU	17.2	5.84 – 57.7	26.8 Complies with WQO DGV	No
	TN	0.35mg/L	1.6	0.5 – 1.6	0.69 Contributes towards achieving WQO over time	No
	TP	0.025mg/L	0.13	0.03 – 0.29	0.105 Contributes towards achieving WQO over time	No
R2 – Purgatory Creek (Estuarine)	Turbidity	0.5-10 NTU	14.1 – 41.65	2.26 – 115	62.67	Yes
	TN	0.3mg/L	0.5 – 5.1	0.5 –6.5	0.47 Contributes towards achieving WQO over time	No
	TP	0.03mg/L	0.27 – 0.58	0.02 – 0.81	0.07 Contributes towards achieving WQO over time	No
R3 – Hunter River Drain (Estuarine)	Turbidity	0.5-10 NTU	20.82 – 55.63	5.95 – 551	38.13 Contributes towards achieving WQO over time	No
	TN	0.3mg/L	1.15 – 3	0.6 – 5.1	0.28 Complies with WQO DGV	No
	TP	0.03mg/L	0.43 – 1.04	0.16 – 1.36	0.05 Contributes towards achieving WQO over time	No
R4 – Windeyers Creek (Lowland river)	Turbidity	6-50 NTU	6.57 – 39.53	5.01 – 71.2	9.32 Complies with WQO DGV	No
	TN	0.35mg/L	0.9 – 2.7	0.6 – 3.8	0.51 Contributes towards achieving WQO over time	No
	TP	0.025mg/L	0.08 – 0.2	0.03 – 0.32	0.068 Contributes towards achieving WQO over time	No

Waterway classification	Indicator	DGV aquatic ecosystem	Existing median concentrations when dry	Existing range concentrations when dry	Modelled median value and comparison against aquatic ecosystems WQO	Further discussion required (refer to Table 11-23)
R5 – Viney Creek (Lowland river)	Turbidity	6-50 NTU	31.58	19.7 – 57.7	55.25	Yes
	TN	0.35mg/L	0.9	0.5 – 0.9	0.59 Contributes towards achieving WQO over time	No
	TP	0.025mg/L	0.1	0.07 – 0.11	0.083 Contributes towards achieving WQO over time	No
R6 – Hunter River (Estuarine)	Turbidity	0.5-10 NTU	37.3 – 66.03	14.8 – 776	22.96 Contributes towards achieving WQO over time	No
	TN	0.3mg/L	1 – 1.6	0.3 – 3.1	1.34 Contributes towards achieving WQO over time	No
	TP	0.03mg/L	0.16 – 0.21	0.06 – 0.68	0.121 Contributes towards achieving WQO over time	No
R7 – Unnamed Coastal Wetland (Estuarine)	Turbidity	0.5-10 NTU	25.75	12.1 – 32.7	29.34	Yes
	TN	0.3mg/L	1.2	0.5 – 1.8	0.67 Contributes towards achieving WQO over time	No
	TP	0.03mg/L	0.07	0.07 – 0.09	0.093	Yes

Where a range is presented for the monitoring results it shows the range of the monitoring points on that stream, some streams only have one monitoring point and therefore have a single data point not a range.

Table 11-23 Project impact on water quality objectives during operation

Waterway	Relevant site specific WQO applied to the assessment					Assessment of project impact during operation
	Aquatic ecosystems	Visual amenity	Secondary contact recreation	Primary contact recreation	Aquatic foods (cooked)	
R1 – Glenrowan Creek (Lowland river)	✓	✓	✓	✓	N/A	The proposed water quality at this waterway complies with the DGV for turbidity and contributes toward the achieving the WQO over time for TN and TP. Therefore, discharges during operation of the project are unlikely to have a significant impact on water quality. A brief discussion on the WQO is provided below. <u>Aquatic ecosystems</u>: Proposed water quality has lower levels of contaminates then either the WQO or the existing environment and are unlikely to have a significant impact on the receiving aquatic ecosystem. <u>Visual amenity</u>: The project would meet the WQO for visual amenity with turbidity levels expected to be below the DGV. Visual clarity is therefore not expected to be reduced. <u>Primary and secondary contact</u>: Secondary contact may be possible for public access and maintenance of assets however primary contact is unlikely due to shallow water and degraded water quality. The project would meet the WQO secondary recreation as operation of the project is not expected to increase bacterial counts that would result in the deterioration of recreational water quality. Additionally, metal and toxicant concentrations are expected to be captured with sediment and therefore are unlikely to be in concentrations that are hazardous to human health.
R2 – Purgatory Creek (Estuarine)	✓	✓	✓	✓	N/A	The proposed water quality at this waterway does not comply with the DGVs for turbidity, however TN and TP however are modelled to be less than existing background and hence contribute to achieving the WQO over time. Further assessment is provided below. The existing water quality and receiving environment at Purgatory Creek is presented in **Table 11-8** where it is shown to be highly disturbed. Ongoing maintenance (flood conveyance) and surrounding livestock grazing land uses are anticipated to result in ongoing impacts to water quality and the aquatic environment. The range of values identified during site monitoring (<115 NTU) display the disturbed and variable condition of the waterway. Flood gates at the downstream end of the creek alter surface flows by containing low and medium flows within the creek channel and hence increase residence time to aid sediment settlement within the confines of the disturbed environment. The proposed turbidity is calculated to require a dilution of 6.2 to meet the existing median ambient

Waterway	Relevant site specific WQO applied to the assessment					Assessment of project impact during operation
	Aquatic ecosystems	Visual amenity	Secondary contact recreation	Primary contact recreation	Aquatic foods (cooked)	
						water quality and as the permanent water quality basins passively discharge only during rainfall events that overtop the designed capacity, it is assumed that there would be adequate water within the catchment to provide sufficient dilution. It is noted that the proposed modelled water quality indicators are lower that the upper value of the existing ambient quality and following dilution, infrequent operational discharge is anticipated to be generally in accordance with the existing surface water and is unlikely to significantly impact on the receiving disturbed environment. Aquatic ecosystems: Turbidity in at Purgatory Creek will not meet the turbidity DGV for protection of aquatic ecosystems, however existing conditions do not comply. Proposed TN and TP levels are less that existing background. Due to the existing water quality, the receiving aquatic ecosystem is habituated to degraded conditions. As the permanent water quality basins passively discharge during rainfall (only) the discharge into the diluted creek is anticipated to reflect the existing variable water quality habitat and is unlikely to have significant impact to the aquatic ecosystem. Visual amenity: Existing turbidity levels do not meet the WQO. The sporadic addition of discharge water during rainfall events that generally complies with the existing turbidity range during rain fall events is unlikely to significantly impact on the visual amenity of the water. Primary and secondary contact: Secondary contact is possible due to landowner access and ongoing asset maintenance, however primary contact recreation is considered highly unlikely as it is a shallow modified drainage channel that is situated within private farmland. Construction discharges shall not generate or consolidate enterococci and as the turbidity of the discharges will be consistent with existing conditions, increased algal blooms are not anticipated. The project is unlikely to significantly impact on secondary contact values.
R3 – Hunter River Drain (Estuarine)	✓	✓	✓	✓	N/A	The proposed water quality at this drain complies with the WQO DGV for TN. Turbidity and TP do not meet the WQO DGV however are lower than the existing environment and hence contribute toward achieving the WQO over time. Therefore, discharges during operation of the project are unlikely to have a significant impact on water quality. A brief discussion on the WQO is provided below.

Waterway	Relevant site specific WQO applied to the assessment					Assessment of project impact during operation
	Aquatic ecosystems	Visual amenity	Secondary contact recreation	Primary contact recreation	Aquatic foods (cooked)	
						Aquatic ecosystems: Discharges to the Hunter River Drain from the operation of the project would not meet the WQO for aquatic ecosystems (estuarine) due to elevated turbidity and TP concentrations. Noting that the drain is not a natural waterway, significant impacts to aquatic ecosystems are unlikely. Visual amenity: The proposed water quality generally consistent with the existing ambient condition and is unlikely to significantly impact on visual amenity. Primary and secondary contact: Secondary contact is possible due to landowner access for flood conveyance management and ongoing asset maintenance, however primary contact recreation is considered highly unlikely as it is a shallow modified drainage channel that is situated within private farmland. Construction discharges shall not generate or consolidate enterococci and as the turbidity of the discharges will be consistent with existing conditions, increased algal blooms are not anticipated. The project is unlikely to significantly impact on secondary contact values.
R4 – Windeyers Creek (Lowland river)	✓	✓	✓	✓	N/A	The proposed water quality at this waterway complies with the DGV for turbidity and contributes toward achieving the DGV over time for nutrients. Discharges from permanent basins are unlikely to have a significant impact on water quality. A brief discussion on the WQO is provided below. Aquatic ecosystems: As the proposed water quality meet the WQO or are better than the existing background levels, the operation of the project is unlikely to significantly impact on the receiving aquatic ecosystems. Visual amenity: The proposed water quality is generally consistent with the existing ambient turbidity and are unlikely to significantly impact on visual amenity Primary and secondary contact: Secondary contact is possible due to open public access to surrounding open spaces and access for maintenance for drainage from the Raymond Terrace Wastewater Treatment Works, however primary contact recreation is considered highly unlikely due to shallow water and poor water quality. Operational discharges shall not generate or consolidate enterococci and as the turbidity of the discharges will be consistent with existing conditions, increased algal blooms are not anticipated. The project is unlikely to significantly impact on secondary contact values.

Waterway	Relevant site specific WQO applied to the assessment					Assessment of project impact during operation
	Aquatic ecosystems	Visual amenity	Secondary contact recreation	Primary contact recreation	Aquatic foods (cooked)	
R5 – Viney Creek (Lowland river)	✓	✓	✓	✓	✓	The proposed water quality at this waterway does not meet the WQO or existing background levels for turbidity. TN and TP are lower than ambient conditions and therefore work towards improving water quality and meeting the WQO over time. Further detailed assessment is provided below. The existing water quality and receiving environment at Viney Creek is presented in **Table 11-8** where it is shown to be disturbed and modified due to complete alteration for its passage through a light industrial precinct. Ongoing maintenance (flood conveyance) and surrounding light industrial land uses are anticipated to result in ongoing impacts to water quality and aquatic environment impacts. A dam constructed within the channel of the creek alters surface flows by containing low and medium flows within the dam, however the dam increases residence time to aid sediment settlement within the confines of the disturbed environment. The proposed turbidity discharged from basins is calculated to require a dilution of 1.1 to meet the existing median ambient water quality and as the permanent water quality basins passively discharge only during rainfall events that overtop the designed capacity, it is assumed that there would be adequate water within the catchment to provide sufficient dilution. It is noted that the proposed modelled discharge is slightly higher in turbidity that the upper limit of the existing environment and following dilution, infrequent operational discharge is anticipated to be generally in accordance with the existing surface water and is unlikely to significantly impact on the receiving disturbed environment. The Aquatic foods (cooked) WQO would not apply to this waterway as there is no commercial fishery and no recreational fishing was identified during project consultation nor in background information reviewed for the EIS. <ins>Aquatic ecosystems</ins>: Proposed turbidity in Viney Creek is marginally higher that the ambient DGV and TN and TP are lower existing conditions, however the diluted turbidity corresponds with the existing water quality. The existing aquatic ecosystems is habituated to existing water quality and therefore the proposed impacts to water quality are considered unlikely to have significant impact to the aquatic ecosystem <ins>Visual amenity</ins>: The proposed water quality is generally consistent with the existing ambient water quality and is unlikely to significantly impact on visual amenity

Waterway	Relevant site specific WQO applied to the assessment					Assessment of project impact during operation
	Aquatic ecosystems	Visual amenity	Secondary contact recreation	Primary contact recreation	Aquatic foods (cooked)	
						<u>Primary and secondary contact</u>: Secondary contact with the water is possible due to its accessibility by the public and its ongoing of maintenance for flood conveyance through the industrial area, however primary contact is unlikely due to shallow water and access limitation due to dense reed growth. Operational discharges shall not generate or consolidate enterococci, and as the modelled turbidity output is lower than the existing range, the project is unlikely to have a significant impact to secondary contact values.
R6 – Hunter River (Estuarine)	✓	✓	✓	✓	✓	The proposed water quality at this waterway would not meet the WQO however as it is lower that both the existing median and range values, the proposed discharges contributes toward the achieving the DGV over time. Discharges from permanent basins are unlikely to have a significant impact on water quality. In the Hunter River, dilution modelling was carried out which indicated that there is sufficient dilution provided by river flows so that basin discharges would not result in any long term changes in water quality. A brief discussion on the WQOs is provided below. <u>Aquatic ecosystems</u>: The existing water quality of the Hunter River does not meet the WQO DGV and is highly variable due to land uses in the catchment and the tidal influence, however the significant water volumes in the river and associated dilution from upstream and downstream sources support the existing aquatic ecosystems described in **Table 11-8**. The existing aquatic ecosystems (such as a lack of seagrass, but broad areas of mangrove forest) reflect the variable turbidity in the surface water quality and the aquatic ecosystems are habituated to the existing conditions. The infrequent operational discharges (point load) from the project are lower than the existing turbidity range and far lower than the existing upper limit observed onsite and are unlikely to have a significant impact on the SRE aquatic ecosystem. Proposed operational nutrient discharge is also well under the existing median and range and is unlikely to significantly impact the aquatic ecosystems <u>Visual amenity</u>: The proposed ambient water quality are generally better than the existing ambient quality and is unlikely to significantly impact on visual amenity <u>Primary and secondary contact</u>: The most probable primary recreational contact with water across the project will be in the Hunter River as it is infrequently used for water sports (skiing, paddling etc) Secondary contact is highly probable due to activities such as shore and boat fishing. The WQOs of primary and secondary contact recreation

Waterway	Relevant site specific WQO applied to the assessment					Assessment of project impact during operation
	Aquatic ecosystems	Visual amenity	Secondary contact recreation	Primary contact recreation	Aquatic foods (cooked)	
						are currently not being met due to high turbidity and nutrient levels and suspended sediments may contain elevated concentrations of metals and toxicants that are hazardous to human health. Permanent operational discharges would not contribute to conditions favouring the growth of or introducing bacteria (i.e. enterococci) to the waterway. Discharges therefore would work toward meeting these WQOs and are unlikely to have a significant impact to primary and secondary contact values. Aquatic foods (cooked): The WQO of aquatic foods (cooked) is currently not being met due to elevated NTU and other contaminates levels above the DGV. The discharges from the permanent water quality basins would improve the background water quality. Additionally, with the large volume of dilution available, the basin discharges are unlikely to hinder the long-term achievement of this WQO and are unlikely to have a significant impact on aquatic food values.
R7 – Unnamed coastal wetland (Estuarine)	✓	✓	✓	✓	✓	The proposed turbidity of the water quality at this waterway does not comply with the DGV and exceeds the existing median background levels for both turbidity and TP. TN is below the existing environment is unlikely to have a significant impact on water quality. The Aquatic foods (cooked) WQO would not apply to this waterway as there is no commercial fishery and no recreational fishing was identified during project consultation nor in background information reviewed for the EIS. Further assessment on turbidity and TP is provided below. The existing water quality and receiving environment is presented in **Table 11-8**. Surrounding livestock grazing land uses are anticipated to result in ongoing impacts to water quality and the aquatic environment. The proposed turbidity is modelled to require a dilution of 1.1 for turbidity and 1.3 for TN to meet ambient median background water quality. As the permanent water quality basins passively discharge only during rainfall events that overtop the designed capacity, it is assumed that there would be adequate surface water within the catchment to provide sufficient dilution. Additionally, the wetland is expected to receive ongoing groundwater inputs from the adjacent Hunter River and upgradient Tomago Sands aquifer and these inputs can also be expected to express as surface water in the channel that may provide further dilution. The infrequent diluted permanent operational

Waterway	Relevant site specific WQO applied to the assessment					Assessment of project impact during operation
	Aquatic ecosystems	Visual amenity	Secondary contact recreation	Primary contact recreation	Aquatic foods (cooked)	
						discharge is anticipated to be generally in accordance with the existing surface water and is unlikely to significantly impact on the receiving water quality. A brief discussion on the WQOs is provided below. <u>Aquatic ecosystems</u>: The wetland and channelized watercourse at the site presents as a wetland of low to moderate condition that is affected by livestock grazing, various underground and overhead utility installations and the flood levee bank that separates the wetland form the adjacent Hunter River. The disturbed aquatic ecosystems at the site have become habituated to the modified water quality and flow conditions. The proposed water quality is within the range(s) identified during site monitoring and the diluted discharges are unlikely to have a significant impact on the receiving aquatic ecosystem. <u>Visual amenity</u>: Existing water quality of the unnamed tributary does not meet the estuarine WQO for visual amenity due to elevated turbidity that reduces visual clarity, Diluted turbidity is anticipated to be generally consistent with the range of turbidity experienced within the waterway and are unlikely to have a significant impact on visual amenity. <u>Primary and secondary contact</u>: Secondary contact with surface water is possible due to access of the site for asset maintenance. Primary contact is unlikely due to shallow water at the site. Permanent operational discharges would not contribute to conditions favouring the growth of or introducing bacteria (i.e. enterococci) to the waterway. Discharges therefore would work toward meeting these WQOs and are unlikely to have a significant impact to secondary contact values.

Hunter Estuary Wetlands Ramsar site

The operation of the project has the potential to impact on the Hunter Estuary Wetlands Ramsar site at Kooragang Nature Reserve as a result of discharges from water quality basins to the Hunter River which have the potential to increase the TSS, TN and TP concentrations entering the wetland. Potential indirect impacts to the Hunter Estuary Wetlands Ramsar site were considered and highlighted in an assessment of significance required under the EPBC Act referral prepared for the project and described in the Biodiversity Assessment Report (**Appendix I**). Impacts to the Hunter Estuary Wetlands Ramsar site were not declared as part of the controlled action status identified for the project by the delegate for the Australian Minister for the Environment.

To gain an understanding of the impact operation of the project could have on the Hunter Estuary Wetlands Ramsar site, a dilution model was simulated to estimate TSS/turbidity, TN and TP concentrations discharged directly into the Hunter River. There are five water permanent water quality basins that discharge directly to the Hunter River, two on the western side and three on the eastern side of the river. It is assumed that discharges from all other permanent water quality basins would not reach the Hunter River and therefore not included in this assessment.

Estimated concentrations and volumes from each of the five water quality basins, together with existing streamflow and median dry weather concentrations in the Hunter River were used to model the concentrations at the discharge and at the downstream Hunter Estuary Wetlands Ramsar site at Kooragang Nature Reserve. Results for TSS were converted to turbidity using the results of the linear regression (refer to Appendix C of the Surface Water and Groundwater Quality Working Paper (**Appendix K**)).

The Hunter River would provide sufficient dilution of the basin discharges so that the basin discharges meet the WQO and do not contribute to higher turbidity, TN or TP at the Hunter Estuary Wetland Ramsar site at Kooragang Nature Reserve. The project is not expected to result in any significant impacts to water quality at the Hunter Estuary Wetland Ramsar site.

11.5 Environmental management measures

The environmental management measures that will be implemented to minimise the surface water and groundwater quality impacts of the project, along with the responsibility and timing for those measures, are presented in **Table 11-24**.

Table 11-24 Environmental management measures (surface water and groundwater quality)

Impact	Reference	Management measure	Responsibility	Timing
General	WQ01	A Construction Soils and Water Management Plan (CSWMP) would be developed as a sub plan of the CEMP and will outline measures to manage soil and water quality impacts associated with the construction work, including contaminated land. The CSWMP would include but not be limited to: • Measures to minimise/manage erosion and sediment transport both within the construction footprint and offsite including requirements for the preparation of erosion and sediment control plans (ESCP) for all progressive stages of construction and the implementation of erosion and sediment control measures • Erosion and sediment control measures, which will be implemented and maintained in accordance with Managing Urban Stormwater – Soils and Construction, Volume 1 (Landcom 2004) and Volume 2D (DECC 2008) • Measures to manage stockpiles including locations, separation of waste types, sediment controls and stabilisation in accordance with the Stockpile Site Management Guideline (Roads and Maritime Services 2015e). • Procedures for dewatering (including waterways, wetlands and excavations and temporary sediment basins) including relevant discharge criteria. • Concrete waste management procedures • Measures to manage accidental spills including the requirement to maintain materials such as spill kits, an emergency spill response procedure and regular visual water quality checks when working near waterways • Measures to manage tannin leachate and potential saline soils • Controls for sensitive receiving environments which may include but not be limited to identification of 'no go' zones for construction plant and equipment (where applicable).	Contractor	Prior to construction/ construction/ operation
	WQ02	A soil conservation specialist will be engaged for the duration of construction of the project to provide advice on the planning and implementation of erosion and sediment control including review of the CSWMP and ESCP.	Transport / Contractor	Prior to construction/ construction/ operation

Impact	Reference	Management measure	Responsibility	Timing
Water reuse	WQ03	A water reuse strategy will be developed as part of the CEMP for both construction and operational phases of the project to reduce reliance on potable water. Any water from sediment basins will be checked to ensure compliance with ANZG (2018) Water Quality Guidelines prior to reuse.	Contractor	Detailed design/ prior to construction/ construction
Discharge of saline groundwater to drinking catchment	WQ04	Basins and swales within the Tomago Sandbeds drawdown area will be lined during construction and operation.	Contractor	Detailed design
Discharge of saline groundwater to surface waterways	WQ05	Basins TB04, TB06, TPB10 (PB12), TPB18 (PB24), PB14 and PB15 shall be further investigated to confirm requirement for lining to avoid discharge of saline groundwater to surface waterways during construction and operation.	Transport	Detailed design
Surface water quality and groundwater quality impacts	WQ06	A water quality monitoring program will be developed in accordance with the Guidelines for Construction Water Quality Monitoring (RTA 2003b). The program will monitor surface water quality and groundwater quality during construction and during operation.	Transport / Contractor	Prior to construction/ construction/ operation
Other relevant management measures				
Salinity	SC02	A Salinity Management Plan will be prepared and implemented as part of the CSWMP and in accordance with the NSW Department of Primary Industries (2014) Salinity Training Handbook. The plan will include (but not be limited to): • Identification and management of saline groundwater discharge sites • Identification of areas sensitive to salinity and subject to saline soil import limitations (such as the Tomago Sandbeds Catchment Area) • Testing and reuse conditions of saline soils • Requirements for reuse of saline water.	Contractor	Prior to construction/ construction
Acid sulfate soils	SC03	An Acid Sulfate Soils Management Plan (ASSMP) will be prepared and implemented as part of the CSWMP and in accordance with TfNSW's Guidelines for the Management of Acid Sulfate Materials (RTA 2005c) and the Acid Sulfate Soil Manual (ASSMAC 1998). The ASSMP will outline how potential ASS within sediments of the waterways and soils that will be disturbed within the construction footprint will be handled, tested, treated and reused during construction.	Contractor	Prior to construction/ construction

11.5.1 Water quality monitoring program

A surface water and ground water monitoring program will be implemented as an environmental management measure to observe any changes in surface water and groundwater quality that may be attributable to the project and inform appropriate management responses. Monitoring locations for surface water and groundwater quality during pre-construction, construction and operation are shown in **Figure 11-1**.

Surface water quality monitoring program

The proposed surface water quality monitoring program will aim to continue monitoring the sites shown on **Figure 11-1**, however, the location of monitoring sites may be refined during detailed design based on site design and location of proposed water quality controls. Monitoring site locations which are expected to become unavailable after construction due to creek adjustment work will be reconsidered and relocated downstream. Additional sites, reference and control sites (i.e. up and downstream of the project) will be identified before construction.

The location, frequency and indicators of the surface water quality monitoring program are presented in **Table 11-25**.

Table 11-25 Location, frequency and indicators for surface water quality monitoring

	Additional baseline data[1]	Construction phase	Operational phase
Location	As per **Figure 11-1**[2]		
Frequency	Quarterly (wet and dry[3]) for a minimum of six months prior to construction	Quarterly (wet and dry[†]) for the duration of construction	Quarterly (wet and dry) for a period of 12 months during operation of the project (i.e. 12 months post construction)
Indicators	• Field parameters (electrical conductivity, pH, turbidity, dissolved oxygen and temperature) • Visible oil and grease[4] • Total dissolved solids and TSS • Total nitrogen • Total phosphorus • Dissolved metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc, iron and manganese)		

1. In addition to the existing baseline data described in the Surface Water and Groundwater Quality Working Paper (**Appendix K**)
2. As described above, the necessity for some of the monitoring sites may be rationalised during detailed design. As a result, the locations shown in **Figure 11-1** are indicative only and are subject to change
3. A wet weather event is classified as 20mm or more of rain within 24 hours, as recorded at the Newcastle University BOM rainfall gauge (#061390). Sampling would occur within 24 hours of the rain event. If rainfall events are regularly less than 20mm, opportunistic wet weather monitoring would be carried out to ensure that some wet weather data is collected
4. If oil and grease visible, sample to be assessed for total petroleum hydrocarbons

Groundwater quality monitoring program

The proposed groundwater quality monitoring program will continue monitoring the existing monitoring network (as shown in **Figure 11-1**). However, the necessity for some of the monitoring sites may be rationalised or adjusted during detailed design based on site design and anticipated impacts. It is also likely during detailed design that additional groundwater investigations will be required that will likely result in further monitoring bores being installed to target specific elements or areas of risk during construction, such as confirming groundwater level and quality at water quality basin locations. Before construction all available groundwater monitoring locations will be reviewed and rationalised as required. Additional sites may be identified before construction as an outcome of detailed site investigation. Sentinel monitoring locations, situated between high risk activities and sensitive receptors, may also considered where applicable.

The location, frequency and indicators of the groundwater quality monitoring program are presented in **Table 11-26**.

Table 11-26 Location, frequency and indicators for groundwater quality monitoring

	Additional baseline data[1]	Construction phase	Operational phase
Location	As per **Figure 11-1**[2]		
Frequency	Two monthly for 12 months prior to construction	Quarterly for the duration of construction	Quarterly for a period of 12 months during operation of the project (i.e. 12 months post construction)
Indicators	• Field parameters (electrical conductivity, pH, turbidity, dissolved oxygen and temperature) • Total dissolved solids • Major ions (sodium, magnesium, calcium, chloride, bicarbonate/carbonate and sulfate)[3] • Nutrients (ammonia, nitrate, TN, TP)[3] • Dissolved metals (aluminium, arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel and zinc)[3]		

1. In addition to the existing baseline data described in the Surface Water and Groundwater Quality Working Paper (**Appendix K**)
2. As described above, the necessity for some of the monitoring sites may be rationalised during detailed design. As a result, the locations shown in **Figure 11-1** are indicative only and are subject to change