Pacific Highway Upgrade – Woolgoolga to Ballina Sections 3 to 11

Water Quality Monitoring Program

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Water Quality Monitoring Program

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Introduction

This Water Quality Monitoring Program (WQMP) outlines monitoring requirements for surface waters and groundwater for the construction and post-construction phases of Sections 3-11 of the Woolgoolga to Ballina Pacific Highway Upgrade. There are 40 surface water locations (76 sampling sites) and 134 groundwater monitoring bores spread over the 124.5 kilometres of upgrade works.

Source: http://www.rms.nsw.gov.au/documents/projects/northern-nsw/woolgoolga-to-ballina/woolgoolga-to-ballina-section-map.pdf

Figure 1.1 Overview of Sections 3-11 of the W2B Pacific Highway Upgrade

1.1 Objectives

The objective of the WQMP is to monitor and manage the construction and operation impacts of the highway upgrade on surface water bodies and groundwater resources.

The key surface water quality objective of the overall Woolgoolga to Ballina (W2B) Pacific Highway Upgrade Program is to protect downstream environments from the potential impacts of surface runoff during the construction and operational phases of the project (RMS, Aurecon, SKM, 2012c:58). Similarly, the key groundwater objectives of the W2B project are to protect environmental receivers of groundwater flows, and groundwater users from the potential impacts on groundwater levels and quality during the construction and operational phases of the project (RMS, Aurecon, SKM, 2012d:10).

The WQMP will play a crucial role in ensuring construction and operation of the W2B project does not have a negative impact on sensitive receiving environments such as Marine Parks, SEPP14 wetlands, threatened species habitat, drinking water catchments, or endangered ecological communities.

The outcomes of the WQMP will assist with achieving water quality and hydrology related management objectives for the W2B project including:

- mitigating impacts to surface water quality in order to protect aquatic ecology and ecosystem characteristics in adjacent catchments; and
- mitigating impacts to groundwater hydrology in order to protect licensed bores and dams, water bodies and groundwater dependant ecosystems.

1.2 Minister's Conditions of Approval

The Minister's Conditions of Approval (MCoA) granted by the Minister for Planning on 24 June 2014 for the Woolgoolga to Ballina Pacific Highway Upgrade includes the following Condition D12 with respect to Soil, Water Quality and Hydrology.

> D12. The Applicant shall prepare and implement a **Water Quality Monitoring Program** to monitor the construction and operation impacts of the SSI on surface and groundwater quality and resources and wetlands, prior to construction. The Program shall be prepared in consultation with the EPA, DPI (Fisheries), NOW, DoE and Rous Water (in relation to the Woodburn borefields), to the satisfaction of the Secretary, and shall include but not necessarily be limited to [the items in **Table 1.1**].

Table 1.2 MCoA Requirements for the Water Quality Monitoring Program

Item	*Details*	*Addressed in*
a)	identification of surface and groundwater quality monitoring locations (including watercourses, waterbodies and SEPP14 wetlands) which are representative of the potential extent of impacts from the SSI.	Section 2
b)	the results of any groundwater modelling undertaken.	Section 3 and Appendices B to J
c)	identification of works and activities during construction and operation of the SSI, including emergencies and spill events, that have the potential to impact on surface water quality of potentially affected waterways and known Oxleyan Pygmy Perch habitat.	Section 1.3, 1.4 and 1.5
d)	development and presentation of parameters and standards against which any changes to water quality will be assessed, having regard to the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000* (Australian and New Zealand Environment Conservation Council, 2000) or relevant baseline data.	Section 7

Item	Details	Addressed in
e)	representative background monitoring of surface and groundwater quality parameters for a minimum of twelve months (considering seasonality) prior to the commencement of construction, to establish baseline water conditions, unless otherwise agreed by the Secretary.	Section 3 and Appendices B to J
f)	a minimum monitoring period of three years following the completion of construction or until the affected waterways and/or groundwater resources are certified by an independent expert as being rehabilitated to an acceptable condition. The monitoring shall also confirm the establishment of operational water control measures (such as sedimentation basins and vegetation swales).	Section 4
g)	contingency and ameliorative measures in the event that adverse impacts to water quality are identified.	Section 8
h)	reporting of the monitoring results to Department of Planning and Environment, EPA, DPI (Fisheries), NOW, DoE and Rous Water (in relation to the Woodburn borefields).	Section 7.5

The Federal Minister for the Environment's Conditions of Approval granted on 14 August 2014 includes the following Condition D21 with respect to reporting.

> 21. Within three months of every 12 month anniversary of the **commencement** of the action, the **approval holder** must publish a report on their website addressing compliance with each of the conditions of this approval, including implementation of any Frameworks, Strategies, Plans, or Packages as specified in the conditions. Documentary evidence providing proof of the date of publication and non-compliance with any of the conditions of this approval must be provided to the **Department** [of the Environment] at the same time as the compliance report is published. The **approval holder** must continue to publish the report until such time as agreed in writing by the **Minister**.

Consultation with the government authorities is detailed in **Appendix L** of this WQMP. In accordance with the Staging Report submitted for the project, the Water Quality Monitoring Program for the Woolgoolga to Glenugie section of the project was submitted to the Department and approved on 8 May 2015. This report addresses the requirements of the remaining sections of the project.

1.3 Risk to Surface Waters

The following provides background information regarding the general risks to surface waters posed by the highway upgrade. The information is largely based on the environmental impact statement documents for the Woolgoolga to Ballina highway upgrade. Refer also to **Section 1.5** and **1.6** in regard to Groundwater Dependent Ecosystems (GDEs) and sensitive receiving environments and high risk areas.

1.3.1 Construction Stage

During construction, the highest risk of impacts on water quality would be associated with:

- Exposure of soils during earthworks (including stripping of topsoil, excavation, stockpiling and materials transport), which may result in soil erosion and off-site movement of eroded sediments by wind and/or stormwater to receiving waterways, resulting in increased nutrients, metals and other pollutants.
- Accidental leaks or spills of chemicals, fuels, oils and/or greases from construction plant and machinery, which may result in pollution of receiving waterways.
- Exposure of acid sulfate soils (as a result of earthworks or dewatering), which may result in generation of sulfuric acid and subsequent acidification of waterways and mobilisation of heavy metals in the environment.

- Disturbance of contaminated land causing contamination of downstream waterways, impacting on aquatic and riparian habitats.
- Removal of riparian vegetation, which may result in soil and stream bank erosion and increased sediment loads in nearby creeks.
- Direct disturbance of waterway beds and banks during culvert and bridge construction and temporary or permanent creek diversions, which may lead to high volumes of sediment entering and polluting the waterways.
- Changes to flow regimes, which can change the volumes and flow rates of water, leading to stagnation of a waterway and changes in turbidity, nitrogen and phosphorus levels. Reduction in flow regimes also has the potential to expose potential acid sulfate soils if it results in a reduction to groundwater levels.
- Leaching of tannins from stockpiles of cleared vegetation, which may have a number of adverse effects on receiving waters, including:
  - Increased biological oxygen demand, with consequent decreases in dissolved oxygen
  - Reduced water clarity and light penetration
  - Decreased pH.
- Increase in pH from concreting and lime stabilisation works.
- Pollution by hydrocarbons during or following sealing or asphalting works.

During construction and operation, changes to water velocities and disturbance to riparian and instream habitats have the potential impact on successful fish passage. This is relevant to both permanent waterway crossings (such as bridges and culverts), as well as temporary waterway crossings (such as causeways, fords). Short term impacts include localised disturbance to riparian and instream habitats such as increased sedimentation and shading (RMS, Aurecon, SKM, 2012e:388).

1.3.2 Operational Stage

Once the highway upgrade is operating, there would be potential for impacts on soils, water quality and groundwater. However, the likelihood and severity of these potential impacts would be minimised by incorporating management and mitigation measures into the design of the highway upgrade, as described in **Section 8**. These measures would protect soils, receiving waters and groundwater.

During operation, the main potential impact on water quality would be associated with runoff from stormwater and direct deposition of airborne particles, causing acute or chronic contamination of water quality in downstream waterways that receive discharged stormwater during rainfall events.

Pollutants from stormwater runoff include sediments, hydrocarbons, metals, and microbials. These deposits build up on road surfaces and pavement areas (including rest areas and truck checking stations) during dry weather and get washed off and transported to downstream waterways when it rains. Other pollutants in the atmosphere, derived from local and regional sources, would also be deposited and build up on the widened road pavement and contribute to impacts on water quality.

In addition, accidental spills of petroleum, chemicals and hazardous materials as a result of vehicle leaks or accidents, and waste discarded by motorists, could pollute downstream waterways and groundwater sources.

The potential impacts of reduced water quality on sensitive receiving environments have also been considered. Because the project includes design measures to minimise the likelihood of impacts on water quality, operation of the project would be unlikely to have an adverse impact on sensitive receiving environments and high risk areas.

As noted in **Section 1.3.1**, changes to water velocities and disturbance to riparian and instream habitats have the potential impact on successful fish passage at permanent waterway crossings (such as bridges and culverts). Long term impacts include the impediment of fish movements within their natural range, habitat changes or pollution (RMS, Aurecon, SKM, 2012e:388).

1.4 Risk to Groundwater

This section provides background information regarding the general risks to groundwater posed by the highway upgrade. The information is largely based on the environmental impact statement documents for the Woolgoolga to Ballina highway upgrade. Refer also to **Section 1.5** and **1.6** in regard to Groundwater Dependent Ecosystems (GDEs) and sensitive receiving environments and high risk areas such as the Rous Water borefields.

1.4.1 Construction Stage

The main risks to groundwater during construction of the project would be from:

- Cuttings changing surface flows, groundwater flow regimes and 'draw down' of the water table as a result of intersection of groundwater and subsequent groundwater discharge.
- Fill embankments changing surface flows and groundwater recharge, and compacting soft soils and thereby restricting near-surface groundwater flow.
- Groundwater contamination, which may occur if construction activities are not adequately managed, particularly in areas of shallow groundwater.

Risks to Groundwater from Cuttings

Localised draw down of the groundwater table can occur around cutting sites where the design profile of the proposed highway cuttings is below the level of the groundwater table. This may impact on groundwater flow to local creeks, streams, springs, local water resources and Groundwater Dependent Ecosystems.

Risks to Groundwater from Fill Embankments

Construction and use of embankments will preferentially direct surface runoff and concentrate recharge to groundwaters. On soft soils, compaction may also occur restricting near-surface groundwater flow resulting in discharge and waterlogging (RMS, Aurecon, SKM, 2012d:69).

Risks to Groundwater Quality from Surface Water

The potential risks to groundwater quality during construction would include contamination by hydrocarbons from accidental fuel and chemical spills, refuelling or through storage facilities, and contamination by contaminants contained in turbid runoff from unpaved surfaces.

In addition, site runoff can infiltrate groundwater sources. The process of infiltration is generally effective in filtering polluting particles and sediment. Hence, the risk of contamination to groundwater from any pollutants bound in particulate form in surface water, such as heavy metals, is generally low. Similarly, low-density pollutants such as insoluble hydrocarbons (oils, tars and petroleum products) would be preferentially retained in the soil profile and would not penetrate to the groundwater table. However, soluble pollutants, such as acids and alkalis, salts and nitrates, and soluble hydrocarbons, would be able to infiltrate through soils into the groundwater source and would pose a risk to that groundwater source. Under certain pH conditions, metals may also become soluble and infiltrate groundwater. In these areas, chemical treatments may be necessary. There is potential for long-term contamination risk to groundwater sources from the long-term accumulation of contaminants in the upper soil profile.

1.4.2 Operational Stage

The main hazard to groundwater quality during the operational phase would be pollutant runoff from the road surface infiltrating groundwater. The risks of groundwater pollution depend on the depth to groundwater and the permeability of the soils and geology that overlay groundwater reservoirs. Where groundwater is shallow or not protected from direct infiltration, the risks of pollution would vary depending on the nature of the pollutants of concern. The process of infiltration is generally effective in removing insoluble substances and contaminants that are readily bound to sediment particles, including heavy metals and hydrocarbons like oils, tars and petroleum. Therefore, runoff or spills of these substances have a relatively low risk of causing groundwater contamination. In contrast, soluble pollutants, such as acids, alkalis, salts and nitrates are less readily removed by the infiltration process and have a greater chance of reaching groundwater.

In areas where cuttings penetrate water tables, ongoing seepage would occur unless measures are put in place. Cuttings in areas of naturally high groundwater would see a reduced risk over time as groundwater pressures relax and re-equilibrate under the elevated discharge regime. In areas cut into rocks of low permeability (such as fractured rocks and porous sediments), the risk would remain high as groundwater pressures would not relax and seepage may continue throughout the life of the road.

1.5 Risk to Groundwater Dependent Ecosystems

Groundwater Dependent Ecosystems (GDEs) occur in nearly all sections of the W2B upgrade. GDE's include ecosystems which have their species composition and natural ecological processes wholly or partially determined by groundwater.

The Woolgoolga to Ballina – Pacific Highway Upgrade Environmental Impact Statement (EIS) documents identify several vegetation communities and habitats as GDEs which comprise vegetation occurring on waterways and floodplains which are reliant on groundwater. They include:

- Freshwater wetlands;
- Sub-tropical coastal floodplain forest;
- Swamp sclerophyll forest;
- Swamp oak floodplain forest; and
- Lowland rainforest.

Construction of the W2B upgrade may potentially impact on these GDEs by blocking or altering subsurface flows and drainage paths. Development associated with future highway construction has the potential to affect GDEs function and viability by alteration of surface and subsurface conditions which are outside the physiological tolerance range or dispersal capabilities of groundwater reliant communities (Serov *et al* 2012 cited in Coffey Geotechnics 2014).

Potential impacts to GDEs may include changes in groundwater reliant communities due to changes in local water tables from over extraction or drainage, exposure and subsequent oxidation of potential acid sulfate soils, and resulting changes to groundwater and surface water quality or from saline intrusion. Potential impacts on groundwater recharge rates from highway construction have been assessed in the EIS to be generally greatest in areas where significant road cuttings are required as excavations may potentially intersect the water table and affect groundwater levels downstream (RMS, Aurecon, SKM, 2012a).

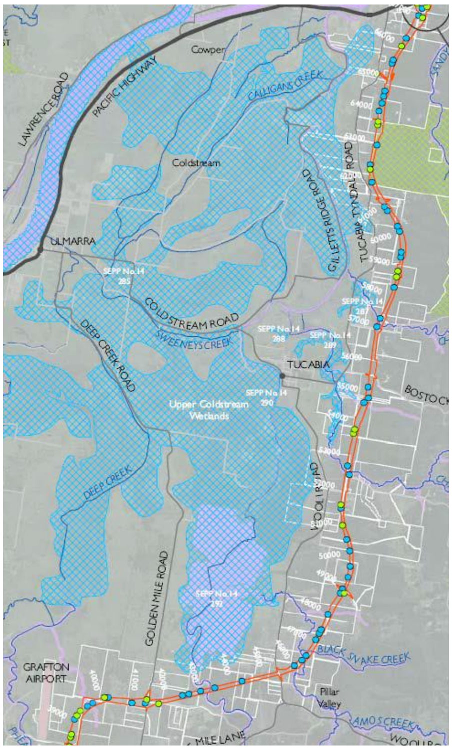
1.6 Sensitive Receiving Environments and High Risk Areas

Sensitive receiving environments include: nationally important wetlands and State Environmental Planning Policy No 14 (SEPP); national parks, marine parks, nature reserves and state conservations areas; threatened ecological communities associated with aquatic ecosystems; and known and potential habitats for threatened fish. Where a number of sensitive receiving environments are located in a single region and where there would be severe implications from changes in surface water quality to the receiving environment, the region has been defined as a high risk area (RMS, Aurecon, SKM, 2012c:74). High risk areas along highway sections 3-11 are:

- Upper Coldstream Wetlands in Section 3
- Tabbimoble Swamp Nature Reserve in Section 7
- The Rous Water borefields in Section 8
- The Broadwater National Park and associated wetlands in Sections 8 and 9
- Wardell Heath in Section 10
- Various areas where the project would discharge to or within 50 metres of a known or potential habitat of a threatened aquatic species.

The proposed monitoring locations in Section 2 have been selected with consideration of these sensitive receiving environments and high risk areas.

Upper Coldstream Wetlands in Section 3



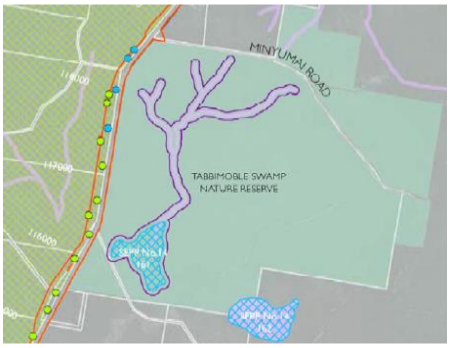
The wetlands are a key fish habitat (but not for any listed threatened fish species), are listed as National Important and contain a number of listed as SEPP 14 wetlands. The Wetlands receive flows from the Coldstream River, Pillar Valley Creek, Black Snake Creek, Chaffin Creek, Champions Creek a number of unnamed waterways. All these waterways cross the project.

There is a high probability of acid sulfate soils occurring around the waterway crossings of these creeks. The construction of bridge piers at these waterways will require work within potential acid sulfate soils. Likewise, the construction of sediment basins and areas of cut may expose acid sulfate soils around these waterways.

The construction of bridges (nine in total within the region) poses a risk to the water quality of the immediate waterway and the downstream Wetlands, as activities may disturb the bed and banks.

Large excavations and stockpile sites also present a risk of sediment runoff to the waterways and Wetlands.

Tabbimoble Swamp Nature Reserve in Section 7

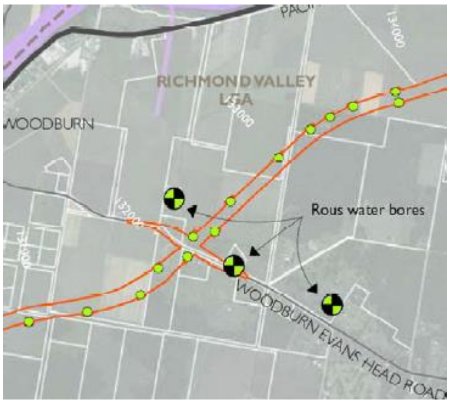


Tabbimoble Swamp is a mapped Oxleyan pygmy perch (OPP) habitat and a SEPP 14 wetland.

There is no known occurrence of acid sulfate soils in the area, however the soil conditions along the alignment within the region are mapped as highly erodible, posing an increased risk of sedimentation to the swamp.

It is noted that monitoring specifically associated with OPP is addressed in the Threatened Fish Management Plan.

The Rous Water borefields in Section 8



In Section 8 of the project, there are three groundwater bores east of Woodburn operated by Rous Water Regional Water Supply. This drinking water supply source draws raw water from the Woodburn Sands aquifer system. The water table is typically located within two metres of the ground surface.

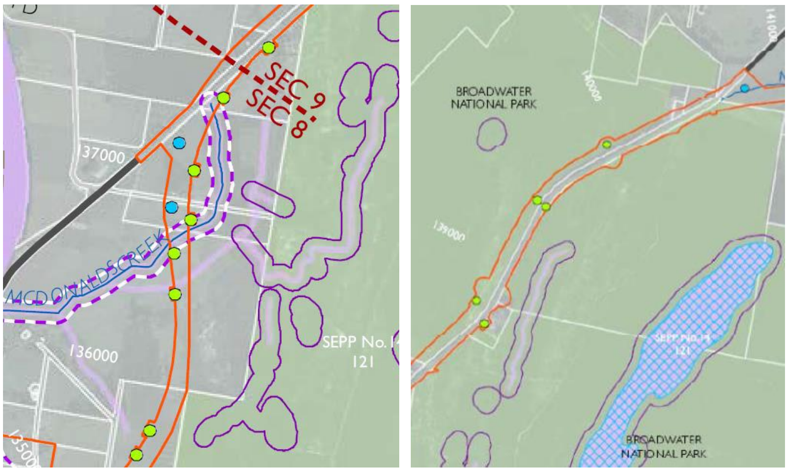
The region is a floodplain and contains a number of cane drains but does not include any named or mapped waterways.

If unmitigated, construction between chainages 131 km and 134 km may result in contamination of this groundwater source with a range of pollutants including sediments, nutrients, hydrocarbons, metals, and pathogens, through direct intersection or infiltration.

Furthermore, the setting of the borefield is in a high risk area for the presence of acid sulfate soils. Any decrease in pH of the groundwater, either through de-watering leading to acid production or allowing infiltration of acid water into the ground water system, would create an elevated risk of dissolved metal contaminants in the Woodburn Sand aquifer system. The implication of any contamination would be that water drawn from the bores may not be suitable for use by Rous Water without additional treatment to what is currently provided.

The Broadwater National Park and associated wetlands in Section 8 and 9

Broadwater National Park is east of the project and close the proposed alignment between chainages 135 km and 141 km in Sections 8 and 9. Wetlands in the park, a number of which are listed SEPP 14 wetlands, are OPP habitat.

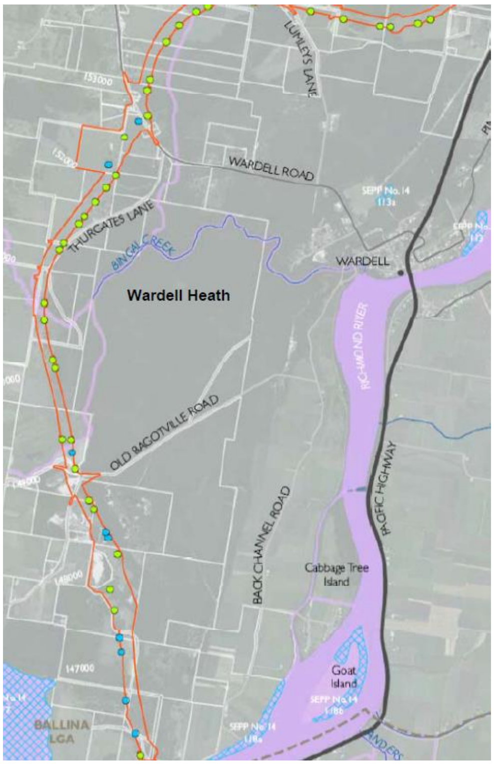


There are two waterways crossing the project in this region – Macdonalds Creek at chainage 136.7 km and an unnamed tributary of Macdonalds Creek at chainage 136.5 km.

Risks to water quality are increased by the presence of highly erodible soils along the project alignment. Around Macdonalds Creek there is a high probability of acid sulfate soils. As noted previously, specific monitoring relating to OPP is addressed in the Threatened Fish Management Plan.

Wardell Heath in Section 10

Wardell Heath is located to the east of the project between chainages 146 km and 157 km in Section 10. It is deemed to be region of high ecological value. There are three unnamed waterways that cross the alignment in this region (at chainages 149.3 km, 150.6 km and 153.9 km), all of which flow to Bingal Creek, which passes through Wardell Heath.



Risks to water quality from construction in this area are increased by highly erodible soils. There is low probability of acid sulfate soils in the area, no major works within waterways and the alignment is not steep, thus limiting risks to water quality from such factors during construction.

Areas within 50 metres of a known or potential habitat of a threatened aquatic species

Areas throughout the project where surface water from the construction site or operational highway would discharge to or within 50 metres distance from a known or potential habitat of a threatened fish are considered to be sensitive receiving environments as well as high risk areas. In particular, a borrow source site (Lang Hill) has been identified adjacent to OPP habitat at chainage 134.7 km.

2

Monitoring Locations

There are 40 surface water monitoring locations including groundwater dependent ecosystems. Most locations include an upstream and downstream sampling site resulting in a total of 76 sampling sites. The sampling sites are listed in **Table 2.1** and mapped in **Appendix A**.

There are 134 groundwater bores monitoring significant cuts and fill embankments. Groundwater levels will be monitored at each bore, and water quality will be monitored at 70 of the 134 bores. The water quality sites have been selected for sites close to sensitive receiving environments or contaminated sites, and to provide an even spread along the works. The monitoring bores are listed in **Table 2.2** and mapped in **Appendix A**.

2.1 Surface Water Monitoring Locations

The objective of the surface water monitoring is to assess potential impacts of the highway upgrade on water quality and its beneficial uses. These beneficial uses can include: protect aquatic ecosystems; agricultural uses including stock watering; recreational uses; and drinking water supplies.

The selected waterways are generally the same as the monitoring sites from the pre-construction monitoring phase but with the addition of an upstream or downstream monitoring site. However, the pre-construction monitoring locations GDE04 and GDE05 (Sections 8) have not been selected due to them being ponds that will be filled as they located directly in the footprint of the proposed highway upgrade.

The selected waterways are associated with sensitive receiving environments, groundwater dependent ecosystems (GDE's) and Oxleyan Pygmy Perch (OPP) habitat. The type of sensitive receiving environment and designation of high risk areas (refer to **Section 1.3**) is indicated in the 'Waterway' column in **Table 2.1**. This information is based on Section 2 of the Water Quality Working Paper (RMS, Aurecon, SKM, 2012c). Refer to **Appendices B** to **J** for the respective highway sections (3 to 11) for descriptions of the sensitive receiving environments associated with the nominated monitoring locations.

The pre-construction sampling locations at each waterway were generally located on the downstream side of the proposed highway alignment at a location near the project boundary. The proposed sampling locations for the construction and post-construction phases are generally located both upstream and downstream of the highway alignment, within proximity to the pre-construction sampling locations. This has been done to allow for a direct comparison between upstream and downstream conditions as well as a comparison with pre-construction monitoring results.

2.2 Groundwater Monitoring

There are a total of 134 groundwater bores to be monitored for groundwater levels. The bores are generally associated with significant cuts ('Type A' cuts) and significant fill embankments. There are also: two bores that are monitoring an existing contaminated site adjoining the alignment; and four bores monitoring the Rous Water borefields (refer to **Section 1.6**). **Table 2.2** indicates the purpose of each bore in terms of whether it is monitoring a significant cut, fill, contaminated sites of the Rous Water borefields. Of the 134 bores, 70 will be monitored for water quality. The bores are listed in **Table 2.2** and mapped in **Appendix A**.

The objectives of the groundwater monitoring are:

- Assess the potential impact of the highway upgrade cut structures on groundwater levels and groundwater quality.
- Assess the potential impact of the highway upgrade on groundwater in order to protect licenced bores, waterways and watercourses, and groundwater dependent ecosystems.

Table 2.1 Surface Water Monitoring Point Locations

Highway Section	*Waterway / (type of sensitive receiving environ't - refer to table notes)*	*Site Identifier*	*High Risk Area*	*Identifier from Pre-Const'n*	*Approx. Chainage*	*Easting*	*Northing*
Section 3 - Glenugie to Tyndale	Picanny Creek / Pheasant Creek (A)	SW3-01		SW01	35700	502919	6704727
		SW3-02		SW02	36300	503180	6705319
	Unnamed tributary of Glenugie Creek (A)	SW3-03		SW03	36900	504445	6708191
		SW3-04				504358	6708281
	Unnamed tributary of Coldstream River (A, B, C, D)	SW3-05	✓	SW04	42400	507255	6708458
		SW3-06	✓			507329	6708595
	Coldstream River (A, B, C, D)	SW3-07	✓	SW05	43350	507910	6708618
		SW3-08	✓			507954	6708752
	Pillar Valley Creek (A, B, C, D)	SW3-09	✓	SW06	46400	510893	6709592
		SW3-10	✓			510879	6709771
	Black Snake Creek (A, B, C, D)	SW3-11	✓	SW07	46600	511113	6709869
		SW3-12	✓			510979	6709887
	Unnamed Creek tributary of Ellis Swamp (A, D)	SW3-13	✓	SW22	50400	512238	6713228
		SW3-14	✓			512152	6713216
	Chaffin Creek (A, B, C, D)	SW3-15	✓	SW08	52450	512152	6715309
		SW3-16	✓			512062	6715349
	Unnamed tributary of Chaffin Creek (A, B, C, D)	SW3-17	✓	SW09	54700	512749	6717380
		SW3-18	✓			512694	6717497
	Champions Creek (A, B, C, D)	SW3-19	✓	SW10	57100	513202	6719731
		SW3-20	✓			513083	6719842
	Unnamed bodies of water (A, D)	SW3-21	✓	SW11	58700	513775	6721320
		SW3-22	✓			513632	6721333
	South Arm Clarence River (A)	SW3-23		SW12	67950	514434	6730050
Section 4 - Tyndale to Maclean	Shark Swamp overflow	SW4-01		SW23	73400	518903	6732813
		SW4-02				518114	6732934
	Shark Creek (A, C)	SW4-03		SW13	74950	519207	6734318
		SW4-04				519109	6734316
	Edwards Creek	SW4-05		SW14	80200	520044	6739410
		SW4-06				519987	6739420

Highway Section	*Waterway / (type of sensitive receiving environ't - refer to table notes)*	*Site Identifier*	*High Risk Area*	*Identifier from Pre-Const'n*	*Approx. Chainage*	*Easting*	*Northing*
Section 5 - Maclean to Iluka Road	Yaegl Wetland (A)	SW5-01		SW24	84400	522372	6742684
		SW5-02				522718	6742860
	Unnamed tributary of James Creek (A, C)	SW5-03		SW15	85100	523030	6743026
		SW5-04				523183	6743066
	Clarence River (A, B)	SW5-05		SW16	86300	523341	6744054
		SW5-06				523547	6744075
	Serpentine Channel (A)	SW5-07		SW17	89350	523513	6747097
		SW5-08				523598	6747096
	North Arm (Clarence River) (A, B, C)	SW5-09		SW18	94200	524306	6751477
		SW5-10				524438	6751489
	Mororo Creek (South) (A)	SW5-11		SW19	94950	523928	6752187
Section 6 - Iluka Road to Devils Pulpit	Unnamed tributary of Mororo Creek (North) (A, B)	SW6-01		SW20	96700	523613	6753865
		SW6-02				523517	6753823
	Tabbimoble Creek (A, B, C)	SW6-03		SW21	101650	521092	6758080
		SW6-04				521269	6758168
	Tabbimoble Overflow (A, B, C)	SW6-05		SW25	102850	520522	6759162
		SW6-06				520697	6759323
Section 7 - Devils Pulpit to Trustums Hill	Unnamed tributary of Tabbimoble Swamp (A, B)	SW7-01		SW01	114000	525617	6769018
		SW7-02				525747	6768772
	Tabbimoble Floodway No.1 (A, B)	SW7-03		SW02	115300	526338	6770283
		SW7-04				526395	6770003
	Oakey Creek (A, B)	SW7-05		SW03	122400	530058	6775786
		SW7-06				530116	6775685
	South of the intersection with the existing Pacific Highway and Norton's Road (A, B)	SW7-07		SW04	124400	531223	6777369
		SW7-08				531315	6777327
Section 8 - Trustums Hill to Broadwater National Park	Tuckombil Canal (becomes Evans River) (A, B)	SW8-01		SW05	130100	533366	6782359
		SW8-02				533465	6782226
	Unnamed watercourse at CH 134 700 m	SW8-03		SW06	134800	537269	6784426
		SW8-04				537309	6784720

Highway Section	Waterway / (type of sensitive receiving environ't - refer to table notes)	Site Identifier	High Risk Area	Identifier from Pre-Const'n	Approx. Chainage	Easting	Northing
Section 8 - Trustums Hill to Broadwater National Park	Unnamed tributary of McDonald's Creek CH 136 450 m (A, B)	SW8-05		SW07	135350	537954	6784929
		SW8-06				537912	6785047
	McDonald's Creek (A, B, D)	SW8-07	✓	SW08	136600	538158	6786141
		SW8-08	✓			538057	6786078
Section 9 - Broadwater National Park to Richmond River	Montis Gully (A, B, C)	SW9-01		SW09	140950	540849	6789051
	Everson's Creek (A, B, C)	SW9-02		SW10	143400	543235	6790040
		SW9-03				543415	6790313
Section 10 - Richmond River to Coolgardie Road	Richmond River (A, B, C)	SW10-01		SW11	145900	542708	6792345
		SW10-02				542801	6792343
	Pond / wetland	GDE07		GDE07	148800	542202	6795080
	Unnamed tributary Bingal Creek CH 149 250 m (A, D)	SW10-03	✓	SW12	149300	541901	6795398
		SW10-04	✓			542052	6795483
	Saltwater Creek	SW10-05		SW13	157200	546054	6800315
		SW10-06				546399	6800244
	Randles Creek	SW10-07		SW14	157800	546289	6800832
		SW10-08				546285	6800456
Section 11 - Coolgardie Road to Ballina Bypass	Duck Creek (A, C)	SW11-01		SW15	164400	548432	6806741
		SW11-02				548847	6806576

Notes: A = key fish habitats
B = mapped, recorded or potential habitat of threatened aquatic species
C = SEPP 14 and Nationally important wetlands
D = high risk areas (refer to **Section 1.6**)

Table 2.2 List of Bores for Groundwater Monitoring

Highway Section	*Borehole Identifier*	*Identifier from Pre-Const'n*	*Chainage*	*Easting*	*Northing*	*Sensitivity[1] (see notes)*	*Monitoring for*	
							Level	*Quality[2]*
Section 3 - Glenugie to Tyndale	GWB3-01	PZ05	38750	503800	6707549	A	Y	-
	GWB3-02	PZ06	38650	503931	6707495	A	Y	-
	GWB3-03	PZ07	39350	504168	6708111	A	Y	-
	GWB3-04	PZ08	39300	504194	6707984	A	Y	-
	GWB3-05	PZ09	39800	504540	6708366	A	Y	Y
	GWB3-06	PZ10	39800	504575	6708258	A	Y	Y
	GWB3-07	PZ13	42950	507650	6708670	Fill	Y	Y
	GWB3-08	PZ14	42950	507664	6708562	Fill	Y	Y
	GWB3-09	PZ15	43750	508420	6708859	Fill	Y	-
	GWB3-10	PZ16	43750	508441	6708759	Fill	Y	-
	GWB3-11	PZ17	45900	510559	6709323	Fill	Y	-
	GWB3-12	PZ18	45900	510498	6709447	Fill	Y	-
	GWB3-13	PZ19	46200	510796	6709494	Fill	Y	Y
	GWB3-14	PZ20	46200	510692	6709581	Fill	Y	Y
	GWB3-15	PZ21	46500	511018	6709716	Fill	Y	-
	GWB3-16	PZ22	46500	510909	6709795	Fill	Y	-
	GWB3-17	PZ23	46800	511188	6710017	Fill	Y	Y
	GWB3-18	PZ24	46800	511100	6710064	Fill	Y	Y
	GWB3-19	PZ25	47750	511604	6710840	Fill	Y	-
	GWB3-20	PZ26	47750	511506	6710867	Fill	Y	-
	GWB3-21	PZ27	48350	511892	6711361	A	Y	Y
	GWB3-22	PZ28	48350	511777	6711419	A	Y	Y
	GWB3-23a[3]	PZ29	51950	512155	6714825	A	Replaced by 23b	
	GWB3-24a[3]	PZ30	51950	512035	6714815	A	Replaced by 24b	
	GWB3-23b[3]	-	52100	512155	6714825	A	Y	-
	GWB3-24b[3]	-	52100	511965	6714981	A	Y	-
	GWB3-25[4]	PZ31[4]	52400	512239	6715255	-	-	-
	GWB3-26[4]	PZ32[4]	52400	512106	6715277	-	-	-
	GWB3-27[4]	PZ34[4]	52500	512129	6715393	-	-	-
	GWB3-28	PZ35	53150	512373	6715987	A	Y	Y
	GWB3-29	PZ36	53150	512253	6716011	A	Y	Y
	GWB3-30	PZ37	54150	512623	6716934	A	Y	Y

Highway Section	*Borehole Identifier*	*Identifier from Pre-Const'n*	*Chainage*	*Easting*	*Northing*	*Sensitivity[1] (see notes)*	*Monitoring for*	
							Level	*Quality[2]*
Section 3 - Glenugie to Tyndale	GWB3-31	PZ38	54150	512432	6716970	A	Y	Y
	GWB3-32	PZ39	55400	512966	6718146	A	Y	Y
	GWB3-33	PZ40	55400	512830	6718165	A	Y	Y
	GWB3-34	PZ41	57100	513237	6719796	Fill	Y	Y
	GWB3-35	PZ43	58000	513567	6720628	A	Y	Y
	GWB3-36	PZ44	58000	513485	6720658	A	Y	Y
	GWB3-37	BH1139	59650	513924	6722241	A	Y	Y
	GWB3-38	PZ45	59600	513768	6722169	A	Y	Y
	GWB3-39	PZ46	63300	513228	6725646	A	Y	Y
	GWB3-40	PZ47	63300	513037	6725647	A	Y	Y
	GWB3-41	PZ48	64850	513362	6727143	A	Y	Y
	GWB3-42a[3]	PZ49	64850	513450	6727131	A	Replaced by 42b	
	GWB3-42b[3]	-	64850	513445	6727070	A	Y	Y
	GWB3-43	BH1159	66600	514247	6728732	A	Y	Y
	GWB3-44	BH1170	66850	514237	6728999	A	Y	-
	GWB3-45	PZ50	66850	514199	6729026	A	Y	Y
	GWB3-46	PZ51	67700	514778	6729714	A	Y	Y
	GWB3-47	BH1187	67650	514551	6729679	A	Y	Y
	GWB3-48	BH1197	68250	514866	6730253	A	Y	-
	GWB3-49	PZ52	68250	514688	6730300	A	Y	-
	GWB3-50	BH1200	68500	514995	6730479	A	Y	Y
	GWB3-51	PZ53	68550	514804	6730578	A	Y	Y
Section 4 - Tyndale to Maclean	GWB4-01	BH1206	69250	515435	6730961	A	Y	Y
	GWB4-02	PZ54	69200	515291	6731062	A	Y	Y
	GWB4-03	PZ55	69950	516029	6731287	Fill	Y	-
	GWB4-04	PZ56	69900	515966	6731183	Fill	Y	-
	GWB4-05	PZ57	72350	518250	6732024	Fill	Y	Y
	GWB4-06	PZ58	72350	518150	6732073	Fill	Y	Y
	GWB4-07	PZ59	74650	519139	6734040	Bridge	Y	-
	GWB4-08	PZ60	74650	519035	6734056	Bridge	Y	-
	GWB4-09	BH1251	76100	519649	6735373	A	Y	Y
	GWB4-10	BH1259	76350	519520	6735678	A	Y	Y
	GWB4-11	BH1261	76650	519699	6735969	A	Y	Y

Highway Section	Borehole Identifier	Identifier from Pre-Const'n	Chainage	Easting	Northing	Sensitivity[1] (see notes)	Monitoring for	
							Level	Quality[2]
Section 4 - Tyndale to Maclean	GWB4-12	PZ61	76650	519552	6735944	A	Y	Y
	GWB4-13	PZ62	77400	519561	6736701	Fill	Y	-
	GWB4-14	PZ63	77400	519682	6736678	Fill	Y	-
	GWB4-15	PZ64	77650	519613	6736940	Fill	Y	-
	GWB4-16	PZ65	77600	519714	6736899	Fill	Y	-
	GWB4-17	PZ66	78200	519674	6737500	A	Y	Y
	GWB4-18	BH1359	78200	519820	6737505	A	Y	Y
	GWB4-19	PZ67	80050	520114	6739294	Fill	Y	-
	GWB4-20	PZ68	80150	520015	6739409	Fill	Y	-
	GWB4-21	PZ69	80450	519892	6739746	Fill	Y	Y
	GWB4-22[4]	PZ70[4]	80600	520197	6739816	-	-	-
Section 5 - Maclean to Iluka Road	GWB5-01	PZ71	85800	523248	6743591	Fill	Y	Y
	GWB5-02	PZ72	85800	523464	6743593	Fill	Y	Y
	GWB5-03	GBH110	89300	523608	6747043	Contam.	Y	Y
	GWB5-04	PZ73	89300	523479	6747035	Contam.	Y	Y
	GWB5-05	PZ74	90600	523067	6748311	Fill	Y	-
	GWB5-06	PZ75	90650	523273	6748349	Fill	Y	-
Section 6 - Iluka Road to Devils Pulpit	Section 6 does not contain significant cuttings or areas of extensive fill for construction of the Pacific Highway Upgrade.							
Section 7 – Devils Pulpit to Trustums Hill	GWB7-01	BH1221	114600	525990	6769467	Fill	Y	-
	GWB7-02[4]	BH1222[4]	118450	527308	6773019	-	-	-
	GWB7-03[4]	BH1223[4]	120650	528793	6774669	-	-	-
	GWB7-04	BH1224	120650	528732	6774720	Fill	Y	-
	GWB7-05	BH1225	123000	530769	6776068	Fill	Y	-
	GWB7-06	BH1226	124800	531417	6777634	Fill	Y	-
	GWB7-07	BH1227	124800	531389	6777691	Fill	Y	-
Section 8 – Trustums Hill to Broadwater National Park	GWB8-01	BH1228	128450	533119	6780685	Fill	Y	-
	GWB8-02	BH1229	128450	532759	6780698	Fill	Y	-
	GWB8-03[4]	BH1230[4]	129200	533163	6781429	-	-	-
	GWB8-04	BH1231	129200	533041	6781443	Fill	Y	Y
	GWB8-05	BH1232	129700	533232	6781942	Fill	Y	-
	GWB8-06	BH1233	129700	533140	6781982	Fill	Y	-

Highway Section	Borehole Identifier	Identifier from Pre-Const'n	Chainage	Easting	Northing	Sensitivity[1] (see notes)	Monitoring for	
							Level	Quality[2]
Section 8 – Trustums Hill to Broadwater National Park	GWB8-07	BH1234	130050	533405	6782246	Fill	Y	Y
	GWB8-08	BH1235	130050	533340	6782299	Fill	Y	Y
	GWB8-09	BH1236	130600	533823	6782582	Fill	Y	-
	GWB8-10	BH1237	130600	533790	6782648	Fill	Y	-
	GWB8-11	BH1238	131400	534559	6782844	Fill	Y	-
	GWB8-12	BH1239	131400	534541	6782734	Fill	Y	-
	GWB8-13	BH1240	132050	535059	6783189	Fill	Y	-
	GWB8-14	BH1241	132050	535176	6783122	Rous	Y	Y
	GWB8-15	BH1242	132150	535405	6783078	Rous	Y	Y
	GWB8-16	BH1243	132200	535221	6783271	Rous	Y	Y
	GWB8-17	BH1244	132250	535086	6783430	Rous	Y	Y
	GWB8-18	BH1245	132750	535592	6783655	Fill	Y	-
	GWB8-19	BH1246	132800	535710	6783622	Fill	Y	-
	GWB8-20	BH1247	134050	536728	6784264	Fill	Y	-
	GWB8-21	BH1248	134150	536892	6784238	Fill	Y	-
	GWB8-22	BH1249	134850	537331	6784734	Fill	Y	Y
	GWB8-23	BH1250	134800	537457	6784496	Fill	Y	Y
	GWB8-24	BH1251	136550	538149	6786022	Fill	Y	-
	GWB8-25	BH1252	136550	538072	6786029	Fill	Y	-
	GWB8-26	BH1253	137050	538194	6786529	Fill	Y	Y
Section 9 - Broadwater National Park to Richmond River	GWB9-01	BH1254	137650	538508	6787013	Fill	Y	Y
	GWB9-02	BH1255	137700	538424	6787105	Fill	Y	Y
	GWB9-03	BH1256	140250	540252	6788872	Fill	Y	Y
	GWB9-04A[5]	BH1257[5]	140250	540323	6788776	Fill	Y	Y
	GWB9-04B	-	140550	540520	6788997	Fill	Y	Y
	GWB9-05	BH1258	140950	540900	6788960	Fill	Y	-
	GWB9-06	BH1259	140950	540891	6789043	Fill	Y	-
	GWB9-07	BH1260	141400	541379	6789029	Fill	Y	Y
	GWB9-08	BH1261	141400	541359	6789098	Fill	Y	Y
	GWB9-09	BH1262	141900	541900	6789172	Fill	Y	-
	GWB9-10	BH1263	141950	541871	6789281	Fill	Y	-
	GWB9-11	BH1264	142950	542767	6789776	Fill	Y	-
	GWB9-12	BH1265	143100	542984	6789752	Fill	Y	-

Highway Section	*Borehole Identifier*	*Identifier from Pre-Const'n*	*Chainage*	*Easting*	*Northing*	*Sensitivity[1] (see notes)*	*Monitoring for*	
							Level	*Quality[2]*
Section 9 - Broadwater National Park to Richmond River	GWB9-13	BH1266	143900	543281	6790470	Bridge	Y	-
	GWB9-14	BH1267	144000	543431	6790523	Bridge	Y	-
	GWB9-15[5]	BH1268[5]	145000	543247	6791425	-	-	-
	GWB9-16[5]	BH1269[5]	145000	543330	6791460	-	-	-
Section 10 – Richmond River to Coolgardie Road	GWB10-01	BH1270	147450	542590	6793770	A	Y	Y
	GWB10-02	BH1271	147750	542371	6794014	A	Y	Y
	GWB10-03	BH1272	148300	542327	6794540	A	Y	-
	GWB10-04	BH1273	148350	542220	6794559	A	Y	Y
	GWB10-05	BH1274	148450	542250	6794686	A	Y	-
	GWB10-06	BH1275	148800	542017	6795003	Fill	Y	-
	GWB10-07	BH1276	148950	542057	6795155	Fill	Y	-
	GWB10-08	BH1277	149050	541863	6795231	Fill	Y	-
	GWB10-09	BH1278	152450	542562	6798396	Fill	Y	Y
	GWB10-10[3]	BH1279[3]	157200	546077	6800224	-	-	-
	GWB10-11	BH1280	157350	545995	6800401	Fill	Y	Y
	GWB10-12[4]	BH1281[4]	157400	546166	6800383	-	-	-
	GWB10-13[4]	BH1282[4]	157600	546237	6800555	-	-	-
Section 11 – Coolgardie Road to Ballina Bypass	GWB11-01	BH1283	159600	546663	6802507	Fill	Y	-
	GWB11-02	BH1284	159600	546744	6802497	Fill	Y	-
	GWB11-03	BH1285	163000	547664	6805746	Fill	Y	Y
	GWB11-04	BH1286	163050	547735	6805763	Fill	Y	Y

Note: 1. "A" = Type A cuts that have potential high impact on groundwater. The final design surface of these cuts will either: sit below the current groundwater table and hence instigate ingress of groundwater onto the pavement; or the watertable is likely to be at or very close to the road design surface.
"Fill" = potential impacts from impediments to groundwater flow, such as deep fill in areas of shallow groundwater tables
"Rous" = Rous Water borefields – refer to **Section 1.6**
"Contam." = in close proximity to a contaminated site
2. Pre-construction water quality monitoring consisted of EC, pH and temperature for the nominated bores in Sections 3-6 and only pH readings for the nominated bores in Sections 7-11.
3. GWB3-23a, GWB3-24a and GWB3-42a (PZ29, PZ30 and PZ49) are outside the realignment and will be replaced by new bores: GWB3-23b, GWB3-24b and GWB3-42b
4. These bores will not be monitored in the construction / operational phases.
5. GWB9-04, GWB9-15 and GWB9-16 (BH1257, 1268 and 1269) have not been constructed.

3

Summary of Pre-Construction Monitoring

Pre-construction monitoring of surface waters and groundwater was undertaken between January 2013 and January 2014 by:

- Coffey Geotechnics Pty Ltd for Sections 3 to 6 (referred to as Glenugie to Devils Pulpit - G2DP) and
- Golder Associates Pty Ltd for Sections 7 to 11 (referred to as Devils Pulpit to Ballina - DP2B).

A total of 43 surface water sampling sites were monitored. The construction monitoring will continue monitoring at each of these sites with the exception of two ponds that will be filled by the highway works.

A total of 142 groundwater bores were monitored. Each bore was monitored for groundwater levels, and 113 of the bores were monitored for basic water quality parameters. Three bores adjoining the Rous Water Woodburn borefield in Section 8 were also monitored for a large range of water quality parameters.

Details of the pre-construction monitoring results for each highway section (3 to 11) are contained in **Appendices B to J**.

3.1 Surface Water Monitoring

The surface water locations monitored in the pre-construction phase are listed in **Table 3.1**.

Appendices B to J provide the following surface water monitoring data for highway sections 3 to 11 respectively:

- List of the monitoring locations and associated sensitive receiving environments
- An overview of the water quality monitoring results in regard to physical properties, chemical properties, hydrocarbons, nutrients, and heavy metals
- A summary of the visual observations and sampling results for each monitoring site
- A summary of the water quality statistics (median, minimum, maximum etc) for each monitoring site.

3.1.1 Number of Monitoring Events

Surface water quality monitoring for Sections 3 to 6 involved a total of 15 monitoring events - 11 dry weather events and 4 wet weather events. Surface water quality monitoring for Sections 7 to 11 involved a total of 13 monitoring events in 2013 (approximately monthly).

3.1.2 Number of Monitoring Locations

Sections 3 to 6

A total of 25 sites were monitored for Sections 3 to 6 which included some groundwater dependent ecosystems (GDE's) as described for each section in the details provided in **Appendices B to E**.

Sections 7 to 11

A total of 25 sites were monitored for Sections 7 to 11 which included:

- nine SW sites (SW04, SW05, SW06, SW07, SW09, SW10, SW11, SW12, SW14)
- three GDE sites (GDE04, GDE05, GDE07)
- six combined SW / GDE sites (SW01 / GDE01, SW02 / GDE02, SW03 / GDE03, SW08 / GDE06, SW13 / GDE08, SW15 / GDE09)

Table 3.1 Surface Water / GDE Quality Monitoring Locations

Highway Section	*Waterway / Type of sensitive receiving environment (refer to table notes for descriptors)*	*Identifier from Pre- Construction Phase*	*Approx. Chainage*
Section 3	Picanny Creek (A)	SW01	35700
	Pheasant Creek (A)	SW02	36300
	Unnamed tributary Glenugie Creek (A)	SW03	36900
	Unnamed tributary of Coldstream River (A, B, C, D)	SW04	42400
	Coldstream River (A, B, C, D)	SW05	43350
	Pillar Valley Creek (A, B, C, D)	SW06	46400
	Black Snake Creek (A, B, C, D)	SW07	46600
	Unnamed Creek tributary of Ellis Swamp (A, D)	SW22	50400
	Chaffin Creek (A, B, C, D)	SW08	52450
	Unnamed tributary of Chaffin Creek (A, B, C, D)	SW09	54700
	Champions Creek (A, B, C, D)	SW10	57100
	Unnamed bodies of water (A, D)	SW11	58700
	South Arm Clarence River (A)	SW12	67950
Section 4	Shark Swamp overflow	SW23	73400
	Shark Creek (A, C)	SW13	74950
	Edwards Creek	SW14	80200
Section 5	Yaegl Wetland (A)	SW24	84400
	Unnamed tributary of James Creek (A, C)	SW15	85100
	Clarence River (A, B)	SW16	86300
	Serpentine Channel	SW17	89350
	North Arm (Clarence River) (A, B, C)	SW18	94200
	Mororo Creek (South) (A)	SW19	94950
Section 6	Unnamed tributary of Mororo Creek (North) (A, B)	SW20	96700
	Tabbimoble Creek (A, B, C)	SW21	101650
	Tabbimoble Overflow (A, B, C)	SW25	102850
Section 7	Unnamed tributary of Tabbimoble Swamp (A, B)	SW01 / GDE01	114000
	Tabbimoble Floodway No.1 (A, B)	SW02 / GDE02	115300
	Oakey Creek (A, B)	SW03 / GDE03	122400
	South of the intersection with the existing Pacific Highway and Norton's Road (A, B)	SW04	124400

Highway Section	Waterway / Type of sensitive receiving environment (refer to table notes for descriptors)	Identifier from Pre- Construction Phase	Approx. Chainage
Section 8	Tuckombil Canal (becomes Evans River) (A, B)	SW05	130100
	Small pond / wetland. Generally dry. Located in footprint of highway upgrade	GDE04	130300
	Large pond / wetland. Located in footprint of highway upgrade	GDE05	133350
	Unnamed watercourse	SW06	134700
	Unnamed tributary of McDonald's Creek (A, B)	SW07	136450
	McDonald's Creek (A, B, D)	SW08 / GDE06	136600
Section 9	Montis Gully (A, B, C)	SW09	140950
	Everson's Creek (A, B, C)	SW10	143400
Section 10	Richmond River (A, B, C)	SW11	145900
	Large pond / wetland.	GDE07	148830
	Unnamed tributary Bingal Creek (A, D)	SW12	149250
	Saltwater Creek	SW13 / GDE08	157200
	Randles Creek	SW14	157800
Section 11	Duck Creek (A, C)	SW15 / GDE09	164400

Notes: A = key fish habitats
B = mapped, recorded or potential habitat of threatened aquatic species
C = SEPP 14 and Nationally important wetlands
D = high risk areas (refer to **Section 1.6**)

3.1.3 Surface Water Monitoring Parameters

Sections 3 to 6

The following parameters were monitored were measured in the field during each monitoring event:

- pH
- Dissolved oxygen (DO)
- Electrical conductivity (EC)
- Temperature
- Turbidity.

Samples were also tested for the following laboratory analysis parameters:

- Total Suspended Solids
- Oil and Grease
- Total Phosphorous and Total Nitrogen
- Cations (Ammonia, Calcium, Magnesium)
- Metals (Aluminium, Arsenic, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury, Nickel, Selenium, Silver and Zinc).

Sections 7 to 11

The following parameters were monitored were measured in the field:

- pH
- Dissolved oxygen (DO)
- Electrical conductivity (EC)
- Redox potential
- Temperature
- Turbidity.

Samples were also tested for the following laboratory analysis parameters (please note that not all sites were tested for all the following parameters):

- Total Suspended Solids
- Oil and Grease
- Total Petroleum Hydrocarbons
- Total Phosphorous and Total Nitrogen
- Ammonia, Nitrate, Nitrite, Total Kjeldahl Nitrogen
- Cations (Calcium, Magnesium)
- Metals (Aluminium, Arsenic, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury, Nickel, Selenium, Silver and Zinc).

The Groundwater Dependent Ecosystem monitoring locations were also tested for major cations and anions in addition to the above parameters.

3.2 Groundwater Monitoring

The groundwater locations monitored in the pre-construction phase are listed in **Table 2.2** under the column heading "Identifier from Pre-Construction" with the exception of BH1257, 1268 and 1269 in Section 9 which had not been constructed during the pre-construction phase.

3.2.1 Groundwater Levels

Groundwater level monitoring was undertaken for all groundwater bores. The automatic data loggers recorded at one hour intervals for Sections 3 to 6 and 15 minute intervals for Sections 7 to 11. Plots of the groundwater level at each bore are shown in **Appendices B to J**.

3.2.2 Groundwater Quality

Statistics for the groundwater quality for each bore are shown in **Appendices B to J**.

In both Sections 3 to 6 and Sections 7 to 11 groundwater quality was monitored four times (quarterly) in 2013.

Number of Monitoring Locations

- 77 bores in Sections 3 to 6 (essentially all the bores in Sections 3 to 6 excluding PZ06 and PZ07 which were dry).
- 36 bores in Sections 7 to 11 as nominated in **Table 2.2** which are located in areas of proposed fill embankments.

Monitoring Parameters

In Sections 3 to 6, the bores were monitored for in-situ parameters of pH, EC and temperature. In Sections 7 to 11, the bores were monitored for pH only, with the exception of three bores in Section 8 (BH1242, BH1243 and BH1244) which were monitored for pH, EC, TDS, hydrocarbons, nutrients, major cations and anions, and heavy metals.

Sampling Regime and Parameters

4.1 Monitoring Duration

The minimum monitoring period for the construction and operational phases of the project are:

- Construction phase: for the duration of the construction period. Commencement of construction is defined by approval by NSW Department of Planning and Environment of the Construction Environmental Management Plan for the main construction activities on site; and
- Operational phase: a minimum of three years following completion of Construction as defined in the project approval or until the affected waterways and/or groundwater resources are certified by an independent expert as being rehabilitated to an acceptable condition. The monitoring shall also confirm the establishment of operational water control measures (such as sedimentation basins and vegetation swales) (refer to infrastructure approval Condition D12 in **Section 1.2** of this report).

4.2 Surface Water

4.2.1 Construction Phase

Sampling over the construction monitoring period will comprise:

- one wet event sampling round per month except for 'high risk areas' where two wet event sampling rounds will be undertaken (refer to **Table 2.1** for high risk areas):
  - Type A parameters every month (every round for 'high risk areas'); plus
  - Type B parameters every second month (every second round for 'high risk areas')
- one dry event sampling round per month for all sites:
  - Type A parameters every month; plus
  - Type B parameters every second month.

Table 4.1 Surface Water Sampling Parameters – Construction Phase

Parameter		*Type A Parameters*	*Type B Parameters*
pH	(measured in the field)	X	
Temperature	(measured in the field)	X	
Electrical Conductivity (EC)	(measured in the field)	X	
Dissolved Oxygen (DO)	(measured in the field)	X	
Turbidity	(measured in the field)	X	
Total Suspended Solids (TSS)			X
Total Oils and Grease (include as Type A parameter if oil/grease is visible)		*	X
Total Phosphorous, Total Nitrogen			X
Total Petroleum Hydrocarbons (TPH) (include as Type A parameter if oil/grease is visible)		*	X

* Note: TPH to be analysed as a Type A parameter if oil/grease is visible

Wet events are defined as 15mm or more of rain within 24 hours. Wet event sampling is to be undertaken within 48 hours of the rain event. Refer to **Section 4.4** regarding rainfall information.

Following the initial 12 months, the sampling regime shall be reviewed by the Environmental Review Group in consideration of the monitoring results. The review shall consider:

- if the frequency of some of the sampling can be reduced or needs increasing; or
- if some analytes / parameters / locations can be omitted from the sampling.

The above review may also be undertaken following the initial 18 months to assess if any changes to the sampling regime are warranted.

4.2.2 Operational Phase

In general terms monthly monitoring is proposed for the first year of operation after which time it is assumed that revegetation will have generally established and stabilised. After the first year of operation, the Project independent water quality expert would review the first 12 months of results, and determine if any changes to the sampling regime are warranted.

4.2.2.1 Operational Phase – First Year of Operation

Sampling over the first year of the operational phase will comprise:

- one **wet event** sampling round per quarter:
  - Type A parameters every quarter (refer to **Table 4.2**); plus
  - Type B parameters every second quarter (refer to **Table 4.2**).
- one **dry event** sampling round every six months (two rounds in the first year of operation):
  - Type A and Type B parameters.

Table 4.2 Surface Water Sampling Parameters – Operational Phase

Parameter		*Type A Parameters*	*Type B Parameters*
pH	(measured in the field)	X	
Temperature	(measured in the field)	X	
Electrical Conductivity (EC)	(measured in the field)	X	
Dissolved Oxygen (DO)	(measured in the field)	X	
Turbidity	(measured in the field)	X	
Total Suspended Solids (TSS)			X
Total Oils and Grease (include as Type A parameter if oil/grease is visible)		*	X
Total Phosphorous, Total Nitrogen			X
Total Petroleum Hydrocarbons (TPH) (include as Type A parameter if oil/grease is visible)		*	X
Heavy Metals (Total): Aluminium, Arsenic, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury, Nickel, Selenium, Silver, Zinc			X

* Note: TPH to be analysed as a Type A parameter if oil/grease is visible

4.2.2.2 Operational Phase – Second and Third Year of Operation

Sampling over the second year of the operational phase will comprise:

- one **wet event** sampling round every six months assessing both Type A and Type B parameters
- one **dry event** sampling round every six months assessing both Type A and Type B parameters.

4.3 Groundwater

4.3.1 Groundwater Level Monitoring Regime

Groundwater level monitoring will be undertaken at each of the 134 groundwater bores nominated in **Table2.2** using automatic water level recorders.

4.3.1.1 Construction Phase

The automatic water level recorders will be set to take readings at a maximum of one hour intervals with data downloaded quarterly.

Quarterly downloads will include physical measurement of total depth of the bore and depth to standing water level at each monitoring bore for correlation with the automatic recordings. The total depth of the bore and depth to standing water level is to be measured before any sampling.

Following the initial 12 months, the groundwater level recording / download frequency shall be reviewed by the Environmental Review Group to assess if any changes are warranted. This review may also be undertaken following the initial 18 months to assess if any changes are warranted.

4.3.1.2 Operational Phase – First Year of Operation

The automatic water level recorders will be set to take readings at a maximum of one hour intervals with data downloaded quarterly.

Quarterly downloads will include physical measurement of total depth of the bore and depth to standing water level at each monitoring bore for correlation with the automatic recordings. The total depth of the bore and depth to standing water level is to be measured before any sampling.

4.3.1.3 Operational Phase – Second and Third Year of Operation

The automatic water level recorders may be set to take readings at a max of three hour intervals if considered suitable based on review of data from first year of operation. The maximum period between downloading and calibration will be six months.

Downloads will include physical measurement of total depth of the bore and depth to standing water level at each monitoring bore for correlation with the automatic recordings. The total depth of the bore and depth to standing water level is to be measured before any sampling.

4.3.2 Groundwater Quality Sampling Regime

4.3.2.1 Construction Phase

Sampling over the construction monitoring period will comprise:

- quarterly sampling of Type A parameters (field analysis parameters - refer to **Table 4.3**) plus
- six-monthly sampling of Type B parameters (laboratory analysis parameters - refer to **Table 4.3**)

Sampling will be conducted on the 70 groundwater bores nominated in **Table 2.2** for quality monitoring. The number of bores and the parameters to be monitored is subject to review following the initial 12 months of monitoring as described below.

Following the initial 12 months, the sampling regime shall be reviewed by the Environmental Review Group in consideration of the monitoring results. The review shall consider:

- if the frequency of some of the sampling can be reduced or needs increasing; or
- if some analytes / parameters / locations can be omitted from the sampling.

The above review may also be undertaken following the initial 18 months.

4.3.2.2 Operational Phase – First Year of Operation

Sampling over the first year of the operational phase will comprise six-monthly monitoring of both Type A and B parameters. The number / location of the bores and the sampling parameters shall be based on the construction sampling regime resulting from the review by the Environmental Review Group as described in **Section 4.3.2.1**.

4.3.2.3 Operational Phase – Second and Third Year of Operation

Sampling over the second and third year of the operational phase will comprise annual monitoring of both Type A and B parameters. The number / location of the bores and the sampling parameters shall be based on the construction sampling regime resulting from the review by the Environmental Review Group as described in **Section 4.3.2.1**.

Table 4.3 Groundwater Quality Sampling Parameters

Parameter/Analytical Group	*Analytes*	*Type A Parameters (Field analysis)*	*Type B Parameters (Laboratory analysis)*
Physical and chemical properties	pH	X	
	Temperature	X	
	Electrical Conductivity (EC)	X	
Hydrocarbons	Total Petroleum Hydrocarbons (TPH)		X
Nutrients	Total Phosphorous, Total Nitrogen		X
Major Cations	sodium (Na^{+}), potassium (K^{+}), calcium (Ca^{2+}) and magnesium (Mg^{2+})		X
Major Anions	chloride (Cl^{-}), sulfate (SO_4^{2-}), bicarbonate (HCO^{3-})		X
Heavy Metals (Dissolved)	Aluminium, Cadmium, Copper, Lead, Zinc		X

4.4 Rainfall Data

For the construction phase rainfall data shall be collected from a range of weather stations including existing BoM stations and site construction weather stations where available. . As noted previously, 'wet events' are defined as 15mm or more of rain within 24 hours.

It is noted that the pre-construction monitoring utilised daily rainfall figures from the following Bureau of Meteorology (BoM) sites:

- Grafton Airport – Station No. 058130: Lat. 29.68 ºS, Long. 152.93 ºE, Elevation 9m.
- Yamba Pilot Station – Station No. 058012: Lat. 29.43 ºS, Long. 153.36 ºE, Elevation 27m.
- Evans Head Station – Station No. 058164: lat. 29.133 ºS, Long. 153.45 ºE, Elevation 31m.

Sampling Methodology

5.1 Pre-Monitoring Tasks

5.1.1 Rainfall Monitoring

Daily records of rainfall will be obtained from the construction site weather stations (refer to **Section 4.4**). This information will be checked/reviewed daily to determine if local rainfall events may trigger a wet weather surface water sampling event as required in **Section 4.2**.

5.1.2 Calibration

The field water quality probe used for surface and groundwater monitoring is to be calibrated in accordance with the manufacturer's recommendations. Any pre-sampling equipment and calibration checks recommended by the manufacturer are to be completed prior to each sampling round. Where sampling extends beyond one day, the probe is to be rechecked for each subsequent day of use. Calibration record sheets are to be completed and retained on the project file.

5.1.3 Preparation of Sample Containers

Sample containers suitable for the required laboratory analysis will be sourced from the laboratory prior to the commencement of monitoring rounds. Sample containers will be labelled prior to field sampling to reduce the potential for labelling errors made in the field.

5.1.4 Sampling equipment

Testing equipment required for surface water monitoring consists of the following:

- water quality probe
- sampling pole
- sample bottles supplied by the laboratory
- chilled insulated container/esky and ice
- additional sample bottles for ex-situ field measurements where required (refer to **Section 5.2.2**)
- camera
- GPS
- field sheets.

Testing equipment required for the groundwater monitoring component will include:

- water quality probe
- electronic dip (water level) meter
- tape measure for measuring depth of bores
- laptop/notebook with software loaded and operational, water level logger licence key and USB cable
- sample bottles supplied by the laboratory
- chilled insulated container/esky and ice
- additional sample bottles for ex-situ field measurements
- camera
- GPS
- field sheets.

5.2 Surface Water Sampling

5.2.1 Field Observations

Observations will be recorded in field sheets at each sampling location upon arrival at the site. This will include:

- date and time of sampling
- weather conditions including air temperature and percentage of cloud cover
- general observations on the condition of the water body such as water colour, stream flow, evidence of recent flooding, any odour, any visible signs of oil/grease on the water surface, gross pollutants, other pollution or other disturbances including relevant adjacent land use activity
- photographic records.

5.2.2 Collection of In-Situ Water Quality Data

The following parameters are to be measured in the field for each monitoring round using a calibrated water quality probe:

- pH
- Temperature
- Electrical Conductivity (EC)
- Dissolved oxygen (DO)
- Turbidity (NTU).

The field measurements are to be made prior to the collection of samples for laboratory analysis. The measurements are to be noted on the field sheets for each surface water monitoring site.

The water quality probe is to be placed approximately 0.5 metres below the water surface or mid-depth in the water column for shallow sites. The water quality readings will be allowed to stabilise before reading/recording in accordance with the manufacturer's instructions.

Where safety concerns do not allow for sampling in-stream (or depth is too shallow for effective probe deployment), a sample may be collected using an appropriate sampling device and measurements undertaken on the stream bank. Where this methodology is employed it will be recorded on the field sheets. To avoid contamination of samples, field measurements are to be made on samples of water separate to samples collected for laboratory analysis.

All equipment will be decontaminated between sampling sites.

5.2.3 Collection of Water Samples for Laboratory Analysis

Water samples will be collected by immersion of a sample bottle on a pole to 0.5 metres below the water surface or mid-depth in the water column for shallow sites. The sample bottle will be rinsed three times with sample water prior to obtaining sample. Rinse water will be emptied downstream of the sampling location to avoid contamination of the sample.

All samples will be stored in a chilled esky and transported to the laboratory as soon as practical.

5.2.3.1 Replicate Samples

One blind replicate water sample will be collected for every 10 samples every monitoring round for laboratory analysis. Blind replicate samples will be submitted to the laboratory as individual samples without any indication to the laboratory that they are replicates.

5.3 Groundwater Sampling

5.3.1 Field Observations

Observations will be recorded in field sheets at each sampling location upon arrival at the site. This will include:

- date and time of sampling
- weather conditions including air temperature and percentage of cloud cover
- general observations on the condition of the groundwater bore, any visible signs of contamination or other disturbances
- photographic records.

5.3.2 Collection of Groundwater Standing Water Levels

Prior to extracting the automatic water level recorders or any purging/sampling, each monitoring well will be gauged by measuring:

- depth to standing water level with an electronic dip (water level) meter
- total depth of the bore. The total depth of the bore is required as the base of the monitoring bores can silt up, and this can occur to the top of the slotted/screened interval. Comparing the measured total depth reading with the depth documented at the time of construction can be useful to determine the status of the bore (Sundaram et. al., 2009:24).

The above measurements will be made from a standard reference point on each of the well casings which will be noted on the field sheets. The readings will be recorded as depth from the Top of Casing (TOC).

The automatic water level recorder will then be extracted at each monitoring well for transfer of data to a laptop/notebook using a compatible shuttle. At the completion of the monitoring event the shuttle will be downloaded and data collected from each well will be stored in a Microsoft Excel spread sheet. The field level data for each monitoring well will be corrected for barometric pressure and converted to a standing water level (SWL). This converted data will then be used to plot the SWL over time for each monitoring well.

5.3.3 Collection of Field Groundwater Quality Data

The following parameters are to be measured in the field for each monitoring round using a calibrated water quality probe:

- pH
- temperature
- electrical conductivity (EC)
- dissolved oxygen (DO)
- turbidity (NTU).

The field measurements are to be made following purging of the wells and prior to the collection of samples for laboratory analysis. The measurements are to be noted on the field sheets for each groundwater monitoring site.

All equipment will be decontaminated between sampling sites.

5.3.4 Collection of Groundwater Samples for Laboratory Analysis

Groundwater samples can be obtained by either a passive sampling approach or purging – either method is considered appropriate.

5.3.4.1 Passive Sampling

A passive sampling approach will utilise a "Hydrasleeve" or similar. The Hydrasleeve is a tool used for passive groundwater sampling that has been specifically designed to capture a "core" sample of water from a user-defined interval/portion of the well.

A one way reed valve allows the Hydrasleeve to be lowered into the well (with the use of a weight and string cut to the desired length) as a thin empty plastic sleeve, thereby preventing the mixing of fluid from higher up the water column. The groundwater sample collection process will involve the placement of Hydrasleeves at a depth of three meters below the top of the screen (or in the case of low yield wells, to the bottom of the well). Once lowered to the desired depth, the Hydrasleeve will be left for a minimum period of one week before being withdrawn and the required groundwater sample retrieved for laboratory analysis. Note that this lag time of one week is a precautionary measure to allow the water in the well to re-equilibrate, should any mixing have occurred.

Given that the Hydrasleeve is a single use item, each Hydrasleeve will be disposed of appropriately upon withdrawal from the well. After the sample has been retrieved from the Hydrasleeve and transferred to the corresponding laboratory supplied bottles for analysis, a new Hydrasleeve will be set up and deployed for retrieval during the next round of monitoring. By taking this passive groundwater sampling approach, the bore does not require purging prior to every sampling event.

5.3.4.2 Purging

Prior to the collection of water samples for analysis each well will be purged. The wells will be purged using either an electric purge pump or a decontaminated stainless steel bailer until the following criteria is met:

- a minimum of three well volumes have been removed from the well; or
- the well has been purged dry.

The purging method will be recorded on the field sheet.

Collection of groundwater samples for laboratory analysis will be undertaken following purging and field measurements. All equipment will be decontaminated between sampling sites.

5.3.5 Replicate Samples

One blind replicate water sample will be collected for every 10 samples every monitoring round for laboratory analysis. Blind replicate samples will be submitted to the laboratory as individual samples without any indication to the laboratory that they are replicates.

6

Quality Management

6.1 Sample Identification and Records

Sample containers will be labelled clearly and include the following information:

- job reference number
- sample location name (e.g. SW01)
- time and date sampled.

A field sheet will be completed for each surface water and groundwater sampling location. The field sheet will include the following details:

- sample location name
- date and time of sampling
- sample equipment used
- name of field personnel
- weather conditions
- field water quality parameter measurements
- water level details including depth to water and total depth within groundwater monitoring bores
- visual and odour observations – refer to **Section 5.2.1** and **5.3.1**
- QA/QC sample collection details – refer to **Section 6.7**

6.2 Sample Collection

To ensure the integrity of all samples taken, the sampling protocol includes the following basic precautions for avoiding contamination during sample collection:

- containers supplied by the analytical laboratory will be utilised
- all field equipment will be pre-cleaned
- sample bottles suitable for each parameter will be used
- containers will be uncapped or removed from their transport bags for minimum amounts of time.

6.3 Sample Preservation and Transport

Water samples are to be collected in laboratory supplied containers and will be kept on ice in a chilled insulated container. Samples are to be couriered to the laboratory under chain of custody protocol within one day of sampling.

6.4 Chain of Custody

Chain of custody documentation to be recorded as part of the sampling program is detailed in **Table 6.1**.

Table 6.1 Chain of Custody Documentation

Process Step	*Quality Assurance Procedure*
Field sampling	Field register of sample number, site, type/technique, time, date, technician, field data sheet
Sample storage and transport	Field register of transport container number and sample numbers, time, date
Laboratory receipt of samples	Laboratory register of transport container number and sample numbers, time, date
Laboratory storage of samples	Laboratory register of storage location, type, temperature, time, date
Sample preparation	Analysis register of sample (laboratory) number, pre-treatment, date, technician
Sample analysis	Analysis register of instrument, calibration, technician, standard method, date, result

6.5 Laboratory Analysis

During laboratory analysis of samples, standard laboratory analytical procedures are employed and all analyses are undertaken by laboratories with NATA-accredited methods.

6.6 Quality Control Samples

Replicate samples will be collected and submitted to the laboratory for analysis as described in **Sections 5.2.3.1** and **5.3.5**. The results for the replicate samples will be compared against the corresponding routine samples and any potential quality control issues will be discussed with the laboratory.

7

Data Analysis and Management

The proposed method in this WQMP for inferring something from the monitoring results is based on the *Australian and New Zealand guidelines for fresh and marine water quality - Volume 1* (ANZECC ARMCANZ, 2000a) and the *Australian guidelines for water quality monitoring and reporting* (ANZECC ARMCANZ, 2000b). The Water Quality Guidelines (ANZECC ARMCANZ, 2000a) advocates that for physical and chemical (non-toxicant) parameters, the median quality values of fresh and marine waters should be lower than the 80th percentile of concentration values of a suitable reference site (above the 20th percentile for parameters such as dissolved oxygen where low values are the problem). Thus the 80th and 20th percentiles from the baseline monitoring (pre-construction monitoring) have been adopted in this WQMP as trigger values.

The pre-construction monitoring data provides an indication of baseline conditions and the degree of variation for a range of water quality parameters. This provides the initial baseline data for comparison with the construction / operational sampling results. However, it is noted there will likely be different climatic factors such as rainfall and drought and potentially land use changes across the project stages that will produce variations from the baseline data, particularly in respect to surface water quality data. Therefore, the baseline data for surface water quality from the pre-construction stage shall be supplemented with data collected from upstream monitoring locations over the construction and operational stages to provide a more robust baseline data set.

For comparative purposes, relevant ANZECC criteria for surface water quality and groundwater quality are provided in **Appendix K** of this WQMP.

7.1 Surface Water

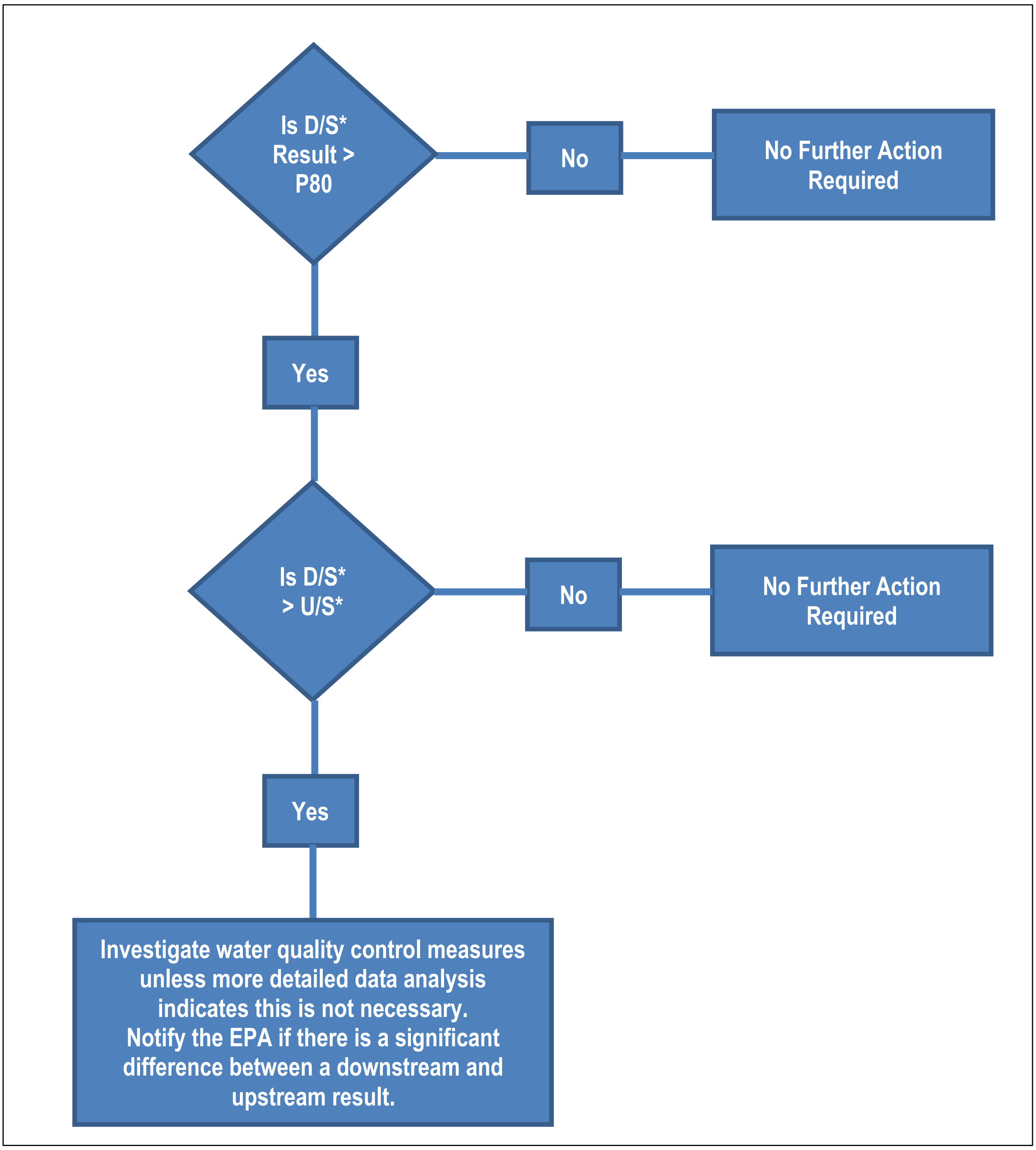
7.1.1 Comparison of Sampling Data and Baseline Data

Comparison of sampling data with baseline data will utilise 80th percentile values from baseline data for trigger values (ANZECC ARMCANZ, 2000b:6-17) and comparison of upstream and downstream data at each sampling location.

The following approach, which is represented in the flow chart in **Figure 7.1**, shall be adopted when assessing surface water quality data collected for each sampling event during the construction and operational phases:

- Compare each downstream construction / operational sampling result with the corresponding 80th percentile figure (P80 figures) from the baseline data (see **Note 1** further below regarding the use of P20 figures for some parameters):
  - Compare dry event sampling results with the P80 for dry events, and wet event sampling results with the P80 for wet events;
  - If a downstream sampling result is greater than the corresponding P80 baseline figure (or less than the corresponding P20 baseline figure for DO), this highlights a possibility of the highway impacting on surface water quality requiring further investigation as per the following steps (refer also to example control chart in **Figure 7.2**);
  - If a downstream sampling result is less than the corresponding P80 baseline figure then no further action is required with respect to the subject parameter.
- If a downstream result is greater than the P80 baseline figure (or less than the P20 figure for DO) then compare the downstream and upstream sampling results at that location for that event:
  - If a downstream sampling result is less than the upstream result then no further action is required with respect to the subject parameter (see **Note 2** further below with respect to DO, pH and EC).

– If the downstream sampling result is greater than the upstream result then investigate existing water quality control measures unless more detailed analysis of data indicates this is not necessary. Notify the EPA representative if there is a significant difference between a downstream and upstream result.



Note: D/S = Downstream; U/S = Upstream

Figure 7.1 Flow Chart for Comparing Surface Water Sampling Data and Baseline Data

Note 1: 20th percentile figure (P20 figures) should be utilised for the following parameters:

- Dissolved Oxygen (DO) – utilise P20 figures instead of P80 figures;
- pH – utilise both P80 and P20 figures.
- Temperature – no comparison required; and
- Electrical Conductivity (EC) – utilise both P80 and P20 figures.

Note 2: for DO, pH, temp. and EC, the following lists the criteria for further investigation when comparing the downstream and upstream sampling results:

- Dissolved Oxygen (DO) - if the downstream sampling result is less than the upstream result, this highlights a possibility of the highway impacting on surface water quality requiring investigation of existing water quality control measures unless more detailed analysis of data indicates this is not necessary. If a downstream sampling result is greater than the upstream result then no further action is required with respect to DO
- pH and Electrical Conductivity (EC) – if the difference between the downstream and upstream sampling results is greater than the standard deviation (Std Dev) from the baseline data, this highlights a possibility of the highway impacting on surface water quality requiring investigation of existing water quality control measures unless more detailed analysis of data indicates this is not necessary. If the difference is less than the standard deviation then no further action is required with respect to the subject parameter
- Temperature – no comparison required.

The technique for comparing sampling results and baseline data / trigger values will use either tabulated results or control charts (or a combination of both). An example of the use of control charts for the comparison of downstream sampling results with the corresponding 80th percentile figure (P80 figures) from the baseline data is shown in **Figure 7.2**. Here, the monthly results for a test parameter for a monitoring location are graphed in a control chart. The results at the downstream or 'impact' site are compared to the trigger value (P80 figures) from the baseline data. It is noted that the baseline data shall be continually adjusted / supplemented with data collected from upstream monitoring locations over the construction and operational stages.

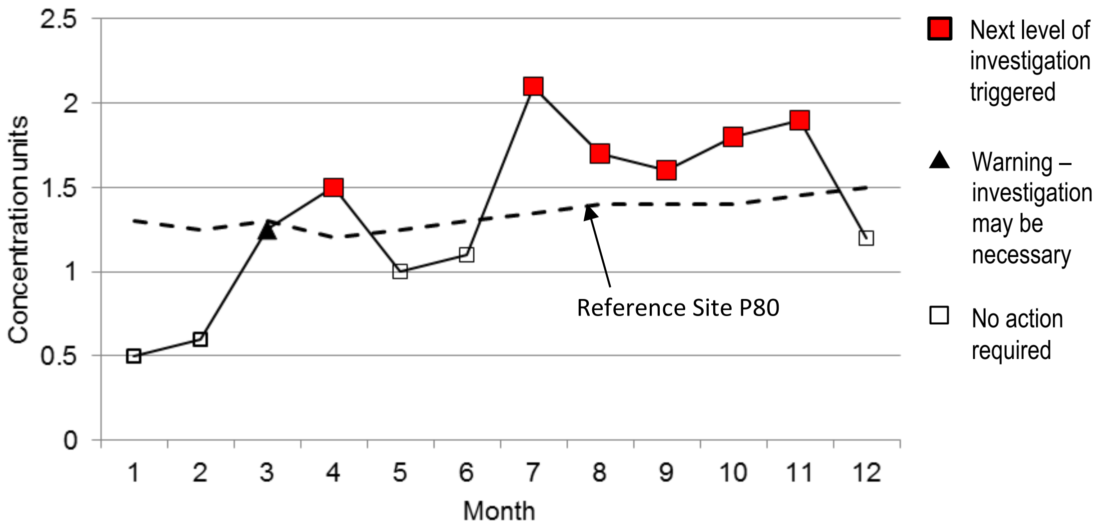


Figure 7.2 Example Control Chart

7.1.2 Adding to Surface Water Quality Baseline Data

The baseline data for surface water quality established from the pre-construction monitoring period will be supplemented with the upstream monitoring data collected during the construction and operational phases of the project. The upstream monitoring sites represent sites not impacted by the highway upgrade and therefore reflect 'baseline' data. This process will provide a more robust set of baseline data over the course of the project.

The baseline data shall be supplemented with the upstream monitoring data on a:

- Monthly basis during the construction phase; and
- Six-monthly basis during the operational phase.

7.2 Groundwater Quality

The following approach, which is represented in the flow chart in **Figure 7.3**, shall be adopted when assessing groundwater quality data collected for each sampling event during the construction and operational phases:

- Compare each construction / operational sampling result with the corresponding 80th percentile figure (P80 figures) from the baseline data (see **Note 1** further below regarding the use of P20 figures for some parameters):
  - If a sampling result is greater than the corresponding P80 baseline figure, this highlights a possibility of the highway impacting on groundwater quality requiring investigation of existing water quality control measures and other potential influences not associated with the highway works unless more detailed analysis of data indicates this is not necessary. Notify the EPA representative if there is a significant difference between a result and the corresponding P80 baseline figure;
  - If a sampling result is less than the corresponding P80 baseline figure then no further action is required with respect to the subject parameter.

Note 1: 20th percentile figure (P20 figures) should be utilised for the following parameters:

- Dissolved Oxygen (DO) – utilise P20 figures instead of P80 figures;
- pH – utilise both P80 and P20 figures.
- Temperature – no comparison required;
- Electrical Conductivity (EC) – utilise both P80 and P20 figures;
- Total Dissolved Solids (TDS) – utilise both P80 and P20 figures.

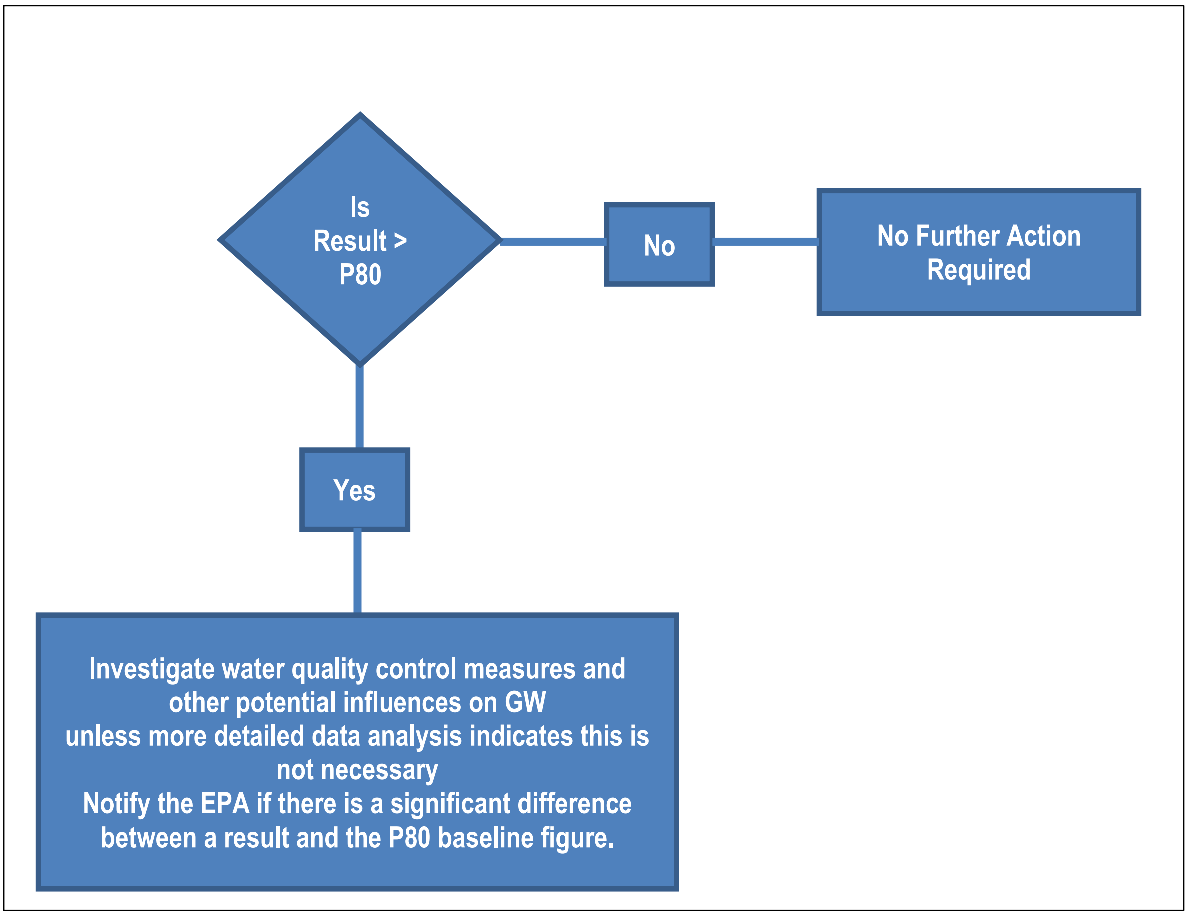


Figure 7.3 Flow Chart for Comparing Groundwater Sampling Data and Baseline Data

7.3 Groundwater Levels

The following approach, which is represented in the flow chart in **Figure 7.4**, shall be adopted when assessing groundwater level data collected for each downloading event during the construction and operational phases:

1. For each cutting site, compare the relative difference between the groundwater levels on either side of the cutting with the P80 baseline figure:
   - If the relative difference is less than the corresponding P80 baseline figure then no further action is required with respect to the subject cutting site.
   - If the relative difference is greater than the corresponding P80 baseline figure, this highlights a possibility of the highway cutting impacting on groundwater flows requiring further investigation as per the following steps
2. If relative difference is greater than the corresponding P80 baseline figure then further assess the groundwater level data to determine if the difference is due to ‘natural’ variations having consideration of:
   - The timing of the cutting excavation works at the specific site;
   - Site observations that indicate interception of groundwater levels;
   - Climatic conditions such as rainfall / extended dry period which may influence one of the groundwater bores more than the other;
3. If the above assessment (Points 1 & 2) indicates the difference is due to ‘natural’ variations then no further action is required.
4. If it is unclear from the above assessment (Points 1 & 2) as to whether the difference may be due to ‘natural’ variations or the highway works, then: notify the EPA representative; and monitor / download the groundwater levels on a quarterly basis at the subject cutting site and repeat the above process for each downloading event. Revert back to original monitor / download frequency if it is determined the difference is due to ‘natural’ variations;
5. If the above assessment (Points 1 & 2) indicates the difference is due to the highway works then: notify the EPA representative; and investigate existing groundwater control measures and additional mitigations as required.

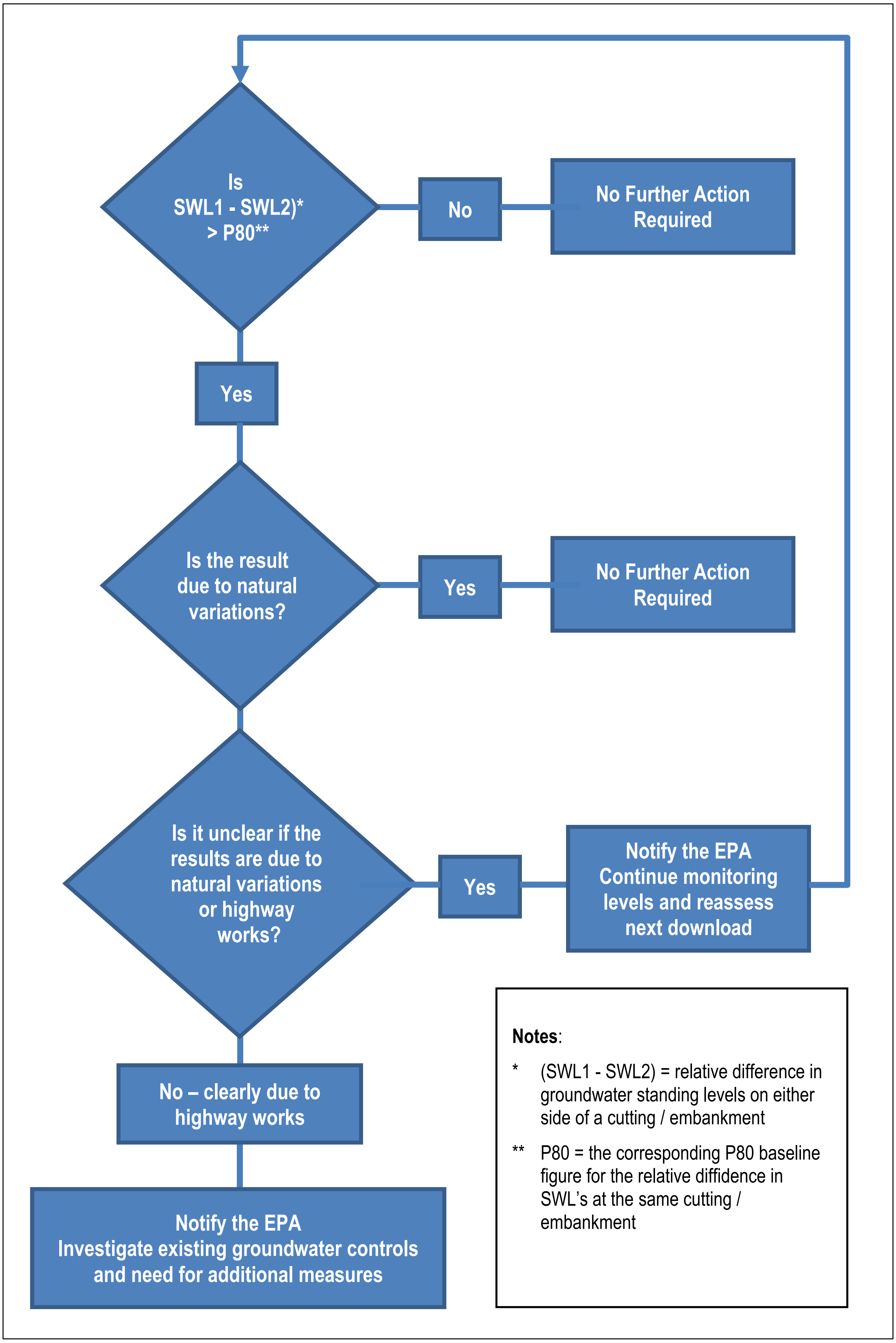


Figure 7.4 Flow Chart for Comparing Groundwater Level Data and Baseline Data

7.4 Data Interpretation

After the data analysis, the results will be collated into a concise statistical summary and assessed in the context of the monitoring objectives below.

7.4.1 Construction Stage

Data interpretation for the construction stage monitoring will address:

- Surface water quality:
  - refinement of baseline surface water quality data for the project by supplementing pre-construction data with upstream monitoring data;
  - identification of potential impacts of the highway upgrade construction on surface water quality;
  - recommendations for any refinements of construction surface water management measures;
- Groundwater quality:
  - identification of potential impacts of the highway upgrade construction on groundwater quality;
  - recommendations for any refinements of construction groundwater quality management measures;
- Groundwater levels:
  - identification of potential impacts of the highway upgrade construction on groundwater levels;
  - recommendations for any refinements of construction groundwater level management measures.

7.4.2 Operational Stage

Data interpretation for the operational stage monitoring will address:

- Surface water quality:
  - refinement of baseline surface water quality data for the project by supplementing pre-construction data with upstream monitoring data;
  - identification of potential impacts of the highway upgrade operation on surface water;
  - recommendations for any refinements of operational surface water management strategies and stabilisation works.
- Groundwater quality:
  - identification of potential impacts of the highway upgrade operation on groundwater quality;
  - recommendations for any refinements of operational groundwater management strategies.
- Groundwater levels:
  - identification of potential impacts of the highway upgrade operation on groundwater levels;
  - recommendations for any refinements of operational groundwater level management measures.

7.5 Reporting

7.5.1 Construction Stage

Reporting during the construction stage will include annual reports and a final report at the completion of the construction stage.

The reports will include any relevant discussion of the results to inform the ongoing management of the surface water and groundwater management measures and the results will be discussed and minuted at the Environmental Review Group meetings.

Annual reports will be forwarded to Department of Planning and Environment, EPA, DPI (Fisheries), NOW, DoE and Rous Water (in relation to the Woodburn borefields) in accordance with Condition D12 (Item h) of the Minister's Conditions of Approval (MCoA) – refer to **Section 1.2** and **Table 1.1** in this WQMP. Annual reporting will also be published in accordance with Condition 21 of the Federal Minister for the Environment's Conditions of Approval – refer to **Section 1.2**. Annual reports will include:

- introduction and background: description of the program and objectives and defining the extent of the highway upgrade works;
- experimental detail, describing the sampling regime and parameters including detail of the sampling locations so they can be unambiguously identified, e.g. GPS directions and descriptions of methods of sampling and analysis;
- presentation, interpretation and discussion of the results addressing the items outlined in **Section 7.4**;
- review and recommendations for the monitoring program for the construction and operational stages; and
- appendices, providing laboratory reports, data tables or other relevant information.

Similarly, the final report at the completion of the construction stage will be of a similar format to that outlined above and will include recommendations for the operational monitoring program. The final report will also be forwarded to Department of Planning and Environment, EPA, DPI (Fisheries), NOW, DoE and Rous Water (in relation to the Woodburn borefields) in accordance with Condition D12 (Item h) of the MCoA.

7.5.2 Operational Stage

Reporting during the operation stage will also include annual reports and a final report at the completion of the first three years of operation.

Annual reports will be forwarded to Department of Planning and Environment, EPA, DPI (Fisheries), NOW, DoE and Rous Water (in relation to the Woodburn borefields) in accordance with Condition D12 (Item h) of the Minister's Conditions of Approval – refer to **Section 1.2** and **Table 1.1** in this WQMP. Annual reporting will also be published in accordance with Condition 21 of the Federal Minister for the Environment's Conditions of Approval – refer to **Section 1.2**. Annual reports will be of a similar format to that outlined in **Section 7.5.1**.

Similarly, the final report at the completion of the first three years of operation will be of a similar format to that outlined in **Section 7.5.1** and will also be forwarded to Department of Planning and Environment, EPA, DPI (Fisheries), NOW, DoE and Rous Water (in relation to the Woodburn borefields) in accordance with Condition D12 (Item h) of the MCoA.

8

Management Actions

This section provides an overview of potential contingency and ameliorative measures that could be implemented in the event that adverse impacts are identified. The following contingency and ameliorative measures are largely based on potential measures outlined in the environmental impact assessment for the project. It is noted that alternative measures may be more suitable. This would be determined when adverse impacts are identified and in full consideration of relevant factors and site specific circumstances.

The development of mitigation measures and specific actions should consider related management plans such as the Threatened Frog Management Plan (RMS *et. al.*, 2014) and Threatened Fish Management Plan (RMS *et. al.*, 2013) to ensure measures are complimentary or to avoid conflicting measures / outcomes. The Contractors environment team involved in soil and water management should also be aware of these related plans.

8.1 Construction Phase - Surface Water Management Actions

The key mitigation measures for the construction stage will be sediment basins and additional erosion and sediment controls to intercept run-off and retain the associated sediments and pollutants. Maintenance and monitoring of these measures by the Contractor will form a key component of the mitigation measures. The measures will address the relevant CoA and the safeguards detailed in the EIS and Submission &/ Preferred Infrastructure Report (SPIR). Construction activities will also be managed to meet water quality objectives in the Environmental Protection Licence (EPL) conditions. The measures will be formulated at the detailed design stage as part of the Construction Soil and Water Management Plan (CSWMP) within the CEMP which will be submitted for approval by the Department of Planning and Environment. The plan will include water quality monitoring at the outlet of the sediment basins. General water quality criteria for discharges from sediment basins will comprise:

- pH between 6.5 - 8.5
- TSS < 50mg/L
- No visible oil and grease.

The measures will integrate with related plans such as the Threatened Fish Management Plan where there may be specific requirements for monitoring or treatment of captured water.

Management actions will also be triggered by assessment of water surface water quality data collected during the construction phase as outlined in **Section 7**. If the sampling results indicate a possibility of the highway impacting on surface water quality (as outlined in **Section 7.1**), the Contractor is to investigate existing water quality control measures to determine any maintenance requirements or additional measures to be implemented at that location.

8.2 Construction Phase - Groundwater Management Actions

Similar to surface water management, some of the key mitigation measures for the construction stage will be construction of erosion and sediment controls. Other measures will include best practice management for siting and bunding of storage areas where appropriate. There will also be additional site specific measures such as in the drinking water catchment of the Rous Water Woodburn Sands borefield where: the design of the basins may be shallower than standard to avoid penetration of the natural clay layer; and certain construction activities may be restricted such as refueling, washdown, and storage of chemicals. Section 5.4 of the Water Quality Working Paper (RMS, Aurecon, SKM, 2012c) includes design criteria for mitigation measures for the Rous Water borefield. Measures will be formulated at the detailed design stage as part of the CEMP which will be submitted for approval by the Department of Planning and Environment.

The following is a non-prescriptive list of potential contingency and ameliorative measures that could be implemented in the event that adverse impacts are identified:

- Where sites used for stockpiles, washdown, batch plants, refuelling and chemical storage are located in areas of sensitive/shallow water table, best practice management for siting, erosion and sediment controls, and bunding of storage areas in combination should be employed.
- Dewatering of excavations would be undertaken in line with RMS' Technical Guideline – Environmental Management of Construction Site Dewatering (RMS, 2011c), and in accordance with any licence conditions.
- Where groundwater is released, recharge of the water table is the preferred option of managing groundwater. This would be facilitated by collecting groundwater in grassed swales for infiltration back to the groundwater source. Where possible, these swales would divert the groundwater around the construction area so that the groundwater does not further mix with construction runoff. Recharge could also include the collection of seepage from the cut face in the drainage system which would be diverted to absorption trenches or to water quality ponds to be tested and possibly treated before being released back to the creek or natural drainage system at some point downstream. Any diversion of groundwater intercepted during construction activities into existing water quality/sediment basins will consider existing design capacity of the basins and any Environmental Protection License requirements that may be impacted by receipt of additional groundwater.

Management actions will also be triggered by assessment of groundwater water quality and groundwater level data collected during the construction phase as outlined in **Section 7**.

8.3 Operational Phase - Surface Water Management Actions

Permanent water quality management and protection measures would be installed to protect adjacent waterways and sensitive receiving environments such as the Rous Borefield from pollutants generated by operation of the project. These would include:

- Water quality ponds;
- Grassed swales; and

Details of the treatment methods will be reviewed and confirmed through the detailed design process. For the Rous Borefield the Water Quality Working Paper (RMS, Aurecon, SKM, 2012c:83) recommends adopting a similar standard of stormwater treatment controls to those used for the T2E project within the constraints of the site.

In the event that adverse impacts are identified from the monitoring, the following procedure should be implemented:

- Identify potential pollutant source based on the parameters that were exceeded (eg. sediment for high TSS reading, or fuel spill / leak for high hydrocarbon reading);
- Inspect and rectify water quality ponds and grassed swales in area where adverse impacts are identified. This would include inspection of water quality ponds to assess available water storage capacity, water quality, sediment build-up, structural integrity and debris levels.

8.4 Operational Phase - Groundwater Management Actions

In the event that adverse impacts are identified from the monitoring, the procedures outlined in **Section 8.2** should be implemented.

8.5 Adaptive Management Framework

RMS acknowledges the importance of undertaking environmental management using an adaptive management approach and as such the WQMP will be a working document. Given the nature of environmental monitoring, an adaptive management approach is considered appropriate to deliver an effective monitoring program during construction and operation. Following review of results and data, improvements and refinements of the WQMP may be identified. The monitoring program will be reviewed and updated accordingly based on this ongoing review process in order to provide a robust monitoring framework in response to the CoA requirements.

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Appendix A