Roads & Maritime

Water Quality Monitoring Program (Sections 1 & 2)

Woolgoolga to Ballina Pacific Highway upgrade

March 2015

Pacific Highway Upgrade – Woolgoolga to Glenugie

Water Quality Monitoring Program

Prepared for: NSW Roads and Maritime Service

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UPR	*Description*	*Date Issued*	*Issued By*
2134 1098	DRAFT – First Issue	22/10/2014	Tim Ruge
2134 1111	DRAFT – Second Issue	03/11/2014	Tim Ruge
2134 1116	DRAFT – Third Issue	14/11/2014	Tim Ruge
2134 1117	FINAL – First Issue	06/03/2015	Tim Ruge
2134 1118	FINAL – Second Issue	27/03/2015	Tim Ruge

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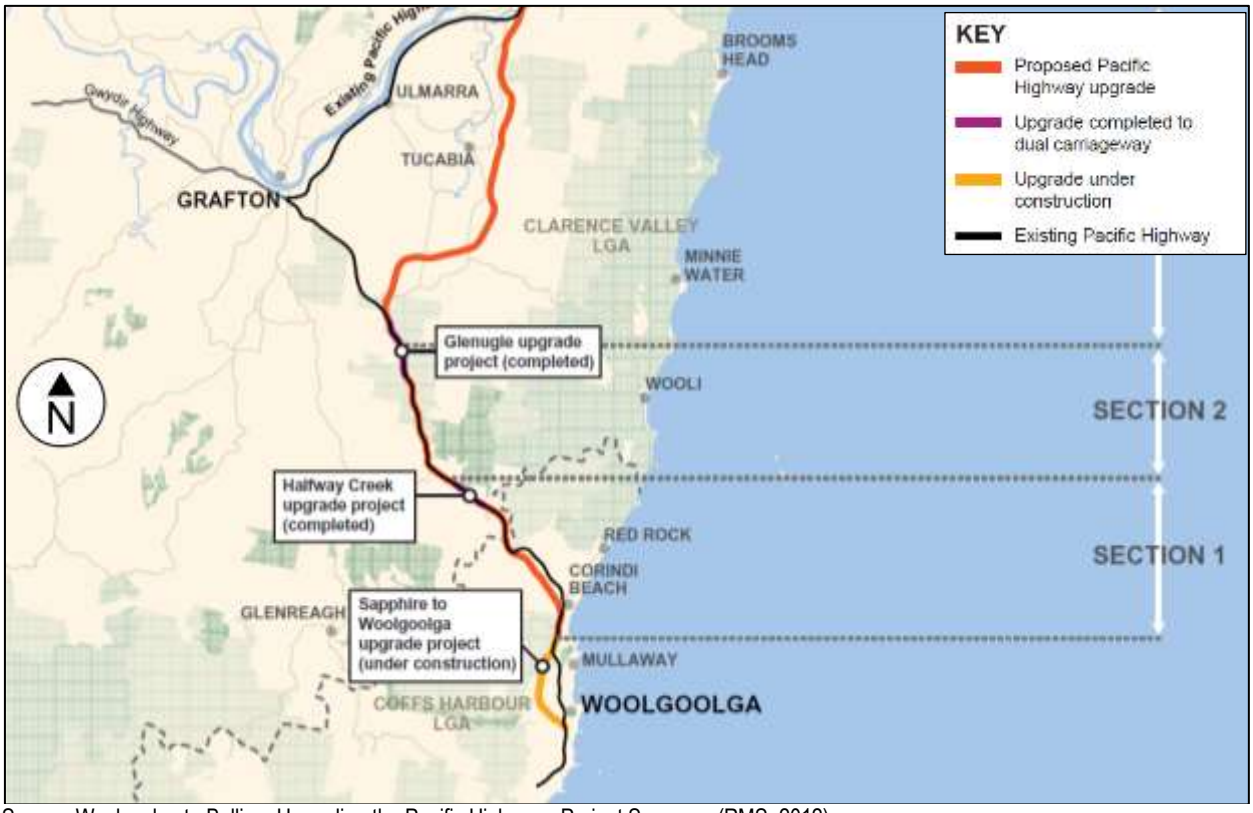
Introduction

This document presents the Water Quality Monitoring Program (WQMP) for the construction and post-construction phase of the Woolgoolga to Glenugie (W2G) section of the Pacific Highway Upgrade.

The W2G section covers a distance of approximately 31 kilometres and forms staging sections 1 and 2 of the proposed Woolgoolga to Ballina Pacific Highway Upgrade Program – refer to **Figure 1.1**.



Source: Woolgoolga to Ballina. Upgrading the Pacific Highway. Project Summary (RMS, 2012)

Figure 1.1 Overview of Woolgoolga to Glenugie section of the Pacific Highway Upgrade

1.2 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 W2G 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 W2G 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.

1.3 Minister's Conditions of Approval

The Minister's Conditions of Approval (MCoA) granted by the Minister for Planning on 24 June 2014 and modified on 15 January 2015 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 1.1 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 Appendix B re: pre-construction groundwater monitoring
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 1.4 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
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, Appendix A and Appendix B

Item	*Details*	*Addressed in*
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

Consultation with the government authorities is detailed in **Appendix E** of this WQMP.

1.4 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.

1.4.1 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).

1.4.2 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 1.4.1**, 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).

1.5 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.

1.5.1 Construction Stage

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

- Changes in surface flows, groundwater flow regimes and 'draw down' of the water table as a result of intersection of groundwater by cuttings and subsequent groundwater discharge.
- Groundwater contamination, which may occur if construction activities are not adequately managed, particularly in areas of shallow groundwater.

1.5.1.1 Risks to Groundwater from Cuttings

The W2G project has:

- Six Type A cuttings (potential high impact): Where the design profile after the cutting is predicted to be below the level of the groundwater table. This could lead to localised draw down of the groundwater table around the cutting sites. Groundwater flow to local creeks, streams, springs and local water resource within around 100 metres of the cutting could result. Potential impacts could also occur to

Groundwater Dependent Ecosystems. Engineered mitigation measures would need to be put in place to divert groundwater away from the site (refer to **Table 2.2** for classification of each cutting); and

- Eight Type B cuttings (low to moderate impact) (refer to **Table 2.2** for classification of each cutting): Where the design profile is above the groundwater table and where the groundwater table is between:
  - Two to three metres below the ground surface (resulting in a moderate impact). These cuttings may require further and possibly ongoing monitoring, but are unlikely to require engineering intervention
  - Three to five metres below the ground surface (resulting in a low impact).

1.5.1.2 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.

1.5.2 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.

2

Monitoring Locations

This section provides an overview of the surface water and groundwater monitoring locations and the existing environment relating to the waterways and groundwater systems. Details of access to each monitoring site are included in **Appendix C** of this protocol.

2.1 Surface Water Monitoring Locations

There are 11 waterways to be monitored for the W2G project. The waterways are listed in **Table 2.1** and shown in **Illustrations 2.1** to **2.2**. At each waterway, with the exception of Blackadder Gully (SW03), there is an upstream and downstream monitoring site. The exact location of the monitoring sites is detailed in **Appendix C**.

The selected waterways are associated with sensitive receiving environments as defined in the Water Quality Working Paper (RMS, Aurecon, SKM, 2012c:16) and listed in **Table 2.1**. Waterways associated with Oxleyan Pygmy Perch (OPP) habitat are noted in **Table 2.1**. It is noted that the nominated waterways may also be associated with endangered ecological communities.

Table 2.1 Waterways Selected for Surface Water Monitoring

Highway Section	*Waterway*	*Identifier*	*Chainage*	*Sensitive Receiving Environment*
Section 1 - Woolgoolga to Halfway Creek	Arrawarra Gully	SW01	300	Tributary of SEPP 14 wetland No. 315 Tributary of Solitary Islands Marine Park (SIMP) Key fish habitat / Potential OPP habitat
	Corindi River	SW02	3600	Tributary of SIMP Key fish habitat / Potential OPP habitat
	Blackadder Gully	SW03	3800	Tributary of SIMP Key fish habitat
	Cassons Creek	SW04	4750	Tributary of SIMP Key fish habitat / Known OPP habitat
	Redbank Creek	SW05	5650	Tributary of SIMP Key fish habitat / Known OPP habitat
	Dirty Creek	SW06	8500	Tributary of SIMP Key fish habitat / Potential OPP habitat
	Dundoo Creek	SW07	10700	Key fish habitat
	Boneys Creek (Halfway Creek tributary)	SW08	13350	Key fish habitat / Potential OPP habitat
Section 2 - Halfway Creek to Glenugie	Halfway Creek	SW09	20700	Key fish habitat / Potential OPP habitat
	Wells Crossing	SW10	22400	Key fish habitat
	Glenugie Creek	SW11	29300	Key fish habitat / Potential OPP habitat

Note: 1. Source – Table G-1 in RMS, Aurecon, SKM, 2012c

Information shown is for illustrative purposes only

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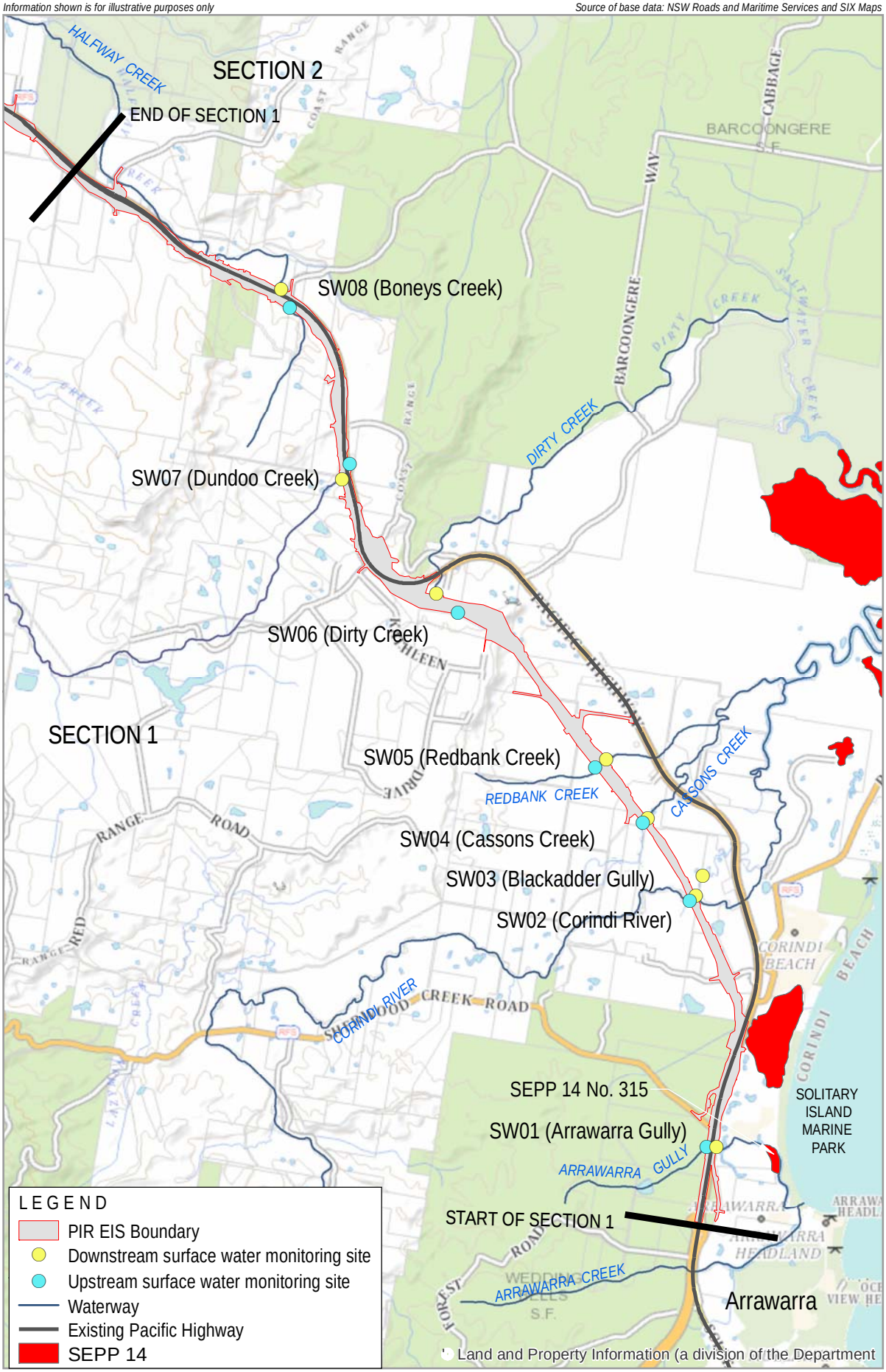
Source of base data: NSW Roads and Maritime Services and SIX Maps



0 1.4 km

North

Section 1 - Woolgoolga to Halfway Creek - Surface Water Monitoring Sites

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W2G - Water Quality Monitoring Program
2134-1109

Illustration 2.1

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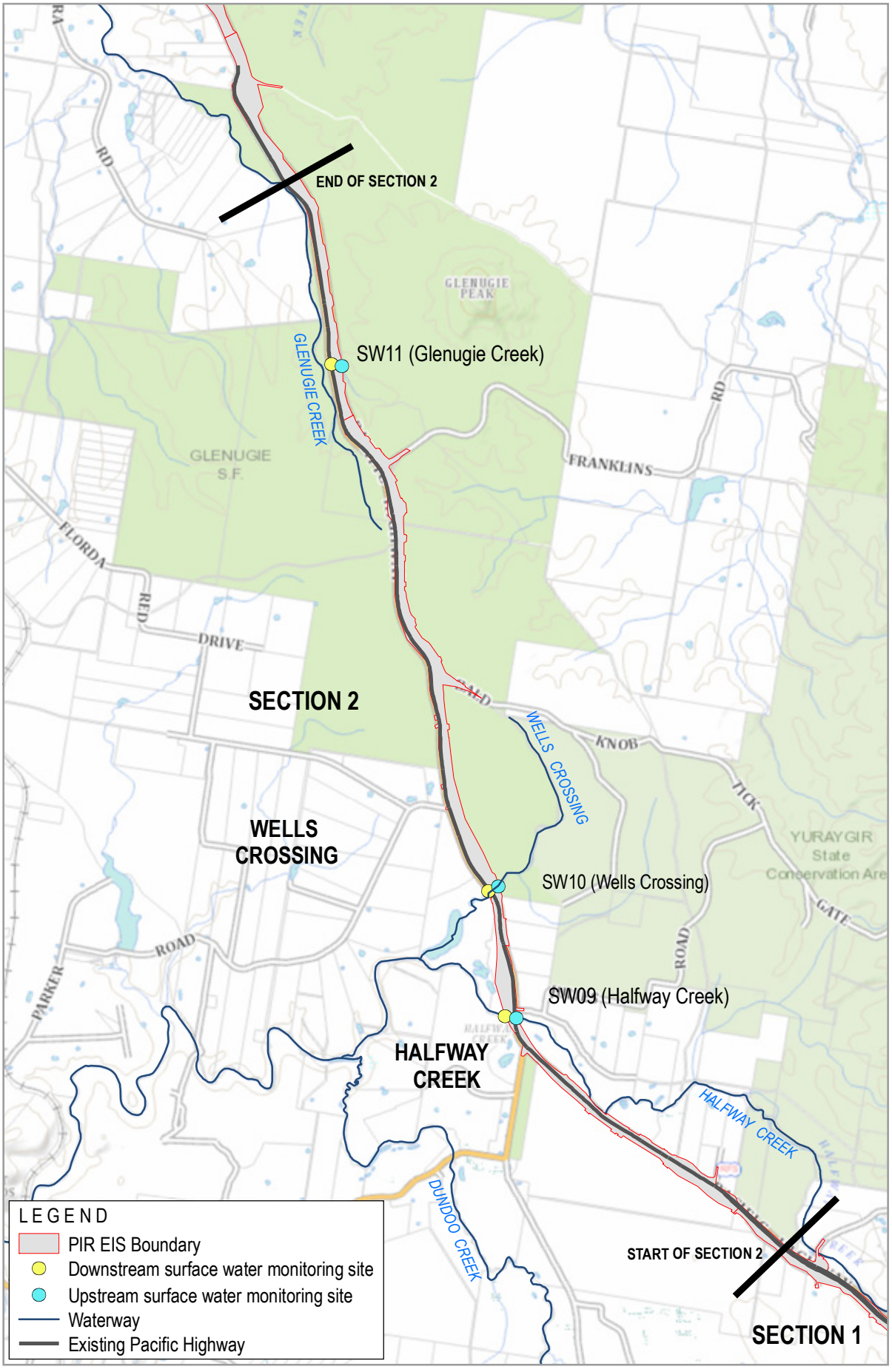
Source of base data: NSW Roads and Maritime Services and SIX Maps



0 1.4 km

North

Section 2 – Halfway Creek to Glenugie - Surface Water Monitoring Sites

GeoLINK environmental management and design

W2G - Water Quality Monitoring Program
2134-1110

Illustration 2.2

2.2 Groundwater Monitoring

There are 28 groundwater bores for groundwater level monitoring but only 13 of the bores have also been selected for groundwater quality monitoring. Refer to discussion further below for reasoning of bore selection for groundwater quality.

Details of access to the monitoring bores are outlined in **Appendix C** of this WQMP.

The selection of monitoring areas for groundwater levels was based on: the EIS Groundwater Working Paper (RMS, Aurecon, SKM, 2012d); refinements by Arup Parsons Brinckerhoff Joint Venture and RCA Australia; and further assessments of groundwater dependant ecosystems (GDEs) (GeoLINK, 2013). Refer to **Appendix D** in regard to GDE details.

The 28 groundwater bores for groundwater level monitoring are listed in **Table 2.2** and shown in **Illustrations 2.3** to **2.4**. It is noted that boreholes GWB11, GWB26 and GWB27 are deliberately omitted from the list - these sites were initially intended to be monitored but were later omitted due to issues concerning access for GWB11, and due to the cut at sites GWB26 and GWB27 being assessed to be low risk (water table levels are below proposed cut depths).

Of the 28 bores being monitored for groundwater levels, 13 bores have also been selected for groundwater quality monitoring. The bores selected for groundwater quality monitoring are listed in **Table 2.2**. These 13 bores were generally selected based on having a high potential for groundwater impact (Type A cuts – refer to **Section 1.5.1.1**). GWB22 and GWB23 were also selected to provide a broader coverage of varying geology.

Table 2.2 List of Bores for Groundwater Level Monitoring

Highway Section of Woolgoolga to Ballina Upgrade	*Borehole Identifier*	*Chainage*	*General Location*	*Cut Type[1]*	*Monitoring for*	
					Level	*Quality*
Section 1 - Woolgoolga to Halfway Creek	GWB01	2500	Kangaroo Trail Road	A	Yes	Yes
	GWB02	2520			Yes	Yes
	GWB03	2600			Yes	-
	GWB04	5300	Post Office Lane	B	Yes	-
	GWB05	5320			Yes	-
	GWB06	7050	Small Cut CH6990-7100	B	Yes	-
	GWB07	7050			Yes	-
	GWB08	7750	Big Cut GWB08 adj BH69 GWB09 retrofitting BH74 GWB10 adj BH76 GWB12 adj BH78/P	A	Yes	Yes
	GWB09	7860			Yes	Yes
	GWB10 [3]	8040			Yes	-
	GWB12 [3]	8200		B	Yes	Yes
	GWB13	8780	Flinty Road	B	Yes	-
	GWB14	8800			Yes	-
	GWB15	9400	Range Road East	B	Yes	-
	GWB16	9820		n/a	Yes	Yes
	GWB17	9820		A	Yes	Yes

Highway Section of Woolgoolga to Ballina Upgrade	*Borehole Identifier*	*Chainage*	*General Location*	*Cut Type[1]*	*Monitoring for*	
					Level	*Quality*
	GWB18	11350	Falconers Lane	A	Yes	Yes
	GWB19	11400			Yes	Yes
	GWB20	12640	Ch12520 - Ch12800	B	Yes	-
	GWB21	12650			Yes	-
	GWB22	13500	Private Property	B	Yes	Yes
	GWB23	13540			Yes	Yes
Section 2 - Halfway Creek to Glenugie	GWB24	21600	Ch21400 - Ch22220	B	Yes	-
	GWB25 [3]	21660			Yes	-
	GWB28 [3]	26860	Glenugie State Forest	A	Yes	-
	GWB29	26880			Yes	-
	GWB30	27120		A	Yes	Yes
	GWB31	27130			Yes	Yes

Note: 1. Type A cuts had a groundwater penetration greater than 5m based on available data. Type B had a groundwater penetration less than 5m based on available data;
2. GW064710 is a pre-existing property groundwater bore located close to the proposed highway alignment which will be monitored to provide background data prior to construction.
3. It is noted that boreholes GWB11, GWB26 and GWB27 are deliberately omitted from the monitoring program due to issues concerning access for GWB11, and due to the cut at sites GWB26 and GWB27 being assessed to be low risk.

Information shown is for illustrative purposes only

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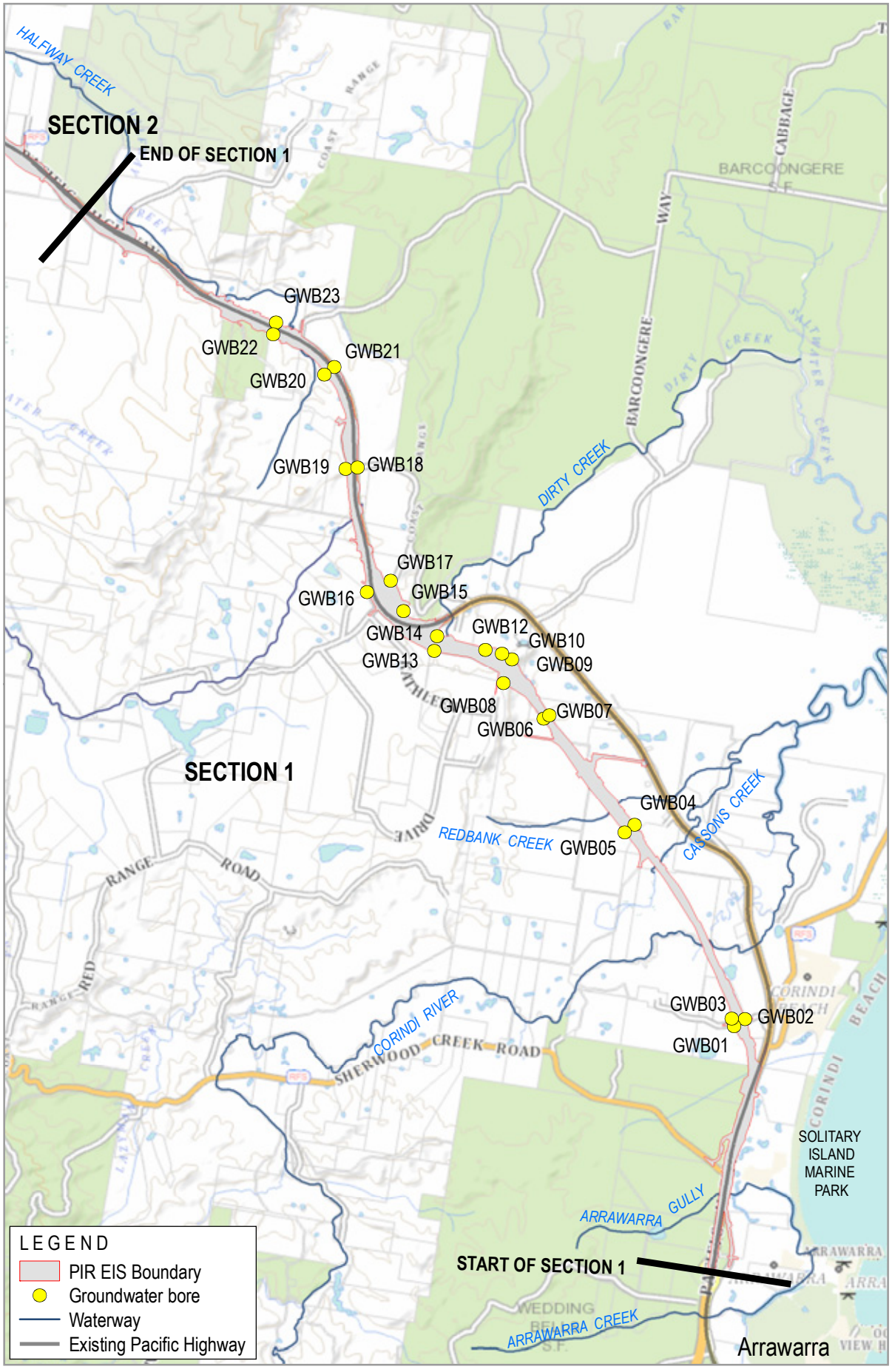
Source of base data: NSW Roads and Maritime Services and SIX Maps



0 1.4 km

North

Section 1 - Woolgoolga to Halfway Creek - Groundwater Bore Monitoring Sites

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W2G - Water Quality Monitoring Program
2134-1112

Illustration 2.3

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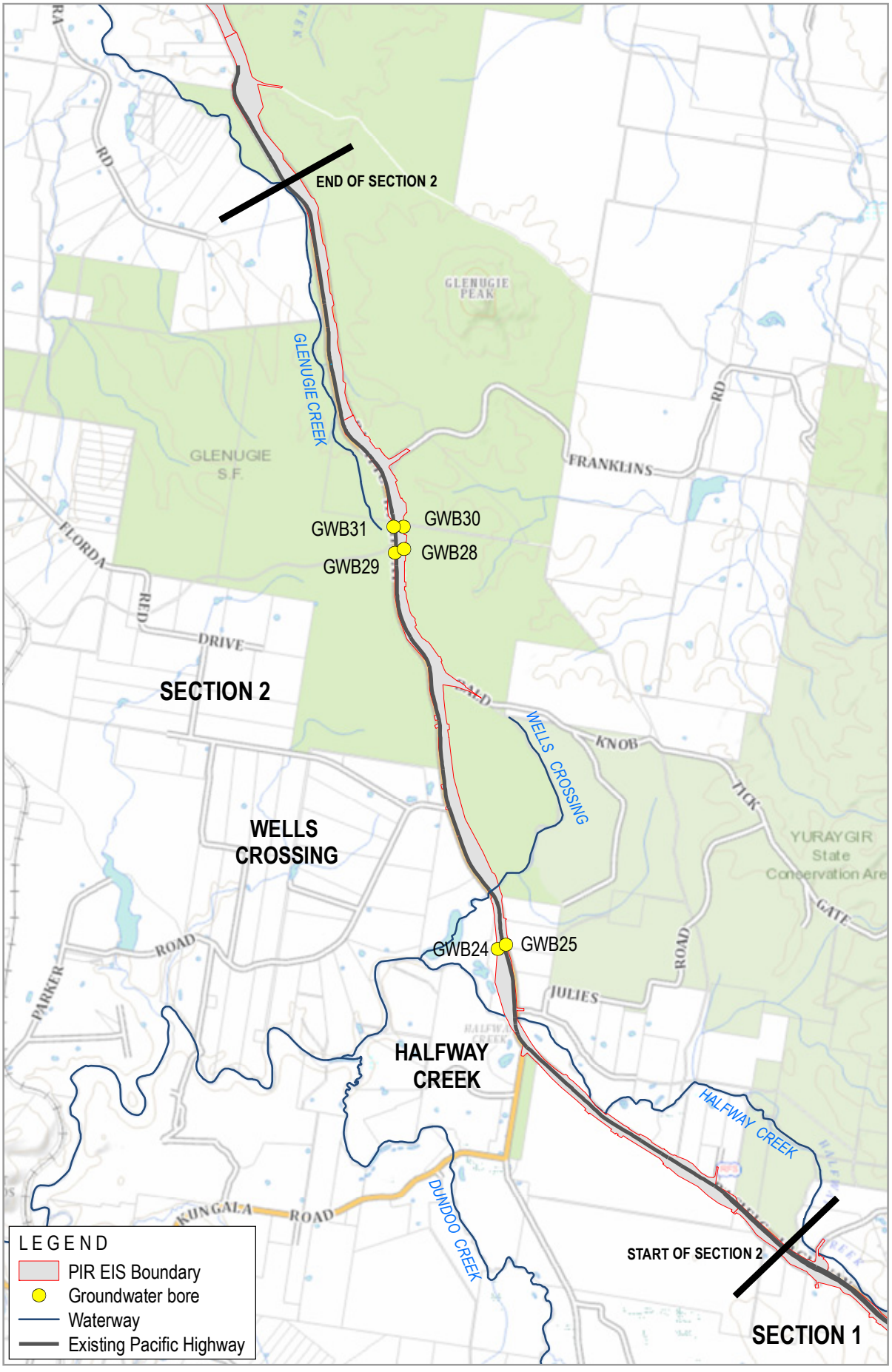


0 1.4 km

North

Section 2 - Halfway Creek to Glenugie - Groundwater Bore Monitoring Sites

GeoLINK environmental management and design

W2G - Water Quality Monitoring Program
2134-1113

Illustration 2.4

3

Summary of Pre-Construction Monitoring

This section of the report provides an overview of the surface water and groundwater monitoring data that has been collected and analysed during the twelve-month pre-construction monitoring phase. The twelve-month pre-construction monitoring phase was undertaken from May 2013 to April 2014.

3.1 Surface Water Monitoring

Table 3.1 summarises the pre-construction phase monitoring results with respect to visual observations and a general summary of the water quality sampling results for each monitoring site. A general summary of the overall results is provided further below.

Statistical values comprising median, minimum, maximum, standard deviation, and 80th percentile (P80) for each sampling site are contained in **Appendix A**. The statistics have been calculated for the total number of samples for each site, and separately for the dry event and wet event samples for each site. The data is also graphed and included in **Appendix A** (the horizontal axis of the graphs refers to the number of sampling events). Graphs have been produced for pH, temperature, electrical conductivity (EC), dissolved oxygen (DO), turbidity, total suspended solids (TSS), total oils and grease, total phosphorous, and total nitrogen. Graphs have not been produced for the speciated nutrients (phosphate, ammonia, nitrate, and nitrite), hydrocarbons, or heavy metals due to the majority of results registering below detection limits (or Limit of Reporting – LOR).

3.1.1 Overview of Surface Water Quality Data for the Pre-Construction Phase

The pre-construction water quality data shows natural variability. Factors such as rainfall intensity during a storm event and the number of dry days preceding a wet event, can affect the magnitude of results, however no discernible trend was exhibited in the results.

The data is considered suitable for use as a baseline data set for comparison with construction and operational phase data.

3.1.1.1 Physical properties

Temperature generally exhibited a gradual increase from approximately 15°C in winter up to 20-25°C in the summer months.

Salinity as measured by electrical conductivity (EC) levels shows variability within the typical ranges for fresh water creeks.

Turbidity and total suspended solids (TSS) data was generally lower for the dry weather events compared to the wet weather events as anticipated, however this was not necessarily the case for some water bodies such as Corindi River and Cassons Creek. There was generally a fair to poor correlation between turbidity and TSS.

3.1.1.2 Chemical properties

pH values were generally consistent for each water body. Median pH levels for all sampling events were generally in the range of 5.5 to 6.5.

The dissolved oxygen (DO) levels were generally higher for the wet weather events compared to the dry weather events. The results also exhibit generally lower DO levels in the summer months of the monitoring period.

3.1.1.3 Hydrocarbons

No oils or grease were observed during sampling at all sites. Laboratory analysis readings were generally below detection limits.

3.1.1.4 Nutrients

Phosphorus values were typically in the range of 0.02 to 0.04 mg/L. Total Nitrogen values were generally less than 1.0 mg/L.

3.1.1.5 Heavy metals

Heavy metals were generally below detection limits in all samples for all waterways.

Table 3.1 Summary of visual observations during sampling events

Site Identifier/ Waterway	***Summary of Visual Observations***	***Overview of Water Quality Sampling Results***
SW01 Arrawarra Gully Section 1 Ch.* 300	▪ No flow evident, light to dark brown water colour ▪ Width of approximately 4.5 m (varying between 7 m during high rainfall and 2 m at driest point of monitoring period) and average depth of approximately 40 cm at monitoring point ▪ Water surface consistently clear of dust, leaf litter etc., with water lilies present on water throughout monitoring period ▪ Reeds present on the creek bed and banks along with small and large paper barks/swamp mahogany.	▪ pH: 5.5 – 7.5 ▪ Temp: 15 - 25°C ▪ EC: 0.2-0.3mS/cm in dry; 0.15-0.4 in wet ▪ DO: 1 – 10mg/L ▪ NTU: 0 – 30 with some outliers ▪ TSS: 0 – 20 with some outliers ▪ O&G: < 3.0mg/L ▪ TP: 0.02 – 0.04mg/L ▪ TN: 0.6 – 0.9mg/L
SW02 Corindi River Section 1 Ch. 3600	▪ Very low flow, light to dark brown water colour ▪ Consistent river width of approximately 10 m, and average depth of approximately 50 cm at monitoring point ▪ Water surface consistently clear of dust, leaf litter, water vegetation etc. ▪ Heavily vegetated river banks with evidence of access by cattle. No correlation was observed between TSS readings and cattle accessing the site.	▪ pH: 6 – 7.2 ▪ Temp: 14 - 25°C ▪ EC: 0.13 - 2.3mS/cm ▪ DO: 2 – 10.5mg/L ▪ NTU: 1 – 9 with some outliers ▪ TSS: 0 – 6 with some outliers ▪ O&G: < 3.0mg/L ▪ TP: 0.02 – 0.04mg/L with some outliers ▪ TN: 0.08 – 0.27mg/L with some outliers
SW03 Blackadder Gully Section 1 Ch. 3800	▪ No flow evident, light brown water colour ▪ Width of approximately 2.5 m and depth of less than 30 cm when water was present ▪ Grassed banks with some reeds, evidence of access by cattle. No correlation was observed between TSS readings and cattle accessing the site. ▪ Gully was dry for six sampling events of the twelve month monitoring period.	▪ pH: 6.48 – 6.54 ▪ Temp: 15 - 25°C ▪ EC: <0.15mS/cm ▪ DO: 5.8 - 10mg/L ▪ NTU: <55 with some outliers ▪ TSS: 5 – 38mg/L with some outliers ▪ O&G: < 1.0mg/L with some outliers ▪ TP: 0.05 – 0.09mg/L with some outliers ▪ TN: 0.02 – 1.5mg/L with some outliers

Site Identifier/ Waterway	*Summary of Visual Observations*	*Overview of Water Quality Sampling Results*
SW04 Cassons Creek Section 1 Ch. 4750	▪ No flow evident, light to dark brown water colour ▪ Average width of approximately 1.5 m and depth of approximately 30 cm at monitoring site ▪ Surface water occasionally had a light film on the surface and a small amount of leaf litter ▪ Creek was dry for five sampling events of the twelve month monitoring period.	▪ pH: 5.5 – 6.9 ▪ Temp: 12 - 24°C ▪ EC: 0.22 – 0.35mS/cm ▪ DO: 1 - 5mg/L ▪ NTU: 2 – 20 with some outliers ▪ TSS: 0.5 – 15mg/L with some outliers ▪ O&G: < 2.5mg/L with some outliers ▪ TP: 0.02 – 0.05mg/L with some outliers ▪ TN: 0.5 – 0.8mg/L with some outliers
SW05 Redbank Creek Section 1 Ch. 5650	▪ No flow evident, light to dark brown water colour ▪ Width of approximately 0.8 m and depth of less than 30 cm ▪ Water surface clear of dust, large amounts of vegetation debris (twigs, small branches and leaf litter) on river banks with some reeds ▪ Creek was dry for two sampling events of the twelve month monitoring period.	▪ pH: 5.5 – 6.9 ▪ Temp: 14 - 24°C ▪ EC: <0.28mS/cm ▪ DO: 2 – 9.5mg/L ▪ NTU: 1 – 48 with some outliers for dry weather and 24 – 170 for wet weather ▪ TSS: 0 – 55mg/L with some outliers ▪ O&G: 1mg/L with some outliers ▪ TP: 0.01 – 0.04mg/L with some outliers ▪ TN: 0.2 – 1.4mg/L
SW06 Dirty Creek Section 1 Ch. 8500	▪ Creek was dry for all but one sampling event (wet weather event in June 2013) of the twelve month monitoring period ▪ Creek bed is heavily vegetated with grass, bushes, vines and small to large trees.	The following are the results from the only sampling event: ▪ pH: 5.5 ▪ Temp: 16.8°C ▪ EC: 0.23mS/cm ▪ DO: 5.7mg/L ▪ NTU: 11.0 ▪ TSS: 4.0mg/L ▪ O&G: 1.0mg/L ▪ TP: 0.010mg/L ▪ TN: 0.19mg/L
SW07 Dundoo Creek Section 1 Ch. 10700	▪ Creek was dry for all but one sampling event (wet weather event in June 2013) of the twelve month monitoring period ▪ The creek bed is heavily vegetated with grass and large trees.	▪ The following are the results from the only sampling event: ▪ pH: 6.3 ▪ Temp: 17.1°C ▪ EC: 0.24mS/cm ▪ DO: 5.0mg/L ▪ NTU: 45.9 ▪ TSS: 19.0mg/L ▪ O&G: 1.0mg/L ▪ TP: 0.040mg/L ▪ TN: 0.44mg/L with some outliers

Site Identifier/ Waterway	*Summary of Visual Observations*	*Overview of Water Quality Sampling Results*
SW08 Boneys Creek Section 1 Ch. 13350	▪ No flow evident, light to dark brown water colour ▪ Width of approximately 3.5 m and depth at monitoring site of approximately 50 cm on average ▪ Water surface was prone to occasional leaf litter and a light film of dust ▪ Lomandra present on the banks of the creek.	▪ pH: 6.3 – 6.9 ▪ Temp: 12 - 23°C ▪ EC: 0.23 – 0.45mS/cm ▪ DO: 3.2 – 5.9mg/L ▪ NTU: 0 – 45mg/L for dry weather and 10 – 155mg/L for wet weather ▪ TSS: 0 – 30mg/L for dry weather and 9 – 84mg/L for wet weather ▪ O&G: <2.5mg/L with some outliers ▪ TP: 0.01 – 0.04mg/L ▪ TN: 0.13 – 0.43mg/L
SW09 Halfway Creek Section 2 Ch. 20700	▪ No flow evident, light to dark brown water colour ▪ Width of approximately 2.5 m and depth of approximately 40 cm at monitoring site ▪ Water surface occasionally had a light film of dust and/or leaf litter ▪ Southern creek bank was sandy at the monitoring site, with significant erosion present on both the southern and northern banks of the creek.	▪ pH: 6 – 6.9 ▪ Temp: 11 - 21°C ▪ EC: 0.13 – 0.3mS/cm ▪ DO: 0.5 – 11mg/L ▪ NTU: 4 – 11mg/L for dry weather and 25 – 38mg/L for wet weather ▪ TSS: 0 – 10.5mg/L for dry weather and 11 – 21mg/L for wet weather ▪ O&G: 1mg/L with some outliers ▪ TP: 0.01 – 0.04mg/L for dry weather and 0.02 – 0.04mg/L for wet weather ▪ TN: 0.1 – 0.7mg/L
SW10 Wells Crossing Section 2 Ch. 22400	▪ No flow evident, often relatively clear water colour varying to dark brown ▪ Average width of approximately 5 m (varying between 12 m during high rainfall events, and 2 m during the driest months of the monitoring period) ▪ Stream bed and banks are dominated by reeds and riparian vegetation ▪ Water surface generally free of dust and leaf litter despite over hanging vegetation and the nearby road.	▪ pH: 4.52 – 6.1 ▪ Temp: 13 – 25.4°C ▪ EC: 0.1 – 0.4mS/cm ▪ DO: 1.8 – 6mg/L with some outliers ▪ NTU: 1 – 10mg/L with some outliers for dry weather and 5 – 25mg/L with some outliners for wet weather ▪ TSS: 0 – 20mg/L with some outliers ▪ O&G: 1 – 3.1mg/L with some outliers ▪ TP: 0.02 – 0.06 with some outliers ▪ TN: 0.3 – 0.8mg/L with some outliers
SW11 Glenugie Creek Section 2 Ch. 29300	▪ No flow evident, light to dark brown water colour ▪ Width of approximately 2 m with water in the stream “pooling” in several locations (including the monitoring site) ▪ Water surface occasionally covered in a light film and some leaf litter ▪ Heavily vegetated stream banks comprising riparian vegetation.	▪ pH: 6.5 – 7.4 ▪ Temp: 13 – 23.5°C ▪ EC: 0.25 – 0.5mS/cm for dry weather and 0.15 – 0.2mS/cm for wet weather ▪ DO: 1 – 2.8mg/L with some outliers ▪ NTU: 0 – 100mg/L with some outliers ▪ TSS: 0 – 38mg/L with some outliers ▪ O&G: 1 – 2mg/L with some outliers ▪ TP: 0.02 – 0.03 with some outliers ▪ TN: 0.2 – 0.3mg/L with some outliers

Note: * Ch. = Highway Chainage

3.2 Groundwater Monitoring

3.2.1 Overview of Groundwater Systems

The landform of the W2G project is generally elevated, with the exception being the southern portion of Section 1 which comprises lowland coastal plains of elevation 2 – 15 metres. The northern portion of Section 1 is characterised by foot slopes, low hills, undulating rises and summit surfaces of the Coast Range. Section 2 generally comprises rolling low hills and undulating terrain between the Halfway Creek and Glenugie localities (RMS, Aurecon, SKM, 2012d:28).

3.2.1.1 Section 1 – Woolgoolga to Halfway Creek

There is a general lack of groundwater information in this section, although water tables are naturally shallow from approximately Chainage 4000 through to 7000, and are deeper in the higher country. There is locally high potential impact related to cut locations at Chainage 2500 and 7900 which will intersect water tables (RMS, Aurecon, SKM, 2012d:89). The cuts at Chainage 9800 (Range Road East interchange) and Chainage 26800 (Franklins Road) are also considered high potential impact cuts (Arup Parsons Brinckerhoff Joint Venture, 2012).

As the project progresses over the Coast Range and back into an undulating landscape, groundwater flow is to the west and lower rainfall results in decreasing recharge rates compared to rates east of the range. Consequently, water tables are generally low and groundwater constitutes a low potential constraint to construction and construction constitutes a low potential impact to groundwater supplies (RMS, Aurecon, SKM, 2012d:89).

There are generally few known occurrences of Acid Sulfate Soils (ASS) throughout the project area, although some areas of low and high probability of ASS occurrence have been mapped for the lowland coastal plains in the southern portion of the route near the Arrawarra and Corindi Beach localities.

Groundwater dependent ecosystems (GDEs) corresponding to areas of endangered ecological community (EEC) vegetation are primarily concentrated in the lowest elevation areas in the southern portion of Section 1 between chainages 0 and 6000. A rainforest EEC (Lowland Rainforest) GDE is located at Dirty Creek near chainage 9000. Refer to **Appendix D** in regard to GDE details and mapping.

Ten 'Type A' cuts were initially identified in the EIS within Section 1 where water table penetration is anticipated to occur and monitoring is recommended (RMS, Aurecon, SKM, 2012d:90). 'Type A' cuts are defined as cuts that have the potential to reduce groundwater to local creeks, streams, springs and local water resource in the vicinity of the cut (within approximately 100 metres of the cutting) or are likely to impact watercourse related GDEs present in the vicinity of cut. Further refined assessment of the cuttings by Arup Parsons Brinckerhoff Joint Venture (2012) and RCA Australia resulted in selection of 14 cuts (6 Type A and 8 Type B -refer to **Table 2.2**) for pre-construction monitoring within Section 1.

3.2.1.2 Section 2 – Halfway Creek to Glenugie

Groundwater levels appear to be deep throughout Section 2, except where local recharge via creeks causes elevated levels. These are generally observed where the project crosses Halfway Creek. Groundwater levels are generally within five metres of the land surface in the southern part, becoming deeper to the north as the elevation rises. There is low potential for construction impacts to groundwater associated with shallow water tables in the southern portion, reducing to minimal potential impact as the topography rises above 50 m AHD. It is unlikely that groundwater would have an impact on operation (RMS, Aurecon, SKM, 2012d:91).

Two 'Type A' cuts and one 'Type B' cut are located within Section 2 - refer to **Table 2.2**. Refer to discussion above regarding 'Type A' and 'Type B' cuts.

GDEs that correspond with areas mapped as Key Habitat are located in parts of Section 2 between chainages 16000 and 22500, with one area near chainage 16000 also being EEC (refer to details in **Appendix D**).

3.2.2 Groundwater Quality Data for the Pre-Construction Phase

Groundwater quality sampling for the pre-construction phase was obtained from the three rounds of sampling undertaken in November 2013, February 2014 and April 2014. A general summary of the overall results for the pre-construction groundwater quality sampling is provided below. Statistical values comprising median, standard deviation, and 80th percentile (P80) for each sampling site are contained in **Appendix B**.

Results are not available for some of the sampling events at the following bores due to insufficient water in the bores:

- GWB12 had insufficient water volume/yield on the first two sampling rounds (November 2013 and February 2014) and only enough water available to perform a partial analysis of parameters on the third sampling round (April 2014).
- GWB18 had insufficient water volume/yield on the first sampling round (November 2013).
- GWB19 had insufficient water volume/yield for all three sampling rounds.
- GWB30 had a low yield throughout the duration of the monitoring period. Insufficient water was available to perform a full analysis of all parameters in the last two sampling rounds (February 2014 and April 2014).
- GWB31 had a low yield throughout the duration of the monitoring period. Insufficient water was available to perform analysis on the first two sampling rounds (November 2013 and February 2014) and only enough water available to perform a partial analysis of parameters on the third sampling round (April 2014).

The data is considered suitable for use as a baseline data set for comparison with construction and post-construction data.

3.2.2.1 Physical properties

Temperature generally exhibited greater variations in the shallower bores ranging from approximately 21-28°C. Temperatures were generally more consistent in the deeper bores with values in the range of 23-26°C.

Salinity as measured by electrical conductivity (EC) levels shows variability between the bores. GWB1 and GWB2 have moderately saline values in the range of 7 – 10 mS/cm. Other bores were generally only slightly saline with values in the range of 0.5 to 2 mS/cm with some values reaching 3.5 mS/cm. Total dissolved solids followed a similar trench to EC, with consistently higher values in GWB1 and GWB2 compared to the other bores.

Turbidity values were varied with some bores recording relatively high values between 100 and 500 NTU.

3.2.2.2 Chemical properties

pH values were generally consistent for each bore. Median pH levels for all sampling events were generally in the range of 5.0 to 7.0.

Dissolved oxygen values were consistently in the range of 1 – 3mg/L.

3.2.2.3 Hydrocarbons

All samples analysed for BTEX were below detection limits. Where sample concentrations were below detection limits, a concentration value of half the detection limit was recorded and used in the calculations and summary tables.

Total recoverable hydrocarbons (TRH's) were below detection limits for: GWB1, GWB12, GWB16, GWB17, GWB18, GWB22 and GWB31. Values at the other bores fluctuated from readings below detection limits to values up to 5,000µg/L – predominantly for the C10-C16 fraction and C10-C14 fraction (within the extractable petroleum hydrocarbons range – also known as the diesel range organics).

3.2.2.4 Nutrients

Phosphorus values were typically in the range 0.01 to 0.13 mg/L. The maximum reading was 0.22 mg/L. Nitrogen values were typically in the range 0.1 to 1.0 mg/L. The maximum reading was 5.6 mg/L.

3.2.2.5 Heavy metals

Cadmium was below detection limits in all samples. Other metals values were below trigger levels for groundwater investigations.

3.2.2.6 Major cations and anions

Cation and anion values were generally relatively low and below trigger levels for groundwater investigations with the exception of chloride which varied from approximately 100 to 3,000 mg/L. The higher chloride readings were generally recorded in GWB1 and GWB2.

3.2.3 Groundwater Level Pre-Construction Monitoring

The groundwater level data has been graphed and presented on the following pages for each cluster of bores at the nominated cutting sites. A summary of the observed data is also provided on each of the following pages.

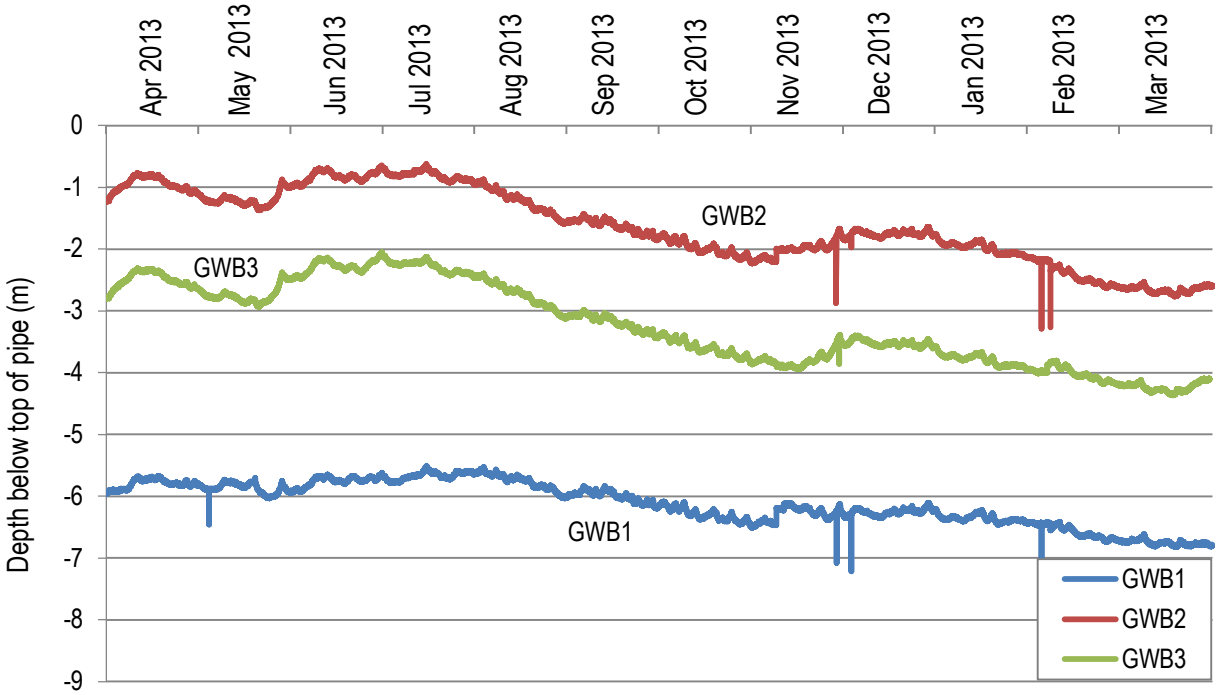
The x-axis on the graphs denotes time over the twelve month monitoring period. The y-axis denotes the depth to groundwater level below the top of the pipe at each bore.

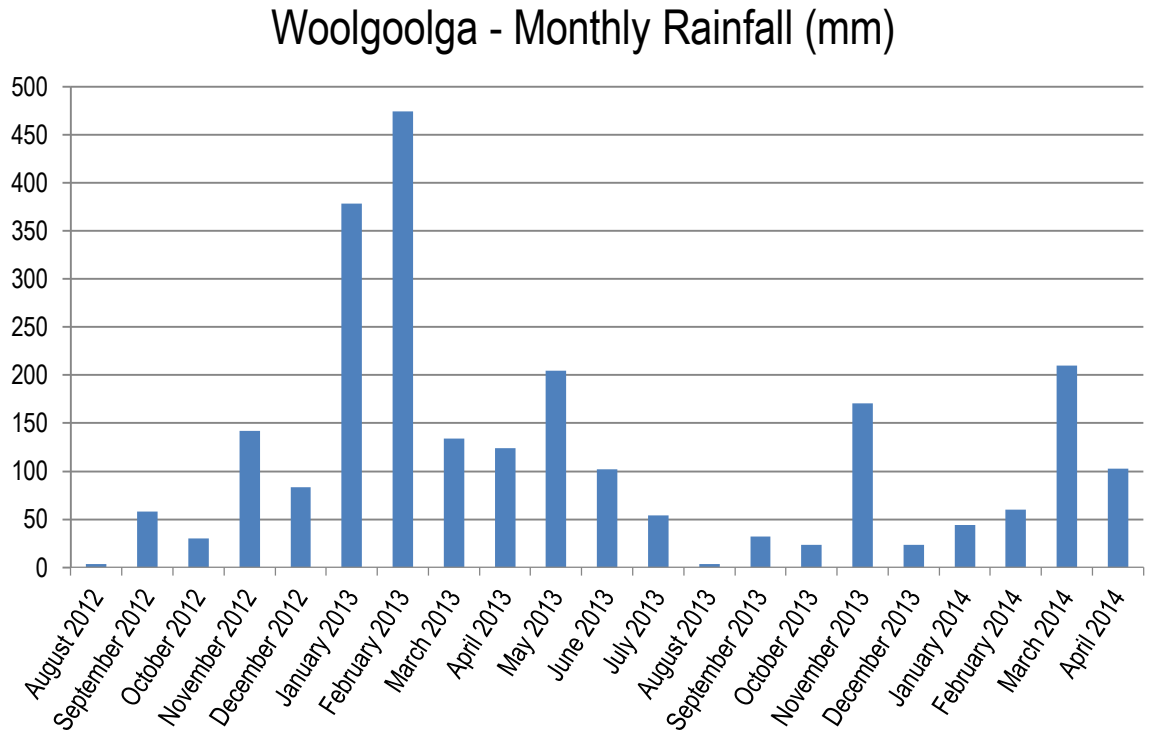
A chart of monthly rainfall is shown on each of the following pages for comparison with the groundwater levels. Monthly rainfall for Woolgoolga weather station has been used for comparison with the groundwater bores south of Dirty Creek Range (GWB1 – GWB17). Monthly rainfall for Grafton Airport weather station has been used for comparison with the groundwater bores north of Dirty Creek Range (GWB18 – GWB31). It is noted that the graphed rainfall records extend back to August 2012, approximately eight months prior to the commencement of the groundwater monitoring. The reason for showing these earlier rainfall records is to show the relatively high rainfall records experienced from Dec 2012 to April 2013 which account for the relatively high groundwater levels in some of the bores at the commencement of the monitoring and the subsequent fall in groundwater levels as a result of the following dry period.

3.2.4 GWB1, GWB2, GWB3 - Kangaroo Trail Road – Ch 2500 - 2600

Consistent groundwater level fluctuations are exhibited between the three bores. There is a general fall in groundwater levels from the commencement of the monitoring with a slight rise in November/December 2013 in response to high rainfall in November 2013.

Figure 3.1 Groundwater levels – GWB1, GWB2, GWB3 - Kangaroo Trail Road – Ch 2500 - 2600

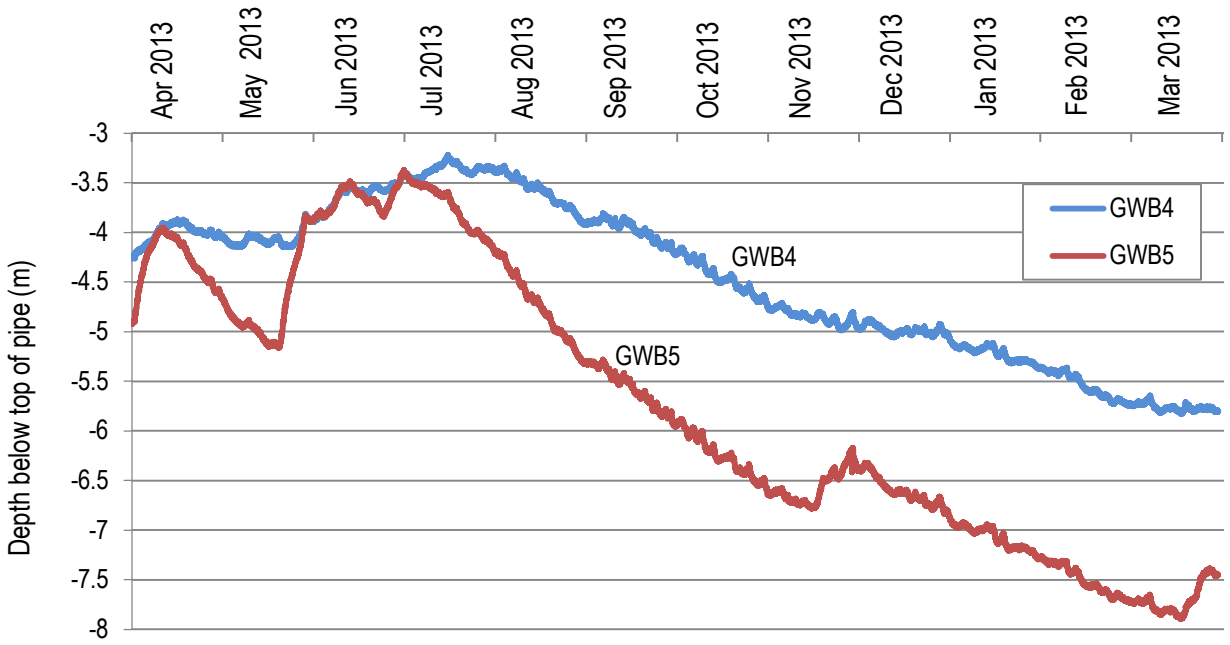


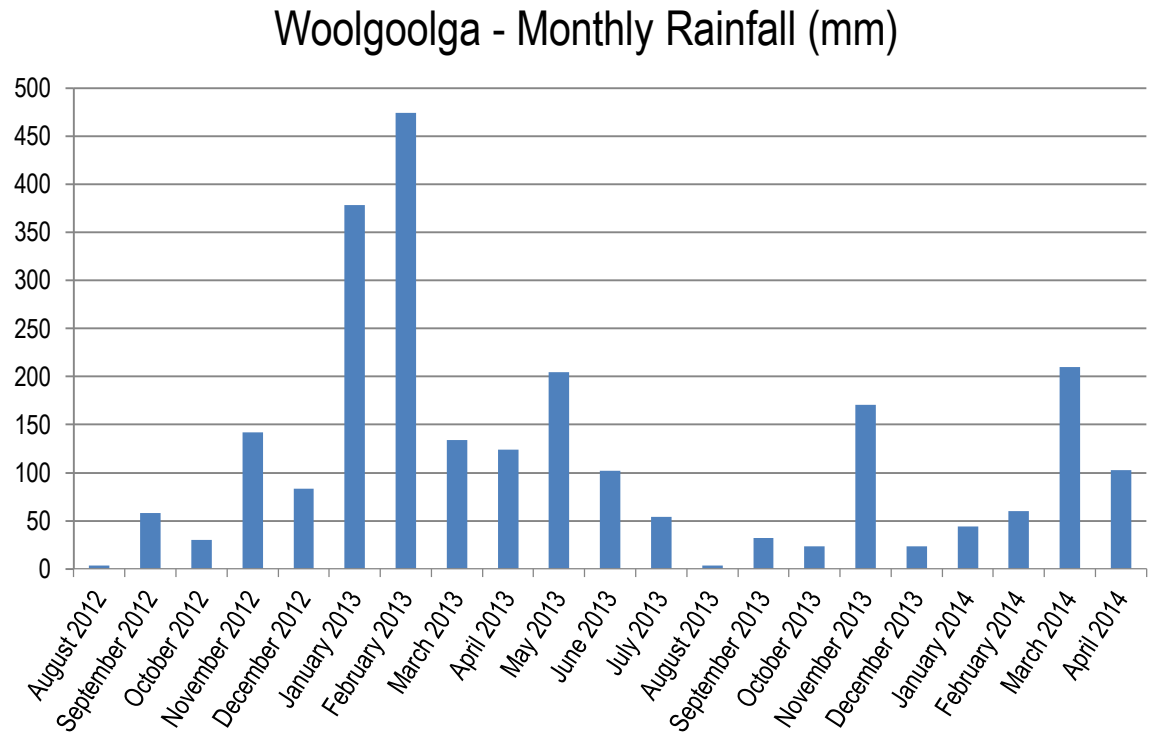


3.2.5 GWB4 and GWB5 - Post Office Lane – Ch 5300

Similar groundwater level patterns are exhibited between the two bores. There is a consistent fall in groundwater levels from July 2013 with only a small rise exhibited in GWB5 in response to high rainfall in November 2013.

Figure 3.2 Groundwater levels – GWB4 and GWB5 - Post Office Lane – Ch 5300

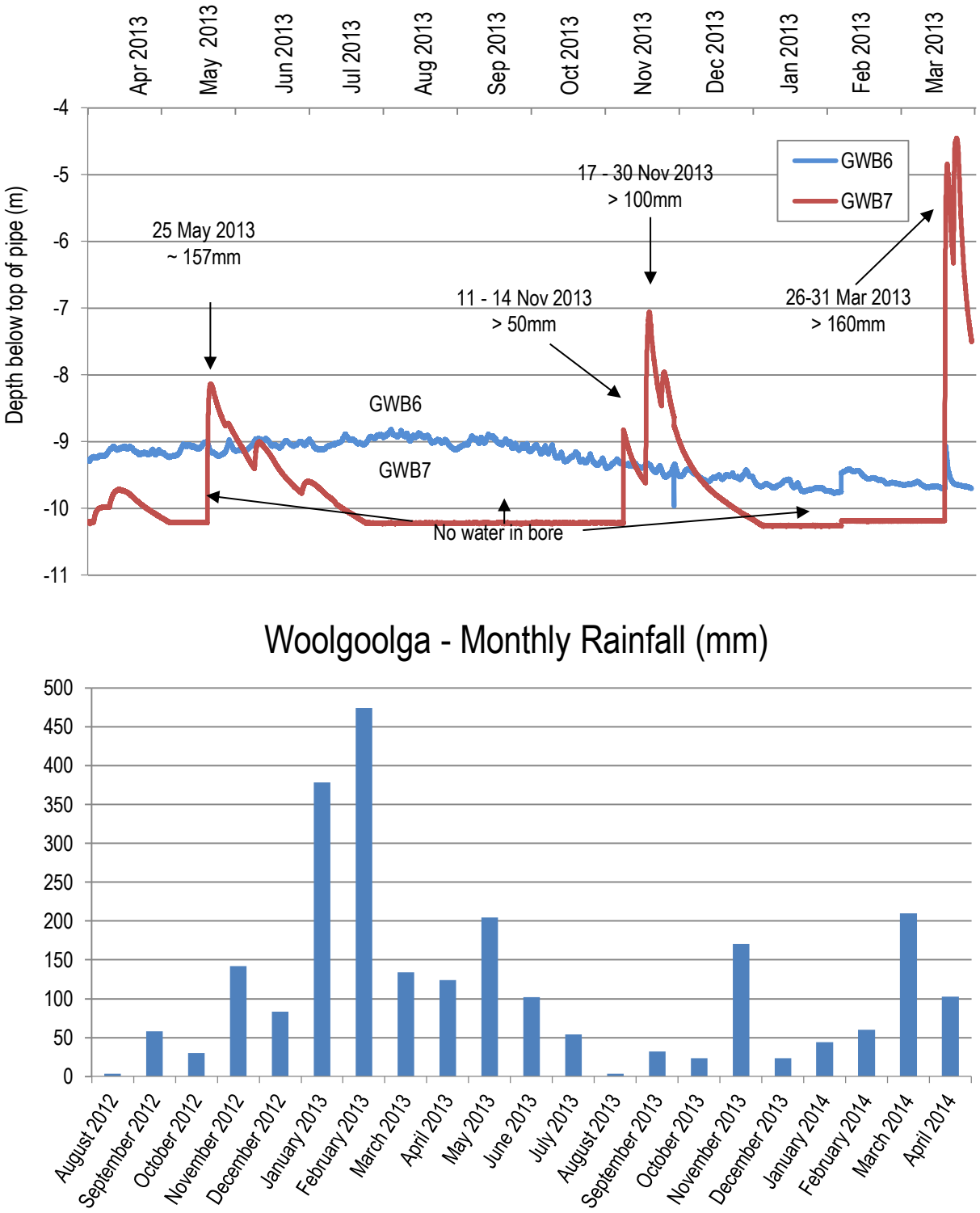




3.2.6 GWB6 and GWB7 - Small Cut – Ch 7050

GWB6 exhibits only minor variations with a small but consistent fall in groundwater levels from August 2013. GWB7 was dry for a significant period of the monitoring and exhibited rapid increases in groundwater level in response to large rainfall events (> 50 mm).

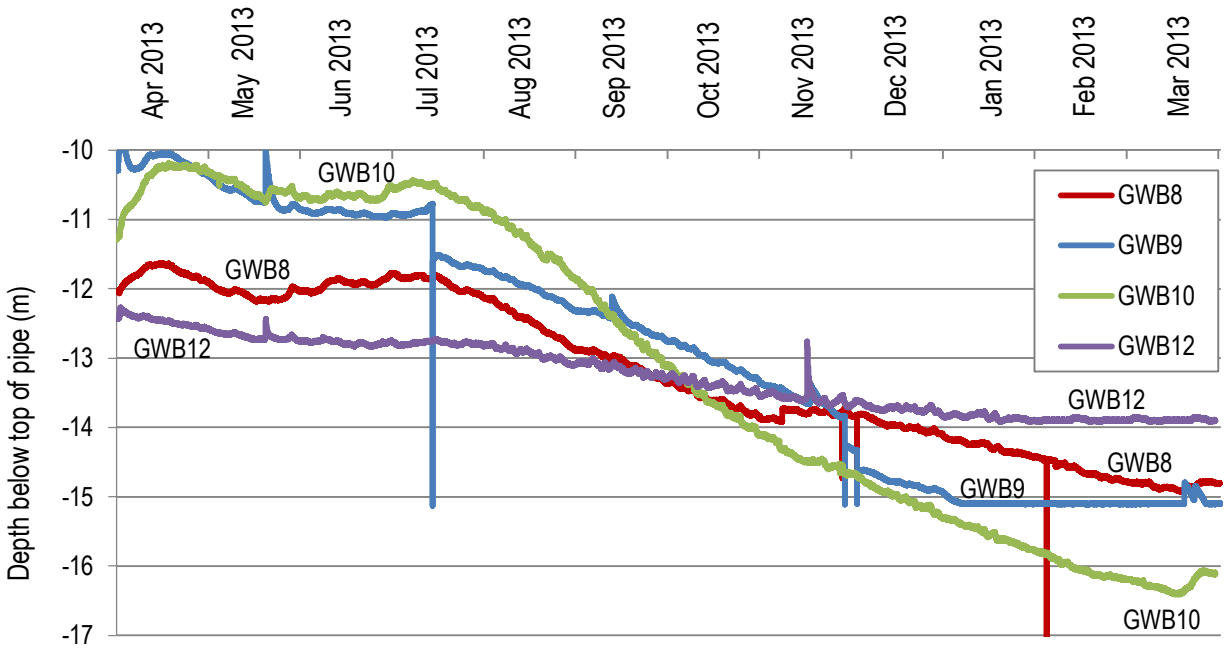
Figure 3.3 Groundwater levels – GWB6 and GWB7 - Small Cut – Ch 7050

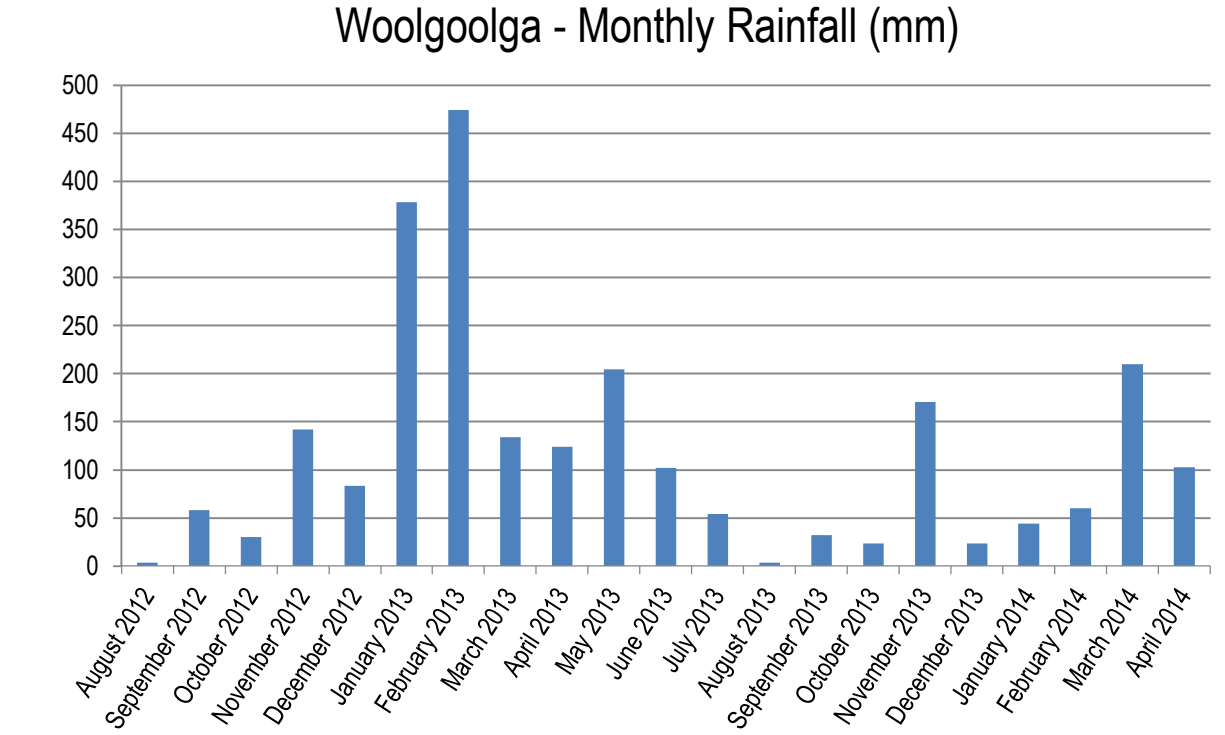


3.2.7 GWB8, GWB9, GWB10 and GWB12 - Big Cut - Ch 7700 - 8200

Similar groundwater level patterns are exhibited between the four bores. There is a general fall in groundwater levels from July 2013. GWB10 exhibits the greatest fluctuations in levels and GWB12 the least. GWB9 appears to reach a 'base level' of 15.1 metres below top of pipe in December2012/January 2013. It is noted that the depth of the bore at GWB9 is approximately 20 metres. Similarly, GWB12 appears to reach a 'base level' of 13.9 metres below top of pipe in January 2013. The depth of the bore at GWB12 is approximately 15.4 metres.

Figure 3.4 Groundwater levels – GWB8, GWB9, GWB10 and GWB12 - Big Cut - Ch7700 - 8200

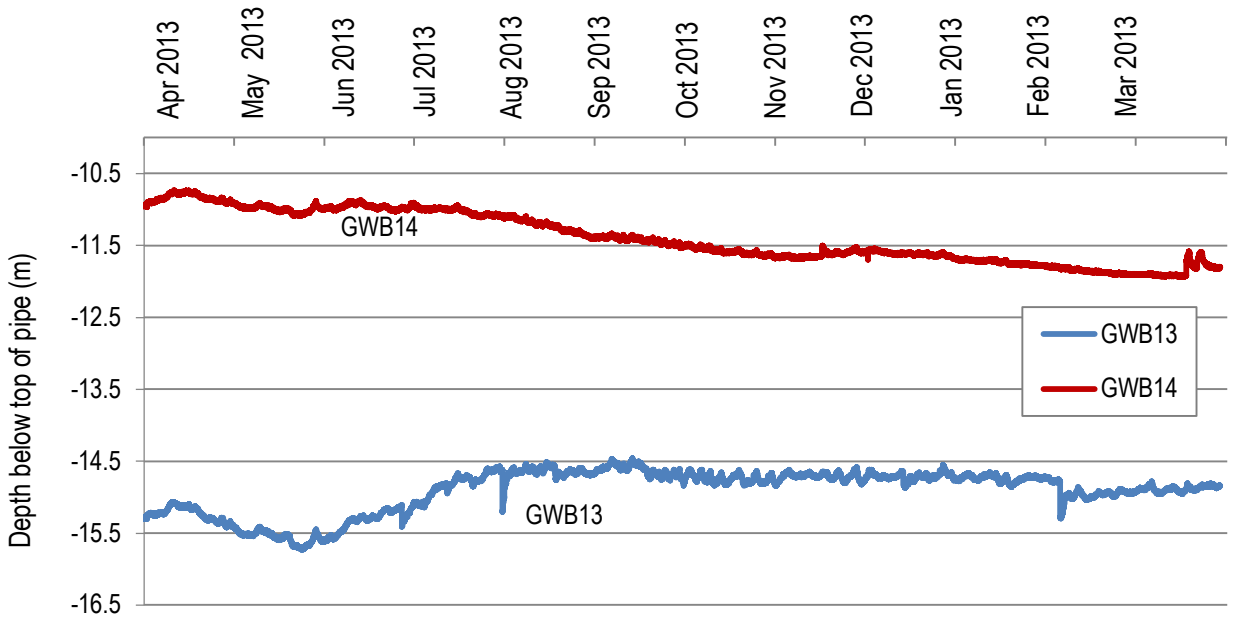


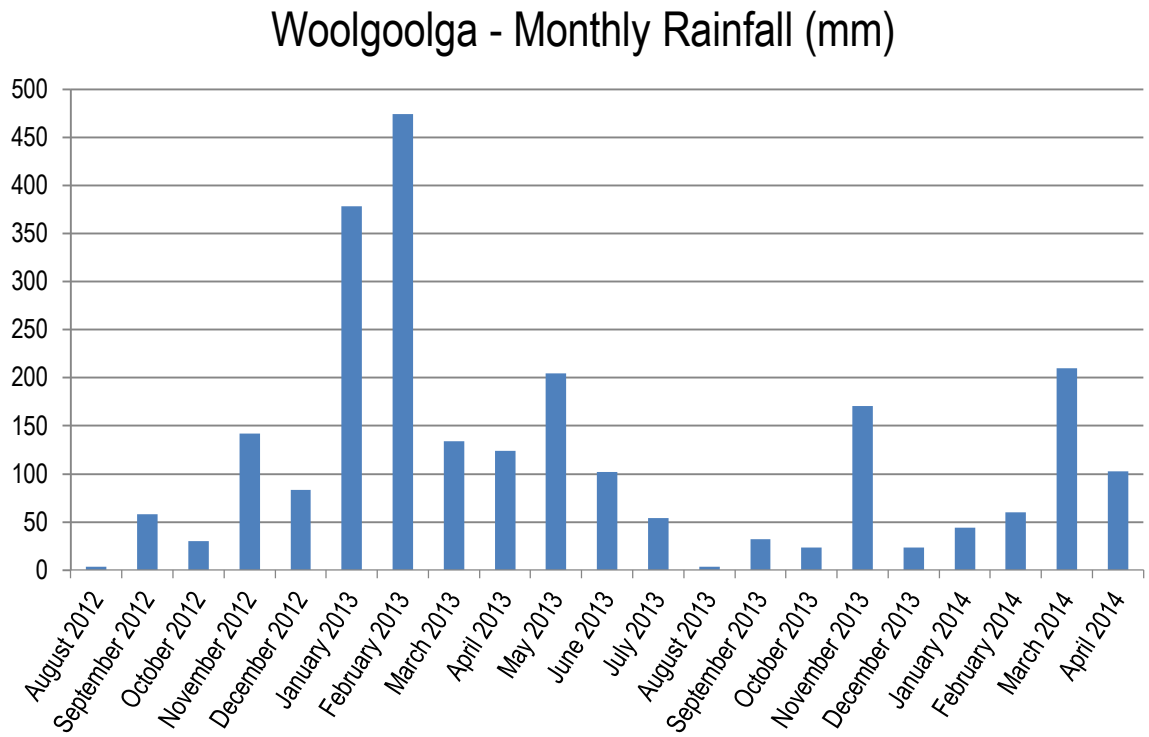


3.2.8 GWB13 and GWB14 - Flinty Road – Ch 8800

GWB13 does not exhibit any significant fall in groundwater level after August 2013 in contrast to most other bores. GWB14 exhibits a consistent fall in groundwater levels from July 2013 with a small rise in November 2013 in response to high rainfall.

Figure 3.5 Groundwater levels – GWB13 and GWB14 - Flinty Road – Ch 8800





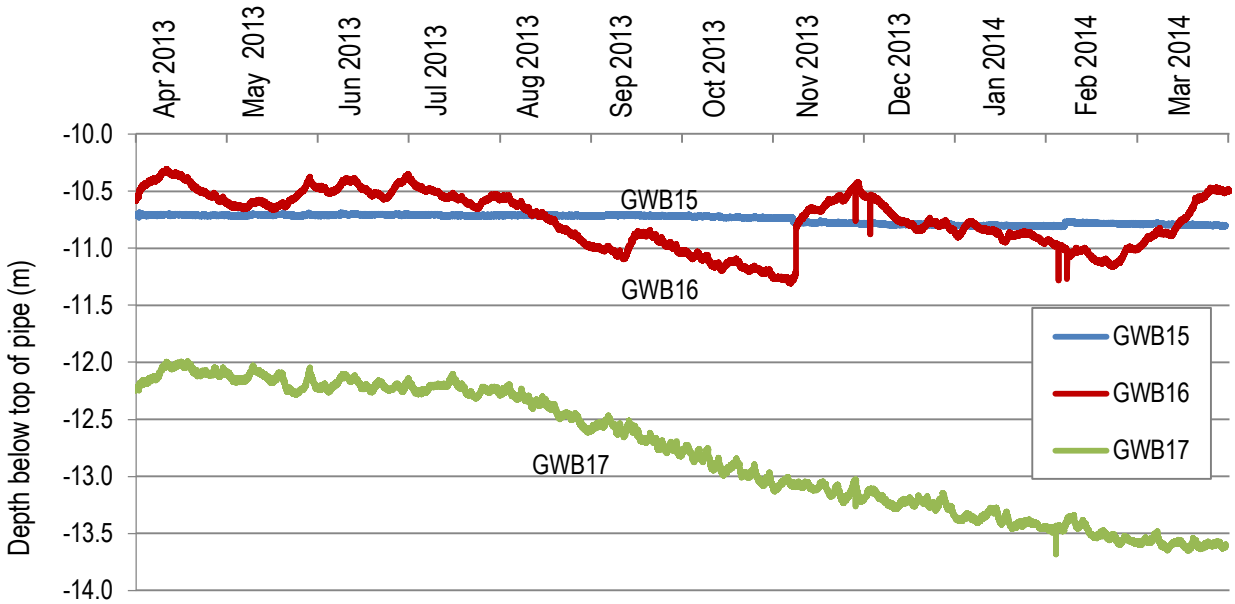
3.2.9 GWB15, GWB16 and GWB17 - Range Road East – Ch 9400 - 9800

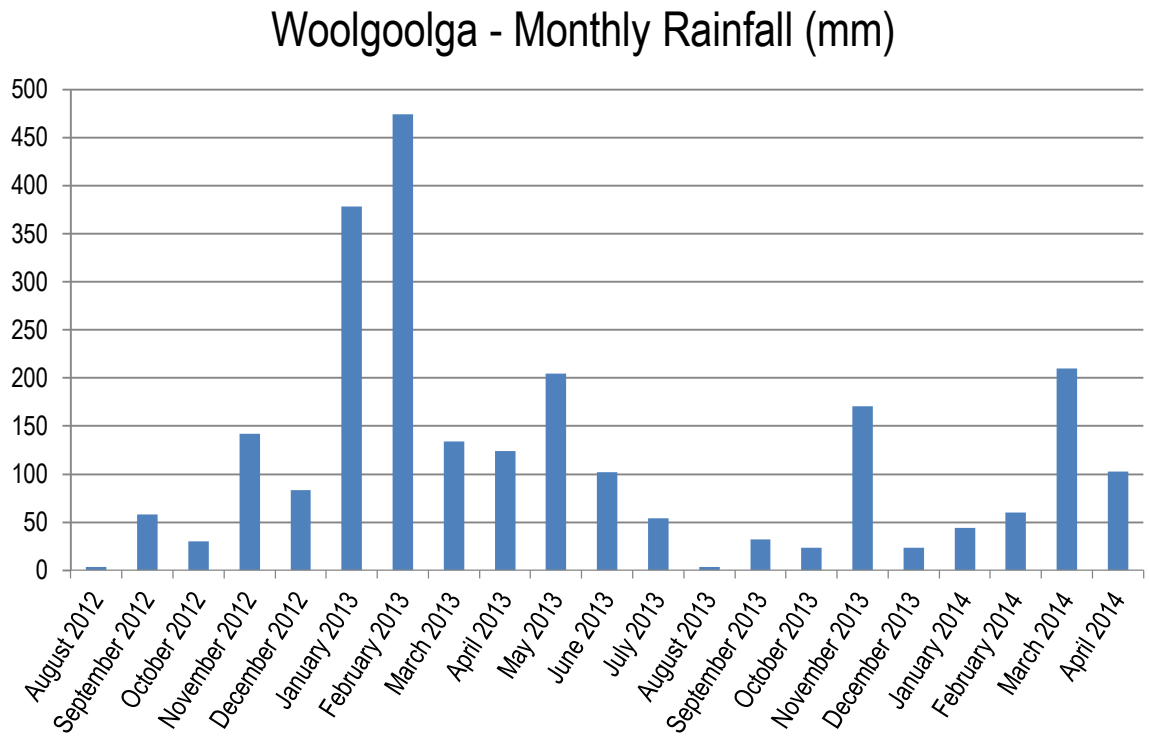
GWB15 exhibits very minor fluctuations with a slight fall from September 2013.

Groundwater levels in GWB16 appears to respond relatively rapidly to rainfall events, however the general rise in groundwater levels in February/March 2014 does not correlate with rainfall records (rainfall was relatively low until 26 March 2014).

GWB17 exhibits a general fall in groundwater levels from August 2013.

Figure 3.6 Groundwater levels – GWB15, GWB16 and GWB17 - Range Road East – Ch 9400 - 9800



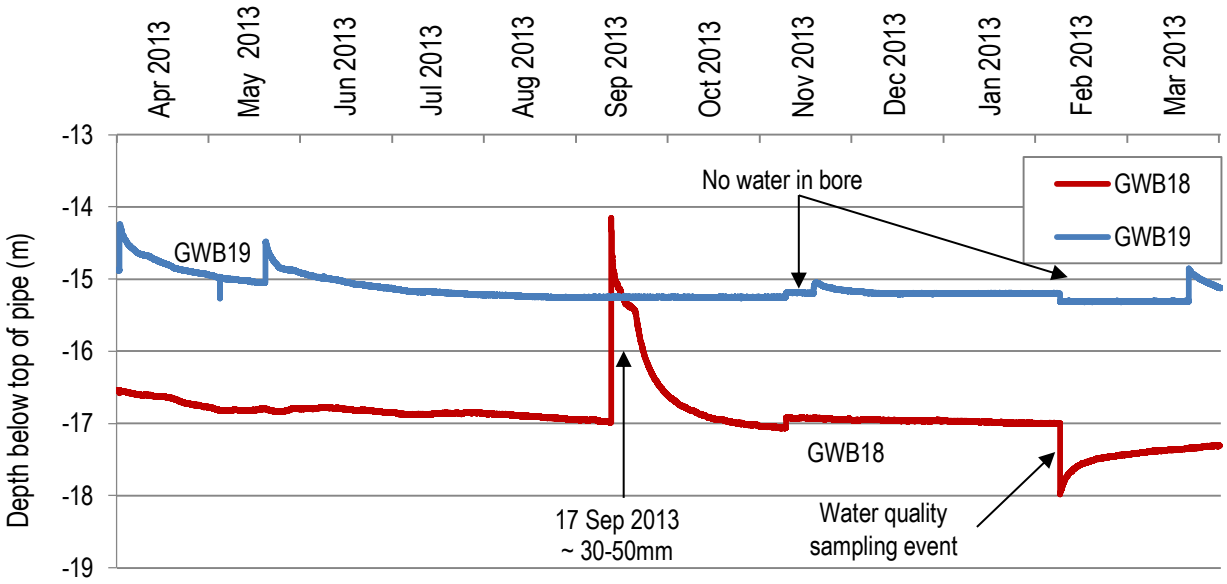


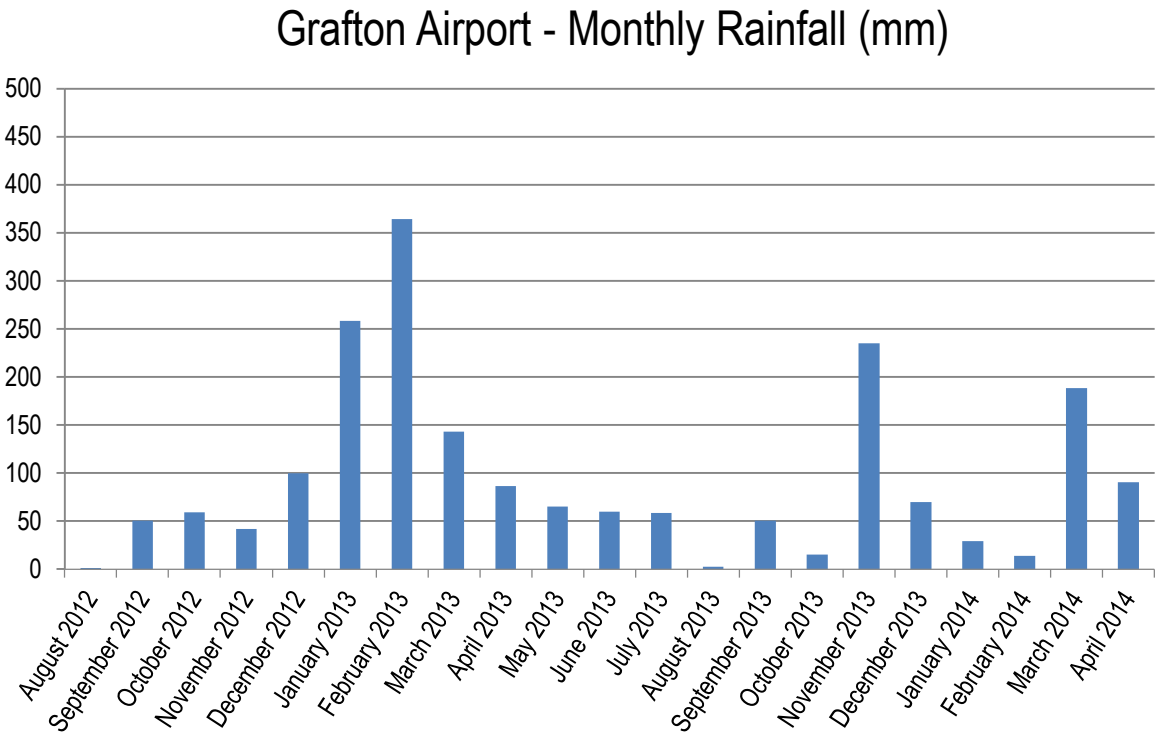
3.2.10 GWB18 and GWB19 - Falconers Lane - Ch 11350

GWB18 exhibits minor fluctuations with the exception of a large rise in groundwater level during the rainfall event on 17 September 2013. It is unknown why there are no other significant level rises in response to other large rainfall events. The water level drops in February 2014 in response to water extraction for water quality sampling. The water level recovery appears relatively slow following the sampling event.

GWB19 was dry for a significant period of the monitoring.

Figure 3.7 Groundwater levels – GWB18 and GWB19 - Falconers Lane - Ch 11350

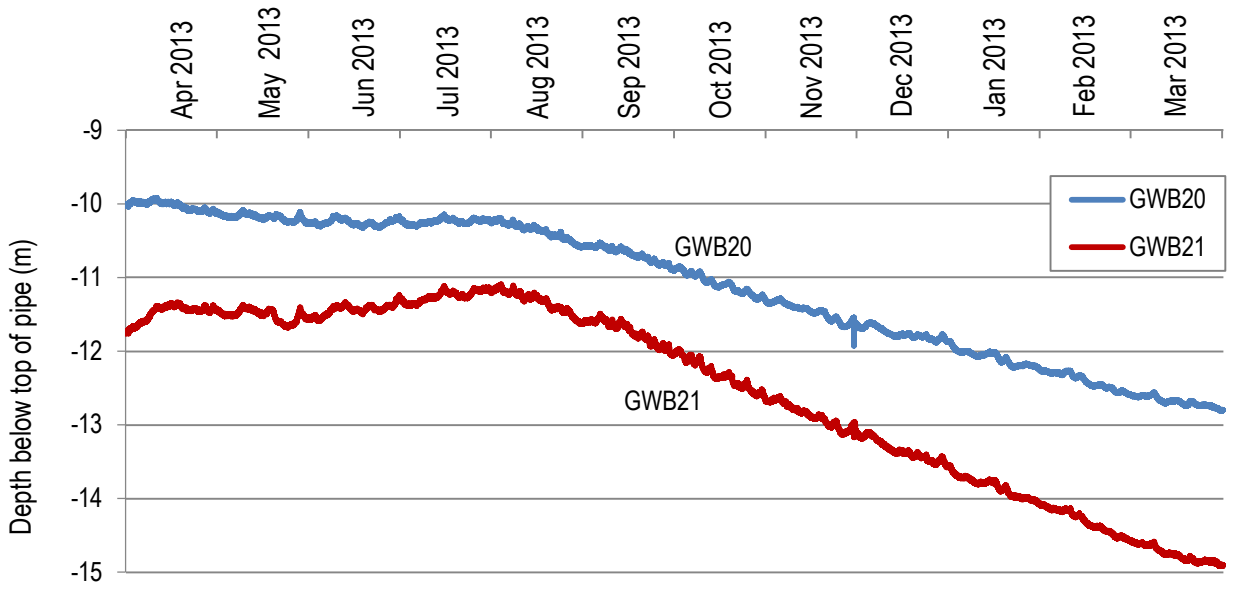


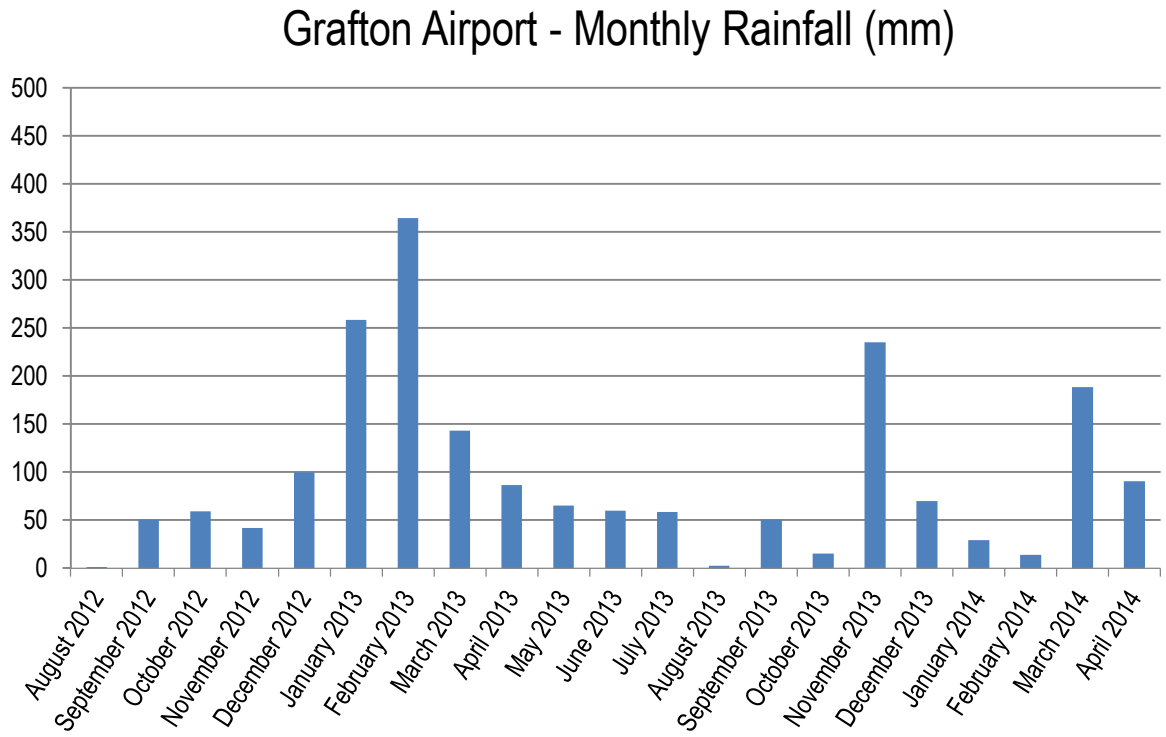


3.2.11 GWB20 and GWB21 - Ch12650

Similar groundwater level patterns are exhibited between the two bores. There is a consistent fall in groundwater levels from August 2013.

Figure 3.8 Groundwater levels – GWB20 and GWB21 - Ch12650

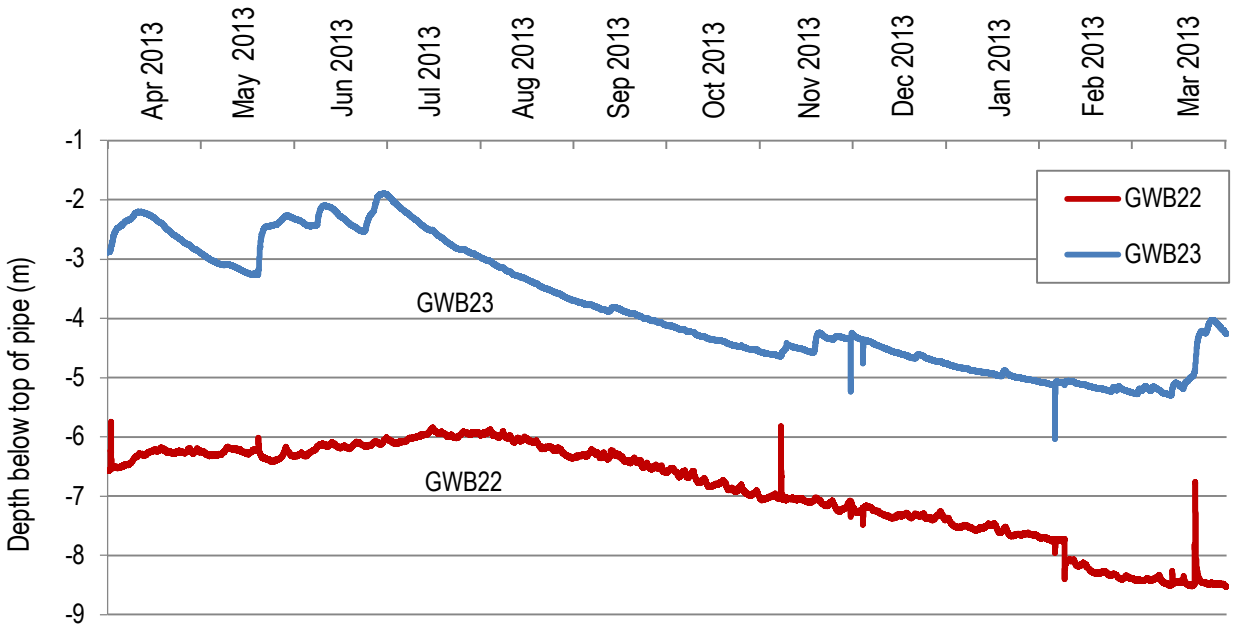


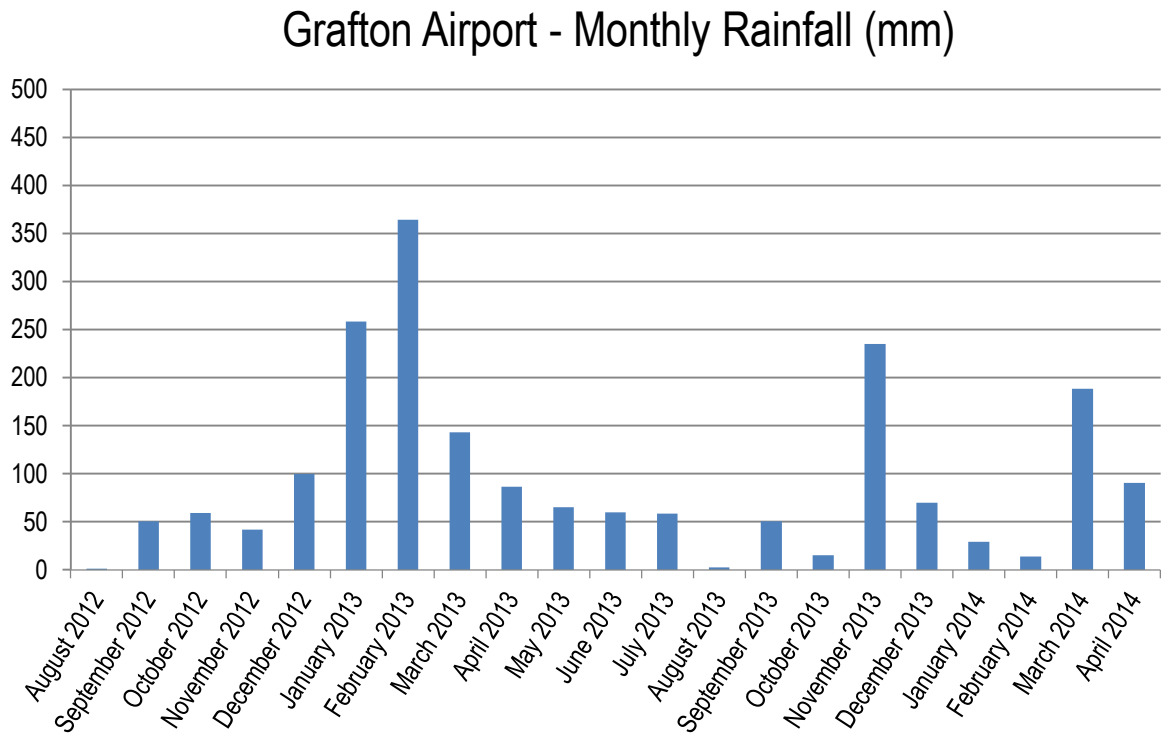


3.2.12 GWB22 and GWB23 - Kelman Property - Ch 13500

Similar groundwater level patterns are exhibited between the two bores following August 2013 with a general fall in groundwater levels. Groundwater levels in GWB23 appear to respond relatively rapidly to some rainfall events.

Figure 3.9 Groundwater levels – GWB22 and GWB23 - Kelman Property - Ch 13500

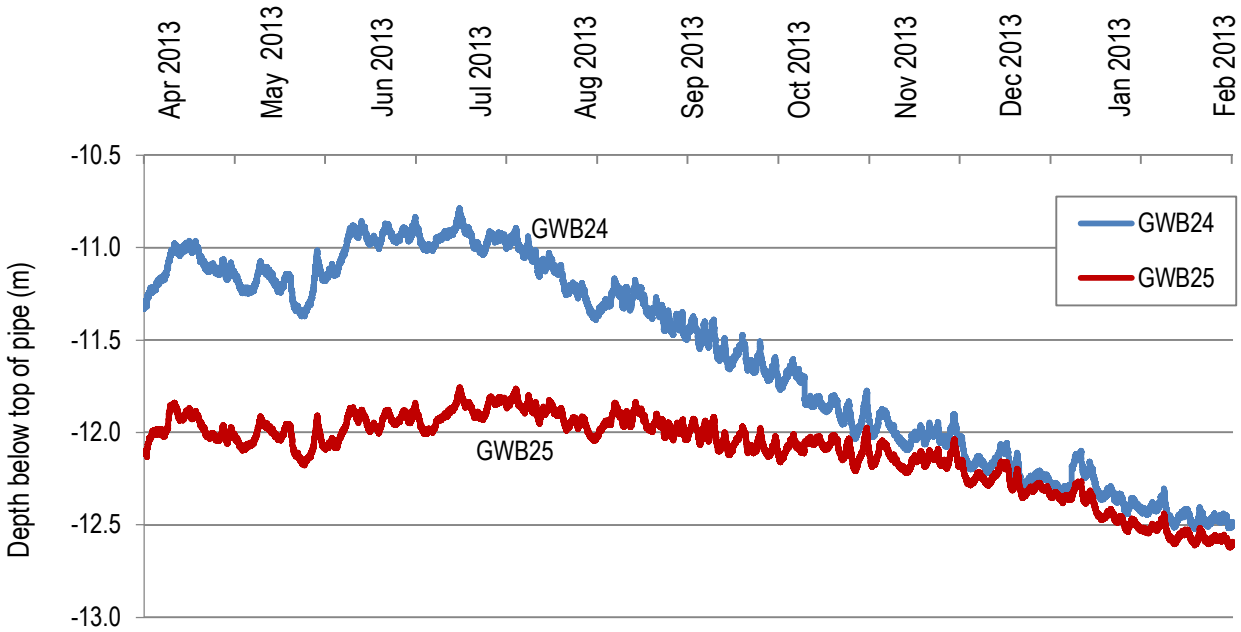


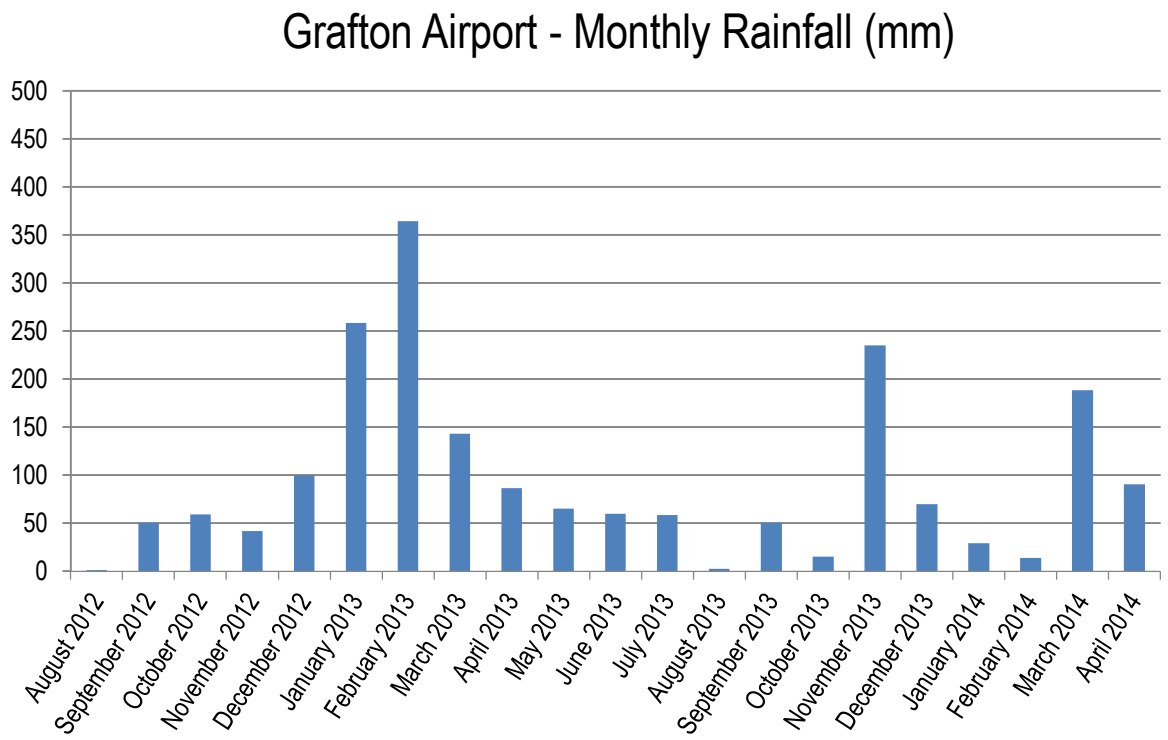


3.2.13 GWB24 and GWB25 - Ch21650

Similar groundwater level patterns are exhibited between the two bores with GWB24 exhibiting greater fluctuations in levels. There is a consistent fall in groundwater levels from July 2013.

Figure 3.10 Groundwater levels – GWB24 and GWB25 - Ch21650

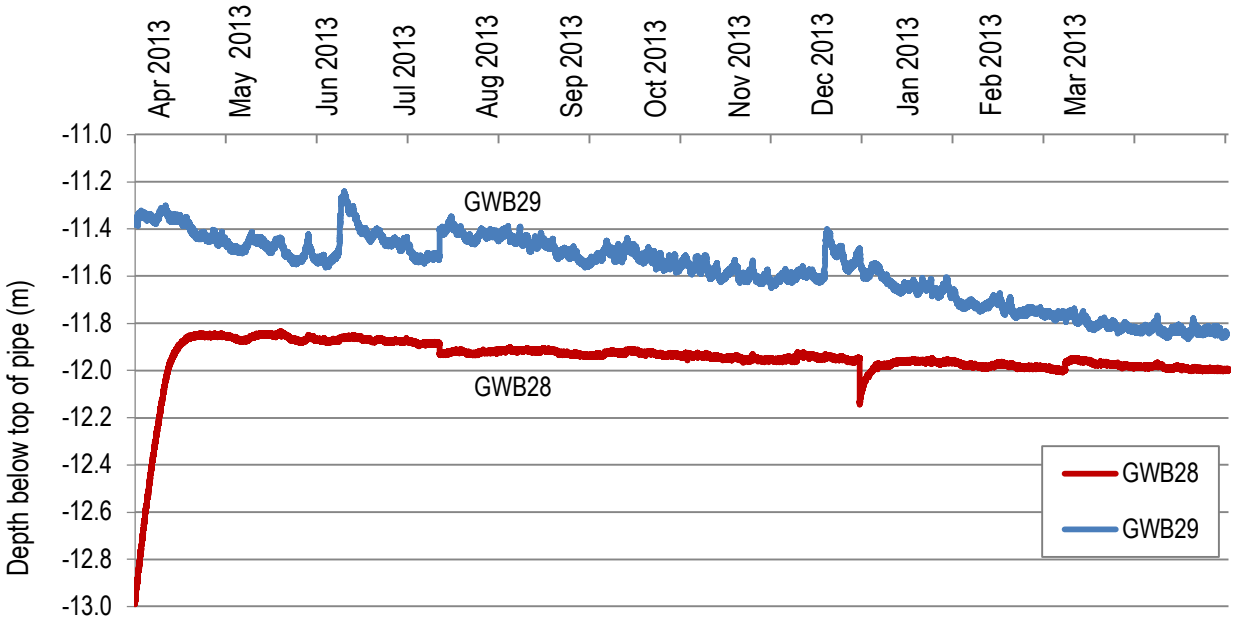


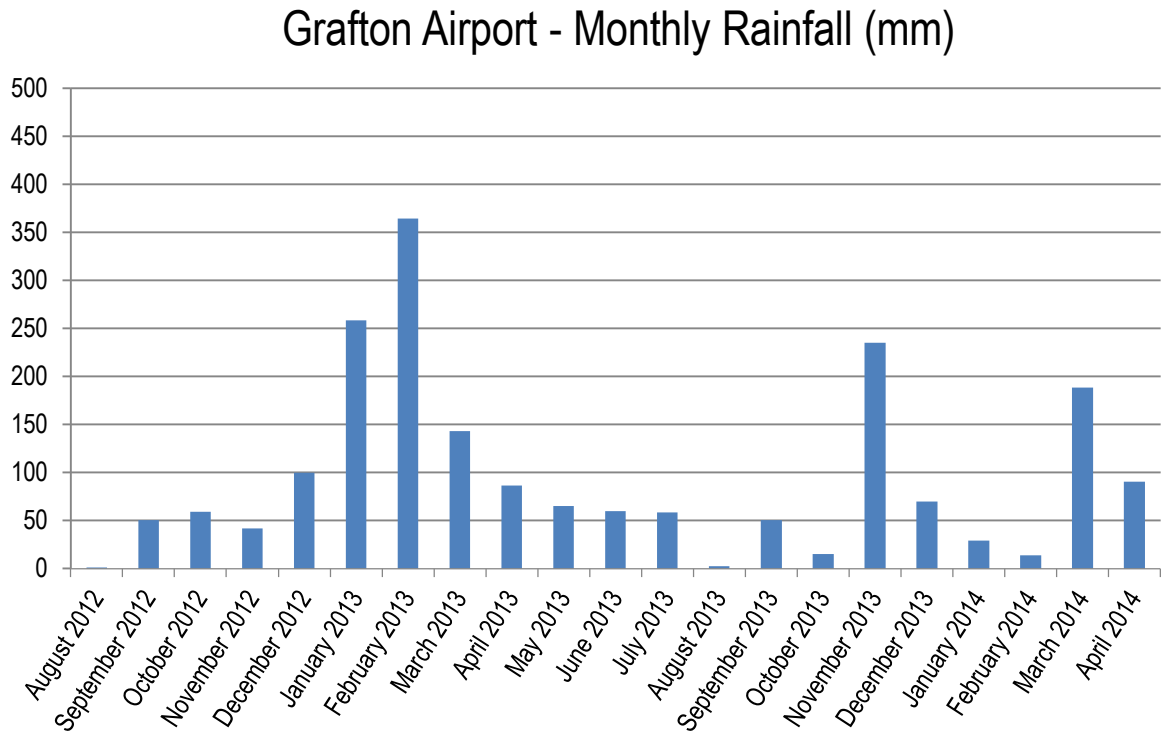


3.2.14 GWB28 and GWB29 - Glenugie State Forest - Ch 26800

Both bores exhibit a general fall in groundwater levels from the commencement of the monitoring but with relatively small fluctuations. The initial rise in groundwater level in GWB28 is thought to be associated with establishment of the bore.

Figure 3.11 Groundwater levels – GWB28 and GWB29 - Glenugie State Forest - Ch 26800



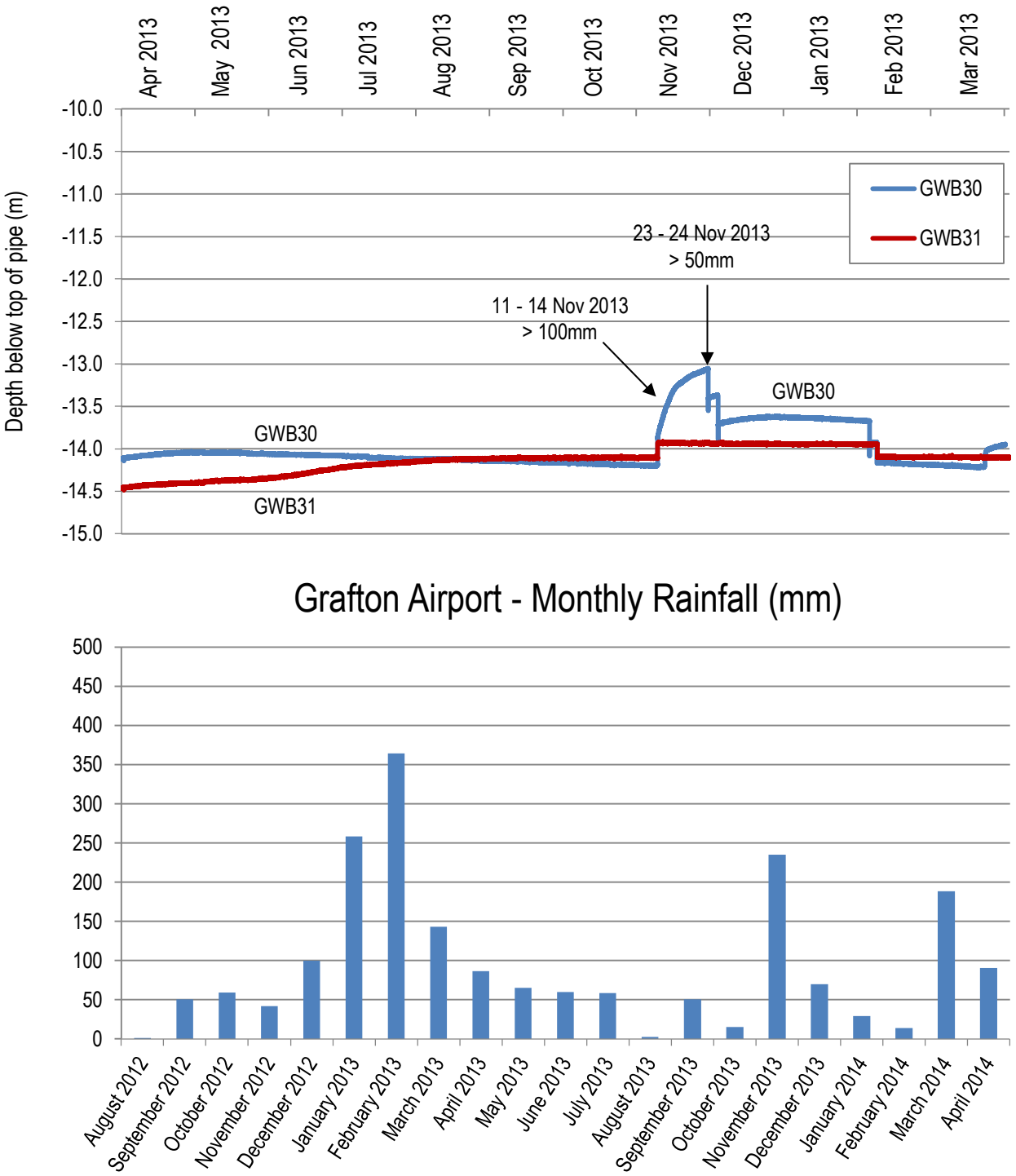


3.2.15 GWB30 and GWB31 - Glenugie State Forest - Ch 27200

GWB30 exhibits minor fluctuations with the exception of a large rise in groundwater level during the large rainfall events in November 2013.

Groundwater levels in GWB 31 were near the base of the bore for the majority of the monitoring period.

Figure 3.12 Groundwater levels – GWB30 and GWB31 - Glenugie State Forest - Ch 27200



4

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 1.3** of this report).

4.2 Surface Water

4.2.1 Construction Phase

Sampling over the construction monitoring period will comprise:

- two wet event sampling rounds per month with:
  - assess Type A parameters every round; and (refer to **Table 4.1**); and
  - assess Type B parameters every second round (refer to **Table 4.1**)
- one dry event sampling round per month:
  - assess Type A parameters every month; and
  - assess Type B parameters every second month.

Table 4.1 Surface Water Sampling Parameters – Construction Phase

Parameter	*Type A Parameters*	*Type B Parameters*
pH	X	
Temperature	X	
Electrical Conductivity (EC)	X	
Dissolved Oxygen (DO)	X	
Turbidity	X	
Total Suspended Solids (TSS)	X	
Total Oils and Grease (TPH to be included as Type A parameter if oil/grease is visible)	X	
Total Phosphorous, Total Nitrogen	X	
Phosphate, Ammonia, Nitrate, Nitrite		X
Total Petroleum Hydrocarbons (TPH) (TPH to be included 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 10mm or more of rain within 24 hours. Wet event sampling is to be undertaken within 24 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 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. Following the first year the frequency will be reduced to once every second month for the second year of operation and then once every six months for the third year of operation.

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

Table 4.2 Surface Water Sampling Parameters – Operational Phase

Parameter	*Type A Parameters*	*Type B Parameters*
pH	X	
Temperature	X	
Electrical Conductivity (EC)	X	
Dissolved Oxygen (DO)	X	
Turbidity	X	
Total Suspended Solids (TSS)	X	
Total Oils and Grease (TPH to be included as Type A parameter if oil/grease is visible)	X	
Total Phosphorous, Total Nitrogen	X	
Phosphate, Ammonia, Nitrate, Nitrite		X
Total Petroleum Hydrocarbons (TPH) (TPH to be included as Type A parameter if oil/grease is visible)	*	X
Heavy Metals (Total): Aluminium, Arsenic, Cadmium, Calcium, Chromium, Copper, Iron, Lead, Magnesium, 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 Year of Operation

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

- one **wet event** sampling round every second month:
  - assess Type A parameters every round; and
  - assess Type B parameters every third round.
- one **dry event** sampling round every six months assessing both Type A and Type B parameters.

4.2.2.3 Operational Phase – Third Year of Operation

Sampling over the third 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 28 groundwater bores listed in **Table 2.2** 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 the 13 groundwater bores listed in **Table 2.3**. All of the parameters listed in **Table 4.2** are to be monitored at each sampling event.

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 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.

4.3.2.2 Operational Phase – First Year of Operation

Sampling over the first year of the operational phase will comprise quarterly sampling of the 13 groundwater bores listed in **Table 2.3**. All of the parameters listed in **Table 4.2** are to be monitored at each sampling event.

4.3.2.3 Operational Phase – Second and Third Year of Operation

Sampling over the first year of the operational phase will comprise six-monthly sampling of the 13 groundwater bores listed in **Table 2.3**. All of the parameters listed in **Table 4.2** are to be monitored at each sampling event.

Table 4.3 Groundwater Quality Sampling Parameters

Parameter/Analytical Group	*Analytes*	*Field analysis*	*Laboratory analysis*
Physical and chemical properties	pH	X	
	Temperature	X	
	Electrical Conductivity (EC)	X	
	Dissolved Oxygen (DO)	X	
	Turbidity	X	
	Total Dissolved Solids (TDS)		X
Hydrocarbons	Total Petroleum Hydrocarbons (TPH)		X
Nutrients	Total Phosphorous, Total Nitrogen		X
Major Cations	sodium (Na+), potassium (K+), calcium (Ca2+) and magnesium (Mg2+)		X
Major Anions	chloride (Cl-), sulfate (SO42-), bicarbonate (HCO3-)		X
Heavy Metals (Dissolved)	Aluminium, Cadmium, Copper, Lead, Zinc		X

4.4 Rainfall Data

For the construction phase rainfall data shall be collected from the construction site weather stations.

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

- Woolgoolga (Clear Place) - Station No. 59039: 1.7 kilometres from Woolgoolga – Lat 30.11 Long 153.20 Elevation: two metres
- Grafton Airport AWS - Station No. 58161: seven kilometres north of Glenugie - Lat 29.76° S Long 153.03° E Elevation: 25 metres
- Wooli (Sandstone Hill) - Station No. 58223: 10 kilometres east of Glenugie – Lat 29.80° S Long 153.14° E Elevation: 250 metres.

5

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 on ice in an esky and transported to the laboratory as soon as practical.

5.2.3.1 Replicate Samples

One blind replicate water sample will be collected every monitoring round for subsequent laboratory analysis. This is based on the general requirement of one blind sample for every 10 samples. 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.

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

Two blind replicate water samples will be collected every monitoring round for laboratory analysis. This is based on the general requirement of one blind sample for every 10 samples. 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. SW01U)
- 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 data established from 12 months of monitoring provides an indication of baseline conditions and the degree of variation for each water quality parameter for existing conditions. 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.

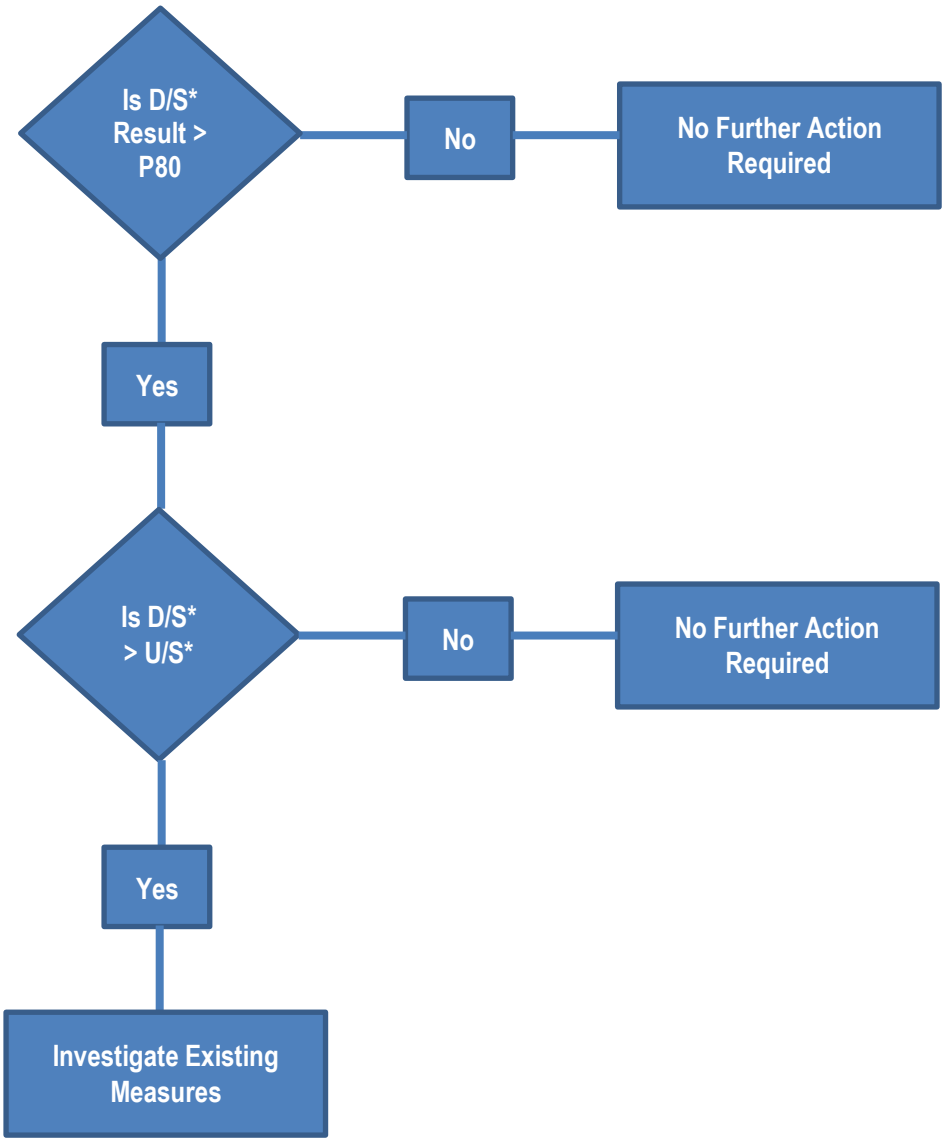
7.1 Surface Water

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, 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 sampling result is greater than the corresponding P80 baseline figure then compare the downstream and upstream sampling results at that location for that event:
  - If the downstream sampling result is greater than the upstream result (see **Note 2** further below with respect to DO, pH, temp. and EC) then this further highlights a possibility of the highway impacting on surface water quality requiring investigation of existing water quality control measures. The EPA shall be notified of the issue within 48 hours of the Contractor receiving the sampling results;
  - If a downstream sampling result is less than the upstream result then no further action is required with respect to the subject parameter.



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

Figure 7.1 Flow Chart for Comparing 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. 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. If the difference is less than the standard deviation then no further action is required with respect to the subject parameter; and
- 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.

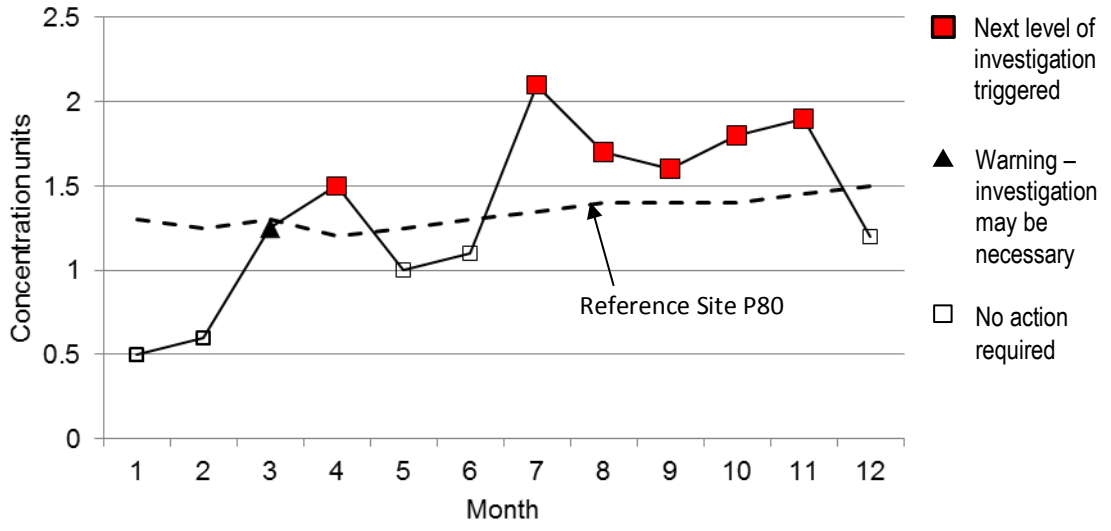


Figure 7.2 Example Control Chart

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 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. The EPA shall be notified of the issue within 48 hours of the Contractor receiving the sampling results;
  - 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.

7.3 Groundwater Levels

The following approach 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 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
   - 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.
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 may indicate any interception of the 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 the highway works then investigate existing groundwater control measures and notify the EPA within 48 hours of the Contractor receiving the groundwater level data;
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 within 48 hours of the Contractor receiving the groundwater level data; and monitor / download the groundwater levels on a monthly 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 'natural' variations then no further action is required.

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 impacts of the highway upgrade construction on surface water quality;
  - determination of any required refinement of construction surface water management measures;
- Groundwater quality:
  - identification of impacts of the highway upgrade construction on groundwater quality;
  - determination of any required refinement of construction groundwater quality management measures;
- Groundwater levels:
  - identification of impacts of the highway upgrade construction on groundwater levels;
  - determination of any required refinement 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 impacts of the highway upgrade operation on surface water;
  - determination of any required adjustment of operational surface water management strategies and stabilisation works.
- Groundwater quality:
  - identification of impacts of the highway upgrade operation on groundwater quality;
  - determination of any required adjustment of operational groundwater management strategies.
- Groundwater levels:
  - identification of impacts of the highway upgrade operation on groundwater levels;
  - determination of any required refinement 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, OEH, EPA, DPI (Fisheries), NOW, DoE in accordance with Condition D12 (Item h) of the Minister's Conditions of Approval (MCoA) – refer to **Section 1.3** and **Table 1.1** in this WQMP. 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, OEH, EPA, DPI (Fisheries), NOW, DoE 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, OEH, EPA, DPI (Fisheries), NOW, DoE in accordance with Condition D12 (Item h) of the Minister's Conditions of Approval – refer to **Section 1.3** and **Table 1.1** in this WQMP. 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, OEH, EPA, DPI (Fisheries), NOW, DoE 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) 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.

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 and notify the EPA within 48 hours of receiving the sampling results.

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. These 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**. If the sampling results indicate a possibility of the highway impacting on groundwater the Contractor is to investigate the issue and notify the EPA within 48 hours of receiving the relevant data as outlined in **Section 7.2** and **7.3**.

8.3 Operational Phase - Surface Water Management Actions

Permanent water quality management and protection measures would be installed to protect adjacent waterways from pollutants generated by operation of the project. These would include:

- Water quality ponds; and
- Grassed swales

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.

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Appendix A

Pre-Construction Surface Water Monitoring Results

Table A.1 Water quality results - Arrawarra Gully (SW01) - Highway Chainage 300

Parameter	All Events						Dry Events						Wet Events					
	Med	Min	Max	Std Dev	P80	P20	Med	Min	Max	Std Dev	P80	P20	Med	Min	Max	Std Dev	P80	P20
pH	6.5	5.4	8.6	0.9	6.9	6.0	6.6	5.4	7.4	0.6	6.9	6.1	6.4	5.6	8.6	1.6	7.7	5.9
Temp. (°C)	21.1	14.2	25.1	3.8	23.4	-	21.2	14.2	25.1	4.1	23.9	-	20.2	15.7	22.8	3.6	21.8	-
EC (mS/cm)	0.27	0.16	0.40	0.07	0.31	0.22	0.27	0.21	0.31	0.04	0.28	0.22	0.35	0.16	0.40	0.13	0.38	0.23
DO (mg/L)	3.2	1.0	9.6	2.9	5.3	1.4	2.8	1.0	9.2	2.7	5.2	1.3	4.4	2.9	9.6	3.5	7.5	3.5
Turbidity (NTU)	14.8	1.4	93.5	28.4	36.9	-	10.3	1.4	67.5	20.4	20.4	-	39.2	16.4	93.5	39.6	71.8	-
TSS (mg/L)	11.5	1.0	57.0	14.4	20.6	-	11.0	1.0	57.0	16.6	19.0	-	21.0	11.0	21.0	5.8	21.0	-
Total Oils and Grease (mg/L)	1.0	1.0	8.9	2.3	2.8	-	1.0	1.0	8.9	2.6	3.0	-	2.0	1.0	2.2	0.6	2.1	-
Total Phosphorus (mg/L P)	0.030	0.020	0.090	0.018	0.040	-	0.030	0.020	0.090	0.020	0.040	-	0.040	0.030	0.050	0.010	0.046	-
Total Nitrogen (mg/L N)	0.73	0.38	1.21	0.22	0.83	-	0.72	0.38	1.21	0.25	0.84	-	0.79	0.67	0.83	0.08	0.81	-
Phosphate (mg/L P)	0.006	0.005	0.006	0.001	0.006	-	0.000	0.000	0.006	0.002	0.000	-	0.000	0.000	0.005	0.003	0.003	-
Ammonia (mg/L N)	0.121	0.037	0.205	0.119	0.171	-	0.000	0.000	0.037	0.012	0.000	-	0.000	0.000	0.205	0.118	0.123	-
Nitrate (mg/L N)	0.0068	0.0025	0.0110	0.0060	0.0093	-	0.0000	0.0000	0.0025	0.0008	0.0000	-	0.0000	0.0000	0.0110	0.0064	0.0066	-
Nitrite (mg/L N)	0.003	0.003	0.003	0.000	0.003	-	0.000	0.000	0.003	0.001	0.000	-	0.000	0.000	0.003	0.002	0.002	-
Silver (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0005	0.0003	0.0003	-
Aluminium (mg/L)	1.40	0.62	2.18	1.10	1.87	-	0.00	0.00	0.62	0.21	0.00	-	0.00	0.00	2.18	1.26	1.31	-
Arsenic (mg/L)	0.001	0.001	0.001	0.000	0.001	-	0.000	0.000	0.001	0.000	0.000	-	0.000	0.000	0.001	0.001	0.001	-
Cadmium (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0005	0.0003	0.0003	-
Chromium (mg/L)	0.0010	0.0010	0.0010	0.0000	0.0010	-	0.0000	0.0000	0.0010	0.0003	0.0000	-	0.0000	0.0000	0.0010	0.0006	0.0006	-
Copper (mg/L)	0.0010	0.0010	0.0010	0.0000	0.0010	-	0.0000	0.0000	0.0010	0.0003	0.0000	-	0.0000	0.0000	0.0010	0.0006	0.0006	-
Iron (mg/L)	1.10	0.96	1.24	0.20	1.18	-	0.00	0.00	0.96	0.32	0.00	-	0.00	0.00	1.24	0.71	0.74	-
Manganese (mg/L)	0.037	0.026	0.048	0.016	0.044	-	0.000	0.000	0.026	0.009	0.000	-	0.000	0.000	0.048	0.028	0.029	-
Nickel (mg/L)	0.00075	0.00050	0.00100	0.00035	0.00090	-	0.00000	0.00000	0.00050	0.00017	0.00000	-	0.00000	0.00000	0.00100	0.00058	0.00060	-
Lead (mg/L)	0.0013	0.0005	0.0020	0.0011	0.0017	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0020	0.0012	0.0012	-
Selenium (mg/L)	0.0010	0.0010	0.0010	0.0000	0.0010	-	0.0000	0.0000	0.0010	0.0003	0.0000	-	0.0000	0.0000	0.0010	0.0006	0.0006	-
Zinc (mg/L)	0.005	0.004	0.005	0.001	0.005	-	0.000	0.000	0.004	0.001	0.000	-	0.000	0.000	0.005	0.003	0.003	-
Mercury (mg/L)	0.00025	0.00025	0.00025	0.00000	0.00025	-	0.00000	0.00000	0.00025	0.00008	0.00000	-	0.00000	0.00000	0.00025	0.00014	0.00015	-
Magnesium (mg/L)	5.50	5.20	5.80	0.42	5.68	-	0.00	0.00	5.80	1.93	0.00	-	0.00	0.00	5.20	3.00	3.12	-
Calcium (mg/L)	6.40	4.70	8.10	2.40	7.42	-	0.00	0.00	4.70	1.57	0.00	-	0.00	0.00	8.10	4.68	4.86	-
(TRH) C6-C9 Fraction (µg/L or ppb)	5	5	5	0	5	-	0	0	5	1.7	0	-	0	0	5	2.9	3	-
(TRH) C10-C14 Fraction (µg/L or ppb)	25	25	25	0	25	-	0	0	25	8.3	0	-	0	0	25	14.4	15	-
(TRH) C15-C28 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	16.7	0	-	0	0	50	28.9	30	-
(TRH) C29-C36 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	16.7	0	-	0	0	50	28.9	30	-
(TRH) C10-C16 Fraction (µg/L or ppb)	25	25	25	0	25	-	0	0	25	8.3	0	-	0	0	25	14.4	15	-
(TRH) C10-C16 less Napthalene Fraction (µg/L or ppb)	25	25	25	0	25	-	0	0	25	8.3	0	-	0	0	25	14.4	15	-
(TRH) C16-C34 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	16.7	0	-	0	0	50	28.9	30	-
(TRH) C34-C40 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	16.7	0	-	0	0	50	28.9	30	-

Table A.2 Water quality results - Corindi River (SW02) - Highway Chainage 3,600

Parameter	All Events						Dry Events						Wet Events					
	Med	Min	Max	Std Dev	P80	P20	Med	Min	Max	Std Dev	P80	P20	Med	Min	Max	Std Dev	P80	P20
pH	6.9	6.0	7.3	0.4	6.9	6.3	6.9	6.0	7.1	0.4	6.9	6.2	6.8	6.6	7.3	0.3	7.1	6.7
Temp. (°C)	21.2	13.4	25.0	3.7	22.7	-	21.4	13.4	25.0	3.9	22.6	-	18.6	16.3	22.9	3.3	21.2	-
EC (mS/cm)	0.18	0.13	0.22	0.03	0.20	0.17	0.18	0.13	0.22	0.03	0.20	0.17	0.17	0.14	0.20	0.03	0.19	0.15
DO (mg/L)	5.3	1.7	10.5	3.5	9.6	2.3	8.7	1.7	10.5	3.7	9.9	2.5	5.1	2.1	5.4	1.8	5.3	3.3
Turbidity (NTU)	5.9	1.9	28.7	9.1	8.4	-	5.6	1.9	28.7	8.1	7.9	-	6.5	3.6	27.5	13.0	19.1	-
TSS (mg/L)	3.0	0.5	17.0	4.4	5.8	-	3.0	0.5	17.0	5.0	5.4	-	2.0	1.2	6.0	2.6	4.4	-
Total Oils and Grease (mg/L)	1.0	1.0	4.3	1.1	2.6	-	1.0	1.0	3.1	0.9	2.5	-	1.0	1.0	4.3	1.9	3.0	-
Total Phosphorus (mg/L P)	0.025	0.020	0.040	0.008	0.030	-	0.020	0.020	0.040	0.007	0.030	-	0.030	0.020	0.040	0.010	0.036	-
Total Nitrogen (mg/L N)	0.18	0.08	0.44	0.12	0.27	-	0.14	0.08	0.44	0.12	0.23	-	0.25	0.18	0.38	0.10	0.33	-
Phosphate (mg/L P)	0.004	0.003	0.005	0.002	0.005	-	0.000	0.000	0.003	0.001	0.000	-	0.000	0.000	0.005	0.003	0.003	-
Ammonia (mg/L N)	0.075	0.014	0.135	0.086	0.111	-	0.000	0.000	0.014	0.005	0.000	-	0.000	0.000	0.135	0.078	0.081	-
Nitrate (mg/L N)	0.0375	0.0330	0.0420	0.0064	0.0402	-	0.0000	0.0000	0.0330	0.0110	0.0000	-	0.0000	0.0000	0.0420	0.0242	0.0252	-
Nitrite (mg/L N)	0.003	0.001	0.005	0.003	0.004	-	0.000	0.000	0.001	0.000	0.000	-	0.000	0.000	0.005	0.003	0.003	-
Silver (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0005	0.0003	0.0003	-
Aluminium (mg/L)	0.23	0.06	0.41	0.25	0.34	-	0.00	0.00	0.41	0.14	0.00	-	0.00	0.00	0.06	0.03	0.03	-
Arsenic (mg/L)	0.001	0.001	0.001	0.000	0.001	-	0.000	0.000	0.001	0.000	0.000	-	0.000	0.000	0.001	0.001	0.001	-
Cadmium (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0005	0.0003	0.0003	-
Chromium (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0005	0.0003	0.0003	-
Copper (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0005	0.0003	0.0003	-
Iron (mg/L)	1.76	1.17	2.36	0.84	2.12	-	0.00	0.00	1.17	0.39	0.00	-	0.00	0.00	2.36	1.36	1.41	-
Manganese (mg/L)	0.842	0.034	1.649	1.142	1.326	-	0.000	0.000	0.034	0.011	0.000	-	0.000	0.000	1.649	0.952	0.989	-
Nickel (mg/L)	0.00050	0.00050	0.00050	0.00000	0.00050	-	0.00000	0.00000	0.00050	0.00017	0.00000	-	0.00000	0.00000	0.00050	0.00029	0.00030	-
Lead (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0005	0.0003	0.0003	-
Selenium (mg/L)	0.0010	0.0010	0.0010	0.0000	0.0010	-	0.0000	0.0000	0.0010	0.0003	0.0000	-	0.0000	0.0000	0.0010	0.0006	0.0006	-
Zinc (mg/L)	0.002	0.001	0.002	0.001	0.002	-	0.000	0.000	0.002	0.001	0.000	-	0.000	0.000	0.001	0.001	0.001	-
Mercury (mg/L)	0.00025	0.00025	0.00025	0.00000	0.00025	-	0.00000	0.00000	0.00025	0.00008	0.00000	-	0.00000	0.00000	0.00025	0.00014	0.00015	-
Magnesium (mg/L)	4.25	2.90	5.60	1.91	5.06	-	0.00	0.00	2.90	0.97	0.00	-	0.00	0.00	5.60	3.23	3.36	-
Calcium (mg/L)	4.95	3.60	6.30	1.91	5.76	-	0.00	0.00	3.60	1.20	0.00	-	0.00	0.00	6.30	3.64	3.78	-
(TRH) C6-C9 Fraction (µg/L or ppb)	5	5	5	0	5	-	0	0	5	1.7	0	-	0	0	5	2.9	3	-
(TRH) C10-C14 Fraction (µg/L or ppb)	25	25	25	0	25	-	0	0	25	8.3	0	-	0	0	25	14.4	15	-
(TRH) C15-C28 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	16.7	0	-	0	0	50	28.9	30	-
(TRH) C29-C36 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	16.7	0	-	0	0	50	28.9	30	-
(TRH) C10-C16 Fraction (µg/L or ppb)	25	25	25	0	25	-	0	0	25	8.3	0	-	0	0	25	14.4	15	-
(TRH) C10-C16 less Napthalene Fraction (µg/L or ppb)	25	25	25	0	25	-	0	0	25	8.3	0	-	0	0	25	14.4	15	-
(TRH) C16-C34 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	16.7	0	-	0	0	50	28.9	30	-
(TRH) C34-C40 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	16.7	0	-	0	0	50	28.9	30	-

Table A.3 Water quality results - Blackadder Gully (SW03) - Highway Chainage 4,000

Parameter	All Events						Dry Events						Wet Events					
	Med	Min	Max	Std Dev	P80	P20	Med	Min	Max	Std Dev	P80	P20	Med	Min	Max	Std Dev	P80	P20
pH	6.3	5.6	6.8	0.5	6.6	5.8	6.0	5.6	6.7	0.5	6.5	5.7	6.6	6.3	6.8	0.4	6.7	6.4
Temp. (°C)	19.4	14.4	25.1	4.1	23.7	-	19.4	14.4	24.0	4.1	22.8	-	21.2	17.4	25.1	5.5	23.6	-
EC (mS/cm)	0.09	0.07	0.15	0.03	0.12	0.08	0.09	0.08	0.15	0.03	0.11	0.09	0.10	0.07	0.12	0.04	0.11	0.08
DO (mg/L)	8.0	5.1	10.2	2.1	9.7	5.8	9.4	5.4	10.2	2.0	9.9	6.7	6.6	5.1	8.0	2.1	7.4	5.7
Turbidity (NTU)	58.8	6.7	307.0	111.7	148.6	-	58.8	6.7	307.0	124.5	111.8	-	89.9	9.7	170.0	113.3	137.9	-
TSS (mg/L)	23.0	6.0	98.0	34.7	60.6	-	23.0	6.0	67.0	24.0	41.4	-	52.5	7.0	98.0	64.3	79.8	-
Total Oils and Grease (mg/L)	1.0	1.0	3.3	1.0	2.9	-	1.0	1.0	3.1	0.9	1.4	-	2.7	2.0	3.3	0.9	3.0	-
Total Phosphorus (mg/L P)	0.070	0.030	0.280	0.106	0.226	-	0.070	0.040	0.280	0.099	0.128	-	0.145	0.030	0.260	0.163	0.214	-
Total Nitrogen (mg/L N)	0.62	0.26	4.08	1.51	2.70	-	0.62	0.26	4.08	1.56	1.96	-	1.64	0.26	3.02	1.95	2.47	-
Phosphate (mg/L P)	0.003	0.003	0.003	0.000	0.003	-	0.000	0.000	0.003	0.001	0.001	-	0.000	0.000	0.000	0.000	0.000	-
Ammonia (mg/L N)	0.029	0.029	0.029	0.000	0.029	-	0.000	0.000	0.029	0.013	0.006	-	0.000	0.000	0.000	0.000	0.000	-
Nitrate (mg/L N)	0.0025	0.0025	0.0025	0.0000	0.0025	-	0.0000	0.0000	0.0025	0.0011	0.0005	-	0.0000	0.0000	0.0000	0.0000	0.0000	-
Nitrite (mg/L N)	0.001	0.001	0.001	0.000	0.001	-	0.000	0.000	0.001	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	-
Silver (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0001	-	0.0000	0.0000	0.0000	0.0000	0.0000	-
Aluminium (mg/L)	0.27	0.27	0.27	0.00	0.27	-	0.00	0.00	0.27	0.12	0.05	-	0.00	0.00	0.00	0.00	0.00	-
Arsenic (mg/L)	0.001	0.001	0.001	0.000	0.001	-	0.000	0.000	0.001	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	-
Cadmium (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0001	-	0.0000	0.0000	0.0000	0.0000	0.0000	-
Chromium (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0001	-	0.0000	0.0000	0.0000	0.0000	0.0000	-
Copper (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0001	-	0.0000	0.0000	0.0000	0.0000	0.0000	-
Iron (mg/L)	0.45	0.45	0.45	0.00	0.45	-	0.00	0.00	0.45	0.20	0.09	-	0.00	0.00	0.00	0.00	0.00	-
Manganese (mg/L)	0.026	0.026	0.026	0.000	0.026	-	0.000	0.000	0.026	0.012	0.005	-	0.000	0.000	0.000	0.000	0.000	-
Nickel (mg/L)	0.00050	0.00050	0.00050	0.00000	0.00050	-	0.00000	0.00000	0.00050	0.00022	0.00010	-	0.00000	0.00000	0.00000	0.00000	0.00000	-
Lead (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0001	-	0.0000	0.0000	0.0000	0.0000	0.0000	-
Selenium (mg/L)	0.0010	0.0010	0.0010	0.0000	0.0010	-	0.0000	0.0000	0.0010	0.0004	0.0002	-	0.0000	0.0000	0.0000	0.0000	0.0000	-
Zinc (mg/L)	0.002	0.002	0.002	0.000	0.002	-	0.000	0.000	0.002	0.001	0.000	-	0.000	0.000	0.000	0.000	0.000	-
Mercury (mg/L)	0.00025	0.00025	0.00025	0.00000	0.00025	-	0.00000	0.00000	0.00025	0.00011	0.00005	-	0.00000	0.00000	0.00000	0.00000	0.00000	-
Magnesium (mg/L)	0.60	0.60	0.60	0.00	0.60	-	0.00	0.00	0.60	0.27	0.12	-	0.00	0.00	0.00	0.00	0.00	-
Calcium (mg/L)	1.30	1.30	1.30	0.00	1.30	-	0.00	0.00	1.30	0.58	0.26	-	0.00	0.00	0.00	0.00	0.00	-
(TRH) C6-C9 Fraction (µg/L or ppb)	5	5	5	0	5	-	0	0	5	2.2	1	-	0	0	0	0.0	0	-
(TRH) C10-C14 Fraction (µg/L or ppb)	25	25	25	0	25	-	0	0	25	11.2	5	-	0	0	0	0.0	0	-
(TRH) C15-C28 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	22.4	10	-	0	0	0	0.0	0	-
(TRH) C29-C36 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	22.4	10	-	0	0	0	0.0	0	-
(TRH) C10-C16 Fraction (µg/L or ppb)	25	25	25	0	25	-	0	0	25	11.2	5	-	0	0	0	0.0	0	-
(TRH) C10-C16 less Napthalene Fraction (µg/L or ppb)	25	25	25	0	25	-	0	0	25	11.2	5	-	0	0	0	0.0	0	-
(TRH) C16-C34 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	22.4	10	-	0	0	0	0.0	0	-
(TRH) C34-C40 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	22.4	10	-	0	0	0	0.0	0	-

Table A.4 Water quality results - Cassons Creek (SW04) - Highway Chainage 4,750

Parameter	All Events						Dry Events						Wet Events					
	Med	Min	Max	Std Dev	P80	P20	Med	Min	Max	Std Dev	P80	P20	Med	Min	Max	Std Dev	P80	P20
pH	6.1	5.5	6.9	0.4	6.3	5.9	6.1	5.5	6.9	0.4	6.3	5.8	6.1	6.0	6.5	0.3	6.3	6.0
Temp. (°C)	21.4	11.9	24.1	4.0	22.7	-	22.2	11.9	24.1	4.2	22.7	-	19.4	16.2	23.9	3.9	22.1	-
EC (mS/cm)	0.32	0.22	0.35	0.04	0.34	0.29	0.32	0.22	0.35	0.05	0.34	0.27	0.29	0.29	0.33	0.03	0.32	0.29
DO (mg/L)	3.6	1.1	5.4	1.2	4.4	2.7	3.2	1.1	5.0	1.2	3.8	2.4	4.6	3.8	5.4	0.8	5.0	4.1
Turbidity (NTU)	6.6	2.5	49.2	14.4	19.1	-	5.5	2.5	49.2	14.8	15.7	-	19.1	4.9	34.2	14.7	28.2	-
TSS (mg/L)	6.5	2.0	21.0	5.8	12.0	-	7.0	2.0	21.0	6.3	13.8	-	4.0	3.0	8.0	2.6	6.4	-
Total Oils and Grease (mg/L)	1.0	1.0	7.4	2.3	2.5	-	1.0	1.0	7.4	2.1	1.6	-	2.2	1.0	6.6	2.9	4.8	-
Total Phosphorus (mg/L P)	0.035	0.020	0.090	0.019	0.048	-	0.040	0.020	0.090	0.020	0.050	-	0.020	0.020	0.030	0.006	0.026	-
Total Nitrogen (mg/L N)	0.55	0.38	1.42	0.36	1.05	-	0.74	0.38	1.42	0.39	1.18	-	0.43	0.42	0.59	0.10	0.53	-
Phosphate (mg/L P)	0.004	0.003	0.005	0.002	0.005	-	0.000	0.000	0.003	0.001	0.000	-	0.000	0.000	0.005	0.003	0.003	-
Ammonia (mg/L N)	0.082	0.053	0.111	0.041	0.099	-	0.000	0.000	0.053	0.018	0.000	-	0.000	0.000	0.111	0.064	0.067	-
Nitrate (mg/L N)	0.0025	0.0025	0.0025	0.0000	0.0025	-	0.0000	0.0000	0.0025	0.0008	0.0000	-	0.0000	0.0000	0.0025	0.0014	0.0015	-
Nitrite (mg/L N)	0.001	0.001	0.001	0.000	0.001	-	0.000	0.000	0.001	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	-
Silver (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0005	0.0003	0.0003	-
Aluminium (mg/L)	0.41	0.15	0.67	0.36	0.56	-	0.00	0.00	0.67	0.22	0.00	-	0.00	0.00	0.15	0.09	0.09	-
Arsenic (mg/L)	0.001	0.001	0.001	0.000	0.001	-	0.000	0.000	0.001	0.000	0.000	-	0.000	0.000	0.001	0.000	0.000	-
Cadmium (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0005	0.0003	0.0003	-
Chromium (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0005	0.0003	0.0003	
Copper (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0005	0.0003	0.0003	-
Iron (mg/L)	0.73	0.70	0.76	0.05	0.75	-	0.00	0.00	0.76	0.25	0.00	-	0.00	0.00	0.70	0.40	0.42	-
Manganese (mg/L)	0.326	0.255	0.397	0.100	0.369	-	0.000	0.000	0.397	0.132	0.000	-	0.000	0.000	0.255	0.147	0.153	-
Nickel (mg/L)	0.00075	0.00050	0.00100	0.00035	0.00090	-	0.00000	0.00000	0.00100	0.00033	0.00000	-	0.00000	0.00000	0.00050	0.00029	0.00030	-
Lead (mg/L)	0.0008	0.0005	0.0010	0.0004	0.0009	-	0.0000	0.0000	0.0010	0.0003	0.0000	-	0.0000	0.0000	0.0005	0.0003	0.0003	-
Selenium (mg/L)	0.0010	0.0010	0.0010	0.0000	0.0010	-	0.0000	0.0000	0.0010	0.0003	0.0000	-	0.0000	0.0000	0.0010	0.0006	0.0006	-
Zinc (mg/L)	0.003	0.001	0.005	0.003	0.004	-	0.000	0.000	0.005	0.002	0.000	-	0.000	0.000	0.001	0.001	0.001	-
Mercury (mg/L)	0.00025	0.00025	0.00025	0.00000	0.00025	-	0.00000	0.00000	0.00025	0.00008	0.00000	-	0.00000	0.00000	0.00025	0.00014	0.00015	-
Magnesium (mg/L)	5.35	4.20	6.50	1.63	6.04	-	0.00	0.00	4.20	1.40	0.00	-	0.00	0.00	6.50	3.75	3.90	-
Calcium (mg/L)	5.80	5.40	6.20	0.57	6.04	-	0.00	0.00	6.20	2.07	0.00	-	0.00	0.00	5.40	3.12	3.24	-
(TRH) C6-C9 Fraction (µg/L or ppb)	5	5	5	0	5	-	0	0	5	1.7	0	-	0	0	5	2.9	3	-
(TRH) C10-C14 Fraction (µg/L or ppb)	25	25	25	0	25	-	0	0	25	8.3	0	-	0	0	25	14.4	15	-
(TRH) C15-C28 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	16.7	0	-	0	0	50	28.9	30	-
(TRH) C29-C36 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	16.7	0	-	0	0	50	28.9	30	-
(TRH) C10-C16 Fraction (µg/L or ppb)	25	25	25	0	25	-	0	0	25	8.3	0	-	0	0	25	14.4	15	-
(TRH) C10-C16 less Napthalene Fraction (µg/L or ppb)	25	25	25	0	25	-	0	0	25	8.3	0	-	0	0	25	14.4	15	-
(TRH) C16-C34 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	16.7	0	-	0	0	50	28.9	30	-
(TRH) C34-C40 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	16.7	0	-	0	0	50	28.9	30	-

Table A.5 Water quality results - Redbank Creek (SW05) - Highway Chainage 5,650

Parameter	All Events						Dry Events						Wet Events					
	Med	Min	Max	Std Dev	P80	P20	Med	Min	Max	Std Dev	P80	P20	Med	Min	Max	Std Dev	P80	P20
pH	5.9	5.2	6.1	0.3	6.0	5.5	5.9	5.2	6.0	0.3	5.9	5.5	5.9	5.5	6.1	0.3	6.0	5.7
Temp. (°C)	21.3	13.6	23.5	3.6	23.1	-	21.6	13.6	23.5	4.0	23.2	-	20.9	16.6	23.0	3.3	22.2	-
EC (mS/cm)	0.20	0.07	0.28	0.06	0.22	0.12	0.21	0.19	0.28	0.03	0.24	0.20	0.12	0.07	0.12	0.03	0.12	0.09
DO (mg/L)	3.9	2.2	9.5	2.1	5.9	3.2	3.5	2.2	9.5	2.5	5.5	3.0	4.6	3.4	6.3	1.4	5.6	3.9
Turbidity (NTU)	30.5	4.6	218.0	82.0	165.0	-	8.5	4.6	218.0	77.2	41.3	-	164.0	21.2	169.0	83.9	167.0	-
TSS (mg/L)	17.5	0.5	84.0	31.4	44.6	-	13.0	0.5	84.0	29.3	29.2	-	35.0	7.0	83.0	38.4	63.8	-
Total Oils and Grease (mg/L)	1.0	1.0	7.2	2.1	1.6	-	1.0	1.0	7.2	2.3	1.0	-	1.0	1.0	3.9	1.7	2.7	-
Total Phosphorus (mg/L P)	0.030	0.010	0.080	0.020	0.040	-	0.030	0.010	0.080	0.024	0.038	-	0.040	0.030	0.040	0.006	0.040	-
Total Nitrogen (mg/L N)	0.69	0.15	1.40	0.42	1.00	-	0.66	0.15	1.40	0.50	1.29	-	0.72	0.51	0.81	0.15	0.77	-
Phosphate (mg/L P)	0.044	0.003	0.086	0.059	0.069	-	0.000	0.000	0.003	0.001	0.000	-	0.000	0.000	0.086	0.050	0.052	-
Ammonia (mg/L N)	0.083	0.016	0.149	0.094	0.122	-	0.000	0.000	0.016	0.006	0.000	-	0.000	0.000	0.149	0.086	0.089	-
Nitrate (mg/L N)	0.0063	0.0025	0.0100	0.0053	0.0085	-	0.0000	0.0000	0.0025	0.0009	0.0000	-	0.0000	0.0000	0.0100	0.0058	0.0060	-
Nitrite (mg/L N)	0.008	0.001	0.015	0.010	0.012	-	0.000	0.000	0.001	0.000	0.000	-	0.000	0.000	0.015	0.009	0.009	-
Silver (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0005	0.0003	0.0003	-
Aluminium (mg/L)	0.94	0.60	1.29	0.49	1.15	-	0.00	0.00	0.60	0.23	0.00	-	0.00	0.00	1.29	0.74	0.77	-
Arsenic (mg/L)	0.001	0.001	0.001	0.000	0.001	-	0.000	0.000	0.001	0.000	0.000	-	0.000	0.000	0.001	0.000	0.000	-
Cadmium (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0005	0.0003	0.0003	-
Chromium (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0005	0.0003	0.0003	-
Copper (mg/L)	0.0008	0.0005	0.0010	0.0004	0.0009	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0010	0.0006	0.0006	-
Iron (mg/L)	0.63	0.48	0.77	0.20	0.71	-	0.00	0.00	0.48	0.18	0.00	-	0.00	0.00	0.77	0.45	0.46	-
Manganese (mg/L)	0.068	0.030	0.105	0.053	0.090	-	0.000	0.000	0.030	0.011	0.000	-	0.000	0.000	0.105	0.061	0.063	-
Nickel (mg/L)	0.00050	0.00050	0.00050	0.00000	0.00050	-	0.00000	0.00000	0.00050	0.00019	0.00000	-	0.00000	0.00000	0.00050	0.00029	0.00030	-
Lead (mg/L)	0.0008	0.0005	0.0010	0.0004	0.0009	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0010	0.0006	0.0006	-
Selenium (mg/L)	0.0010	0.0010	0.0010	0.0000	0.0010	-	0.0000	0.0000	0.0010	0.0004	0.0000	-	0.0000	0.0000	0.0010	0.0006	0.0006	-
Zinc (mg/L)	0.003	0.002	0.004	0.001	0.004	-	0.000	0.000	0.004	0.002	0.000	-	0.000	0.000	0.002	0.001	0.001	-
Mercury (mg/L)	0.00025	0.00025	0.00025	0.00000	0.00025	-	0.00000	0.00000	0.00025	0.00009	0.00000	-	0.00000	0.00000	0.00025	0.00014	0.00015	-
Magnesium (mg/L)	1.80	1.60	2.00	0.28	1.92	-	0.00	0.00	2.00	0.76	0.00	-	0.00	0.00	1.60	0.92	0.96	-
Calcium (mg/L)	2.55	0.80	4.30	2.47	3.60	-	0.00	0.00	4.30	1.63	0.00	-	0.00	0.00	0.80	0.46	0.48	-
(TRH) C6-C9 Fraction (µg/L or ppb)	5	5	5	0	5	-	0	0	5	1.9	0	-	0	0	5	2.9	3	-
(TRH) C10-C14 Fraction (µg/L or ppb)	25	25	25	0	25	-	0	0	25	9.4	0	-	0	0	25	14.4	15	-
(TRH) C15-C28 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	18.9	0	-	0	0	50	28.9	30	-
(TRH) C29-C36 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	18.9	0	-	0	0	50	28.9	30	-
(TRH) C10-C16 Fraction (µg/L or ppb)	25	25	25	0	25	-	0	0	25	9.4	0	-	0	0	25	14.4	15	-
(TRH) C10-C16 less Napthalene Fraction (µg/L or ppb)	25	25	25	0	25	-	0	0	25	9.4	0	-	0	0	25	14.4	15	-
(TRH) C16-C34 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	18.9	0	-	0	0	50	28.9	30	-
(TRH) C34-C40 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	18.9	0	-	0	0	50	28.9	30	-

Table A.6 Water quality results - Dirty Creek (SW06) - Highway Chainage 8,500

Parameter	All Events						Dry Events						Wet Events					
	Med	Min	Max	Std Dev	P80	P20	Med	Min	Max	Std Dev	P80	P20	Med	Min	Max	Std Dev	P80	P20
pH	5.5	5.5	5.5	0.0	5.5	5.5	n/a	n/a	n/a	n/a	n/a	n/a	5.5	5.5	5.5	0.0	5.5	5.5
Temp. (°C)	16.8	16.8	16.8	0.0	16.8	-	n/a	n/a	n/a	n/a	n/a	n/a	16.8	16.8	16.8	0.0	16.8	-
EC (mS/cm)	0.23	0.23	0.23	0.00	0.23	0.23	n/a	n/a	n/a	n/a	n/a	n/a	0.23	0.23	0.23	0.00	0.23	0.23
DO (mg/L)	5.7	5.7	5.7	0.0	5.7	5.7	n/a	n/a	n/a	n/a	n/a	n/a	5.7	5.7	5.7	0.0	5.7	5.7
Turbidity (NTU)	11.0	11.0	11.0	0.0	11.0	-	n/a	n/a	n/a	n/a	n/a	n/a	11.0	11.0	11.0	0.0	11.0	-
TSS (mg/L)	4.0	4.0	4.0	0.0	4.0	-	n/a	n/a	n/a	n/a	n/a	n/a	4.0	4.0	4.0	0.0	4.0	-
Total Oils and Grease (mg/L)	1.0	1.0	1.0	0.0	1.0	-	n/a	n/a	n/a	n/a	n/a	n/a	1.0	1.0	1.0	0.0	1.0	-
Total Phosphorus (mg/L P)	0.010	0.010	0.010	0.000	0.010	-	n/a	n/a	n/a	n/a	n/a	n/a	0.010	0.010	0.010	0.000	0.010	-
Total Nitrogen (mg/L N)	0.19	0.19	0.19	0.00	0.19	-	n/a	n/a	n/a	n/a	n/a	n/a	0.19	0.19	0.19	0.00	0.19	-
Phosphate (mg/L P)	0.000	0.000	0.000	0.000	0.000	-	n/a	n/a	n/a	n/a	n/a	n/a	0.000	0.000	0.000	0.000	0.000	-
Ammonia (mg/L N)	0.000	0.000	0.000	0.000	0.000	-	n/a	n/a	n/a	n/a	n/a	n/a	0.000	0.000	0.000	0.000	0.000	-
Nitrate (mg/L N)	0.0000	0.0000	0.0000	0.0000	0.0000	-	n/a	n/a	n/a	n/a	n/a	n/a	0.0000	0.0000	0.0000	0.0000	0.0000	-
Nitrite (mg/L N)	0.000	0.000	0.000	0.000	0.000	-	n/a	n/a	n/a	n/a	n/a	n/a	0.000	0.000	0.000	0.000	0.000	-
Silver (mg/L)	0.0000	0.0000	0.0000	0.0000	0.0000	-	n/a	n/a	n/a	n/a	n/a	n/a	0.0000	0.0000	0.0000	0.0000	0.0000	-
Aluminium (mg/L)	0.00	0.00	0.00	0.00	0.00	-	n/a	n/a	n/a	n/a	n/a	n/a	0.00	0.00	0.00	0.00	0.00	-
Arsenic (mg/L)	0.000	0.000	0.000	0.000	0.000	-	n/a	n/a	n/a	n/a	n/a	n/a	0.000	0.000	0.000	0.000	0.000	-
Cadmium (mg/L)	0.0000	0.0000	0.0000	0.0000	0.0000	-	n/a	n/a	n/a	n/a	n/a	n/a	0.0000	0.0000	0.0000	0.0000	0.0000	-
Chromium (mg/L)	0.0000	0.0000	0.0000	0.0000	0.0000	-	n/a	n/a	n/a	n/a	n/a	n/a	0.0000	0.0000	0.0000	0.0000	0.0000	-
Copper (mg/L)	0.0000	0.0000	0.0000	0.0000	0.0000	-	n/a	n/a	n/a	n/a	n/a	n/a	0.0000	0.0000	0.0000	0.0000	0.0000	-
Iron (mg/L)	0.00	0.00	0.00	0.00	0.00	-	n/a	n/a	n/a	n/a	n/a	n/a	0.00	0.00	0.00	0.00	0.00	-
Manganese (mg/L)	0.000	0.000	0.000	0.000	0.000	-	n/a	n/a	n/a	n/a	n/a	n/a	0.000	0.000	0.000	0.000	0.000	-
Nickel (mg/L)	0.00000	0.00000	0.00000	0.00000	0.00000	-	n/a	n/a	n/a	n/a	n/a	n/a	0.00000	0.00000	0.00000	0.00000	0.00000	-
Lead (mg/L)	0.0000	0.0000	0.0000	0.0000	0.0000	-	n/a	n/a	n/a	n/a	n/a	n/a	0.0000	0.0000	0.0000	0.0000	0.0000	-
Selenium (mg/L)	0.0000	0.0000	0.0000	0.0000	0.0000	-	n/a	n/a	n/a	n/a	n/a	n/a	0.0000	0.0000	0.0000	0.0000	0.0000	-
Zinc (mg/L)	0.000	0.000	0.000	0.000	0.000	-	n/a	n/a	n/a	n/a	n/a	n/a	0.000	0.000	0.000	0.000	0.000	-
Mercury (mg/L)	0.00000	0.00000	0.00000	0.00000	0.00000	-	n/a	n/a	n/a	n/a	n/a	n/a	0.00000	0.00000	0.00000	0.00000	0.00000	-
Magnesium (mg/L)	0.00	0.00	0.00	0.00	0.00	-	n/a	n/a	n/a	n/a	n/a	n/a	0.00	0.00	0.00	0.00	0.00	-
Calcium (mg/L)	0.00	0.00	0.00	0.00	0.00	-	n/a	n/a	n/a	n/a	n/a	n/a	0.00	0.00	0.00	0.00	0.00	-
(TRH) C6-C9 Fraction (µg/L or ppb)	0	0	0	0	0	-	n/a	n/a	n/a	n/a	n/a	n/a	0	0	0	0.0	0	-
(TRH) C10-C14 Fraction (µg/L or ppb)	0	0	0	0	0	-	n/a	n/a	n/a	n/a	n/a	n/a	0	0	0	0.0	0	-
(TRH) C15-C28 Fraction (µg/L or ppb)	0	0	0	0	0	-	n/a	n/a	n/a	n/a	n/a	n/a	0	0	0	0.0	0	-
(TRH) C29-C36 Fraction (µg/L or ppb)	0	0	0	0	0	-	n/a	n/a	n/a	n/a	n/a	n/a	0	0	0	0.0	0	-
(TRH) C10-C16 Fraction (µg/L or ppb)	0	0	0	0	0	-	n/a	n/a	n/a	n/a	n/a	n/a	0	0	0	0.0	0	-
(TRH) C10-C16 less Napthalene Fraction (µg/L or ppb)	0	0	0	0	0	-	n/a	n/a	n/a	n/a	n/a	n/a	0	0	0	0.0	0	-
(TRH) C16-C34 Fraction (µg/L or ppb)	0	0	0	0	0	-	n/a	n/a	n/a	n/a	n/a	n/a	0	0	0	0.0	0	-
(TRH) C34-C40 Fraction (µg/L or ppb)	0	0	0	0	0	-	n/a	n/a	n/a	n/a	n/a	n/a	0	0	0	0.0	0	-

Table A.7 Water quality results - Dundoo Creek (SW07) - Highway Chainage 10,700

Parameter	All Events						Dry Events						Wet Events					
	Med	Min	Max	Std Dev	P80	P20	Med	Min	Max	Std Dev	P80	P20	Med	Min	Max	Std Dev	P80	P20
pH	6.3	6.3	6.3	0.0	6.3	6.3	n/a	n/a	n/a	n/a	n/a	n/a	6.3	6.3	6.3	0.0	6.3	6.3
Temp. (°C)	17.1	17.1	17.1	0.0	17.1	-	n/a	n/a	n/a	n/a	n/a	n/a	17.1	17.1	17.1	0.0	17.1	-
EC (mS/cm)	0.24	0.24	0.24	0.00	0.24	0.24	n/a	n/a	n/a	n/a	n/a	n/a	0.24	0.24	0.24	0.00	0.24	0.24
DO (mg/L)	5.0	5.0	5.0	0.0	5.0	5.0	n/a	n/a	n/a	n/a	n/a	n/a	5.0	5.0	5.0	0.0	5.0	5.0
Turbidity (NTU)	45.9	45.9	45.9	0.0	45.9	-	n/a	n/a	n/a	n/a	n/a	n/a	45.9	45.9	45.9	0.0	45.9	-
TSS (mg/L)	19.0	19.0	19.0	0.0	19.0	-	n/a	n/a	n/a	n/a	n/a	n/a	19.0	19.0	19.0	0.0	19.0	-
Total Oils and Grease (mg/L)	1.0	1.0	1.0	0.0	1.0	-	n/a	n/a	n/a	n/a	n/a	n/a	1.0	1.0	1.0	0.0	1.0	-
Total Phosphorus (mg/L P)	0.040	0.040	0.040	0.000	0.040	-	n/a	n/a	n/a	n/a	n/a	n/a	0.040	0.040	0.040	0.000	0.040	-
Total Nitrogen (mg/L N)	0.44	0.44	0.44	0.00	0.44	-	n/a	n/a	n/a	n/a	n/a	n/a	0.44	0.44	0.44	0.00	0.44	-
Phosphate (mg/L P)	0.000	0.000	0.000	0.000	0.000	-	n/a	n/a	n/a	n/a	n/a	n/a	0.000	0.000	0.000	0.000	0.000	-
Ammonia (mg/L N)	0.000	0.000	0.000	0.000	0.000	-	n/a	n/a	n/a	n/a	n/a	n/a	0.000	0.000	0.000	0.000	0.000	-
Nitrate (mg/L N)	0.0000	0.0000	0.0000	0.0000	0.0000	-	n/a	n/a	n/a	n/a	n/a	n/a	0.0000	0.0000	0.0000	0.0000	0.0000	-
Nitrite (mg/L N)	0.000	0.000	0.000	0.000	0.000	-	n/a	n/a	n/a	n/a	n/a	n/a	0.000	0.000	0.000	0.000	0.000	-
Silver (mg/L)	0.0000	0.0000	0.0000	0.0000	0.0000	-	n/a	n/a	n/a	n/a	n/a	n/a	0.0000	0.0000	0.0000	0.0000	0.0000	-
Aluminium (mg/L)	0.00	0.00	0.00	0.00	0.00	-	n/a	n/a	n/a	n/a	n/a	n/a	0.00	0.00	0.00	0.00	0.00	-
Arsenic (mg/L)	0.000	0.000	0.000	0.000	0.000	-	n/a	n/a	n/a	n/a	n/a	n/a	0.000	0.000	0.000	0.000	0.000	-
Cadmium (mg/L)	0.0000	0.0000	0.0000	0.0000	0.0000	-	n/a	n/a	n/a	n/a	n/a	n/a	0.0000	0.0000	0.0000	0.0000	0.0000	-
Chromium (mg/L)	0.0000	0.0000	0.0000	0.0000	0.0000	-	n/a	n/a	n/a	n/a	n/a	n/a	0.0000	0.0000	0.0000	0.0000	0.0000	-
Copper (mg/L)	0.0000	0.0000	0.0000	0.0000	0.0000	-	n/a	n/a	n/a	n/a	n/a	n/a	0.0000	0.0000	0.0000	0.0000	0.0000	-
Iron (mg/L)	0.00	0.00	0.00	0.00	0.00	-	n/a	n/a	n/a	n/a	n/a	n/a	0.00	0.00	0.00	0.00	0.00	-
Manganese (mg/L)	0.000	0.000	0.000	0.000	0.000	-	n/a	n/a	n/a	n/a	n/a	n/a	0.000	0.000	0.000	0.000	0.000	-
Nickel (mg/L)	0.00000	0.00000	0.00000	0.00000	0.00000	-	n/a	n/a	n/a	n/a	n/a	n/a	0.00000	0.00000	0.00000	0.00000	0.00000	-
Lead (mg/L)	0.0000	0.0000	0.0000	0.0000	0.0000	-	n/a	n/a	n/a	n/a	n/a	n/a	0.0000	0.0000	0.0000	0.0000	0.0000	-
Selenium (mg/L)	0.0000	0.0000	0.0000	0.0000	0.0000	-	n/a	n/a	n/a	n/a	n/a	n/a	0.0000	0.0000	0.0000	0.0000	0.0000	-
Zinc (mg/L)	0.000	0.000	0.000	0.000	0.000	-	n/a	n/a	n/a	n/a	n/a	n/a	0.000	0.000	0.000	0.000	0.000	-
Mercury (mg/L)	0.00000	0.00000	0.00000	0.00000	0.00000	-	n/a	n/a	n/a	n/a	n/a	n/a	0.00000	0.00000	0.00000	0.00000	0.00000	-
Magnesium (mg/L)	0.00	0.00	0.00	0.00	0.00	-	n/a	n/a	n/a	n/a	n/a	n/a	0.00	0.00	0.00	0.00	0.00	-
Calcium (mg/L)	0.00	0.00	0.00	0.00	0.00	-	n/a	n/a	n/a	n/a	n/a	n/a	0.00	0.00	0.00	0.00	0.00	-
(TRH) C6-C9 Fraction (µg/L or ppb)	0	0	0	0	0	-	n/a	n/a	n/a	n/a	n/a	n/a	0	0	0	0.0	0	-
(TRH) C10-C14 Fraction (µg/L or ppb)	0	0	0	0	0	-	n/a	n/a	n/a	n/a	n/a	n/a	0	0	0	0.0	0	-
(TRH) C15-C28 Fraction (µg/L or ppb)	0	0	0	0	0	-	n/a	n/a	n/a	n/a	n/a	n/a	0	0	0	0.0	0	-
(TRH) C29-C36 Fraction (µg/L or ppb)	0	0	0	0	0	-	n/a	n/a	n/a	n/a	n/a	n/a	0	0	0	0.0	0	-
(TRH) C10-C16 Fraction (µg/L or ppb)	0	0	0	0	0	-	n/a	n/a	n/a	n/a	n/a	n/a	0	0	0	0.0	0	-
(TRH) C10-C16 less Napthalene Fraction (µg/L or ppb)	0	0	0	0	0	-	n/a	n/a	n/a	n/a	n/a	n/a	0	0	0	0.0	0	-
(TRH) C16-C34 Fraction (µg/L or ppb)	0	0	0	0	0	-	n/a	n/a	n/a	n/a	n/a	n/a	0	0	0	0.0	0	-
(TRH) C34-C40 Fraction (µg/L or ppb)	0	0	0	0	0	-	n/a	n/a	n/a	n/a	n/a	n/a	0	0	0	0.0	0	-

Table A.8 Water quality results - Boneys Creek (SW08) - Highway Chainage 13,350

Parameter	All Events						Dry Events						Wet Events					
	Med	Min	Max	Std Dev	P80	P20	Med	Min	Max	Std Dev	P80	P20	Med	Min	Max	Std Dev	P80	P20
pH	6.4	6.3	6.9	0.2	6.7	6.4	6.5	6.3	6.9	0.2	6.7	6.4	6.3	6.3	6.4	0.1	6.4	6.3
Temp. (°C)	20.5	12.0	23.1	3.5	21.5	-	20.9	12.0	23.1	3.8	21.5	-	18.6	16.8	20.3	2.5	19.6	-
EC (mS/cm)	0.31	0.19	0.45	0.08	0.35	0.23	0.32	0.19	0.45	0.08	0.36	0.24	0.26	0.23	0.30	0.05	0.28	0.24
DO (mg/L)	3.9	2.3	5.9	1.4	5.7	3.2	3.6	2.3	5.9	1.3	4.9	2.9	5.8	5.7	5.8	0.1	5.8	5.7
Turbidity (NTU)	8.2	3.4	153.0	46.4	20.5	-	6.6	3.4	48.0	14.8	13.6	-	81.0	9.0	153.0	101.8	124.2	-
TSS (mg/L)	7.0	0.5	83.0	24.9	17.6	-	5.5	0.5	32.0	10.0	12.4	-	45.5	8.0	83.0	53.0	68.0	-
Total Oils and Grease (mg/L)	1.0	1.0	4.5	1.2	2.4	-	1.0	1.0	2.6	0.7	1.8	-	2.8	1.0	4.5	2.5	3.8	-
Total Phosphorus (mg/L P)	0.030	0.010	0.040	0.010	0.040	-	0.025	0.010	0.040	0.011	0.036	-	0.035	0.030	0.040	0.007	0.038	-
Total Nitrogen (mg/L N)	0.35	0.13	0.74	0.18	0.43	-	0.30	0.13	0.74	0.20	0.42	-	0.41	0.37	0.44	0.05	0.43	-
Phosphate (mg/L P)	0.003	0.003	0.003	0.000	0.003	-	0.000	0.000	0.003	0.001	0.000	-	0.000	0.000	0.000	0.000	0.000	-
Ammonia (mg/L N)	0.077	0.077	0.077	0.000	0.077	-	0.000	0.000	0.077	0.027	0.000	-	0.000	0.000	0.000	0.000	0.000	-
Nitrate (mg/L N)	0.0420	0.0420	0.0420	0.0000	0.0420	-	0.0000	0.0000	0.0420	0.0148	0.0000	-	0.0000	0.0000	0.0000	0.0000	0.0000	-
Nitrite (mg/L N)	0.001	0.001	0.001	0.000	0.001	-	0.000	0.000	0.001	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	-
Silver (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0000	0.0000	0.0000	-
Aluminium (mg/L)	0.34	0.34	0.34	0.00	0.34	-	0.00	0.00	0.34	0.12	0.00	-	0.00	0.00	0.00	0.00	0.00	-
Arsenic (mg/L)	0.001	0.001	0.001	0.000	0.001	-	0.000	0.000	0.001	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	-
Cadmium (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0000	0.0000	0.0000	-
Chromium (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0000	0.0000	0.0000	-
Copper (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0000	0.0000	0.0000	-
Iron (mg/L)	2.11	2.11	2.11	0.00	2.11	-	0.00	0.00	2.11	0.75	0.00	-	0.00	0.00	0.00	0.00	0.00	-
Manganese (mg/L)	0.124	0.124	0.124	0.000	0.124	-	0.000	0.000	0.124	0.044	0.000	-	0.000	0.000	0.000	0.000	0.000	-
Nickel (mg/L)	0.00100	0.00100	0.00100	0.00000	0.00100	-	0.00000	0.00000	0.00100	0.00035	0.00000	-	0.00000	0.00000	0.00000	0.00000	0.00000	-
Lead (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0000	0.0000	0.0000	-
Selenium (mg/L)	0.0010	0.0010	0.0010	0.0000	0.0010	-	0.0000	0.0000	0.0010	0.0004	0.0000	-	0.0000	0.0000	0.0000	0.0000	0.0000	-
Zinc (mg/L)	0.004	0.004	0.004	0.000	0.004	-	0.000	0.000	0.004	0.001	0.000	-	0.000	0.000	0.000	0.000	0.000	-
Mercury (mg/L)	0.00025	0.00025	0.00025	0.00000	0.00025	-	0.00000	0.00000	0.00025	0.00009	0.00000	-	0.00000	0.00000	0.00000	0.00000	0.00000	-
Magnesium (mg/L)	9.00	9.00	9.00	0.00	9.00	-	0.00	0.00	9.00	3.18	0.00	-	0.00	0.00	0.00	0.00	0.00	-
Calcium (mg/L)	7.30	7.30	7.30	0.00	7.30	-	0.00	0.00	7.30	2.58	0.00	-	0.00	0.00	0.00	0.00	0.00	-
(TRH) C6-C9 Fraction (µg/L or ppb)	5	5	5	0	5	-	0	0	5	1.8	0	-	0	0	0	0.0	0	-
(TRH) C10-C14 Fraction (µg/L or ppb)	25	25	25	0	25	-	0	0	25	8.8	0	-	0	0	0	0.0	0	-
(TRH) C15-C28 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	17.7	0	-	0	0	0	0.0	0	-
(TRH) C29-C36 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	17.7	0	-	0	0	0	0.0	0	-
(TRH) C10-C16 Fraction (µg/L or ppb)	25	25	25	0	25	-	0	0	25	8.8	0	-	0	0	0	0.0	0	-
(TRH) C10-C16 less Napthalene Fraction (µg/L or ppb)	25	25	25	0	25	-	0	0	25	8.8	0	-	0	0	0	0.0	0	-
(TRH) C16-C34 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	17.7	0	-	0	0	0	0.0	0	-
(TRH) C34-C40 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	17.7	0	-	0	0	0	0.0	0	-

Table A.9 Water quality results - Halfway Creek (SW09) - Highway Chainage 20,700

Parameter	All Events						Dry Events						Wet Events					
	Med	Min	Max	Std Dev	P80	P20	Med	Min	Max	Std Dev	P80	P20	Med	Min	Max	Std Dev	P80	P20
pH	6.5	6.0	6.9	0.2	6.5	6.3	6.4	6.0	6.9	0.3	6.6	6.3	6.5	6.3	6.5	0.1	6.5	6.4
Temp. (°C)	19.7	11.6	21.4	3.0	20.5	-	19.8	11.6	21.4	3.4	20.7	-	17.7	16.8	20.5	1.9	19.4	-
EC (mS/cm)	0.19	0.13	0.30	0.05	0.23	0.15	0.19	0.13	0.30	0.05	0.23	0.15	0.19	0.14	0.22	0.04	0.21	0.16
DO (mg/L)	4.9	0.6	11.3	3.8	9.0	1.5	4.5	0.6	11.3	3.9	7.8	1.3	6.6	1.9	9.6	3.9	8.4	3.8
Turbidity (NTU)	9.6	3.8	37.9	10.4	22.0	-	9.0	3.8	11.0	2.4	10.2	-	26.7	24.7	37.9	7.1	33.4	-
TSS (mg/L)	7.0	0.5	21.0	6.4	11.0	-	4.0	0.5	11.0	3.9	9.8	-	18.0	11.0	21.0	5.1	19.8	-
Total Oils and Grease (mg/L)	1.0	1.0	6.2	1.6	1.0	-	1.0	1.0	6.2	1.7	1.0	-	1.0	1.0	3.4	1.4	2.4	-
Total Phosphorus (mg/L P)	0.020	0.010	0.040	0.011	0.030	-	0.020	0.010	0.040	0.011	0.030	-	0.030	0.020	0.040	0.010	0.036	-
Total Nitrogen (mg/L N)	0.23	0.09	0.72	0.22	0.52	-	0.21	0.09	0.72	0.20	0.37	-	0.55	0.21	0.71	0.26	0.65	-
Phosphate (mg/L P)	0.003	0.003	0.003	0.000	0.003	-	0.000	0.000	0.003	0.001	0.000	-	0.000	0.000	0.003	0.001	0.002	-
Ammonia (mg/L N)	0.280	0.045	0.515	0.332	0.421	-	0.000	0.000	0.045	0.015	0.000	-	0.000	0.000	0.515	0.297	0.309	-
Nitrate (mg/L N)	0.0235	0.0200	0.0270	0.0049	0.0256	-	0.0000	0.0000	0.0270	0.0090	0.0000	-	0.0000	0.0000	0.0200	0.0115	0.0120	-
Nitrite (mg/L N)	0.004	0.001	0.007	0.005	0.006	-	0.000	0.000	0.001	0.000	0.000	-	0.000	0.000	0.007	0.004	0.004	-
Silver (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0005	0.0003	0.0003	-
Aluminium (mg/L)	0.29	0.19	0.38	0.13	0.34	-	0.00	0.00	0.38	0.13	0.00	-	0.00	0.00	0.19	0.11	0.12	-
Arsenic (mg/L)	0.001	0.001	0.001	0.000	0.001	-	0.000	0.000	0.001	0.000	0.000	-	0.000	0.000	0.001	0.001	0.001	-
Cadmium (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0005	0.0003	0.0003	-
Chromium (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0005	0.0003	0.0003	-
Copper (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0005	0.0003	0.0003	-
Iron (mg/L)	2.66	1.25	4.07	1.99	3.51	-	0.00	0.00	1.25	0.42	0.00	-	0.00	0.00	4.07	2.35	2.44	-
Manganese (mg/L)	0.432	0.030	0.834	0.569	0.673	-	0.000	0.000	0.030	0.010	0.000	-	0.000	0.000	0.834	0.482	0.500	-
Nickel (mg/L)	0.00050	0.00050	0.00050	0.00000	0.00050	-	0.00000	0.00000	0.00050	0.00017	0.00000	-	0.00000	0.00000	0.00050	0.00029	0.00030	-
Lead (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0005	0.0003	0.0003	-
Selenium (mg/L)	0.0010	0.0010	0.0010	0.0000	0.0010	-	0.0000	0.0000	0.0010	0.0003	0.0000	-	0.0000	0.0000	0.0010	0.0006	0.0006	-
Zinc (mg/L)	0.002	0.001	0.002	0.001	0.002	-	0.000	0.000	0.002	0.001	0.000	-	0.000	0.000	0.001	0.001	0.001	-
Mercury (mg/L)	0.00025	0.00025	0.00025	0.00000	0.00025	-	0.00000	0.00000	0.00025	0.00008	0.00000	-	0.00000	0.00000	0.00025	0.00014	0.00015	-
Magnesium (mg/L)	3.90	2.80	5.00	1.56	4.56	-	0.00	0.00	2.80	0.93	0.00	-	0.00	0.00	5.00	2.89	3.00	-
Calcium (mg/L)	5.10	2.90	7.30	3.11	6.42	-	0.00	0.00	2.90	0.97	0.00	-	0.00	0.00	7.30	4.21	4.38	-
(TRH) C6-C9 Fraction (µg/L or ppb)	5	5	5	0	5	-	0	0	5	1.7	0	-	0	0	5	2.9	3	-
(TRH) C10-C14 Fraction (µg/L or ppb)	25	25	25	0	25	-	0	0	25	8.3	0	-	0	0	25	14.4	15	-
(TRH) C15-C28 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	16.7	0	-	0	0	50	28.9	30	-
(TRH) C29-C36 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	16.7	0	-	0	0	50	28.9	30	-
(TRH) C10-C16 Fraction (µg/L or ppb)	25	25	25	0	25	-	0	0	25	8.3	0	-	0	0	25	14.4	15	-
(TRH) C10-C16 less Napthalene Fraction (µg/L or ppb)	25	25	25	0	25	-	0	0	25	8.3	0	-	0	0	25	14.4	15	-
(TRH) C16-C34 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	16.7	0	-	0	0	50	28.9	30	-
(TRH) C34-C40 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	16.7	0	-	0	0	50	28.9	30	-

Table A.10 Water quality results - Wells Crossing (SW10) - Highway Chainage 22,400

Parameter	All Events						Dry Events						Wet Events					
	Med	Min	Max	Std Dev	P80	P20	Med	Min	Max	Std Dev	P80	P20	Med	Min	Max	Std Dev	P80	P20
pH	5.6	4.7	6.2	0.4	5.7	5.5	5.7	4.7	6.1	0.4	5.7	5.5	5.6	5.5	6.2	0.4	5.9	5.5
Temp. (°C)	22.7	13.1	27.1	4.7	24.8	-	22.8	13.1	27.1	5.3	25.5	-	19.4	17.2	24.1	3.5	22.2	-
EC (mS/cm)	0.21	0.09	0.40	0.11	0.37	0.16	0.22	0.13	0.40	0.11	0.38	0.17	0.16	0.09	0.34	0.13	0.27	0.12
DO (mg/L)	3.9	1.5	9.8	2.1	5.2	3.4	4.0	1.5	9.8	2.3	4.9	3.0	3.5	3.4	5.9	1.4	4.9	3.4
Turbidity (NTU)	7.4	1.5	37.0	12.1	22.1	-	6.7	1.5	32.0	9.3	10.4	-	25.0	5.9	37.0	15.7	32.2	-
TSS (mg/L)	12.0	2.0	133.0	38.4	20.4	-	11.0	2.0	133.0	44.2	43.0	-	16.0	12.0	18.0	3.1	17.2	-
Total Oils and Grease (mg/L)	1.6	1.0	6.1	1.9	4.1	-	1.0	1.0	6.1	1.7	2.8	-	4.3	1.0	5.2	2.2	4.8	-
Total Phosphorus (mg/L P)	0.035	0.020	0.130	0.031	0.050	-	0.030	0.020	0.130	0.036	0.054	-	0.040	0.020	0.050	0.015	0.046	-
Total Nitrogen (mg/L N)	0.55	0.28	1.43	0.37	0.86	-	0.49	0.28	1.43	0.42	1.01	-	0.61	0.50	0.86	0.18	0.76	-
Phosphate (mg/L P)	0.003	0.003	0.003	0.000	0.003	-	0.000	0.000	0.003	0.001	0.000	-	0.000	0.000	0.003	0.001	0.002	-
Ammonia (mg/L N)	0.061	0.008	0.113	0.074	0.092	-	0.000	0.000	0.008	0.003	0.000	-	0.000	0.000	0.113	0.065	0.068	-
Nitrate (mg/L N)	0.0043	0.0025	0.0060	0.0025	0.0053	-	0.0000	0.0000	0.0025	0.0008	0.0000	-	0.0000	0.0000	0.0060	0.0035	0.0036	-
Nitrite (mg/L N)	0.004	0.003	0.004	0.001	0.004	-	0.000	0.000	0.003	0.001	0.000	-	0.000	0.000	0.004	0.002	0.002	-
Silver (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0005	0.0003	0.0003	-
Aluminium (mg/L)	0.47	0.24	0.71	0.33	0.61	-	0.00	0.00	0.71	0.24	0.00	-	0.00	0.00	0.24	0.14	0.14	-
Arsenic (mg/L)	0.001	0.001	0.001	0.000	0.001	-	0.000	0.000	0.001	0.000	0.000	-	0.000	0.000	0.001	0.000	0.000	-
Cadmium (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0005	0.0003	0.0003	-
Chromium (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0005	0.0003	0.0003	-
Copper (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0005	0.0003	0.0003	-
Iron (mg/L)	0.79	0.69	0.90	0.14	0.86	-	0.00	0.00	0.69	0.23	0.00	-	0.00	0.00	0.90	0.52	0.54	-
Manganese (mg/L)	0.139	0.024	0.254	0.163	0.208	-	0.000	0.000	0.024	0.008	0.000	-	0.000	0.000	0.254	0.147	0.152	-
Nickel (mg/L)	0.00050	0.00050	0.00050	0.00000	0.00050	-	0.00000	0.00000	0.00050	0.00017	0.00000	-	0.00000	0.00000	0.00050	0.00029	0.00030	-
Lead (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0005	0.0003	0.0003	-
Selenium (mg/L)	0.0010	0.0010	0.0010	0.0000	0.0010	-	0.0000	0.0000	0.0010	0.0003	0.0000	-	0.0000	0.0000	0.0010	0.0006	0.0006	-
Zinc (mg/L)	0.004	0.003	0.004	0.001	0.004	-	0.000	0.000	0.003	0.001	0.000	-	0.000	0.000	0.004	0.002	0.002	-
Mercury (mg/L)	0.00025	0.00025	0.00025	#DIV/0!	0.00025	-	0.00000	0.00000	0.00025	0.00008	0.00000	-	0.00000	0.00000	0.00000	0.00000	0.00000	-
Magnesium (mg/L)	4.35	2.20	6.50	3.04	5.64	-	0.00	0.00	2.20	0.73	0.00	-	0.00	0.00	6.50	3.75	3.90	-
Calcium (mg/L)	4.95	3.30	6.60	2.33	5.94	-	0.00	0.00	3.30	1.10	0.00	-	0.00	0.00	6.60	3.81	3.96	-
(TRH) C6-C9 Fraction (µg/L or ppb)	5	5	5	0	5	-	0	0	5	1.7	0	-	0	0	5	2.9	3	-
(TRH) C10-C14 Fraction (µg/L or ppb)	25	25	25	0	25	-	0	0	25	8.3	0	-	0	0	25	14.4	15	-
(TRH) C15-C28 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	16.7	0	-	0	0	50	28.9	30	-
(TRH) C29-C36 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	16.7	0	-	0	0	50	28.9	30	-
(TRH) C10-C16 Fraction (µg/L or ppb)	25	25	25	0	25	-	0	0	25	8.3	0	-	0	0	25	14.4	15	-
(TRH) C10-C16 less Napthalene Fraction (µg/L or ppb)	25	25	25	0	25	-	0	0	25	8.3	0	-	0	0	25	14.4	15	-
(TRH) C16-C34 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	16.7	0	-	0	0	50	28.9	30	-
(TRH) C34-C40 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	16.7	0	-	0	0	50	28.9	30	-

Table A.11 Water quality results - Glenugie Creek (SW11) - Highway Chainage 29,300

Parameter	All Events						Dry Events						Wet Events					
	Med	Min	Max	Std Dev	P80	P20	Med	Min	Max	Std Dev	P80	P20	Med	Min	Max	Std Dev	P80	P20
pH	7.0	6.4	7.3	0.2	7.2	6.9	7.0	6.8	7.3	0.2	7.2	6.9	6.9	6.4	7.1	0.4	7.0	6.6
Temp. (°C)	21.5	12.4	23.2	3.5	22.2	-	21.7	12.4	23.1	3.8	22.2	-	21.3	17.7	23.2	2.8	22.4	-
EC (mS/cm)	0.33	0.13	0.49	0.12	0.40	0.21	0.39	0.25	0.49	0.08	0.44	0.30	0.19	0.13	0.20	0.04	0.20	0.16
DO (mg/L)	3.3	0.7	10.3	2.5	5.2	2.2	2.7	0.7	10.3	2.8	3.4	2.0	5.3	5.0	5.4	0.2	5.3	5.1
Turbidity (NTU)	19.4	3.6	269.0	75.9	95.8	-	16.2	3.6	104.0	32.9	37.0	-	109.0	51.0	269.0	112.9	205.0	-
TSS (mg/L)	10.5	3.0	125.0	34.0	28.0	-	7.0	3.0	28.0	8.3	13.8	-	37.0	28.0	125.0	53.6	89.8	-
Total Oils and Grease (mg/L)	1.0	1.0	6.5	1.7	2.7	-	1.0	1.0	6.5	1.9	1.8	-	2.0	1.0	3.3	1.2	2.8	-
Total Phosphorus (mg/L P)	0.020	0.020	0.050	0.009	0.030	-	0.020	0.020	0.030	0.004	0.024	-	0.030	0.020	0.050	0.015	0.042	-
Total Nitrogen (mg/L N)	0.48	0.27	0.82	0.19	0.64	-	0.38	0.27	0.82	0.18	0.54	-	0.65	0.46	0.81	0.18	0.75	-
Phosphate (mg/L P)	0.006	0.005	0.006	0.001	0.006	-	0.000	0.000	0.006	0.002	0.000	-	0.000	0.000	0.005	0.003	0.003	-
Ammonia (mg/L N)	0.070	0.029	0.111	0.058	0.095	-	0.000	0.000	0.029	0.010	0.000	-	0.000	0.000	0.111	0.064	0.067	-
Nitrate (mg/L N)	0.0410	0.0050	0.0770	0.0509	0.0626	-	0.0000	0.0000	0.0050	0.0017	0.0000	-	0.0000	0.0000	0.0770	0.0445	0.0462	-
Nitrite (mg/L N)	0.003	0.001	0.004	0.002	0.003	-	0.000	0.000	0.001	0.000	0.000	-	0.000	0.000	0.004	0.002	0.002	-
Silver (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0005	0.0003	0.0003	-
Aluminium (mg/L)	0.72	0.57	0.87	0.21	0.81	-	0.00	0.00	0.57	0.19	0.00	-	0.00	0.00	0.87	0.50	0.52	-
Arsenic (mg/L)	0.001	0.001	0.001	0.000	0.001	-	0.000	0.000	0.001	0.000	0.000	-	0.000	0.000	0.001	0.001	0.001	-
Cadmium (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0005	0.0003	0.0003	-
Chromium (mg/L)	0.0005	0.0005	0.0005	0.0000	0.0005	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0005	0.0003	0.0003	-
Copper (mg/L)	0.0008	0.0005	0.0010	0.0004	0.0009	-	0.0000	0.0000	0.0005	0.0002	0.0000	-	0.0000	0.0000	0.0010	0.0006	0.0006	-
Iron (mg/L)	0.54	0.51	0.57	0.04	0.55	-	0.00	0.00	0.57	0.19	0.00	-	0.00	0.00	0.51	0.29	0.30	-
Manganese (mg/L)	0.046	0.035	0.056	0.015	0.052	-	0.000	0.000	0.035	0.012	0.000	-	0.000	0.000	0.056	0.032	0.034	-
Nickel (mg/L)	0.00075	0.00050	0.00100	0.00035	0.00090	-	0.00000	0.00000	0.00100	0.00033	0.00000	-	0.00000	0.00000	0.00050	0.00029	0.00030	-
Lead (mg/L)	0.0010	0.0010	0.0010	0.0000	0.0010	-	0.0000	0.0000	0.0010	0.0003	0.0000	-	0.0000	0.0000	0.0010	0.0006	0.0006	-
Selenium (mg/L)	0.0010	0.0010	0.0010	0.0000	0.0010	-	0.0000	0.0000	0.0010	0.0003	0.0000	-	0.0000	0.0000	0.0010	0.0006	0.0006	-
Zinc (mg/L)	0.003	0.002	0.004	0.001	0.004	-	0.000	0.000	0.002	0.001	0.000	-	0.000	0.000	0.004	0.002	0.002	-
Mercury (mg/L)	0.00025	0.00025	0.00025	0.00000	0.00025	-	0.00000	0.00000	0.00025	0.00008	0.00000	-	0.00000	0.00000	0.00025	0.00014	0.00015	-
Magnesium (mg/L)	14.60	7.10	22.10	10.61	19.10	-	0.00	0.00	22.10	7.37	0.00	-	0.00	0.00	7.10	4.10	4.26	-
Calcium (mg/L)	13.60	11.90	15.30	2.40	14.62	-	0.00	0.00	15.30	5.10	0.00	-	0.00	0.00	11.90	6.87	7.14	-
(TRH) C6-C9 Fraction (µg/L or ppb)	5	5	5	0	5	-	0	0	5	1.7	0	-	0	0	5	2.9	3	-
(TRH) C10-C14 Fraction (µg/L or ppb)	25	25	25	0	25	-	0	0	25	8.3	0	-	0	0	25	14.4	15	-
(TRH) C15-C28 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	16.7	0	-	0	0	50	28.9	30	-
(TRH) C29-C36 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	16.7	0	-	0	0	50	28.9	30	-
(TRH) C10-C16 Fraction (µg/L or ppb)	25	25	25	0	25	-	0	0	25	8.3	0	-	0	0	25	14.4	15	-
(TRH) C10-C16 less Napthalene Fraction (µg/L or ppb)	25	25	25	0	25	-	0	0	25	8.3	0	-	0	0	25	14.4	15	-
(TRH) C16-C34 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	16.7	0	-	0	0	50	28.9	30	-
(TRH) C34-C40 Fraction (µg/L or ppb)	50	50	50	0	50	-	0	0	50	16.7	0	-	0	0	50	28.9	30	-

Appendix B

Pre-Construction Groundwater Monitoring Results

Table B.1 Groundwater quality results – GWB1 - Kangaroo Trail Road - Ch 2500

Parameter / Analytical Groups	Row Labels	13/11/2013	10/02/2014	08/04/2014	Median	Standard Deviation	P80	P20
Physical and chemical properties	pH	5.81	6.03	5.53	5.8	0.3	5.9	5.6
	Temp. (°C)	27.99	23.18	21.51	23.2	3.4	26.1	-
	EC (mS/cm)	8.63	7.89	9.7	8.6	0.9	9.3	8.2
	DO (mg/L)	2.85	1.79	2.56	2.6	0.5	2.7	2.1
	Turbidity (NTU)	406	160	74.5	160	172	308	-
	TDS (g/L) (Solids)	5.44	7.27	6.087	6.09	0.93	6.80	5.70
Hydrocarbons	TRH C6-C9 Fraction (µg/L or ppb)	5	5	5	5	0	5	-
	TRH C10-C14 Fraction (µg/L or ppb)	25	25	25	25	0	25	-
	TRH C15-C28 Fraction (µg/L or ppb)	50	50	50	50	0	50	-
	TRH C29-C36 Fraction (µg/L or ppb)	50	50	50	50	0	50	-
	TRH C10-C16 Fraction (µg/L or ppb)	25	25	25	25	0	25	-
	TRH C10-C16 less Napthalene Fraction (µg/L or ppb)	25	25	25	25	0	25	-
	TRH C16-C34 Fraction (µg/L or ppb)	50	50	50	50	0	50	-
	TRH C34-C40 Fraction (µg/L or ppb)	50	50	50	50	0	50	-
Nutrients	Total Nitrogen (mg/L N)	0.36	0.13	0.13	0.13	0.13	0.27	-
	Total Phosphorus (mg/L P)	0.22	0.03	0.02	0.03	0.11	0.14	-
Major Cations	Sodium (mg/L)	1465	1632	1509	1509	87	1583	-
	Potassium (mg/L)	12	10.2	10.8	10.8	0.9	11.5	-
	Calcium (mg/L)	52.6	46.6	59.9	52.6	6.7	57.0	-
	Magnesium (mg/L)	238.8	241	258	241	11	251	-
Major Anions	Chloride (mg/L)	2839	2806	2900	2839	48	2876	-
	Sulfate (mg/L SO42)	176	155	214	176	30	199	-
	Bicarbonate (Alkalinity) (mg/L CaCO3 equiv)	135	45	100	100	45	121	-
Heavy Metals (Dissolved)	Aluminium (mg/L)	0.064	0.162	0.081	0.081	0.052	0.130	-
	Cadmium (mg/L)	0.0005	0.0005	0.0005	0.001	0.000	0.001	-
	Copper (mg/L)	0.001	0.144	0.011	0.011	0.080	0.091	-
	Lead (mg/L)	0.002	0.0005	0.0005	0.001	0.001	0.001	-
	Zinc (mg/L)	1.693	0.764	0.671	0.764	0.565	1.321	-
BTEX	Benzene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	Toluene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	Ethylbenzene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	m+p-Xylene (µg/L or ppb)	1	1	1	1.0	0.0	1.0	-
	o-Xylene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	Napthalene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-

Table B.2 Groundwater quality results – GWB2 - Kangaroo Trail Road - Ch 2520

Parameter / Analytical Groups	Row Labels	13/11/2013	10/02/2014	08/04/2014	Median	Standard Deviation	P80	P20
Physical and chemical properties	pH	5.46	5.04	5.08	5.1	0.2	5.3	5.1
	Temp. (°C)	26.49	23.27	21.61	23.3	2.5	25.2	-
	EC (mS/cm)	7.56	7.88	8.03	7.9	0.2	8.0	7.7
	DO (mg/L)	2.03	1.5	2.54	2.0	0.5	2.3	1.7
	Turbidity (NTU)	55.3	88.8	126	89	35	111	-
	TDS (g/L) (Solids)	4.76	5.89	5.153	5.15	0.57	5.60	4.92
Hydrocarbons	TRH C6-C9 Fraction (µg/L or ppb)	5	5	5	5	0	5	-
	TRH C10-C14 Fraction (µg/L or ppb)	25	25	25	25	0	25	-
	TRH C15-C28 Fraction (µg/L or ppb)	370	50	50	50	185	242	-
	TRH C29-C36 Fraction (µg/L or ppb)	160	50	50	50	64	116	-
	TRH C10-C16 Fraction (µg/L or ppb)	55	25	25	25	17	43	-
	TRH C10-C16 less Napthalene Fraction (µg/L or ppb)	55	25	25	25	17	43	-
	TRH C16-C34 Fraction (µg/L or ppb)	480	50	50	50	248	308	-
	TRH C34-C40 Fraction (µg/L or ppb)	50	50	50	50	0	50	-
Nutrients	Total Nitrogen (mg/L N)	0.1	0.14	0.16	0.14	0.03	0.15	-
	Total Phosphorus (mg/L P)	0.06	0.01	0.01	0.01	0.03	0.04	-
Major Cations	Sodium (mg/L)	1390	1326	1362	1362	32	1379	-
	Potassium (mg/L)	9.6	9.3	9.9	9.6	0.3	9.8	-
	Calcium (mg/L)	19.1	27.6	21.7	21.7	4.4	25.2	-
	Magnesium (mg/L)	194.9	171	193	193	13	194	-
Major Anions	Chloride (mg/L)	2624	2484	2699	2624	109	2669	-
	Sulfate (mg/L SO42)	43	41	108	43	38	82	-
	Bicarbonate (Alkalinity) (mg/L CaCO3 equiv)	35	0.5	0.5	1	20	21	-
Heavy Metals (Dissolved)	Aluminium (mg/L)	0.213	0.886	0.937	0.886	0.404	0.917	-
	Cadmium (mg/L)	0.0005	0.0005	0.0005	0.001	0.000	0.001	-
	Copper (mg/L)	0.004	0.038	0.036	0.036	0.019	0.037	-
	Lead (mg/L)	0.001	0.001	0.001	0.001	0.000	0.001	-
	Zinc (mg/L)	0.078	0.595	0.563	0.563	0.290	0.582	-
BTEX	Benzene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	Toluene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	Ethylbenzene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	m+p-Xylene (µg/L or ppb)	1	1	1	1.0	0.0	1.0	-
	o-Xylene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	Napthalene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-

Table B.3 Groundwater quality results – GWB8 - Big Cut – Ch 7750

Parameter / Analytical Groups	Row Labels	12/11/2013	10/02/2014	09/04/2014	Median	Standard Deviation	P80	P20
Physical and chemical properties	pH	6.24	6.74	7.33	6.7	0.5	7.1	6.4
	Temp. (°C)	24.81	23.87	23.63	23.9	0.6	24.4	-
	EC (mS/cm)	0.576	0.768	0.82	0.8	0.1	0.8	0.7
	DO (mg/L)	1.89	2.33	2.14	2.1	0.2	2.3	2.0
	Turbidity (NTU)	20.1	7.5	84.2	20	41	59	-
	TDS (g/L) (Solids)	0.369	573	873	573.00	443.36	753.00	229.42
Hydrocarbons	TRH C6-C9 Fraction (µg/L or ppb)	5	5	5	5	0	5	-
	TRH C10-C14 Fraction (µg/L or ppb)	2000	25	240	240	1084	1296	-
	TRH C15-C28 Fraction (µg/L or ppb)	50	50	50	50	0	50	-
	TRH C29-C36 Fraction (µg/L or ppb)	50	50	50	50	0	50	-
	TRH C10-C16 Fraction (µg/L or ppb)	2100	25	230	230	1143	1352	-
	TRH C10-C16 less Napthalene Fraction (µg/L or ppb)	2100	25	230	230	1143	1352	-
	TRH C16-C34 Fraction (µg/L or ppb)	140	50	50	50	52	104	-
	TRH C34-C40 Fraction (µg/L or ppb)	50	50	50	50	0	50	-
Nutrients	Total Nitrogen (mg/L N)	2.99	0.68	1.16	1.16	1.22	2.26	-
	Total Phosphorus (mg/L P)	0.03	0.02	0.03	0.03	0.01	0.03	-
Major Cations	Sodium (mg/L)	54.3	115	174	115	60	150	-
	Potassium (mg/L)	2.5	6.1	4.8	4.8	1.8	5.6	-
	Calcium (mg/L)	43.1	38.2	42.8	42.8	2.7	43.0	-
	Magnesium (mg/L)	8.6	14.9	17.9	15	5	17	-
Major Anions	Chloride (mg/L)	67	84	154	84	46	126	-
	Sulfate (mg/L SO42)	8	26	105	26	52	73	-
	Bicarbonate (Alkalinity) (mg/L CaCO3 equiv)	175	55	340	175	143	274	-
Heavy Metals (Dissolved)	Aluminium (mg/L)	0.034	0.023	0.06	0.034	0.019	0.050	-
	Cadmium (mg/L)	0.0005	0.0005	0.0005	0.001	0.000	0.001	-
	Copper (mg/L)	0.001	0.0005	0.003	0.001	0.001	0.002	-
	Lead (mg/L)	0.001	0.0005	0.0005	0.001	0.000	0.001	-
	Zinc (mg/L)	0.048	0.003	0.029	0.029	0.023	0.040	-
BTEX	Benzene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	Toluene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	Ethylbenzene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	m+p-Xylene (µg/L or ppb)	1	1	1	1.0	0.0	1.0	-
	o-Xylene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	Napthalene (µg/L or ppb)2	0.5	0.5	0.5	0.5	0.0	0.5	-

Table B.4 Groundwater quality results – GWB9 - Big Cut – Ch 7860

Parameter / Analytical Groups	Row Labels	12/11/2013	10/02/2014	09/04/2014	Median	Standard Deviation	P80	P20
Physical and chemical properties	pH	4.59	5.92	5.87	5.9	0.8	5.9	5.1
	Temp. (°C)	24.18	25.19	24.27	24.3	0.6	24.8	-
	EC (mS/cm)	0.523	0.532	0.657	0.5	0.1	0.6	0.5
	DO (mg/L)	2.99	1.45	2.44	2.4	0.8	2.8	1.8
	Turbidity (NTU)	43.2	11.2	39.4	39	17	42	-
	TDS (g/L) (Solids)	0.335	553	533	533.00	313.47	545.00	213.40
Hydrocarbons	TRH C6-C9 Fraction (µg/L or ppb)	5	5	5	5	0	5	-
	TRH C10-C14 Fraction (µg/L or ppb)	4900	2900	220	2900	2348	4100	-
	TRH C15-C28 Fraction (µg/L or ppb)	120	190	0	120	96	162	-
	TRH C29-C36 Fraction (µg/L or ppb)	50	50	50	50	0	50	-
	TRH C10-C16 Fraction (µg/L or ppb)	4900	2900	230	2900	2343	4100	-
	TRH C10-C16 less Napthalene Fraction (µg/L or ppb)	4900	2900	230	2900	2343	4100	-
	TRH C16-C34 Fraction (µg/L or ppb)	160	220	50	160	86	196	-
	TRH C34-C40 Fraction (µg/L or ppb)	50	50	50	50	0	50	-
Nutrients	Total Nitrogen (mg/L N)	4.79	0.84	0.75	0.84	2.31	3.21	-
	Total Phosphorus (mg/L P)	0.03	0.02	0.03	0.03	0.01	0.03	-
Major Cations	Sodium (mg/L)	77.4	106	94.1	94	14	101	-
	Potassium (mg/L)	3.7	4.7	5.7	4.7	1.0	5.3	-
	Calcium (mg/L)	4.6	7.6	5.4	5.4	1.6	6.7	-
	Magnesium (mg/L)	10.5	17.6	20.5	18	5	19	-
Major Anions	Chloride (mg/L)	127	165	299	165	90	245	-
	Sulfate (mg/L SO42)	18	16	62	18	26	44	-
	Bicarbonate (Alkalinity) (mg/L CaCO3 equiv)	34	195	60	60	86	141	-
Heavy Metals (Dissolved)	Aluminium (mg/L)	0.478	0.313	0.431	0.431	0.085	0.459	-
	Cadmium (mg/L)	0.0005	0.0005	0.0005	0.001	0.000	0.001	-
	Copper (mg/L)	0.068	0.005	0.011	0.011	0.035	0.045	-
	Lead (mg/L)	0.009	0.003	0.003	0.003	0.003	0.007	-
	Zinc (mg/L)	0.062	0.012	0.02	0.020	0.027	0.045	-
BTEX	Benzene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	Toluene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	Ethylbenzene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	m+p-Xylene (µg/L or ppb)	1	1	1	1.0	0.0	1.0	-
	o-Xylene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	Napthalene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-

Table B.5 Groundwater quality results – GWB12 - Big Cut – Ch 8200

Parameter / Analytical Groups	Row Labels	11/11/2013	10/02/2014	09/04/2014	Median	Standard Deviation	P80	P20
Physical and chemical properties	pH			5.57	5.6	0.0	5.6	5.6
	Temp. (°C)			23.75	23.8	0.0	23.8	-
	EC (mS/cm)			0.299	0.3	0.0	0.3	0.3
	DO (mg/L)			3.56	3.6	0.0	3.6	3.6
	Turbidity (NTU)			3.8	4	0	4	-
	TDS (g/L) (Solids)							
Hydrocarbons	TRH C6-C9 Fraction (µg/L or ppb)			5	5	0	5	-
	TRH C10-C14 Fraction (µg/L or ppb)			25	25	0	25	-
	TRH C15-C28 Fraction (µg/L or ppb)			50	50	0	50	-
	TRH C29-C36 Fraction (µg/L or ppb)			50	50	0	50	-
	TRH C10-C16 Fraction (µg/L or ppb)			25	25	0	25	-
	TRH C10-C16 less Napthalene Fraction (µg/L or ppb)			25	25	0	25	-
	TRH C16-C34 Fraction (µg/L or ppb)			50	50	0	50	-
	TRH C34-C40 Fraction (µg/L or ppb)			50	50	0	50	-
Nutrients	Total Nitrogen (mg/L N)							-
	Total Phosphorus (mg/L P)							-
Major Cations	Sodium (mg/L)							-
	Potassium (mg/L)							-
	Calcium (mg/L)							-
	Magnesium (mg/L)							-
Major Anions	Chloride (mg/L)							-
	Sulfate (mg/L SO42)							-
	Bicarbonate (Alkalinity) (mg/L CaCO3 equiv)							-
Heavy Metals (Dissolved)	Aluminium (mg/L)							-
	Cadmium (mg/L)							-
	Copper (mg/L)							-
	Lead (mg/L)							-
	Zinc (mg/L)							-
BTEX	Benzene (µg/L or ppb)			0.5	0.5	0.0	0.5	-
	Toluene (µg/L or ppb)			0.5	0.5	0.0	0.5	-
	Ethylbenzene (µg/L or ppb)			0.5	0.5	0.0	0.5	-
	m+p-Xylene (µg/L or ppb)			1	1.0	0.0	1.0	-
	o-Xylene (µg/L or ppb)			0.5	0.5	0.0	0.5	-
	Napthalene (µg/L or ppb)			0.5	0.5	0.0	0.5	-

Note: GWB12 had a low yield throughout the duration of the monitoring period. Insufficient water was available to perform analysis in November and February, with only enough water available to perform a partial analysis of parameters in April.

Table B.6 Groundwater quality results – GWB16 - Range Road East – Ch 9820

Parameter / Analytical Groups	Row Labels	12/11/2013	10/02/2014	09/04/2014	Median	Standard Deviation	P80	P20
Physical and chemical properties	pH	7.01	6.49	6.95	7.0	0.3	7.0	6.7
	Temp. (°C)	27.02	25.8	24.64	25.8	1.2	26.5	-
	EC (mS/cm)	1.11	1.28	1.18	1.2	0.1	1.2	1.1
	DO (mg/L)	1.69	2.31	2.82	2.3	0.6	2.6	1.9
	Turbidity (NTU)	5.7	3.2	3.8	4	1	5	-
	TDS (g/L) (Solids)	0.709	720	680	680.00	404.23	704.00	272.43
Hydrocarbons	TRH C6-C9 Fraction (µg/L or ppb)	5	5	5	5	0	5	-
	TRH C10-C14 Fraction (µg/L or ppb)	25	25	25	25	0	25	-
	TRH C15-C28 Fraction (µg/L or ppb)	50	50	50	50	0	50	-
	TRH C29-C36 Fraction (µg/L or ppb)	50	50	50	50	0	50	-
	TRH C10-C16 Fraction (µg/L or ppb)	25	25	25	25	0	25	-
	TRH C10-C16 less Napthalene Fraction (µg/L or ppb)	25	25	25	25	0	25	-
	TRH C16-C34 Fraction (µg/L or ppb)	50	50	50	50	0	50	-
	TRH C34-C40 Fraction (µg/L or ppb)	50	50	50	50	0	50	-
Nutrients	Total Nitrogen (mg/L N)	0.05	0.29	0.27	0.27	0.13	0.28	-
	Total Phosphorus (mg/L P)	0.02	0.01	0.02	0.02	0.01	0.02	-
Major Cations	Sodium (mg/L)	210.9	242	233	233	16	238	-
	Potassium (mg/L)	3.3	3.6	3.3	3.3	0.2	3.5	-
	Calcium (mg/L)	20.2	32.2	20	20.2	7.0	27.4	-
	Magnesium (mg/L)	12.9	18.9	15	15	3	17	-
Major Anions	Chloride (mg/L)	237	279	356	279	60	325	-
	Sulfate (mg/L SO42)	36	56	95	56	30	79	-
	Bicarbonate (Alkalinity) (mg/L CaCO3 equiv)	190	195	190	190	3	193	-
Heavy Metals (Dissolved)	Aluminium (mg/L)	0.007	0.001	0.004	0.004	0.003	0.006	-
	Cadmium (mg/L)	0.0005	0.0005	0.0005	0.001	0.000	0.001	-
	Copper (mg/L)	0.001	0.0005	0.001	0.001	0.000	0.001	-
	Lead (mg/L)	0.001	0.0005	0.0005	0.001	0.000	0.001	-
	Zinc (mg/L)	0.085	0.01	0.013	0.013	0.042	0.056	-
BTEX	Benzene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	Toluene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	Ethylbenzene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	m+p-Xylene (µg/L or ppb)	1	1	1	1.0	0.0	1.0	-
	o-Xylene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	Napthalene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-

Table B.7 Groundwater quality results – GWB17 - Range Road East – Ch 9820

Parameter / Analytical Groups	Row Labels	11/11/2013	10/02/2014	08/04/2014	Median	Standard Deviation	P80	P20
Physical and chemical properties	pH	6.78	6.64	6.89	6.8	0.1	6.8	6.7
	Temp. (°C)	24.1	29.66	22.6	24.1	3.7	27.4	-
	EC (mS/cm)	3.34	3.5	2.65	3.3	0.5	3.4	2.9
	DO (mg/L)	1.35	1.88	2.61	1.9	0.6	2.3	1.6
	Turbidity (NTU)	5.1	40	31.7	32	18	37	-
	TDS (g/L) (Solids)	2.14	2520	2313	2313.00	1397.77	2437.20	926.48
Hydrocarbons	TRH C6-C9 Fraction (µg/L or ppb)	5	5	5	5	0	5	-
	TRH C10-C14 Fraction (µg/L or ppb)	25	25	25	25	0	25	-
	TRH C15-C28 Fraction (µg/L or ppb)	330	50	50	50	162	218	-
	TRH C29-C36 Fraction (µg/L or ppb)	170	50	50	50	69	122	-
	TRH C10-C16 Fraction (µg/L or ppb)	25	25	25	25	0	25	-
	TRH C10-C16 less Napthalene Fraction (µg/L or ppb)	25	25	25	25	0	25	-
	TRH C16-C34 Fraction (µg/L or ppb)	450	50	50	50	231	290	-
	TRH C34-C40 Fraction (µg/L or ppb)	50	50	50	50	0	50	-
Nutrients	Total Nitrogen (mg/L N)	0.09	0.06	0.07	0.07	0.02	0.08	-
	Total Phosphorus (mg/L P)	0.06	0.01	0.01	0.01	0.03	0.04	-
Major Cations	Sodium (mg/L)	415	456	420	420	22	442	-
	Potassium (mg/L)	13.8	12.9	13.9	13.8	0.6	13.9	-
	Calcium (mg/L)	189.2	198	197	197.0	4.8	197.6	-
	Magnesium (mg/L)	73.8	74.3	77.6	74	2	76	-
Major Anions	Chloride (mg/L)	811	798	926	811	70	880	-
	Sulfate (mg/L SO42)	94	90	148	94	32	126	-
	Bicarbonate (Alkalinity) (mg/L CaCO3 equiv)	420	385	400	400	18	412	-
Heavy Metals (Dissolved)	Aluminium (mg/L)	0.005	0.001	0.004	0.004	0.002	0.005	-
	Cadmium (mg/L)	0.0005	0.0005	0.0005	0.001	0.000	0.001	-
	Copper (mg/L)	0.0005	0.0005	0.0005	0.001	0.000	0.001	-
	Lead (mg/L)	0.001	0.0005	0.0005	0.001	0.000	0.001	-
	Zinc (mg/L)	0.021	0.003	0.01	0.010	0.009	0.017	-
BTEX	Benzene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	Toluene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	Ethylbenzene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	m+p-Xylene (µg/L or ppb)	1	1	1	1.0	0.0	1.0	-
	o-Xylene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	Napthalene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-

Table B.8 Groundwater quality results – GWB18 - Falconers Lane – Ch 11350

Parameter / Analytical Groups	Row Labels	14/11/2013	10/02/2014	08/04/2014	Median	Standard Deviation	P80	P20
Physical and chemical properties	pH		6.71	6.84	6.8	0.1	6.8	6.7
	Temp. (°C)		24.36	23.53	23.9	0.6	24.2	-
	EC (mS/cm)		2.45	2.65	2.6	0.1	2.6	2.5
	DO (mg/L)		2.27	2.61	2.4	0.2	2.5	2.3
	Turbidity (NTU)		224	31.7	128	136	186	-
	TDS (g/L) (Solids)		3530	3167	3348.50	256.68	3457.40	3239.60
Hydrocarbons	TRH C6-C9 Fraction (µg/L or ppb)		5	5	5	0	5	-
	TRH C10-C14 Fraction (µg/L or ppb)		25	25	25	0	25	-
	TRH C15-C28 Fraction (µg/L or ppb)		50	50	50	0	50	-
	TRH C29-C36 Fraction (µg/L or ppb)		50	50	50	0	50	-
	TRH C10-C16 Fraction (µg/L or ppb)		25	25	25	0	25	-
	TRH C10-C16 less Napthalene Fraction (µg/L or ppb)		25	25	25	0	25	-
	TRH C16-C34 Fraction (µg/L or ppb)		50	50	50	0	50	-
	TRH C34-C40 Fraction (µg/L or ppb)		50	50	50	0	50	-
Nutrients	Total Nitrogen (mg/L N)		0.1	0.09	0.10	0.01	0.10	-
	Total Phosphorus (mg/L P)		0.13	0.13	0.13	0.00	0.13	-
Major Cations	Sodium (mg/L)		456	436	446	14	452	-
	Potassium (mg/L)		5.8	5.4	5.6	0.3	5.7	-
	Calcium (mg/L)		221	232	226.5	7.8	229.8	-
	Magnesium (mg/L)		50.1	55.8	53	4	55	-
Major Anions	Chloride (mg/L)		337	442	390	74	421	-
	Sulfate (mg/L SO42)		82	137	110	39	126	-
	Bicarbonate (Alkalinity) (mg/L CaCO3 equiv)		730	735	733	4	734	-
Heavy Metals (Dissolved)	Aluminium (mg/L)		0.188	0.07	0.129	0.083	0.164	-
	Cadmium (mg/L)		0.0005	0.0005	0.001	0.000	0.001	-
	Copper (mg/L)		0.008	0.0005	0.004	0.005	0.007	-
	Lead (mg/L)		0.001	0.0005	0.001	0.000	0.001	-
	Zinc (mg/L)		0.033	0.005	0.019	0.020	0.027	-
BTEX	Benzene (µg/L or ppb)		0.5	0.5	0.5	0.0	0.5	-
	Toluene (µg/L or ppb)		0.5	0.5	0.5	0.0	0.5	-
	Ethylbenzene (µg/L or ppb)		0.5	0.5	0.5	0.0	0.5	-
	m+p-Xylene (µg/L or ppb)		1	1	1.0	0.0	1.0	-
	o-Xylene (µg/L or ppb)		0.5	0.5	0.5	0.0	0.5	-
	Napthalene (µg/L or ppb)		0.5	0.5	0.5	0.0	0.5	-

*Note: GWB18 had a low yield throughout the duration of the monitoring period. Insufficient water was available to perform analysis in the month of November.

Table B.9 Groundwater quality results – GWB22 - Kelman Property – Ch 13500

Parameter / Analytical Groups	Row Labels	13/11/2013	10/02/2014	11/04/2014	Median	Standard Deviation	P80	P20
Physical and chemical properties	pH	5.18	5.19	5.87	5.2	0.4	5.6	5.2
	Temp. (°C)	25.05	25.91	23.09	25.1	1.4	25.6	-
	EC (mS/cm)	1.49	2	1.16	1.5	0.4	1.8	1.3
	DO (mg/L)	1.84	1.78	2.61	1.8	0.5	2.3	1.8
	Turbidity (NTU)	190	170	509	190	190	381	-
	TDS (g/L) (Solids)	0.954	1320	520	520.00	664.49	1000.00	208.57
Hydrocarbons	TRH C6-C9 Fraction (µg/L or ppb)	5	5	5	5	0	5	-
	TRH C10-C14 Fraction (µg/L or ppb)	25	25	25	25	0	25	-
	TRH C15-C28 Fraction (µg/L or ppb)	50	50	50	50	0	50	-
	TRH C29-C36 Fraction (µg/L or ppb)	50	50	50	50	0	50	-
	TRH C10-C16 Fraction (µg/L or ppb)	25	25	25	25	0	25	-
	TRH C10-C16 less Napthalene Fraction (µg/L or ppb)	25	25	25	25	0	25	-
	TRH C16-C34 Fraction (µg/L or ppb)	50	50	50	50	0	50	-
	TRH C34-C40 Fraction (µg/L or ppb)	50	50	50	50	0	50	-
Nutrients	Total Nitrogen (mg/L N)	0.16	0.09	0.59	0.16	0.27	0.42	-
	Total Phosphorus (mg/L P)	0.03	0.01	0.1	0.03	0.05	0.07	-
Major Cations	Sodium (mg/L)	283	359	213	283	73	329	-
	Potassium (mg/L)	4	5.2	3.2	4.0	1.0	4.7	-
	Calcium (mg/L)	10.1	12	7.8	10.1	2.1	11.2	-
	Magnesium (mg/L)	15.9	24.4	10.2	16	7	21	-
Major Anions	Chloride (mg/L)	380	523	280	380	122	466	-
	Sulfate (mg/L SO42)	34	32	25	32	5	33	-
	Bicarbonate (Alkalinity) (mg/L CaCO3 equiv)	150	8	75	75	71	120	-
Heavy Metals (Dissolved)	Aluminium (mg/L)	0.275	0.507	0.249	0.275	0.142	0.414	-
	Cadmium (mg/L)	0.0005	0.0005	0.0005	0.001	0.000	0.001	-
	Copper (mg/L)	0.053	0.103	0.12	0.103	0.035	0.113	-
	Lead (mg/L)	0.006	0.001	0.004	0.004	0.003	0.005	-
	Zinc (mg/L)	0.257	0.299	0.169	0.257	0.066	0.282	-
BTEX	Benzene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	Toluene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	Ethylbenzene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	m+p-Xylene (µg/L or ppb)	1	1	1	1.0	0.0	1.0	-
	o-Xylene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	Napthalene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-

Table B.10 Groundwater quality results – GWB23 - Kelman Property – Ch 13540

Parameter / Analytical Groups	Row Labels	14/11/2013	10/02/2014	08/04/2014	Median	Standard Deviation	P80	P20
Physical and chemical properties	pH	5.9	6.6	5.98	6.0	0.4	6.4	5.9
	Temp. (°C)	26.97	28.52	22.46	27.0	3.1	27.9	-
	EC (mS/cm)	1.03	1.33	3.51	1.3	1.4	2.6	1.2
	DO (mg/L)	1.26	1.63	2.02	1.6	0.4	1.9	1.4
	Turbidity (NTU)	10.1	15.4	5	10	5	13	-
	TDS (g/L) (Solids)	0.657	845	607	607.00	435.36	749.80	243.19
Hydrocarbons	TRH C6-C9 Fraction (µg/L or ppb)	5	5	5	5	0	5	-
	TRH C10-C14 Fraction (µg/L or ppb)	570	150	460	460	218	526	-
	TRH C15-C28 Fraction (µg/L or ppb)	50	50	50	50	0	50	-
	TRH C29-C36 Fraction (µg/L or ppb)	50	50	50	50	0	50	-
	TRH C10-C16 Fraction (µg/L or ppb)	560	1500	440	560	580	1124	-
	TRH C10-C16 less Napthalene Fraction (µg/L or ppb)	560	1500	440	560	580	1124	-
	TRH C16-C34 Fraction (µg/L or ppb)	50	50	50	50	0	50	-
	TRH C34-C40 Fraction (µg/L or ppb)	50	50	50	50	0	50	-
Nutrients	Total Nitrogen (mg/L N)	2.9	1.6	1.93	1.93	0.68	2.51	-
	Total Phosphorus (mg/L P)	0.13	0.06	0.01	0.06	0.06	0.10	-
Major Cations	Sodium (mg/L)	240	309	214	240	49	281	-
	Potassium (mg/L)	1.7	2.2	1.7	1.7	0.3	2.0	-
	Calcium (mg/L)	11.1	12	5.5	11.1	3.5	11.6	-
	Magnesium (mg/L)	7	9.9	4.7	7	3	9	-
Major Anions	Chloride (mg/L)	238	303	349	303	56	331	-
	Sulfate (mg/L SO42)	9	20	93	20	46	64	-
	Bicarbonate (Alkalinity) (mg/L CaCO3 equiv)	263	245	175	245	46	256	-
Heavy Metals (Dissolved)	Aluminium (mg/L)	0.013	0.006	0.003	0.006	0.005	0.010	-
	Cadmium (mg/L)	0.0005	0.0005	0.0005	0.001	0.000	0.001	-
	Copper (mg/L)	0.001	0.001	0.001	0.001	0.000	0.001	-
	Lead (mg/L)	0.001	0.0005	0.0005	0.001	0.000	0.001	-
	Zinc (mg/L)	0.074	0.006	0.008	0.008	0.039	0.048	-
BTEX	Benzene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	Toluene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	Ethylbenzene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	m+p-Xylene (µg/L or ppb)	1	1	1	1.0	0.0	1.0	-
	o-Xylene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	Napthalene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-

Table B.11 Groundwater quality results – GWB30 - Glenugie State Forest – Ch 27120

Parameter / Analytical Groups	Row Labels	14/11/2013	10/02/2014	09/04/2014	Median	Standard Deviation	P80	P20
Physical and chemical properties	pH	7.33	7.29	7.41	7.3	0.1	7.4	7.3
	Temp. (°C)	26.54	26.57	22.46	26.5	2.4	26.6	-
	EC (mS/cm)	3.02	3.34	3.51	3.3	0.2	3.4	3.1
	DO (mg/L)	1.69	1.37	2.02	1.7	0.3	1.9	1.5
	Turbidity (NTU)	5.6	12	5	6	4	9	-
	TDS (g/L) (Solids)	1.93			1.93	0.00	1.93	1.93
Hydrocarbons	TRH C6-C9 Fraction (µg/L or ppb)	5	5	5	5	0	5	-
	TRH C10-C14 Fraction (µg/L or ppb)	4100	2100	660	2100	1728	3300	-
	TRH C15-C28 Fraction (µg/L or ppb)	190	50	50	50	81	134	-
	TRH C29-C36 Fraction (µg/L or ppb)	50	50	50	50	0	50	-
	TRH C10-C16 Fraction (µg/L or ppb)	4100	2100	640	2100	1737	3300	-
	TRH C10-C16 less Napthalene Fraction (µg/L or ppb)	4100	2100	640	2100	1737	3300	-
	TRH C16-C34 Fraction (µg/L or ppb)	240	50	50	50	110	164	-
	TRH C34-C40 Fraction (µg/L or ppb)	50	50	50	50	0	50	-
Nutrients	Total Nitrogen (mg/L N)	5.57			5.57	0.00	5.57	-
	Total Phosphorus (mg/L P)	0.13			0.13	0.00	0.13	-
Major Cations	Sodium (mg/L)	661			661	0	661	-
	Potassium (mg/L)	2.2			2.2	0.0	2.2	-
	Calcium (mg/L)	85.6			85.6	0.0	85.6	-
	Magnesium (mg/L)	15.6			16	0	16	-
Major Anions	Chloride (mg/L)	466			466	0	466	-
	Sulfate (mg/L SO42)	433			433	0	433	-
	Bicarbonate (Alkalinity) (mg/L CaCO3 equiv)	630			630	0	630	-
Heavy Metals (Dissolved)	Aluminium (mg/L)	0.007			0.007	0.000	0.007	-
	Cadmium (mg/L)	0.0005			0.001	0.000	0.001	-
	Copper (mg/L)	0			0.000	0.000	0.000	-
	Lead (mg/L)	0.0005			0.001	0.000	0.001	-
	Zinc (mg/L)	0.004			0.004	0.000	0.004	-
BTEX	Benzene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	Toluene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	Ethylbenzene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	m+p-Xylene (µg/L or ppb)	1	1	1	1.0	0.0	1.0	-
	o-Xylene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-
	Napthalene (µg/L or ppb)	0.5	0.5	0.5	0.5	0.0	0.5	-

*Note: GWB30 had a low yield throughout the duration of the monitoring period. Insufficient water was available to perform a full analysis of parameters in February and April.

Table B.12 Groundwater quality results – GWB31 - Glenugie State Forest – Ch 27130

Parameter / Analytical Groups	Row Labels	14/11/2013	10/02/2014	09/04/2014	Median	Standard Deviation	P80	P20
Physical and chemical properties	pH			6.96	7.0	0.0	7.0	7.0
	Temp. (°C)			21.51	21.5	0.0	21.5	-
	EC (mS/cm)			1.48	1.5	0.0	1.5	1.5
	DO (mg/L)			3.4	3.4	0.0	3.4	3.4
	Turbidity (NTU)			131	131	0	131	-
	TDS (g/L) (Solids)							
Hydrocarbons	TRH C6-C9 Fraction (µg/L or ppb)			5	5	0	5	-
	TRH C10-C14 Fraction (µg/L or ppb)			25	25	0	25	-
	TRH C15-C28 Fraction (µg/L or ppb)			50	50	0	50	-
	TRH C29-C36 Fraction (µg/L or ppb)			50	50	0	50	-
	TRH C10-C16 Fraction (µg/L or ppb)			25	25	0	25	-
	TRH C10-C16 less Napthalene Fraction (µg/L or ppb)			25	25	0	25	-
	TRH C16-C34 Fraction (µg/L or ppb)			50	50	0	50	-
	TRH C34-C40 Fraction (µg/L or ppb)			50	50	0	50	-
Nutrients	Total Nitrogen (mg/L N)							-
	Total Phosphorus (mg/L P)							-
Major Cations	Sodium (mg/L)							-
	Potassium (mg/L)							-
	Calcium (mg/L)							-
	Magnesium (mg/L)							-
Major Anions	Chloride (mg/L)							-
	Sulfate (mg/L SO42)							-
	Bicarbonate (Alkalinity) (mg/L CaCO3 equiv)							-
Heavy Metals (Dissolved)	Aluminium (mg/L)							-
	Cadmium (mg/L)							-
	Copper (mg/L)							-
	Lead (mg/L)							-
	Zinc (mg/L)							-
BTEX	Benzene (µg/L or ppb)			0.5	0.5	0.5	0.5	-
	Toluene (µg/L or ppb)			0.5	0.5	0.5	0.5	-
	Ethylbenzene (µg/L or ppb)			0.5	0.5	0.5	0.5	-
	m+p-Xylene (µg/L or ppb)			1	1.0	1.0	1.0	-
	o-Xylene (µg/L or ppb)			0.5	0.5	0.5	0.5	-
	Napthalene (µg/L or ppb)			0.5	0.5	0.5	0.5	-

*Note: GWB31 had a low yield throughout the duration of the monitoring period. Insufficient water was available to perform analysis in November and February, with only enough water available to perform a partial analysis of parameters in April.

Appendix C

Sampling Location Access

C.1 Surface Water Sampling Locations

The location of each surface water sampling site is summarised in **Table C.1** and shown in **Illustration C.1** to **Illustration C.10.** Details of access to the site are also shown on the illustrations and described in **Table C.3**.

The sampling locations at each waterway are located on the downstream side of the proposed highway alignment at a location near the project boundary to enable the same locations to be utilised during the construction phase. This will enable direct comparison of results between the pre-construction and construction monitoring phases. At sites SW10 and SW11 where the proposed highway alignment adjoins the existing highway, the monitoring location has been positioned upstream of the existing highway to eliminate any 'interference' from runoff from the existing highway.

Table C.1 Location of Surface Water Sampling Sites

Site Identifier	*Waterway*	*Chainage*	*Easting*	*Northing*
SW01	Arrawarra Gully	300	517940	6675429
SW02	Corindi River	3,600	517677	6678593
SW03	Blackadder Gully	4,000	517771	6678843
SW04	Cassons Creek	4,750	517077	6679559
SW05	Redbank Creek	5,650	516554	6680301
SW06	Dirty Creek	8,500	514420	6682393
SW07	Dundoo Creek	10,700	513233	6683823
SW08	Boneys Creek	13,350	512444	6686105
SW09	Halfway Creek	20,700	506490	6690540
SW10	Wells Crossing	22,400	506310	6692125
SW11	Glenugie Creek	29,300	504320	6698688

C.2 Groundwater Sampling Locations

The location and site access to each groundwater sampling site is shown in **Illustration C.1** to **Illustration C.21**. The locations are summarised overleaf in **Table C.2.**

Table C.2 Location of Groundwater Sampling Sites

Highway Section of Woolgoolga to Ballina Upgrade	*Borehole Identifier*	*Chainage*	*Easting*	*Northing*	*General Location*
Section 1 - Woolgoolga to Halfway Creek	GWB01	2500	517998	6677515	Kangaroo Trail Road
	GWB02	2520	518135	6677604	
	GWB03	2600	517972	6677612	
	GWB04	5300	516634	6679934	Post Office Lane
	GWB05	5320	516758	6680030	
	GWB06	7050	515618	6681360	Small Cut CH6990-7100
	GWB07	7050	515689	6681402	
	GWB08	7750	515113	6681805	Big Cut GWB08 adj BH69 GWB09 retrofitting BH74 GWB10 adj BH76 GWB12 adj BH78/P
	GWB09	7860	515223	6682099	
	GWB10	8040	515097	6682170	
	GWB12	8200	514893	6682218	
	GWB13	8780	514251	6682205	Flinty Road
	GWB14	8800	514284	6682387	
	GWB15	9400	513868	6682705	Range Road East
	GW064710[1]	9700	513440	6682842	
	GWB16	9820	513411	6682939	
	GWB17	9820	513706	6683082	
	GWB18	11350	513290	6684498	Falconers Lane
	GWB19	11400	513142	6684480	
	GWB20	12640	512877	6685655	Ch12520 - Ch12800
	GWB21	12650	513000	6685756	
	GWB22	13500	512237	6686159	Kelman Property
	GWB23	13540	512274	6686311	
Section 2 - Halfway Creek to Glenugie	GWB24	21600	506396	6691380	Ch21400 - Ch22220
	GWB25	21660	506512	6691373	
	GWB28	26860	505224	6696379	Glenugie State Forest
	GWB29	26880	505115	6696333	
	GWB30	27120	505218	6696658	
	GWB31	27130	505099	6696658	

Note: 1. GW064710 is a pre-existing property groundwater bore located close to the proposed highway alignment which will be monitored to provide background data prior to construction.

Table C.3 Surface Water Sampling Locations and Access

Site Information	*Access and Sample Location*	
SW01 - Arrawarra Gully		
Chainage: 300 Hwy; Ch 825 on Eggins Drive **Coordinates:** Easting:517939 Northing: 6675428	**Access**: ▪ access is directly off Eggins Drive at Chainage 825 (Eggins Drive), on the opposite side of the white painted fence (refer to **Table C.1**). **Sample Location**: ▪ southern bank of the gully, approximately 20 metres from Eggins Drive.	
SW02 - Corindi River		
Chainage: 3600 **Coordinates:** Easting: 517677 Northing: 6678592	**Access**: ▪ access is via first property driveway north of Corindi River (refer to **Illustration C.2**); ▪ at the end of the property, veer to the right of the property to the gate at the rear of the property; ▪ after passing through this gate, continue down the carriage-way as far as Blackadder Gully, and follow the adjoining fence south towards Corindi River; ▪ walk to the west and pass over the fence. The monitoring site is located in the upcoming clearing approximately 15 metres ahead; and ▪ alternate access is via the last property driveway before Casson's Creek (approximately 1.1 kilometres north). Follow this trail south towards Corindi River (refer to **Illustration C.2**). **Sample Location**: ▪ northern bank of Corindi River, on low terrace within main channel.	

Site Information	*Access and Sample Location*	
SW03 - Blackadder Gully		
Chainage: 3800 **Coordinates:** Easting: 517770 Northing: 6678843	**Access**: ▪ as described above, via first property driveway north of Corindi River (refer to **Illustration C.2**); ▪ upon reaching Blackadder Gully, pass over/under the northern fence of the Carriage-way to access the site; and ▪ alternate access is via the last property driveway before Casson's Creek (approximately 1.1 kilometres north). Follow this trail south towards Corindi River (refer to **Illustration C.2**). **Sample Location**: ▪ the sample location is found at the bend in the gully (refer to **Illustration C.2**).	
SW04 – Cassons Creek		
Chainage: 4750 **Coordinates:** Easting: 517077 Northing: 6679558	**Access**: ▪ access to the site is via the driveway immediately before Cassons Creek (refer to **Illustration C.3**); ▪ follow this track until a gate is reached approximately 650 metres from the driveway turn off; and ▪ upon reaching this gate, veer right and pass through the gate leading onto a bush trail. Follow this trail for approximately 120 metres before veering north towards the creek. **Sample Location**: ▪ the sample site is located in the stream approximately 20 metres north-west of the dominant Casson Creek water body/billabong.	

Site Information	*Access and Sample Location*	
SW05 – Redbank Creek		
Chainage: 5650 **Coordinates:** Easting: 516554 Northing: 6680300	**Access**: ▪ access is via Post Office Lane. Follow the driveway of 18 Post Office Lane until the track veers left; and ▪ veer to the right towards an opening in the bush, and follow this track to the site, as shown in **Illustration C.4**. **Sample Location**: ▪ sample site is located on the southern bank of Redbank Creek.	
SW06 – Dirty Creek		
Chainage: 8700 **Coordinates:** Easting: 514420 Northing: 6682392	**Access**: ▪ access is via Flinty Road. Follow Flinty Road for approximately 130 metres until entering the property on the right; ▪ follow this road for approximately 50 metres before veering right to reach Dirty Creek; and ▪ follow dirty creek upstream for approximately 80 metres (refer to **Illustration C.5**). **Sample Location**: ▪ sample site located on the southern bank of Dirty Creek where stream flow is higher and the creek is relatively narrow.	

Site Information	*Access and Sample Location*	
SW07 – Dundoo Creek		
Chainage: 10700 **Coordinates:** Easting: 513232 Northing: 6683823	**Access**: ▪ Access is via Dundoo Reach. Follow Dundoo Reach for approximately 250 metres before reaching Dundoo Creek (refer to **Illustration C.6**). **Sample Location**: ▪ Sample site is located approximately 20 metres west of Dundoo Reach, where the creek is relatively free from reeds.	
SW08 – Boneys Creek		
Coordinates: Easting: 512443 Northing: 6686104	**Access**: ▪ access to the site is via McPhilips Road. Follow McPhilips Road for approximately 80 metres; and ▪ enter the adjacent property to the left and walk in a westerly direction for approximately 100 metres before reaching Boneys Creek (refer to **Illustration C.7**). **Sample Location**: ▪ the sample site is located on the eastern bank of Boneys Creek.	

Site Information	*Access and Sample Location*	
SW09 – Halfway Creek		
Chainage: 20700 **Coordinates:** Easting: 506490 Northing: 6690539	**Access**: ▪ access to the site is via the service centre immediately north of Kungala Road; ▪ follow the grass track which runs parallel to the highway before reaching Halfway Creek; and ▪ walk west along Halfway Creek for approximately 60 metres to reach the site. **Sample Location**: ▪ the site is located on the southern bank of Halfway Creek, at a bend in the stream approximately 80 metres west of the Pacific Highway.	
SW10 – Wells Crossing		
Chainage: 22400 **Coordinates:** Easting: 506310 Northing: 6692125	**Access**: ▪ access to the site is directly off the Pacific Highway to the east (refer to **Illustration C.9**). **Sample Location**: ▪ the sample site is located on the northern bank of Wells Crossing, approximately 20 metres east of the Pacific Highway.	

Site Information	*Access and Sample Location*	
SW11 – Glenugie Creek		
Chainage: 29300 **Coordinates:** Easting: 504319 Northing: 6698687	**Access**: ▪ access to the site is directly off the Pacific Highway, on the eastern side of the northbound lane (refer to **Illustration C.10**). **Sample Location**: ▪ the sample site is located on the southern bank of Glenugie Creek, approximately 20 metres east of the Pacific Highway northbound dual lane.	

Table C.4 Groundwater Sampling Locations and Access

Site Information	*Access and Sample Location*
GWB01, GWB02, GWB03 – Kangaroo Trail Road	
Chainage: 2500-2600 **Coordinates:** **GWB01** Easting:517997 Northing: 6677515 **GWB02** Easting: 518135 Northing: 6677604 **GWB03** Easting: 517971 Northing: 6677611	Refer to **Illustration C.11** **Access:** ▪ **GWB01:** Follow Kangaroo Trail Road for approximately 550m until a clearing is reached at the top of the hill. The bore is located in the clearing south of Kangaroo Trail Road, approximately 20 metres from the road boundary. ▪ **GWB02:** Follow Kangaroo Trail Road for approximately 450 metres**.** The bore is located on the northern side of Kangaroo Trail Road**,** approximately 10 metres from the road boundary. ▪ **GWB03:** GWB03 is located in the field adjacent to GWB01**,** on the northern side of Kangaroo Trail Road. The bore is located approximately 75 metres into the field from the boundary of Kangaroo Trail Road, and approximately 70 metres west of the vegetation line.
GWB04, GWB05 – Post Office Lane	
Chainage: 5300 **Coordinates:** **GWB04** Easting: 516633 Northing: 6679934 **GWB05** Easting: 516757 Northing: 6680030	Refer to **Illustration C.12** **Access:** ▪ **GWB05:** Access is via Post Office Lane. Follow the track/driveway which enters onto 18 Post Office Lane. Continue on this track past the driveway of the last property, and follow the track to the left. Veer right (north-west) and continue along the track into the vegetation for a further 60 metres to arrive at GWB05. ▪ **GWB04**: To access GWB04, continue along the track from GWB05 in a south-west direction for a further 120 metres.
GWB06, GWB07 – Small Cut Ch. 7050	
Chainage: 7050 **Coordinates:** **GWB06** Easting: 515617 Northing: 6681359 **GWB07** Easting: 515689 Northing: 6681402	Refer to **Illustration C.13** **Access:** ▪ **GWB07:** Access is via Bottle Brush Drive. Take the first right on Bottle Brush Drive and follow this track for approximately 680 metres. Upon reaching the fork in the road adjacent to an on-ground water tank, veer right and continue for a further 140 metres before veering off left to anther track. **GWB07** is located a further 150 metres down this track. ▪ **GWB06:** From **GWB07** continue down this track for a further 70 metres
GWB08, GWB09, GWB10, GWB12 – Big Cut Ch. 7700-8200	
Chainage: 7700-8200 **Coordinates:** **GWB08** Easting: 515113 Northing: 6681805 **GWB09** Easting: 515223 Northing: 6682098 **GWB10** Easting: 515097	Refer to **Illustration C.14** **Access:** ▪ Access to all of the above sites is via the access road into the quarry at Dirty Creek on the western side of the existing highway. This access track is opposite to Barcoongere Way access on the eastern side of the Pacific Highway. ▪ Upon exiting the highway, stay on this track as it veers to the right (west), and then turns sharply left before heading steeply uphill to the south around the western fringe of the quarry. Veer right at the top of the hill and follow the track for approximately 100 metres to the south-

Site Information	*Access and Sample Location*
Northing: 6682170 **GWB12** Easting: 514892 Northing:6682217	west. Exit the vehicle at the western project boundary, which borders an aboriginal heritage site. Vehicle access through the aboriginal heritage area is not permitted. Therefore, proceed on foot for a further 80 metres before reaching an intersection in the track. ▪ **GWB08:** From the intersection**,** continue to follow the ridgeline to the south for approximately 300 metres. The bore is located on the left hand side of the track within another aboriginal heritage area. ▪ **GWB09:** From the previously mentioned intersection, follow the track downhill to the east for approximately 25 metres before veering north-east and walking for an additional 20 metres before arriving at the bore**.** ▪ **GWB10:** From the previously mentioned intersection, follow the track to the north-west for approximately 110 metres. Upon reaching a slight clearing on the right of the trail, continue into the clearing for approximately 40 metres before reaching the bore. ▪ **GWB12:** From **GWB10,** return to the track and continue in a north-west direction for approximately 200 metres. The bore is located where the trail veers to the left.
GWB13, GWB14 – Flinty Road Ch. 8800	
Chainage: 8800 **Coordinates:** **GWB13** Easting: 514250 Northing: 6682205 **GWB14** Easting: 514284 Northing: 6682386	Refer to **Illustration C.15** **Access:** ▪ **GWB14:** Access is via Flinty Road. Follow Flinty Road for approximately 130 metres from the highway then enter the "Johnson" property on the right. Continue along the Johnson property driveway and veer to the right to cross Dirty Creek. Continue uphill along the four-wheel drive track into the clearing for approximately 200 metres before reaching the bore. ▪ **GWB13:** From **GWB14,** continue south uphill along the track for additional 180 metres before reaching the bore at the edge of the vegetation line behind the shed and near the dam.
GWB15, GW064710, GWB16, GWB17 – Range Road East Ch. 9400-9800	
Chainage: 9400 - 9800 **Coordinates:** **GWB15** Easting: 513868 Northing: 6682705 **GWB064710** Easting: 513440 Northing: 6682842 **GWB16** Easting: 513410 Northing: 6682939 **GWB17** Easting: 513705 Northing: 6683082	Refer to **Illustration C.16** **Access:** ▪ **GWB17:** Access is from the south via Dirty Creek Road. Follow Dirty Creek Road for approximately 1.7 kilometres before turning left onto the gravel road at the intersection. Travel south west along the road for a further 400 metres to reach the bore on the northern side of the road. ▪ **GWB15:** Continue westward along gravel road from GWB17 for approximately 100 metres then turn left (south) onto an access track. Follow this track south along the highway, and then left as it veers to the west for approximately 580 metres before reaching GWB15. ▪ **GWB064710:** Access is via Range Road. From the existing highway drive 30 metres along Range Road then turn right at the first intersection and follow the road north for approximately 130 metres. Exit the vehicle and walk westward into the vegetated area for approximately 40 metres to reach the bore. ▪ **GWB16:** Continue north along the access road adjacent to GWB064710 for a further 80 metres then turn left at the intersection and continue westward for a further 30 metres. The bore is located on the northern side of the road amongst remnant vegetation.

Site Information	*Access and Sample Location*
GWB18, GWB19 – Falconers Lane Ch. 11350	
Chainage: 11350 **Coordinates:** **GWB18** Easting: 513290 Northing: 6684498 **GWB19** Easting: 513142 Northing: 6684479	Refer to **Illustration C.17** **Access:** ▪ **GWB18:** Access is from the south via Dirty Creek Road. Follow Dirty Creek Road for approximately 3.3 kilometres until the road comes to an end. The bore is located on the northern side of the road in the vegetated area, approximately 15 metres from the road boundary. ▪ **GWB19:** Access is via Falconers Lane. From the existing highway, follow Falconers Lane south for approximately 770 metres to where the road bends to the south-west. The bore is located on the southern side of the road, approximately 8 metres from the road boundary in a cleared area.
GWB20, GWB21 – Ch. 12650	
Chainage: 12,650 **Coordinates:** **GWB20** Easting: 512877 Northing: 6685655 **GWB21** Easting: 512999 Northing: 6685755	Refer to **Illustration C.18** **Access:** ▪ **GWB20:** Access is directly off Pacific Highway. Approximately 150 metres south of the McPhillips Road turn off, pull over on the north bound side of the Pacific Highway. The bore is located approximately 270 metres south west from the Pacific Highway. ▪ **GWB21:** Access is directly off Pacific Highway. Approximately 150 metres south of the McPhillips Road turn off, pull over on the south bound side of the Pacific Highway. The bore is located approximately 30 metres north-east of the Pacific Highway
GWB22, GWB23 – Kelman Property 13550	
Chainage: 13,550 **Coordinates:** **GWB22** Easting: 512237 Northing: 6686158 **GWB23** Easting: 512273 Northing: 6686310	Refer to **Illustration C.19** **Access:** ▪ **GWB22:** Access is via a driveway off the western side of the Pacific Highway approximately 200 metres north of the McPhillips Road intersection. Follow this driveway south-westward for approximately 100 metres before turning right (westward) into a cleared strip of vegetation. Follow this path for approximately 100 metres before reaching a small clearing where the bore is located on the left. ▪ **GWB23:** Access is from the south bound lane of the Pacific Highway via the access road located at chainage 13750 (approximately 560 metres north of the McPhillips Road intersection). Follow this road for approximately 20 metres from the highway before turning right and travelling for approximately 155 metres in an east-south-east direction. Continue east-south-east for a further 55 metres past the point where the road veers left into a driveway.

Site Information	*Access and Sample Location*
GWB24, GWB 25 – Ch. 21650	
Chainage: 21650 **Coordinates:** **GWB24** Easting: 506395 Northing: 6691379 **GWB25** Easting: 506500 Northing: 6691431	Refer to **Illustration C.20** **Access:** ▪ **GWB24:** Access is from a track adjacent to the west side of the Pacific Highway. Travel approximately 1.4 kilometres north of Kungala Road, and turn into the driveway on the western side of the Pacific Highway at chainage 21680. Follow this driveway for approximately 30 metres from the highway before turning left onto a track. Continue south along track for approximately 60 metres and then turn right (west) and precede approximately 30 metres between the vegetation to the bore. ▪ **GWB25:** Access is directly off the eastern side of the Pacific Highway approximately 1.37 kilometres north of Kungula Road. There is a 'left lane ends' sign here, as well as a private entrance/driveway running off the eastern side of the Pacific Highway. Follow this road for approximately 30 metres before reaching the bore on the right hand side of the road
GWB28, GWB29, GWB30, GWB31 – Ch. 26800 - 27200	
Chainage: 26800 - 27200 **Coordinates:** **GWB28** Easting: 505224 Northing: 6696378 **GWB29** Easting: 513440 Northing: 6696332 **GWB30** Easting: 505218 Northing: 6696657 **GWB31** Easting: 505098 Northing: 6696658	Refer to **Illustration C.21** **Access:** ▪ Access for all sites is directly off the Pacific Highway. ▪ **GWB28:** Access is directly off the eastern side of the Pacific Highway approximately 700 metres south of Franklins Road. Walk approximately 85 metres east into the vegetation to locate the bore. ▪ **GWB 29:** Access is directly off the western side of the Pacific Highway approximately 730 metres south of Franklins Road. Walk approximately 20 metres west into the vegetation to locate the bore. ▪ **GWB30:** Access is directly off the eastern side of the Pacific Highway approximately 450 metres south of Franklins Road. Walk approximately 90 metres west into the vegetation before turning south and walking for approximately 20 metres to locate the bore. ▪ **GWB31:** Access is directly off the western side of the Pacific Highway approximately 460 metres south of Franklins Road. Walk approximately 20 metres west to locate the bore.

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Source of base data: NSW Roads and Maritime Services

Information shown is for illustrative purposes only

NOTE: SW01 is located at Eggins Drive Ch.825 (Ch.300 Pacific Highway)

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North

SW01 - Arrawarra Gully Ch. 300

GeoLINK environmental management and design

W2G - Water Quality Monitoring Program
2134-1099

Illustration C.1

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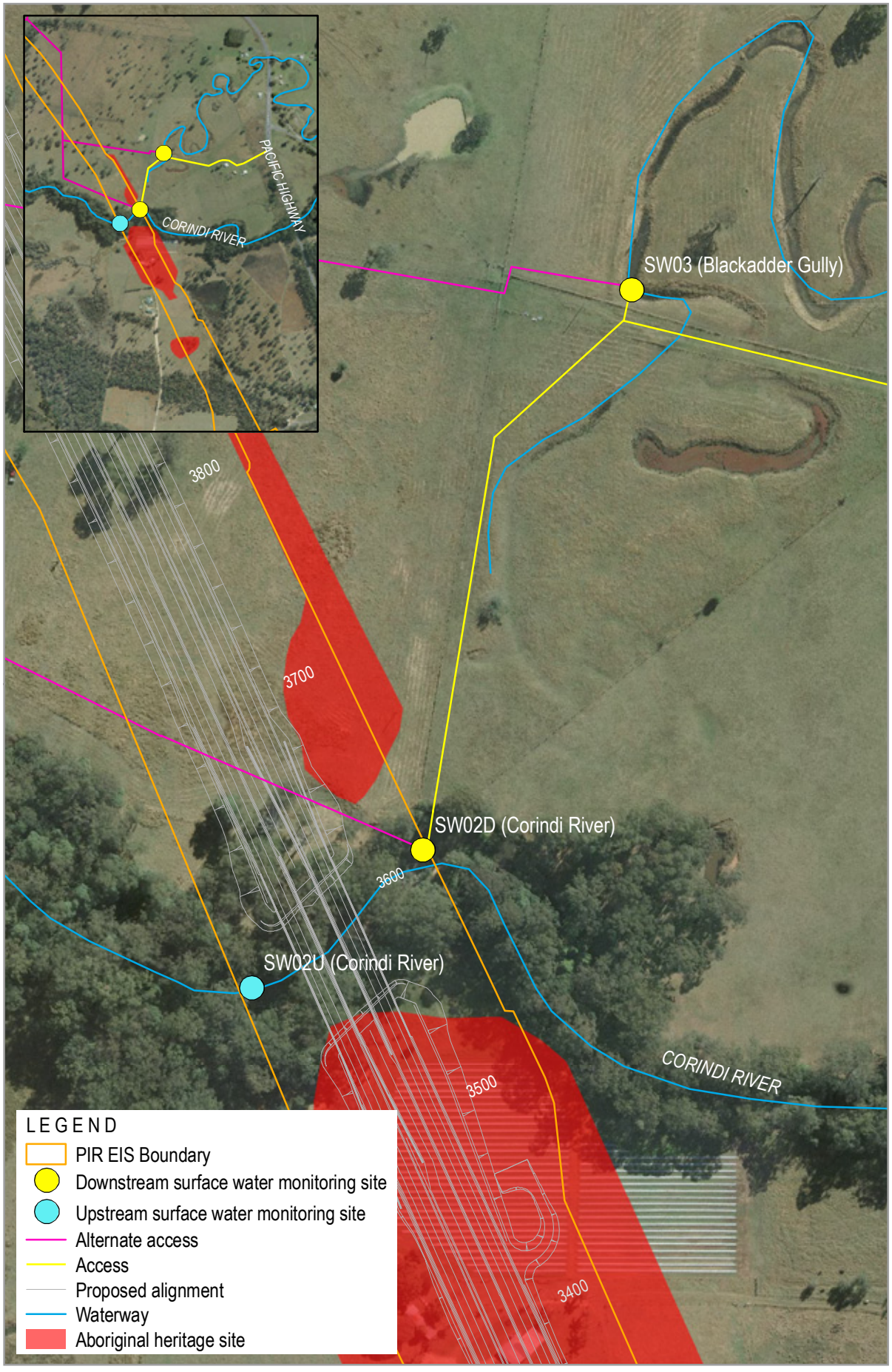
Source of base data: NSW Roads and Maritime Services



North

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SW02 SW03 - Corindi River Ch. 3600 & Blackadder Gully Ch. 3800

GeoLINK environmental management and design

W2G - Water Quality Monitoring Program
2134-1100

Illustration C.2

Information shown is for illustrative purposes only

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Source of base data: NSW Roads and Maritime Services

North

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SW04 - Cassons Creek Ch. 4750

GeoLINK environmental management and design

W2G - Water Quality Monitoring Program
2134-1101

Illustration C.3

Information shown is for illustrative purposes only

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Source of base data: NSW Roads and Maritime Services

North

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SW05 - Redbank Creek Ch. 5650

GeoLINK environmental management and design

W2G - Water Quality Monitoring Program
2134-1102

Illustration C.4

Information shown is for illustrative purposes only

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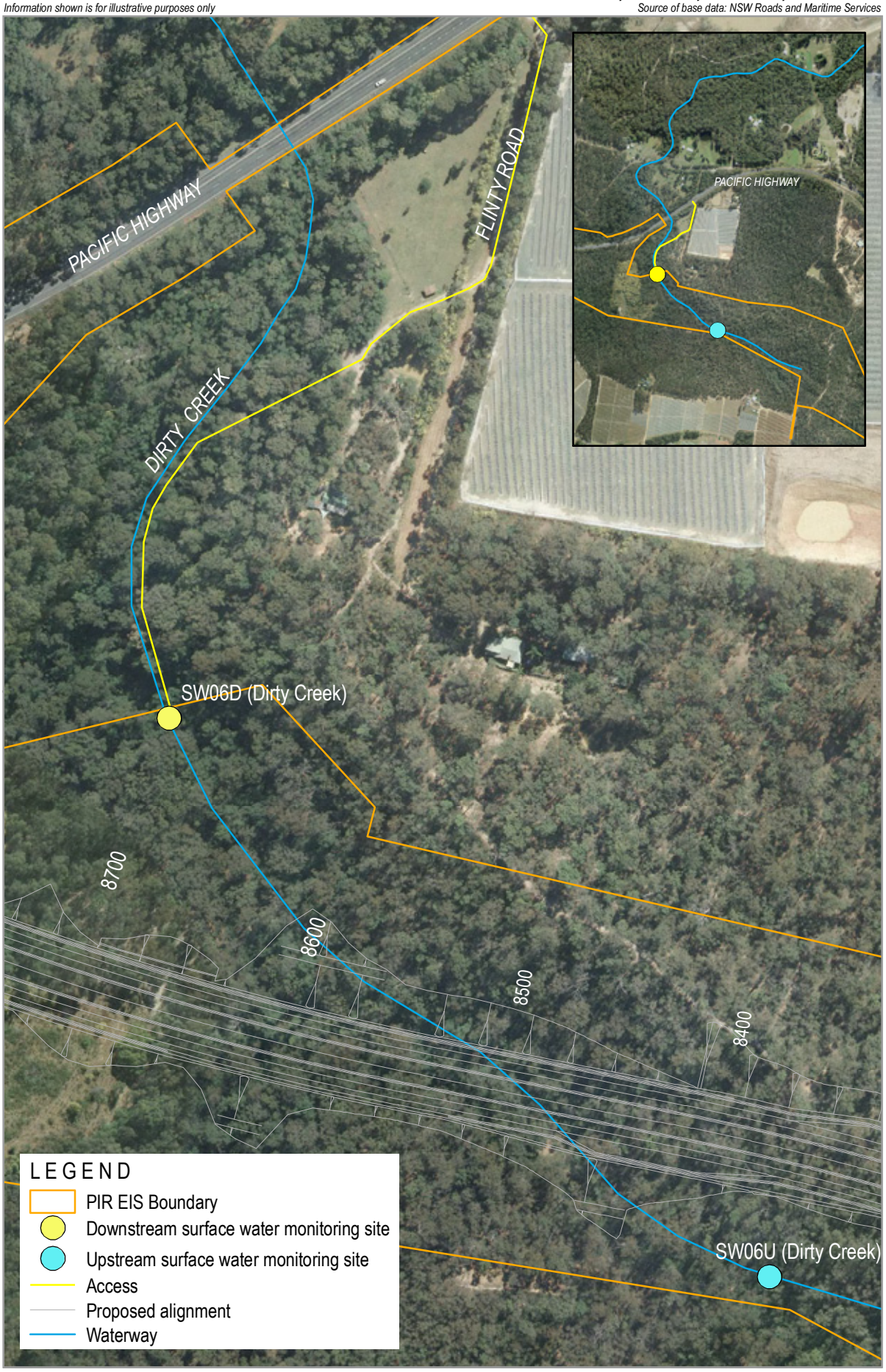
Source of base data: NSW Roads and Maritime Services



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North

SW06 - Dirty Creek Ch. 8700

GeoLINK environmental management and design

W2G - Water Quality Monitoring Program
2134-1103

Illustration C.5

Information shown is for illustrative purposes only

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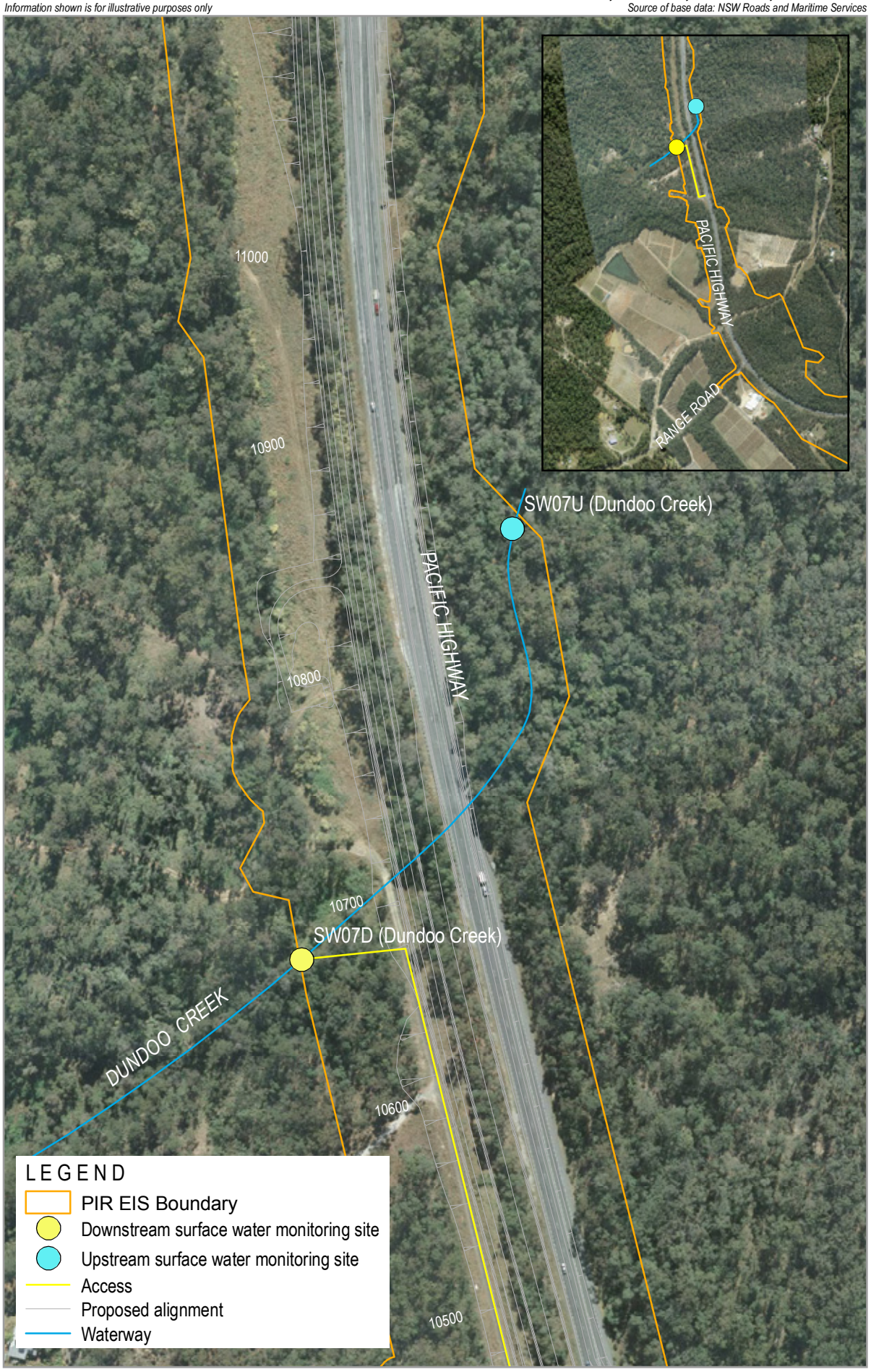
Source of base data: NSW Roads and Maritime Services



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North

SW07 - Dundoo Creek Ch. 10700

GeoLINK environmental management and design

W2G - Water Quality Monitoring Program
2134-1104

Illustration C.6

Information shown is for illustrative purposes only

Drawn by: RE Checked by: TIM Reviewed by: TIM Date: 09/10/14
Source of base data: NSW Roads and Maritime Services

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North

SW08 - Boneys Creek Ch. 13350

GeoLINK environmental management and design

W2G - Water Quality Monitoring Program
2134-1105

Illustration C.7

Information shown is for illustrative purposes only

Drawn by: RE Checked by: TIM Reviewed by: TIM Date: 09/10/14
Source of base data: NSW Roads and Maritime Services

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North

SW09 - Halfway Creek Ch. 20700

Information shown is for illustrative purposes only

Drawn by: RE Checked by: TIM Reviewed by: TIM Date: 09/10/14
Source of base data: NSW Roads and Maritime Services

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North

SW10 - Wells Crossing Ch. 22400

GeoLINK environmental management and design

W2G - Water Quality Monitoring Program
2134-1107

Illustration C.9

Information shown is for illustrative purposes only

Drawn by: RE Checked by: TIM Reviewed by: TIM Date: 09/10/14
Source of base data: NSW Roads and Maritime Services

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North

SW11 - Glenugie Creek Ch. 29300

Information shown is for illustrative purposes only

Drawn by: RE Checked by: MVE Reviewed by: TIM Date: March 2013
Source of base data: NSW Roads and Maritime Services

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North

GeoLINK environmental management and design

W2G - Water Quality Monitoring Program
2134-1018

GWB01 GWB02 GWB03 - Kangaroo Trail Road Ch. 2500 - 2600

Illustration C.11

Information shown is for illustrative purposes only

Drawn by: RE Checked by: MVE Reviewed by: TIM Date: March 2013
Source of base data: NSW Roads and Maritime Services

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North

GeoLINK environmental management and design

W2G - Water Quality Monitoring Program
2134-1021

GWB04 GWB05 - Post Office Lane Ch. 5300

Illustration C.12

Information shown is for illustrative purposes only

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Source of base data: NSW Roads and Maritime Services

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North

GeoLINK environmental management and design

W2G - Water Quality Monitoring Program
2134-1022

GWB06 GWB07 - Small Cut Ch. 7050

Illustration C.13

Information shown is for illustrative purposes only

Drawn by: RE Checked by: MVE Reviewed by: TIM Date: February 2013
Source of base data: NSW Roads and Maritime Services

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North

GeoLINK environmental management and design

W2G - Water Quality Monitoring Program
2134-1023

GWB08 GWB09 GWB10 GWB12 - Big Cut Ch. 7700 - 8200

Illustration C.14

Information shown is for illustrative purposes only

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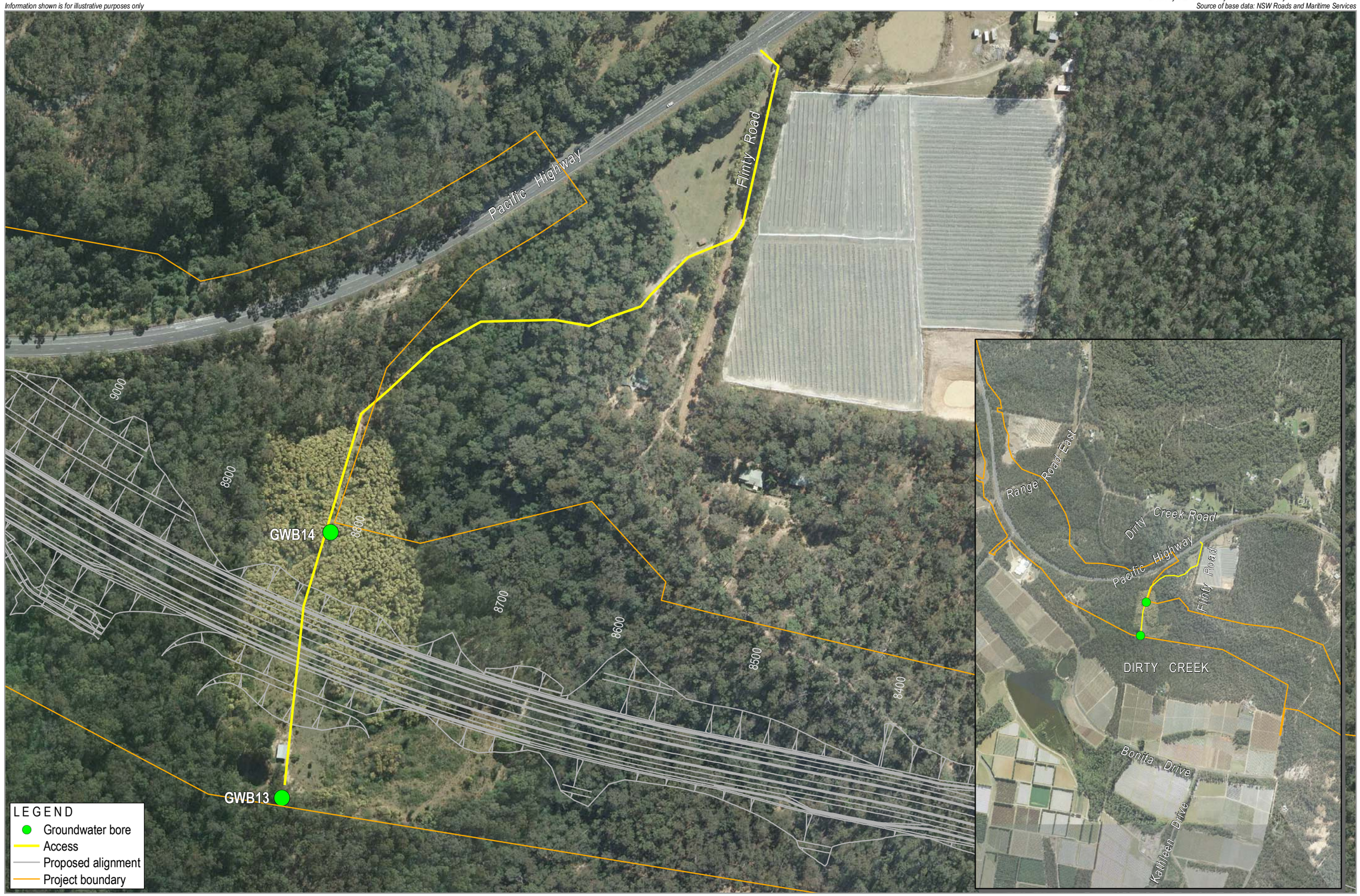
Source of base data: NSW Roads and Maritime Services



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North

GeoLINK environmental management and design

W2G - Water Quality Monitoring Program
2134-1024

GWB13 GWB14 - Flinty Road Ch. 8800

Illustration C.15

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Source of base data: NSW Roads and Maritime Services

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North

GeoLINK environmental management and design

W2G - Water Quality Monitoring Program
2134-1025

GWB15 GW064710 GWB16 GWB17 - Range Road East Ch. 9400 - 9800

Illustration C.16

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Source of base data: NSW Roads and Maritime Services

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North

GeoLINK environmental management and design

W2G - Water Quality Monitoring Program
2134-1026

GWB18 GWB19 - Falconers Lane Ch. 11350

Illustration C.17

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Source of base data: NSW Roads and Maritime Services

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North

GeoLINK environmental management and design

W2G - Water Quality Monitoring Program
2134-1027

GWB20 GWB21 - Ch. 12650

Illustration C.18

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Source of base data: NSW Roads and Maritime Services

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North

GeoLINK environmental management and design

W2G - Water Quality Monitoring Program
2134-1028

GWB22 GWB23 - Kelman Property Ch. 12650

Illustration C.19

Information shown is for illustrative purposes only

Drawn by: RE Checked by: MVE Reviewed by: TIM Date: March 2013
Source of base data: NSW Roads and Maritime Services

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North

GeoLINK environmental management and design

W2G - Water Quality Monitoring Program
2134-1029

GWB24 GWB25 - Ch. 21650

Illustration C.20

Information shown is for illustrative purposes only

Drawn by: RE Checked by: MVE Reviewed by: TIM Date: March 2013
Source of base data: NSW Roads and Maritime Services

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North

GeoLINK environmental management and design

W2G - Water Quality Monitoring Program
2134-1031

GWB28 GWB29 GWB30 GWB31 - Glenugie State Forest Ch. 26800 - 27200

Illustration C.21

Appendix D

Groundwater Dependent Ecosystem Assessment

D.1 Background

Groundwater Dependent Ecosystems (GDEs) are defined by the Office of Water (2012) as *'ecosystems which have their species composition and natural ecological processes wholly or partially determined by groundwater.'* These ecosystems can include subsurface ecosystems (such as Karst and cave systems) and surface ecosystems (including estuarine and near-shore marine ecosystems, groundwater dependent wetlands and groundwater dependent terrestrial vegetation). Considering the location of Sections 1 and 2 and the underlying geology, GDEs likely to occur would primarily consist of terrestrial vegetation communities.

There are a range of levels of groundwater dependence for vegetation communities. Some communities may only rely on groundwater on a seasonal basis or during extended drought periods. These are termed 'facultative GDEs'. Other communities may be entirely dependent on groundwater and are termed 'obligate GDEs'. Typically most karst, wetland and hypogean / aquifer GDEs, all baseflow and some terrestrial GDEs will be obligate (Office of Water 2012).

Office of Water (2012) use the rule of thumb that in those areas where water-table levels are more than 10m below ground level (areas of high dunes and hills) vegetation is less likely to be dependent on groundwater. It follows then that those areas most likely to support terrestrial vegetation GDEs are located in those parts of the landscape where the water-table is consistently the highest, such as on floodplains and in the riparian zone of creeks in hilly locations.

The Office of Water has produced a four volume set of risk assessment guidelines for GDEs consisting of:

- Volume 1 Risk assessment guidelines for groundwater dependent ecosystems – the conceptual framework;
- Volume 2 Risk assessment guidelines for groundwater dependent ecosystems - worked examples for seven pilot coastal aquifers;
- Volume 3 Identification of High Probability Groundwater Dependent Ecosystems on the Coastal Plains of NSW and their Ecological Value; and
- Volume 4 The Ecological Value of Groundwater Sources on the Coastal Plains of NSW and the Risk from groundwater extraction.

These Office of Water documents were reviewed to provide a background for determining the location and conservation value of high probability GDEs in Sections 1 and 2.

Other relevant documentation is contained within the W2B Working Papers for Biodiversity, Water Quality and Groundwater (RMS, Aurecon, SKM, 2012a, 2012b and 2012c). Vegetation mapping was undertaken as part of this biodiversity working paper including identifying those vegetation communities considered to be GDEs (refer to Table 3-5 of RMS, Aurecon, SKM, 2012a). These probable GDEs occurring in Sections 1 and 2 are:

- Paperbark swamp forest of the coastal lowlands of the North Coast;
- Swamp Box swamp forest of the coastal lowlands of the North Coast;
- Swamp Mahogany swamp forest of the coastal lowlands of the North Coast; and
- Swamp Oak swamp forest of the coastal lowlands of the North Coast.

This assessment aims to verify the status, location and extent of high probability GDEs in Sections 1 and 2 of the W2B Pacific Highway Upgrade. The assessment focuses on verifying the status of terrestrial vegetation GDEs as mapped for the W2B Biodiversity Working Paper (RMS, Aurecon, SKM, 2012a). This report also provides a prioritisation of these GDEs in terms of conservation significance and identification of locations for potential groundwater monitoring.

D.2 Methodology

The methodology undertaken for this assessment of GDEs is detailed below.

Desktop review

- Review documents including the Office of Water GDE risk assessment for GDEs (volumes 1-4, Office of Water 2012) and GDE information contained within reports prepared for the project EIS, including the W2B EIS Biodiversity Working Paper (RMS, Aurecon, SKM, 2012a) and W2B EIS Groundwater Working Paper (RMS, Aurecon, SKM, 2012b);
- Review GIS mapping of significant wetlands and floodplain areas (OEH data) occurring in Sections 1 and 2 that may indicate the location of GDEs; and
- Desktop review of vegetation mapping produced for Sections 1 and 2 within the W2B Biodiversity Working Paper (Figures 3-6 to 3-10 of RMS, Aurecon, SKM, 2012a). Identifying areas of high probability GDEs based on those vegetation communities listed as GDEs in RMS, Aurecon, SKM, 2012a.

Ground-truthing of high probability GDEs

During the desktop review of vegetation communities, some potential inaccuracies were noted in the identification and location of EECs, particularly in the hilly country within Section 2. Consequently, it was considered prudent to ground-truth all areas identified as high probability GDEs from the desktop review. Due to the nature of the investigation and time limitations, this did not involve intensive field work to establish vegetation mapping units. Instead, the ground-truthing aimed to look at each area identified as being a high probability GDE and to:

- Classify the vegetation within each area into the following broad vegetation types:
  - Swamp Sclerophyll Forest;
  - Mixed Eucalypt Floodplain Forest; and
  - Rainforest.
- Verify whether or not the vegetation types match the vegetation types within W2B Biodiversity Working Paper (RMS, Aurecon, SKM, 2012a); and
- Determine which areas qualify as Endangered Ecological Communities (EEC).

Determination of conservation significance of identified high probability GDEs

The methodology for determining the conservation significance of GDEs follows section 6.1, Volume 3 of Office and Water (2012) and is based around a subset of those variables identified in this document as being useful for indicating high conservation value of GDEs. This subset consists of the following variables: Areas that:

- Are an EEC;
- Are a rainforest community;
- Occur within one of the following:
  - National Park Estate; or
  - Area mapped as SEPP 14 Coastal Wetlands;
- Are listed on the Ramsar/ Directory of Important Wetlands (Protected Matters Search Tool online – http://www.environment.gov.au/epbc/pmst/index.html);
- Are identified as Critical Habitat (Office of Environment and Heritage);
- Are identified as Key Habitat under the NSW National Parks and Wildlife Service "Key Habitats and Corridors Mapping".

Mapping of high probability GDEs

A GIS layer was produced that compiles this information showing high probability GDEs, identification of GDEs that are also EECs, and an indication of the GDEs that are of high conservation value.

D.3 Identification of High Probability GDEs

Illustrations D.1 to **D.9** show the location and extent of high probability GDEs along sections 1 and 2 of the W2B Pacific Highway Upgrade Project. The EEC status of each area of vegetation is also shown on these illustrations.

No high probability wetland GDEs were identified within Sections 1 and 2.

High probability terrestrial vegetation GDEs were identified in Sections 1 and 2. To enable comparison with previous work undertaken for the highway upgrade, the nomenclature used for verification of vegetation communities corresponds as closely as possible to that used in the W2B Biodiversity Working Paper (RMS, Aurecon, SKM, 2012a). These vegetation units consist of:

- Swamp Forest – Paperbark;
- Swamp Forest - Swamp Box;
- Swamp Forest – Swamp Mahogany/ Forest Red Gum
- Swamp Oak Forest;
- Forest Red Gum-Swamp Box Forest;
- Narrow-leaved Red Gum Woodlands;
- Riparian Rainforest; and
- Lowland Rainforest

For the purposes of determining the likely occurrence of high probability GDEs, these communities were simplified into the following broad vegetation types:

- Swamp Sclerophyll Forest (combining Swamp Forest-Paperbark, Swamp Forest – Swamp Box, and Swamp Forest – Swamp Mahogany/ Forest Red Gum);
- Swamp Oak Floodplain Forest;
- Mixed Coastal Floodplain Forest (combining Forest Red Gum – Swamp Box Forest and Narrow-leaved Red Gum Woodlands); and
- Rainforest (consisting of Riparian Rainforest and Lowland Rainforest).

GDEs are identified by these broad vegetation types in **Illustrations D1** to **D9**.

These vegetation types include areas of vegetation that correspond with the following EECs:

- Swamp sclerophyll forest on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions;
- Swamp oak floodplain forest of the NSW North Coast, Sydney Basin and South East Corner bioregions,
- Subtropical coastal floodplain forest of the NSW North Coast bioregion; and
- Lowland Rainforest in NSW North Coast and Sydney Basin Bioregion.

Some discrepancies in the location of EECs as mapped in the W2B EIS Biodiversity Working Paper (RMS, Aurecon, SKM, 2012a) are apparent. For instance, some areas were broadly mapped in this GDE assessment as being swamp sclerophyll forest. However, this does not necessarily indicate that the vegetation type is consistent with all of the characteristics of Swamp Sclerophyll Forest EEC. For instance, in hilly areas of Section 2, vegetation that is floristically equivalent to Swamp Sclerophyll Forest EEC occurs along minor drainage lines. However, due to these areas being at elevations of greater than 50 m this is inconsistent with the determination of this vegetation as Swamp Sclerophyll Forest EEC (NSW Scientific Committee 2004).

The total areas of GDEs by broad vegetation type within approximately 100 m from the centre of the alignment are shown in **Table D.1**.

Table D.1 Areas of GDE by Broad Vegetation Type

Broad Vegetation Type	*Area (ha)*
Swamp Sclerophyll Forest	31.38
Swamp Oak Floodplain Forest	10.91
Mixed Coastal Floodplain Forest	23.63
Rainforest	0.59

D.4 Conservation Significance of GDEs

GDEs with the highest conservation significance according to the variables outlined in **Section D.2** are present in the following locations:

- GDEs corresponding to areas of EEC vegetation are primarily concentrated in the lowest elevation areas in the southern part of Section 1 between chainages 0 and 6000.
- A rainforest/ EEC (Lowland Rainforest) GDE is located at Dirty Creek near chainage 9000.
- GDEs that correspond with areas mapped as Key Habitat (NPWS Key Habitats and Corridor Mapping) are located in parts of Section 2 between chainages 16000 and 22500.

D.5 Potential impacts on GDEs

GDEs that are in proximity to prominent highway cuttings are the primary concern with changes relating to groundwater. However, none of the GDEs identified above with high conservation significance are in proximity to significant cuttings along the proposed W2G upgrade. Potentially the only exception is the lowland rainforest located at Chainage 9000 (refer to **Illustration D4**) which is approximately 700 m from the cutting near Range Road East (chainage 9400 – 9800) which will be monitored by GWB15, GW064710, GWB16 and GWB17. However, the nature of the topography between the cutting and the EEC would indicate that any potential impacts from the cutting on groundwater would not influence the groundwater system at the location of the EEC.

The other GDEs identified above with high conservation significance are located in areas where the proposed highway upgrade involves minor embankment fill that is not anticipated to have a significant impact on groundwater systems. In many of these locations the highway upgrade is located adjacent to the existing highway alignment. The highway upgrade also involves the construction of bridges and culverts at locations where GDEs have been identified alongside waterways thereby mitigating potential impacts to groundwater systems.

D.6 References

Office of Water (2012). *Risk assessment guidelines for groundwater dependent ecosystems (Volumes 1-4).* NSW Office of Water, Sydney, NSW.

NSW Scientific Committee (2004). Final determination - Swamp Sclerophyll Forest on Coastal Flood plains of the NSW North Coast, Sydney Basin and South East Corner bioregions.

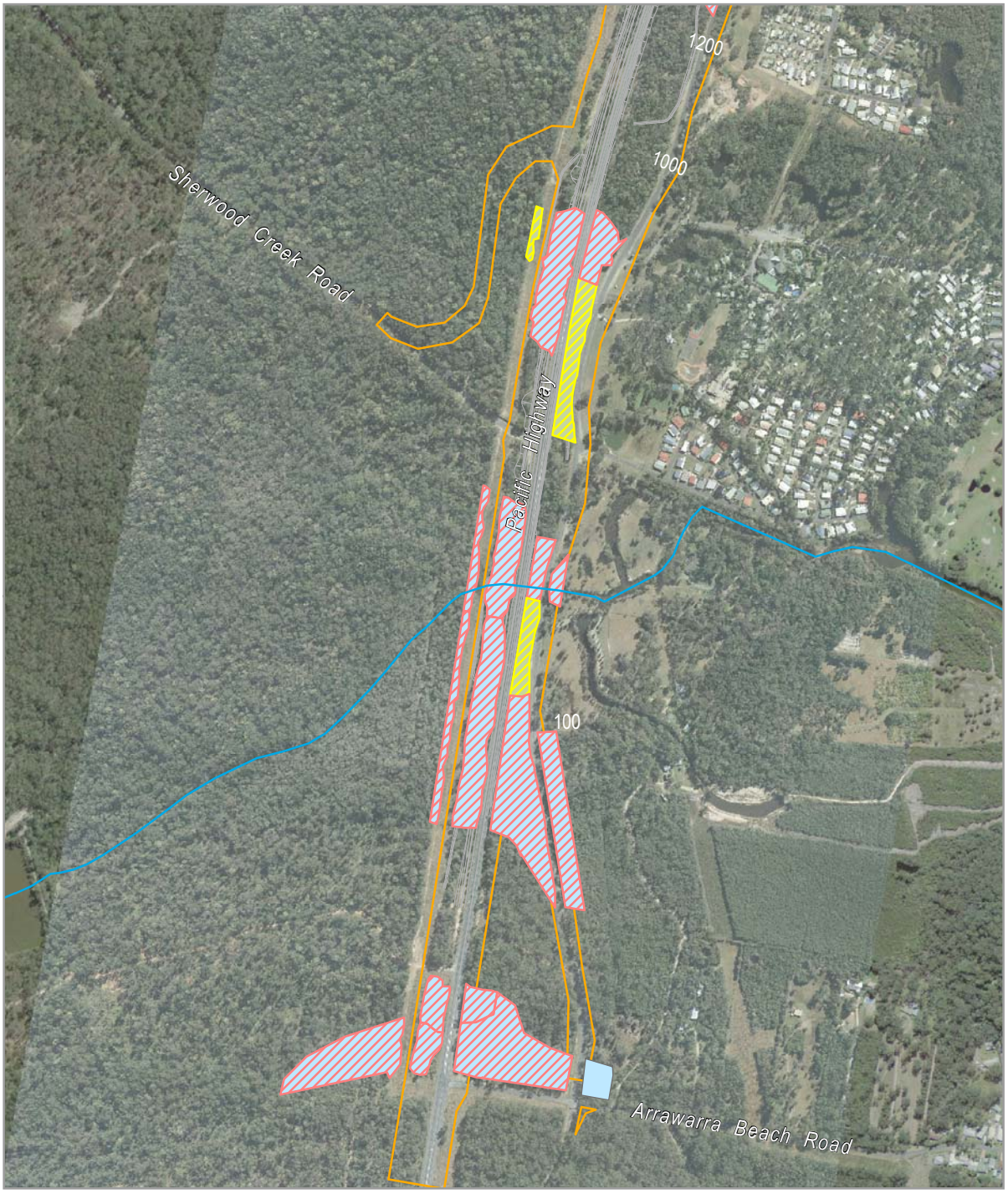
RMS, Aurecon, SKM (2012a). *Woolgoolga to Ballina EIS Working Paper*: *Biodiversity Assessment.* Report prepared for the Roads and Maritime Services NSW.

RMS, Aurecon, SKM (2012b). *Woolgoolga to Ballina EIS Working Paper*: *Groundwater.* Report prepared for the Roads and Maritime Services NSW.

RMS, Aurecon, SKM (2012c). *Woolgoolga to Ballina EIS Working Paper – Water Quality.* Report prepared for the Roads and Maritime Services. NSW Sample Parameters.

Information shown is for illustrative purposes only

Drawn by: RE Checked by: MVE Reviewed by: GJM Date: March 2013
Source of base data: Roads and Maritime Services



LEGEND

Waterways
W2G highway alignment
Project boundary

EEC

Swamp Oak Floodplain Forest
Swamp Sclerophyll Forest on Coastal Floodplains

Vegetation Type

Swamp Oak Forest
Swamp Sclerophyll Forest

North

0 200

Location of High Probability GDEs - W2G

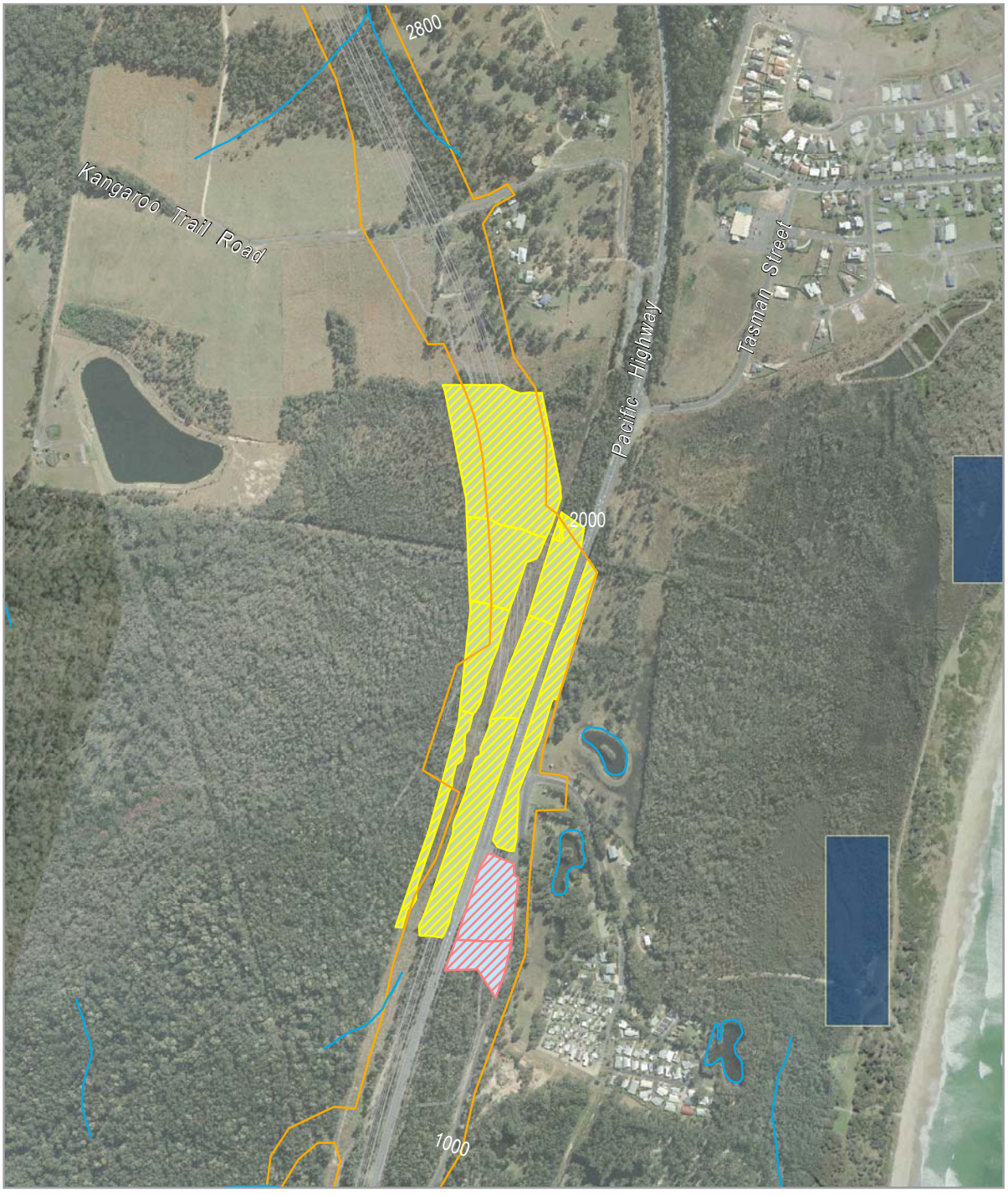
GeoLINK environmental management and design

W2G - Surface and Groundwater Quality Monitoring Protocol
2134-1032

Illustration D1

Information shown is for illustrative purposes only

Drawn by: RE Checked by: MVE Reviewed by: TJP Date: March 2013
Source of base data: Roads and Maritime Services



LEGEND

- Waterway
- Project boundary
- W2G highway alignment
- Key habitat

EEC

- Swamp Oak Floodplain Forest
- Swamp Sclerophyll Forest on Coastal Floodplains

Vegetation Type

- Swamp Oak Forest
- Swamp Sclerophyll Forest

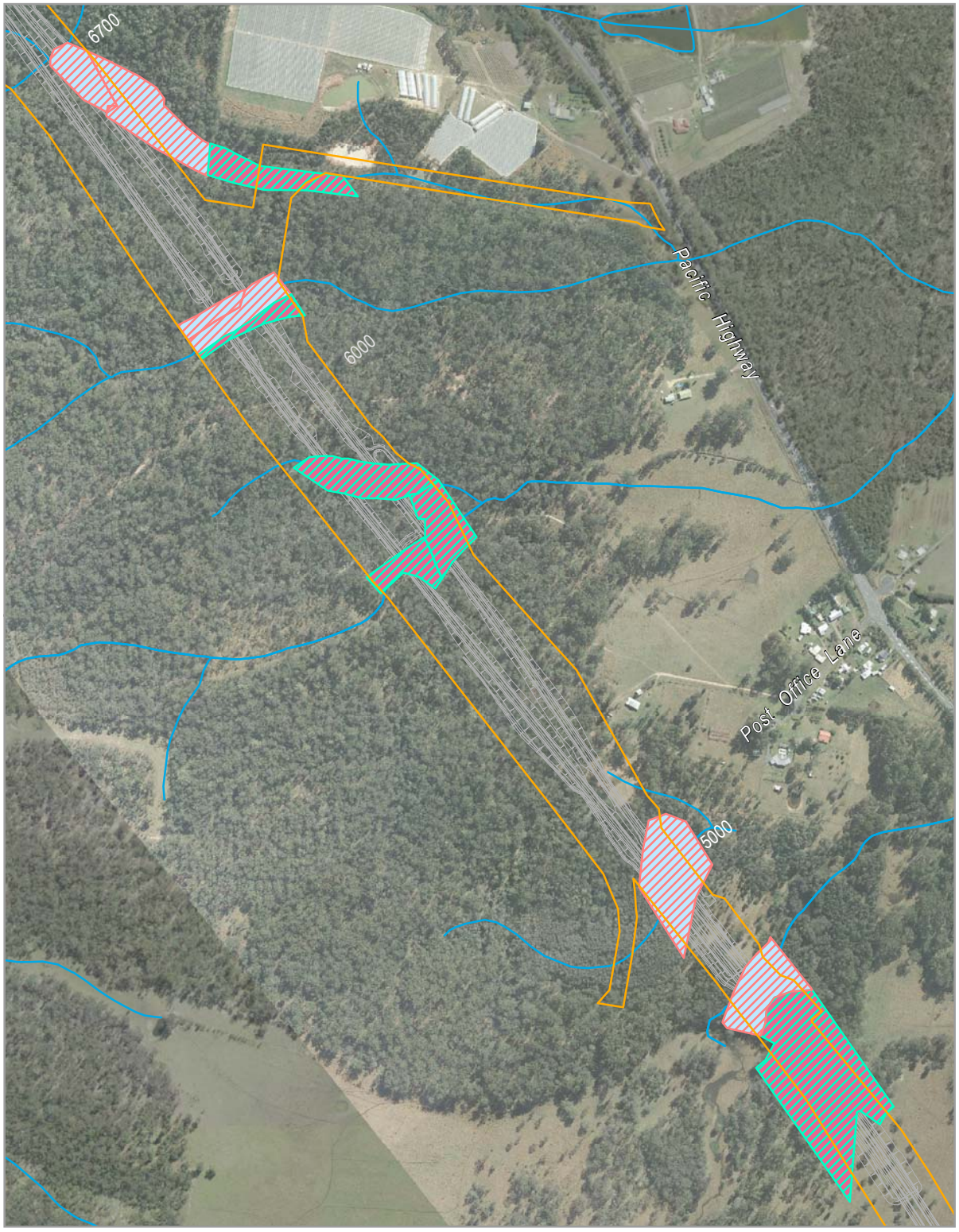
North

0 200

Location of High Probability GDEs - W2G

Information shown is for illustrative purposes only

Drawn by: TJP Checked by: MVE Reviewed by: GJM Date: March 2013
Source of base data: Roads and Maritime Services



LEGEND

- Waterway
- Project boundary
- W2G highway alignment

EEC

- Subtropical Coastal Floodplain Forest
- Swamp Sclerophyll Forest on Coastal Floodplains

Vegetation Type

- Mixed Coastal Floodplain Forest
- Swamp Sclerophyll Forest

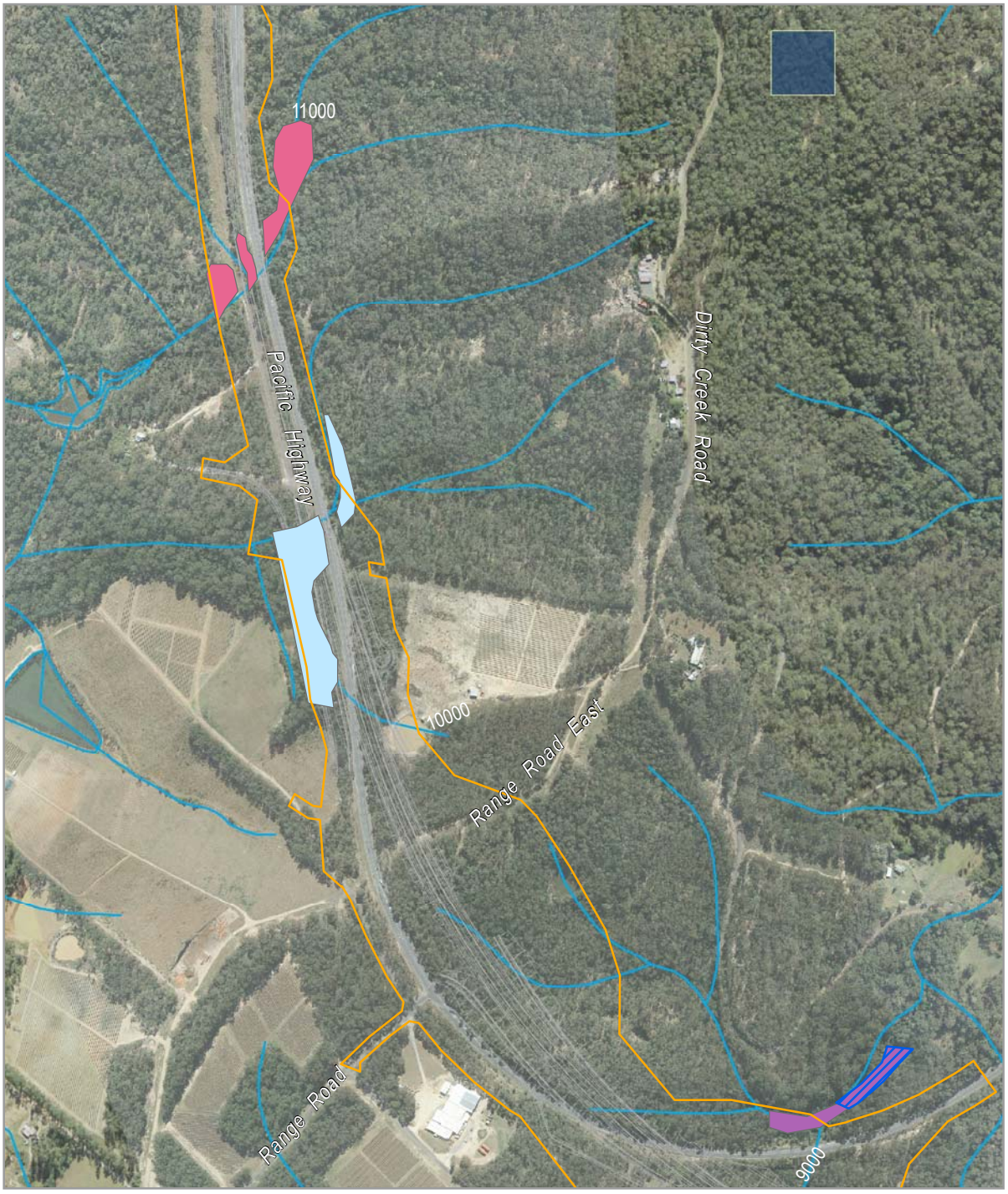
0 200

North

Location of High Probability GDEs - W2G

Information shown is for illustrative purposes only

Drawn by: TJP Checked by: MVE Reviewed by: GJM Date: March 2013
Source of base data: Roads and Maritime Services



LEGEND

- Waterway
- Project boundary
- W2G highway alignment
- Key habitat

EEC

- Subtropical Coastal Floodplain Forest
- Lowland Rainforest

Vegetation Type

- Mixed Coastal Floodplain Forest
- Rainforest
- Swamp Sclerophyll Forest

0 200

North

Location of High Probability GDEs - W2G

Information shown is for illustrative purposes only

Drawn by: TJP Checked by: MVE Reviewed by: GJM Date: March 2013
Source of base data: Roads and Maritime Services

LEGEND

Waterway

Project boundary

W2G highway alignment

Vegetation Type

Mixed Coastal Floodplain Forest

North

0 200

Location of High Probability GDEs - W2G

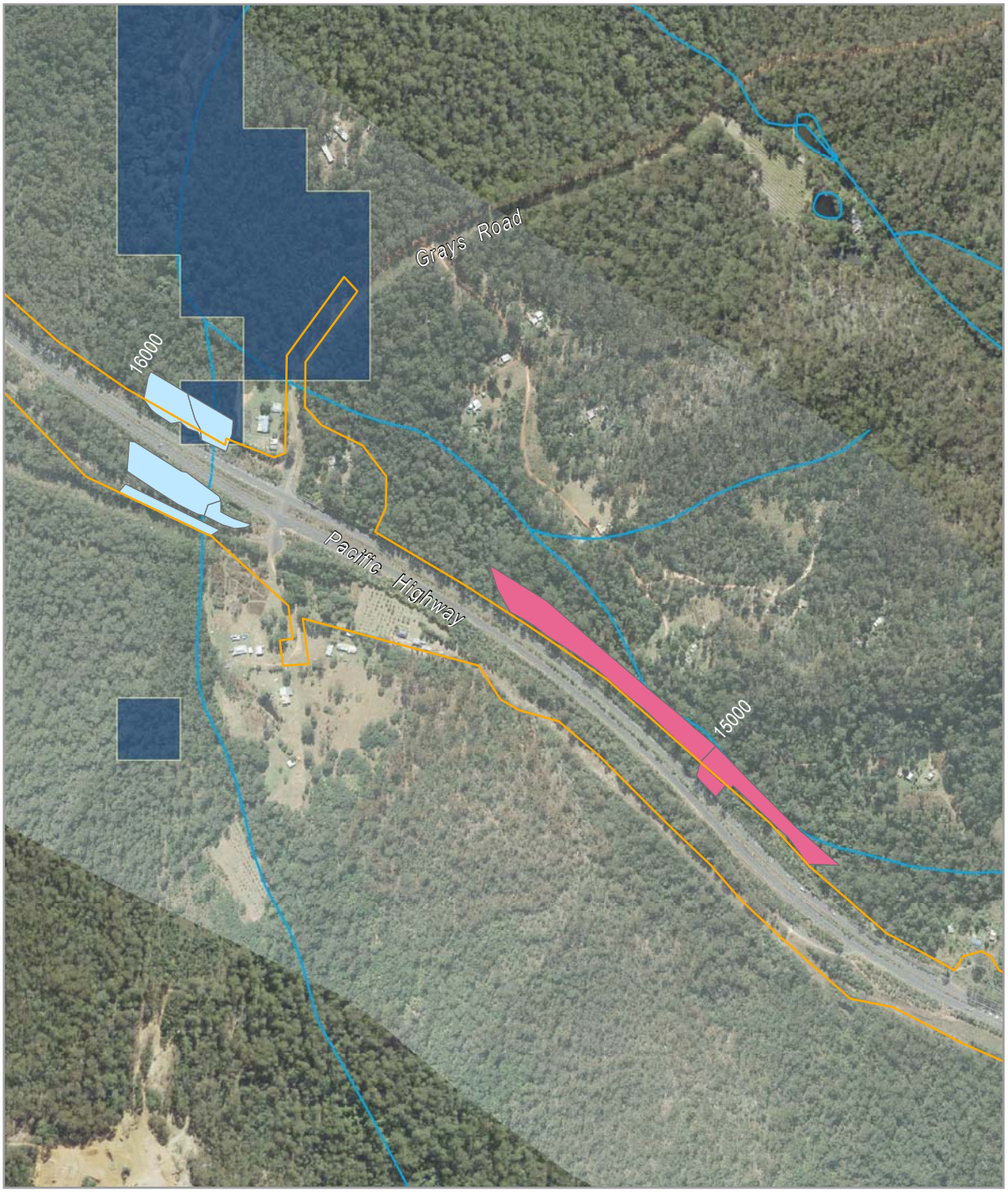
GeoLINK environmental management and design

W2G - Surface and Groundwater Quality Monitoring Protocol
2134-1036

Illustration D5

Information shown is for illustrative purposes only

Drawn by: TJP Checked by: MVE Reviewed by: GJM Date: March 2013
Source of base data: Roads and Maritime Services



LEGEND

- Waterway
- Project boundary
- W2G highway alignment
- Key habitat

EEC

- Swamp Sclerophyll Forest on Coastal Floodplains

Vegetation Type

- Mixed Coastal Floodplain Forest
- Swamp Sclerophyll Forest

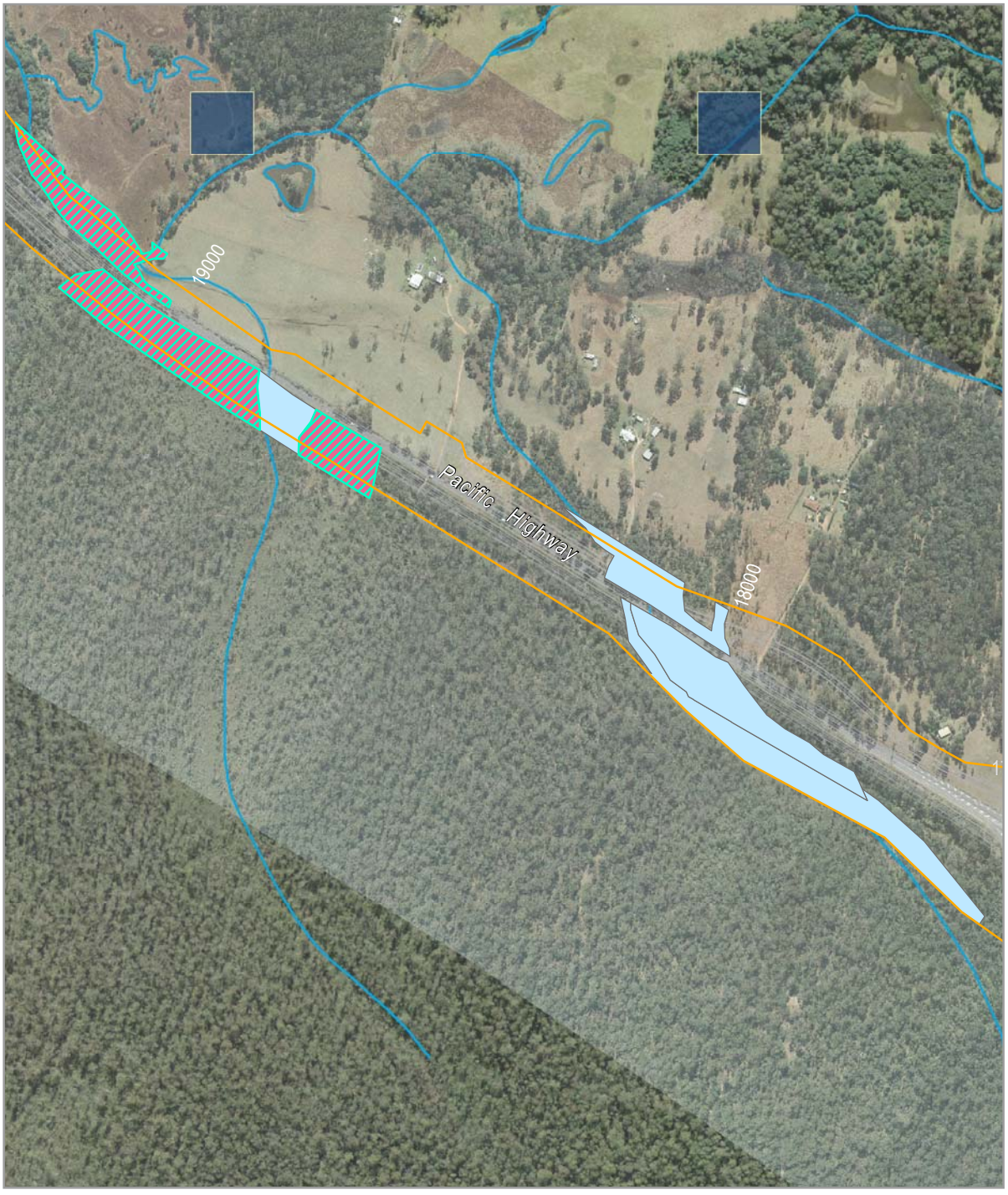
North

0 200

Location of High Probability GDEs - W2G

Information shown is for illustrative purposes only

Drawn by: TJP Checked by: MVE Reviewed by: GJM Date: March 2013
Source of base data: Roads and Maritime Services



LEGEND

- Waterway
- Project boundary
- W2G highway alignment
- Key habitat

EEC

- Subtropical Coastal Floodplain Forest

Vegetation Type

- Mixed Coastal Floodplain Forest
- Swamp Sclerophyll Forest

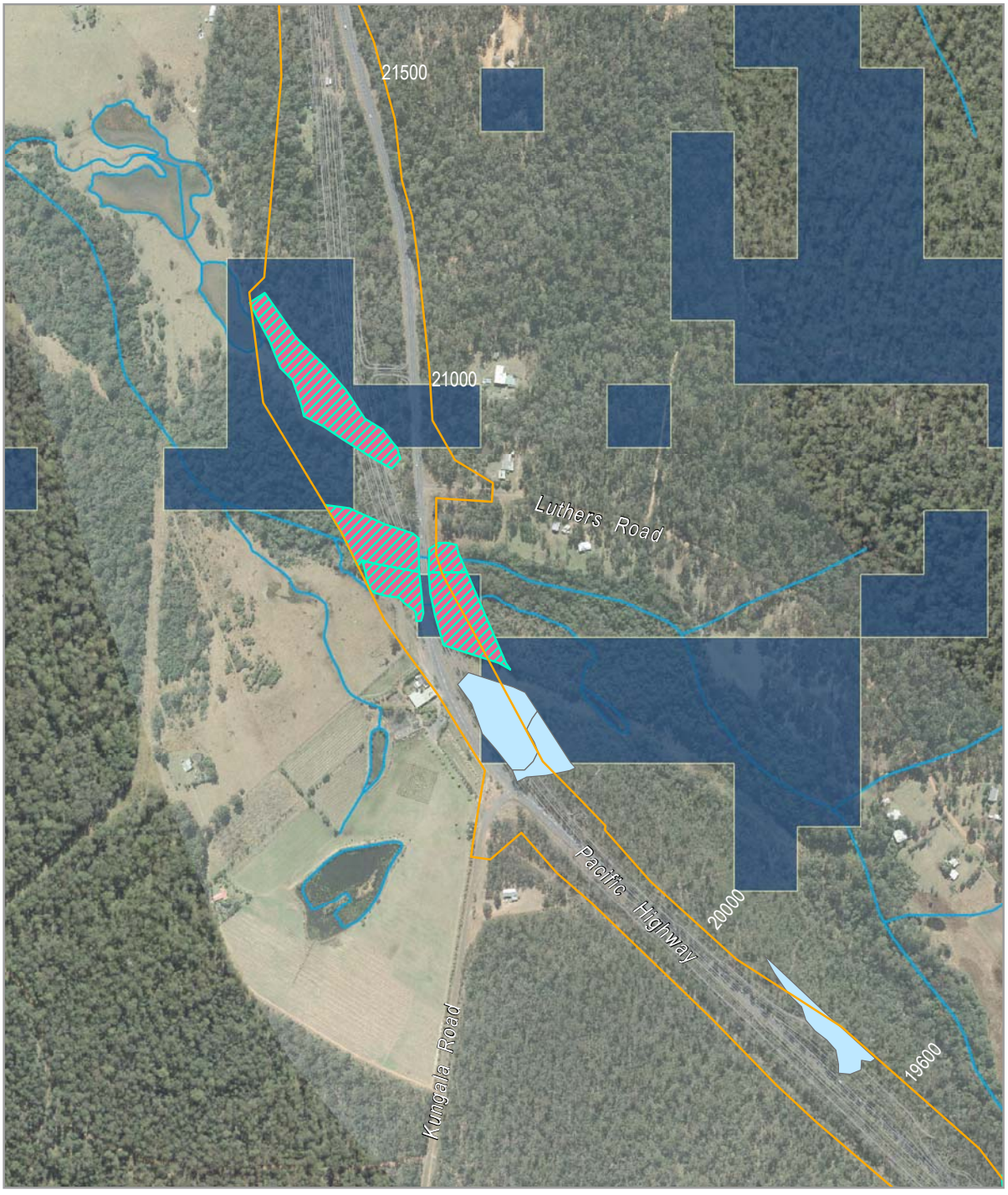
North

0 200

Location of High Probability GDEs - W2G

Information shown is for illustrative purposes only

Drawn by: TJP Checked by: MVE Reviewed by: GJM Date: March 2013
Source of base data: Roads and Maritime Services



LEGEND

- Waterway
- Project boundary
- W2G highway alignment
- Key habitat

EEC

- Subtropical Coastal Floodplain Forest

Vegetation Type

- Mixed Coastal Floodplain Forest
- Swamp Sclerophyll Forest

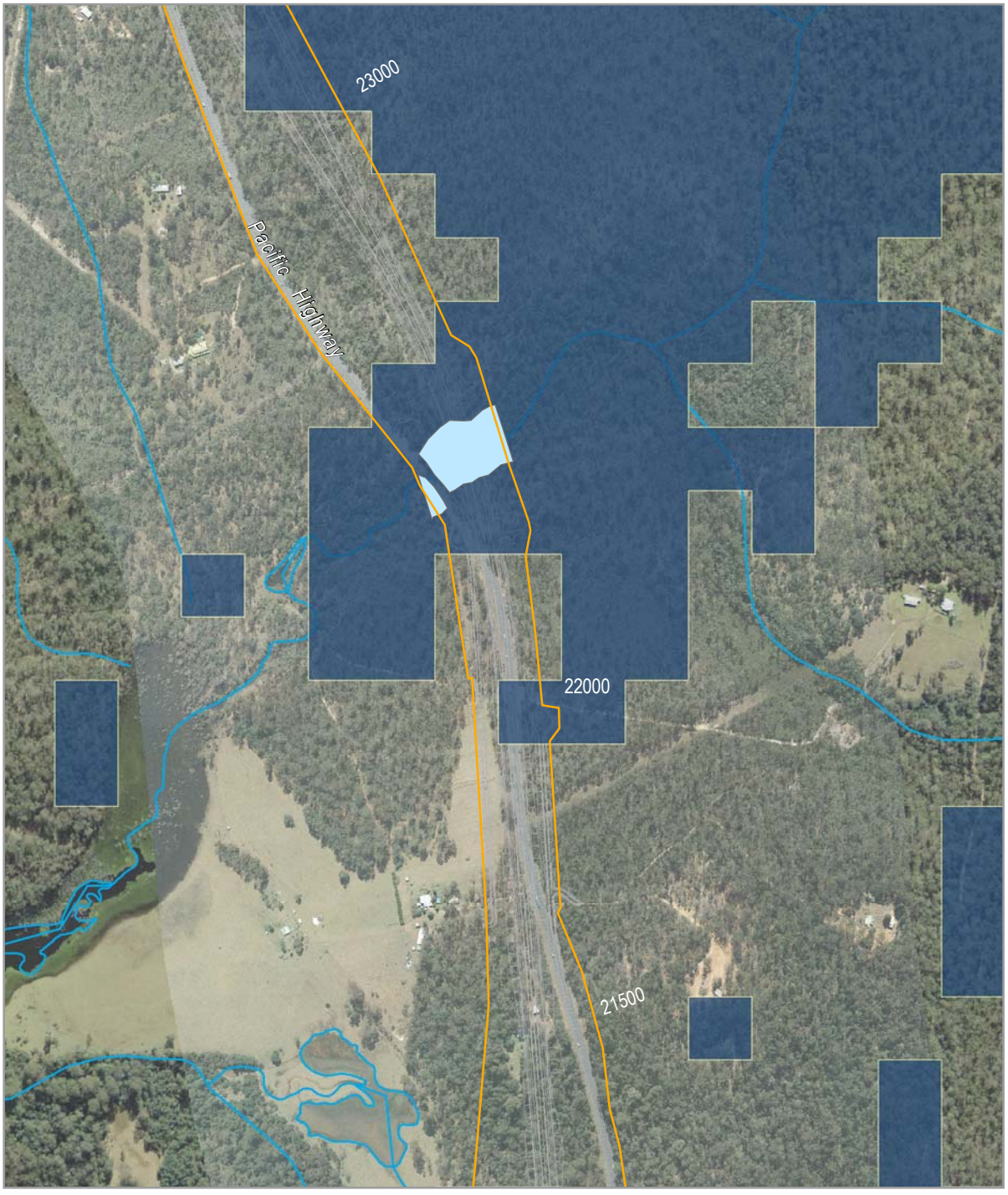
North

0 200

Location of High Probability GDEs - W2G

Information shown is for illustrative purposes only

Drawn by: TJP Checked by: MVE Reviewed by: GJM Date: March 2013
Source of base data: Roads and Maritime Services



LEGEND

- Waterway
- Project boundary
- W2G highway alignment
- Key habitat
- Subtropical Coastal Floodplain Forest
- Swamp Oak Floodplain Forest
- Swamp Sclerophyll Forest on Coastal Floodplains
- Lowland Rainforest
- Mixed Coastal Floodplain Forest
- Rainforest
- Swamp Oak Forest
- Swamp Sclerophyll Forest

0 200

North

Location of High Probability GDEs - W2G

Appendix E

Consultation with Government Authorities

Pacific Highway Upgrade – Woolgoolga to Glenugie

Draft Water Quality Monitoring Program (CoA D12)

No.	DoE Comments	RMS Response
1	The Department notes that the level of detail included in this document regarding the methodology and location of baseline surveys undertaken will enable robust replication of surveys as part of ongoing monitoring. The Department supports this approach, and recommends that a similar level of detail should be provided for the baseline surveys undertaken in the threatened species management plans.	Comment noted. No amendment to Water Quality Monitoring Program for Woolgoolga to Glenugie.
2	Page 3 – please include a reference to water velocity changes and the impacts on successful fish passage	Reference to impacts to fish passage included on page 3 and 4 in reference to Construction Stage and Operational Stage impacts. Source of information is: RMS, Aurecon, SKM (2012e). *Upgrading the Pacific Highway. Woolgoolga to Ballina. Working Paper – Biodiversity Assessment*. November 2012
3	Page 17 – reference is made to an occurrence of lowland rainforest EEC. Please clarify whether this is the EPBC Act listed community? If this occurrence is indeed the listed community, could a reference please be made to which plan impacts, avoidance, and mitigation for this CEEC will be addressed?	The area of rainforest referred to is located at Chainage 9200 Biosis (2014) classified the patch as Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast EEC, a State listed community under the TSC Act. No amendment to Water Quality Monitoring Program for Woolgoolga to Glenugie.
4	The Department notes that no measurements of water velocity are provided. While this is less relevant for sections 1 and 2, this will be a relevant consideration for waterways which are likely to provide habitat for Oxleyan	Comment noted and will be addressed in Water Quality Monitoring Program for Sections 3 to 11 of Woolgoolga to Ballina upgrade. No amendment to Water Quality Monitoring Program for Woolgoolga to Glenugie.

No.	DoE Comments	RMS Response
	Pygmy Perch and will need to be addressed in the plans covering these areas.	
5	The Department notes that the plan states that details of mitigation and corrective measures will be included in the CEMPs, and that none are currently proposed in the plan. The Department recommends that the key commitments regarding these mitigation measures and corrective actions be included in this plan (for example, should the water quality thresholds identified in the plan be exceeded, that corrective actions would be undertaken to ensure that the water quality returned to within the below the thresholds within a specified timeframe).	General references to key commitments for the mitigation measures have been included in Section 8 including general water quality criteria for discharges from sediment basins. No other specific commitments to timeframes and water quality limits have been included due to the range of potential scenarios that may require a different approach and timeframe / water quality limit. However, to ensure that a commitment is made when an issue arises, the following requirement has been added into Section 7 and 8 of the WQMP: if assessment of surface water quality data, groundwater quality data and groundwater level data indicates a possibility of the highway impacting on surface water quality / groundwater quality / groundwater levels then the Contractor is to investigate and notify EPA within 48 hours of the Contractor receiving the relevant data indicating the issue.
6	The Department notes that a high risk of erosion and sedimentation has been identified at as part of the Threatened Frog management plan for Dirty Creek. The Department requests that this be addressed as part of the Water Quality Monitoring Plan, or if not, that further information is included in the Threatened Frog Management plan and stronger links drawn between these two plans.	Comment noted. Review of the W2B Threatened Frog Management Plan did not highlight any specific water quality measure that requires inclusion in the WQMP beyond standard best practice measures. No amendment to Water Quality Monitoring Program for Woolgoolga to Glenugie. The development of mitigation measures and specific actions should consider related management plans such as the Threatened Frog Management Plan (RMS et. al., 2014) to ensure measures are complimentary or to avoid conflicting measures / outcomes. The Contractors environment team involved in soil and water management will also be aware of these related plans and any specific mitigation measures or actions.

Comment number	Document section/Ref CoA	DP&E Comments	RMS Response
1.	CoA D12	The condition requires the Water Quality Monitoring Program (WQMP) to be prepared in consultation with a number of government authorities. It is noted that comments have been received from DPI and NoW.	

Comment number	Document section/Ref CoA	DP&E Comments	RMS Response
		It is questioned whether consultation was undertaken with OEH, DoE and EPA as required by the condition of approval? If not, consultation is to be undertaken.	OEH comments have not been sought on the W2G WQMP in line with the modification to the original CoA D12 (Modification 1 approved on 15 January 2015). The modified condition D.12 removed OEH from the consultation process.
		Section 1 should state that the WQMP has been prepared in consultation with the government authorities listed in the condition of approval. An appendix should be included which sets out the response from each authority and where the issues raised have been addressed in the WQMP.	This has been stated at the end of Section 1.3. Appendix E has been added listing the government authority comments and the responses.
		It is noted that DPI recommended the inclusion of two items in Section 1.4.1.	2 dot points added to Section 1.4.1 as suggested
2.	CoA D12(d)	The 20th percentile values for surface water and groundwater quality parameters should be included in Appendices A and B where this value is the adopted trigger value.	Appendices A and B have been modified to include the 20th percentile values for the relevant parameters.
3.	CoA D12(g)	Section 8.1 should include details on the contingency and ameliorative measures that would be implemented in the event that adverse water quality impacts are identified. Currently, it only states the key mitigation measures that would be implemented to intercept runoff and avoid water quality impacts. Section 8.2 lists measures that would be implemented to minimise groundwater impacts, not contingency and ameliorative measures.	Section 8.1 and 8.2 amended – refer to RMS response in regard to DoE Comment No.5 in table above
4.	Section 2.1	The section reference has not been included in the last sentence in the first paragraph.	Section reference amended

Comment number	Document section/Ref CoA	DP&E Comments	RMS Response
5.	Table 2.1	The table indicates those locations that are key fish habitat. The table should also identify whether the waterway is Oxleyan Pygmy perch habitat.	Table amended to show known / potential OPP habitat based on Table G-1 in *Upgrading the Pacific Highway. Woolgoolga to Ballina. Working Paper – Water Quality*. November 2012 (RMS, Aurecon, SKM, 2012c).
6.	Illustration 2.1	The figure should show the location of SEPP 14 wetland No.315.	Illustration 2.1 has been amended to show the location of SEPP 14 wetland No.315.
7.	Illustration 2.4	The figure should illustrate the location of groundwater dependent ecosystems (GDE), highlighting the GDE that is also an EEC.	The detail of the GDE mapping would not translate well to the scale of Illustration 2.4, therefore GDE mapping has been included separately in Appendix D of the WQMP.
8.	Section 2.2	Justification should be provided as to why only 13 bores have been selected for groundwater quality monitoring along with the factors considered in selecting the 13 bores.	The bore selection for groundwater monitoring was generally based on monitoring those designated to be a higher risk cut (Type A cuts) plus consideration of covering a wide range of geology. The WQMP has been amended to include discussion of this in Section 2.2.
9.	Section 3.2.1.2	The last paragraph on page 17 refers the reader to Table 2.2 for details on a GDEs. Table 2.2 does not indicate the location of GDEs, in particular, it does not refer to the GDE that is an EEC near chainage 16000.	Reference to Table 2.2 has been replaced by reference to Appendix D. Appendix D inserted which contain details / illustrations of GDEs.
10.	Sections 4.2.2, 4.3.1 and 4.3.2	These sections should address what modifications would be implemented to the monitoring regime to determine the effectiveness of any management measures that may be implemented in the event that water quality impacts are identified or groundwater levels affected. For example, extension of the first year sampling program for a second year/ x number of months post implementation of the management measures.	Section 7 has been amended to include the requirement that the Contractor is to investigate and notify EPA within 48 hours of the Contractor receiving the relevant data indicating an issue with surface water quality / groundwater quality / groundwater levels (refer to Sections 7.1.1, 7.2 and 7.3). It is considered that it would be best for the EPA and Contractor to determine what modifications would be implemented to the monitoring regime on an issue-specific basis as some instances may not warrant extensive monitoring as others.

Comment number	Document section/Ref CoA	DP&E Comments	RMS Response
11.	Appendix C Section 8.5 and Table C3	This section and table state “error references”.	Error references rectified

Comment number	Document section/Ref CoA	DPI Fisheries Comments	RMS Response
1.	CoA D12	Include 2 dot points in 1.4.1 construction stage: Increase in pH from concreting and lime stabilisation works. Pollution by hydrocarbons during or following sealing or asphalting works.	2 dot points added to Section 1.4.1 as suggested

Report Reference	EPA Comments	RMS Response
P13. Section 3.1.1 Overview of Surface Water Quality Data for Pre-Construction Phase.	The EPA notes the comment that the data shows natural variability. The EPA also notes that in table 3.1 there is a record of observations that indicate cattle were accessing the site. There are no comments in the monitoring data that reveal if the higher TSS readings were as a result of cattle disturbing the water prior to sampling.	Comment noted The TSS results did not show any significant deviation that could be attributed to cattle accessing the site. Plus it was unknown exactly when cattle did access the site. Therefore no correlation was made with TSS readings. A comment has been included in Table 3.1. Generally, the higher TSS readings occurred during wet events or in the ‘dry event’ sampling rounds following significant rainfall. Comment noted

Report Reference	EPA Comments	RMS Response
	The EPA also notes the comment that "The data is considered suitable for use as a baseline data set for comparison with construction and operational phase data". How is this sampling considered suitable as it was an extended dry period and does not reflect the usual conditions over both wet and dry seasons and this is not accounted for in the document?	The annual rainfall over the pre-construction period was in the range of 1,200 mm (Grafton Airport) to 1,400mm (Woolgoolga) which is close to average annual rainfall figures for these areas. The distribution of the rainfall throughout the pre-construction monitoring months was also generally consistent with average distributions. Therefore the rainfall is considered to be reflective of normal conditions and subsequently the sampling is considered suitable for use as a baseline data set. No change is proposed to WQMP.
P18. Section 3.2.2 Groundwater Quality Data for the Pre-Construction Phase.	The EPA notes that groundwater sampling for the pre-construction phase was collected over three rounds in November 2013, February 2014 and April 2014 (over a 6 month period). The EPA also notes that insufficient water meant that a number of bores were not analysed. The EPA notes the comment that "The data is considered suitable for use as a baseline data set for comparison with construction and post-construction data". How is this sampling considered suitable as it was an extended dry period and does not reflect the usual conditions over both wet and dry seasons and the limited data collected?	In regard to the rainfall / climatic conditions, similar to the above comment, the conditions experienced during the pre-construction phase are considered to be reflective of normal conditions, and therefore the data is considered suitable in this respect. In regard to the limited groundwater quality data collected from a number of the bores (due to bores being dry) – it is acknowledged that limited data is available for two sets of groundwater bore 'clusters' ie. GWB18/19 and GWB30/31. In regard to GWB18/19, given that the data for GWB18 is not significantly different to the nearby clusters of GWB16/17 and GWB22/23, it is considered there is adequate data to provide an indication of baseline conditions at GWB18/19. Similarly, in regard to GWB30/31, given that the data for GWB30 is generally consistent with the set of groundwater quality data, it is considered there is adequate data to provide an indication of baseline conditions at GWB30/31. No change is proposed to WQMP.

Report Reference	EPA Comments	RMS Response
P18. Section 3.2.2.3 Hydrocarbons.	The EPA notes that the C10-C16 and C10-C14 fractions (within the extractable petroleum hydrocarbon range – also known as the diesel range organics) were found to be at levels up to 5,000µg/L. Was there any explanation for the higher values? If so, what was it and are any actions required?	There is no discernible explanation for the higher readings recorded at GWB8, 9, 23 and 30. It is noted that TRH is a measure of extractable petroleum, biological and non-petroleum hydrocarbons and can provide a conservative estimate of petroleum hydrocarbon if soil organic matter is high. For each of the samples that recorded a high C10-C16 / C10-C14 reading, the corresponding BTEX readings were below detection limits, indicating that the high C10-C16 / C10-C14 reading MAY be due to organic matter (but not conclusively). A silica gel clean-up test would need to be undertaken to confirm if the readings are due to true petroleum hydrocarbons. A silica gel clean-up test will be undertaken for these specific bores for one sampling round to clarify if the high C10-C16 / C10-C14 readings are due to organic matter. If this proves positive then no further silica gel clean-up tests will be undertaken for these specific bores unless high BTEX readings are recorded.
P31. Section 3.2.3 - Groundwater Level Pre-construction monitoring	There is no proposed discussion or explanation as to why bores behave in particular ways i.e. is it because they are high/low in the landscape or geology off the location or are there bores or dams adjacent that influence the observed behaviour?. This would be useful in understanding what is occurring at each bore location.	It is recommended that further investigation of why bores / groundwater quality behave in particular ways if construction / post-construction sampling indicate significant deviation from baseline conditions. Sections 7.2 and 7.3 of the WQMP have been amended to reflect this approach.
P53 to 77 - Appendices A and B – Preconstruction monitoring results.	These results reveal the small number of monitoring events and the insufficient duration of monitoring to allow for seasonality. This is very relevant as the past 18 months has been a very dry period. With this in mind it is important to understand that the monitoring results may not reflect the usual background water quality for the locations sampled. As noted in Section 7.1.2 the baseline data should be supplemented with upstream monitoring data collected during construction and operational phases to provide more robust baseline data.	Comment noted. No change is proposed to WQMP.

Comment number	Document section/Ref CoA	NOW Comments	RMS Response
1.	CoA D12	The proponent has suitably identified potential impacts to groundwater, proposed a suitable monitoring regime to monitor for potential impacts, and proposed mitigation measures should monitoring show a breach of identified impact thresholds.	Comment noted. No change is proposed to WQMP.
2.	CoA D12	The mitigation provisions described by the proponent for the incidental groundwater take and groundwater receptor impacts are adhered to as a condition of approval	Comment noted. No change is proposed to WQMP.
3.	CoA D12	The proponent liaises with the Office of Water in relation to any water licensing requirements.	Comment noted. No change is proposed to WQMP.
4.	CoA D12	Any surface water monitoring to be in accordance with any requirements outlined by the Environmental Protection Authority.	Comment noted. No change is proposed to WQMP.
5.	CoA D12	The Water Quality Monitoring Plan as presented is satisfactory to the Office of Water.	Comment noted. No change is proposed to WQMP.