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APPENDIX B4

Construction Soil and Water Quality Management Plan

Wells Crossing to Glenugie

Pacific Highway Upgrade

SEPTEMBER 2019

Document control

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8	17/09/2019	Wells Crossing to Glenugie - LLE Update	

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Glossary / Abbreviations

CEMP	Construction Environmental Management Plan
LLE	Lendlease Engineering
CoA	Condition of Approval
EPBC	Commonwealth Environment Protection and Biodiversity Conservation Act 1999
DoEE	Commonwealth Department of the Environment and Energy
DECC	Former Department of Environment and Climate Change (NSW) now NSW Office of Environment and Heritage.
DP&E	NSW Department of Planning and Environment (Note - now NSW Department of Planning, Industry and Environment)
DPI	NSW Department of Primary Industries (Fishing and Aquaculture)
EEC	Endangered Ecological Community
EIS	Woolgoolga to Ballina Pacific Highway Upgrade Environmental Impact Statement (December, 2012)
EPA	NSW Environment Protection Authority
EP&A Act	NSW Environmental Planning and Assessment Act 1979
EPL	NSW Environment Protection Licence under the Protection of the Environment Operations Act 1997.
ESCP	Erosion and Sediment Control Plan
EWMS	Environmental Work Method Statements
FM Act	NSW Fisheries Management Act 1994
G36	RMS QA Specification G36 Environmental Protection
G38	RMS QA Specification G36 Soil and Water Management
WC2G	Wells Crossing to Glenugie Project
Minister, the	NSW Minister for Planning and Public Spaces'.
NOW	NSW Office of Water
OEH	NSW Office of Environment and Heritage
PoEO Act	NSW Protection of the Environment Operations Act 1997
SEPP 14	State Environmental Planning Policy No 14 – Coastal Wetlands
RMS	New South Wales Roads and Maritime Service
SPIR	Woolgoolga to Ballina Pacific Highway Upgrade Submissions Preferred Infrastructure Report (November, 2013)

1 Introduction

1.1 Context

This Construction Soil and Water Quality Management Plan (CSWQMP or Plan) forms part of the Construction Environmental Management Plan (CEMP) for the upgrade of the Pacific Highway from Wells Crossing to Glenugie (Section 2 & associated tie in works to Glenugie upgrade). Section 2 of the Woolgoolga to Ballina (W2B) Pacific Highway upgrade project was approved by the Minister for Planning in June 2014.

This CSWQMP has been prepared to address the requirements of the Minister's Conditions of Approval (CoA) and the mitigation measures listed in the Pacific Highway Upgrade Woolgoolga to Ballina Environmental Impact Statement RMS Dec 2012 (EIS), Submissions / Preferred Infrastructure Report (Nov 2013)(SPIR) and all applicable legislation.

The Wells Crossing to Glenugie project ties into the southern extent of the existing Glenugie Upgrade. The Glenugie Upgrade Project was approved separately by the Minister for Planning in December 2009. Relevant conditions of approval for these projects have been referenced in the CEMP and plans as appropriate.

1.2 Background

The EIS assessed the impacts of construction and operation of the Project on soils and water, within Chapters 8 and 9.

As part of EIS development, detailed groundwater and water quality assessments were prepared to address the Environmental Assessment Requirements issued by the Department of Planning and Environment. These assessments were included in the EIS as Working Paper: Water Quality, Working Paper: Hydrology and Flooding and Working Paper: Groundwater.

The EIS identified the potential for direct and indirect impacts on water quality but concluded that, with implementation of appropriate impact mitigation measures, there would be no significant impacts to waterways crossed by the project, or to high risk areas or sensitive receiving environments downstream of the project.

Additional management measures were provided within the *Woolgoolga to Ballina Submissions / Preferred Infrastructure Report Nov 2013*, with applicable management measures from that report included as part of this CSWQMP.

1.3 Environmental management systems overview

The overall Environmental Management System for the Project is described in the Construction Environmental Management Plan (CEMP).

The CSWQMP is part of Lendlease Engineerings environmental management framework for the Project, as described in Section 4.1 of the CEMP. In accordance with CoA D26 (c), this Plan has been developed in consultation with EPA, DPI (Fisheries & Aquaculture NSW), NOW, DoEE and the Clarence Valley Council.

Management measures identified in this Plan will be incorporated into site or activity specific Environmental Work Method Statements (EWMS) and Erosion and Sediment Control Plans (ESCP).

EWMS will be developed and signed off by environment and management representatives prior to associated works and construction personnel will be required to undertake works in accordance with the identified safeguards. For high risk activities, such as construction of working platforms in waterways, EWMS will be provided to EPA and DPI Fisheries Conservation and Aquaculture for input prior to sign off (refer to Section 4.1.3 of the CEMP).

ESCP are designed for use as a practical guide and may be produced in conjunction with Environmental Work Method Statement (EWMS) to provide more detailed site-specific environmental mitigation measures. ESCP will be developed by the environment team in consultation with construction personnel and the Project Soil Conservationist, and modified as required when:

- Site conditions evolve.
- Flow paths change.
- Construction activities that affect the characteristics of ground conditions change.

Used together, the CEMP, strategies, procedures, EWMS and ESCP form management guides that clearly identify required environmental management actions for reference by Lendlease Engineering's personnel and sub-contractors.

The review and document control processes for this Plan are described in Sections 9 and 10 of the CEMP.

2 Purpose and objectives

2.1 Purpose

The purpose of this Plan is to describe how construction impacts on soil and water will be minimised and managed.

2.2 Objectives

The key objective of the CSWQMP is to ensure that impacts on water quality are minimised and within the scope permitted by the planning approval. To achieve this objective, Lendlease Engineering will undertake the following:

- Ensure best management practice controls and procedures are implemented during construction activities to avoid or minimise erosion/sedimentation impacts and potential impacts to water quality in rivers, creeks and groundwater along the Project corridor.
- Ensure appropriate measures are implemented to address the relevant CoA outlined in Table 3.1 and the safeguards detailed in the EIS and Submission / Preferred Infrastructure Report (SPIR).
- Ensure appropriate measures are implemented to comply with all relevant legislation and other requirements as described in Section 3.1 of this Plan.

2.3 Targets

The following targets have been established for the management of soil and water impacts during the project:

- Ensure full compliance with the relevant legislative requirements and CoA.
- Meet environment protection licence water quality discharge parameters for all planned basin discharges (ie those within design capacity).
- Manage downstream water quality impacts attributable to the project (ie maintain water waterway health by avoiding the introduction of nutrients, sediment and chemicals outside of that permitted by the environmental protection licence and/or ANZECC guidelines).
- Ensure training on best practice soil and water management is provided to all construction personnel through site inductions.

3 Environmental requirements

3.1 Relevant legislation and guidelines

3.1.1 Legislation

Legislation relevant to soil and water management includes:

- *Environmental Planning and Assessment Act 1979* (EP&A Act).
- Environmental Planning and Assessment Regulation 2000.
- *Protection of the Environment Operations Act 1997*.
- *Water Management Act 2000.*
- *Fisheries Management Act 1994.*
- *Commonwealth Environment Protection and Biodiversity Conservation Act 1999.*
- *Water Act 1912*.

Relevant provisions of the above legislation are explained in the register of legal and other requirements included in Appendix A1 of the CEMP.

3.1.2 Guidelines and standards

The main guidelines, specifications and policy documents relevant to this Plan include:

- Acid Sulfate Soil Manual (ASSMAC 1998).
- Acid Sulfate Soil and Rock – Victorian EPA Publication 655.1 – July 2009.
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ 2000).
- Department of Environment and Conservation (DEC): Bunding & Spill Management. Insert to the Environment Protection Manual for Authorised Officers - Technical section "Bu" November 1997.
- Managing Urban Stormwater: Soils and Construction. Landcom, (4th Edition) March 2004 (reprinted 2006) (the “Blue Book”). Volume 1 and Volume 2.
- Volume 2A Installation of Services (DECCW 2008).
- Volume 2C Unsealed Roads (DECCW 2008).
- Volume 2D Main Roads Construction (DECCW 2008).
- DIPNR Roads and Salinity Guideline, 2003.
- DLWC, 1998. Constructed Wetlands Manual.
- Fairfull, S. and Witheridge, G. (2003) Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings. NSW Fisheries, Cronulla, 16 pp.
- *NSW Fisheries, November 2003. Fishnote – Policy and Guidelines for Fish Friendly* Waterway Crossings (Ref: NSWF – 1181).
- RMS Dewatering Guideline.
- RMS Pacific Highway Practice Note for Dewatering.
- RTA’s Code of Practice for Water Management – Road Development and Management (1999).

- Approved Methods for the Sampling and Analysis of Water Pollutants in NSW – March 2004.
- Guidelines for the Management of Acid Sulphate materials: Acid Sulphate Soils, Acid Sulphate Rock and Monosulphidic Black Ooze (RTA 2005).
- RMS Environment Direction Management of Tannins from Vegetation Mulch.
- Stockpile Site Management Guideline, RMS 2011.
- Environmental Best Management Practice Guideline for Concreting Contractors, DEC, 2004.
- Guidelines for Controlled Activities Watercourse Crossings (Department of Water and Energy, February 2008); and
- Policy and Guidelines for Fish Habitat Conservation and Management (DPI Fisheries, 2013).

3.2 Minister's Conditions of Approval

The CoA relevant to this Plan are listed Table 3-1. A cross reference is also included to indicate where the condition is addressed in this Plan or other Project management documents.

Table 3-1 Conditions of Approval relevant to the CSWQMP

CoA No.	Condition Requirements	Document Reference
B34	**Construction Soil and Water Management** Soil and water management measures consistent with *Managing Urban Stormwater - Soils and Construction Vols 1 and 2, 4th Edition* (Landcom, 2004) and *Managing Urban Stormwater Soil and Construction Vols 2A and 2D Main Road Construction* (Department of Environment and Climate Change, 2008) shall be employed during the construction of the SSI to minimise soil erosion and the discharge of sediment and other pollutants to land and/or waters.	This plan Sect 6
B35	Where available, and of appropriate chemical and biological quality, stormwater, recycled water or other water sources shall be used in preference to potable water for construction activities, including concrete mixing and dust control.	This plan Table 6.1
B36	All surface water and groundwater shall be adequately treated as far as is practicable, prior to entering the stormwater system to protect the receiving water source quality.	This plan Table 6.1
B37	Prior to the commencement of site preparation and excavation activities, or as otherwise agreed by the Secretary, in areas identified as having a moderate to high risk of contamination, a site audit shall be carried out by a suitably accredited contaminated site auditor. A **Site Audit Report** is to be prepared by the site auditor detailing the outcomes of Phase 2 contamination investigations within these areas. The Site Audit Report shall detail, where	The RCA Factual Contamination Report (July 2014) has not identified any contaminated sites within the WC2G project

CoA No.	Condition Requirements	Document Reference
	relevant, whether the land is suitable (for the intended land use) or can be made suitable through remediation. Where the investigations identify that the site is suitable for the intended operations and that there is no need for a specific remediation strategy, measures to identify, handle and manage potential contaminated soils, materials and groundwater shall be identified in the Site Audit Report and incorporated into the Construction Environmental Management Plan. Where the investigations identify that the site is suitable for the intended operations and that a remediation strategy is required, the Site Audit Report shall include a remediation strategy for addressing the site contamination, and how the environmental and human health risks will be managed during the disturbance, remediation and/or removal of contaminated soil or groundwater, and be incorporated into the Construction Environmental Management Plan. Where remediation is required, a **Site Audit Statement(s)** shall be prepared verifying that the site has been remediated to a standard consistent with the intended land use. *Note* *Terms used in this condition have the same meaning as in the Contaminated Land Management Act 1997.*	boundary .
B38	**Watercourse crossings** Watercourse crossings shall be designed in consultation with the DPI (Fisheries NSW), EPA, NOW and DoE, and where feasible and reasonable, be consistent with the *Guidelines for Controlled Activities Watercourse Crossings* (Department of Water and Energy, February 2008*)*, *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (Fairfull and Witheridge, 2003), *Policy and Guidelines for Fish Friendly Waterway Crossings* (NSW Fisheries, February 2004*),* and *Policy and Guidelines for Fish Habitat Conservation and Management* (DPI Fisheries, 2013). Where multiple cell culverts are proposed for crossings of fish habitat streams, at least one cell shall be provided for fish passage, with an invert or bed level that mimics watercourse flows.	This plan Table 6.1
B39	All crossings of known Giant Barred Frog habitat or waterways with the confirmed presence of the species shall be designed and constructed with bridges. Should the Applicant construct a crossing structure other than a bridge, the Applicant shall demonstrate maintained connectivity for the Giant Barred Frog upstream and downstream of that crossing for a monitoring period of three consecutive years, or such other period agreed by the Secretary in consultation with the OEH.	N/A for WC2G

CoA No.	Condition Requirements	Document Reference
	Demonstration of maintained habitat connectivity shall: (a) be based on baseline data that confirms the presence, nature and distribution of Giant Barred Frog population using a survey methodology that has been endorsed by the OEH, and detailed in the Mitigation Framework required in condition D1**Error! Reference source not found.**, and an assessment of the connectivity of the crossing site prior to commencement; or, if adequate baseline data is not provided to the satisfaction of the Secretary, be based on the assumption of occurrence of a population on either side of the crossing site; and (b) be based on evidence that the Giant Barred Frog has remained present upstream and downstream of the crossing site for the monitoring period, with periodic monitoring to occur at least biannually. Should the results of any instance of periodic monitoring record an absence of the Giant Barred Frog, the Applicant shall be required to demonstrate that this change is not as a result of the SSI within one month of the completion of that instance of periodic monitoring, to the satisfaction of the Secretary. Should the Secretary not be satisfied that the change is not a result of the SSI, the SSI will be deemed as the cause of the impact and the Applicant shall offset the loss of the habitat in accordance with this approval.	
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 OEH, 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: (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; (b) the results of any groundwater modelling undertaken; (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	Appendix A

CoA No.	Condition Requirements	Document Reference
	potentially affected waterways and known Oxleyan Pygmy Perch habitat; (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; (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; (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); (g) contingency and ameliorative measures in the event that adverse impacts to water quality are identified; and (h) reporting of the monitoring results to Department of Planning and Environment, OEH, EPA, DPI (Fisheries), NOW, DoE and Rous Water (in relation to the Woodburn borefields).	
D26 (c)	a **Construction Soil and Water Quality Management Plan** to manage surface and groundwater impacts during construction of the SSI. The Plan shall be developed in consultation with the EPA, DPI (Fisheries), NOW, Rous Water (in relation to the Woodburn borefield), DoE and the relevant council and include, but not necessarily be limited to: (i) details of construction activities and their locations, which have the potential to impact on water courses, storage facilities, stormwater flows, and groundwater; (ii) surface water and ground water impact assessment criteria consistent with Australian and New Zealand Environment Conservation Council (ANZECC) guidelines or relevant site specific baseline data collected for known Oxleyan Pygmy Perch waterways;	This plan (Note that OPP habitat waterway management framework is not relevant to this plan) Chapter 5.2 N/A

CoA No.	Condition Requirements	Document Reference
	(iii) management measures to be used to minimise surface and groundwater impacts, including details of how spoil and fill material required by the SSI will be sourced, handled, stockpiled, reused and managed; erosion and sediment control measures; salinity control measures and the consideration of flood events;	Table 6.1, Appendix B, H, I
	(iv) a **Groundwater and Soil Salinity report** should geotechnical investigations determine the presence, extent and severity of soil salinity within the SSI boundary, The report shall detail the outcomes of geotechnical investigations and identify and mitigate impacts to groundwater resources;	N/A - Groundwater Investigations did not identify issues with soil salinity within the project boundary.
	(v) an **Acid Sulfate Soils contingency plan**, consistent with the *Acid Sulfate Soils Manual*, to deal with the unexpected discovery of actual or potential acid sulfate soils, including procedures for the investigation, handling, treatment and management of such soils and water seepage;	CEMP Appendix B11 Appendix D
	(vi) a **tannin leachate management protocol** to manage the stockpiling of mulch and use of cleared vegetation and mulch filters for erosion and sediment control;	
	(vii) ~~an **Oxleyan Pygmy Perch habitat waterway management framework** to detail the measures and construction methods that will be employed to avoid direct discharge of construction water to known Oxleyan Pygmy Perch habitat waterways and downstream impacts to suitable habitat;~~	Appendix F Section 7.3
	(viii) management measures for contaminated material and a contingency plan to be implemented in the case of unanticipated discovery of contaminated material during construction;	
	(ix) a description of how the effectiveness of these actions and measures would be monitored during the proposed works, clearly indicating how often this monitoring would be undertaken, the locations where monitoring would take place, how the results of the monitoring would be recorded and reported, and, if any exceedance of the criteria is detected how any non-compliance can be rectified; and mechanisms for the monitoring, review and amendment of this plan.	

CoA No.	Condition Requirements	Document Reference
2.5 (Glenugie Upgrade approval 2009)	The Proponent shall apply all appropriate measures to prevent soil erosion and the discharge of sediments and pollutants from the project during construction and operation consistent with *Managing Urban Stormwater - Soils and Construction Vols* 1 *and* 2, *4th Edition* (Landcom, 2004) and *Managing Urban Stormwater Soils And Construction Vol2d Main Road Construction* (DECC 2008).	This plan
2.6 (Glenugie Upgrade approval 2009)	Where available and of appropriate chemical and biological quality, the Proponent shall use stormwater, recycled water or other water sources in preference to potable water for construction activities, including concrete mixing and dust control.	This plan
2.7 (Glenugie Upgrade approval 2009)	Prior to the commencement of construction of the project, or relevant parts of the project, the Proponent shall undertake detailed design of the construction and permanent stormwater, drainage and water management systems for the project in consultation with Council, DECCW and I&INSW, to the satisfaction of the Director General. The detailed design of this infrastructure shall be developed to: (a) take into account relevant Council stormwater management policies and integration with existing Council drainage infrastructure where relevant; (b) include measures to minimise changes to afflux and flooding behaviour as a result of the project; and (c) ensure structural integrity of the drainage network is maintained.	This plan

4 Existing environment

The following sections summarise what is known about factors influencing soils and water within and adjacent to the Project corridor.

The key reference documents are Chapters 8 and 9 of the EIS, Working Paper: Water Quality, Working Paper: Hydrology and Flooding and Working Paper: Groundwater.

4.1 Topography and soil characteristics

The topography throughout the project comprises elevated areas consisting of rolling low hills and undulating terrain between Wells Crossing and Glenugie.. A rise in elevation occurs heading further north, up to 109 metres AHD at Bald Nob Tick Gate Road, prior to dropping back down to 85 metres AHD where the northern extent of the project meets the existing Glenugie Upgrade alignment. No published soil landscape mapping is available for the project, however it is likely that the soil types are erosional or transferal and are highly erodible and have low bearing strength.

Topography and soils for each project section are also outlined in Table 4-1.

Table 4-1 Topography and soils

Section	Topography	Soil type	Soil characteristics
2	Elevated	No published soil landscape map is available for this section.	Assumed to be highly erodible. Reported presence of soft soils.

Acid Sulfate Soils

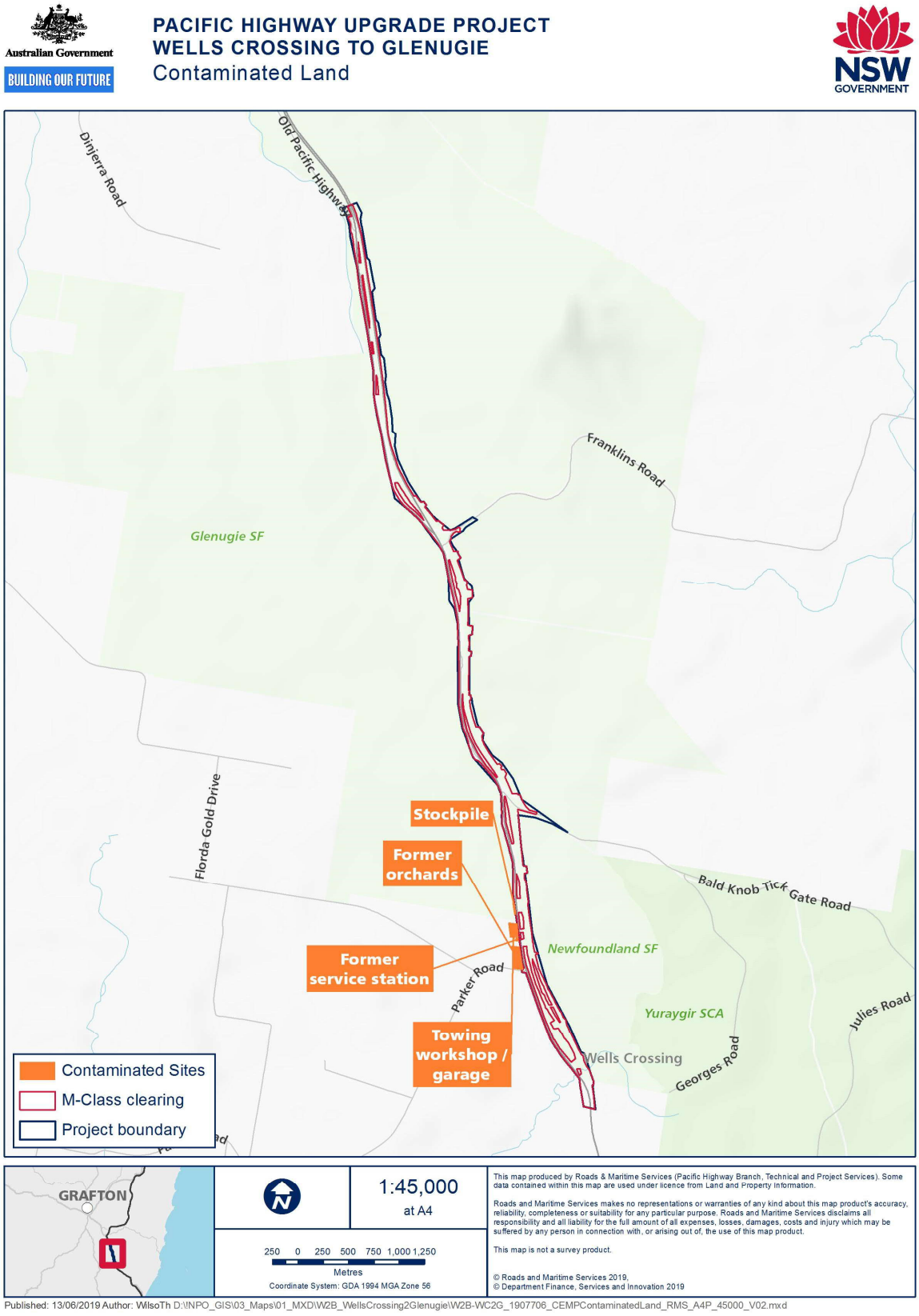
There are no known occurrences of ASS within the project corridor, as it is located on elevated terrain where ASS are not expected. ASS mapping for the project is shown in Figure 4-1

Contamination

EIS investigations identified 4 adjacent sites containing potential contamination associated with past land uses, including service stations, orchards, workshops, and stockpiles. Contaminants associated with these sites include hydrocarbons, heavy metals, pesticides, arsenic, PCBs, solvents, asbestos, and VOCs.

Potential contamination sites directly adjacent to the project corridor are shown in Figure 4-1. The EIS required that soil contamination would be addressed through further studies prior to construction with appropriate mitigation and management measures identified. Appropriate mitigation measures in relation to contamination are included in Section 6.

Figure 4-1 Potential ASS and Contamination



4.2 Surface water

The project crosses 2 waterways, which are typical of lowland freshwater systems. These are listed in Table 4-2.

There are no sensitive receiving environments located in the vicinity of the project, such as SEPP 14 wetlands, key fish habitat, or threatened species habitat.

Existing water quality monitoring data for waterways within each section was reviewed as part of the EIS. The existing water quality data indicate that the majority of the waterways potentially impacted by the project have a history of water quality problems, with conditions commonly found to be below the standard required for protection of aquatic ecosystems. The occurrence of poor water quality can be attributed to a number of factors, including modification of channel structure, macrophyte growth and soil erosion.

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.

Table 4.3 summarises the pre-construction phase monitoring results with respect to visual observations and a general summary of the water quality sampling results for the monitoring site Figure 4.3.

The data is considered suitable for use as a baseline data set for comparison with construction and operational phase data. (Geo-Link 2014)

Table 4-2 Watercourses, wetlands and water quality

Section	Waterways	Summary of water quality
2	• Wells Crossing Creek • Glenugie Creek	Samples from Glenugie Creek in 2007 indicated that dry weather water quality failed to meet the ANZECC/ ARMCANZ guidelines. At the time of sampling, the waterway was affected by low flows and excessive macrophyte growth, which would have contributed to low dissolved oxygen levels. Water quality was substantially higher during wet weather, complying with ANZECC/ ARMCANZ guidelines for all water quality indicators measured.

Table 4-3 Water quality summary (Geo-Link 2014)

Site Identifier/ Waterway	Summary of Visual Observations	Overview of Water Quality Sampling Results
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	• 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

	vegetation • Water surface generally free of dust and leaf litter despite over hanging vegetation and the nearby road.	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.	• 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

4.2.1 Construction surface water quality monitoring

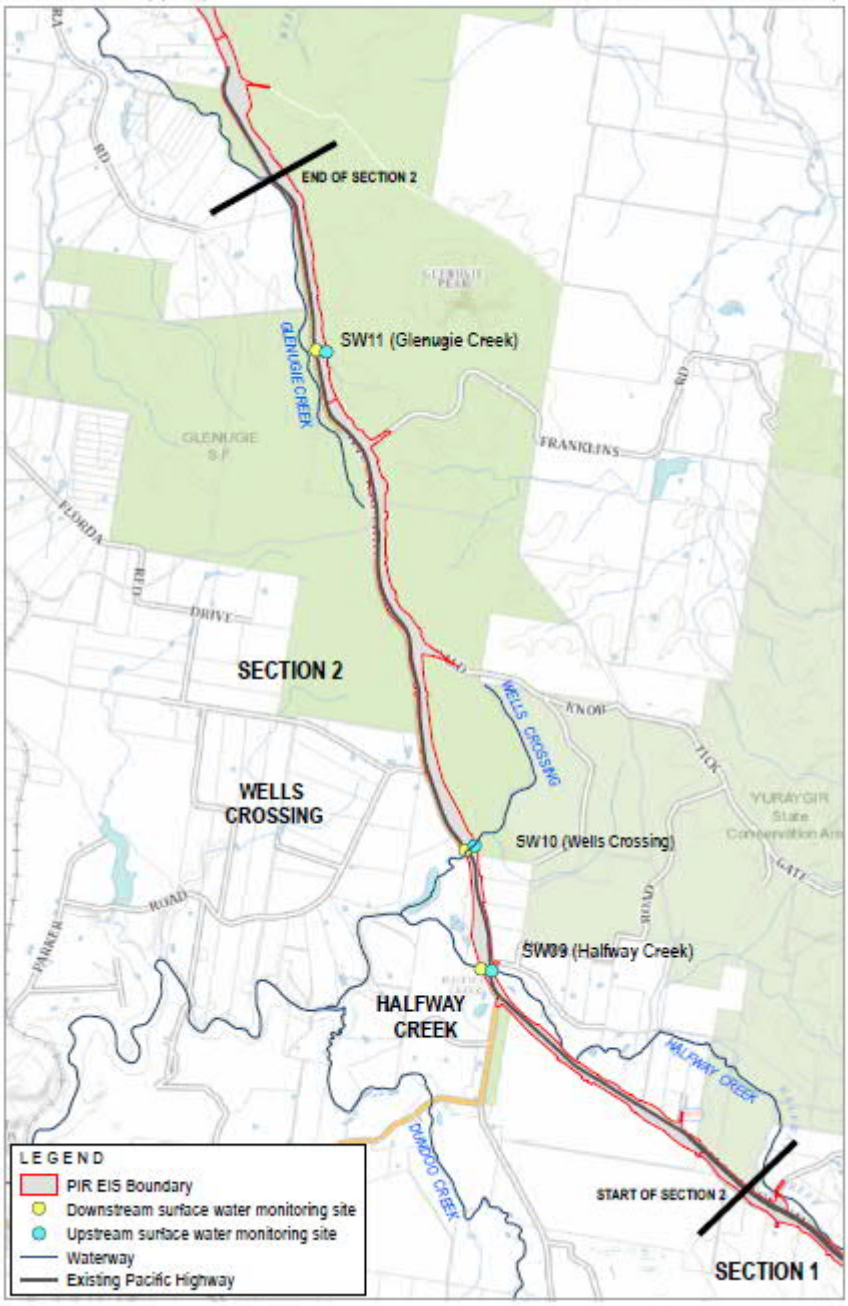
The water quality monitoring program to be implemented during and following construction is provided as Appendix A.

The paired (upstream and downstream) sites to be monitored are identified in Table 4.4 and Figure 4-2.

Table 4-4 Monitoring Locations

Waterway	Identifier	Chainage	Sensitive Receiver
Wells Crossing	SW10	22400	Fish Habitat
Glenugie Creek	SW11	29300	Fish Habitat

Figure 4-2 Surface water monitoring locations (Geo-Link 2014)



4.3 Groundwater

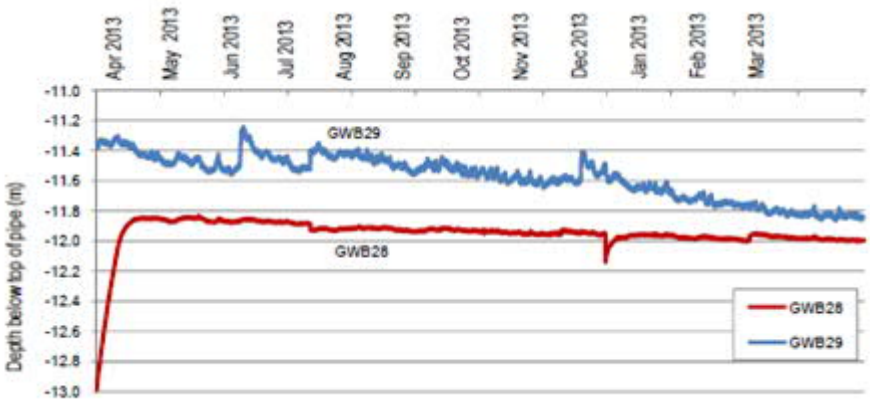
The project alignment runs through elevated areas, with shallower water tables within 5 metres of the surface in the southern portion, and becoming deeper to 50 metres in the north as elevation rises. There is low potential for impacts to occur to groundwater levels during construction in the southern portion, reducing to minimal potential in the north as the topography rises. Figure 4-3 details the groundwater depth adjacent to the deepest cut in Section 2 which is approximately 9 metres.

The depth of the earthworks at the three ground water monitoring locations is:

- GW 28 and 29 at Chainage 26800 cut depth is 7 metres and groundwater depth ranges from 11.3 metres to 13.0 metres.
- GW 30 and 31 at Chainage 27200 cut depth is 9 metres and groundwater depth ranges from 13.0 metres to 14.5 metres.

Therefore no significant impacts to groundwater or water course related Groundwater Dependent Ecosystems (GDEs) is anticipated.

Figure 4-3 Groundwater depth at shallowest location (Geo-Link 2014)



4.3.1 Construction ground water quality monitoring

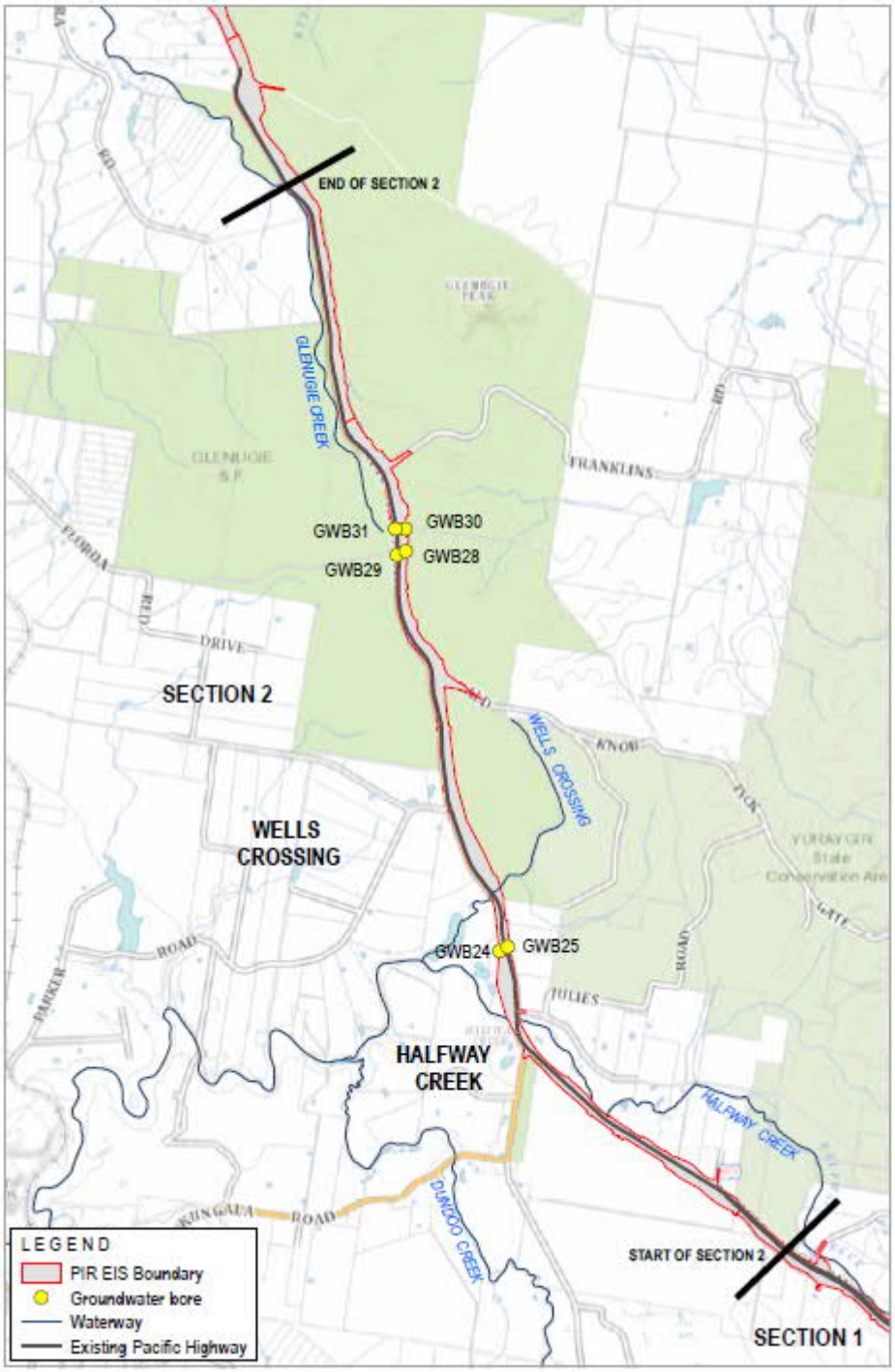
The water quality monitoring program to be implemented during and following construction is provided as Appendix A.

Groundwater monitoring is to occur at 4 locations as identified in Water Quality Monitoring Program, these are detailed in Table 4.5 and Figure 4-4.

Table 4-5 Groundwater monitoring

Borehole Identifier	Chainage	General Location	Cut Type	Monitoring for	
				Level	Quality
GWB28	26860		A	Yes	
GWB29	26880			Yes	-
GWB30	27120		A	Yes	Yes
GWB31	27130			Yes	Yes

Figure 4-4 Groundwater monitoring locations (Geo-Link 2014)



Note- GWB's 24 and 25 are not in the WC2G project.

4.4 Rainfall

The rainfall records from Grafton have been selected to reflect the potential rainfall conditions across the Project site due to its location within the overall site, and extent of available data (from 1886 to present). A summary of the rainfall records from the Bureau of Meteorology is provided in Table 4-6.

Figure 4-5 Monthly Rainfall

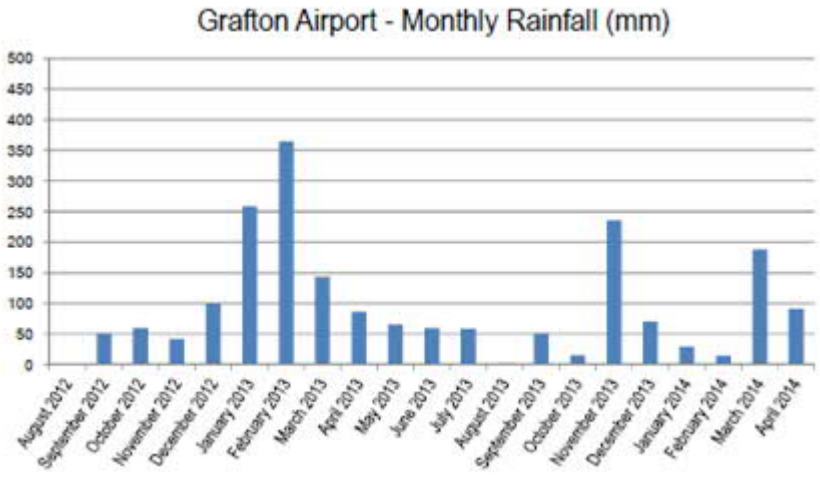


Table 4-6 Summary of rainfall records

Summary of rainfall record from 1888 to present													
	Summer / Autumn					Winter / Spring							
	Dec	Jan	Feb	Mar	Apr	Ma	Jun	July	Aug	Sep	Oct	Nov	Year
Mean rainfall (mm)	*119.3*	*143.7*	*150.8*	*129.4*	*88.4*	*79.5*	*69.2*	*38.1*	*40.9*	*37.7*	*77.9*	*106.1*	*1080.0*
Mean rain days	*10.0*	*10.6*	*10.9*	*11.2*	*8.0*	*7.5*	*5.8*	*4.6*	*4.3*	*5.2*	*7.3*	*9.4*	*94.8*
Mean dry days	*6.3*	*6.3*	*4.2*	*7.0*	*9.0*	*10.2*	*11.5*	*13.9*	*15.5*	*14.0*	*9.4*	*7.9*	*115.2*
Mean wind speed (km/h)	*6.2*	*5.8*	*5.7*	*6.1*	*6.8*	*5.9*	*6.0*	*5.7*	*7.2*	*7.3*	*7.8*	*6.6*	*6.4*
Mean maximum temp (0C)	*29.6*	*30.1*	*29.3*	*28.2*	*26.2*	*23.1*	*20.8*	*20.5*	*22.2*	*24.9*	*26.7*	*28.1*	*25.8*
Mean minimum temp (0C)	*18.4*	*19.7*	*19.7*	*18.0*	*14.9*	*11.2*	*8.1*	*6.4*	*7.2*	*10.4*	*13.7*	*16.3*	*13.7*

Rainfall is typically higher during summer and autumn. Winter and spring are typically drier periods during the year.

4.5 Rainfall erosivity factor

The rainfall erosivity factor is a measure of the ability of rainfall to cause erosion (referred as "R" in the Revised Universal Soil Loss Equitation RUSLE). The rainfall erosivity factor is used to determine the soil loss in tonnes per hectare over one year, and is used in calculations when sizing construction sediment basins.

The Project has a Rainfall Erosivity Factor ranging from 3720 in the northern section to 4030 towards the southern section.

4.6 Flooding

The project is located in the Northern Rivers catchment management area, and is located in an elevated position in the landscape, outside of floodplain areas. The project intersects the watercourses of, Wells Crossing Creek & Glenugie Creek and a number of small unnamed drainage lines.

Chapter 8.3 of the EIS includes an assessment of construction impacts in relation to hydrology and flooding, including ancillary sites. As the project is situated in an elevated position outside of the floodplain, and the W2B EIS determined that construction and operation of this section of the road alignment would not result in any significant flooding or hydrological impacts to surrounding properties.

5 Environmental aspects and impacts

5.1 Construction activities

Key aspects of the Project that could result in adverse impacts to soils and water include:

- Vegetation clearing and topsoil stripping.
- Mulching of vegetation
- Bulk earthworks.
- Cuts and fills
- Site access including temporary waterway crossings.
- Culvert and drainage works.
- Bridge construction.
- Material stockpiles including the treatment of acid sulphate soil and rock.
- Batch plant operation.
- Paving activities.
- Water use / extraction.
- Compounds operation including fuel and chemical storage, refuelling and chemical handling.
- Noxious weed treatment including herbicide spraying.

Refer also to the Aspects and Impacts Register included in Appendix A2 of the CEMP.

5.2 Potential Impacts

The potential for impacts on soil and water will depend on a number of factors. Primarily impacts will be dependent on the nature, extent and magnitude of construction activities and their interaction with the natural environment. Potential impacts attributable to construction might include:

- Exposure of soils during vegetation clearing and earthworks, creating the potential for off-site transport of eroded sediments and pollutants.
- Sensitive area damage from inappropriate stockpiling activities.
- Production of tannins from mulch during clearing.
- Alteration of surface and subsurface flows that could cause disturbances to hydrology and hydraulics.
- Intercepting with cuts perched water tables or layers of relatively low permeability soil/rock that support surrounding ecosystems and groundwater sensitive areas.
- A reduction in groundwater levels and flows, and off-site discharge of water containing sediment from dewatering activities.
- Interception and interference with an aquifer that could obstruct groundwater flow and limit groundwater availability.
- Contamination of soils, and surface and groundwater from accidental spills or oil leaks. This might include grease or fuel from machinery and vehicles, construction sites or

compounds, or spills of other chemicals that may be used during the course of construction.

- Disturbance of unidentified contaminated land eg former cattle tick dip sites, or other pesticide/chemical concentrations in soil from historical land use practices, and subsequent generation of contaminated runoff.

The risk assessment conducted for the project indicates that there is a high risk of impact to soil and water. Relevant aspects and the potential for related impacts have been considered in a risk assessment at Section 3.4 and Appendix A2 of the CEMP. Chapter 6 provides a suite of mitigation measures that will be implemented to avoid or minimise those impacts.

6 Environmental control measures

A range of environmental requirements and control measures are identified in the various environmental documents, including the EIS, supplementary assessments, Conditions of Approval and RMS documents, and from recent experience on similar road projects. Specific measures and requirements to address impacts on soil and water are outlined in Table 6-1.

Table 6-1 Soil and water management and mitigation measures

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
GENERAL					
SW1	Training will be provided to all project personnel, including relevant sub-contractors on sound erosion and sediment control practices and the requirements from this plan through inductions, toolboxes and targeted training.	Training package	Pre-construction / Construction	Roadworks Manager / Environment Manager	G38/G36, Good practice
SW2	A Project Soil Conservationist will be engaged during detailed design to develop an erosion and sedimentation management report to inform the soils and water management plan and will be regularly consulted throughout construction to provide advice on erosion and sediment control design, installation and maintenance.	Management staff	Pre-construction / Construction	Environment Manager	G38, Good practice, Submissions / PIR (SSW5)
SW3	An environmental protection licence (EPL) will be obtained for the Project. All relevant conditions relating to soil and water management will be implemented as required by the licence.	Management staff	Construction / Post construction	Roadworks Manager	POEO Act 1997
PROCEDURES AND PLANS					
SW4	Erosion and Sediment Control Plans (ESCPs) will be prepared and implemented in advance of construction, including earthworks and stockpiling. ESCPs and will be updated as required.	Soil conservationist	Pre-construction / Construction	Environment Coordinator / Foreman	Managing Urban Stormwater: Soils and Construction Volume 1 and Volume 2D, EIS (SSW4)
SW5	The following EWMS will be prepared and implemented to manage soil and water impacts. EWMS for activities identified as having high environmental risk will undergo a period of consultation with EPA, the Office of Water, and DPI (Fisheries and Aquaculture). Those marked with an asterisk below are those likely to be subject to consultation: • Activities that impact on environmentally sensitive areas* • Working platforms in or adjacent to waterways* • Sediment basin construction and maintenance* • Concreting activities	Field & management staff	Construction	Superintendent / Environment Manager	G36 and G40

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	• Batch plant operation* • Management of Acid Sulfate Materials* • Dewatering* • Managing tannin leachate* • Vegetation clearing and grubbing* • Topsoil stripping*				
SW6	Any ASS or PASS disturbed during the construction process will be managed in accordance with RMS Acid Sulfate Soil Management Procedure (incorporating an Acid Sulfate Soils contingency plan as required under CoA D26(c)v) attached at Appendix C.	Field & management staff	Pre-construction / Construction	Superintendent / Environment Manager	Submissions / PIR (SSW25) CoA D26(c) v
SW7	The requirements of the spoil and fill management procedure attached at Appendix B will be implemented throughout construction. The plan includes, among other detail, the types of material expected to be encountered during construction, and how excavated material will be handled, transported, stockpiled, reused and disposed.	Field & management staff	Construction	Superintendent / Foreman	CoA D25(d)ix
SW8	Dewatering will be undertaken and managed in accordance with the Pacific Highway Projects Dewatering Guidelines attached at Appendix G. A specific EWMS for dewatering will be prepared and will consider and/or incorporate the following detail: • Areas of the site that will require dewatering. • Dewatering methods that will minimise potential environmental impacts. • Opportunities for reuse. • The limitations for any proposed reuse methods. • Discharge locations and adequate energy dissipation. • Water quality criteria for discharge and/or reuse. • Treatment techniques required to meet the water quality criteria. • Water sampling and testing requirements.	Field & management staff	Construction	Superintendent / Environment Manager	G38 (Section3.5)

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
SOIL EROSION AND SEDIMENTATION CONTROL					
SW9	Appropriate erosion and sediment controls, following the guidelines of the 'Blue Books' (Landcom, 2004 and DECC, 2008), will be established before the start of construction and maintained in effective working order for the duration of the construction period until site stabilisation. Specific controls will include: • Sediment fences and filters to intercept and filter small volumes of non-concentrated construction runoff • Rock check dams across swales and diversion channels to reduce the velocity of flow, thereby reducing erosion of the channel bed and trapping sediment • Level spreaders to convert erosive, concentrated flow into sheet flow • Diversion drains that collect construction runoff and direct it away from unstable and/or exposed soil to treatment facilities • Diversion drains to collect clean runoff from upstream of the construction area and divert it around or through the site without it mixing with construction runoff • Lining of channels and other concentrated flow paths • Sedimentation basins to capture sediment and associated pollutants in construction runoff (see further details below) Specific measures and procedures for works within waterways, such as the use of silt barriers and temporary creek diversions, in accordance with RMS' Technical Guideline – Temporary Stormwater Drainage for Main Road Construction (RMS, 2011).	Field & management staff	Construction	Superintendent / Foreman / Environment Manager	CoA B34 Submissions / PIR (SSW26) / EPL/ POEO Act
SW10	Erosion and sediment control plans will be developed in line with current Roads and Maritime specifications and as detailed in the Working paper – Water quality.	Soil conservationist	Pre-construction and construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW4)
SW11	Sedimentation basins and water quality ponds will be sized and located in accordance with the principles identified in the	Soil conservationist	Pre-construction	Environment Manager /	Submissions / PIR

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	Working paper – Water quality.		and construction	Superintendent / Foreman	(SSW6)
SW12	Exposed areas will be progressively rehabilitated. Methods will include permanent revegetation, or temporary protection with spray mulching or cover crops.	Revegetation equipment	Construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW7)
SW13	Any necessary approvals will be obtained in accordance with Roads and Maritime specification G36 for permanent and temporary waterway crossings.	Soil conservationist	Construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW8)
SW14	Sensitive receiving environments will be reconsidered during detailed design to include any threatened ecological communities and non- aquatic species and their habitats that may be affected by the project. Appropriate management measures will be implemented, if required.	Sensitive area plan	Pre-construction	Environment Manager / Design Manager	EIS (SSW34)
SW15	The design and construction of works within riparian corridors and within the minimum required distance from waterways will be undertaken in accordance with NSW Office of Water guidelines for working within riparian corridors.	Field & management staff	Pre-construction / Construction	Superintendent / Foreman / Environment Manager	EIS (SSW36)
SW16	Flow discharge points will be designed with erosion controls to slow the flow velocities.	Soil conservationist	Pre-construction	Design Manager	EIS (SSW37)
SW17	In steep areas, the length between sediment fences and other physical controls will be decreased to reduce soil erosion.	N/A	Construction	Superintendent / Foreman	EIS (SSW38)
SW18	Construction sequencing and temporary diversions of water will be developed and designed to consider the impact of change on flow regimes and to minimise these changes throughout construction.	Soil conservationist	Pre-construction / Construction	Superintendent / Foreman	EIS (SSW39)
SW19	Works will be programmed to minimise the extent and duration of disturbance to vegetation. This will include leaving clearing (undertaken by manual means) and initial earthworks in intermittent and permanent watercourses until subsequent works are about to commence.	Field & management staff	Pre-construction / Construction	Superintendent / Foreman	G38
SW20	Wastewater or “dirty” water generated during the construction	Field &	Construction	Superintendent /	G38 / EPL / POEO Act

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	process will, wherever possible, be collected, treated and disposed of by appropriate means, including the installation of sediment barriers downslope of all disturbed areas. In areas where it is not possible to direct dirty water to sediment basins, other sediment controls will be implemented in accordance with “Blue book” best practice.	management staff		Foreman	
SW21	Clean and dirty water runoff will be adequately separated to avoid mixing where possible through the use of diversions, clean water drains, and the early installation of permanent drainage infrastructure.	Field & management staff	Construction	Superintendent / Foreman	G38
SW22	Active work areas will be stabilised at the end of each day’s work and/or just prior to inclement weather, by means such as grading or smooth drum rolling to create a smooth surface and by installing of temporary “catch” drains to prevent / minimise transport of sediment.	Field & management staff	Construction	Superintendent / Foreman	G38
SW23	Catch drains; contour and diversion drains across exposed areas will be installed immediately following clearing, and re-established and maintained during topsoil removal and earthwork operations.	Field & management staff	Construction	Superintendent / Foreman	G38
SW45	Hardstand material, rumble grids or similar will be provided at exit points from construction areas onto public roads to minimise the tracking of soil and particulates onto public roads.	Field & management staff	Pre-construction / Construction	Superintendent / Foreman	G38
SW25	Vehicle movements from site will be minimised during wet weather if the tracking of mud may become an issue.	Field & management staff	Pre-construction / Construction	Superintendent / Foreman	Good practice
SW26	Loose rock, soil, debris etc. will be removed from road surfaces (including sweeping of the road) at the end of each work shift.	Field & management staff	Pre-construction / Construction	Superintendent / Foreman	G38
SW27	All required sediment basins and associated drainage will be installed and commissioned prior to the commencement of clearing and grubbing works in that catchment that could cause sediment to leave site. (Except where clearing is required for basin installation).	Field & management staff	Construction	Superintendent / Foreman	G38, Good practice
SW28	Sediment basins will be operated and maintained in accordance with the Sediment Basin Management and		Construction	Superintendent /	Good practice

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	Discharge Procedure and Water Quality Monitoring Program contained in Appendix H and Appendix A, respectively. Basins will not be discharged until all monitoring and water quality criteria has been verified and documented.			Foreman	
SW29	Works within waterways will consider the need to maintain fish passage, in consultation with the Department of Primary Industries (Fisheries).	Management staff, DPI Fisheries	Construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW27)
SSW30	Flow discharge points will be designed with erosion controls to manage the flow velocities.	Soil conservationist	Pre-construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW28)
DESIGN OF CUT AND FILL BATTERS					
SW31	Batter slope gradients will be designed to minimise erosion of select topsoil.	Field & management staff	Pre-construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW1)
SW32	Where feasible, bench cuttings will be diverted onto contours and surface flow drainage paths designed to spread flow at the source in preference to concentrating the flow and treating it further downstream.	Field & management staff	Pre-construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW2)
CONSTRUCTION SEDIMENT BASINS					
SW33	Where appropriate, construction phase sedimentations basins will be designed so they could be retained and used as permanent operational water quality ponds, where required for operational purposes.	Soil conservationist	Pre-construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW29)
SW34	Sedimentation basins will be inspected at regular intervals and following significant rainfall events to assess available water storage capacity, water quality, structural integrity and debris levels.	Field & management staff	Construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW31)
SW35	Where appropriate, an approved flocculent will be applied to sedimentation basins as early as possible so that early mixing of flocculants occurs. Water quality in the sediment basin will be tested prior to discharge in accordance with any licence	Testing regime	Construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW32)

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	requirements and the receiving waters quality criteria as defined in the RMS Dewatering Practice Note and detailed in the surface water quality results in the EIS..				
SW36	Where sediment has built up in a basin to a point where the total sediment storage zone has reached capacity, sediment will be removed and appropriately disposed of in accordance with the Construction Waste and Energy Management Plan, Appendix B7.	Field & management staff	Construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW33)
SW37	Water from sedimentation basins will be used for construction purposes, such as dust suppression, where feasible.	Field & management staff	Construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW34)
SW38	When sedimentation basins require pumping out rather than discharge via a flow outlet, a float will be attached to the suction hose or the hose will be located inside a bucket to prevent sediment from the basin floor from being discharged.	Field & management staff	Construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW35)
SW39	Records will be kept of water quality monitoring and erosion and sediment control inspections, including details of rain events, use of flocculants, discharge, sediment removal and dewatering activities.	Environment manager	Construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW36)
ANCILLARY FACILITY AND STOCKPILE MANAGEMENT					
SW40	Stockpiles and ancillary facilities will be located to minimise erosion and in accordance with the criteria outlined in Appendix A3 of the CEMP and Appendix I of this plan.	Field & management staff	Pre-construction / Construction	Superintendent / Foreman / Environment Manager	CoA D21, CoA D25(d)ix, G38, Submissions / PIR (SSW11 – SSW13)
SW41	Measures to be implemented to minimise impacts to surface and ground water quality include: • Impervious bunded, and covered storage facilities for fuels and chemicals • Bunded areas for refuelling and washdown	Field & management staff	Construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW37)
SW42	At ancillary facilities, management of runoff and spills will	Field &		Environment	Submissions / PIR

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	include: • Restricting vehicle movements to designated pathways where feasible. • Paving areas that will be exposed for extended periods, such as car parks and main access roads, where reasonable and feasible. • Diverting off-site runoff around sites where required. • Locating chemical or other hazardous material storage areas away from areas of known near-surface groundwater supplies, in areas where the water table is more than five metres below the surface; otherwise, areas be lined if they are to be located over a shallow groundwater source less than two metres deep.	management staff	Construction	Manager / Superintendent / Foreman	(SSW38)
SW43	Soil and water management at borrow source sites will be in line with Volume 2E of the Blue Book which covers water management of mines and quarries.	Soil conservationist	Construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW39)
SW44	Topsoil, earthworks and other excess spoil material will be stockpiled and managed in accordance with the Stockpile Management Protocol, Appendix I, Roads and Maritime Stockpile Management Guidelines (Roads and Maritime, 2011a) and the "Management of Surplus Material" in Section 3.9 of the Submissions / Preferred Infrastructure Report.	Stockpile protocol	Construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW10)
SW45	Where reasonable and feasible, stockpiles will: • Not require removal of areas of native vegetation. • Be located outside of known areas of weed infestation. • Be located such that waterways and drainage lines are not directly or indirectly impacted.	Field & management staff	Construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW11)
SW46	Where practicable, stockpiles will be located away from areas subject to concentrated overland flow. Stockpiles located on a floodplain be finished and contoured so as to minimise loss of material in flood or rainfall events.	Field & management staff	Construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW12)

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
SW48	All construction stockpiles will comply with the requirements of the *Protection of the Environment Operations Act 1997* and NSW Waste Avoidance and Resource Recovery Strategy 2007 for any waste activities that involve the generation, storage and/or disposal of waste and also consider the NSW Resource Recovery Exemptions as applying the storage of stockpiled material.	Stockpile protocol	Construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW14)
SW49	Stockpiles containing potential acid sulfate soils will be lined, bunded and covered in accordance with relevant guidelines.	CASMMP	Construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW15)
SW50	Management of tannin leaching from vegetation mulch will be in accordance with Roads and Maritime' Environmental Direction – Management of Tannins from Vegetation Mulch (Roads and Maritime, 2012).	Field & management staff	Construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW16), Appendix D
DRAINAGE AND WATERWAY					
SW51	The EWMS for working platforms in or adjacent to waterways will detail how the works are to be undertaken to reduce erosion and minimise impacts on water quality and riparian fauna and flora. Considerations will include: • Ensuring that where possible earth and/or rock platforms for driving piles are constructed to minimise impacts on the direct water channel. • Keeping vegetation clearing to a minimum. • Constructing rock platforms for driving piles / girder erection only where necessary. • Selecting the optimum rock size for platforms/ haul roads to account for all issues including safety and environment. • Using larger rock size and grades on the lower side of the works to assist in reducing failure risks. • Addressing stormwater overflow design and pipe capacity. • Enclosing platforms in geotextile fabric and appropriate	Field & management staff	Pre-construction / Construction	Environment Manager / Superintendent	G36, Good practice

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	erosion and sediment controls before clearance commences. The EWMS will be prepared in consultation with EPA and DPI (Fisheries Conservation and Aquaculture).				
SW52	Watercourse crossings shall be designed in consultation with the DPI (Fisheries NSW), EPA, NOW and DoE, and where feasible and reasonable, be consistent with the *Guidelines for Controlled Activities Watercourse Crossings* (Department of Water and Energy, February 2008), *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (Fairfull and Witheridge, 2003), *Policy and Guidelines for Fish Friendly Waterway Crossings* (NSW Fisheries, February 2004), and *Policy and Guidelines for Fish Habitat Conservation and Management* (DPI Fisheries, 2013). Where multiple cell culverts are proposed for crossings of fish habitat streams, at least one cell shall be provided for fish passage, with an invert or bed level that mimics watercourse flows. Where temporary crossings are required, these will be designed, constructed and maintained in accordance with *Managing Urban Stormwater Soils and Construction* Volumes 2A and 2D *Main Road Construction* (DECC 2008) and section 5.3.4 of the guideline *Managing Urban Stormwater 4th edition Volume 1 Soils and Construction* and subject to the preparation of an EWMS identified in SW2 and SW31. Temporary crossings will: • Be 'fish friendly' with a lower section of the temporary crossing provided to act as an emergency spillway. • Be used for the shortest time required to complete their designed operational function. • Use material that will not result in fine sediment material entering the waterway. • Where rock crossings are used, the rock will be of suitable size to prevent / reduce the likelihood of the material being washed away in a storm or flood event, with large sized rock on the lower side of crossings	Environment manager, guidelines	Construction	Environment Manager / Superintendent / Engineers	CoA B38 G36, PIR(B21)

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	where water velocity increases. • Waterflow is to be maintained at all times in watercourses.				
SW53	Scour protection will be installed at the base of permanent and temporary drainage outlets, and will be integrated where feasible into current banks to minimise impacts.	Field & management staff	Construction	Environment Manager / Superintendent / Foreman	G36, G38
SW54	Drainage works will be stabilised against erosion by appropriate selection of channel dimensions, slope and lining, and the inclusion, if necessary, of drop structures and energy dissipaters.	Field & management staff	Construction	Environment Manager / Superintendent / Foreman	G38, Good practice
SW55	Culverts and permanent stream protection measures will be installed as early as possible in the construction program to facilitate transverse drainage during the early stages of construction.	Roadworks Manager	Construction	Environment Manager / Superintendent / Foreman	Good practice
MANAGEMENT OF GROUNDWATER INTERSECTION					
SW56	Where groundwater is released, recharge of the water table is the preferred option of managing groundwater. This will be facilitated by collecting groundwater in grassed swales for infiltration back to the groundwater source. Where possible, these swales will divert the groundwater around the construction area so that the groundwater does not further mix with construction runoff.	Field & management staff	Construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW42)
SW57	If recharging is not possible or suitable, then discharging groundwater will be collected via the sedimentation basins before discharge into natural waterways. If discharging to downstream groundwater, then the potential effects of mounding will be mitigated.	Field & management staff	Pre-construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW43)
SW58	Dewatering of excavations will be undertaken in line with Roads and Maritime' Technical Guideline – Environmental Management of Construction Site Dewatering (Roads and Maritime, 2011c), and in accordance with any licence conditions.	Guideline	Construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW44)
GROUNDWATER					

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
SW59	The monitoring of locations in the vicinity of type A and B cuttings and major embankments will commence before construction to identify the need to implement any mitigation measure.	Water monitoring equipment	Pre-construction, construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW47)
SW60	If required to manage groundwater impacts at type A and type B cuttings and major embankments, the following engineering mitigation measures will be considered: • Engineering measures that transfer the seepage water downstream. Standard practice will be to collect the seepage from the cut face in the drainage system for the highway, which will be diverted into water quality basins before being released back into the creek or natural drainage system at some point downstream. • Engineering impact mitigation measures that transfer the seepage water (where present) into the groundwater ecosystem immediately downslope of the cutting or embankments.	Engineer	Pre-construction and construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW48)
SW61	Major embankments will be designed to enable distributed flow of surface waters.	Field & management staff	Pre-construction and construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW49)
SW62	Sites used for batch plants, refuelling and chemical storage will be managed so that no groundwater intrusion occurs.	Management plan	Pre-construction and construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW51)
SW63	Implement mitigation measures contained in the Groundwater Management Strategy attached at Appendix E.	Appendix E	Pre-construction / Construction	Superintendent / Environment Manager	
WATER QUALITY AND USE					
SW64	Appropriate scour protection for drainage measures will be determined during detailed design.	Engineer	Operation	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW61)
SW65	Except as may be expressly provided by an EPL, the	Field &	Pre-construction	Environment	CoA B30, Good practice

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	contractor shall comply with section 120 of the Protection of the Environment Operations Act 1997. Water will be used during construction for a number of purposes, including, but not limited to: • Concrete and asphalt batching. • Dust control. • Washing of plant and equipment. • Drinking water. • Amenities. • Landscaping and re-vegetation. Prior to and during construction, water needs will be identified and water sources assessed to determine the most appropriate water source(s). When determining the most appropriate water source(s), the use of non-potable water sources will be considered in preference to potable water where appropriate. The water sources likely to be considered for construction include: • Creeks. • Groundwater. • Farm dams. • Sediment basins. • Rainwater collection. • Potable water. • Effluent reuse where available and meeting suitable standards. Appropriate licences and/or permits will be sought for each water source as required.	management staff	/Construction	Manager / Superintendent / Foreman	/ EPL / POEO Act
SW66	Where available, and of appropriate chemical and biological quality, stormwater, recycled water or other water sources shall be used in preference to potable water for construction activities, including concrete mixing and dust control.	Field & management staff	Construction		CoA B35

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
SW67	All surface water and groundwater shall be adequately treated as far as is practicable, prior to entering the stormwater system to protect the receiving water source quality.	Field & management staff, PESCP	Construction		CoA B36
MATERIAL STORAGE AND MANAGEMENT					
SW68	Concrete pumping or concreting activities will be undertaken in accordance with Environmental Best Management Practice Guideline for Concreting Contractors 2002 to prevent and/or minimise spillages.	Guideline	Construction	Superintendent / Foreman	G38
SW69	Designated impervious bunded facilities will be provided for washout of concrete trucks and cleaning and/or maintenance of other vehicles, plant or equipment. These facilities will be located at least 40 metres away from natural waterways, or 40m away from the outlet of built drainage lines.	Field & management staff	Construction	Superintendent / Foreman	G38
SW70	An EWMS for managing tannin leachate (tannin leachate management protocol) will be prepared in accordance with the RMS Environmental Direction for the Management of Tannins from Vegetation Mulch attached at Appendix D. The requirements include detail on: • Planning and staging vegetation processing activities. • Stockpile location and management to minimise the production and release of tannins. • Monitoring the stockpiles for the production of tannins. • Response to tannin production.	Protocol	Construction	Environment Manager / Foreman	RMS Environmental Direction for the Management of Tannins from Vegetation Mulch CoA D26(c)vi
SW71	Where refuelling on site is required, the following management practices will be implemented: • Refuelling will be undertaken on level ground and at least 20 metres from drainage lines, waterways and/or environmentally sensitive areas. • Refuelling will be undertaken within the designated refuelling areas with appropriate bunding and/or absorbent material. • Refuelling will not be undertaken on or in the vicinity	Field & management staff	Construction	Foreman	Good practice

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	vegetated areas (even roadside grasses). • Refuelling will be attended at all times. • Spill kits will be readily available and personnel trained in their use. A spill kit will be kept on the refuelling truck at all times. Hand tools will be refuelled within lined trays of site vehicles wherever possible.				
SW72	Physical controls to address the potential risks associated with the use and storage of chemicals on site will include: • Use of appropriately bunded storage facilities for chemicals and fuels. • Use of appropriately bunded areas for refueling and washdown. • Availability of effective spill kits at all construction sites • Staff suitably trained in response to spills and the use of spill kits..	Field & management staff	Construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW37)
CONTAMINATION					
SW73	A Stage 1 Preliminary Site Investigation will be conducted to verify past and present potentially contaminating activities, potential contaminants of concern and the need for further investigation. This will include a review of past highway crashes and spills and the associated contamination risks.	Environment Manager	Pre-construction	Roadworks Manager / Environment Manager	Submissions / PIR (SSW17), CoA B37
SW74	If necessary, a Stage 2 Detailed Site Investigation will be undertaken to: • Provide information on the type, nature, extent and concentrations of contamination present, and the corresponding risks to human health and the environment. • Examine pathways of contaminant dispersal and exposure, the potential for off-site impacts and the management requirements and options.	Environment Manager	Pre-construction	Roadworks Manager / Environment Manager	Submissions / PIR (SSW18)
SW75	If required, a Stage 3 Remedial Action Plan will be produced, detailing the remediation goals, environmental safeguards,	Environment Manager, guidelines	Pre-construction	Roadworks Manager /	Submissions / PIR (SSW19)

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	and any necessary approval and licence requirements in accordance with NSW Office of Environment and Heritage guidelines.			Environment Manager	
SW76	Where further assessment indicates that further action is not required, Roads and Maritime' Contaminated Land Management Guideline (RTA, 2005a) will be applied to address any contamination issues and prevent any associated adverse impacts.	Environment Manager	Pre-construction	Roadworks Manager / Environment Manager	Submissions / PIR (SSW20)
SW77	A hazardous materials buildings assessment will be carried out before the demolition of any structures or buildings to identify the issues of concern and the management requirements. This is required under Clause 1.6 of Australian Standard AS 2601 – 2001 The Demolition of Structures.	Specialist staff	Construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW21)
SW78	Permanent water quality basins will incorporate measures to contain accidental fuel and chemical spills resulting from vehicle accidents on the highway. Basins will be designed to accommodate a spill volume of up to 40,000 litres.	Design	Operation	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW59)
SW79	An emergency spill response plan will be developed and incorporated into the soils and water management plan. This plan will detail measures for the prevention, containment and clean-up of accidental spills of fuels and chemicals.	Plan	Construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW22)
SW80	The storage, handling and use of the chemicals and fuels will be in accordance with the Work Health and Safety Act 2000 and Workcover's Storage and Handling of Dangerous Goods Code of Practice (WorkCover, 2005).	Code of practice	Construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW23)
ACID SULFATE SOILS					
SW81	All ASS or PASS disturbed during the construction process will be managed in accordance with RMS Acid Sulfate Soil Management Procedure attached at Appendix C. Specific controls to be implemented will include: • Capping of exposed surfaces with clean fill to prevent oxidation. • Placing excavated acid sulfate soils separately in a lined, bunded and covered area.	CASMMP	Construction	Foreman / Superintendent / Environment Manager	EIS (SSW31, SSW32), CoA D26 (c)(v)

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	• Neutralising acid sulfate soils for reuse (where appropriate) by using additives such as lime. • Disposing of acid sulfate soils where necessary in accordance with the relevant guidelines set out in DECC (2008). The requirements will be incorporated into the EWMS for "Management of Acid Sulfate Materials" referred to in SW6.				
SW82	Strategies to remove / reduce risks associated with acid sulfate soils will be identified.	CASMMP	Pre-construction and Construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (SSW24)
REHABILITATION AND LANDSCAPING					
SW83	Disturbed areas will be progressively stabilised during the construction phase eg with a cover crop, hydromulch, hydroseeding, topsoil and/or mulch. Wherever possible, permanent landscaping and revegetation works will take place progressively in accordance with the Urban Design and Landscape Plan.	Field & management staff	Construction	Superintendent / Foreman	G38, EIS (SSW7)
MONITORING					
SW84	Surface water quality monitoring will be undertaken in accordance with Roads and Maritime' Guideline for Construction Water quality Monitoring (RTA, 2003), and as per the framework outlined in the Working paper – Water quality and the Water Quality Monitoring Program, Appendix A	Guideline	Pre-construction	Superintendent / Foreman / Environmental Manager / Environment Coordinator	Submissions / PIR (SSW62)
SW85	Groundwater monitoring will be undertaken in accordance with the framework outlined in the Working paper – Groundwater (Section 5.2). Appendix A	N/A	Construction	Superintendent / Foreman / Environmental Manager / Environment Coordinator	Submissions / PIR (SSW63)
SW86	Rainfall forecasts will be monitored daily and the site managed to avoid erosion and sedimentation, and to minimise the impact of heavy rainfall and flood events.	Weather station	Construction	Superintendent / Foreman / Environmental	G38

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
				Manager / Environment Coordinator	
SW87	Erosion and sediment controls will be inspected at least daily (with maintenance and/or modifications made as necessary). Inspections and/or maintenance during wet-weather maybe increased where necessary.	Field & management staff	Construction	Foreman	G38, Good practice
SW88	A project soil conservation specialist will inspect the work areas, typically on a fortnightly basis, or as required where high-risk activities are proposed, or where sensitive areas have the potential to be affected eg SEPP 14 wetland, heritage sites.	Soil conservationist	Pre-construction / Construction	Soil Conservation Specialist Environment Manager	Good practice / EPL / POEO Act
SW89	Monitoring of sediment basin water quality will be undertaken in accordance with EPL requirements. See Sediment Basin Management and Discharge Procedure in Appendix H.	Field & management staff	Construction	Environment Coordinator	Appendix H
RECORDS					
SW90	Records of dewatering activities will be maintained. Details will include: i. A copy of the work method statement(s). ii. Date, time and estimated volume released at each discharge location. iii. Water quality test results for each discharge. iv. The personnel approving the dewatering activities. v. Evidence of discharge monitoring, or risk assessment and mitigation measures used to eliminate the risks of pollution.	Discharge procedure	Construction	Environment Manager	G36
HYDROLOGY AND FLOODING					
HF1	Any permanent fencing at culvert and bridge crossings will consider the potential for blockage and be designed and operated to maintain the existing flood regime	N/A	Pre-construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (HF4)
HF2	Detailed design for permanent road fencing will consider hydrology and flooding impacts	N/A	Pre-construction	Roadworks Manager /	Submissions / PIR (HF5)

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
				Environment Manager	
HF3	Scour and erosion protection measures at temporary and permanent waterway crossings will be provided upstream and downstream of the highway, particularly within 50 metres of Class 1 waterways or within the range of the Oxleyan Pygmy Perch as identified in section 3.9.6 of the Working paper – Biodiversity and the supplementary biodiversity assessment in Appendix E of the Submissions / Preferred Infrastructure Report. This will be undertaken in consultation with the Department of Primary Industries (Fisheries). (Refer Appendix L)	Design	Pre-construction.	Roadworks Manager / Environment Manager	Submissions / PIR (HF6)
HF4	Waterway diversions will be designed in consultation with Office of Environment and Heritage, NSW Office of Water and Department of Primary Industries (Fisheries) so that the final diversion mimics, where feasible and reasonable, the characteristics of the waterway that is being diverted. Characteristics include flow regime, flow velocity, base material, vegetation and habitat for aquatic fauna.	Field & management staff	Construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (HF7)
HF5	Revegetation of waterway diversions and surrounding areas will be undertaken in accordance with the following principles: • Diversions will be stabilised prior to the diversion receiving flows, in conjunction with the establishment of other scour and erosion control measures. • Diversions will establish appropriate vegetation communities along the channel bed and banks, using endemic native species.	Field & management staff	Construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (HF8)
HF6	All work within 40 metres of a permanent watercourse, crossed by the project, will be undertaken in accordance with the NSW Office of Water 'Guidelines for Controlled Actions' and industry best practice including maintaining where feasible and reasonable the geomorphic integrity and natural hydrological flow regime.	Field & management staff	Construction	Environment Manager / Superintendent / Foreman	Submissions / PIR (HF19)
HF7	Recommendations made in Table 8-8 of Working paper – Hydrology and flooding to minimise the flood impacts of	Management staff	Pre-construction	Roadworks Manager /	Submissions / PIR

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	ancillary facilities will be considered in the final location and layout of ancillary facilities.			Environment Manager	(HF22)

7 Compliance management

7.1 Roles and responsibilities

Lendlease Engineering's Project Team's organisational structure and overall roles and responsibilities are outlined in Section 4.2 of the CEMP. Specific responsibilities for the implementation of environmental controls are detailed in Section 6 of this Plan.

7.2 Training

All employees, contractors and utility staff working on site will undergo site induction training relating to soil and water management issues. The induction training will address elements related to soil and water management including:

- Existence and requirements of this sub-plan.
- Relevant legislation.
- Roles and responsibilities for soil and water management.
- Procedure to be implemented in the event of an unexpected find of ASS or PASS.
- Water quality management and protection measures.
- Procedure to be implemented in the event of an unexpected discovery of contaminated land.

Targeted training in the form of toolbox talks or specific training will also be provided to personnel with a key role in soil and water management. Examples of training topics include:

- ERSED control installation methodology.
- Sediment basin construction.
- Sediment basin operation.
- Sediment basin maintenance.
- Working near or in drainage lines and creeks.
- Emergency response measures in high rainfall events / Pollution Incident Response Management Plan (PIRMP).
- Preparedness for high rainfall events.
- Lessons learnt from incidents and other event eg high rainfall/flooding.
- Mulch and tannin management.
- Spill response.
- Stockpile location criteria.
- Identification of potentially contaminated spoil and fill material.

Further details regarding staff induction and training are outlined in Section 5 of the CEMP.

7.3 Monitoring and inspection

Regular monitoring and inspections will be undertaken in the lead up to, during and following construction. Monitoring and inspections will include, but not be limited to:

- Up and downstream of the project alignment water quality monitoring at nominated locations as identified in the approved Surface and Ground Water Quality Management Plan (Appendix A).
- Groundwater monitoring, both level and quality at nominated locations as identified in the approved Surface and Ground Water Quality Management Plan (Appendix A).
- Construction sediment basin water quality monitoring prior to discharge to ensure compliance with Table 7-1 / EPL requriements.
- Weekly and post rainfall site inspections to evaluate the effectiveness of erosion and sediment controls measures in accordance with Section 8.1.1 of the CEMP.
- All monitoring will be carried out in accordance with AS 5667.1 1987.

The type, timing, frequency, assessment criteria and associated reporting requirements for the up and down stream water monitoring are detailed in the Water Quality Monitoring Program (required as per CoA D12) attached at Appendix A.

Additional requirements and responsibilities in relation to inspections are documented in Section 8.2 of the CEMP.

7.4 Licenses and permits

An Environment Protection License (EPL) will be obtained for the scheduled activity "road construction". The EPL typically prescribes water quality parameters to be measured and associated discharge criteria. They also detail the monitoring and analytical requirements by reference to authority publications eg Approved Methods for Sampling and Analysis of Water Pollutants in NSW, 2004. The water quality discharge criteria for the Project are listed in Table 7-1. Lendlease Engineering will update table 7-1 following issue of the EPL for the Project.

Table 7-1 Discharge water quality criteria

Parameter	Criteria	Sampling method	Analytical method
pH*	6.5 –8.5	Probe or Grab Sample	Field analysis and confirmed as required with laboratory assessment
Turbidity	TBA following correlation with TSS results	Grab Sample	Field analysis and confirmed as required with laboratory assessment, regularly updating correlations and having a factor of conservatism.
Total Suspended Solids*	50 mg/L	Grab Sample	Laboratory analysis
Oil and Grease*	No visible	Grab Sample	Field analysis and confirmed as required with laboratory assessment

Any other relevant licenses or permits will be obtained in the lead up to and during construction as required. Refer to CEMP – Section 3.3 Approvals, permits & Licences.

7.5 Weather monitoring

Rainfall at the premises will be measured and recorded in millimetres per 24-hour period at the same time each day from the time that the site office associated with the activities is established. Automatic rainfall intensity/ weather devices will be installed on the project, likely to be at the major compounds. The data collected from the automatic weather station and gauges shall;

- Provide a more detailed early understanding of potential rainfall and other adverse weather impacts

- Provide a proactive and early inspection and maintenance regime response to erosion and sedimentation and the effects of other adverse climatic conditions before pollution occurs
- Trigger weather alarms and messages to relevant site personnel to take action where appropriate
- Assess and validate the performance of installed erosion and sediment control measures against the design performance criteria, and
- Provide compliance data for statutory monitoring on-site.

The station and gauges shall record rainfall, temperature, relative humidity, wind speed, wind direction and bathometric pressure. The rain gauge within each mobile automatic weather station shall be of the tipping bucket type. The station and gauges shall have a battery or voltage meter and shall target 98% reliability. Manual rain gauges will also be used across the project to assist with assessment of rainfall data accuracy. The weather station and gauges shall conform to relevant standards for the location of such devices and shall be fully protected and secured.

Data from the automatic weather station shall be accessible via SMS alarms or queries to a mobile phone and downloadable to a desktop console logger or laptop computer. SMS queries and alarms shall be sent to RMS Representatives as necessary. All data shall be accessible at all times by the RMS representative(s). The mobile automatic weather stations shall download data to the internet and allow live views of weather data by authorised users, which shall include RMS Representative(s), the Project Verifier and the Environmental Representative. The mobile automatic weather stations shall also be compatible with and communicate live data to RMS's online weather station page.

In accordance with normal standard construction practices weather forecasts shall be used to guide work activities undertaken on-site. Forecasts shall be checked at the start of each day and prior to undertaking new work activities that may be affected by rainfall or adverse weather. Where weather forecasts predict conditions that may pose an environmental risk, site environmental controls shall be inspected and secured to reduce erosion and sediment control impacts. Contingency planning to prevent spills shall also involve monitoring for predicted flood events and the removal of fuels and chemicals from flood prone areas.

7.6 Auditing

Audits (both internal and external) will be undertaken to assess the effectiveness of environmental controls, compliance with this plan, CoA and other relevant approvals, licenses and guidelines.

Audit requirements are detailed in Section 8.3 of the CEMP.

7.7 Reporting

Reporting requirements and responsibilities are documented in the Water Quality Monitoring Program, EPL and Chapter 7 and Section 8.3 of the CEMP.

8 Review and improvement

8.1 Continuous improvement

Continuous improvement of this Plan will be achieved by the ongoing evaluation of environmental management performance against environmental policies, objectives and targets for the purpose of identifying opportunities for improvement.

The continuous improvement process will be designed to:

- Identify areas of opportunity for improvement of environmental management and performance.
- Determine the cause or causes of non-conformances and deficiencies.
- Develop and implement a plan of corrective and preventative action to address any non-conformances and deficiencies.
- Verify the effectiveness of the corrective and preventative actions.
- Document any changes in procedures resulting from process improvement.
- Make comparisons with objectives and targets.

8.2 CSWMP update and amendment

The processes described in Section 8 and Section 9 of the CEMP may result in the need to update or revise this Plan. This will occur as needed.

Only the Environment Manager, or delegate, has the authority to change any of the environmental management documentation with approval from the Environmental Representative for minor changes to the CEMP/Sub-plans in accordance with CoA D23(e). All other amendments must be approved by the secretary.

A copy of the updated plan and changes will be distributed to all relevant stakeholders in accordance with the approved document control procedure – refer to Section 10.2 of the CEMP.

Appendix A
Water Quality Monitoring Program

NSW GOVERNMENT Transport Roads & Maritime Services

Pacific Highway Upgrade Woolgoolga to Glenugie

WATER QUALITY MONITORING PROGRAM

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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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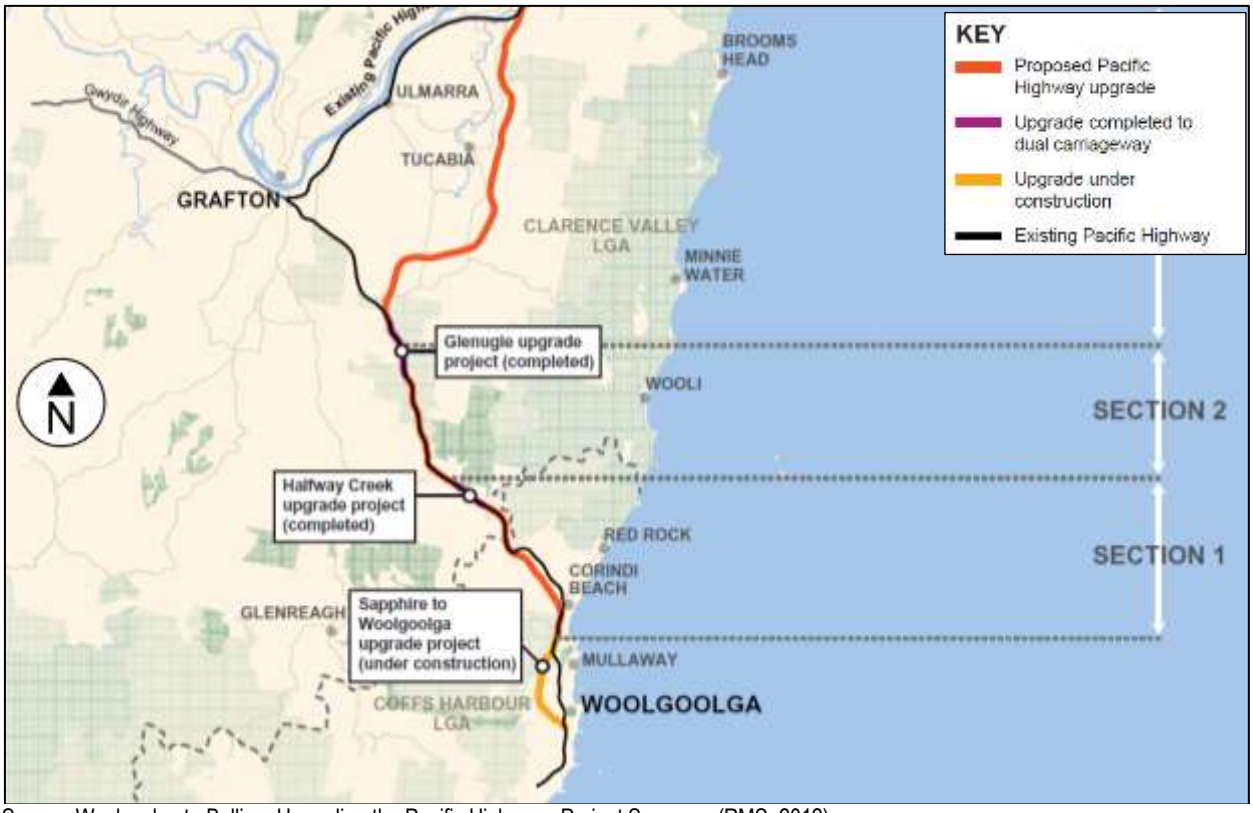
1

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.

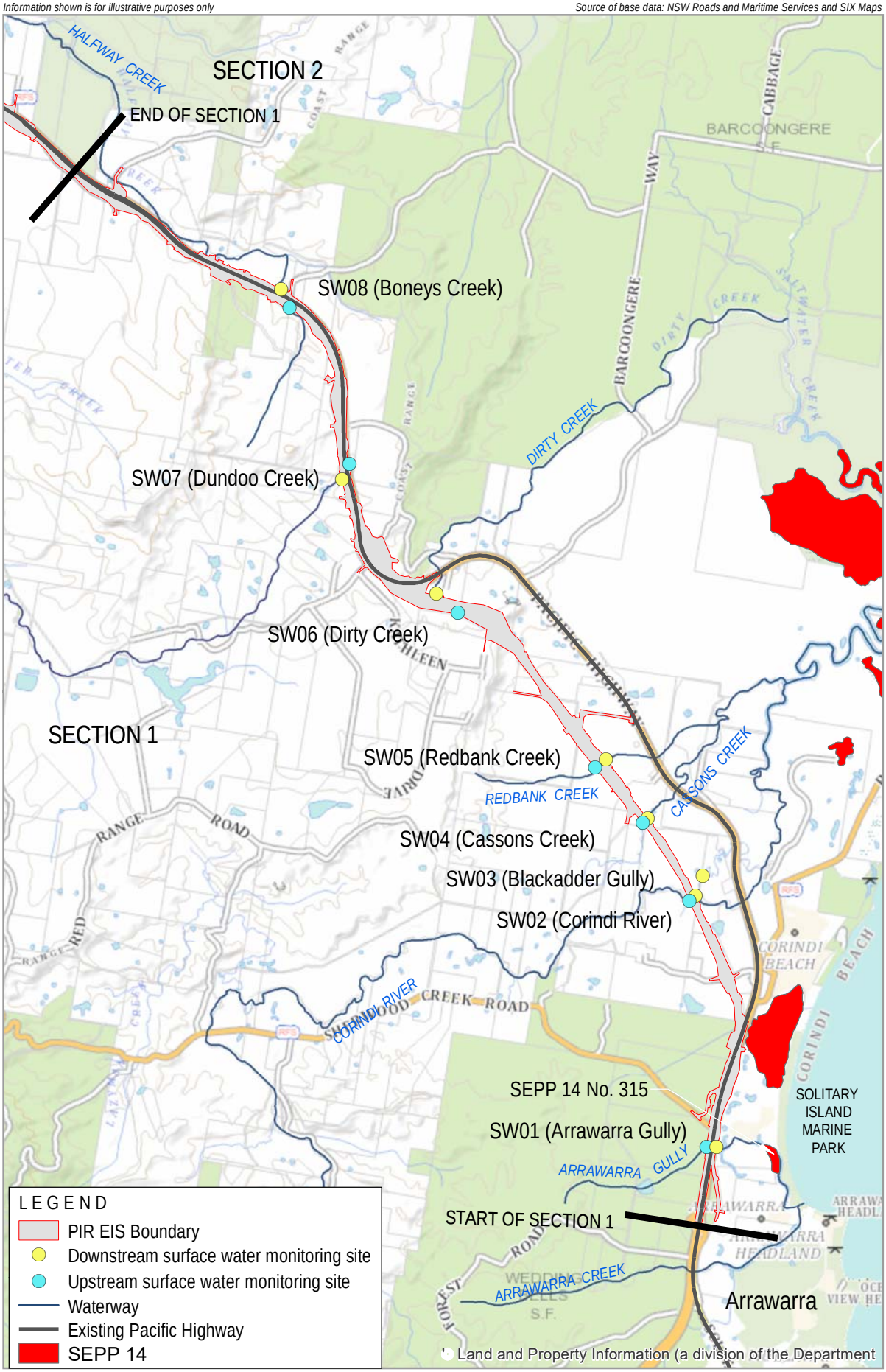
Table 2.1 Waterways Selected for Surface Water Monitoring

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

Drawn by: KHP Checked by: TIM Reviewed by: TIM Date: 20/03/15
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

GeoLINK environmental management and design

W2G - Water Quality Monitoring Program
2134-1109

Illustration 2.1

Information shown is for illustrative purposes only

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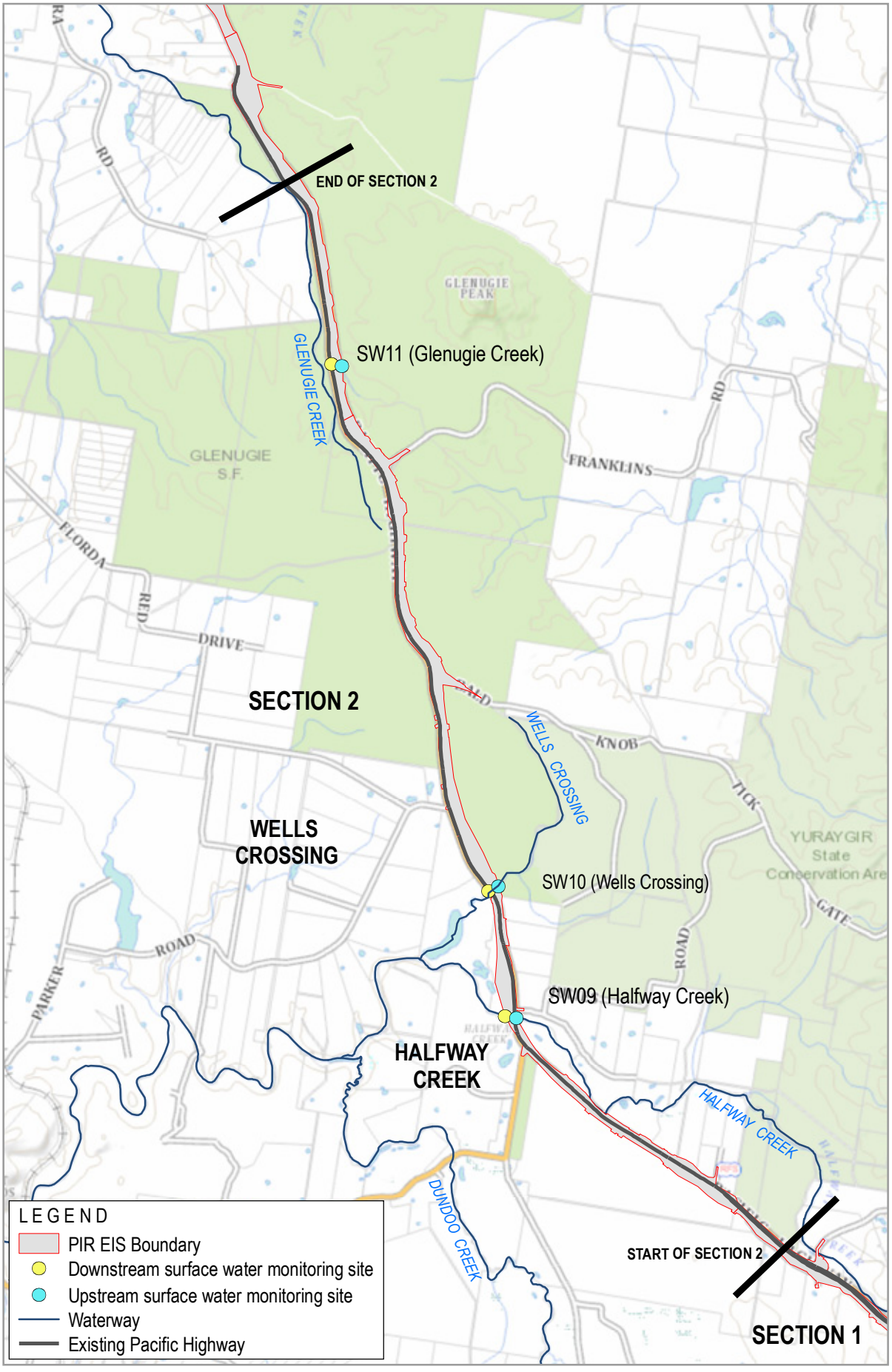
Source of base data: NSW Roads and Maritime Services and SIX Maps



0 1.4 km

North

Section 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

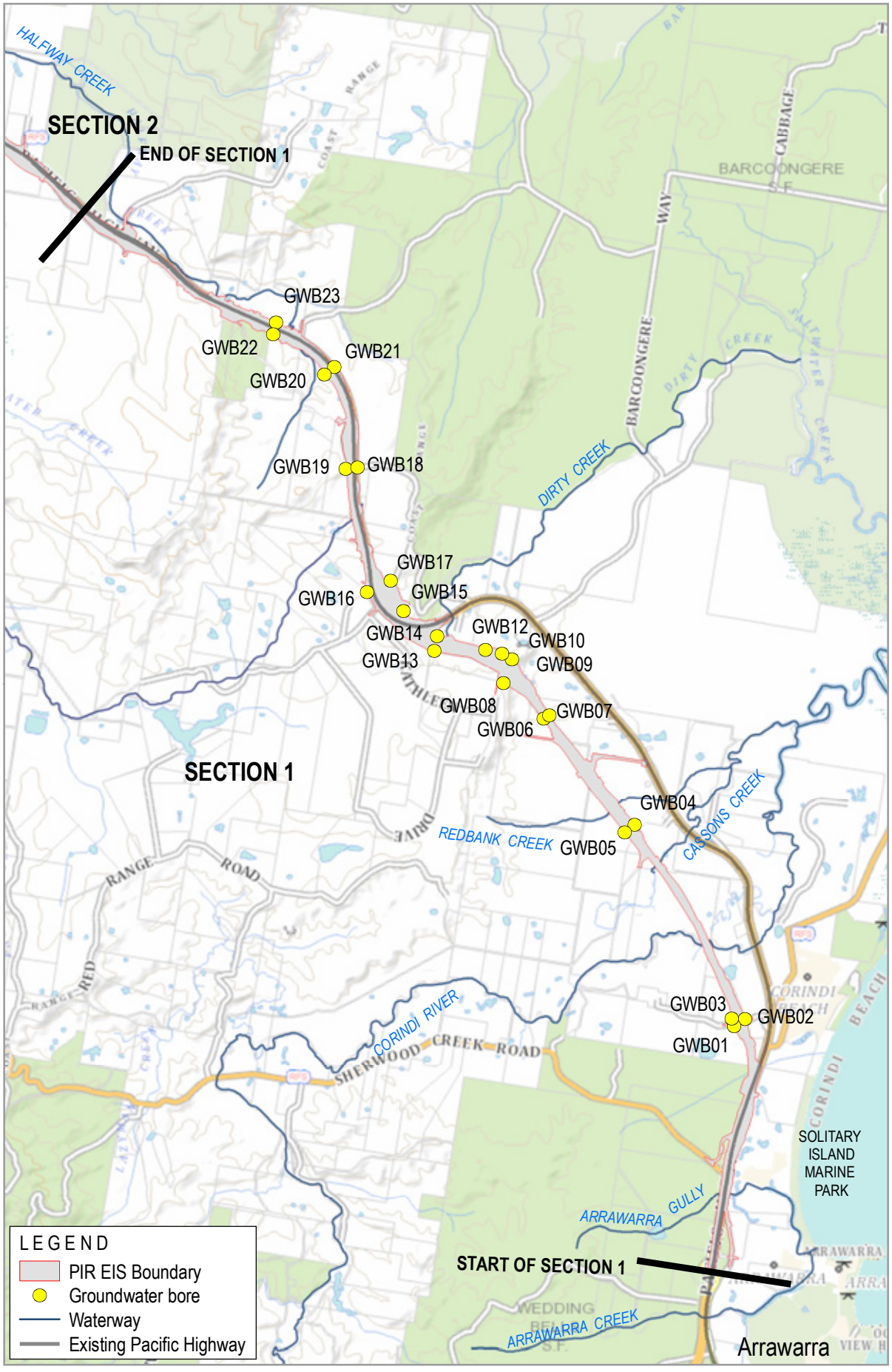
Highway Section of Woolgoolga to Ballina Upgrade	*Borehole Identifier*	*Chainage*	*General Location*	*Cut Type[1]*	*Monitoring for*	
					Level	*Quality*
Section 1 - Woolgoolga to Halfway Creek	GWB01	2500	Kangaroo Trail Road	A	Yes	Yes
	GWB02	2520			Yes	Yes
	GWB03	2600			Yes	-
	GWB04	5300	Post Office 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

Drawn by: RE Checked by: TIM Reviewed by: TIM Date: 31/10/14
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

GeoLINK environmental management and design

W2G - Water Quality Monitoring Program
2134-1112

Illustration 2.3

Information shown is for illustrative purposes only

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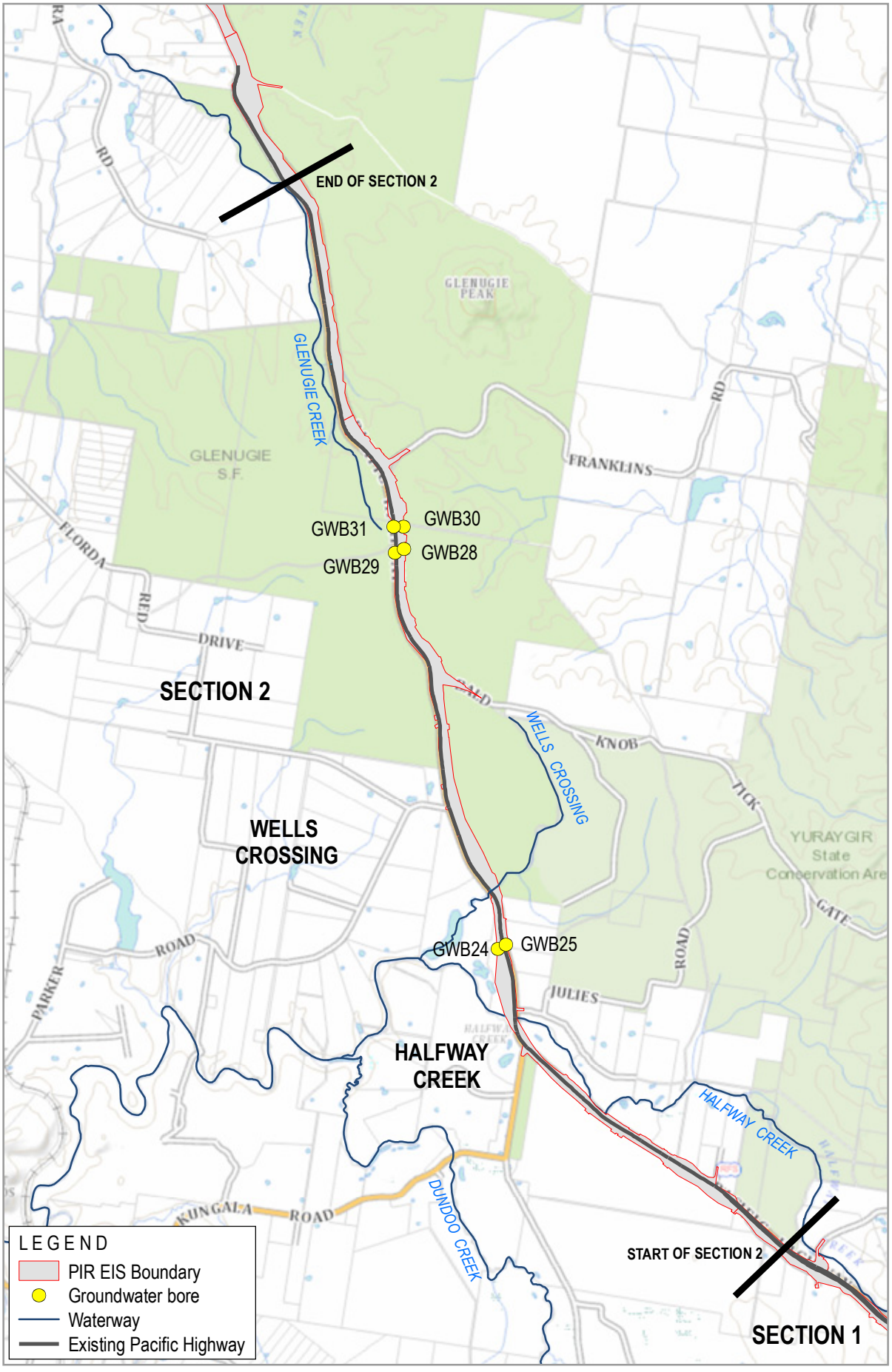
Source of base data: NSW Roads and Maritime Services and SIX Maps



0 1.4 km

North

Section 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.

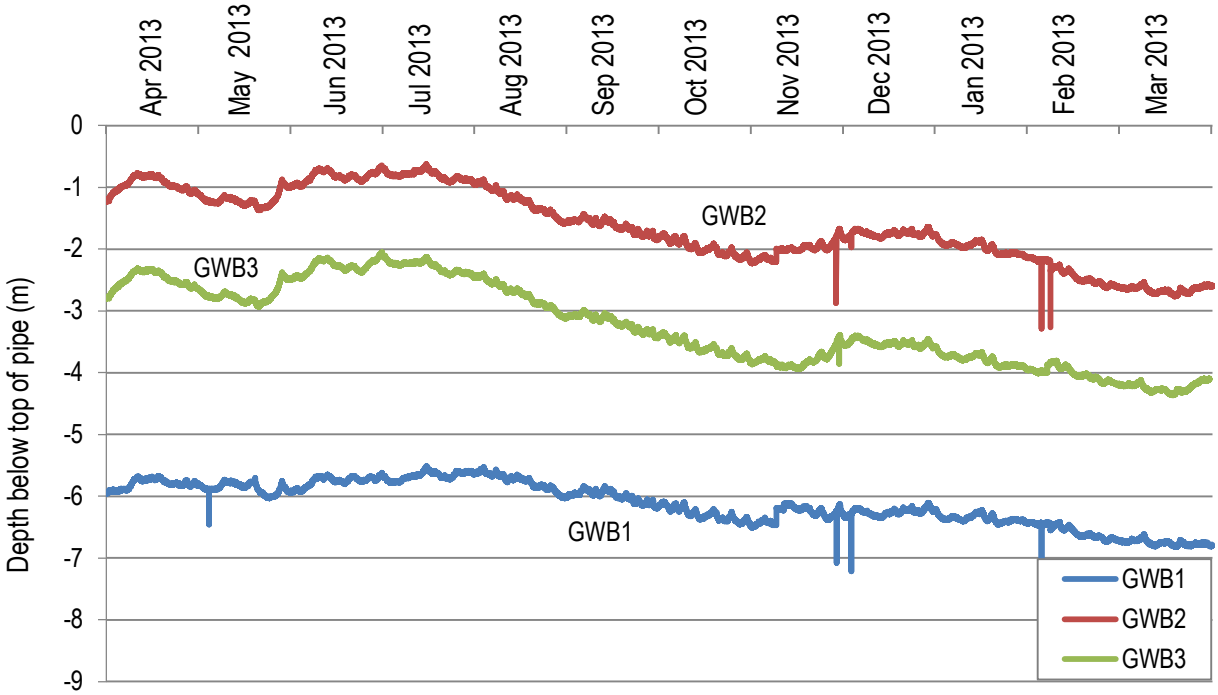
The x-axis on the graphs denotes time over the twelve month monitoring period. The y-axis denotes the depth to groundwater level below the top of the pipe at each bore.

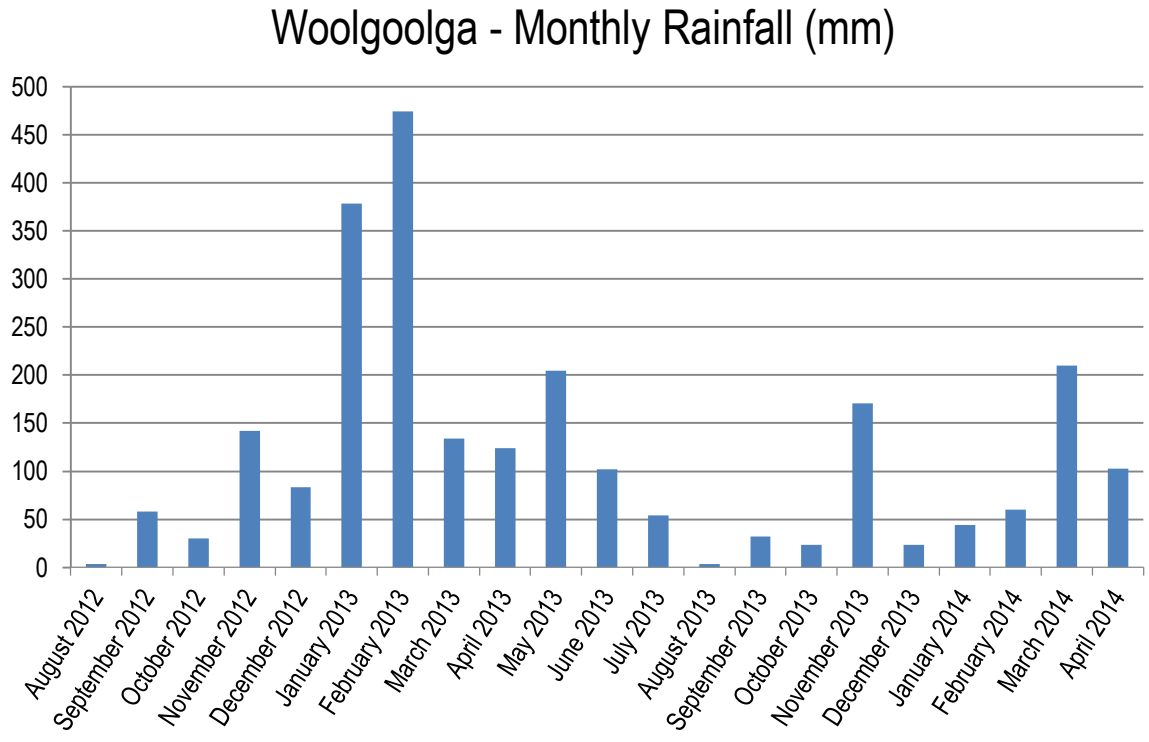
A chart of monthly rainfall is shown on each of the following pages for comparison with the groundwater levels. Monthly rainfall for Woolgoolga weather station has been used for comparison with the groundwater bores south of Dirty Creek Range (GWB1 – GWB17). Monthly rainfall for Grafton Airport weather 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

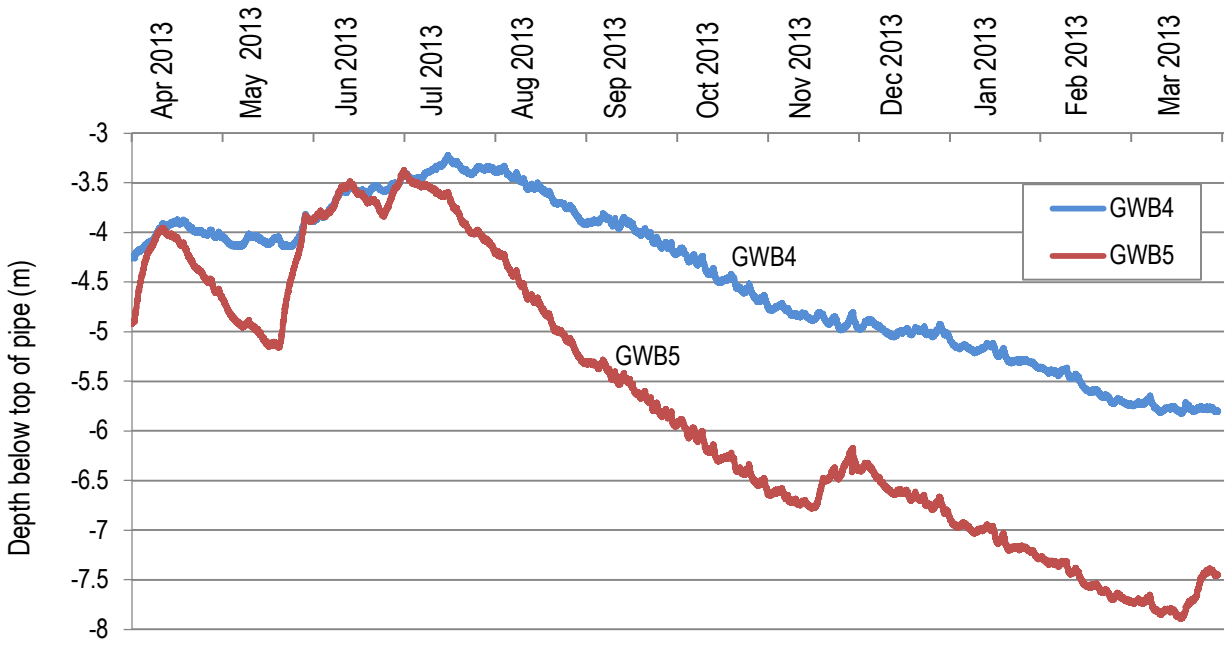


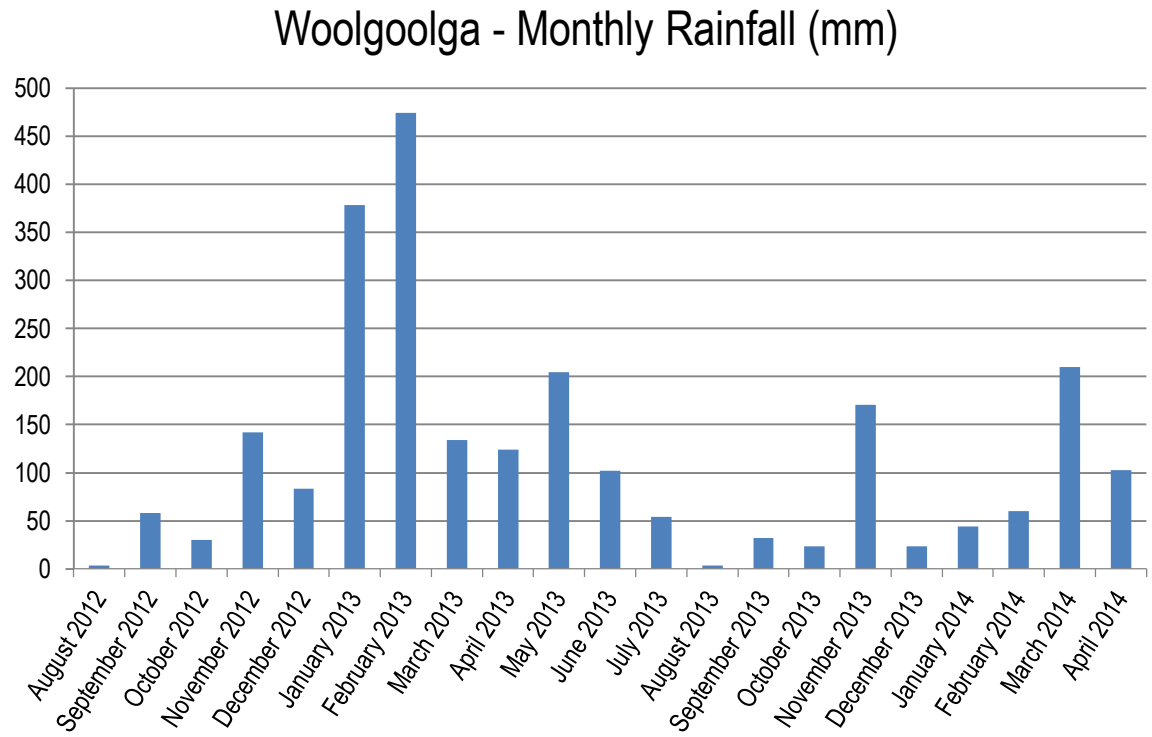


3.2.5 GWB4 and GWB5 - Post Office Lane – Ch 5300

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

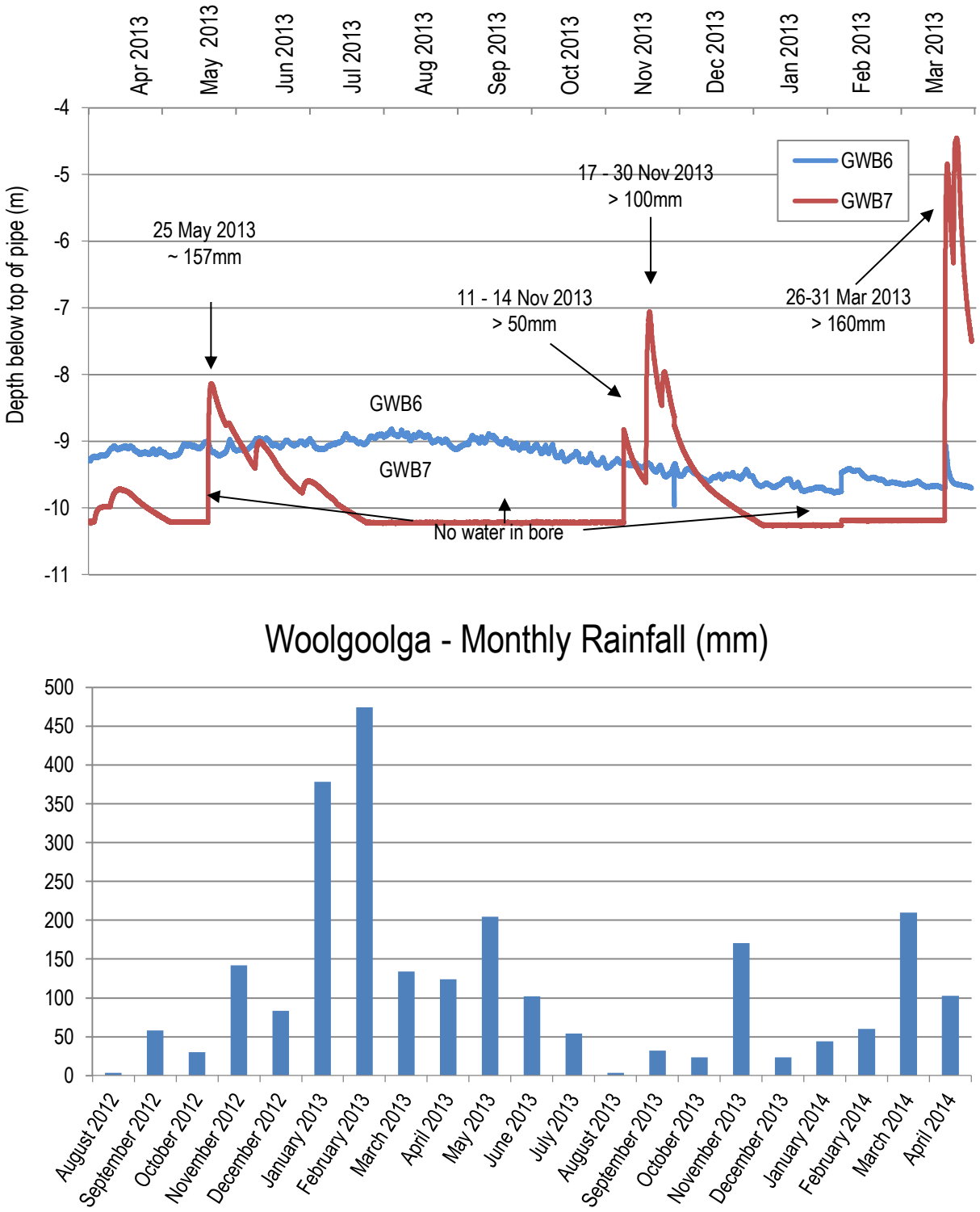




3.2.6 GWB6 and GWB7 - Small Cut – Ch 7050

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).

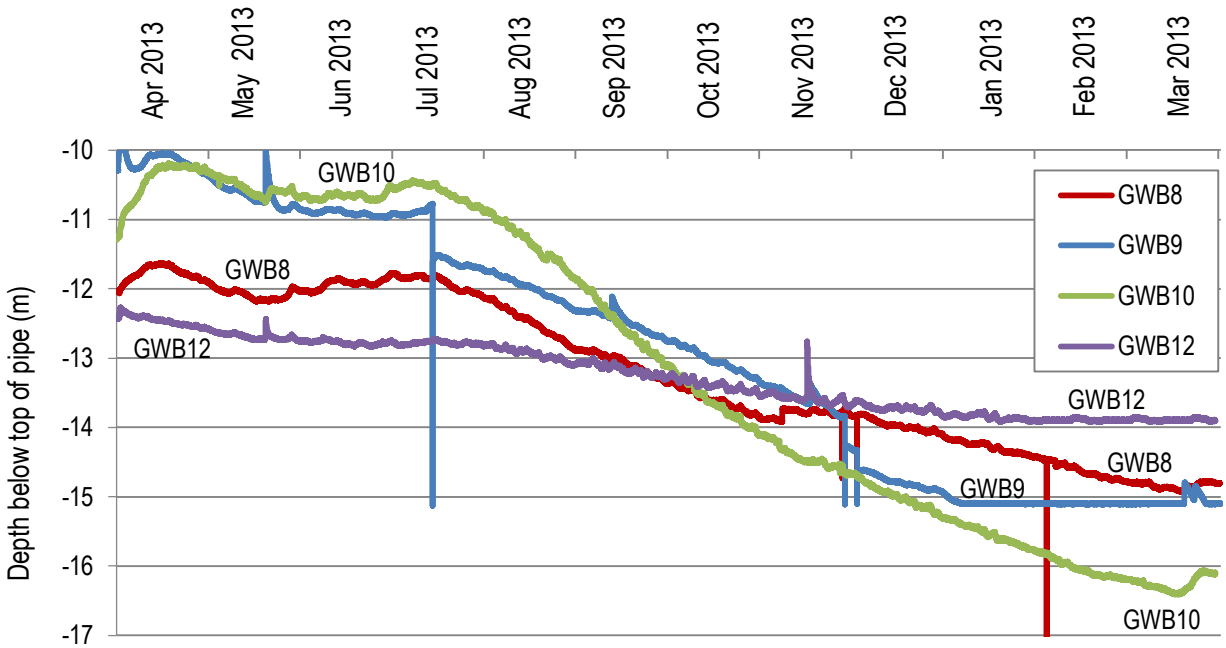
Figure 3.3 Groundwater levels – GWB6 and GWB7 - Small Cut – Ch 7050

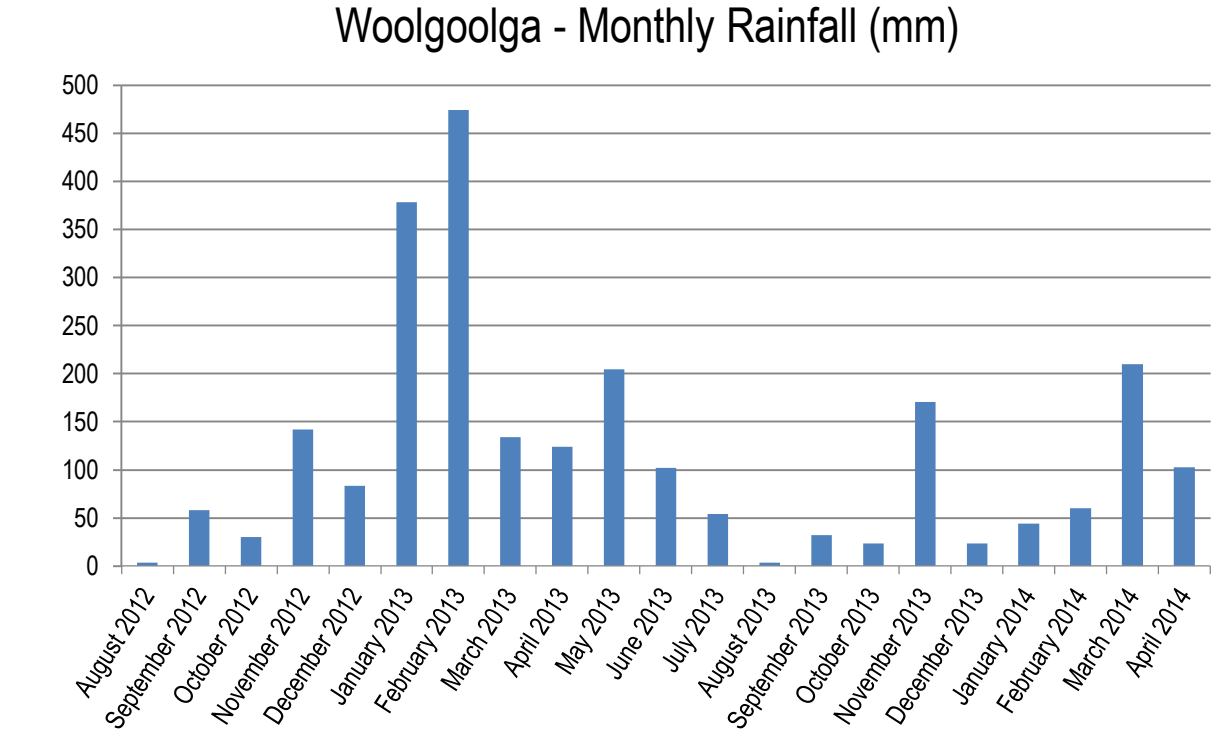


3.2.7 GWB8, GWB9, GWB10 and GWB12 - Big Cut - Ch 7700 - 8200

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

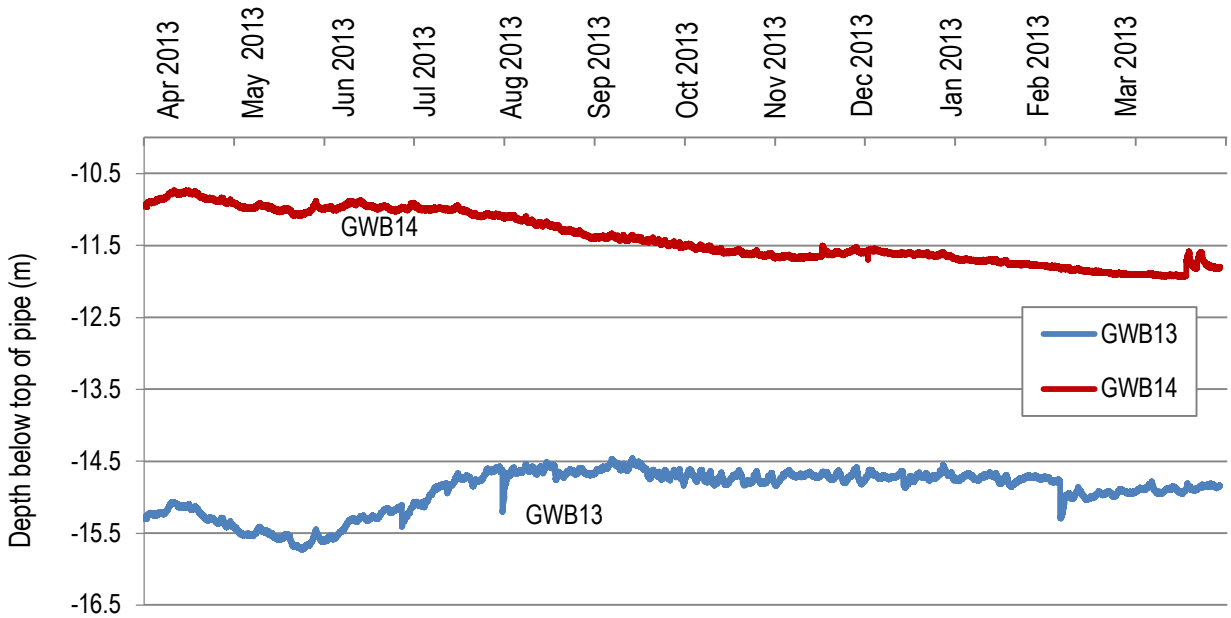


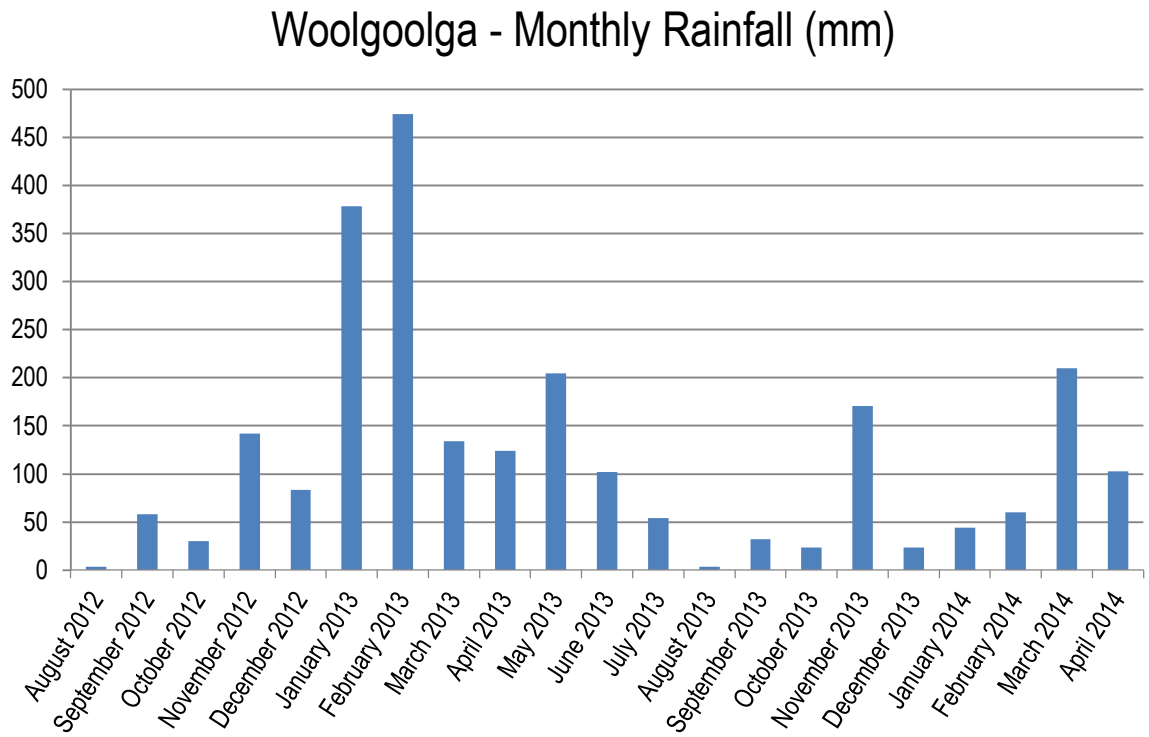


3.2.8 GWB13 and GWB14 - Flinty Road – Ch 8800

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





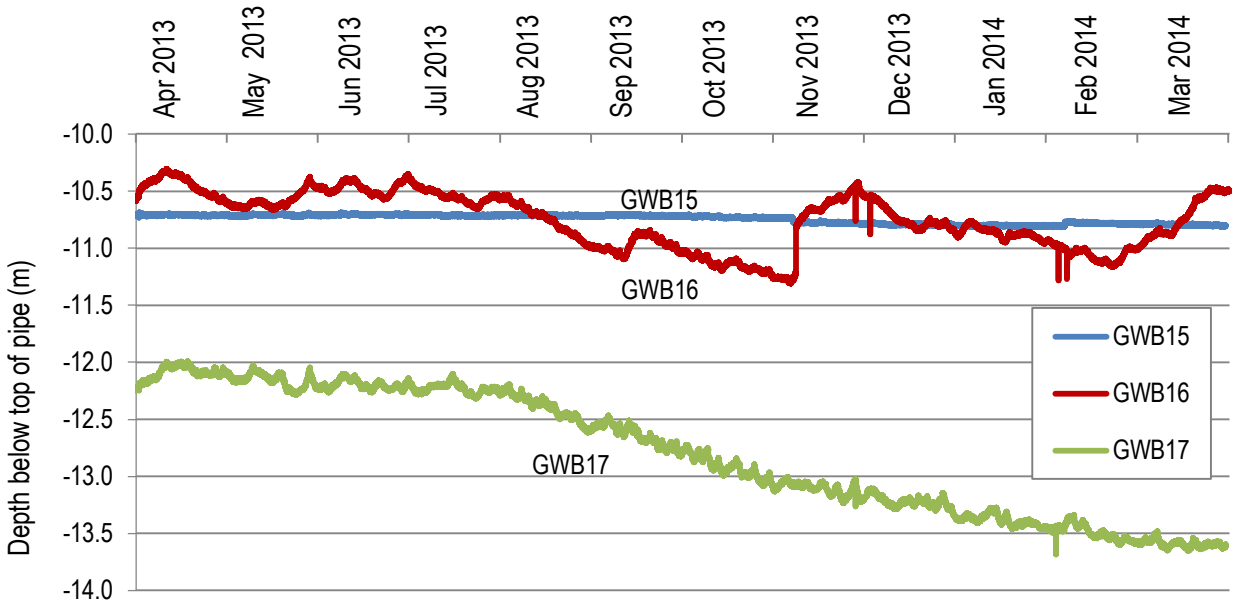
3.2.9 GWB15, GWB16 and GWB17 - Range Road East – Ch 9400 - 9800

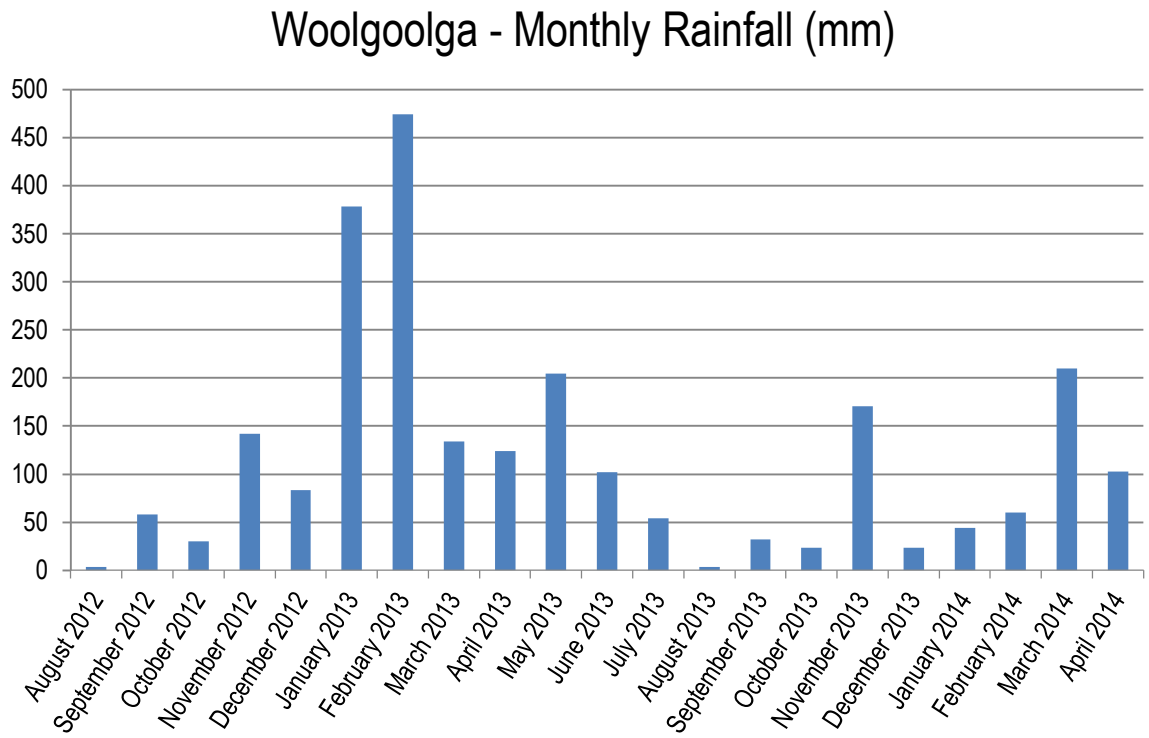
GWB15 exhibits very minor fluctuations with a slight fall from September 2013.

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



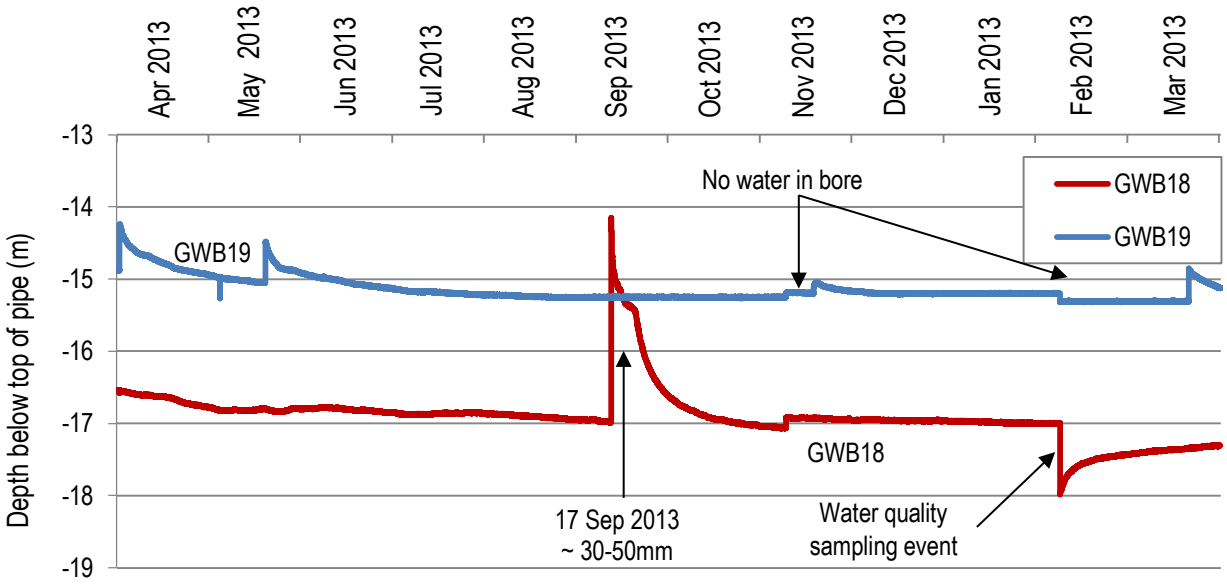


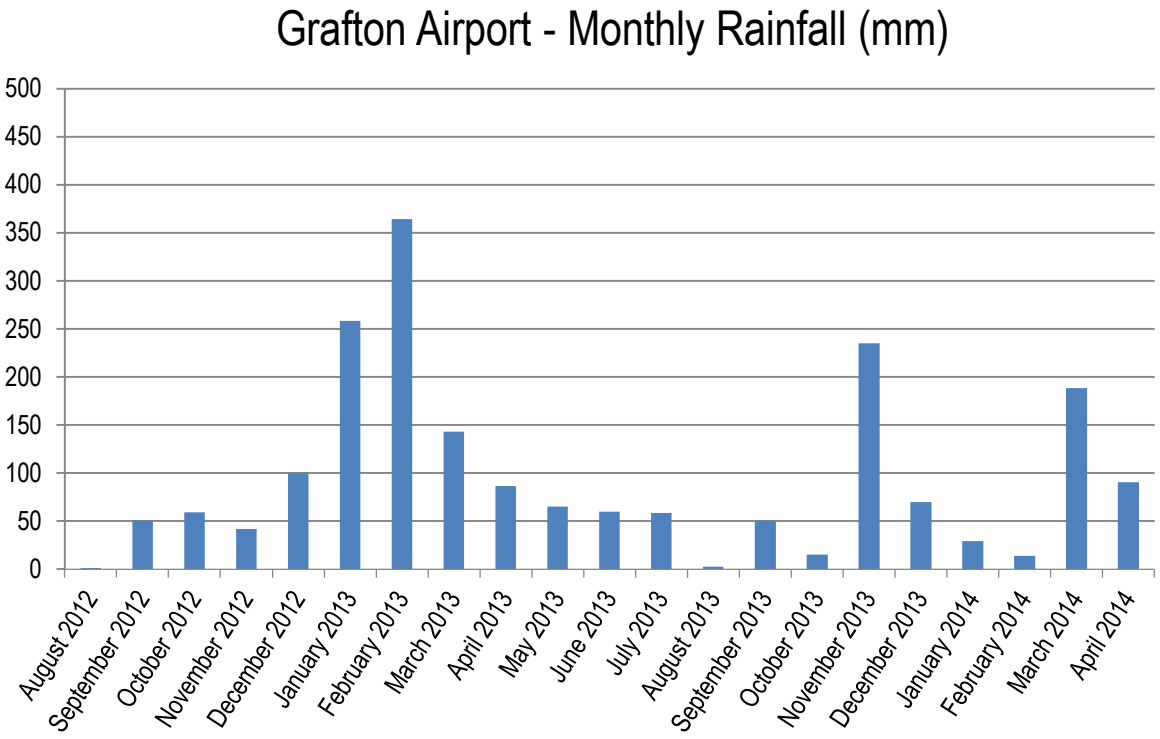
3.2.10 GWB18 and GWB19 - Falconers Lane - Ch 11350

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

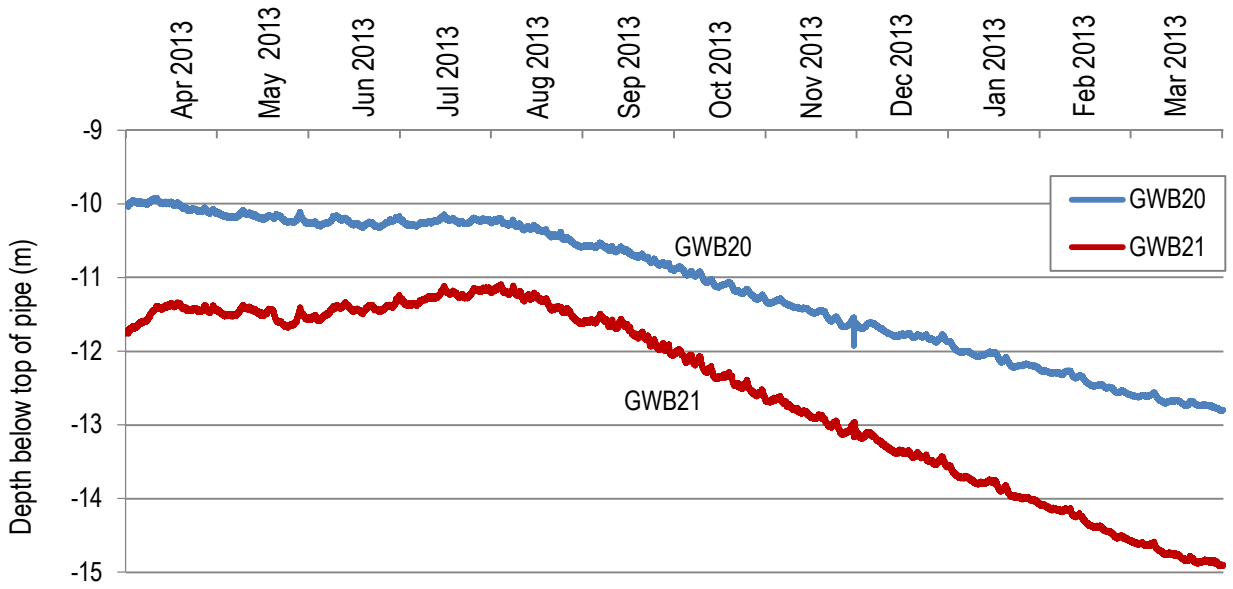


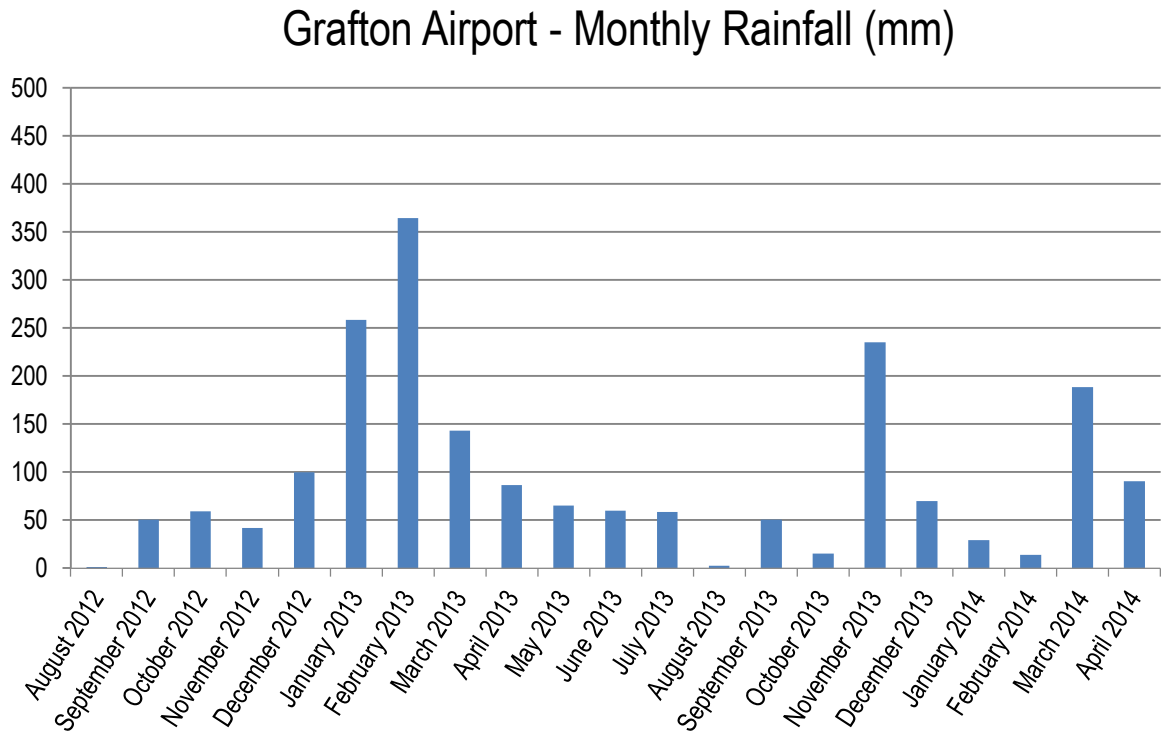


3.2.11 GWB20 and GWB21 - Ch12650

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

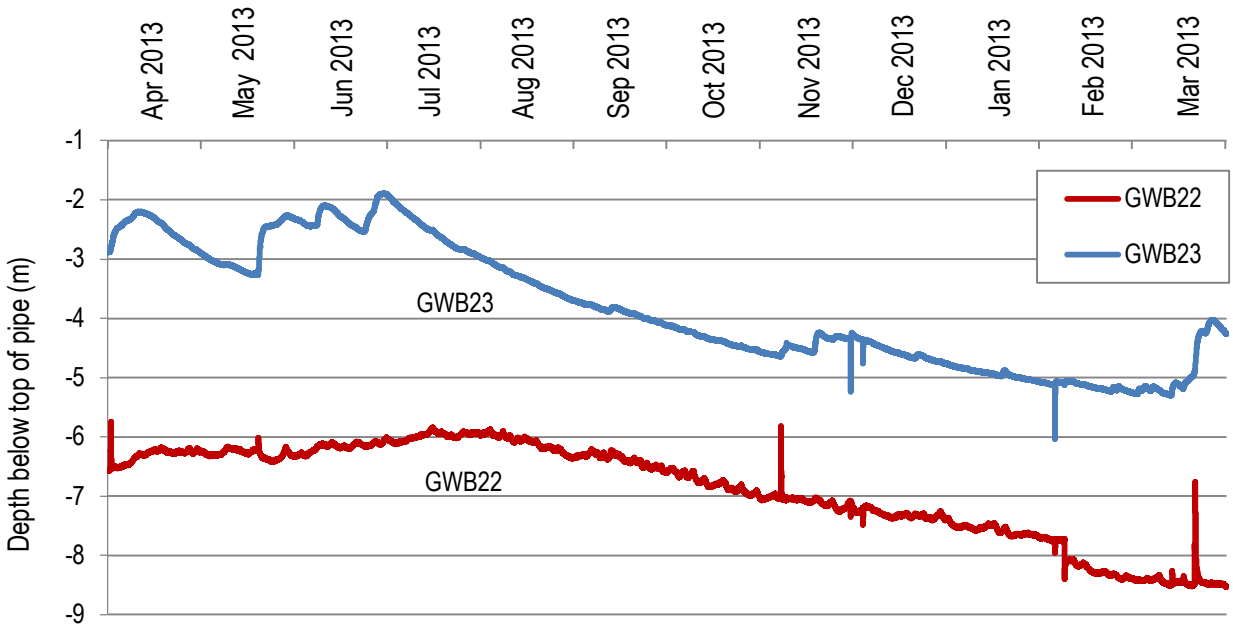


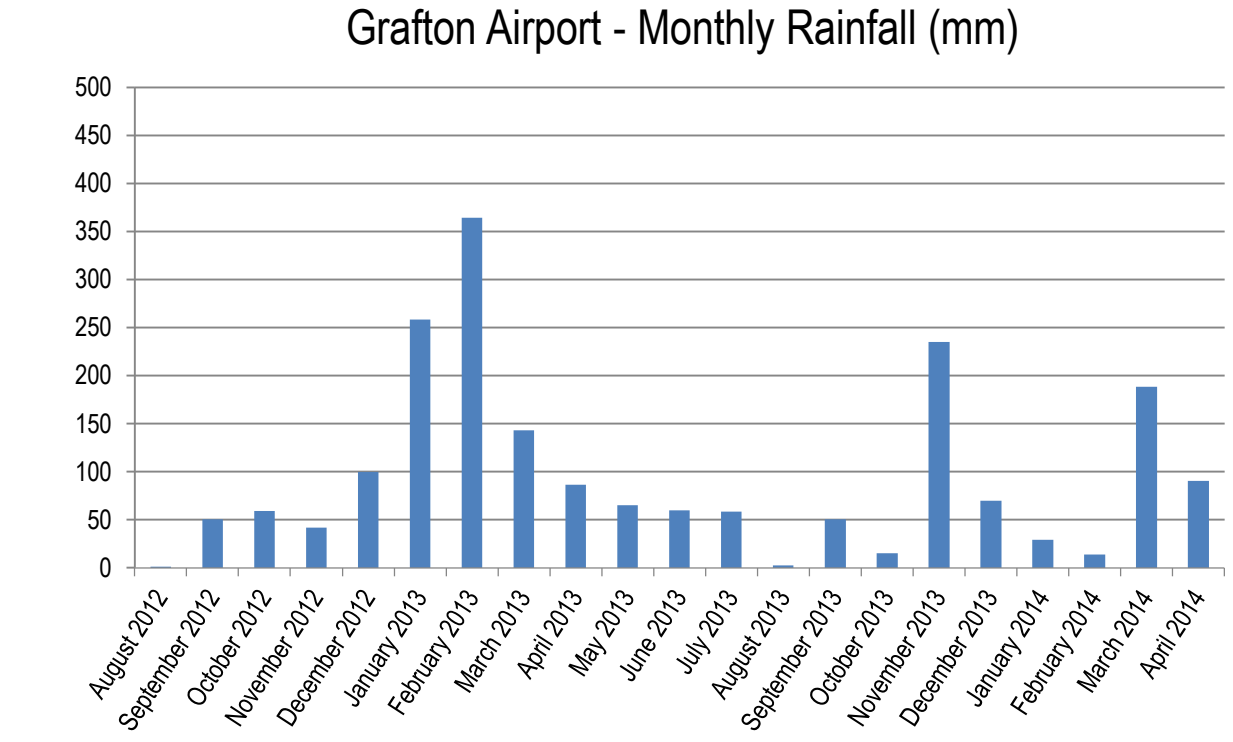


3.2.12 GWB22 and GWB23 - Kelman Property - Ch 13500

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

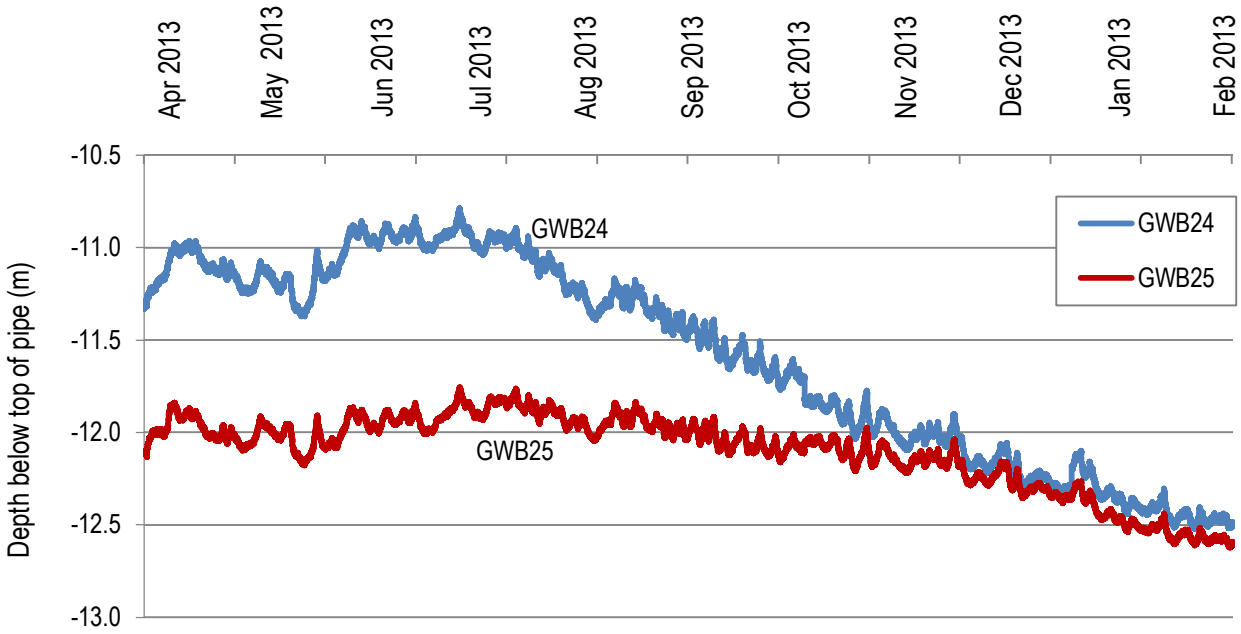


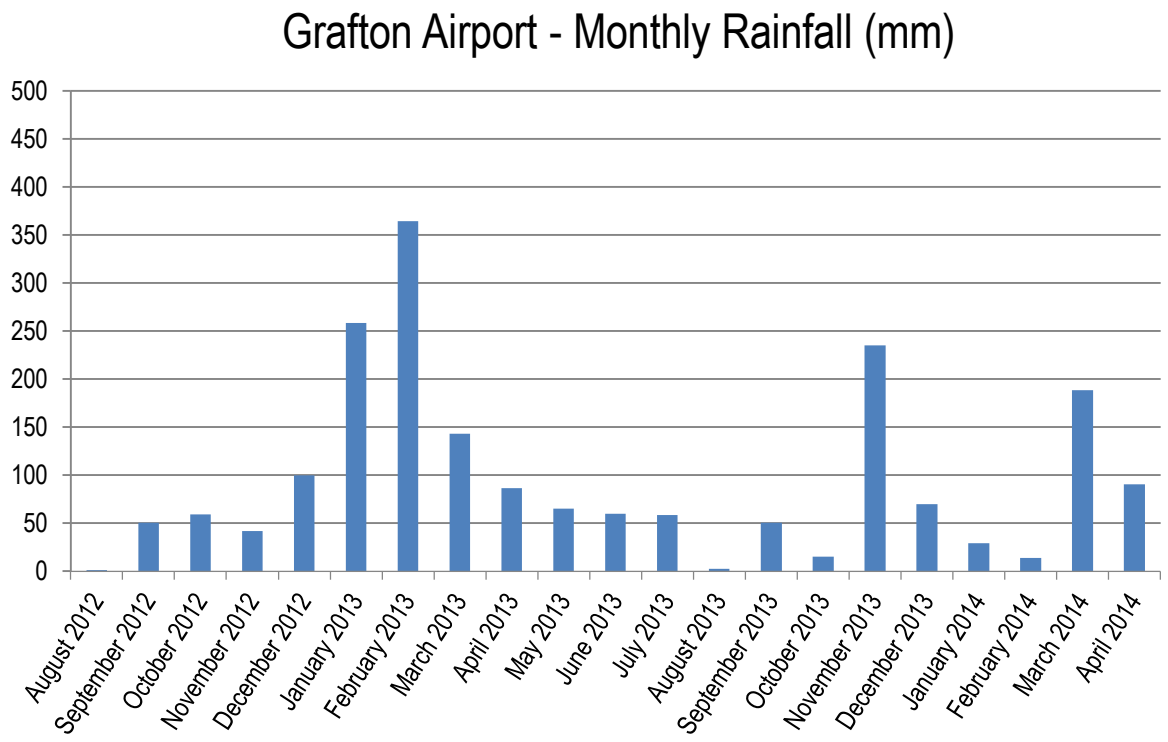


3.2.13 GWB24 and GWB25 - Ch21650

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

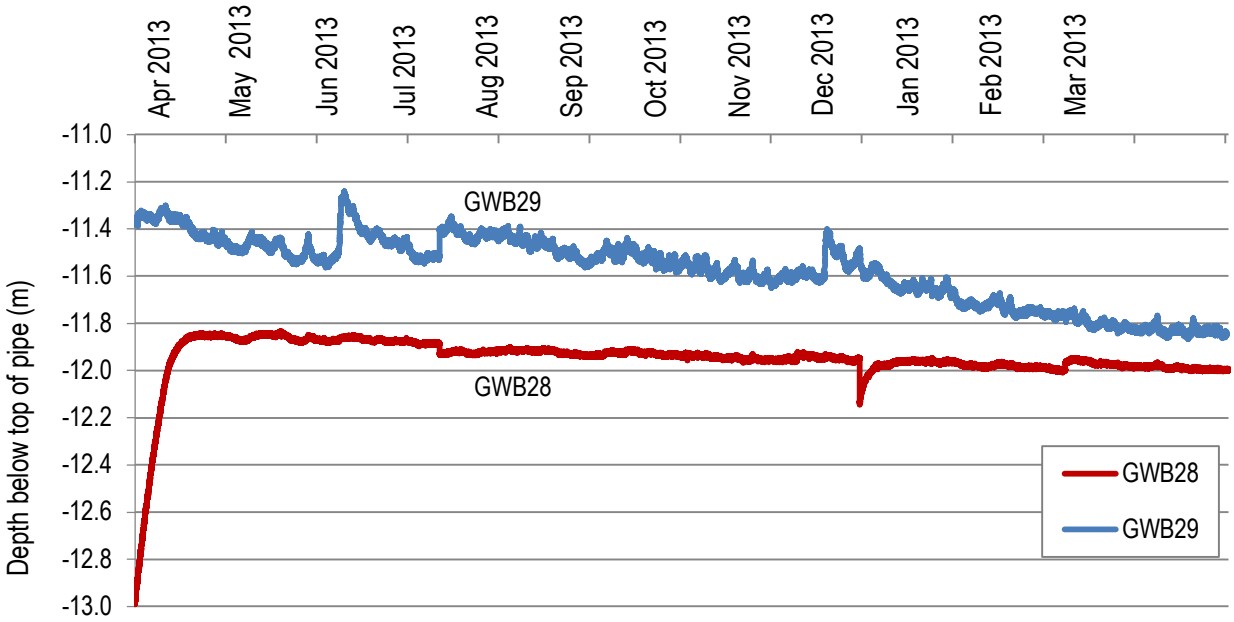


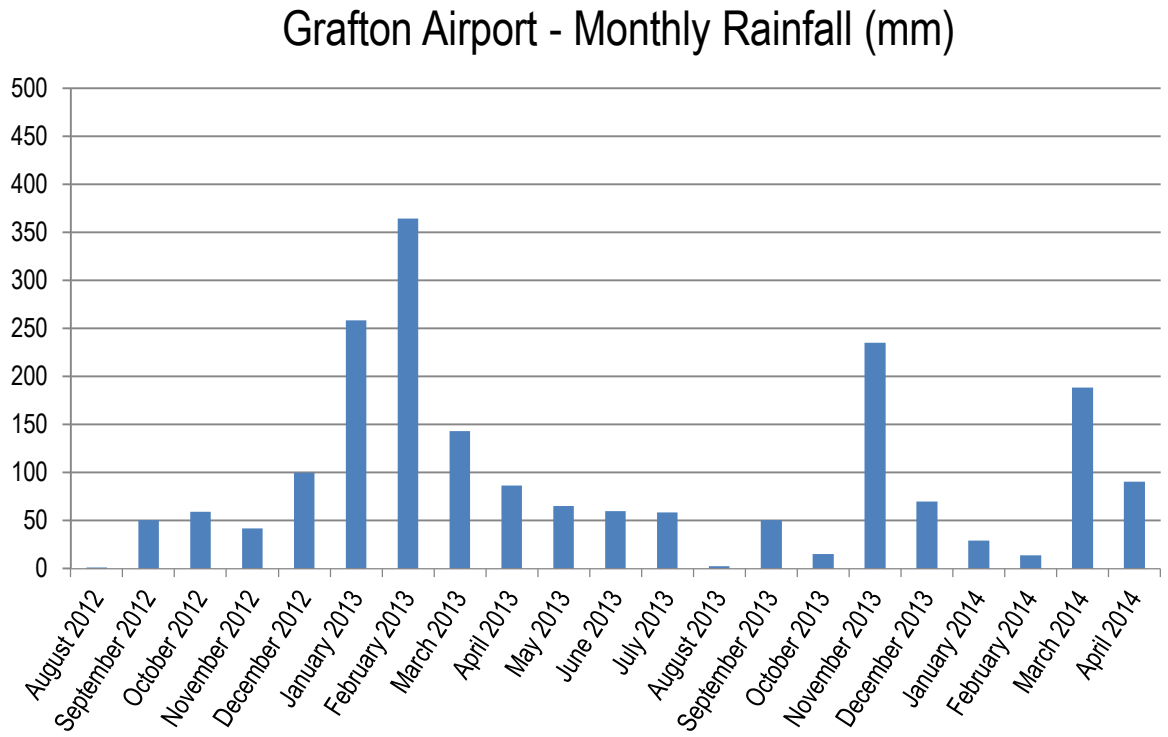


3.2.14 GWB28 and GWB29 - Glenugie State Forest - Ch 26800

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



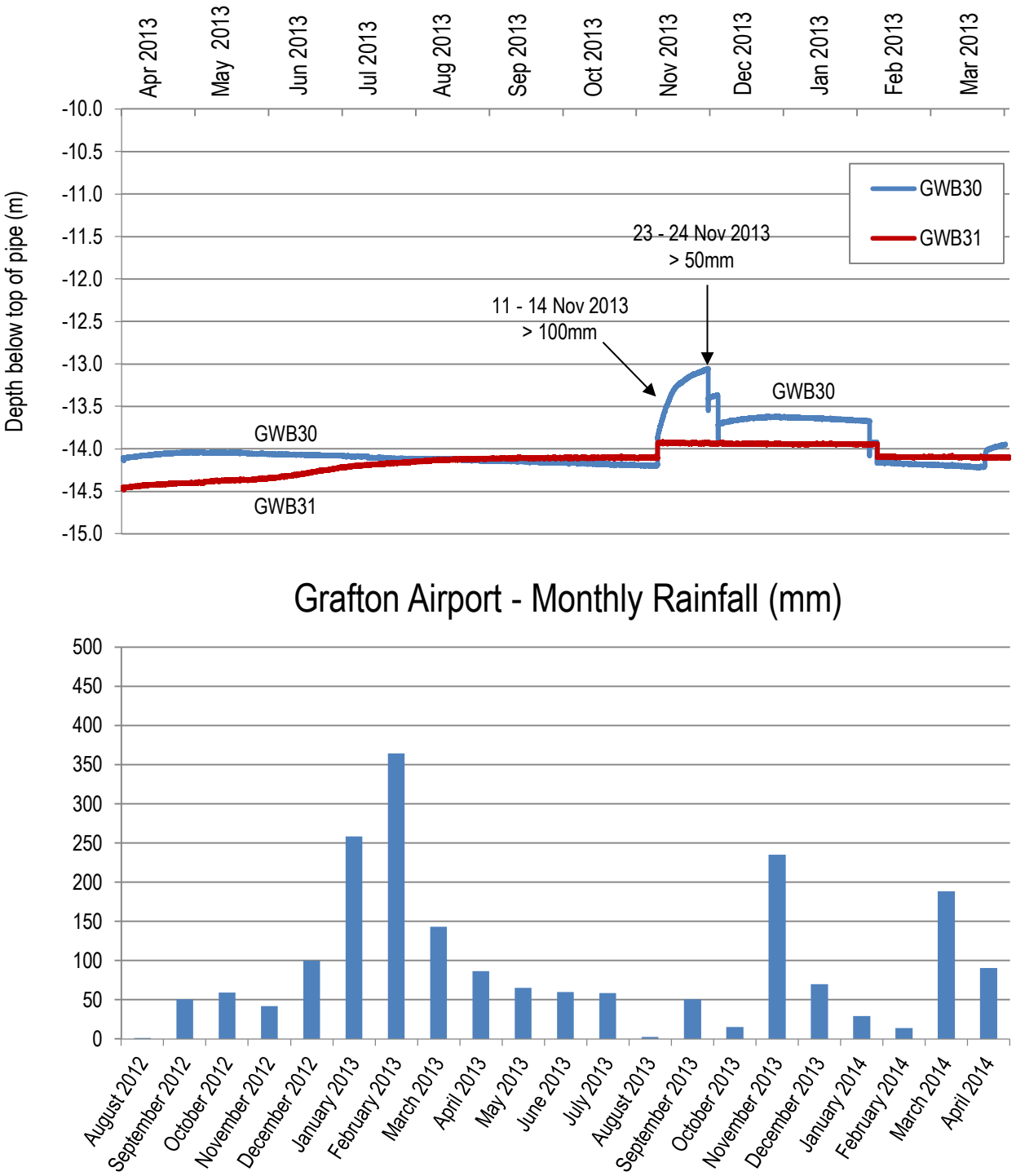


3.2.15 GWB30 and GWB31 - Glenugie State Forest - Ch 27200

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.

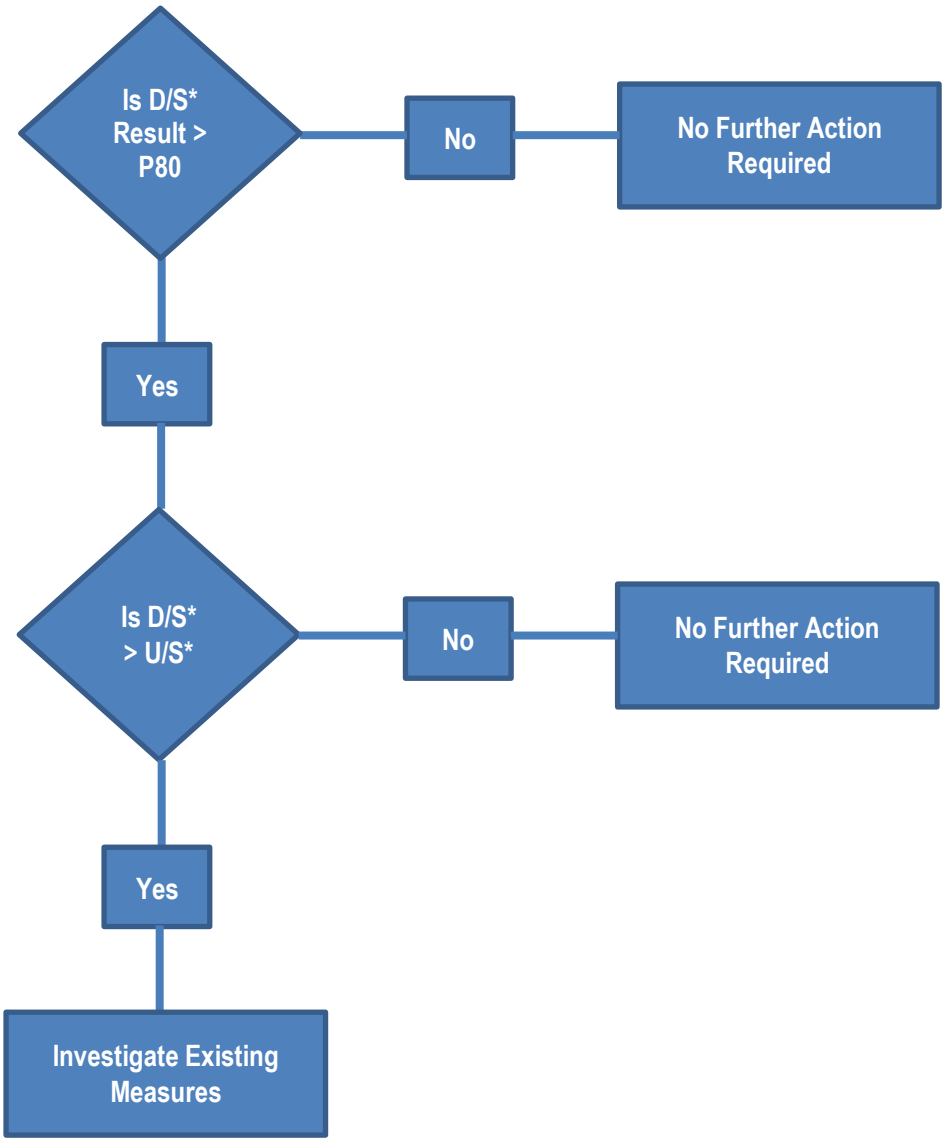
7.1 Surface Water

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.

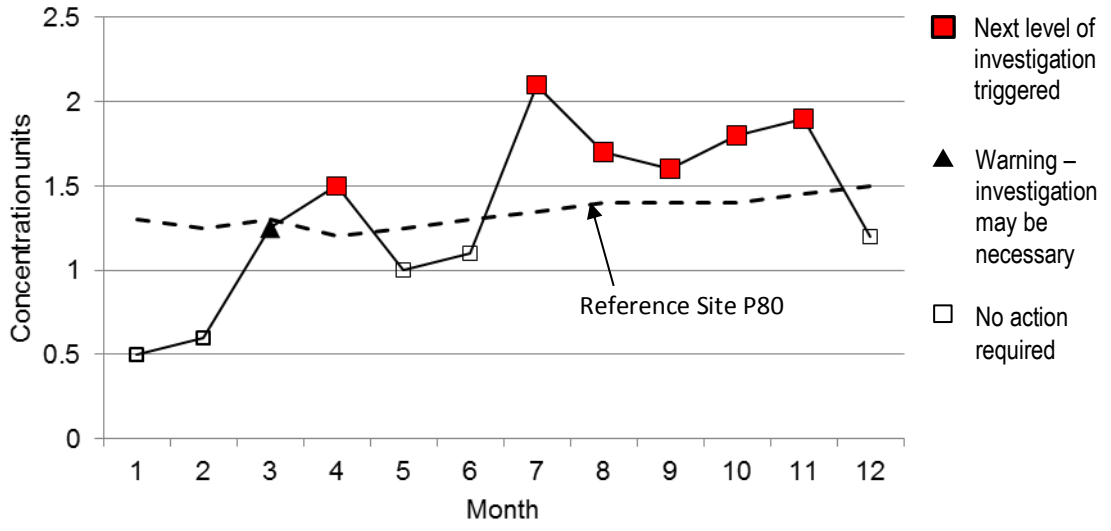


Figure 7.2 Example Control Chart

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)

0 40

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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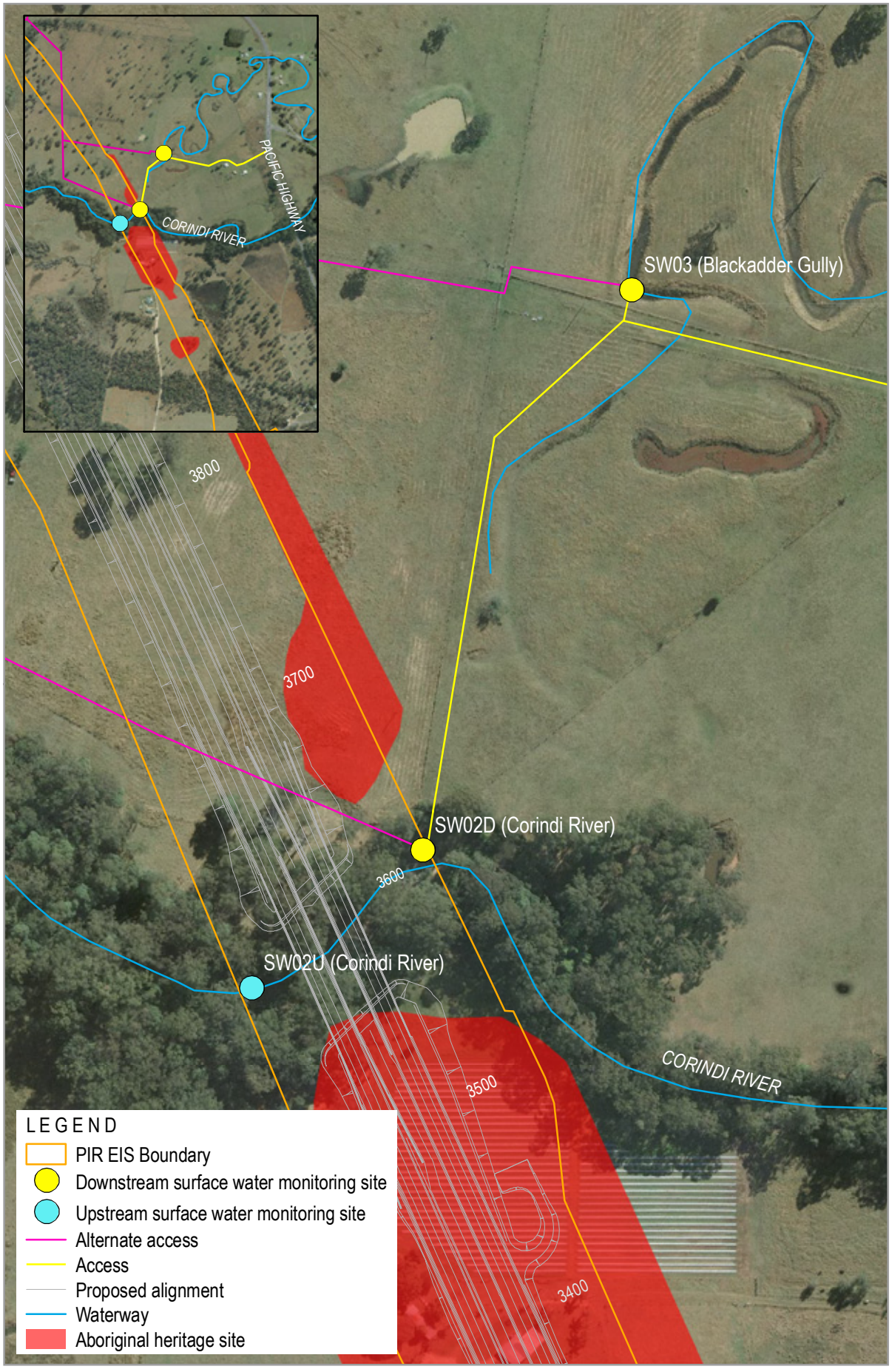
Source of base data: NSW Roads and Maritime Services



North

0 50

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

0 40

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

0 40

SW05 - Redbank Creek Ch. 5650

GeoLINK environmental management and design

W2G - Water Quality Monitoring Program
2134-1102

Illustration C.4

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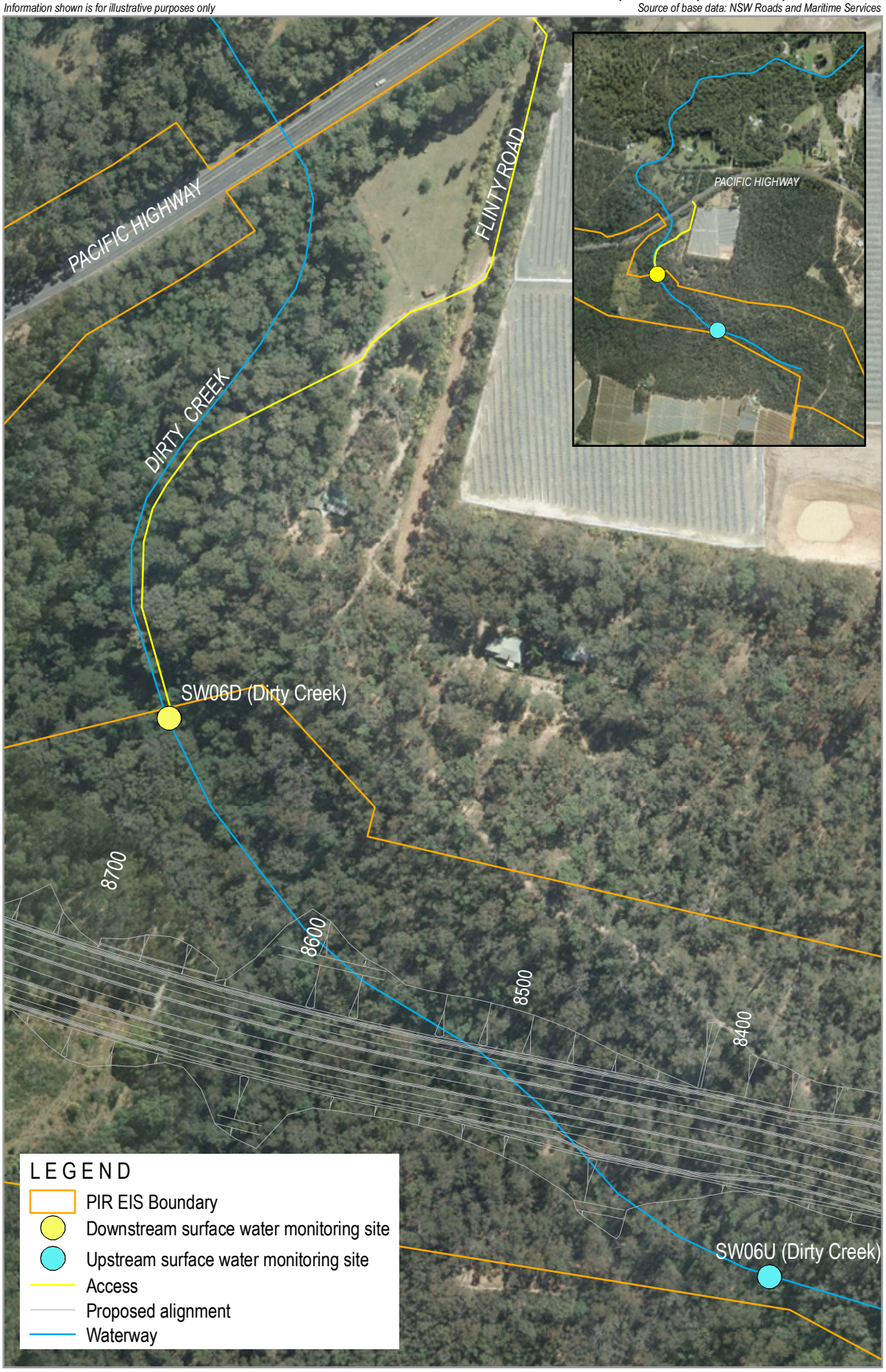
Source of base data: NSW Roads and Maritime Services



0 50

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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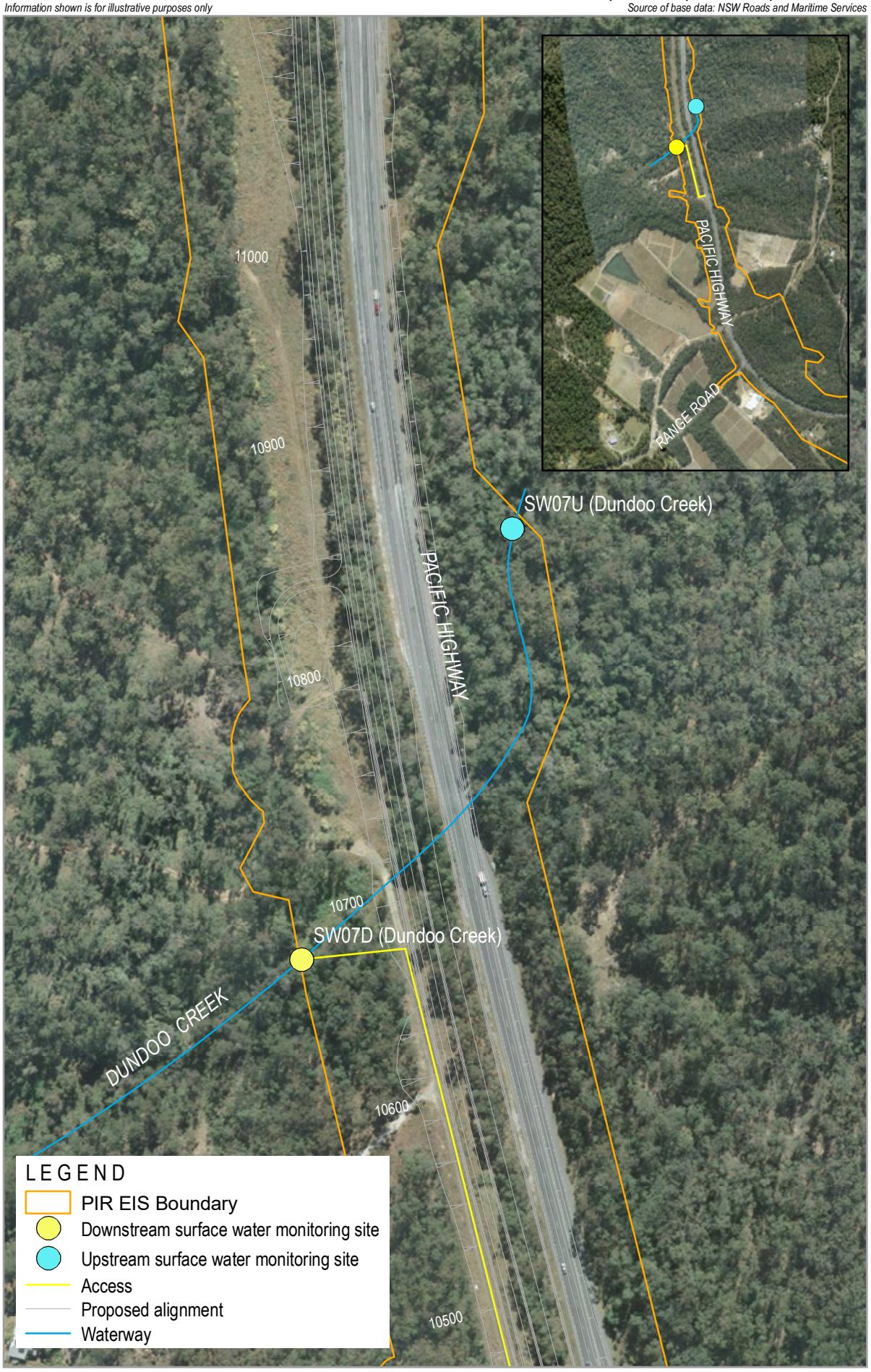

0 50

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

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Source of base data: NSW Roads and Maritime Services

0 50

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

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Source of base data: NSW Roads and Maritime Services

0 40

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

0 40

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

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0 40

North

SW11 - Glenugie Creek Ch. 29300

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Source of base data: NSW Roads and Maritime Services

0 40

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

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Source of base data: NSW Roads and Maritime Services

0 40

North

GeoLINK environmental management and design

W2G - Water Quality Monitoring Program
2134-1021

GWB04 GWB05 - Post Office Lane Ch. 5300

Illustration C.12

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Source of base data: NSW Roads and Maritime Services

0 40

North

GeoLINK environmental management and design

W2G - Water Quality Monitoring Program
2134-1022

GWB06 GWB07 - Small Cut Ch. 7050

Illustration C.13

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Source of base data: NSW Roads and Maritime Services

0 40

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

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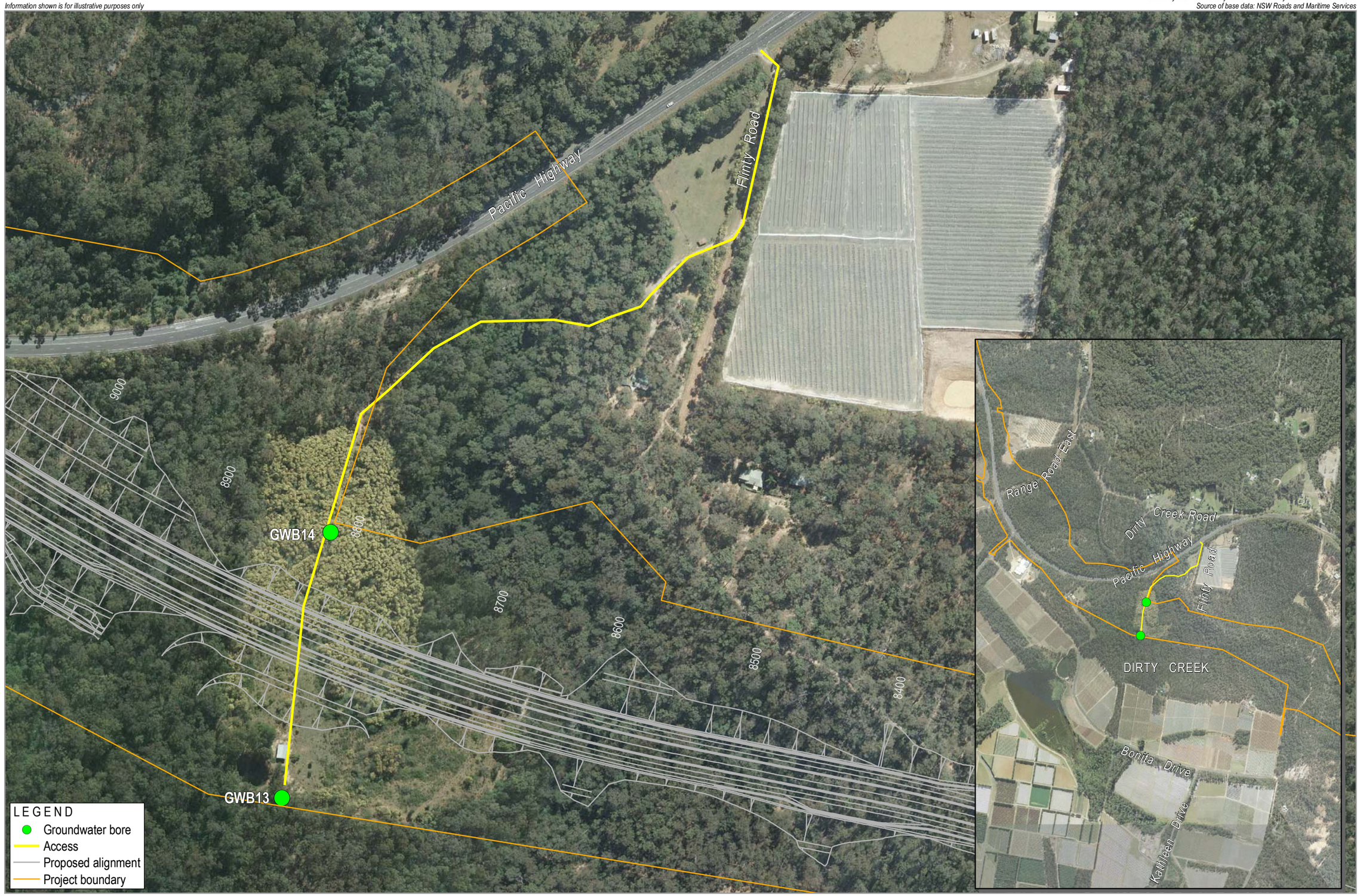
Source of base data: NSW Roads and Maritime Services



0 50

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

0 40

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

Information shown is for illustrative purposes only

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Source of base data: NSW Roads and Maritime Services

0 40

North

GeoLINK environmental management and design

W2G - Water Quality Monitoring Program
2134-1026

GWB18 GWB19 - Falconers Lane Ch. 11350

Illustration C.17

Information shown is for illustrative purposes only

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Source of base data: NSW Roads and Maritime Services

0 40

North

GeoLINK environmental management and design

W2G - Water Quality Monitoring Program
2134-1027

GWB20 GWB21 - Ch. 12650

Illustration C.18

Information shown is for illustrative purposes only

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Source of base data: NSW Roads and Maritime Services

0 40

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

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Source of base data: NSW Roads and Maritime Services

0 40

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

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Source of base data: NSW Roads and Maritime Services

0 40

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.

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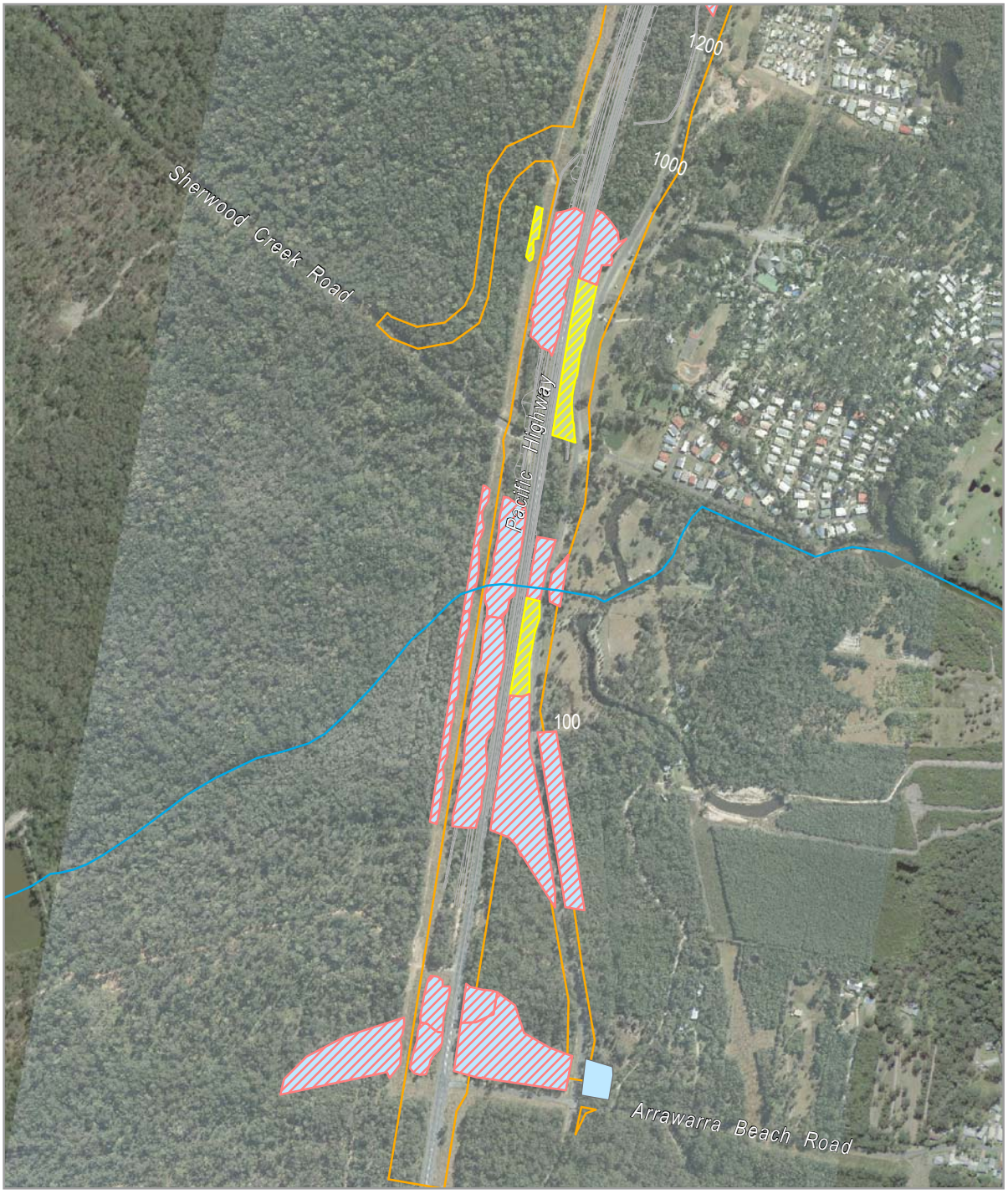
Source of base data: Roads and Maritime Services



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

0 200

North

Location of High Probability GDEs - W2G

GeoLINK environmental management and design

W2G - Surface and Groundwater Quality Monitoring Protocol
2134-1032

Illustration D1

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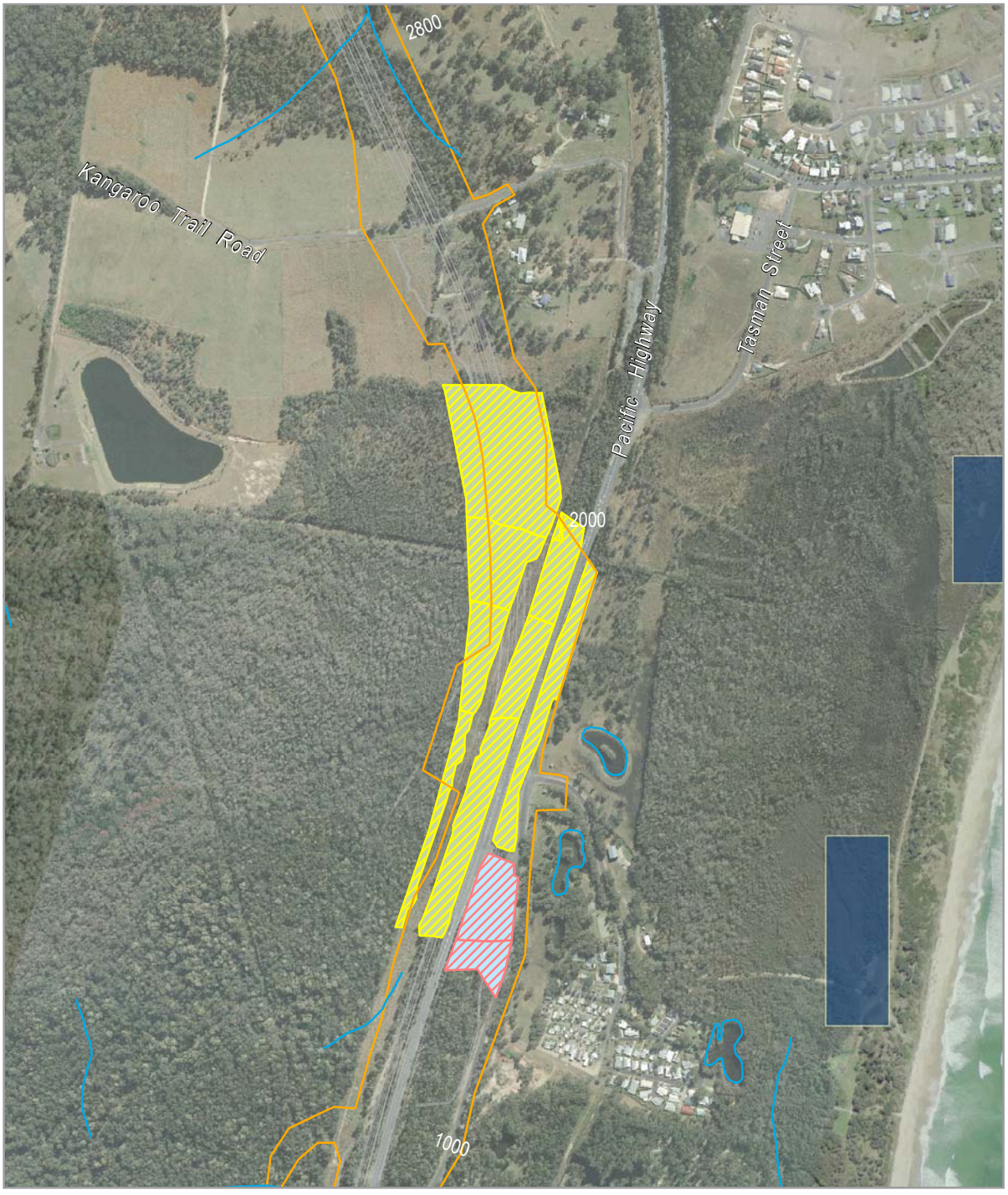

LEGEND

- 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

GeoLINK environmental management and design

W2G - Surface and Groundwater Quality Monitoring Protocol
2134-1033

Illustration D2

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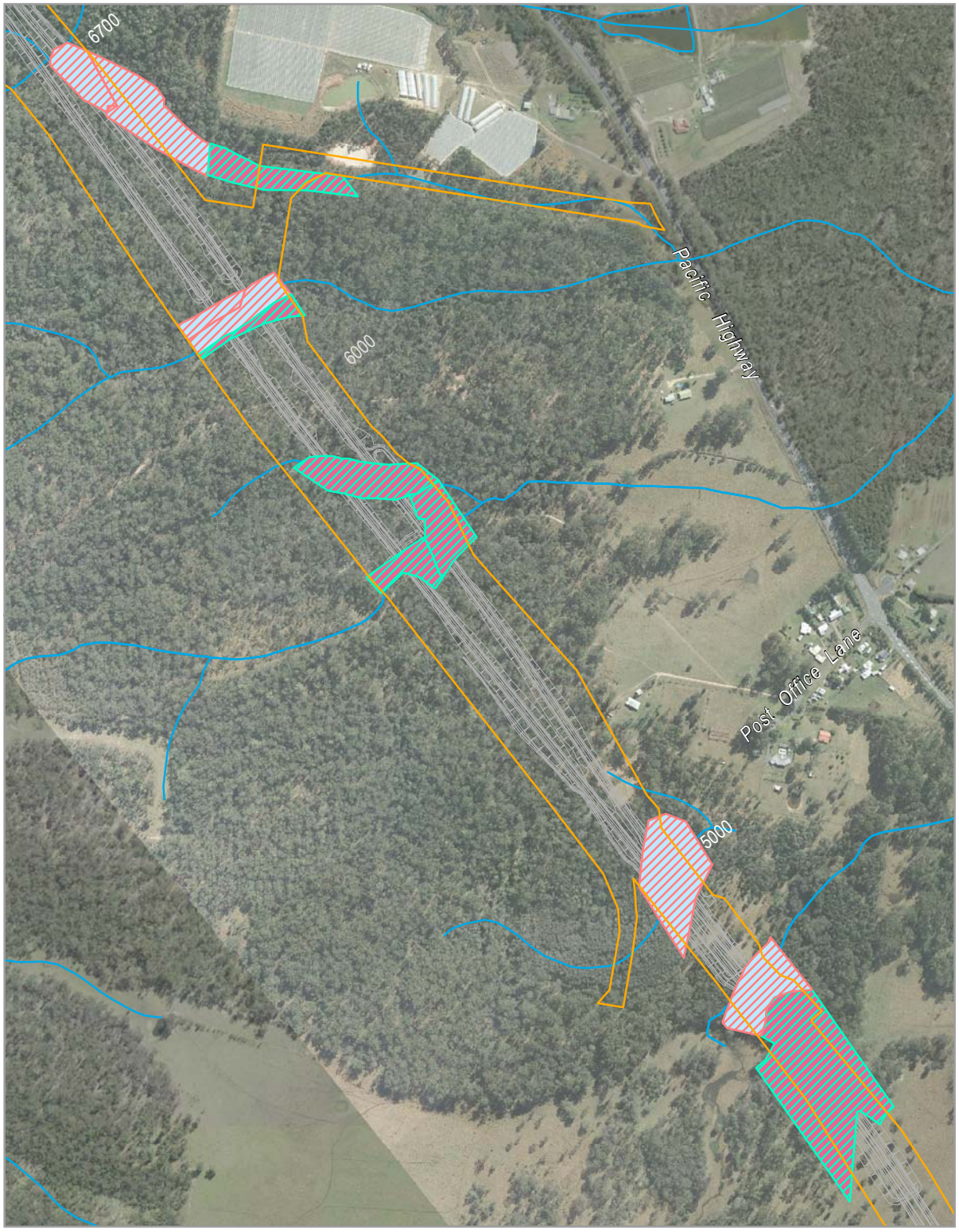

LEGEND

- 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

GeoLINK environmental management and design

W2G - Surface and Groundwater Quality Monitoring Protocol
2134-1034

Illustration D3

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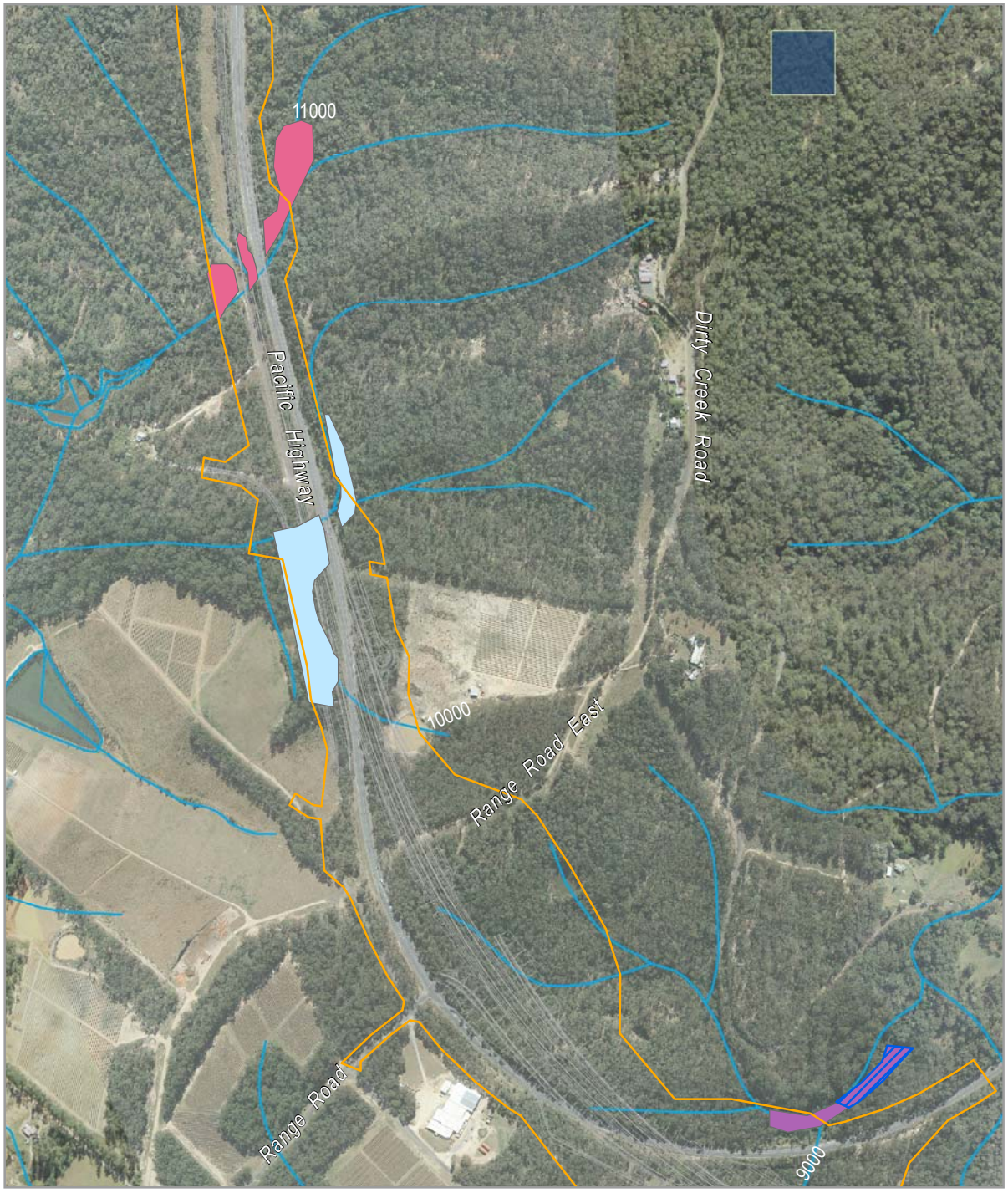
Source of base data: Roads and Maritime Services



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

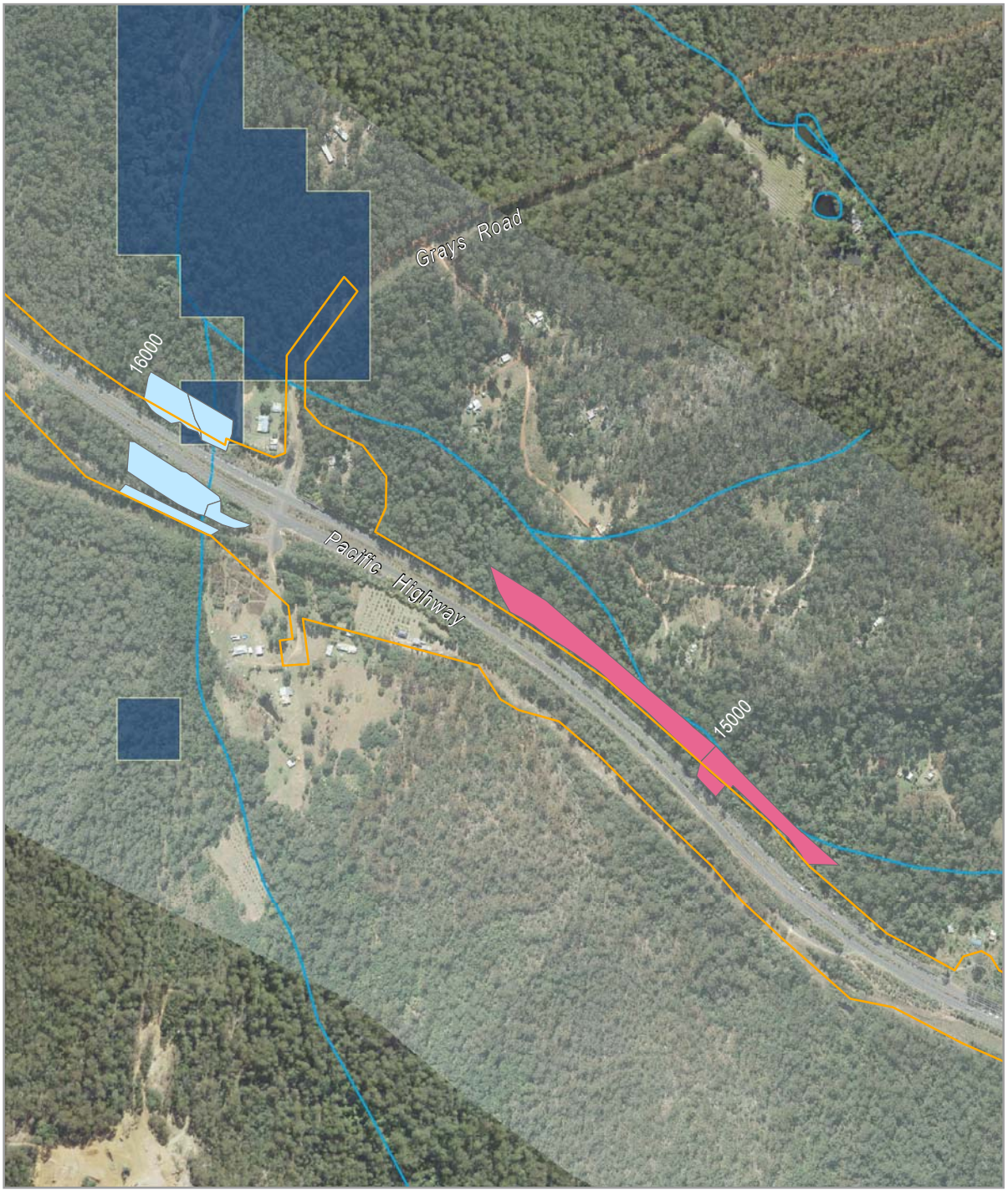
North

0 200

Location of High Probability GDEs - W2G

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

GeoLINK environmental management and design

W2G - Surface and Groundwater Quality Monitoring Protocol
2134-1037

Illustration D6

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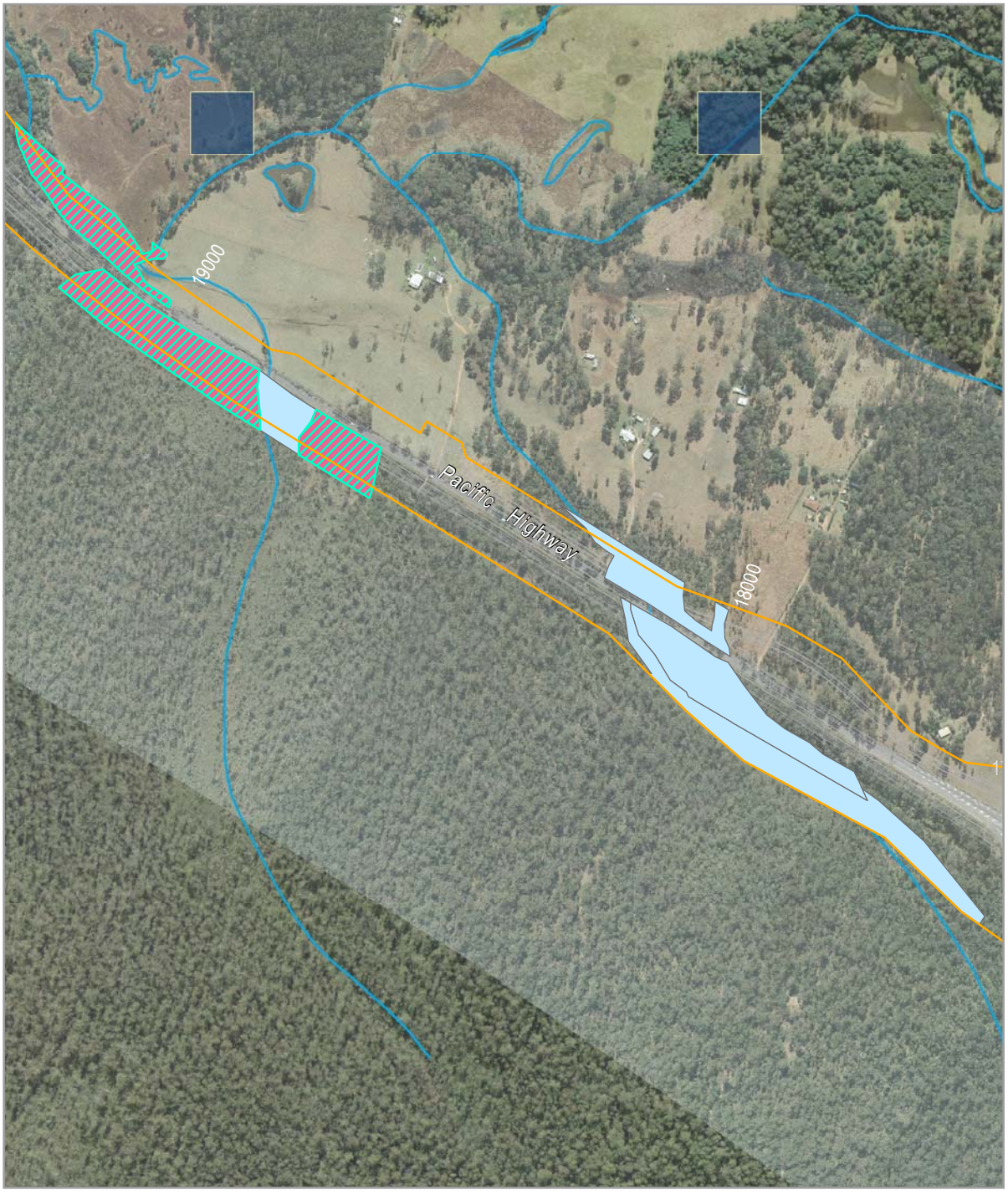
Drawn by: TJP Checked by: MVE Reviewed by: GJM Date: March 2013
Source of base data: Roads and Maritime Services



LEGEND

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

EEC

- Subtropical Coastal Floodplain Forest

Vegetation Type

- Mixed Coastal Floodplain Forest
- Swamp Sclerophyll Forest

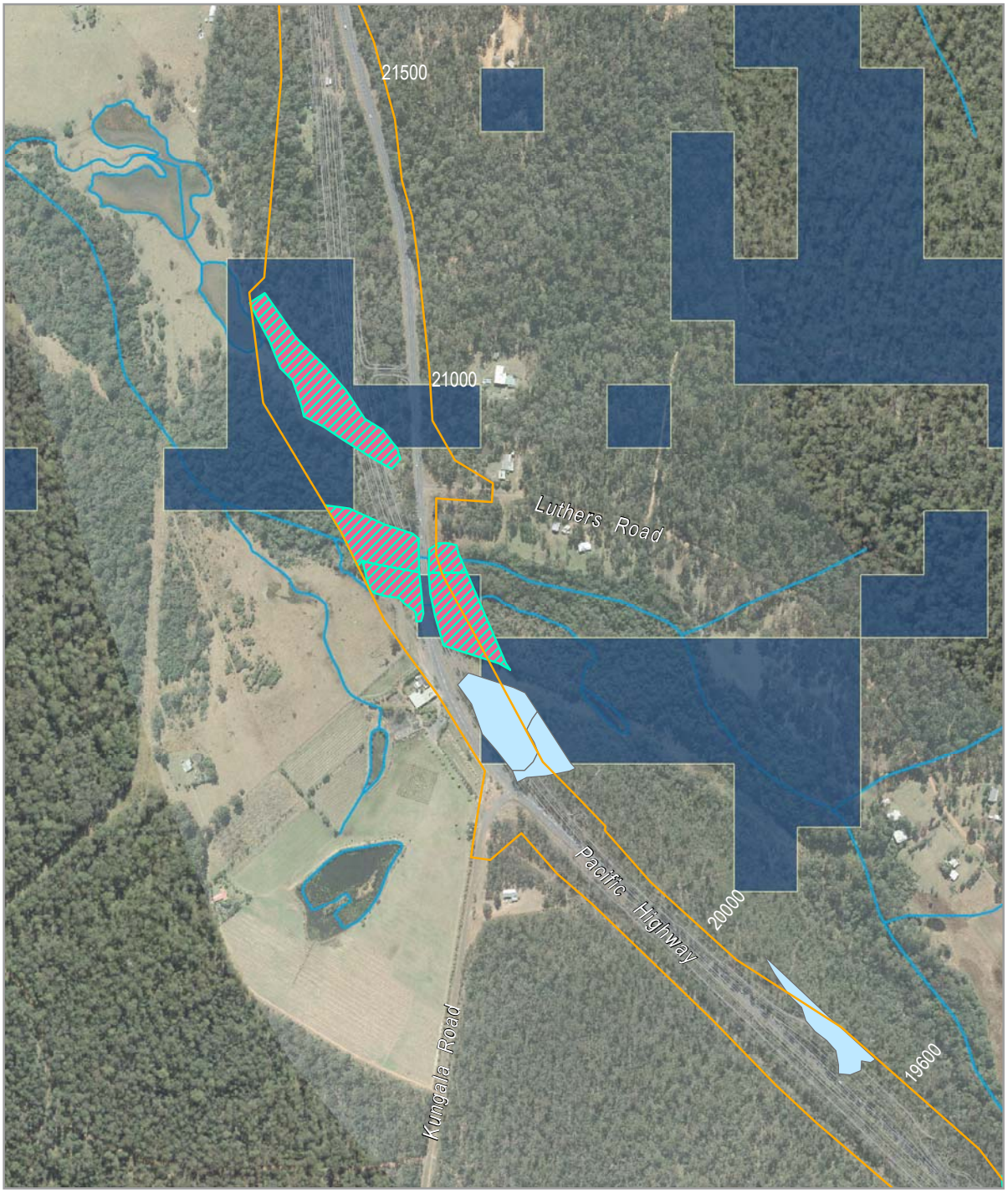
0 200

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

Vegetation Type

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- Swamp Sclerophyll Forest

North

0 200

Location of High Probability GDEs - W2G

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Drawn by: TJP Checked by: MVE Reviewed by: GJM Date: March 2013
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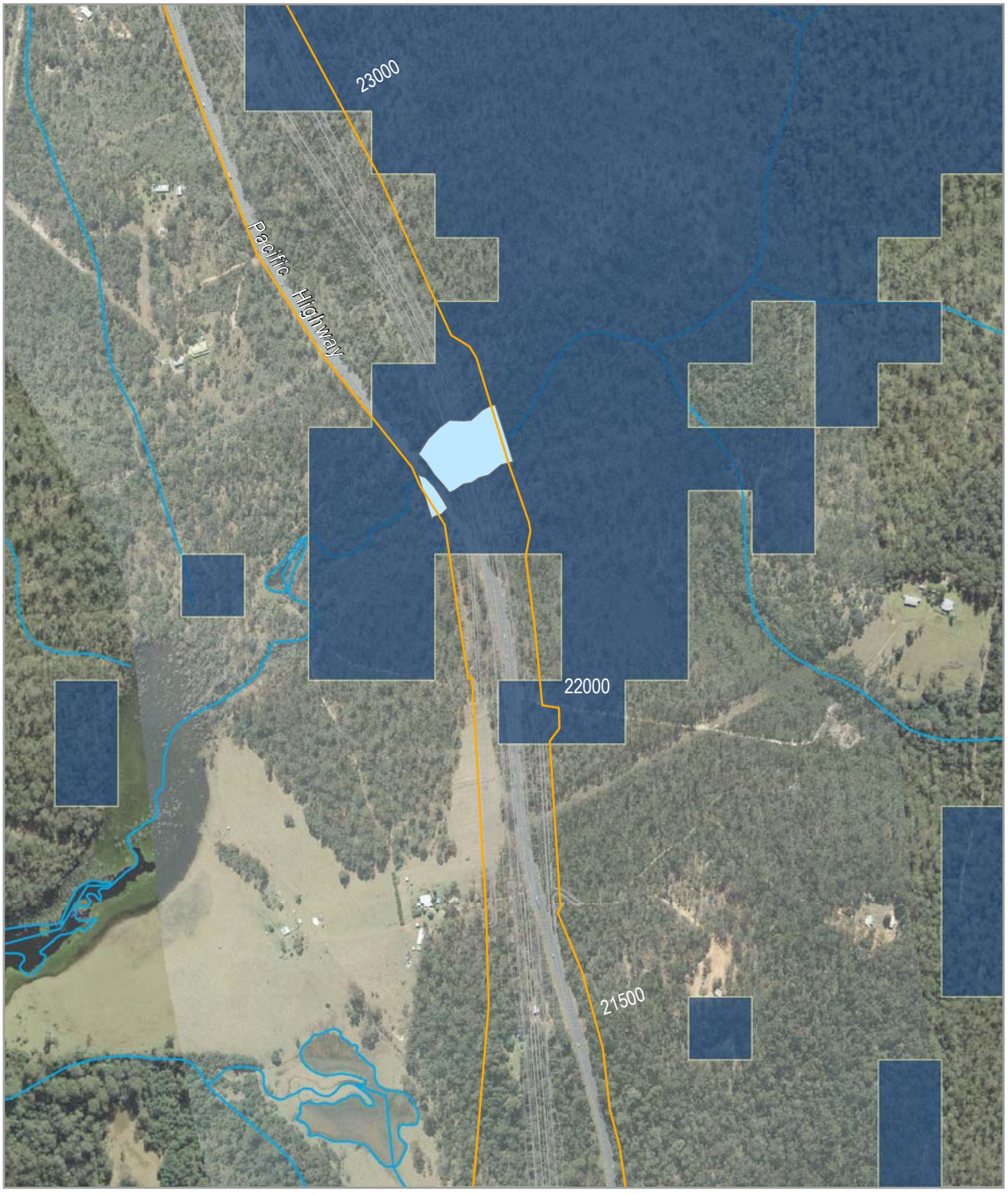


LEGEND

- 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. 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. It is noted that DPI recommended the inclusion of two items in Section 1.4.1.	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. This has been stated at the end of Section 1.3. Appendix E has been added listing the government authority comments and the responses. 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.

Appendix B
Spoil and Fill Management Procedure

Spoil and Fill Management Procedure

Project description: Wells Crossing to Glenugie

Approval				
Revision	Date	Name	Position	Signature
A	17/09/2019	Hari Corliss	Environmental Manager	H Corliss

Contents

Purpose

The Spoil and Fill Management Procedure (SFMP) has been developed to ensure spoil and fill is appropriately managed The objectives of this SFMP are to:

- identify spoil and fill issues potentially arising from the Project;
- present processes for spoil and fill material handling, transportation and
- movement, stockpiling, reuse and disposal to protect the environment and
- maximise the reuse of earthen materials generated on site;
- identify and describe measures to be implemented relating to spoil and fill
- activities that may impact on air quality, sedimentation, contamination, noise
- and local amenity; and
- outline an effective monitoring, auditing and reporting framework to assess the effectiveness of the controls implemented.

Induction / Training

All employees, contractors and utility staff working on site will undergo site induction training relating to environmental issues, including spoil and fill management. A specific Toolbox Talk which will address the following elements related to spoil and fill management will be delivered to all staff involved in the establishment and maintenance of stockpiles and spoils sites:

- the existence and requirements of this sub-plan;
- spoil handling, stockpiling and disposal management requirements;
- haulage routes and haul management;
- managing contaminated soil; and
- dust and Erosion and Sediment (E&S) control mitigation measures.
- Segregation requirements e.g. topsoil horizons, EECs, weed infested material, contaminated material etc.
- Signage requirements

Records would be kept of all personnel undertaking the site induction and training, including the contents of the training, date and name of trainer/s.

Scope

This procedure is applicable to all activities that may lead to the generation, transportation, storage or disposal of spoil or fill.

Aspects and Impacts

Material Types

For the purpose of this procedure, spoil can be defined as any earthen material that is surplus to requirements or unsuitable for reuse in fill and embankments, or material that is contaminated.

For the purpose of this procedure, fill can be defined as earthen material excavated from either along the corridor and relocated elsewhere as compacted fill or imported from off site for utilisation in earthworks.

Select Material Zone (SMZ) is earthen material of comparatively higher quality than general fill material and necessary for engineered backfilling.

Unsuitable (non-contaminated) spoil comprises soil of comparatively lower engineering quality than SMZ and may be utilised for general fill or landscaping works. Unsuitable material may be won during earthworks from areas including:

- creek beds;
- water courses;
- pile spoils;
- low lying fill foundation areas; and
- shallow cut locations.

Topsoil occurs between approximately 50-200mm of natural ground surface. Topsoil reuse will be maximised on site to minimise the import of external topsoil for revegetation and landscaping purposes. Topsoil needs to be carefully managed to ensure microbial life, physical properties and seed bank viability is maintained, processes to maximise viability are included in Table 5-1.

Spoil Classification

The classification of spoil will be undertaken in accordance with the EPA Waste Classification Guidelines, 2014, including the implementation of a spoil sampling and analysis program during excavations, where required. This will determine the type of spoil:

- Virgin Excavated Natural Material (VENM): DECCW places no specific restrictions on reuse options of VENM
- Clean fill: If deemed suitable (i.e. waste classification and poses no environmental or OH&S risk) can be used as fill on site. Topsoils are suitable for reuse in rehabilitation works
- Potentially contaminated material: Requires management or disposal in accordance with DECCW Waste classification guidelines 2009 and the Hazard and Risk Management Plan.
- The risk of encountering Acid Sulfate Soils is very low, however if it is identified it will be treated as per the Acid Sulfate Material procedure Appendix C.

Transport of Spoil

Spoil and fill will be required to be transported both within and outside the project boundary during construction, however, wherever possible haulage will be along the Project corridor.

In instances where haulage of cut material is required by road, exit from and entry to the project will be via specific Project access points, using designated haul routes, as detailed in the Traffic Management Plan.

Where the construction program necessitates movement of material prior to haul roads being established, or for other justified reasons, material may be hauled on public roads by road trucks. When this is required, standard dust and mud tracking controls will be implemented and additional requirements will be detailed in other project traffic and safety plans.

Storage of Spoil

Temporary stockpile areas for the Project will be located as detailed in the Stockpile Management Protocol.

Fill material required for engineering purposes in road construction will be managed to maximise direct placement and minimise double handling and stockpiling requirements.

Dust and E&S control measures will be implemented as required to minimise air water quality impacts as per the Air Quality Management Plan and the Soil and Water Management Plan.

Risk assessment

Work must not commence if an activity has a risk that has been assessed as Extreme. Consider hierarchy of controls - Elimination|Substitution|Engineering|Administration|PPE.	Consequence severity level (from table above)				
	1	2	3	4	5
A -Almost certain - It is expected to occur at least once in the life of the project	High	High	Extreme	Extreme	Extreme
B -Likely - Will probably occur; may occur every second similar type project	Medium	High	High	Extreme	Extreme
C -Moderate - Should occur at some time; once in 5 similar type projects	Low	Medium	High	Extreme	Extreme
D -Unlikely - Could occur at some time; once in 10 similar type projects	Low	Low	Medium)	High)	Extreme
E- Rare - May occur only in exceptional circumstances	Low	Low	Medium	High	High

Level	Likelihood	Description
A	Almost certain	Is expected to occur during the project, 90% or > probability
B	Likely	Will probably occur during the project, ~50% probability
C	Moderate	Might occur at sometime during the project, ~10% probability
D	Unlikely	Could occur at some time during the project, ~1% probability
E	Rare	Only occur in exceptional circumstances, < 1% probability
Level	Consequence	Description
1	Insignificant	Insignificant Breach of Environmental Statutes
2	Minor	Minor Breach of Environmental Statutes

3	Moderate	Moderate Breach of Environmental Statutes
4	Major	Major Breach of Environmental Statutes
5	Severe	Shutdown of Project Due to Environmental Breach

Aspects and Mitigation

Table 1 Aspects and Mitigation

Np	Aspect	Risk	Mitigation Measures	Risk	Responsibility	Timing
General						
SFM1	Training and awareness	High	All staff and subcontractors will undergo a site induction and ongoing toolbox talks where required that will detail environmental issues including spoil and fill management where applicable.	Low	ESR, PM	Prior to works
SFM2	Waste and reuse	High	The NSW Governments Waste Management Hierarchy of "avoid-reduce-reuse-recycle-dispose" will be followed as the framework of waste management throughout the project.	Low	All	During construction
SFM3	Control	High	Mitigation measures from this sub plan will be included in relevant activity or area specific Work Method Statements (WMSs)	Low	ESR	Prior to works
SFM4	Monitoring and records	Med	The weekly environmental inspection checklist will be completed as described in the CEMP and will record spoil and fill related issues where required	Low	ESR	Weekly
SFM5	Waste and reuse	Med	Excavated material from cuttings and excavations will be utilised where possible as engineering fill on the site (as opposed to importing fill from off site).	Low	Foreman, Roadworks Manager	During construction
SFM6	Contaminated material	High	If suspected contaminated materials are encountered during spoil and fill activities, including Acid Sulphate Soils works with the potential to affect the contaminated materials will be stopped and the processes in the Hazard and Risk Management Plan (HRMP) and Soil and Water Management Plan (SWMP) will be complied with.	Low	Foreman/All	During construction
SFM7	Operations	Med	Scrapers, dozers, dump trucks, moxy trucks and b-double trucks will be used to transport spoil and fill material, whilst graders, compactors, dozers, water trucks and rollers will be used to place the material.	Low	Foreman, Roadworks Manager	During construction
SFM8	Monitoring and records	Med	Records of all spoil and fill movements will be kept in accordance with the project Earthworks Management Plan. This includes daily records of cut to fill movements, tip sheets and overall mass haul calculations.	Low	Foreman, Roadworks Manager	During construction
SFM9	ERSED	High	Dust and E&S controls will be installed and maintained to manage spoil and fill areas (cuts, fills, stockpiles etc) in accordance with the project Air Quality and Soil and Water Management Plans	Med	Foreman, Roadworks Manager	During construction
SFM10	Rehabilitation	High	Restoration of stockpile site areas must be undertaken progressively following completion of stockpiling operations in each area.	Low	Foreman, Roadworks Manager,ESR	During construction
Stockpiling						
SFM11	Locations	High	The locations of all stockpiles of spoil and fill material will be in accordance with the Stockpile Management Protocol. All stockpile locations will be included in the project CEMP. All stockpiles will be signed to indicate material type, soil horizon, EEC and location as applicable.	Low	Foreman, Roadworks Manager	During construction
SFM12		Med	In addition to the above criteria, stockpile locations will not be under the drip zone of native vegetation and minimum distances from drains and gutters will be determined in consultation with the project Soil Conservationist.	Low	All	During construction
SFM13	Topsoil management	High	Topsoil stockpiles identified for reuse will be designed and managed in accordance with the requirements of the Soil and Water Management. Environmental Work Method Statement, Topsoil Stripping and Stockpiling, will be prepared to ensure these requirements are met and will include the requirements to separate different topsoil horizons, limit stockpile heights and timeframes to ensure seed bank viability and ensure topsoil is used in the same vegetation region from which it was removed..	Med	Foreman, Roadworks Manager, ESR	During construction
SFM14	Noise	High	Where nearby residents may potentially be impacted by noise from the project, stockpiles will be placed to provide noise barriers where feasible	Low	Foreman, Roadworks Manager, ESR	During construction

Transportation of Spoil and Fill						
SFM15	Community	High	Designated haulage routes will be communicated to relevant personnel and sub-contractors and periodic surveillance undertaken to ensure routes are being used	Low	Foreman	During construction
SFM16	ERSED	High	Dust and E&S controls will be installed and maintained for spoil and fill transportation in accordance with the project Air Quality and Soil and Water Management Plans	Low	Foreman, Roadworks Manager	During construction
SFM17	Air quality	High	Vehicle movements associated with spoil and fill movement will be reassessed on site where dust generation, sedimentation or mud tracking may result	Low	Foreman, Roadworks Manager	During construction
SFM18	Community	High	Spoil and fill materials will be moved along project haul roads through the construction corridor where possible.	Low	Foreman, Roadworks Manager	During construction
Imported Fill						
SFM19	Quality	Med	Verification of the source and quality of imported materials will be undertaken to confirm that the material is not contaminated.	Low	Foreman	Prior to use
Surplus Material						
SFM20	Waste	Med	Unsuitable material determined to be unsatisfactory for use as engineering fill in the project will be managed in one or more of the following ways, (in order of preference): • Reused within the job for noise mitigation, landscape shaping, batter flattening, etc • Taken off site to be used in other RTA projects • Used for landscape works in community areas • Offer to local council for noise mitigation and landscaping • Offer to local residents and businesses • As a last resort taken to landfill	Low	Foreman, Roadworks Manager	During construction
SFM21		Med	Removal of any spoil off site will be in compliance with the processes described in the project Waste and Reuse Management Plan (WRMP).	Low	Foreman, ESR	During construction
Mulch						
SFM22	Water quality	High	Stockpile sites will be located away from drainage lines and watercourses and arranged to minimise damage to natural vegetation and trees. The stockpile sites will be accessible, and have temporary erosion and sediment control measures installed.	Med	Foreman, Roadworks Manager	During construction
SFM23	Rehab	Med	Mulch stockpile areas will be progressively restored following completion of stockpiling in that area.	Low	Foreman, Roadworks Manager	During construction
SFM24	Water qulity	High	Run off from the mulch stockpile will be managed in accordance with the RMS publication 'Management of Tanins from Vegetation Mulch 2012'	Low	Foreman, ESR	During construction
SFM25	Fire	Med	Stockpiles must be monitored and managed to avoid spontaneous combustion	Low	Foreman, Roadworks Manager	During construction

Maintenance, monitoring and evaluation of performance

Inspections

All control and mitigation measures will be inspected weekly, following rain events and corrective actions implemented if non-conformance is observed.

Targeted inspections will be conducted by the Environmental Site Representative during high risk activities, such as excavation works.

Monitoring

Following liming, the pH of the treated soils is to be monitored twice a day for one week to ensure there is adequate lime application.

Stockpiles will be monitored on a daily basis by the Foreman to ensure all controls are maintained. The Environmental site Representative will undertake weekly inspections to ensure compliance with this and other CEMP requirements.

Incidents and corrective action

Incident reporting

In the event of an environmental incident, Roads and Maritime Environmental Incident Classification and Reporting Procedure will be implemented in conjunction with Lendlease Engineerings procedures. Typically, environmental incidents will be notified verbally immediately and in writing within one hour of any incident occurring to the Roads and Maritime Representative and the Environmental Representative. Incident reports will be provided to the Roads and Maritime Representative and the Environmental Representative within 24 hours of the incident occurring, including lessons learnt from each environmental incident and proposed measures to prevent the occurrence of a similar incident.

The following reporting procedure will be followed for any incident resulting in an emergency situation:

Step	Details	Contact number
1	Call Emergency Services if incident presents an immediate threat to human health or property	000
2	Call the appropriate regulatory authority (ARA) (DPI (Fisheries))	1300 550 474
3	Call the EPA, if not the ARA	131 555
4	Call the Ministry of Health via the local Public Health Unit	1300 066 055
5	Call the Work Cover Authority	13 10 50
6	Call the local authority (Grafton City Council), if this is not the ARA	(02) 6643 0200
7	Call Fire and Rescue NSW (unless 000 has already been called)	1300 729 579

Notifiable event

The EPA will be notified of any environmental incidents or pollution incidents on or around the site via the EPA Environment Line (telephone 131 555) in accordance with Part 5.7 of the PoEO Act. The circumstances where this will take place include:

a) If the actual or potential harm to the health or safety of human beings or ecosystems is not trivial.

b) If actual or potential loss or property damage (including clean-up costs) associated with an environmental incident exceeds $10,000.

Pollution incident means an incident or set of circumstances during or as a consequence of which there is or is likely to be a leak, spill or other escape or deposit of a substance, as a result of which pollution has occurred, is occurring or is likely to occur. It includes an incident or set of circumstances in which a substance has been placed or disposed of on premises, but it does not include an incident or set of circumstances involving only the emission of any noise.

In addition the following notification requirements will be implemented.

Event	Notification Requirements	Responsibility
Fish kills	DPI (Fisheries) and the Principal	PM
Pollution of Glenugie Creek	EPA and the Principal	PM
Fauna death or injury	EPA and the Principal	PM
Harm to aboriginal heritage artefact	Registered Aboriginal Parties and the Principal	PM
Harm to non-aboriginal heritage artefact	EPA and the Principal	PM

Corrective action

Corrective actions will be implemented in response to an event or identified improvement and are intended to ensure that prompt and immediate action is taken to correct the event. The Project Manager will ensure that corrective actions identified on daily and weekly inspections and audits and incident reports are transferred in accordance with the Prinicpal contractors reporting procedures and timeframes and responsibilities assigned. Outstanding actions will be reviewed at weekly project meetings.

Review and improvement

Document review

This Procedure will be reviewed and updated every three months in accordance with the project's CEMP.

Auditing

Audits will be scheduled as per the requirements of the CEMP and Lendlease Engineerings Environmental Management System. These audits will review on-site performance against the Procedure and suitability of the Procedure in meeting legislative and contractual requirements.

Reporting

Complaint and environmental incidents will be reported using the Incident Management Procedure and additional procedures outline in the CEMP.

A report will be submitted to the Client on a monthly basis. This report will contain but not be limited to:

- Objectives and targets
- Monitoring results
- Complaints
- Incidents
- Audit results
- Corrective/preventative actions and improvements.

Appendix C
Acid Sulfate Soil Management Procedure

Refer to Appendix B11 Acid Sulfate Materials Management Plan

Appendix D
Management of Tannins from Vegetation Mulch

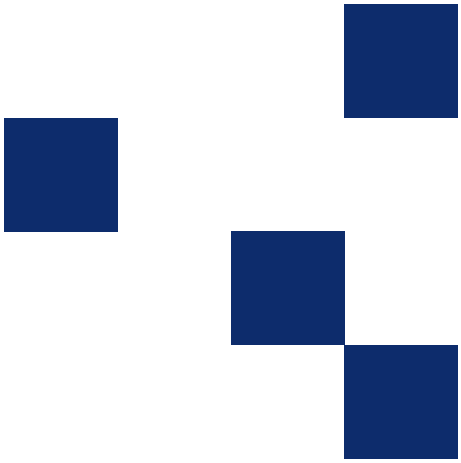
Transport Roads & Maritime Services

NSW GOVERNMENT

ENVIRONMENTAL DIRECTION

Management of Tannins from Vegetation Mulch

JANUARY 2012



ABOUT THIS RELEASE

Environmental Direction number	25
Environmental Direction title	Management of Tannins from Vegetation Mulch
Author	Environment Branch (Environmental Policy)

Issue	Date	Revision description
1	December 2011	Final draft
2	January 2012	Final

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CONTENTS

1 PURPOSE

The purpose of this environmental direction is to set RMS's minimum management measures to minimise the generation and discharge of tannins from vegetation mulch on Roads and Maritime Services (RMS) construction projects. Additional background information on tannins and the use of mulch on construction sites is included in section 3 of this direction.

2 MANAGEMENT MEASURES

The primary focus must be to minimise tannin generation on construction sites.

2.1 General mulch management measures

These general mulch management measures are to be followed for all RMS construction projects.

2.1.1 Planning and works staging

The first step in planning and works staging is to identify the amount of mulch to be generated. With this information, a strategy can be prepared to manage mulch on site. Staging of chipping, tub grinding and/or mulching activities should be planned to reduce the volume of mulch to be managed at any one time. The volume of excess mulch can then be assessed and plans made to dispose of this off site.

Other general considerations at the planning and works staging phase are as follows:

- Mulch stockpile sites should be established with appropriate controls in place before the main site clearing activities commence. Limited clearing may be required earlier for establishment of stockpile areas and access.
- Stage the mulching of cleared vegetation to ensure that mulch can be progressively moved to elevated, or otherwise suitable, stockpile locations. It is preferred that mulch should be transferred to a stockpile or reused on the day of mulching.
- Plan to efficiently reuse mulch in progressive works to reduce the time that mulch is concentrated in stockpile locations.
- Excess mulch can be managed by community giveaway. This takes considerable time and mulch needs to be suitably located and managed as this occurs. The conditions for community giveaway of mulch are included as Appendix 3.
- Any other form of bulk offsite mulch disposal (eg to Council parkland or a development site) must be assessed to ensure waste management provisions are adhered to for off site disposal.

2.1.2 Stockpile location and management

- Mulch stockpile sites should be established on elevated ground where possible.
- Stockpile sites with a duration of not more than 1 month should be constructed not less than 20 metres from a watercourse, including floodplains.
- Stockpile sites with a duration of more than 1 month should be constructed not less than 50 metres from a watercourse, including floodplains.
- Mulch stockpiles should be designed and constructed to divert upgradient water to prevent it from entering the stockpile site.

2.1.3 Management measures for the use of mulch on site

- Do not use mulch for surface cover or sedimentation controls in any low lying areas of the site that remain consistently wet. Alternative controls such as geofabric (for surface protection) or sediment fence will be required in these areas.
- Do not spread surface mulch in thicker than 100mm layers. Mixing mulch with topsoil is encouraged for batters to prevent loss of topsoil during initial stabilisation. It should be noted that mulch will generally cause nitrogen draw down which may inhibit plant growth, unless mulch has been composted first.
- Care is to be taken to ensure that excessive mulch is not applied for sedimentation controls such as perimeter bunds or catch dams.

2.1.4 Monitoring and response

- Monitor the site for generation of tannins. Tannin impacts can be readily identified visually as dark coloured ponded water. Site staff should be trained to identify and report potential impacts to the site project management or environment staff.
- Review management practices where required to prevent the generation of tannins in identified problem areas.

2.2 Mulch management methods for high risk sites

2.2.1 High risk sites

High risk sites, where additional management measures may be required, include:

- where large quantities of mulch will be generated and stockpiled.
- where high tannin generating vegetation types are to be mulched (see 3.1).
- where the receiving environment is identified as sensitive (eg Marine Park, threatened aquatic species habitat).
- where tannins have been observed to be generated or discharged from an operating site with standard management controls.

2.2.2 Stockpile management measures for high risk sites

- Mulch stockpiles for high tannin generating vegetation types should incorporate an impermeable bund to capture stockpile leachate or tannin impacted water. Impervious bunds must be a minimum of 300 mm high, preferably higher to capture tannin impacted water. All bunded stockpiles that are in place for a period longer than one month must include a lined discharge point for overflow in extreme rainfall events.
- Stockpiles established on sloping sites must be designed to provide temporary stormwater containment equivalent to a 300 mm minimum height bund on a flat site.
- Tannin impacted water should be pumped out of bunded stockpiles within 5 days of the end of a rainfall event to maintain the storage capacity. This water should be used for on site purposes including dust suppression and landscape watering. These activities must be managed to prevent any pooling or runoff of tannin impacted water.
- Bunded stockpiles must be inspected within 24 hours of cessation of any rainfall event greater than 10mm to ensure tannin impacted water does not overflow.

2.3 Site management procedures

Site management procedures must be prepared for all sites where tannins are identified as a potential issue. Site management procedures should be based on the management measures provided in this Environmental Direction.

3 BACKGROUND

3.1 Tannin generation from vegetation mulch

See Plates 1 – 3 in Appendix 1.

Tannins are naturally occurring plant compounds. Tannin generation from vegetation mulch is likely to be highest from low-lying coastal floodplain areas. The species of vegetation (eg *Melaleuca*) will have a major impact on the likelihood of tannin generation.

Tannin generation is generally highest from mulched vegetation that is stockpiled in areas that are subject to inundation. Placement in wet areas will result in accelerated leaching of tannins into water, concentration of tannins in pooled water, and greater impacts on water quality.

3.2 Tannin impacts on water quality

See Plates 4 – 5 in Appendix 1.

The main concern with the discharge of water that is high in tannins is that it may increase the biological oxygen demand (BOD) of the receiving environment. Increases in BOD may result in a decrease in available dissolved oxygen. A lack of dissolved oxygen is identified as the main cause of about 80 percent of fish kills in NSW rivers and estuaries.

Tannin impacts may result in dark coloured water discharge from construction sites. This impact can be obvious and may raise the concern of the community and other stakeholders including regulatory authorities. Once discharged to the environment, tannins may reduce visibility and light penetration and change the pH of receiving waters. These impacts may affect aquatic ecosystems in receiving environments.

Tannins cannot be readily treated with standard construction site water quality controls. Once water on site is impacted with tannins it is not possible to treat effectively with currently approved flocculants. Minimisation of tannin generation in the first place is the management strategy that must be applied.

3.3 Use of mulch on construction sites

See Plates 10 – 16 in Appendix 2.

The RMS Biodiversity Guidelines provide guidance on the benefits of reusing various sizes of vegetation for different purposes. Mulch is a readily available and cheap source of material for temporary site stabilisation and sedimentation control. The re-use of mulch reduces the need to transport this material off-site and reduces handling and disposal costs for construction contracts.

Unprotected mulch sedimentation controls should not be placed in concentrated flow lines where mulch may be washed away. Mulch may be protected by wrapping it with geofabric or other materials to provide a stable control. All temporary catch dams constructed from mulch must have a stable outlet to minimise the washing away of mulch in high rainfall events, and the possible failure of the control.

4 ADDITIONAL RESOURCES

- RTA Biodiversity Guidelines- Protecting and Managing Biodiversity on RTA Projects, 2011
- Pacific Highway Mulch Protocol 2011

5 APPENDICES

Appendix 1: Plates showing tannin generation & water quality impacts

Plate 1: Melaleuca vegetation community – mulch from this vegetation type will generally produce high amounts of tannins.

Plate 2: Vegetation mulching activity – mulch should be progressively moved into prepared stockpile areas.

Plate 3: Tannin generation from recently felled and partially mulched vegetation in an area subject to localised inundation. Mulched vegetation should be progressively moved to prepared stockpiles to manage tannin impacted water.

Plate 4: Tannin impact in stormwater at the discharge point from a road construction site. The discharge of impacted water may be obvious to community and other stakeholders.

Plate 5: Tannins in a drainage line generated from very thickly applied mulch on the batter above. Note that the sedimentation fence is not effective in treating the tannins.

Appendix 2: Plates showing the use of mulch for erosion & sedimentation controls

Plate 6: Mulched vegetation stockpiled in a low-lying area subject to inundation. This is not an appropriate stockpile location and may increase the generation of tannins from stockpiled mulch.

Plate 7: Mulch being placed as batter erosion control. Mulch should not be applied in layers more than 100 mm thick for surface stabilisation.

Plate 8: Site showing recent application of a mulch/topsoil mix on batters (40% mulch to 60% topsoil). Mulch mixes are used to provide temporary stabilisation to prevent the loss of topsoil from batters in heavy rainfall events. Mulch use is also shown as a mounded sedimentation control to prevent sediment entering the median drain.

Plate 9: A mulch/topsoil mix used to provide temporary batter stabilisation and to assist cover crop establishment.

Plate 10: Successful establishment of cover crops on batters where mulch has been used with topsoil to assist temporary stabilisation.

Plate 11: Geofabric wrapped mulch bunds used for sedimentation control

Plate 12: Mulch used as a bund for a temporary sedimentation catch dam. Mulch is effective as it can provide both containment and filtering of site water. Mulch should not be used as a control in areas of concentrated flow where it may be washed away. Any mulch containment control should have a defined and lined outlet that allows discharge from the control without washing mulch away. Note that this control does not have a defined discharge outlet which should be installed to prevent failure of the control in heavy rainfall events.

Appendix 3: Minimum requirements for community mulch giveaways

The purpose of community mulch giveaways is to provide mulch for residential landscaping purposes.

The activities of a community mulch giveaway are permissible under the *Protection of the Environment Operations (Waste) Regulation 2005 – General Exemption Under Part 6, Clause 51 and 51A* (the Raw Mulch Exemption 2008). However, the activities remain subject to other relevant environmental regulations within the Act and Regulations. The Raw Mulch Exemption 2008 is subject to the following conditions:

- The raw mulch can only be applied to land for the purposes of filtration or as a soil amendment material or used either singularly or in any combination as input material(s) to a composting process.
- The consumer must land apply the raw mulch within a reasonable period of time.

Further information can be found at: www.environment.nsw.gov.au/resources/waste/ex08mulch.pdf

It is the mulch generators responsibility to ensure that the mulch is reused in an environmentally responsible manner.

A safe work method statement (SWMS) must be prepared that identifies potential OHS risks and all prevention and mitigation measures. The SWMS must apply to both the community and site workers involved in the mulch giveaway.

Each member of the community who participates in the mulch giveaway must read and understand a site specific information sheet. A template information sheet is attached as Appendix 4.

The site occupier must maintain written records for each load of mulch that is taken away and to ensure that each community participant understands the conditions of the community mulch giveaway information sheet. A suggested template to record this information is attached as Appendix 5.

Appendix 4: Community mulch giveaway information sheet

The following community mulch giveaway information sheet must be populated with site specific information.

Community Mulch Giveaway
Information Sheet

Details of Mulch Supply	
Site Occupier	<insert name of contractor / alliance etc>
Project Name	<insert project name>
Location	<insert location of mulch stockpile>
Mulch stockpile access directions	<insert adequate directions for community members to find the stockpile location>

Background

- This information sheet supports the non-commercial giveaway of mulch for local residents.
- The product is raw vegetation mulch from <insert project location / name>.

Conditions

- Any one individual may only take a maximum of 5 trailer loads from this project.
- The mulch may only be used for residential landscaping purposes.
- Mulch must not be placed in or immediately adjacent to waterways.
- The raw mulch can only be applied to land for the purposes of filtration or as a soil amendment material or used either singularly or in any combination as input material(s) to a composting process.
- The consumer must apply the raw mulch to land within a reasonable period of time.

Community Safety Requirements

- <add in any safety requirements or mitigation measures from the SWMS that apply to the community>
- <add in any safety requirements or mitigation measures from the SWMS that apply to the community>
- <add in any safety requirements or mitigation measures from the SWMS that apply to the community>
- <add in any safety requirements or mitigation measures from the SWMS that apply to the community>

Appendix 5: Records template for community mulch giveaway

The records in the following suggested template must be kept as a minimum.

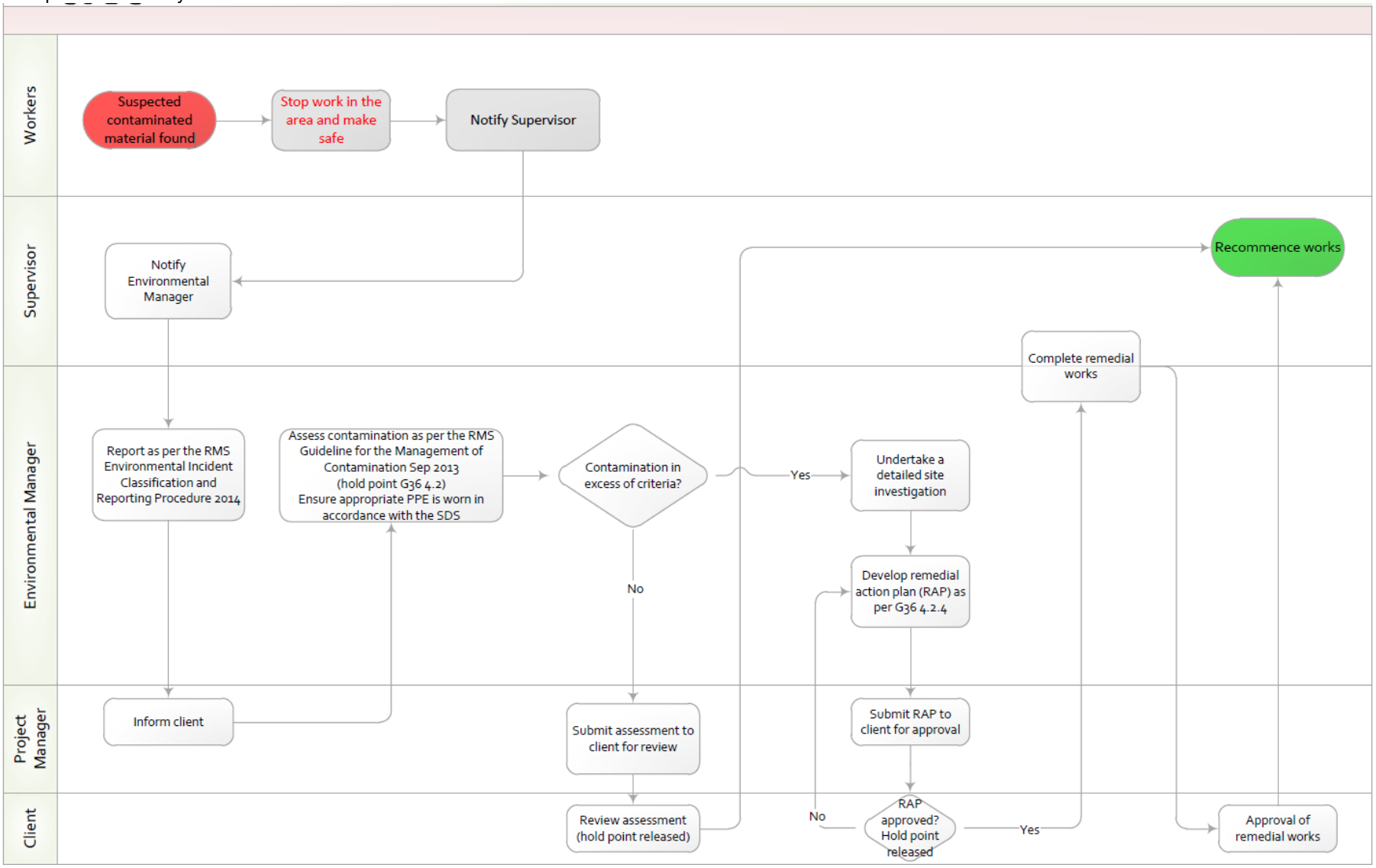
Community Mulch Giveaway Record Sheet				
Date	**Car Registration**	**I have read and understand the 'Community Mulch Giveaway Information Sheet'**	**Name**	**Signature**
		❑ Yes		
		❑ Yes		
		❑ Yes		
		❑ Yes		
		❑ Yes		
		❑ Yes		
		❑ Yes		
		❑ Yes		
		❑ Yes		
		❑ Yes		
		❑ Yes		

Appendix E
Groundwater Management Strategy
Not Applicable

Appendix F
Unexpected Discovery of Contaminated Land Procedure

Appendix F

Wells Crossing to Glenugie
Unexpected Discovery of Contaminated Land Procedure



Appendix G
Pacific Highway Projects Dewatering Practice Note

Appendix G

DEWATERING PRACTICE NOTE

Pacific Highway Projects

May 2012

Document control

Document Title	Dewatering Practice Note (Pacific Highway Projects)
Author	RMS Pacific Highway Office

Issue	Date	Revision Description
1	January 2012	Draft
2	February 2012	Draft
3	May 2012	Final

Disclaimer

The information contained within this practice note is for general information only and is not intended to constitute legal advice. RMS accepts no responsibility for any loss arising out of reliance on any information contained in this document.

Acknowledgements

This practice note was prepared by RMS Pacific Highway Office.

RMS Pacific Highway Office would like to acknowledge RMS Environment Branch (Environmental Policy) and their publication *Environmental Management of Construction Site Dewatering EMS-TG-011*; this publication has served as the basis for this practice note.

RMS Pacific Highway Office would also like to acknowledge the assistance of EPA who provided comment on and assisted in the development of this practice note.

Contents

1. How to use the Practice Note

The Dewatering Practice Note is intended for use by RMS project managers, staff and contractors on Pacific Highway construction projects. It has been designed as a means to ensure key mitigation and management principles for dewatering are indentified and included in project specific Environmental Work Method Statements (EWMS) to be implemented prior to the need to conduct dewatering activities. It should be employed by RMS project teams as a means to proactively plan, assess and improve on-site procedures involving dewatering. When used correctly the practice note will aid in the enhancement of RMS environmental procedures, ensuring detrimental environmental impacts from RMS construction projects are kept to a minimum.

Refer to this practice note when preparing or assessing EWMS for work activities associated with the removal of ponded stormwater or infiltrated groundwater from any location on site, as well as the subsequent reuse or discharge of that water.

2. Introduction

2.1. Background

Dewatering is considered as any activity involving the removal of ponded stormwater or infiltrated groundwater from any location on site. For the purposes of this practice note and other RMS documentation, dewatering also encompasses any activity involving the subsequent reuse or discharge of such water.

Dewatering is a necessary part of any construction or maintenance project as captured stormwater and infiltrating groundwater will fill and pool in low-lying areas of construction sites over time. Without dewatering, pooling water may otherwise adversely affect project objectives. Reduced sediment control effectiveness, damage to formations and excavations, decreased site-access and increased downtime may all result without dewatering activity.

2.2. Objective

It is a requirement of all RMS Pacific Highway construction projects that ALL dewatering activities are undertaken in a manner that does not pollute the environment. As such project teams working on Pacific Highway projects must develop and comply with appropriately planned, approved and supervised procedures to govern such activities. Documentation of such procedures shall be in the form of an environmental work method statement (EWMS). An EWMS shall be both activity related and project specific and ALL dewatering activities must be addressed for each project. Minimum requirements for each EWMS have been outlined within this practice note, although the use of innovation is encouraged to continually enhance RMS environmental best practice.

Specific aims of this practice note are to deliver best practise and due diligence requirements on Pacific Highway construction projects that enable:

- dewatering activities to be managed to avoid pollution and/or environmental harm as defined under the Protection of the Environment Operations Act (NSW, 1997), (POEO Act) and Regulation;
- that promote sustainability in reusing valuable resources; and
- compliance with conditions of approval, permits, and licence conditions.

3. Considerations in planning dewatering activities

Every dewatering activity must be planned to achieve satisfactory environmental outcomes. In the preparation of an effective and acceptable dewatering EWMS, the following actions must be undertaken:

- Identify areas of the site that will require dewatering
- Identify receiving environment where water will be discharged with consideration and assessment of the sensitivity of the receiving environment (E.g. threatened frog/fish species habitat, Marine Park Areas, etc) - wherever possible dewatering to environmentally sensitive areas should be avoided.
- Consider dewatering methods that will minimise potential environmental impacts
- Assess opportunities for reuse

- Assess limitations for any proposed reuse methods
- Select discharge locations and provide adequate energy dissipation
- Determine and document water quality criteria for discharge and/or reuse
- Assess the treatment techniques required to meet the water quality criteria
- Assess water sampling and testing requirements
- Where discharge to sensitive areas is unavoidable, discharge methods, monitoring, sampling and testing should all reflect the specific nature of that receiving environment, its sensitivity and potential threats. This includes specifically targeting relevant parameters based on consideration of the nature of these sensitive environments.
- Identification of any potential contaminants. It is possible that previous land use activity and or the natural geology may produce contaminants. Where there is evidence to suggest there may be contamination within the catchment of an area requiring dewatering the testing regime should identify any risk and be targeted to ensure that risk is managed.
- Indication of likely volumes and duration of dewatering
- Monitoring requirements / regime
- Ensuring that dewatering does not result in discharged water re-entering the site / disturbed surfaces.
- Considering and addressing potential impacts on natural flows / water levels down stream.
- Considering and addressing mixing rates and dilution to the receiving environment.
- Training requirements / assessment of competency
- Incident management response
- Arrangement and management of the pump inlet
- Bunding of the pump

The subsequent sections (*sections 3.1 to 3.8*) will outline considerations associated with each of the actions listed above. These actions are highly recommended in the early stages of preparing an EWMS although do not constitute necessary deliverable inclusions in an EWMS document. (for minimum deliverable requirements in an EWMS document refer *Section 4: Minimum requirements for dewatering environmental work method statements*)

In addition the *Appendix* of this document provides photographs taken of dewatering activities on RMS construction projects. The photographs may be used to illustrate example designs, aiding in the design consideration process.

3.1. Identify areas of the site that will require dewatering

Dewatering locations will be identified through detailed design, in the development of the CEMP and during construction phase as earthworks and construction processes result in changing site drainage conditions. Typically locations that will require dewatering on RMS projects include:

- Sedimentation controls (e.g. sedimentation basins and sumps)
- Excavations
- Culvert and drainage constructions
- Low lying areas of road formations

3.2. Consider dewatering methods to minimise potential environmental impacts

There are various methods for dewatering sedimentation controls and inundated areas of construction excavation and formations. Common dewatering methods for sedimentation controls such as basins include pumping, low flow pipes and siphon discharges.

When selecting dewatering methods, consideration should be given to alternatives to pumped discharges where practical. Pumped dewatering presents specific risks relating to the pump inlet falling to the level of deposited sediment. This would result in direct discharge of polluted water to the receiving environment. In situations where pumping is necessary, additional protection measures should be designed into the dewatering methodology to prevent this scenario from occurring. Likewise, deposited sediment in controls such as basins must be routinely maintained (removed) to ensure that inlets to dewatering pumps and pipes are always above the level of deposited sediment.

There are two general methods for achieving water quality objectives for any site discharge, these being:

1) Water quality treatment prior to discharge.

This is required for sedimentation basins and is the preferred method for any construction excavation of inundated area that has sufficient volume and depth of water to provide flocculation of sediments prior to discharge. Any area other than defined sedimentation basins that can be treated prior to discharge should have a designed dewatering method (e.g. a defined pumping point, low flow or siphon discharge). This method would be designed to address appropriate water quality parameters and limits, and the type and volume of treatments required.

2) Treatment with best practise controls prior to discharge.

Best practise controls are those referred to within Blue Book Volume 1 and Volume 2D. Controls may include sedimentation fences, mulch bunds, sedimentation sumps, geofabric wrapped gravel or mulch bunds, use of onsite grassed areas or a combination of techniques. Treatment with best practise controls is undertaken prior to discharge. These controls must be designed, implemented, monitored and maintained to prevent erosion of the receiving environment and pollution of waters.

Treatment with best practise erosion and sedimentation controls during discharge is only applicable for minor stormwater ponding and for activities such as individual culvert extensions where the volume of stormwater captured is minor and the dewatering activity is infrequent. Addressing due diligence, risk pollution and environmental harm, site conditions and receiving environment would still need to be considered when determining whether to treat or not to treat water prior to discharge, When considering discharge location and treatment method. The following factors should also be considered:

- application rates,
- soil types,
- hydraulic loading,
- evapo-transpiration rates (as per s6.2 Blue Book Volume 2D, page 28).

The effectiveness of treatments are to be monitored and assessed and need to rectify controls and management strategy as required.

3.3. Assess opportunities for reuse

Onsite reuse of stormwater or detained groundwater should be considered as a priority for all dewatering activities. Onsite reuse may include applications such as dust suppression, earthworks compaction, vegetation establishment/rehabilitation, and plant/vehicle wash-down.

Reuse of water on construction site may reduce the need for imported or extracted water and provide a lower risk to the environment than direct discharge to the environment. A common minimum requirement for any reuse activity is that any reuse should not cause the ponding or runoff of water, which may then cause concentrated runoff and unauthorised discharge.

3.4. Assess limitations for any proposed reuse methods

Any reuse activity may be limited by climatic or site conditions. During heavy rainfall periods, when there is the greatest need to remove treated stormwater from sedimentation basins, construction sites may be closed or access limited due to the wet conditions. In such cases, onsite reuse for dust suppression or compaction is neither feasible nor possible. In these cases the water must be discharged to meet the sedimentation basin maintenance timeframes specified in either the environmental protection licence or the CEMP (for non-licensed site).

Planning for any reuse activity and the EWMS for dewatering must take these limitations into consideration, and an EWMS developed for the management of discharge which may be required as a result of high rainfall events. Planning may include controls such as lining basins, sumps, and excavations with gypsum and/or ensuring the capacity of sumps, excavations are re-instated prior to forecast rain events.

3.5. Select discharge locations and provide adequate energy dissipation

It is important to ensure that dewatering activities do not cause erosion at the discharge location or in receiving environments. Consideration must be given to the potential for erosion at discharge locations when designing dewatering outlets. Preference for treated discharge should be given to locations with established drainage and outlet structures. Locations of designated discharge points should be included on all relevant erosion and sediment control plans for the specific construction activity.

Energy dissipation must be provided at all dewatering discharge points. This may include the use of surface protection such as concrete aprons, rock bunds, geofabric, shade cloth, gabions or form ply and will be dependent on the condition of the receiving environment.

Discharge locations should be chosen with consideration to the receiving environment that may contain environmentally sensitive receivers such as threatened frog/fish species, Marine Park, etc.

Where it is not possible to avoid discharges to sensitive areas, discharge methods, monitoring, sampling and testing should all reflect the specific nature of the receiving environment and relevant parameters should be targeted to monitor, control and minimise any potential impacts.

It is possible that previous land use activity and or the natural geology of the receiving environment may produce contaminants requiring identification and assessment. Where there is evidence to suggest there may be contamination within the catchment of an area requiring dewatering then the testing regime should also identify any risk and be targeted so that the risk is managed.

3.6. Determine and document water quality criteria for discharge and/or reuse

Sites with environmental protection licences will have defined water quality objectives for licensed discharge points. The water quality parameters are also only applicable to basin discharges registered under the license. A discharge that does not achieve the environmental outcomes permitted by an EPL is likely to be considered pollution under s120 of the POEO Act. Any discharges containing contaminants other than those specifically identified in the EPL must not result in pollution to waterways. Best management practice applies when discharging water from all other sites or non-licensed discharge points. This includes defining representative water quality criteria for the receiving environment and ensuring all discharges comply with these requirements as required under the license. For the majority of EPLs for Pacific Highway projects only the outlets of basins is a licensed discharge point registered under the EPL. Standard project water quality objectives criteria for Pacific Highway projects are as follows:

- Total suspended solids 50mg/L
- pH 6.5 – 8.5
- Oil and grease no visible trace

Additional specified receiving water quality criteria may be required for activities that have the potential to impact water quality through a range of pollutants including:

- general earthworks in soils with contamination issues
- earthworks in naturally occurring problematic soils such as acid sulphate soils, saline soil or high levels of other sulphide minerals
- lime storage areas
- tannin leachate
- hydrocarbon spills
- concrete works (including batching operations)
- stabilised pavements
- precoat aggregates and spray sealing
- polymers
- curing compounds

Generally a review of environmental assessment and approval conditions and onsite conditions will provide further information on potential pollutants that may be present onsite or in site waters. Other methods to determine water pollutants may include the use of a testing probe, indicator strips, laboratory analysis, local knowledge and consultation with environmental officers and regulatory agencies.

If reuse activities are properly designed and managed then ponded stormwater or groundwater may be able to be reused onsite without specific treatment.

3.7. Assess the treatment techniques required to meet the water quality criteria

Treatments should be designed to achieve the water quality outcome specified, as well as to cater for the time constraints that may be applicable to the activity (i.e. 5 day management period for sedimentation basins). Treatments should be applied to waters, and should be applied only by

experienced and competent personnel. Care needs to be taken to ensure treatment methods do not adversely affect water quality or the receiving environment.

Examples of common treatment applicable to RMS projects may include:

- Flocculation of turbid waters to minimise the settling duration of suspended particles, as well as facilitate the clearing of waters exposed to dispersive soils. Flocculation enables water quality standards to be achieved within an acceptable time period. A suitable flocculent should be chosen for sites based on an impact assessment of the receiving environment. In most cases RMS projects would utilise gypsum, which is considered to be inert. There are other flocculants available; however the use of these must be subject to consultation with relevant stakeholders, including EPA and NSW DPI (Fisheries) prior to use.
- pH adjustment using a base such as hydrated lime (for acidic waters) and inversely an acid such as hydrochloric acid (for alkaline waters). Low volume trials for each location will need to be carried out to determine dosage rates. Special care must be taken when adjusting pH to understand the buffer capacity of the waters, ensuring the neutral point is not over-shot. Any personnel involved in the adjustment of pH must be suitably trained and competent in the use of any additives.
- Absorption of oils and grease is used to remove traces of hydrocarbons that may have been mobilised by rainfall. Sources of oil and grease on a project may include spills and leaks from machinery, runoff from precoat aggregate stockpiles and runoff from adjacent travel lanes. Generally oils and grease will be removed from the surface of water detention by the use of floating booms, pads and absorption socks.

Additional information is provided in Blue Book references:

- Appendix B, page 41 of Blue Book Volume 2D for basin management immediately after rain
- Appendix E of the Blue Book Volume 1 with regards to the best practice methodology of flocculation of basins.
- Attachment 5, page 51 of Blue Book V2D for managing pH.

3.8. Assess water sampling and testing requirements

Water quality sampling and testing may be required to ensure that the water quality objectives are met both prior to and during either reuse or discharge of the water. Techniques may include sample collection and laboratory testing or in-situ field assessment.

A list of approved testing methods for various analytes can be referenced from "Approved Methods for the Sampling and Analysis of Water Pollutant in New South Wales" (EPA 2004). All sampling should be representative of the water to be discharged and testing methods in accordance with this document. Licensed premises require approved testing methods as per the conditions of the environmental protection licence (EPL) unless formal agreement has been reached with the relevant agencies. Any such agreement must be documented, and records kept onsite at all times.

Using turbidity as a tool for Total Suspended Solids (TSS) requires an established NTU/TSS correlation and ongoing laboratory verification to ensure the NTU/TSS correlation being applied for the project is correct.

4. Minimum requirements for dewatering environmental work method statements (EWMS)

4.1. EWMS format

The format of site-specific EWMS is flexible according to the procedures used by each project team. This practice note and RMS specification G36 do not require an individual EWMS for each dewatering location on each site although it is necessary for ALL dewatering activities to be accounted for within a documented EWMS.

The EWMS should provide clear guidance for each dewatering activity utilising each of the following:

a) a map showing areas of the site/project that will require dewatering. This map should identify environmentally sensitive areas and features to be considered when planning discharge locations
b) detailed description and staged methodology of selected dewatering methods. This should include a clear and concise step by step procedure
c) description of onsite water reuse requirements
d) a map showing proposed discharge locations for any offsite discharge
e) design requirements for each offsite discharge location to prevent erosion at the discharge location or in the receiving environment
f) water quality objectives relevant to the type of dewatering activity
g) description of the water quality treatment techniques to be used
h) water sampling and testing regime to validate water quality prior to and (if required) during dewatering. Water quality sampling records should include, times, persons, method, parameters, treatment, consistent location, results etc.
i) Treatment volumes, time of application, who, how etc.
j) details of delegated approval of dewatering activities eg. Internal permit signed off by Environment Construction Manager.
k) proposed monitoring and supervision regimes.

If changes are proposed to the dewatering method used at any location or new dewatering requirements are identified during construction the project team must submit either of the following to the Principal before commencing the activity:

a) a revised and updated the site/project EWMS, or
b) a new stand-alone EWMS for the activity.

5. Document the site activity approvals process

All sites discharging water must have a robust procedure in place for the approval of all controlled discharges from dewatering activities and include a mechanism for quality assurance and verification. This process is to be clearly documented in the EWMS and must nominate specific personnel who can approve dewatering activities and specifically the controlled discharge of water. Delegates responsible for dewatering approval must be suitably trained and experienced in their duties. The approval process for dewatering activities is to be included in the worksite induction and training of onsite personnel. The inclusion and enforcement of these procedures will ensure that the risk of unauthorised discharges is significantly reduced.

The minimum requirements of this approval are:

- water quality is demonstrated to meet the objectives in the EWMS and this practice note
- inspections of intake and discharge locations, equipment and receiving environments are completed
- trained personnel are available to supervise and monitor the activity as specified on the EWMS.

5.1. Document training and induction requirements

All staff responsible for approval and/or execution of dewatering activities must be trained and inducted into use of the EWMS. The EWMS should include an induction register as a record of staff that are approved to conduct or approve dewatering activities.

5.2. Document the requirements for supervision of dewatering activities

The EWMS must provide a clear description of all supervision and monitoring required for each dewatering activity. All dewatering activities must be inspected by inducted, experienced and competent personnel. Prior to commencing any dewatering activity of the entire system including intake and outlet, pump, and discharge locations must be inspected.

All dewatering activities must be directly supervised for the entire duration of the dewatering. To remove the need for direct supervision, sites may carry out risk assessments and implement mitigation measures to ELIMINATE risks of causing environmental harm. Due diligence must be demonstrated to eliminate the possibilities of the following incidents:

- intakes dropping into deposited sediments and discharging sediment-laden waters
- erosion of the discharge locations and downstream environment
- inadvertent or intentional controlled discharge of untreated waters.

5.3. Record keeping for dewatering activities

You must keep the following records:

a) a copy of the dewatering EWMS
b) date, time and estimated volume of water released for each discharge location
c) water quality test results for each discharge
d) records to verify persons monitoring, and monitoring data including water quality parameters and criteria, timing and location of monitoring
e) records indicating who provides approval for each dewatering activity, and
f) evidence of discharge monitoring or risk assessment

Appendix:
Photographs of Dewatering Activity on RMS Projects

Figure 1. Application to a sediment basin allows faster settling of sediments and improvements to water quality prior to discharge.

Figure 2. Consideration should always be given to measures to prevent pumped inlets from falling into sediment zones at the bottom of basins. In this example an anchored bucket was seen to be effective.

Figure 3. Informal use of bunding and geotextile was assessed as a suitable outlet treatment for scour protection in this example. The use of a tyre provided both energy dissipation for the discharge flow and anchorage for the discharge pipe.

Figure 3. Use of formal signage indicating discharge procedures was an effective management tool to prevent unauthorised discharges.

Figure 4. A sump adjacent to a working area may require higher levels of maintenance in order to remain effective. Dewatering to a larger sediment basin will be a more viable treatment measure when compared to flocculating the sump itself. Consideration to minimising exposed fines around the immediate catchment (e.g. bottom left corner of the figure) will also reduce sediment entering the sump if deemed practical for construction purposes.

Figure 5. A siphon and float system used for discharging a basin without use of pumps. Floats may be useful for preventing inlets from falling into sediment zones.

Figure 6. An inlet designed with up-turned pipe to ensure settled sediment is not sucked up during discharge. Note that sediment storage zone needs regular maintenance to ensure levels do not reach the inlet level.

Appendix H
Sediment Basin Management and Discharge Procedure

Project description: Upgrade of the Pacific Highway, Wells Crossing to Glenugie

Sediment Basin Management and Discharge Procedure

Approval				
Revision	Date	Name	Position	Signature
A	17/09/2019	Hari Corliss	Environmental Manager	H Corliss

Sediment basin management and discharge procedure

Table of Contents

Sediment basin management and discharge procedure

Introduction

Purpose

This Sediment Basin Management and Discharge Management Procedure is an appendix to the Construction Environmental Management Plan (CEMP) Upgrade of the Pacific Highway, Wells Crossing to Glenugie (HC2G) (the project). The purpose of this Procedure is to provide guidance for the ongoing management of sediment basins and also for the de-watering of the basins

Relevant legislation, guidelines, licences and approvals

The following legislation, guidelines and standards are considered relevant to soil and water management for the project:

Type	Details
Legislation	• Protection of the Environment Operations Act 1997 (POEO Act) • Water Management Act 2000 • Fisheries Management Act 1994
Guidelines	• Soils and Construction Vol 1, Managing Urban Stormwater, Landcom 2004 (The Blue Book) • RMS Technical Guideline Environmental Management of Construction Site Dewatering (EMCSD) • RMS Pacific Highway Practice Note for Dewatering • Occupational Health and Safety guidelines • ANZECC Water Quality Criteria
Contract documents	• RMS Specification G36, G38 • Submissions/Preferred Infrastructure Report (SPIR)
Related documents	• Soil and Water Management Plan • Emergency Response Sub-Plan • Environmental Work Method Statement – Sediment Basin Management

Introduction

This Sediment Basin and Discharge Management Procedure forms part of the Construction Environmental Management Plan (CEMP) for the upgrade of the Pacific Highway from Wells Crossing to Glenugie (Section 2 & associated tie in works to Glenugie upgrade). Section 2 of the Woolgoolga to Ballina (W2B) Pacific Highway upgrade project was approved by the Minister for Planning in June 2014.

The Wells Crossing to Glenugie project ties into the southern extent of the existing Glenugie Upgrade. The Glenugie Project was approved separately by the Department of Planning and Environment and relevant conditions of this approval have been referenced in the CEMP and this plan as appropriate.

Objectives and targets

Objectives	Targets
To ensure sediment basins are managed appropriately	To ensure that there is no unplanned release from or failure of a sediment basin
To comply with guidelines and legislation	No penalty infringement notices.
Implement control measures to ensure basins are dewatered in accordance with EPL requirements.	No infringements

Responsibilities and authorities

Who	What
All staff	• Complete a site induction prior to commencement of work. • Implement and comply with this procedure. • Report any damaged or failed controls and any activity that has resulted in, or has the potential to result in environmental harm to their Foremans.
Project Manager	• Ensure implementation of the procedure. • Lead by example – develop a 'beyond compliance' culture within the team. • Provide necessary resources and technical support for implementation of procedure. • Ensure non-conformances/corrective actions have been investigated and closed out appropriately.
Project Engineer	• Implementation of requirements outlined in procedure. • Ensure this SBMDP is reviewed when planning activities that may generate ASS/PASS. • Ensure all staff including sub-contractors are inducted prior to commencement of works. • Notify the Project Manager of incidents/non-conformances. • Conduct and document weekly site inspections. • Advise Site Foreman immediately of any corrective actions that are required upon completion of site inspections. • Report non-conformances to the Project Manager.
Foreman	• Implementation of requirements outlined in procedure. • Ensure all staff including sub-contractors are inducted prior to commencement of works. • Install and maintain controls as outlined in EWMSs'. • Conduct daily visual inspections of environmental control measures on site. • Notify the Project Engineer and/or Project Manager of incidents/non-conformances.
Environmental Site Representative	• Ensure the results of daily and weekly monitoring are forwarded to the Client monthly as required. • Conduct/commission and record all monitoring. • Ensure any breaches or NCR's are reported in a timely fashion. • Complete all reporting requirements. • Accompany the Superintendent on periodic inspections and audits.

Control procedures

Location

Sediment basins shall be located at the sites identified by the Soil Conservationist in the approved Erosion and Sediment Control Plans (ESCP). These locations are to be confirmed by survey to ensure the design parameters outlined below can be met. If they can not be met, the Soil Conservationist is to assess whether the location or size of the basins is to change or whether alternative controls are to be used.

Basin discharge points will be specified in the Environmental Protection Licence (EPL).

Risk assessment

Work must not commence if an activity has a risk that has been assessed as Extreme. Consider hierarchy of controls - Elimination|Substitution|Engineering|Administration|PPE.	Consequence severity level (from table above)				
	1	2	3	4	5
A -Almost certain - It is expected to occur at least once in the life of the project	High	High	Extreme	Extreme	Extreme
B -Likely - Will probably occur; may occur every second similar type project	Medium	High	High	Extreme	Extreme

C -Moderate - Should occur at some time; once in 5 similar type projects	Low	Medium	High	Extreme	Extreme
D -Unlikely - Could occur at some time; once in 10 similar type projects	Low	Low	Medium)	High)	Extreme
E- Rare - May occur only in exceptional circumstances	Low	Low	Medium	High	High

Level	Likelihood	Description
A	Almost certain	Is expected to occur during the project, 90% or > probability
B	Likely	Will probably occur during the project, ~50% probability
C	Moderate	Might occur at sometime during the project, ~10% probability
D	Unlikely	Could occur at some time during the project, ~1% probability
E	Rare	Only occur in exceptional circumstances, < 1% probability
Level	Consequence	Description
1	Insignificant	Insignificant Breach of Environmental Statutes
2	Minor	Minor Breach of Environmental Statutes
3	Moderate	Moderate Breach of Environmental Statutes
4	Major	Major Breach of Environmental Statutes
5	Severe	Shutdown of Project Due to Environmental Breach

Work Sequence

Sequence of work activities		Potential hazards	Risk level	Details	Residual risk level	Responsibility
Maintenance						
1	Inspections	Excessive volume, damage	Med (C2)	• All sediment basins will be inspected for capacity and water quality immediately following cessation of a rain period. • Check all visible pipe connections for leaks, and repair as necessary. • Remove all trash and other debris from the basin and riser. • Ensure all rock protection on inlet and outlets are as per design • Check basin walls and drainage lines for signs of scouring and/or failure	Low (D95)	Foreman
2	Stormwater capacity	Insufficient capacity	High (C3)	• Re-establish stormwater capacity of sediment basins promptly after each rainfall event (routinely within 5 days but sooner if a major rainfall event substantially diminishes residual stormwater capacity). • This may involve reuse of the water for dust suppression or discharge after treatment of the water that meets water quality objectives. • Any controlled release of water from the sediment basins will be tested to comply with the EPL water quality requirements prior to being discharged from site (refer to water quality testing process below). • If water within the sediment basins is going to be used within the construction site for dust-suppression purposes and will flow back into the sediment capture system it does not require flocculation. • If water is pumped into a tanker truck for later use, it cannot be discharged offsite without first being tested and if required, treated. • Water maybe used for irrigating landscaping if this approved by and meets EPL requirements.	Med (C2)	Foreman
3	Sediment Capacity	Insufficient sediment capacity	High (C3)	• • Clean out sediment basins, at a minimum, whenever the accumulated sediment exceeds 60% of the sediment storage zone this level will be clearly marked on the marker post.. • Remove accumulated sediment from sediment basins and traps in such a manner as not to damage the structures. Dispose of the sediment removed in such locations that the sediment will not be conveyed back into the construction areas, into watercourses or offsite. • Provide and maintain suitable access to sediment basins and sediment traps to allow cleaning out	Med (C2)	Foreman

Sequence of work activities		Potential hazards	Risk level	Details	Residual risk level	Responsibility
				in all weather conditions.		
Water Quality Testing						
4	Water Quality Objectives	Pollution	High (C3)	• Before discharging water from a basin, test the water to ensure that it meets EPL criteria, which are as follows: (modify to suit EPL requirements o pH: 6.5 – 8.5, o total suspended solids: less than 50mg/L; and o oil and grease no visible trace.	Med (C2)	ESR
5	pH	Pollution	High (C3)	• Test basin water with meter • No action if pH reading between 6.5 and 8.5 • Lime to be added if pH below 6.5 • Hydrochloric Acid (32% Muriatic) to be added if pH above 8.5 • Determine volume of water in basin • Determine percentage of lime or acid required by taking a 10-litre sample of basin water and adding a known amount of lime or acid (initially 0.004%). If the pH is still not acceptable, vary the amount of lime or acid until within the limits. • Once the required percentage has been determined, calculate the actual amount of lime or acid to be added by multiplying the volume of water in the basin by the determined percentage • Treat the water for pH prior to T.S.S in accordance with the flocculation section below.	Med (C2)	ESR
6	T.S.S or Turbidity	Pollution	High (C3)	• Collect grab sample for NATA approved laboratory testing – or use correlated Turbidity levels if methodology approved by Environmental Rep and endorsed by the EPA.No action if T.S.S. reading <50mg/l (or as determined by EPL) • If basins require flocculation (eg T.S.S. >50mg/l) treat with gypsum in accordance with the flocculation process below.	Med (C2)	ESR
7	Oil and grease	Pollution	Med (C2)	• Examine surface of water for evidence (eg sheen, discolouration) • Sample as per EPL requirements • No action if no visual contamination • Oil absorbent material to be spread if there is contamination (eg cell-u-sorb)	Low (D2)	ESR

Sediment basin management and discharge procedure

Sequence of work activities		Potential hazards	Risk level	Details	Residual risk level	Responsibility
Flocculation (Further details also be detailed in the Sediment Basin Management Discharge Procedure as part of the SWMP)						
8	Trigger	Poor water quality	Med (C2)	• The sediment basins will be effectively flocculated, settled, tested to comply with the discharge requirements and discharged within 5-days or less following a rainfall event.	Low (D2)	Foreman
9	Quantity	Waste	Med (C2)	• Before using any flocculating agent, determine the amount of the agent that is appropriate for the volume to be treated, the sediment type and the prevailing weather conditions.	Low (D2)	ESR

10	Process	Ineffective flocculation	Med (C2)	• Where flocculation is necessary to settle suspended sediments in the basins, apply calcium sulphate (gypsum) as the flocculating agent to settle the sediments within 24 hours of the conclusion of each rain event causing runoff.
				• Flocculation can be achieved by using gypsum at a rate of approximately 30kg /100m3 of stormwater. Alternative flocculating agents can only be used if approval by RMS has been granted.
				• Methods of application to include (in order of preference):
				  ○ Spray gypsum across surface using a hydromulcher
				  ○ Mixing in a drum with water and pumping through a hose on large basins (ie >200m3)
				  ○ Broadcast by shovels on small basins (ie <200m3) least effective
				• Ensure the flocculation/coagulant is thoroughly mixed/diluted with water (e.g. within and IBC) prior to spreading evenly over the entire pond surface for proper treatment of water. Dirty water from the basins will be used to mix the flocculent/coagulant.
					Low (D2)	ESR

Dewatering (Further details also be detailed in the Sediment Basin Management Discharge Procedure as part of the SWMP)						
11	Approval	Unapproved discharge	High (C3)	• Discharges from sediment basins are only to be carried out following approval from the Environmental Advisor/Manger issued via a Permit to Discharge form (Appendix A). • Water must not be dewatered in any other way than that stated within this procedure • Water must be de-watered in accordance with the Pacific Highway Practice Note for Dewatering	Low (D5)	All
12	Process	Non-compliance	High (C3)	• After flocking leave basins to compensate for 24 to 48 hours. • After retesting, and once the above field tests indicate, the water quality is acceptable and a Permit to Discharge is approved, the stop valve should be opened by two or three notches, for discharge and monitor outlet to ensure there is no erosion or disturbance of sediments. Adjust valve to dewater in the quickest time without causing harm. • If using a syphon prime the syphon with a portable pump before releasing the release valve and act as above. Ensure inlet of syphon is above sediment level to ensure sediments are not sucked through. Ensure outlet is on to a stabilised area and erosion does not occur.	Low (D5)	ESR, Foreman

Sediment basin management and discharge procedure

Sequence of work activities		Potential hazards	Risk level	Details	Residual risk level	Responsibility
				• If dewatering with a pump ensure intake is above the floor of the basin to ensure sediments are not sucked through. Ensure outlet is on to a stabilised area and erosion does not occur. Do not leave pump unattended. • Ensure scouring does not occur at the outlet/discharge point. •		

Maintenance, monitoring and evaluation of performance

Inspections

All control and mitigation measures will be inspected weekly and corrective actions implemented if non-conformance is observed.

Targeted inspections will be conducted by the Environmental Site Representative during high risk activities, such as excavation works.

Incidents and corrective action

Incident reporting

In the event of an environmental incident, Roads and Maritime Environmental Incident Classification and Reporting Procedure will be implemented in conjunction with Lendlease Engineerings procedures. Typically, environmental incidents will be notified verbally immediately and in writing within one hour of any incident occurring to the Roads and Maritime Representative and the Environmental Representative. Incident reports will be provided to the Roads and Maritime Representative and the Environmental Representative within 24 hours of the incident occurring, including lessons learnt from each environmental incident and proposed measures to prevent the occurrence of a similar incident.

The following reporting procedure will be followed for any incident resulting in an emergency situation:

Step	Details	Contact number
1	Call Emergency Services if incident presents an immediate threat to human health or property	000
2	Call the appropriate regulatory authority (ARA) (DPI (Fisheries))	1300 550 474
3	Call the EPA, if not the ARA	131 555
4	Call the Ministry of Health via the local Public Health Unit	1300 066 055
5	Call the Work Cover Authority	13 10 50
6	Call the local authority (Grafton City Council), if this is not the ARA	(02) 6643 0200
7	Call Fire and Rescue NSW (unless 000 has already been called)	1300 729 579

Notifiable event

The EPA will be notified of any environmental incidents or pollution incidents on or around the site via the EPA Environment Line (telephone 131 555) in accordance with Part 5.7 of the PoEO Act. The circumstances where this will take place include:

a) If the actual or potential harm to the health or safety of human beings or ecosystems is not trivial.

b) If actual or potential loss or property damage (including clean-up costs) associated with an environmental incident exceeds $10,000.

Pollution incident means an incident or set of circumstances during or as a consequence of which there is or is likely to be a leak, spill or other escape or deposit of a substance, as a result of which pollution has occurred, is occurring or is likely to occur. It includes an incident or set of circumstances in which a substance has been placed or disposed of on premises, but it does not include an incident or set of circumstances involving only the emission of any noise.

In addition the following notification requirements will be implemented.

Event	Notification Requirements	Responsibility
Fish kills	DPI (Fisheries) and the Principal	PM
Pollution of HC2G Creek	EPA and the Principal	PM
Fauna death or injury	EPA and the Principal	PM
Harm to aboriginal heritage artefact	Registered Aboriginal Parties and the Principal	PM
Harm to non-aboriginal heritage artefact	EPA and the Principal	PM

Corrective action

Corrective actions will be implemented in response to an event or identified improvement and are intended to ensure that prompt and immediate action is taken to correct the event. The Project Manager will ensure that corrective actions identified on daily and weekly inspections and audits and incident reports are captured in accordance with Lendlease Engineering's procedures and timeframes and responsibilities assigned. Outstanding actions will be reviewed at weekly project meetings.

Review and improvement

Document review

This Procedure will be reviewed and updated every three months in accordance with the project's CEMP.

Auditing

Audits will be scheduled as per the requirements of the CEMP and Lendlease Engineerings Environmental Management System. These audits will review on-site performance against the Procedure and suitability of the Procedure in meeting legislative and contractual requirements.

Reporting

Complaint and environmental incidents will be reported using the Incident Management Procedure and additional procedures outline in the CEMP.

A report will be submitted to the Client on a monthly basis. This report will contain but not be limited to:

- Objectives and targets
- Monitoring results
- Complaints
- Incidents
- Audit results
- Corrective/preventative actions and improvements.

Appendices

A1 Permit to Discharge

Appendix I
Stockpile Management Protocol

Wells Crossing to Glenugie - Stockpile Management Protocol

Activity	**Stockpile Management**		
Project	Wells Crossing to Glenugie	Project number	
Project Manager	Mike Curry	Senior Project Engineer	Adam Schubert
Environmental Rep	Hari Corliss	Current as at	17/09/2019

Document control

File name	Protocol - Stockpile Management
Report name	Wells Crossing to Glenugie - *Stockpile Management Protocol*
Revision number	3

Protocol approved by:

Lendlease Environmental Manager

Revision history

Revision	Date	Description	Approval
0	2015/05/01	Draft	
1	13/05/15	Agency feedback included	
2	7/6/19	Wells Crossing to Glenugie	
3	9/7/19	Wells Crossing to Glenugie – updated with Agency comments.	
4	17/09/2019	Wells Crossing to Glenugie – LLE Update	

Contents

1 Glossary / Abbreviations

CEMP	Construction Environmental Management Plan
CoA	Condition of Approval
CSWQMP	Construction Soil and Water Quality Management Plan
CWEMP	Construction Waste and Energy Management Plan
EPBC	Commonwealth Environment Protection and Biodiversity Conservation Act 1999
DoEE	Commonwealth Department of the Environment and Energy
DP&E	NSW Department of Planning and Environment
DPI	NSW Department of Primary Industries (Fishing and Aquaculture)
EEC	Endangered Ecological Community
EIS	Woolgoolga to Ballina Pacific Highway Upgrade Environmental Impact Statement (December, 2012)
EPA	NSW Environment Protection Authority
EPL	NSW Environment Protection Licence under the Protection of the Environment Operations Act 1997.
ESCP	Erosion and Sediment Control Plan
EWMS	Environmental Work Method Statements
FM Act	NSW Fisheries Management Act 1994
G36	RMS QA Specification G36 Environmental Protection
G38	RMS QA Specification G36 Soil and Water Management
WC2G	Wells Crossing to Glenugie Project
Minister, the	NSW Minister for Planning
NOW	NSW Office of Water
OEH	NSW Office of Environment and Heritage
PoEO Act	NSW Protection of the Environment Operations Act 1997
RMS	New South Wales Roads and Maritime Service
SMP	Stockpile Management Protocol
SPIR	Woolgoolga to Ballina Pacific Highway Upgrade Submissions Preferred Infrastructure Report (November, 2013)

1 Objectives

The objective of this protocol is to provide specific control measures so as to ensure that stockpiles are in accordance with the Minister's Conditions of Approval, CoA D25(d)(ix) and D26(c)(iii), shown in Table 1 and are managed correctly so that the material stockpiled is preserved and does not cause environmental harm or nuisance, materials are stored within approved clearing limits wherever possible, heritage impacts are avoided, impacts are reduced and greenhouse reduction approaches used where achievable. This Stockpile Management Protocol (SMP) is subject to the approval of the Secretary as a part of the CEMP and then stockpiles would not assessed be as ancillary facilities..

Table 1 Minister's Conditions of Approval

CoA No.	Condition Requirements	Document Reference
D25	The Applicant shall prepare and implement (following approval) a Construction Environmental Management Plan for the SSI, prior to the commencement of construction, or as otherwise agreed by the Secretary. The Plan shall be prepared in consultation with the EPA, OEH, DPI (Fisheries), NOW and DoE and outline the environmental management practices and procedures that are to be followed during construction, and shall be prepared in consultation with the relevant government agencies and in accordance with the Guideline for the Preparation of Environmental Management Plans (Department of Infrastructure, Planning and Natural Resources, 2004). The Plan shall include, but not necessarily be limited to: **(d)** an environmental risk analysis to identify the key environmental performance issues associated with the construction phase and details of how environmental performance would be managed and monitored to meet acceptable outcomes, including what actions will be taken to address identified potential adverse environmental impacts (including any impacts arising from the staging of the construction of the SSI). In particular, the following environmental performance issues shall be addressed in the Plan: **(ix)** measures to monitor and manage spoil, fill and materials stockpile sites including details of how spoil, fill or material would be handled, stockpiled, reused and disposed in a Stockpile Management Protocol. The Protocol shall include details of the locational criteria that would guide the placement of temporary stockpiles, and management measures that would be implemented to avoid/minimise amenity impacts to surrounding residents and environmental risks (including surrounding water courses). Stockpile sites that affect heritage, threatened species, populations or endangered ecological communities require the approval of the Secretary, in consultation with the EPA, OEH and DPI (Fisheries);	CEMP
D26	As part of the Construction Environmental Management Plan for the SSI, the Applicant shall prepare and implement: a Construction Soil and Water Quality Management Plan to manage surface and groundwater impacts during construction of the SSI. The Plan shall be developed in consultation with the EPA, DPI (Fisheries), NOW, Rous Water (in relation to the Woodburn borefield), DoE and the relevant council and include, but not necessarily be limited to: **(iii)** management measures to be used to minimise surface and groundwater impacts, including details of how spoil and fill material required by the SSI will be sourced, handled, stockpiled, reused and managed; erosion and sediment control measures; salinity control measures and the consideration of flood events;	CSWQMP

2 Purpose/Scope

This protocol is relevant to the planning, placement and management of all stockpiles on/related to the Wells Crossing to Glenugie project. It would attempt to outline the locational criteria used to guide the placement of temporary stockpiles and provides both standard and site-specific mitigation measures to be implemented to minimise impacts on the environment. Stockpile sites may typically be required to store material including, but not limited to:

- Temporary storage of excavated material to be used in fill embankments and other design features.
- ASS subject to treatment prior to reuse.
- Temporary storage of excavated material unsuitable for reuse in the formation.
- Excess concrete, pavement, rock, steel and other material stored for either future use in the Project or prior to removal from site.
- Topsoil,
- Mulch, excess timber for landscaping and revegetation works.
- Gravels, fill and asphalt profiling's. If there are risks, these materials would be discussed with RMS

Temporary stockpiles would be removed for re-use within the project or disposed off-site at approved locations and comply with RMS Stockpile Site Management Guideline, and relevant legislation as outlined in the Construction Soil and Water Quality Management Plan (CSWQMP).

Note, the process for monitoring and managing spoil and fill including details of how excavated material would be handled, stockpiled, reused and disposed is detailed in the Earthworks Management Plan, CSWQMP and the Construction Waste and Energy Management Plan (CWEMP).

This includes ensuring the offsite disposal of materials to an appropriately licensed facility or in accordance with the waste exemptions; and records including section 143 certificates to be completed and retained for any material to be disposed of outside of the project boundary.

3 Approval Process

As outlined in the CoA ancillary definition, where a SMP has been approved by the Secretary for the SSI, material stockpile areas are not considered to be ancillary facilities. Consequently this SMP is being forwarded to DPE for approval.

Where stockpile affect heritage, threatened species, populations or endangered ecological communities they will require the approval of the Secretary, in consultation with the EPA, OEH and DPI (Fisheries)

4 Stockpile Location Criteria

Stockpiles on the Project will be located according to the following criteria: These criteria have been derived from CoA, best practice on other Pacific Highway projects and also derived from the G36-38, R44 and R178 RMS Specifications.

- Be located at least 5 metres clear of all areas of possible concentrated water flow.
- Be located at least 50 metres from a defined waterway such as Glenugie creek and 10m from a drainage line.
- Be located on land with slopes less than 10%.
- Have ready access to the road network or direct access to the construction corridor.
- On land that does not require the removal of threatened species, EECs or roosting habitat for listed threatened fauna species.
- Be located in areas of low heritage conservation significance (including identified Aboriginal cultural value) and not impact on heritage sites beyond those already impacted by the project. (refer to Sensitive Area Map Appendix 5 of CEMP)

Where the stockpile location is proposed either outside of the approved clearing limit, Project corridor, or does not meet all of the stockpile criteria, an environmental assessment or environmental review of the proposed stockpile location would be undertaken. This would be submitted to the Environmental Representative for comment and RMS for approval. Where heritage, threatened species, or endangered ecological communities are affected, the Secretary's approval is required. This assessment will include as a minimum a review of heritage, ecological and water quality issues, distance from receivers, noise, dust issues and may also detail land ownership and lease agreements, and measures to manage or mitigate potential environmental impacts.

Table 3 and associated mapping (Attachment 1: Stockpile Locations) will be updated as stockpile areas are identified and approved. Changes to Table 3 and the mapping will be approved by RMS and the Environmental Representative as minor updates to the Stockpile Management Protocol (and SWMP) as described in Section 1.6 of the CEMP.

5 Mitigation

Prior to the establishment of any stockpile on site as part of the project, ensure that:

1. The location of the stockpile is considered against the site selection criteria and Table 3 and include detail of how the stockpile site meets each of the criteria is provided.

2. Site-specific mitigation measures, where they are necessary to further reduced impacts, are identified and detailed in Table 3.

3. Mitigation measures for each stockpile site include as a minimum are detailed in Table 2

Table 2 Mitigation Measures

ID	Measure/Requirement	Responsibility	Reference
1	The requirements of the CEMP and management plans.	Project Manager	CEMP
2	The perimeter of the stockpile (excluding vehicle access points) will be delineated with a bund (made out of earth/rock or similar) or other type of fencing or barrier such as sediment fence.	Foreman	CSWQMP
3	Be located at least 5 metres clear of all areas of possible concentrated natural water flow It will be avoided where reasonable and practicable that materials will not be stockpiled under the drip lines trees or native vegetation to be retained, and never pushed up around the base of trees. Mulch stockpiles are exempt from this requirement as they do not erode and are light, so as to have minimal impact on compaction of the root systems.	Roadworks Manager	Best practice
4	Erosion and sedimentation controls will be erected between the site and any drainage lines or down-slope areas.	Foreman	CSWQMP
5	A diversion bund will be installed on the uphill side of the stockpile to divert water around the site.	Foreman	CSWQMP
6	Short-term stockpiles will be covered with plastic or kept damp to control dust where required. Longer-term stockpiles (i.e. to remain for greater than 20 days) will be stabilised with cover crop or similar as per the mitigation measures in Table 6-1 of the SWMP	Foreman	CAQMP
7	Potentially affected residents within 200 metres of stockpiles will be notified regarding the location of the stockpile areas in advance of works, the potential impact from constructing the stockpile (including visual and odour impacts) and proposed mitigation measures. Should a resident express concern or are not satisfied with the proposed mitigation measures, the stockpile location or associated mitigation measures would be revised accordingly.	Community Manager	Communication strategy
8	Where stockpiles are located within 200 metres of residences, these stockpile areas will be monitored for odour. If nuisance odours are generated and are impacting sensitive receivers, odour control measures will implemented, if feasible and reasonable. If this is not possible, material found to be emitting odours will be relocated to an alternative stockpile location away from residences.	Foreman	CAQMP
9	ASS or mulch stockpile management, including leachate containment, will be in accordance with the CSWQMP, ASSMP and Tannin Leachate Management Protocol	Environment Manager	CSWQMP

ID	Measure/Requirement	Responsibility	Reference
	respectively.		
10	Dust management measures (including for vehicle movements associated with stockpiling activities) will be implemented in accordance with the requirements of the Construction Air Quality Management Plan.	Foreman	CAQMP
11	Topsoil stockpiles free from subsoil, other excavated materials, contaminated materials, refuse, clay lumps and stones, timber or other rubbish;	Foreman	RMS R44 clause 2.3.2
12	Topsoil stockpiles trimmed to a regular shape to facilitate measuring with a height not exceeding 2.5m and batter slopes not steeper than 2H:1V;	Foreman	RMS R44 clause 2.3.2
13	Have their batters track rolled or stabilised by other means;	Foreman	RMS R44 clause 2.3.2
14	Be seeded in accordance with Specification Roads and Maritime R178 clause 6 to encourage vegetation cover.	Foreman	RMS R44 clause 2.3.2
15	Be clearly signed with vegetation community type, soil horizon, collection area (by chainage) and date of stockpiling	Environment Manager	RMS R44 clause 2.3.2
16	Be stockpiled in areas separate from all other stockpiled material to minimise the potential for weed contamination.	Foreman	RMS R178 clause 2.1.1.4.3
17	Be stockpiled separately by vegetation community type. For each vegetation community type, topsoil is to be stockpiled with A1, A2 and B1 horizons in separate windrows with A1 horizon up to 1 metre high and A2 and B1 up to 2.5 metres. (ERG approval)	Foreman	RMS R178 clause 2.1.1.4.3
18	Not stockpiled for periods greater than 12 months unless otherwise approved by the principal	Foreman	RMS R178 clause 2.1.1.4.3
19	Stockpiles shall be located more than 50 metres from defined waterways such as Glenugie Creek and Wells Crossing.	Roadworks Manager	DPI (Fisheries)
20	The rehabilitation of stockpile areas following their removal will be in accordance with the Stockpile Management Guideline, May 2011, RMS requirements/RMS R178 and as follows: Where no further stockpiling or work is proposed on the disturbed site, they would be rapidly and progressively stabilised and/or rehabilitated as they are completed. Rehabilitation would aim to achieve at least 70% cover (i.e. C-factor of 0.05 or less) within 60 days. Where further works or stockpiling is proposed, temporary ground covers would be used for any temporary cessation in works in an area exceeding 20 days, to achieve at least 50% cover (i.e. a C-factor of 0.15 or less). This would apply to stockpile sites and other exposed areas and measures may include (but are not limited to) biodegradable polymer soil binders, geotextile fabrics; erosion control blankets, temporary seeding and mulching.	Roadworks Manager	Stockpile Management Guideline, 2011/RMS R178

6 Induction/Training

Personnel involved in planning or managing stockpiles will be trained in the requirements of this Protocol. Training will also include inductions, toolbox talks, pre-starts and targeted training as required.

7 Protocol update and amendment

The processes described in Section 8 and Section 9 of the CEMP may result in the need to update or revise this Plan. This will occur as needed.

Only the Environment Manager, or delegate, has the authority to change any of the environmental management documentation with approval from the Environmental Representative for minor changes to the CEMP/Sub-plans in accordance with CoA D23(e). All other amendments must be approved by the secretary.

A copy of the updated plan and changes will be distributed to all relevant stakeholders in accordance with the approved document control procedure – refer to Section 10.2 of the CEMP.

8 Relevant documents

Progressive Erosion and Sediment Control Plans	Construction Waste and Energy Management Sub- Plan
Clearing and Grubbing EWMS	Construction Soil and Water Quality Management Plan
Construction Air Quality Management Plan	RMS Specifications G36, G38, G40, R44, R178
Sensitive Area Plans	Soils and Construction Vol 1, Managing Urban Stormwater (Blue Book)
Construction Acid Sulfate Materials Management Plan	Topsoil Stripping EWMS
Stockpile Management Guideline, RMS 2011	

Table 3 update table.

Document Revision	Table Reference numbers	Date	Reason for update	RMS/ ER approval

Table 3 - Stockpile management protocol temporary locations Register (To be completed by Lendlease Engineering)

Ref no.	Location (chainage)	Landowner	Purpose	a) Be located at least 5 metres clear of all areas of possible concentrated water flow.	b) Be located at least 50 metres from a waterway	c) Be located on land with a slope less than 10%	d) Have ready access to the road network or direct access to the construction corridor.	e) On land that does not require the removal of threatened species, EECs or roosting habitat for listed threatened fauna species.	f) Be located in areas of low heritage conservation significance (including identified Aboriginal cultural value) and not impact on heritage sites beyond those already impacted by the project.	Complies?	Site specific mitigation measures or other actions

9 Attachment 1: Stockpile Locations

Appendix J
Emergency Spill Response Plan

–Wells Crossing to Glenugie Emergency response - Spills

Purpose and scope

The purpose of this procedure is to detail the actions to be taken in response to environmental spills and accidents involving solid and liquid contaminants.

All response procedures are based on the SCARR method: safety, contain, absorb, remove, report.

This procedure is to be read in conjunction with the Lendlease Engineering Emergency Preparedness and Response Procedure and any other relevant procedures.

Contacts

Position / Contact	Name / Company	Number
Project Manager	Mike Curry – Lendlease Engineering	0419 714 448
General Superintendent	Daryl Faithful – Lendlease Engineering	0424 019 193
Environmental Coordinator	Andrew Darnell – Lendlease Engineering	0437 873 046
Emergency Services	Fire / police / ambulance	000 or 011
Pollution hotline	EPA	131 555
Liquid spill contractor	TBA	TBA

–Wells Crossing to Glenugie Emergency response - Spills

Identification and containment

Procedure	Details	Responsibility
Identify the material	• Immediately inform the Foreman and / or EnvC of spilt material • Where possible, identify the spilt product and take precautions as per the MSDS • Approach the spill with the wind behind you checking for dangerous goods labels, Hazchem signage or U.N. number on packaging • Treat any unmarked packages as a hazardous substance • If the material presents a significant explosion threat (e.g. petrol or kerosene) or another serious hazard to workers, undertake all safe and practical means to remove any ignition sources and shut off or control the source of the spillage	All Site Personnel
Isolate the Hazard	• If the spill creates a hazard to the general public (e.g. oil on road), isolate the area and if necessary establish traffic control	General Superintendent
External agency notification	• Major spills or those impacting public safety – contact Emergency Services & provide details of the material, quantity and environment (water, drains, etc.) • Ring pollution hotline	General Superintendent/ EnvC
Contain and Absorb the Spill – On **Land**	• If possible, prevent more material from being spilt (e.g. turn off taps, plug up leaks, turn container upright) • Construct bunding around the immediate area to prevent the flow reaching stormwater systems • Blocking off inlets to drainage lines, nearby waterbodies and the stormwater system and bunding of table-drains within the proximity of the spillage • Where possible absorbent spill kits and other specific absorbent products should be used in preference to cement, sand and sawdust • Different absorbents absorb different materials (e.g. some are designed for hydrocarbon, some are designed for acids) – make sure you use the right kind of absorbent, REFER MSDS	General Superintendent
Contain and Absorb the Spill – On **Water**	• If possible, prevent more material from being spilt (e.g. turn off taps, plug up leaks, turn container upright) • Place an absorbent boom downstream of the spill and progress back towards the source of the spill, and/or construct a bund using clean fill material • Ensure that the length of floating (hydrophobic) absorbent boom and pad is **at least 1.5 times the width of the waterway** • Only those absorbents designed specifically for use in water should be used	General Superintendent

–Wells Crossing to Glenugie Emergency response - Spills

Site clean up and reporting

Procedure	Details	Responsibility
LIQUID spills	• Use a suitable absorbent to soak up the spilt liquid • Work the absorbent into the liquid using a broom or rake • Allow sufficient time for the liquid to be soaked up by the absorbent • Sweep up the absorbent or pick up using a shovel or front end loader • Place the absorbent in a leak proof container for disposal • If the liquid has soaked into the ground, the contaminated soil may have to be removed or treated using in-situ bioremediation	General Superintendent
SOLID spills	• Sweep up the spilt material or puck up sing a front end loader or shovel and then sweep up any remaining residue • Do not wash the spill away or bury it	General Superintendent
Spills on **WATER**	• Cast absorbent net or absorbent boom over the surface of the spill • If using a boom, spread the absorbent while drawing in the booms to reduce the surface area of the spill • Caution must be taken to ensure the spill remains contained at all times • If the shoreline is contaminated the area must be treated using in-situ bioremediation	General Superintendent
Disposal / Reuse of material	• If unsuitable for reuse, arrangements should be made for the material to be promptly disposed of in accordance with the requirements of the DEHP and local Shire Council. Contact the DEHP or the Local Authority for advice on disposal • Material awaiting disposal is to be stored in a way that prevents or minimises the likelihood of contaminants re-entering the environment • Examples include storing in suitably labelled drums/containers; bunding and covering contaminated stockpiles	General Superintendent
Incident Reporting	• Investigation into causes and actions to prevent recurrences and shall ensure that the incident is reported and recorded in accordance with Lendlease Engineerings incident reporting procedure	PM/ General Superintendent

–Wells Crossing to Glenugie Emergency response - Spills
