



Transport
Roads & Maritime
Services

APPENDIX B4

Construction Soil and Water Quality Management Sub-plan

Foxground and Berry bypass

September 2017



Document control

File name	CSWQMP RevF September 2017
Report name	Construction Soil and Water Quality Management Sub-plan Foxground and Berry bypass
Revision number	F

Plan approved by:

Michael Phillips - Ryder

Jacob Cooper

Ryan Whiddon

Contractor Project Director

Contractor EM

RMS representative

Revision history

Revision	Date	Description	Approval
F	11/09/17	Updated project personnel and Section 3.3.2 in relation to natural groundwater zinc levels.	
E	29/10/15	Construction phase revision Updated with minor editorial changes (tracked) to Sections 3, 5	
D	03/09/14	Fourth draft in response to DP&E comments. Updated Glossary / Abbreviations to include Director General and 'Secretary'.	
C	28/07/14	Third draft for submission to DP&E. All comments addressed.	
B	21/07/14	Second draft for review and approval by RMS and ER. All comments addressed except those from EPA which are pending.	
A	29/05/14	Draft for RMS, ER, EPA, OEH (Biodiversity), NSW Office of Water (NOW) and DPI (Fishing and Aquaculture) review	

Distribution of controlled copies

Copy no.	Issued to	Version
1	RMS – Ryan Whiddon	Rev F
2	Project ER – Toby Hobbs	Rev F
3	Fulton Hogan – Michael Phillips Ryder	Rev F

Contents

1	Introduction	1
1.1	Purpose	1
1.2	Background.....	1
1.3	Structure of CSWQMP	1
1.4	Consultation for preparation of the CSWQMP	1
2	Legal and other requirements.....	2
2.1	Legislation	2
2.2	Guidelines and standards	2
2.3	Minister’s Conditions of Approval	4
2.4	Statement of commitments	7
3	Existing environment.....	9
3.1	Topography and soils.....	9
3.2	Surface water.....	14
3.3	Groundwater	17
3.4	Climate	18
3.5	Flooding.....	19
4	Environmental aspects and impacts	21
5	Environmental mitigation measures.....	21
5.1	General.....	22
5.2	Minimising disturbance	23
5.3	Drainage control	23
5.4	Erosion and sediment control.....	24
5.5	Works in and around waterways	26
5.6	Management of sediment basins	27
5.7	Stabilisation of disturbed areas	28
5.8	Management of contaminated materials	29
5.9	Surface water quality management.....	29
5.10	Groundwater management	30
5.11	Management of other activities with potential water quality impact.....	31
6	Compliance management	34
6.1	Roles and responsibilities	34
6.2	Training.....	34
6.3	Monitoring and inspections	35
6.4	Non-conformances.....	35
6.5	Complaints.....	35
6.6	Audits.....	35
7	Review and improvement of CSWQMP.....	35

Glossary / Abbreviations

ANZECC	The Australian and New Zealand Environment Conservation Council
ASS	Acid sulfate soils
CAQMP	Construction Air Quality Management Sub-plan
CEMP	Construction Environmental Management Plan
CSWQMP	Construction Soil and Water Quality Management Sub-plan
CWEMP	Construction Waste and Energy Management Sub-plan
CoA	Condition of Approval
DEC	Department of Environment and Conservation
DECCW	Department of Environment, Climate Change and Water
DP&E	Department of Planning and Environment
Director General	Director General of the NSW Department of Planning and Infrastructure (or delegate). Now the Secretary of the Department of Planning and Environment.
DLWC	Department of Land and Water Conservation
DNR	Department of Natural Resources
DPI	Department of Primary Industries (Fishing and Aquaculture)
DSEWPC	Department of Sustainability, Environment, Water, Population and Communities
EA	Environmental Assessment
EEC	Endangered Ecological Community
EPA	Environment Protection Authority
EP&A Act	<i>Environmental Planning and Assessment Act 1979</i>
EPL	Environmental Protection Licence
EPBC Act	<i>Commonwealth Environment Protection and Biodiversity Conservation Act 1999</i>
ER	Environmental Representative
EWMS	Environmental Work Method Statement
FM Act	<i>Fisheries Management Act 1994</i>
NOW	NSW Office of Water
OEH	Office of Environment and Heritage
PASS	Potential acid sulfate soils
PESCP	Progressive Erosion and Sediment Control Plan
POEO Act	<i>Protection of the Environment Operations Act 1997</i>
Project, the	The Princes Highway Upgrade - Foxground and Berry Bypass Project, defined as “ <i>The construction and operation of approximately 11.6 kilometres of two lane divided carriageways (with the exception of the cutting through Toolijooa Ridge which comprises two lanes plus a climbing lane in each direction), with provisions for the possible future widening to three lanes within the road corridor (if required in the future).</i> ”
RMS	Roads and Maritime Services
RTA	Roads and Traffic Authority (now RMS)
Secretary	Secretary of the Department of Planning and Environment
SDS	Safety Data Sheet

SoC	Revised Statement of Commitments included in the Submissions Report
Water Act	<i>Water Act 1912</i>
WM Act	<i>Water Management Act 2000</i>

1 Introduction

1.1 Purpose

This Construction Soil and Water Quality Management Sub-plan (CSWQMP) describes how Fulton Hogan will manage potential environmental impacts on surface and groundwater during construction of the Foxground and Berry Bypass Project (the Project).

This CSWQMP has been prepared to address the requirements of the Minister's Conditions of Approval (CoA), the RMS Statement of Commitments (SoC), the mitigation measures listed in the *Foxground and Berry Bypass Environmental Assessment* (EA) (AECOM, 2012) and applicable legislation.

1.2 Background

Sections 7.4, 7.5 and 8.1 of the *Princes Highway upgrade – Foxground and Berry bypass Environmental Assessment* (AECOM, 2012) assessed the impacts of construction and operation of the Project on soil and water.

As part of the EA development, detailed water quality, flooding and soils assessments were prepared to address the Director General's Requirements. The surface water, groundwater and flooding assessment was included in the EA as *Volume 2 Appendix H Technical paper: surface water, groundwater and flooding*.

1.3 Structure of CSWQMP

This CSWQMP is part of Fulton Hogan's environmental management framework for the Project and is supported by other documents such as primary and progressive erosion and sediment control plans and environmental work method statements. The review and document control processes for this CSWQMP are described in Chapter 10 of the CEMP.

1.4 Consultation for preparation of the CSWQMP

This CSWQMP has been developed in consultation with the EPA, OEH (Biodiversity), NOW and DPI (Fishing and Aquaculture). A summary of consultation undertaken during the preparation of this CSWQMP is provided in Appendix A2 of the CEMP.

2 Legal and other requirements

2.1 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 (POEO Act)
- Water Management Act 2000 (WM Act)
- Fisheries Management Act 1994 (FM Act)
- Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act), and
- Water Act 1912 (Water Act).

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

2.2 Guidelines and standards

The main guidelines, specifications and policy documents relevant to this CSWQMP 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)
- *National Water Quality Management Strategy* (NWQMS) (Department of Sustainability, Environment, Water, Population and Communities (DSEWPC), 1994)
- *NSW Water Quality and River Flow Objectives* (DECCW, 2006)
- 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 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* (EPA, 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*
- *RMS Technical Guideline: Temporary stormwater drainage for road construction*
- *Stockpile Site Management Guideline*, RMS 2011
- *Environmental Best Management Practice Guideline for Concreting Contractors* (DEC, 2004)
- *RMS Road Design Guideline: Section 8 Erosion and Sedimentation* (RTA, 2003)
- *RMS Guideline for Construction Phase Water Quality Monitoring* (RTA, n.d.)
- *RMS Erosion and Sedimentation Management Procedure* (RTA, 2009)
- *Procedures for Selecting Treatment Strategies to Control Road Runoff* (RTA, 2003a)
- *RMS Water Policy* (RTA, 1997)
- *Road Runoff and Drainage: Environmental Impacts and Management Options, AP-R180* (Austroads, 2001)
- *Floodplain Development Manual* (NSW Government, 2005)
- *RMS Technical Guideline: Environmental Management of Construction Site Dewatering* (RTA, 2011)
- *Coastal Lakes: Independent Inquiry into Coastal Lakes and Statement of Joint Intent* (Healthy Rivers Commission of NSW, 2002)
- The relevant targets within the *State Water Management Outcomes Plan* (NOW, 2003)
- *State Groundwater Policy Framework Document* (Department of Land and Water Conservation (DLWC), 1997)
- The NSW State *Groundwater Quality Protection Policy* (DLWC, 1998)
- (Draft) NSW State *Groundwater Quantity Management Policy* (DLWC, n.d.)
- NSW State *Groundwater Dependent Ecosystems Policy* (DLWC, 2002)
- *National Water Quality Management Strategy Guidelines for Groundwater Protection in Australia* (Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) and ANZECC, 1995)
- *Guidelines for Treatment of Stormwater Runoff from Road Infrastructure, AP-R232* (Austroads, 2003), and
- *Guidelines for the Assessment and Management of Groundwater Contamination* (NSW DEC, 2007).

2.3 Minister's Conditions of Approval

The CoA relevant to this CSWQMP are listed in Table 2-1 below. A cross reference is also included to indicate where the condition is addressed in this CSWQMP or other project / environmental management documents.

Table 2-1 Conditions of Approval relevant to this CSWQMP

CoA No.	Condition Requirements	Document Reference
CoA B15	Prior to the commencement of construction, unless otherwise agreed by the Director General, the Proponent shall in consultation with the EPA and NOW, undertake groundwater modelling on the concept design for the Project, subject to the modelling being revised should the detailed design have a significantly different impact on groundwater than the concept design. The modelling shall be undertaken by a suitably qualified and experienced groundwater expert and assess the construction and operational impacts of the proposal on the groundwater resources, groundwater quality, groundwater hydrology and groundwater dependent ecosystems and provide details of contingency and management measures in the groundwater management strategy required under condition B36(d).	Appendix B - Water Quality Monitoring Program Detailed Design
CoA B16	The Proponent shall prepare and implement a Water Quality Monitoring Program to monitor the impacts of the project on surface and groundwater quality and resources and wetlands, during construction and operation. The Program shall be developed in consultation with the OEH, EPA, DPI (Fishing and Aquaculture) and NOW and shall include but not necessarily be limited to: <ul style="list-style-type: none"> (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 project; (b) the results of the groundwater modelling undertaken under condition B15; (c) identification of works and activities during construction and operation of the project, including emergencies and spill events, that have the potential to impact on surface water quality of potentially affected waterways; (d) development and presentation of parameters and standards against which any changes to water quality will be assessed, having regard to the <i>Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000</i> (Australian and New Zealand Environment Conservation Council, 2000); (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 Director General; (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 the Department, OEH, EPA and NOW. 	Appendix B - Water Quality Monitoring Program

CoA No.	Condition Requirements	Document Reference
	The Program shall be submitted to the Director General for approval 6 months prior to the commencement of construction of the Project, or as otherwise agreed by the Director General. A copy of the Program shall be submitted to the OEH, EPA, DPI (Fishing and Aquaculture) and NOW prior to its implementation.	
CoA B35(e)	<p>The following performance issues shall be addressed (in the CEMP):</p> <p>(ii) measures to minimise hydrology impacts, including measures to stabilise bed and bank structures as required,</p> <p>(vi) 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 and a stockpile management protocol detailing location criteria that would guide the placement of stockpiles and management measures that would be implemented to avoid / minimise amenity impacts to surrounding residents and environmental risks (including to surrounding water courses). Stockpile sites that affect heritage, threatened species, populations or endangered ecological communities require the approval of the Director General, in consultation with the OEH;</p>	<p>Chapter 5 Detailed design</p> <p>Chapter 5 Appendix F – Stockpile Management Protocol Refer to the CWEMP for disposal options.</p>
CoA B36	<p>As part of the CEMP for the project required under condition B35, the Proponent shall prepare and implement the following sub plan(s):</p> <p>(d) a Construction Soil and Water Quality Management Sub plan to manage surface and groundwater impacts during construction of the project. The sub-plan shall be developed in consultation with the OEH, EPA, DPI (Fishing and Aquaculture) and NOW and include, but not necessarily be limited to:</p> <p>(i) identification of potential sources of erosion and sedimentation, and water pollution (including those resulting from maintenance activities);</p> <p>(ii) details of how construction activities would be managed and mitigated to minimise erosion and sedimentation consistent with condition C20;</p> <p>(iii) where construction activities have the potential to impact on waterways or wetlands (through direct disturbance such as construction of waterway crossings or works in close proximity to waterways or wetlands), site specific mitigation measures to be implemented to minimise water quality, riparian and stream hydrology impacts as far as practicable, including measures to stabilise bed and / or bank structures where feasible and reasonable, and to rehabilitate affected riparian vegetation to existing or better condition. The timing of rehabilitation of the waterways shall be identified in the sub-plan;</p> <p>(iv) a 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;</p> <p>(v) a tannin leachate management protocol to manage the stockpiling of mulch and use of cleared vegetation and mulch filters for erosion and sediment control;</p>	<p>This CSWQMP</p> <p>Section 1.4</p> <p>Chapter 4</p> <p>Chapter 5</p> <p>Section 5.5</p> <p>Appendix C – Unexpected Discovery of Contaminated Land Procedure Appendix E - Acid Sulfate Soil Management Procedure</p> <p>Appendix D – RMS Environmental Direction Management of Tannins from Vegetation Mulch</p>

CoA No.	Condition Requirements	Document Reference
	(vi) construction water quality monitoring requirements consistent with condition B16; and	Appendix B – Water Quality Monitoring Program
	(vii) a groundwater management strategy, including (but not necessarily limited to): <ul style="list-style-type: none"> i. description and identification of groundwater resources (including depths of the water table and water quality) potentially affected by the project based on baseline groundwater monitoring undertaken in accordance with condition B15; ii. identification of surrounding licensed bores, dams or other water supplies and groundwater dependant ecosystems and potential groundwater risks associated with the construction of the project on these groundwater users and ecosystems; iii. measures to manage identified impacts on water table, flow regimes and quality and to groundwater users and ecosystems; iv. groundwater inflow control, handling, treatment and disposal methods; and v. a detailed monitoring plan to identify monitoring methods, locations, frequency, duration and analysis requirements; and 	Appendix B – Water Quality Monitoring Program
CoA C20	Soil and water management measures consistent with <i>Managing Urban Stormwater - Soils and Construction</i> Vols 1 and 2, 4th Edition (Landcom, 2004) and <i>Managing Urban Stormwater Soils and Construction</i> Vols 2A and 2D Main Road Construction (DECC, 2008) shall be employed during the construction of the project for erosion and sediment control.	Section 2.2 Chapter 5 mitigation measure ID CSWQMM3, CSWQMM50 and CSWQMM69.
CoA C21	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.	Chapter 5 mitigation measure ID CSWQMM42 and CSWQMM77.
CoA C22	All surface water and groundwater must be adequately treated prior to entering the stormwater system to protect the receiving water source quality.	Chapter 5 mitigation measure ID CSWQMM36, CSWQMM40, CSWQMM58 and CSWQMM69.

2.4 Statement of commitments

Relevant SoC are listed in Table 2-2 below. This includes reference to required outcomes and a reference to where the commitment is addressed in this CSWQMP or other project / environmental management documents.

Table 2-2 Statements of commitment relevant to this CSWQMP

Outcome	Ref #	Commitment	Document Reference
Minimise erosion and sedimentation	SW1	Management measures will be designed, installed and maintained to minimise erosion and sedimentation from construction activities.	Chapter 5
	SW2	A soil conservation specialist will be engaged to provide advice on erosion and sedimentation control.	Chapter 5
	SW3	Stabilisation of exposed areas will be undertaken progressively.	Chapter 5
Avoid contamination of waterways	SW4	Monitoring of water quality upstream and downstream of the project site will be undertaken before and during construction. Also refer to SG4	Appendix B – Water Quality Monitoring Program
Acid sulfate soils (ASS) to be avoided are protected	SW5	Areas of ASS to be avoided will be fenced and signposted as exclusion zones before and during any works in the vicinity.	Appendix E – Acid Sulfate Soil Management Procedure
Impact of exposing acid sulfate soils is minimised	SW6	Exposed ASS will be neutralised and protected from surface run-on will be minimised. Any acid runoff or acid material will be contained and treated.	Appendix E – Acid Sulfate Soil Management Procedure
Impact of exposing unforeseen occurrences of contaminated soils is minimized.	SW7	Targeted soil contamination investigations will be undertaken during detailed design, if required. A remedial action plan will be developed if contamination is found to pose unacceptable risks to the environment and human health.	Appendix C – Unexpected Discovery of Contaminated Land Procedure
Minimise impacts to water quality during construction and operation.	SG1	Water quality measures such as water quality basins, swales or bioretention systems at sensitive receiving environments will be designed and installed to respond to the project water quality design criteria.	Chapter 5
Minimise water quality impacts to the flow regimes of Town Creek and Bundewallah Creek.	SG2	A design and revegetation strategy for the Town Creek diversion will be developed during detailed design and will include measures to: <ul style="list-style-type: none"> maintain flushing efficiency mitigate erosion risk at the connection with Bundewallah Creek. 	Detailed Design Urban Design and Landscape Plan

Outcome	Ref #	Commitment	Document Reference
		The design of the diversion will be finalised in consultation with directly affected landowners. The Town Creek diversion will be stabilised to mitigate erosion risk prior to operation.	
Minimise impacts on farm dams.	SG3	Permanent losses to farm dam catchments and inflows will be identified during detailed design. Mitigation strategies will be developed in consultation with affected landowners and implemented where reasonable and feasible.	Detailed Design
Minimise impacts on drinking water supply.	SG4	Drinking water drawn from Broughton Creek will be maintained through measures identified in commitment AQ1. In the event that water drawn from Broughton Creek does not meet existing drinking water quality standards, an appropriate source of potable water will be made available to affected residents, following consultation.	Detailed Design CAQMP Table 5-1
	SG5	RMS will consult with landholders along the existing Town Creek alignment, below the proposed diversion, to confirm that there are no Basic Landholder Rights (under the <i>Water Management Act 2000</i>) to access water for domestic or stock purposes.	Compliance Tracking Program
Minimise changes in current flow regimes.	SG6	Waterway structures will be designed to maintain existing flow regimes, where practicable.	Detailed Design
Manage the impacts associated with changes to flooding and drainage.	SG7	Detailed design will seek to minimise increases in peak flood levels in the 1 in 100 year flood event.	Detailed Design
	SG8	Changes to flood impacts on property will be identified as part of detailed design. Where increased flood impacts to structures, such as residences, are identified, mitigation measures will be proposed and implemented where reasonable and feasible.	Detailed Design Hydrological Mitigation Report
Minimise impacts on channel structure.	SG9	Impacts on stream channel structure diversion will be minimised during detailed design. Measures to be considered may include culvert sizing, energy dissipation measures, scour protection and other design features to control flow intensity and direction.	Detailed Design
Minimise the impact on groundwater levels.	SG10	Groundwater monitoring of water levels and water quality will be undertaken. Where levels and / or quality indicate that the project is potentially having an adverse impact, mitigation measures will be considered and implemented where reasonable and feasible.	Appendix B – Water Quality Monitoring Program
Conservation of water.	SG11	Water efficient work practices, such as water reuse and recycling for road construction and revegetation irrigation will be implemented, where feasible. In the event that surface water from watercourses or groundwater is required to supply water to the project, a site specific impact assessment will be carried out in consultation with the NSW Office of Water and potentially affected stakeholders.	Chapter 5

3 Existing environment

The following sections summarise the factors influencing soil and water within and adjacent to the Project corridor based on the information provided in Section 7.4, Section 7.5, Section 8.1 and Appendix H of the EA.

3.1 Topography and soils

3.1.1 Topography

The Project area consists of two main topographic groups:

- the undulating hills and foothills extending north-west from the South Coast Railway line, and
- the Shoalhaven lowland plain, extending south-east of the foothills towards the Shoalhaven Bight.

The elevated north-western portion of the Project area is influenced by the Cambewarra Mountain Range (north-west of Berry) which is a narrow, low range that runs roughly parallel with the coastline. The lower slopes of this range extend into the Project area as the ridge lines approach Berry. Harley Hill and Toolijooa Ridge are situated towards the eastern part of the Project area and are disjointed from the Cambewarra Range.

A ridge of moderate elevation, from Foxground to Toolijooa Ridge, and a flatter ridge to the south-west of Toolijooa Ridge, separates the Broughton Creek floodplain from the Crooked River floodplain.

3.1.2 Geology

The geology of the Project area corresponds to the Permian Shoalhaven Group, which can be further divided into the Volcanic Sandstones sub-group (also referred to as the Budgong Sandstone), the Volcanics Facies subgroup and Berry Siltstone formation.

The younger Volcanic Sandstones and the Volcanics Facies are interbedded volcanic sandstones and latites that are found following ridgelines through Toolijooa Ridge and high points to Harley Hill. These sub-groups are comprised of Jamberoo Sandstone, Kiama Sandstone and Bumbo Latite. The Berry Siltstone occurs south-east of the Crooked River and is comprised of siltstone and fine grained sandstones with interbedded shale.

3.1.3 Soils

Table 3-1 lists the soil landscape units present within the Project area. The location of the soil landscapes is shown on Figure 3-1.

Table 3-1 Soil landscape units

Soil landscape unit	Description
Kiama landscape unit	<ul style="list-style-type: none"> • occurring in areas closer to Toolijooa Road • characterised by sandy clay loams and stuff to hard clays • erosion hazard: moderate to extreme • limitations: low wet bearing strength and potential for localised mass movement.
Wattamolla Road landscape unit	<ul style="list-style-type: none"> • occurring in steeper areas around Toolijooa Ridge • characterised by shallow soils consisting of sandy and silt loams, very stiff to hard clays and extremely weathered rock developed in units associated with the

Soil landscape unit	Description
	<ul style="list-style-type: none"> underlying rock units erosion hazard: high to extreme limitation: low wet bearing strength, potential for localised mass movement.
Shoalhaven landscape unit	<ul style="list-style-type: none"> corresponds to creeks and floodplain areas at Broughton Creek and Berry consists of alluvial soils, comprised of gravel, sand, silt and clay derived mainly from sandstone and shale that overlay buried estuarine sediments; erosion hazard: slight to low subject to seasonal waterlogging and has potential for ASS.
Coolangatta landscape unit	<ul style="list-style-type: none"> corresponds to the undulating hills between Austral Park Road and north of Berry consists of sands, and stiff to hard clays erosion hazard: extreme topsoils are highly to moderately erodible limitations: low wet bearing strength, potential for localised surface and mass movement.

3.1.4 Acid Sulfate Soils

Acid Sulfate Soils (ASS) are a naturally occurring soil and sediment that contains iron sulphides. ASS can be classified into two types – actual ASS and potential ASS (PASS). PASS are waterlogged soils rich in iron sulphides that have not been oxidised. PASS are harmless to the environment if kept in this state or under water. However any exposure of PASS to air or the lowering of the water table leads to the formation of sulphuric acid and the development of actual ASS.

The Project generally passes over geological conditions mapped as having no known occurrence of ASS (Department of Land and Water Conservation (DLWC), 1997). An area close to a section of the highway alignment south of Berry has been identified as being of low ASS risk and located at depths greater than 4 m. The alluvial floodplain soils at the Broughton Creek floodplain, and at the bypass of Berry, also have a low risk of encountering PASS.

The location of ASS and PASS in the Project Area are shown on Figure 3-2 and Figure 3-3 respectively.

3.1.5 Soft soils

Soft soils generally occur in low lying areas or floodplains where deep alluvial soils are present. Soft soils have limited resistance to loads. Roads constructed on soft soils, without ground improvement works, risk the requirement for ongoing maintenance as a result of ground settlement resulting in poor road conditions and pavement damage.

The presence and depth of alluvial soils varies across the length of the Project. The greatest depth of alluvial soils occurs at the Broughton Creek floodplain at approximately 5 m below ground level. Alluvial soils occur to a lesser extent at stream channels between Austral Park Road and Tindalls Lane, and along the floodplain near Berry. The depth of alluvial soils at these locations is estimated at 2 – 4 m below ground level.

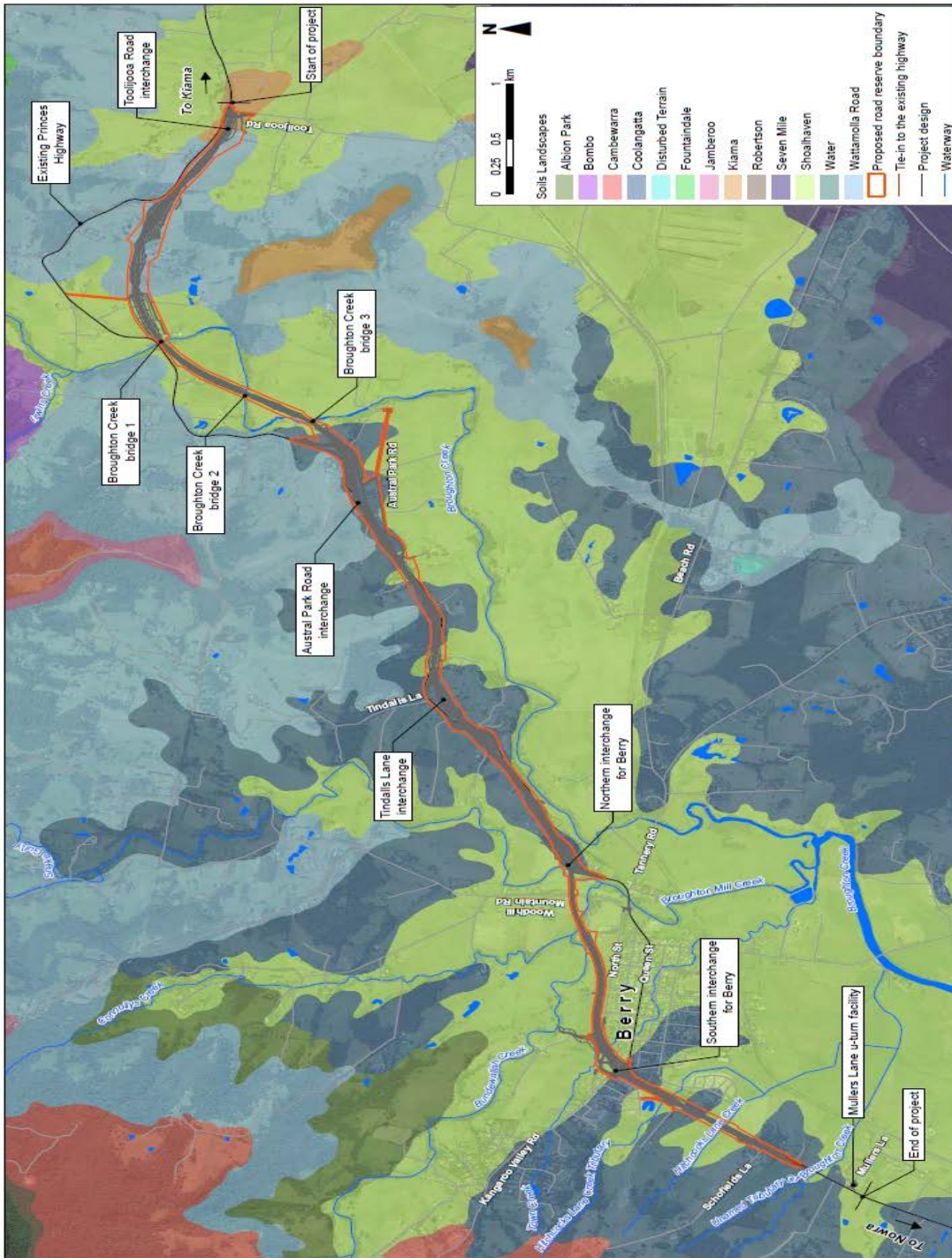


Figure 3-1 Soil landscape units according to Soil Landscapes of Kiama 1:100,000 Sheet (Hazelton, 1992)

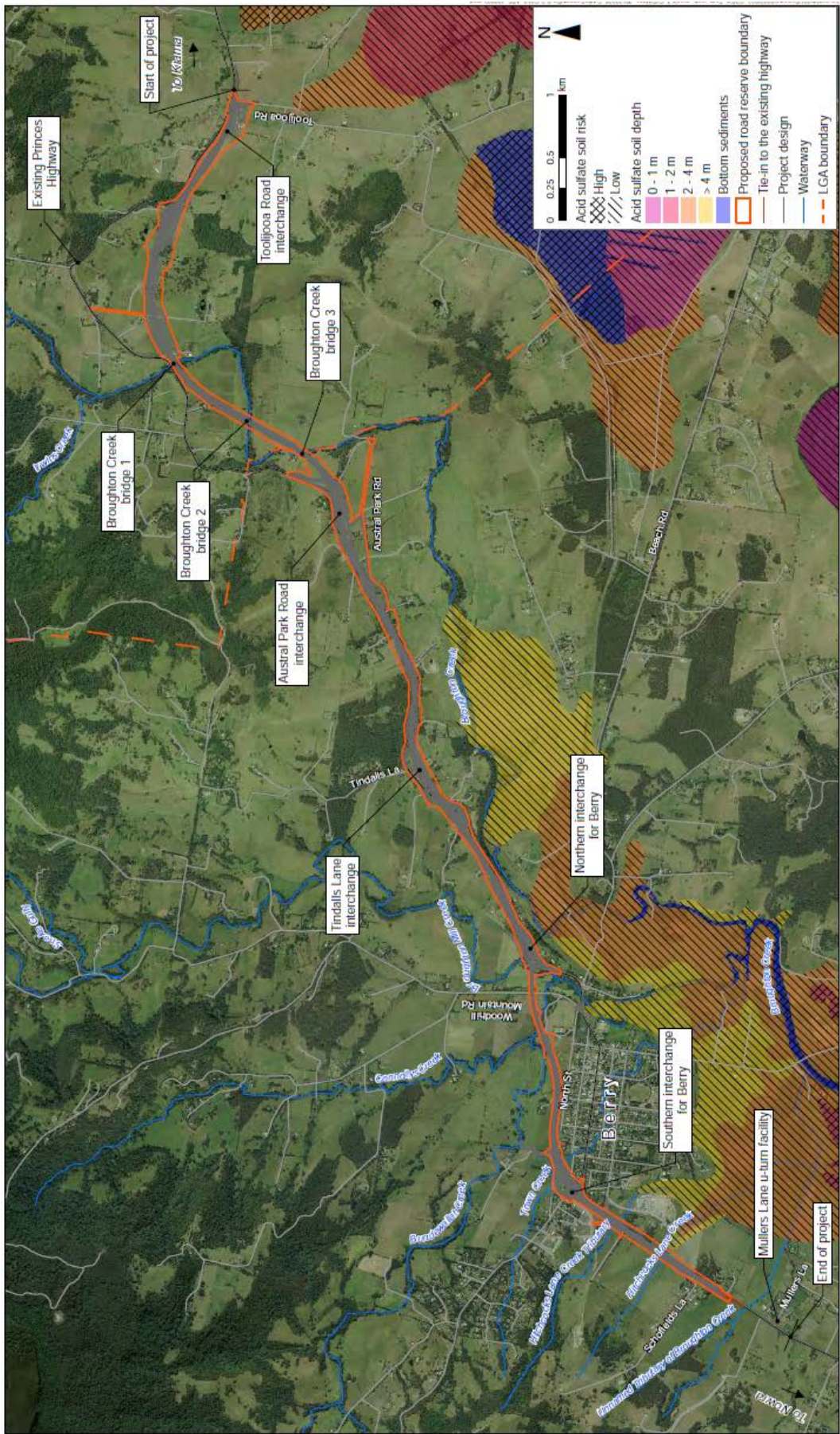


Figure 3-2 Acid Sulfate Soils in the project area

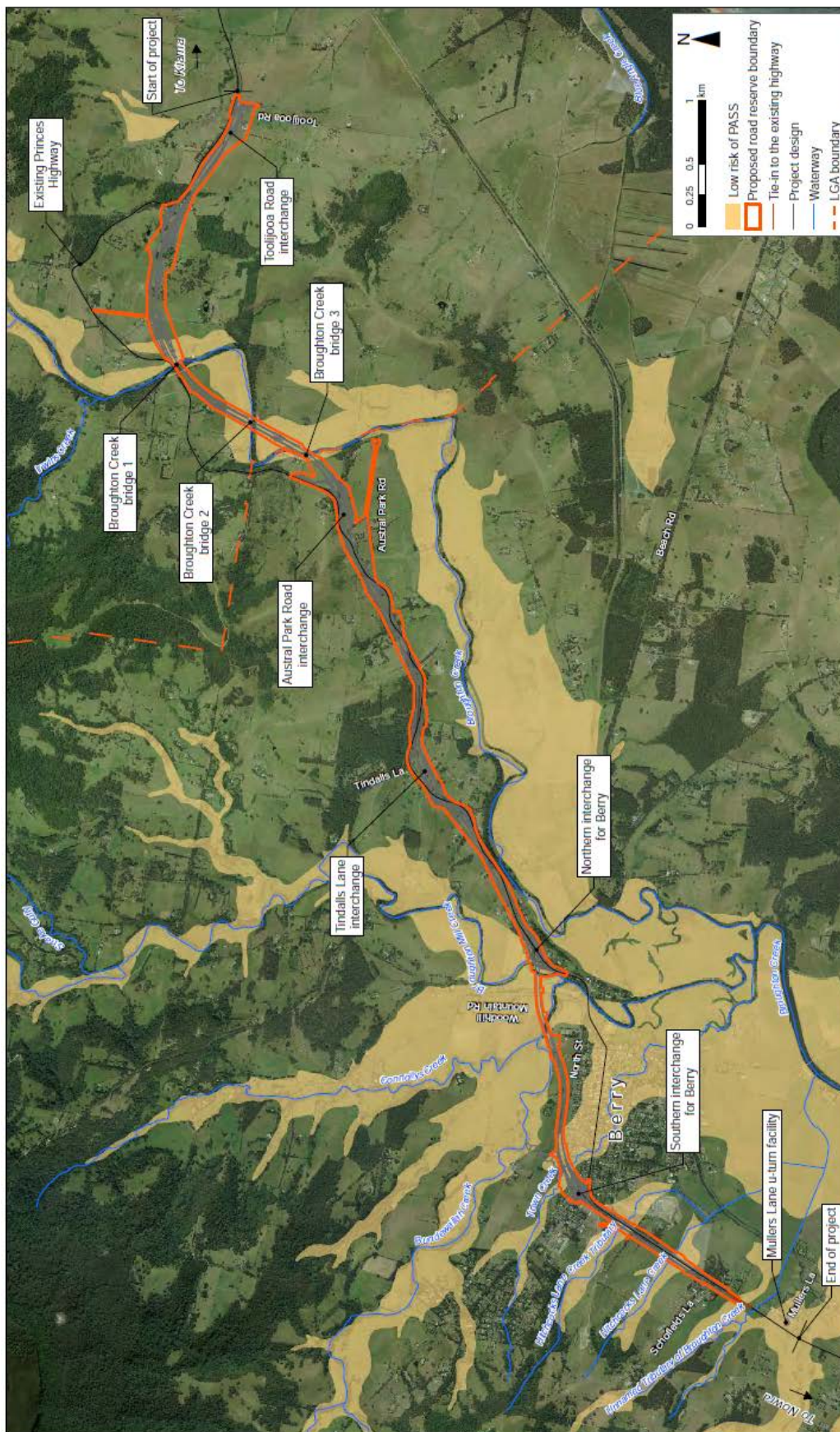


Figure 3-3 Additional areas of potential Acid Sulfate Soil risk

3.1.6 Contamination

The preliminary contamination assessment undertaken during the route selection process did not identify the presence of major potential contamination sites such as large waste dumps, landfills, chemical manufacturing plants and fuel depots which may be associated with larger scale contamination issues.

The preliminary assessment did not identify the presence of any contamination from tanneries, cattle tick dip sites, properties where use of pesticides or chemicals may have been intensive, night soil depots, timber treatment, gasworks, mining or extractive industries (other than the quarry avoided by the Project) or power stations.

There is little obvious evidence of significant land filling or fill stockpiling in areas of rural land use.

A search of the NSW OEH website did not identify any notices within the Project area under the *Contaminated Land Management Act 1997* or the *Environmentally Hazardous Chemicals Act 1985*.

3.2 Surface water

3.2.1 Waterways in project area

The main waterways that interact with the Project are Broughton Creek, Broughton Mill Creek, Bundewallah Creek, Connollys Creek and Town Creek and their associated catchments. The location of the waterways and catchments in the Project area are shown on Figure 3-4.

A small section of the Project area is located within the upper Crooked River catchment, near Toolijooa Ridge. The creeks and streams that form part of the Crooked River catchment start at Currys Mountain and flow in a south-easterly direction into a coastal floodplain before discharging into the ocean via the estuarine Crooked River Lagoon. No significant or ephemeral waterways within the Crooked River catchment are located within the Project footprint.

Broughton Creek, which starts below the Illawarra Plateau, is the main watercourse in the Project area. The Broughton Creek catchment lies next to and south of the Crooked River catchment, and is separated by the ridge that extends from Currys Mountain to Toolijooa Hill, Moeyan Hill and eventually Coolangatta Mountain. After crossing the existing Princes Highway corridor, Broughton Creek flows in a south west direction. At Berry, Broughton Creek is joined by Broughton Mill Creek at the entrance of a coastal floodplain and eventually discharges into the lower Shoalhaven River. The Broughton Creek catchment upstream of Berry is around 30 km² in area.

To the north and north-west of Berry are the Broughton Mill Creek and Bundewallah Creek catchments respectively. Broughton Mill Creek originates underneath the Illawarra Plateau as a number of secondary streams. It flows south through Broughton Vale and crosses the existing Princes Highway near the Woodhill Mountain Road intersection on the eastern edge of Berry, around two kilometres upstream of its confluence with Broughton Creek.

Bundewallah Creek starts to the north west of Berry and flows eastwards under a bridge at Woodhill Mountain Road to join Broughton Mill Creek. Connollys Creek enters Bundewallah Creek about 600 m upstream of the point Bundewallah Creek joins Broughton Mill Creek. Bundewallah Creek and Connollys Creek have catchment areas of around 1,500 ha and 630 ha respectively. Broughton Mill Creek has a catchment area of around 2,000 ha immediately upstream of the confluence with Bundewallah Creek.

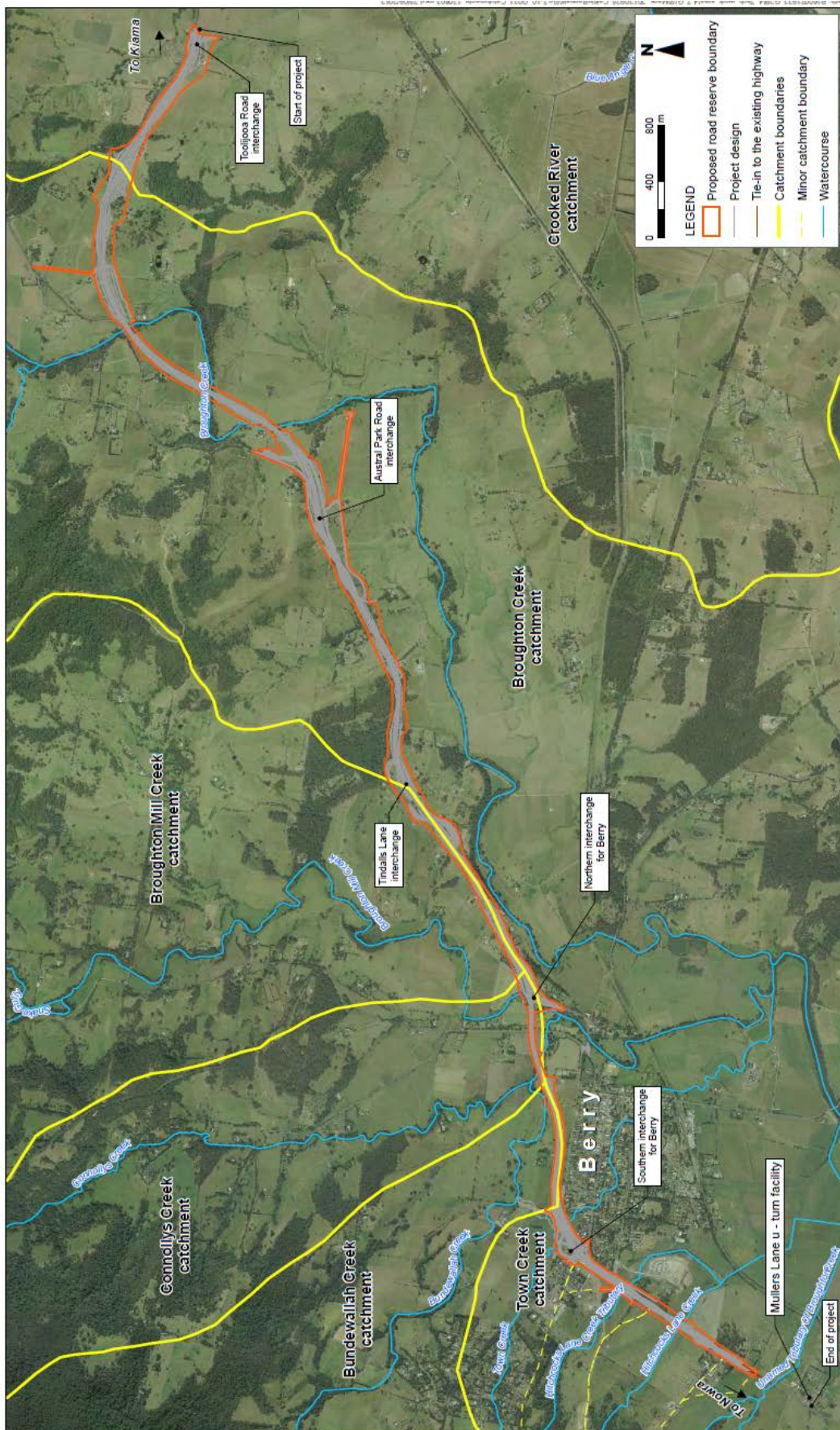


Figure 3-4 Location of catchments within the project area

Town Creek is a small ephemeral watercourse that passes directly through the Berry township. It has a catchment area of 70 ha upstream of Berry. Town Creek crosses the undeveloped section of North Street, on the north west edge of Berry, before crossing the town between Princess Street and Queen Street and exiting via Prince Alfred Street. Town Creek flows south east before joining Broughton Mill Creek near its confluence with Broughton Creek. The reach of Town Creek through Berry is in poor condition.

Hitchcocks Lane Creek, its tributary and an unnamed tributary of Broughton Creek flow across the existing highway, south of Berry. These watercourses join southwest of the existing highway and eventually discharge into the estuarine reach of Broughton Creek. Hitchcocks Lane Creek and its tributary have a catchment area of 68 ha and 75 ha respectively. The unnamed tributary of Broughton Creek has a catchment area of 6.2 ha.

3.2.2 Water quality in waterways

The long term regional agricultural land use is dominated by dairying and turf farming and has resulted in waterway pollution that is greater than the water quality levels considered sustainable for maintaining ecosystem integrity. The values of total phosphorus within the Crooked River and Broughton Creek catchments are regularly above the ANZECC guidelines. The application of fertilisers and manure from stock is the likely sources of the high nutrient levels.

Broughton Creek, Broughton Mill Creek, Connollys Creek and Bundewallah Creek are considered to be sensitive receiving environments due to the ecological values of these waterways.

Previous studies within the Crooked River and Broughton Creek catchments have found that water quality was generally within the ANZECC threshold limits for pH and conductivity, and to a lesser extent, turbidity. Sampling carried out in 2007 during a period of low rainfall found that sites within Crooked River and Broughton Creek catchments were frequently below ANZECC lower limits for dissolved oxygen. Low dissolved oxygen values can be caused by low flow conditions and / or high in-stream organic loads.

Crooked River, Broughton Creek and Broughton Mill Creek have previously been found to be within ANZECC aquatic ecosystem threshold limits for a range of organochlorine pesticides, oxides of nitrogen and trace elements, although all were above the ANZECC guidelines for chloride. Crooked River was also above the ANZECC guidelines for copper and recorded concentrations of oil and grease, and suspended solids, that were much higher than samples taken from sites within the Broughton Creek catchment.

The existing highway, which has no water quality controls, is also likely to contribute pollutant loads to nearby waterbodies particularly at or near creek crossings. This would include oil, grease and other hydrocarbon products generated by general vehicular use of the highway.

The water quality within Town Creek is expected to be characteristic of a watercourse with a developed residential and agricultural catchment, which is also subjected to impacts caused by upstream sub-division and housing development. The long-term urban and agricultural land use in the area has likely lead to elevated nutrient levels (for example from fertilisers and livestock manure), low dissolved oxygen and raised suspended solids resulting from the erosion of soils.

3.3 Groundwater

3.3.1 Aquifer systems

The two main aquifer systems present in the Project area include:

- the unconsolidated and unconfined alluvial / colluvial aquifers, and
- the Shoalhaven Group sediments.

The alluvial / colluvial aquifer occurs as sand, silt clay and gravels adjacent to the creek systems and as more widespread floodplain deposits. Within the floodplain sediments, localised perched groundwater is expected above interbedded clay horizons. Groundwater movement within the alluvial aquifer and floodplain sediments would flow towards low lying topographical features, discharging into local creek systems or as springs. Groundwater available for extraction within the aquifer would be limited, and would be of low salinity given low residence times and recharge via infiltration of rain and local runoff.

Groundwater within the Shoalhaven Group sediments is present within the volcanoclastic Broughton Formation, as well as within latite and underlying Berry Siltstone. Groundwater within the Shoalhaven Group sediments occurs in perched horizons within the sandstone, latite and siltstone, and within the deeper regional aquifer. Bores constructed in the Shoalhaven Group sediments in the area have variable yields. The deep aquifers are accessed by the majority of licensed bores in the area, extracting groundwater from depths typically between 30 m and 50 m below ground level. Based on limited data, groundwater from the Broughton Sandstone is expected to be of better quality than that derived from the Berry Siltstone due to the poor quality groundwater within the shale lenses leaking into the Berry Siltstone aquifer.

The depth of groundwater along the Project alignment is influenced by position in the landscape and proximity to discharge features. Typically, the watertable is a reflection of the topography, deepest beneath hills and shallowest adjacent to creeks and wetlands.

Groundwater along the route is shallow and typically less than 10 m below ground level for all lithologies. The elevation of groundwater is variable, ranging from 6 m AHD in low lying silts and gravels, up to 100 m AHD within latite in topographically elevated areas. The watertable fluctuates naturally in response to climatic variation. Groundwater levels increase following significant rainfall and decline following periods of low rainfall. The degree of the groundwater response is variable and dependent upon landscape position and aquifer type. Low to moderate groundwater fluctuations of less than 1 m were recorded in the siltstone and sandstone aquifers, whereas larger fluctuations (typically 3 - 4 m) were measured in the sandstone and latite aquifers.

3.3.2 Groundwater bores

There are 16 registered bores located within 500 m of the Project. Groundwater in the Project area is a valuable resource for stock, domestic and agricultural purposes to supplement surface water supplies collected in dams and pumped from creeks. Groundwater is extracted from a variety of aquifers including latite, gravels, sandstone, shale and fractured rock. The groundwater yield is variable, but is typically less than 2 L/s. Data recorded within various bores has indicated elevated levels of zinc, these levels are considered to be of natural occurrence.

3.3.3 Drinking water catchments

There are no drinking water catchments in the Project area. Groundwater has low use within the region because the area receives a relatively high rainfall and Shoalhaven Water provides a reticulated water supply from the Shoalhaven River catchment to Berry. North of Berry water users are more reliant on tank water and groundwater.

3.4 Climate

The Climate Classification Maps from the Bureau of Meteorology (BOM) indicate that the Project is located in a climate zone characterised by warm summer and cold winter. Rainfall records from at Kiama Bowling Club (BOM station 068038) have been used to reflect the potential rainfall conditions due to its proximity to the Project site. A summary of the mean monthly rainfall data is provided in Table 3-2 below.

Table 3-2 Average monthly rainfall data – Kiama Bowling Club (BOM station 068038)

	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Year
Mean rainfall (mm)	107.2	119.2	142.5	130.7	119.4	123.6	88.3	80.7	73.4	86.8	89.5	92.7	1253.8
Mean rain days	9.0	9.0	9.7	8.7	8.0	7.7	6.7	6.5	6.9	8.0	8.7	8.3	97.2

February is the wettest month with an average monthly rainfall of 142.5mm. August is the driest month with an average monthly rainfall of 73.4mm.

Monthly evapotranspiration (ET) data for a location near Berry was obtained from Bureau of Meteorology (2002), Climatic Atlas of Australia: Evapotranspiration (CD, Version 1.0). The data is provided in Table 3-3 below.

Table 3-3 Potential and Actual monthly ET Data - Berry

	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Year
Average Areal Actual ET (mm)	98	110	84	71	35	21	22	21	18	29	66	93	666
Average Areal Potential ET (mm)	156	171	128	117	77	50	37	39	56	77	120	146	1,173

Tables 3-2 and 3-3 provide a consideration of typical rainfall and evaporation factors that contribute to the proliferation of dust particulates. In addition to the exposure of unconsolidated material during construction, e.g. earthworks, climatic factors such as prolonged dry weather, combined with high winds, can increase the likelihood of dust particulate emissions.

Data on wind direction and wind speed was collected in 2000 from a site at the Gerroa Tip, which is located around 5 km south-west of Gerringong. On an annual basis, the most common winds are from the west, west northwest and north east. The annual average wind speed is 2.4 m/s. A stability class was assigned to each hour of the meteorological data using concurrent cloud cover information and the methodology of Turner as documented in the Workbook of Atmospheric Dispersion Estimates (Turner, 1970). Stability is dependent on a number of factors, such as wind speed, terrain and the temperature profile of the atmosphere. Class A is defined as very unstable through to Class F which is defined as very stable conditions.

In the Project area, the most common stability occurrences were calculated to be D class (21% of the time) and E and F classes (20% of the time each). E and F class conditions would be more stable and would generally have lower wind speed than D class conditions. As a result, emissions are likely to disperse more quickly under D class conditions but more slowly under the E and F class conditions.

3.5 Flooding

Broughton Creek is a tributary of the Shoalhaven River which drains across the northern side of the Shoalhaven floodplain. Agriculture is the major land use in the vicinity of the Project, with extensive areas utilised for dairy and cattle grazing. Downstream of the Berry township, the terrain is flat, swampy and generally below the level of the Broughton Creek levees. Tidal influence extends around 12 km upstream of the point where Broughton Creek and the Shoalhaven River merge, to the vicinity of the Coolangatta Road bridge.

Floods inundate areas of rural land adjacent to Broughton Creek. There are few structures located within the floodplain (defined by the extent of a 100 year Average Recurrence Interval (ARI) flood), with the majority of land utilised for agricultural purposes. During large flood events, the banks of the upper Broughton Creek are overtopped with flood waters taking the shorter routes across the floodplains and returning to Broughton Creek some distance downstream.

Berry and its immediate surrounds are also flood prone, with Broughton Mill Creek, Connollys Creek, Bundewallah Creek and Town Creek being the main sources of flood waters (SMEC Australia Pty Ltd, 2008). Town Creek presents a particular flood risk to a significant number of properties within Berry, which are impacted by the 100 year ARI flood event.

The existing Princes Highway at Berry is also impacted during major flood events at the following locations:

- the highway crossing at Broughton Mill Creek and Hitchcocks Lane Creek is overtopped in a 2 year ARI flood event.
- the highway is overtopped as a result of flooding of Town Creek during a 20 year ARI flood event, and
- the highway is overtopped as a result of flooding of the Hitchcocks Lane tributary during a 100 year ARI flood event.

Flooding of the highway can prevent access for north and south bound highway traffic.

Rural / residential areas near the Hitchcocks Lane tributary can also be flooded during the 100 year ARI flood event.

Indicative 100 year ARI flood extents along the Project alignment are shown in Figure 3-5.

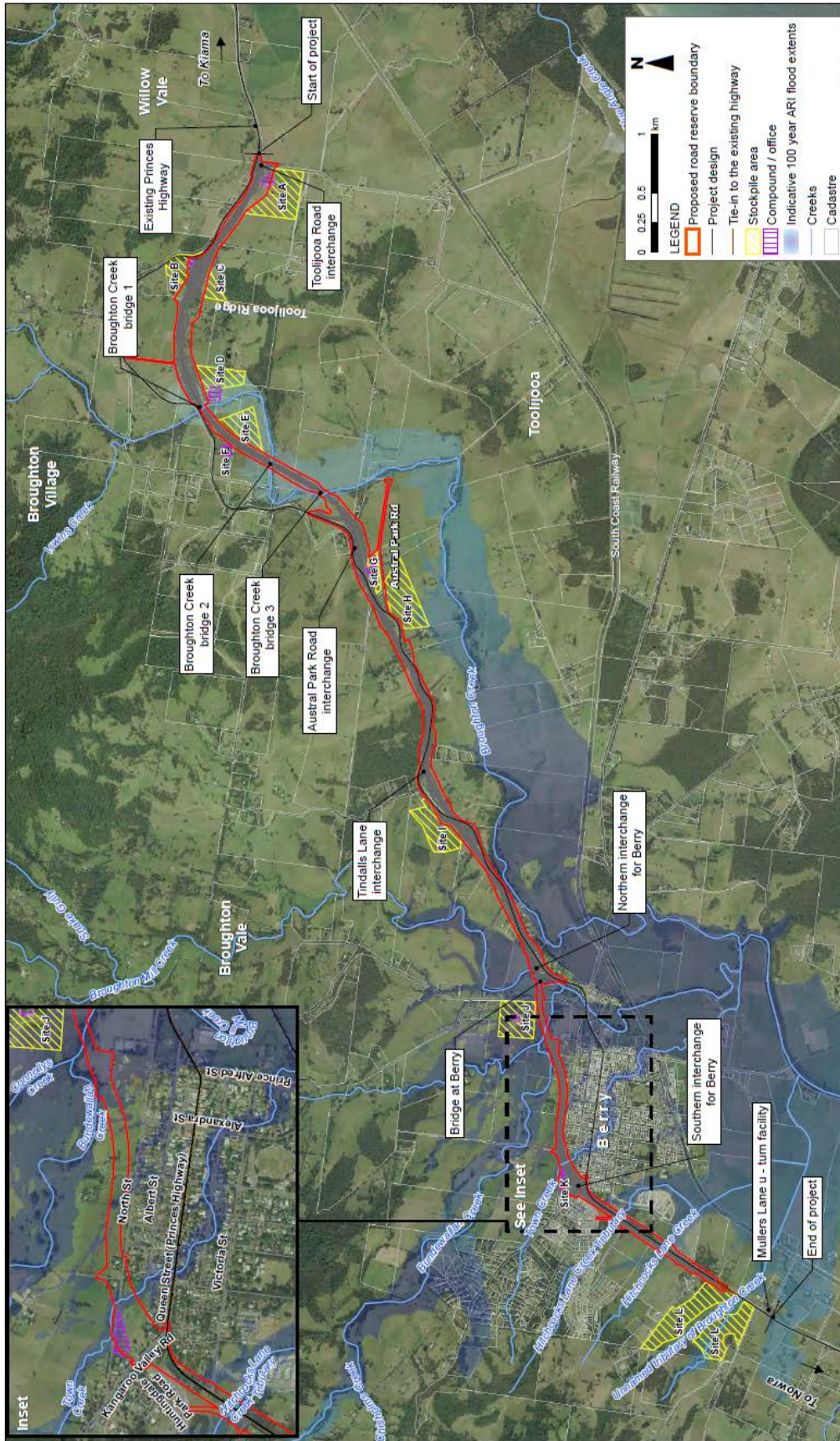


Figure 3-5 Indicative 100 year ARI flood extents along the Project alignment

4 Environmental aspects and impacts

The key construction activities and the associated potential sources of erosion, sedimentation and water pollution were identified through a risk management approach. The consequence and likelihood of each activity's impact on the environment was assessed to prioritise its significance. The results of this risk assessment are included in Appendix A3 of the CEMP.

5 Environmental mitigation measures

Specific mitigation measures to address impacts on soil and water are outlined in Table 5-1.

Table 5-1 Soil and water quality mitigation measures

ID	Mitigation Measure	Timing		Responsibility
		PC ¹	C ²	
5.1 General				
CSWQMM1	Engage a specialist soil conservationist with experience in road construction to provide expert assistance with key aspects of design of the erosion and sediment controls both before and during construction.	✓	✓	Environmental Manager
CSWQMM2	Install erosion and sediment controls in all construction areas where soil disturbance is going to occur, prior to soil disturbance occurring.		✓	Environmental Manager Project Engineers Foreman
CSWQMM3	Install all erosion and sediment controls in accordance with the <i>Erosion and Sediment Control Plan (ESCP)</i> included in Appendix A of this plan. The plan was prepared in accordance with the Blue Book (Landcom, 2004 and DECC, 2008) and includes relevant standard drawings and details from these texts.		✓	Environmental Manager Project Engineers Foreman
CSWQMM4	Consult relevant government agencies in relation to control measures in watercourses and creeks and the design of waterway crossings (e.g. NSW Office of Water, DPI (Fishing & Aquaculture), Office of Environment and Heritage).	✓	✓	Environmental Manager
CSWQMM5	Prepare Progressive Erosion and Sediment Control Plans (PESCPs) prior to commencing each stage or parcel of work. Prepare, review and issue the PESCPs in accordance with the <i>Project Document and Data Control Procedure</i> to ensure their currency and relevance at all times.		✓	Environmental Manager Project Engineers
CSWQMM6	Implement appropriate erosion and sediment control measures for each particular section of works in accordance with the PESCP, prior to the commencement of any clearing, stripping or earthworks.		✓	Project Engineers Foreman
CSWQMM7	Install certain structures and controls (i.e. sediment basins, pipes and culverts) early (i.e. prior to clearing and stripping) to promote successful erosion and sediment control during construction (principally, during clearing, stripping and earthworks).		✓	Project Engineers Foreman

¹ PC – pre-construction

² C - construction

ID	Mitigation Measure	Timing		Responsibility
		PC ¹	C ²	
CSWQMM8	Install a weather station for the duration of the Project. The Environmental Team will monitor weather conditions and forecasts (including rainfall prediction maps) daily and pass on relevant information to the site Superintendent/ Foremen to allow for adequate planning for significant rain events.		✓	Environmental Manager
CSWQMM9	Implement relevant documentation and systems for recording erosion and sediment control activities in accordance with the procedure for site environmental inspections outlined in the CEMP.		✓	Environmental Manager
5.2 Minimising disturbance				
CSWQMM10	Establish clearing limits and work boundaries that are well defined using barrier tape (or equivalent) prior to any construction, clearing or stripping works commencing.		✓	Environmental Manager Project Engineers Foreman
CSWQMM11	Minimise the extent of clearing as much as possible.		✓	Project Engineers Foreman
CSWQMM12	Clearly mark all vegetation that is to be retained.		✓	Environmental Manager Project Engineers Foreman
CSWQMM13	Clear land progressively and clear the areas associated with the current section/stage of works only.		✓	Project Engineers Foreman
CSWQMM14	Initially clear and grub leaving the soil surface in a reasonably rough condition with some surface vegetative cover.		✓	Project Engineers Foreman
5.3 Drainage control				
CSWQMM15	Maximise the separation of 'clean' (offsite) run-on water from 'dirty' (onsite) (e.g. turbid) construction area runoff as much as possible.	✓	✓	Environmental Manager Project Engineers Foreman
CSWQMM16	Construct drainage structures early in the project including: <ul style="list-style-type: none"> • sediment basins and traps along with dirty water drains engaged to the sediment control facilities; • upstream catch drains; and 	✓	✓	Project Engineers Foreman

ID	Mitigation Measure	Timing		Responsibility
		PC ¹	C ²	
	<ul style="list-style-type: none"> transverse culverts/pipes and associated inlet and outlet protection (e.g. dissipaters) to enable clean water flows under through works area without impacting water quality. 			
CSWQMM17	Maximise the diversion of turbid construction runoff into sediment basins or other appropriate control where basins are not viable.		✓	Project Engineers Foreman
CSWQMM18	Control runoff during the construction of embankments (e.g. fill shaping and the construction of temporary dykes, contour lines and batter drains).		✓	Project Engineers Foreman
CSWQMM19	Divert formation runoff into pits and the stormwater drainage system as soon as practical to reduce surface flow lengths, where drainage is confirmed to outlet into basins..		✓	Project Engineers Foreman
CSWQMM20	Divert offsite run-on water around the works site as much as possible. Use permanent cut-off drains to achieve this as much as possible.		✓	Project Engineers Foreman
CSWQMM21	Maintain slope lengths at appropriate lengths (refer to the standard drawings in the Primary ESCP) to slow flows down and minimise erosion. Use catch drains to collect and divert runoff from the slopes.		✓	Project Engineers Foreman
CSWQMM22	Use geotextile lining, plastic sheeting or soil stabilising polymer agents to provide temporary surface protection in areas where appropriate (e.g. batter drains, culvert construction).		✓	Project Engineers Foreman
CSWQMM23	Use check dams within diversion drains where required to slow flows down and minimise erosion within the drains.		✓	Project Engineers Foreman
CSWQMM24	Locate stockpiles in accordance with the <i>Stockpile Management Protocol</i> included in Appendix F of this CSWQMP to ensure that e.g. the number of stockpiles sites is minimised and stockpiles are at least 50m from a waterway.		✓	Project Engineers Foreman
5.4 Erosion and sediment control				
CSWQMM25	Undertake progressive stabilisation of ground surfaces as they are completed rather than at the end of the works program.		✓	Project Engineers Foreman
CSWQMM26	Where using cover crop species to progressively revegetate disturbed areas, use Rye Corn during the months of April to August or Japanese Millet during the months of September to March.		✓	Project Engineers Foreman
CSWQMM27	Immediately commence stabilisation of waterways, including their beds and banks, after the completion of any works within these areas. All stabilised areas to mimic a naturalised creek system and the disturbed areas are planted with native species.		✓	Project Engineers Foreman

ID	Mitigation Measure	Timing		Responsibility
		PC ¹	C ²	
CSWQMM28	Control dust through progressive revegetation techniques and by watering unsealed areas.		✓	Project Engineers Foreman
CSWQMM29	Use temporary ground covers such as soil stabilisers (e.g. Gluon or P47 polymer emulsion), hydroseed or hydromulch as much as possible to stabilise batters, stockpiles and large surface areas.		✓	Project Engineers Foreman
CSWQMM30	Construct sediment control measures as close to the potential source of sediment as possible.		✓	Environmental Manager Project Engineers Foreman
CSWQMM31	Ensure sediment basin management of turbid water immediately after rain as required with one or a combination of: <ul style="list-style-type: none"> flocculation with gypsum (or approved alternative flocculant), and pump-out for construction purposes or dust control. 		✓	Environmental Manager Project Engineers Foreman
CSWQMM32	Do not release water from sediment basins prior to achieving acceptable water-quality standards.		✓	Environmental Manager Project Engineers Foreman
CSWQMM33	Control the tracking of mud and soil material onto local roads using shakers, rubble pads or washdown areas.		✓	Foreman
CSWQMM34	Provide sediment fencing or equivalent downslope of disturbed areas that can't be directed into a designated sediment basin, trap or bund unless completely impractical (e.g. works within watercourses). Implement alternative controls (i.e. silt curtains and enhanced erosion controls) in these locations.		✓	Environmental Manager Project Engineers Foreman
CSWQMM35	Use mulch bunds or straw bales as alternatives to sediment fencing where appropriate. Do not use mulch in concentrated flow areas or where it has the potential to result in tannin leachate into waterways. Refer to Appendix D <i>RMS Environmental Direction No.25 Management of Tannins from Vegetation Mulch</i> .		✓	Environmental Manager Project Engineers Foreman
CSWQMM36	Treat water accumulating within any excavation, trap or low point on site that cannot be re-used in construction or dust suppression, as per the requirements for sediment basins before discharge from site.		✓	Environmental Manager Project Engineers Foreman
CSWQMM37	Install sediment controls around stormwater inlet pits where appropriate and where they won't cause or exacerbate flooding. Consider traffic management and safety if installing such devices on live traffic roads.		✓	Environmental Manager Project Engineers Foreman

ID	Mitigation Measure	Timing		Responsibility
		PC ¹	C ²	
CSWQMM38	Remove sediment controls only after adequate stabilisation of disturbed surfaces is achieved.		✓	Environmental Manager Project Engineers Foreman
CSWQMM39	Provide suitable access into sediment basin locations to allow for safe cleaning and maintenance operations.		✓	Environmental Manager Project Engineers Foreman
CSWQMM40	Test sediment basins and, if required, treat, prior to discharge within 5 days of the conclusion of any rain event. Alternatively pump them out for construction or dust control purposes to ensure the required capacities remain available for future rainfall.		✓	Environmental Manager Project Engineers Foreman
CSWQMM41	Carry out dust suppression whenever necessary to minimise sediments becoming air borne due to wind erosion.		✓	Foreman
CSWQMM42	Source water for dust suppression preferentially from sediment basins. However, identify an alternative water source prior to starting construction works for periods when the sediment basins are dry.		✓	Environmental Manager Project Engineers Foreman
5.5 Works in and around waterways				
CSWQMM43	Install temporary bridge structures over all Class 1 and 2 waterways instead of box culverts to reduce the potential for scouring.	✓	✓	Project Engineers Foreman
CSWQMM44	Undertake all works in and around waterways in accordance with the area-specific <i>Works in Waterways EWMS</i> .		✓	Environmental Manager Project Engineers Foreman
CSWQMM45	Undertake construction works in and around waterways in stages to minimise disturbance at any given time and allow the full bypassing of stream flows around the works to maintain fish passage, unless otherwise authorised by NSW DPI Fisheries and Aquaculture.		✓	Environmental Manager Project Engineers Foreman
CSWQMM46	Where practical, undertake works during the periods when flood flows and fish passage are less likely to occur; consult Project Ecologist regarding the fish migration and breeding periods in the area.		✓	Project Engineers Foreman
CSWQMM47	Complete any vegetation clearing and removal of topsoil near the waterways in accordance <i>with Clearing & Grubbing EWMS</i> ; minimise removal of native riparian vegetation, where practical.		✓	Environmental Manager Project Engineers

ID	Mitigation Measure	Timing		Responsibility
		PC ¹	C ²	
				Foreman
CSWQMM48	Carry out scour protection works using clean aggregate, small rock or other similar stable material on downstream batters and bank crests to prevent scouring. Establish a temporary cover crop, where necessary, to stabilise the batter surface prior to final landscaping.		✓	Project Engineers Foreman
CSWQMM49	Undertake appropriate replanting with local native species in accordance with the <i>Urban Design and Landscape Plan</i> , as soon as practicable after completion of construction.		✓	Project Engineers Foreman
5.6 Management of sediment basins				
CSWQMM50	Design all sediment basins in accordance with the Blue Book (Landcom, 2004 and DECC, 2008).	✓	✓	Environmental Manager Project Engineers Foreman
CSWQMM51	Establish and maintain suitable access measures to allow for safe cleaning operations in wet weather/muddy conditions.		✓	Environmental Manager Project Engineers Foreman
CSWQMM52	Inspect all sedimentation basins at least weekly and following any rainfall event causing runoff.		✓	Environmental Manager Project Engineers Foreman
CSWQMM53	Immediately schedule de-silting and water treatment as per the procedure below, if sediment accumulates to a level above 30% of the sediment storage zone marker.		✓	Environmental Manager Project Engineers Foreman
CSWQMM54	Apply flocculant to settle sediments within 24 hours of the conclusion of the last rainfall event, where safe to do so		✓	Environmental Manager Project Engineers Foreman
CSWQMM55	Include the following items on sediment basins: <ul style="list-style-type: none"> a spillway constructed and stabilised to the 100-year ARI event with appropriate levels of designed freeboard a marker peg (or equivalent) showing the boundary between the Sediment (Storage) and Water (Settling) zones of the basin lined inlets to minimise scour, and 		✓	Environmental Manager Project Engineers Foreman

ID	Mitigation Measure	Timing		Responsibility
		PC ¹	C ²	
	<ul style="list-style-type: none"> measures to minimise the safety risk for site workers. Identification signage inclusive of basin details and respective discharge point numbering in accordance with project EPL. 			
CSWQMM56	Adequately compact and stabilise sediment basin walls with appropriate protective ground cover. Provide freeboard of at least 600mm from the spillway invert to the top of any earth wall.		✓	Environmental Manager Project Engineers Foreman
CSWQMM57	Preferably reuse water from sediment basins onsite for compaction and dust suppression.		✓	Environmental Manager Project Engineers Foreman
CSWQMM58	Treat water in sediment basins as described above and discharge within a 5 day period after a rain event.		✓	Environmental Manager Project Engineers Foreman
CSWQMM59	Undertake all dewatering on site in accordance with RMS's guidelines titled <i>Environmental Management of Construction Site Dewatering</i> . Prepare and implement a <i>Construction Site Dewatering Environmental Work Method Statement</i> to ensure that the waters being discharged meet the specified water quality criteria.		✓	Environmental Manager Project Engineers Foreman
CSWQMM60	Issue a <i>Dewatering Permit</i> prior to any dewatering on site.		✓	Environmental Manager Project Engineers Foreman
5.7 Stabilisation of disturbed areas				
CSWQMM61	Where using cover crop species to progressively revegetate disturbed areas, use Rye Corn during the months of April to August or Japanese Millet during the months of September to March.		✓	Project Engineers Foreman
CSWQMM62	Commence stabilisation of waterways, including their beds and banks, immediately after the completion of any works within these areas		✓	Project Engineers Foreman
CSWQMM63	Control dust through progressive revegetation techniques and by watering unsealed areas.		✓	Project Engineers Foreman

ID	Mitigation Measure	Timing		Responsibility
		PC ¹	C ²	
CSWQMM64	Use temporary ground covers such as soil stabilisers (e.g. Gluon polymer emulsion), hydroseed or hydromulch as much as possible to stabilise batters, stockpiles and large surface areas.		✓	Project Engineers Foreman
5.8 Management of contaminated materials				
CSWQMM65	In the event that contamination is identified implement <i>Unexpected Discovery of Contaminated Land Procedure</i> included in Appendix E of this Plan.		✓	Environmental Manager
CSWQMM66	Develop a remedial action plan if contamination is found to pose unacceptable risks to the environment or human health. Undertake remediation works in consultation with the EPA.		✓	Environmental Manager
CSWQMM67	Should the presence of ASS be confirmed, follow ASS Management Procedure included in Appendix E of this plan.		✓	Environmental Manager Project Engineers Foreman
CSWQMM68	Prepare an ASSMP if required, to identify strategies to remove or reduce the risks associated with ASS.		✓	Environmental Manager
5.9 Surface water quality management				
CSWQMM69	<p>Test and, if required, treat water before it is released from any discharge points (i.e. from sediment basins). Then re-test (and, if required, re-treat) the water. Do not release until the following water quality parameters are met:</p> <ul style="list-style-type: none"> pH 6.5-8.5 TSS < 50mg/L No visible oil or grease. <p>Note: As of 6/5/15, EPA has agreed to the correlation between Site turbidity of 105 NTU being equal to total suspended solids of 50mg/L, with a conservative approach that 85NTU is permissible for discharge. This is on the basis that 10% of all samples are sent for independent NATA laboratory analysis to maintain quality assurance and ongoing evaluation on the relationship between NTU & TSS.</p> <p>Promptly distribute the results of water quality monitoring to relevant project staff for action and further investigate any exceedances. Where a discharge occurs solely as a result of rainfall exceeding the 5-day 85th percentile rainfall depth value of 48.2mm (from EPL), the abovementioned pH and TSS do not apply.</p>		✓	Environmental Manager
CSWQMM70	Carry out testing within 24 hours of a controlled or scheduled discharge of waters, or daily for any discharge caused by a rainfall event less than or equal to 42.1mm.		✓	Environmental Manager

ID	Mitigation Measure	Timing		Responsibility
		PC ¹	C ²	
CSWQMM71	If water is to be re-used for dust suppression or construction purposes, the above criteria do not apply providing water does not leave the site (either directly or indirectly via runoff).		✓	Environmental Manager
CSWQMM72	Provide and maintain access to the sediment basins to permit: <ul style="list-style-type: none"> • clear identification of each sediment basin and discharge point • easy collection of samples • collection of representative samples of water discharged from the sediment basin(s), and • access to the sampling point(s) at all times by an authorised officer of the EPA. 		✓	Environmental Manager
CSWQMM73	Complete construction water quality monitoring in accordance with the <i>Water Quality Monitoring Program</i> included in Appendix B of this plan.		✓	Environmental Manager
CSWQMM74	Record and retain the results of any monitoring: <ul style="list-style-type: none"> • in a legible form, or in a form that can readily be reduced to a legible form • for at least 4 years after the monitoring or recording event to which they relate took place, and • so that they can be produced in a legible form to any authorised officer of the EPA who asks to see them. 		✓	Environmental Manager
CSWQMM75	Check weather forecasts daily and implement the <i>Heavy Rainfall Event Procedure</i> (included in Appendix G of this plan), if warranted.		✓	Environmental Manager
CSWQMM76	Manage vegetation stockpiles to minimise the impact of tannins leaching into the surrounding environment in accordance with <i>Environmental Direction – Management of Tannins from Vegetation Mulch</i> (RMS, 2012) included in Appendix D of this plan.		✓	Environmental Manager Project Engineers Foreman
CSWQMM77	Manage and use treated effluent, if used for dust suppression on site, in accordance with RMS' <i>Environmental Direction No: 19 - Use of Reclaimed Water</i> (RTA 2006) and RMS' <i>Tip Sheet – Use of Reclaimed Water</i> (RTA 2006) included in Appendix H of this plan.		✓	Environmental Manager Project Engineers Foreman
5.10 Groundwater management				
CSWQMM78	Establish a groundwater monitoring network along the Project to monitor groundwater quality in accordance with the <i>Water Quality Monitoring Program</i> included in Appendix B of this plan.	✓	✓	Environmental Manager Project Engineers Foreman

ID	Mitigation Measure	Timing		Responsibility
		PC ¹	C ²	
CSWQMM79	Detail the establishment of a groundwater monitoring network along the route to adequately characterise groundwater quality and establish background water quality within the alluvial / colluvial aquifers and Shoalhaven Group Sediments, including the Broughton Sandstone and latite as per the <i>Water Quality Monitoring Program</i> included in Appendix B of this plan.	✓	✓	Environmental Manager Project Engineers Foreman
CSWQMM80	Install monitoring wells adjacent to major cuts to confirm existing groundwater levels and to monitor the effect on groundwater levels by construction activity, where groundwater is encountered as per the <i>Water Quality Monitoring Program</i> included in Appendix B of this plan.	✓	✓	Environmental Manager Project Engineers Foreman
CSWQMM81	Implement a groundwater monitoring program that would assess the performance of groundwater mitigation measures during construction as per the <i>Water Quality Monitoring Program</i> included in Appendix B of this plan.		✓	Environmental Manager Project Engineers Foreman
5.11 Management of other activities with potential water quality impact				
Concreting and Saw Cutting				
CSWQMM82	Wash concrete mixers, pumps, concrete tools and other equipment at specially designated washout areas that are constructed in a manner that will prevent storm water surface run-off from being contaminated.		✓	Environmental Manager Foreman
CSWQMM83	Locate washout areas within an area that is not subject to natural surface storm water run-off and away from drainage lines. Post signs to advise workers of their locations.		✓	Environmental Manager Foreman
CSWQMM84	Construct the washout areas with an impermeable type material capable of retaining any contaminated water and concrete residue.		✓	Environmental Manager Foreman
CSWQMM85	Monitor the washout areas to ensure that they are not getting over full and that the washing activity is not contaminating the surrounding area.		✓	Environmental Manager Foreman
CSWQMM86	As part of the project induction program, advise all personnel performing concreting or saw cutting activities of the concrete washout areas and their obligations to: <ul style="list-style-type: none"> • clean their plant, tools and equipment within the designated area • maintain the area in a clean condition, and • ensure that contaminated water associated with their activities is appropriately controlled and prevented from reaching natural storm water surface drainage areas. 		✓	Environmental Manager
Spray Sealing and Asphalt Paving				

ID	Mitigation Measure	Timing		Responsibility
		PC ¹	C ²	
CSWQMM87	Properly maintain and regularly check spray sealing and asphalt paving plant, equipment and associated tools to minimise the risk of spills.		✓	Foreman
CSWQMM88	Promptly contain and collect any spills of fuel or bitumen materials using spill kits. Maintain spill kits and fire extinguishers at all times in the spray trucks, tankers and associated plant.		✓	Foreman
CSWQMM89	Promptly report all spills to the Environmental Manager.		✓	Environmental Manager Foreman
CSWQMM90	Allocate designated equipment washdown and cleaning areas for major asphalt works with appropriate environmental controls in place to prevent washout water from reaching the receiving environment.		✓	Foreman
Storage and Handling of Fuels and Chemicals				
CSWQMM91	Where practicable, do not locate storage areas within 50 meters of natural surface drainage areas, storm drainage systems or poorly drained or flood prone areas or any area with a slope steeper than 10%.		✓	Project Engineers Foreman
CSWQMM92	Maintain the Safety Data Sheet (SDS) and Hazardous Products Register and copies of all SDS documents in the site office within a special SDS folder.		✓	Safety Manager
CSWQMM93	Clearly label, use and handle liquid and dry chemicals (including oils and fuels) in accordance with the instructions provided in its SDS document.		✓	Foreman
CSWQMM94	Keep liquid chemicals and fuels in bunded storage areas or sheds that have the capacity to contain spills from leaky containers or from an incident involving a decanting activity. Ensure the bunded capacity is at least 120% of the total capacity of all containers stored inside the bunded area or shed.		✓	Foreman
CSWQMM95	Where practicable, locate designated plant refuelling areas, plant service/maintenance areas and concrete/plant wash down areas at least 5 meters from native vegetation and at least 50m from the following: <ul style="list-style-type: none"> a natural surface drainage area, and a built drainage structure such as a storm water pipe or box culvert. 		✓	Foreman
CSWQMM96	During site induction, advise all personnel of the following: <ul style="list-style-type: none"> The location of bunded storage areas, liquid absorbent materials and other spill containment materials and kits. Storage of large quantities of fuel for construction plant is not permitted. Licensed fuel trucks carrying emergency fuel spill kits must be used to service plant and equipment. All drums and decanted containers must be labelled and stored within bunded areas whenever they are not in use. Whenever practical, all unattended drums/containers must be returned to the bunded storage area. 		✓	Environmental Manager

ID	Mitigation Measure	Timing		Responsibility
		PC ¹	C ²	
Temporary batching plants				
CSWQMM97	Locate temporary batching plants in accordance with the <i>Ancillary facilities assessment</i> included in Appendix A5 of the CEMP.	✓	✓	Environmental Manager
CSWQMM98	Establish and operate concrete batching plants in accordance with the <i>Concrete batching establishment and operation EWMS</i> .		✓	Environmental Manager Project Engineers Foreman

6 Compliance management

6.1 Roles and responsibilities

Fulton Hogan's Project Team organisational structure and overall roles and responsibilities are outlined in Section 4.1 of the CEMP. Specific responsibilities for the implementation of environmental controls are detailed in Table 5-1 of this CSWQMP.

6.2 Training

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

- existence and requirements of this CSWQMP
- relevant legislation
- roles and responsibilities for soil and water management
- the location of ASS or PASS
- water quality management and protection measures
- groundwater issues, and
- 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
- preparedness for high rainfall events
- lessons learnt from incidents and other event e.g. high rainfall / flooding
- mulch and tannin management
- spill response
- stockpile location criteria, and
- identification of potentially contaminated spoil and fill material.

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

6.3 Monitoring and inspections

Regular monitoring and inspections will be undertaken during construction in accordance with **Table 6-1**. Additional requirements and responsibilities in relation to inspections and monitoring are documented in Sections 8.1 and 8.2 of the CEMP.

Table 6-1 Monitoring and inspection

Monitoring details	Area	Record	Responsibility	Frequency
Surface and groundwater monitoring	As per Appendix B - Water Quality Monitoring Program	Monthly Environmental Reports	Environmental Officer	Monthly
Groundwater observations during excavation	As required during excavation activities	Site Environmental Inspection Report	Environmental Officer	Weekly
Site inspections by Soil Conservationist	All	Soil Conservationist's report	Environmental Manager	At least fortnightly
Potential rainfall and other adverse weather impacts	All	Automatic weather station web portal	Environmental Officer	Daily

6.4 Non-conformances

Non-conformances will be dealt with and documented in accordance with Section 8.5 of the CEMP.

6.5 Complaints

Complaints will be recorded and addressed in accordance with Section 6.3 of the CEMP and the Community Communication Strategy (CCS).

6.6 Audits

Audits (both internal and external) will be undertaken to assess the effectiveness of environmental controls, compliance with this CSWQMP, CoA and other relevant approvals, licenses and guidelines. Audit requirements are detailed in Section 8.4 of the CEMP.

7 Review and improvement of CSWQMP

The CSWQMP will be reviewed annually to ensure compliance with legislative requirements and its suitability and effectiveness for the project.

The review may be in the form of:

- a formal management review
- a second party audit, and/or
- an inclusion as a separate item at a site meeting.

The Environmental Manager can review and update the CSWQMP more regularly where:

- significant changes in construction activities occur
- where targets are not being achieved, or
- in response to audits and nonconformity reports.

Minor changes to the CSWQMP will be approved by the Environmental Representative in accordance with section 1.7 of the CEMP.

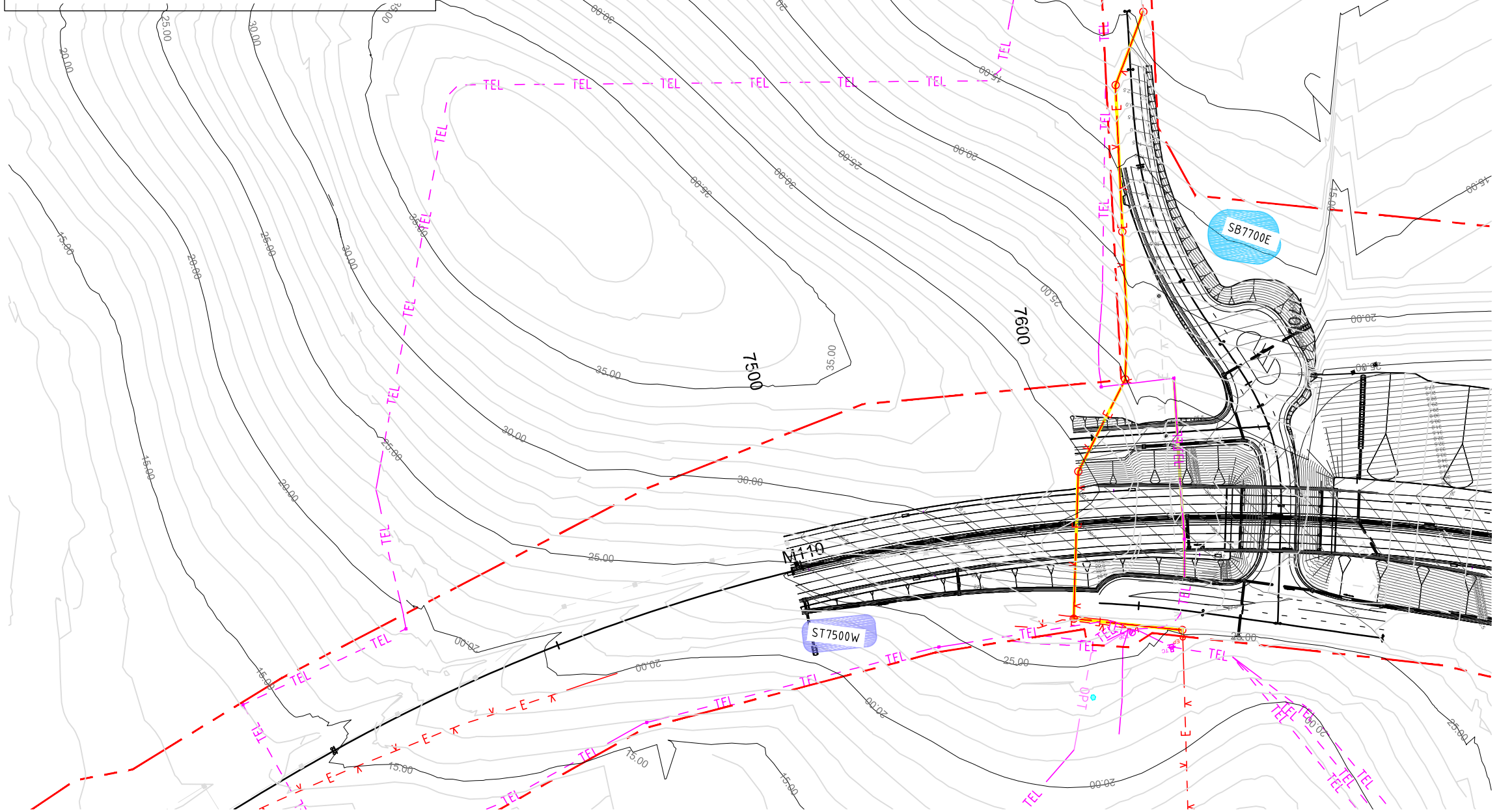
Appendix A

Erosion and Sediment Control Plan






To be provided as a separate file

EROSION AND SEDIMENT CONTROL PLAN - GENERAL NOTE

THESE PLANS ARE PRIMARY ESCPs USING BLUE BOOK (LANDCOM, 2004) DEFAULT VALUES BASED ON SURROUNDING LOCATIONS. THE CONTROLS SHOWN ONLY INCLUDE MAJOR SEDIMENT BASINS/TRAPS AND CLEAN WATER DIVERSIONS. DETAILED PROGRESSIVE ESCPs MUST BE COMPLETED PRIOR TO CONSTRUCTION WORKS IN CONSULTATION WITH RMS, EPA AND OTHER RELEVANT REGULATORY AUTHORITIES.



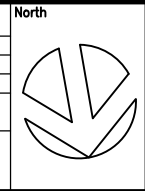
LEGEND

-  NATURAL/EXISTING CREST LOCATION
-  PROPOSED ROAD CREST LOCATION
-  SEDIMENT BASIN (SB) - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX FOR SEDIMENT BASIN VOLUMES)
-  SEDIMENT TRAP (ST) / TEMPORARY ONLINE BASIN - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX)
-  TEMPORARY WATERWAY DIVERSION AROUND CULVERT WORKS (DETAIL A/C)

NOT FOR CONSTRUCTION

REV	DATE	DES.	DRN.	APP.	REVISION DETAILS
A	29/05/14	A.J.B.	A.J.B.		DRAFT - SEDIMENT BASIN/TRAP LOCATIONS - FOR CONSULTATION

DRAWING STATUS	
DESIGN BY	A.M. / A.J.B.
DRAWN BY	A.J.B.
FINAL APPROVAL	
SCALE:	1:2000
(on A3 Original)	
DRAFT	



CLIENT




PO Box 1098, Bowral, NSW, 2576
 Suites 9 & 10, Bowral Mall
 Cnr. Bowley & Station Streets, Bowral.
 (t) 02 4862 1633
 (f) 02 4862 3088
 email: reception@seec.com.au
 WWW.SEEC.COM.AU

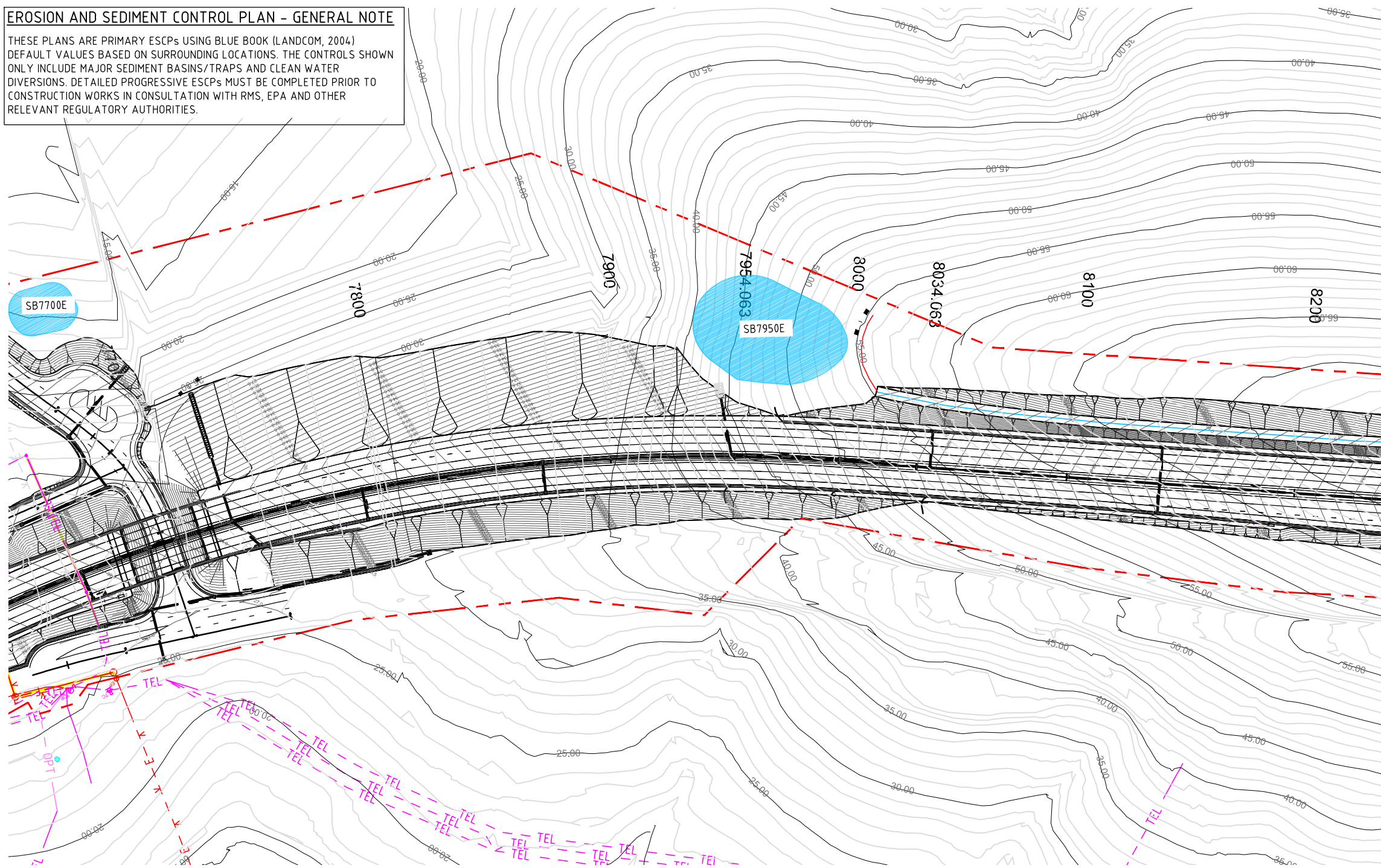
PROJECT TITLE

**HW1 PRINCES HIGHWAY
 FOXGROUND AND BERRY BY-PASS
 TOOLIJOOA ROAD TO
 SCHOFIELDS LANE**






DRAWING TITLE			
PRIMARY EROSION AND SEDIMENT CONTROL PLAN CH7500 TO CH7700			
PROJECT NO.	SUB-PR NO.	DRAWING NO.	REV
13000157	P02	ESCP101	A

EROSION AND SEDIMENT CONTROL PLAN - GENERAL NOTE

THESE PLANS ARE PRIMARY ESCPs USING BLUE BOOK (LANDCOM, 2004) DEFAULT VALUES BASED ON SURROUNDING LOCATIONS. THE CONTROLS SHOWN ONLY INCLUDE MAJOR SEDIMENT BASINS/TRAPS AND CLEAN WATER DIVERSIONS. DETAILED PROGRESSIVE ESCPs MUST BE COMPLETED PRIOR TO CONSTRUCTION WORKS IN CONSULTATION WITH RMS, EPA AND OTHER RELEVANT REGULATORY AUTHORITIES.



LEGEND

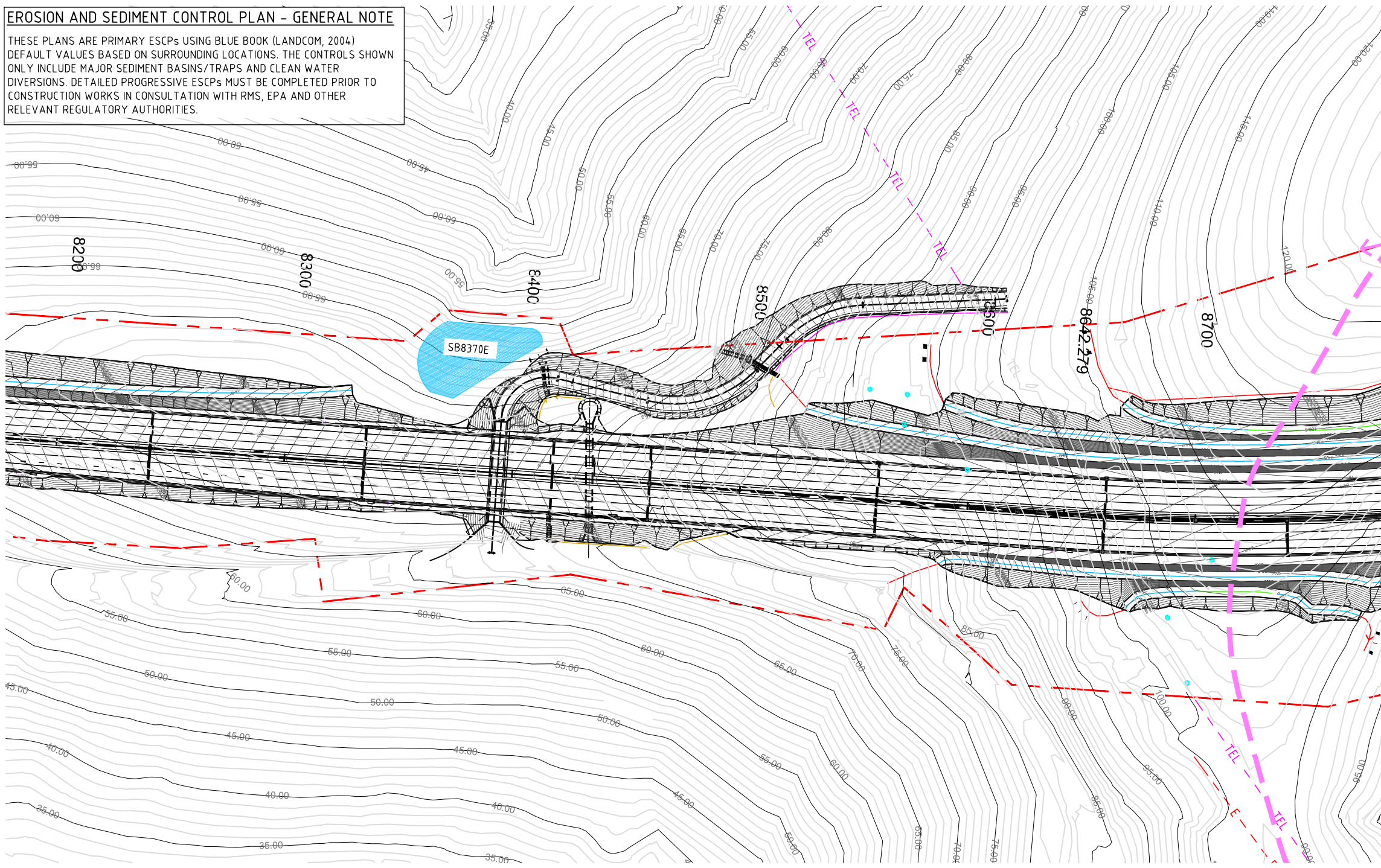
-  NATURAL/EXISTING CREST LOCATION
-  PROPOSED ROAD CREST LOCATION
-  SEDIMENT BASIN (SB) - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX FOR SEDIMENT BASIN VOLUMES)
-  SEDIMENT TRAP (ST) / TEMPORARY ONLINE BASIN - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX)
-  TEMPORARY WATERWAY DIVERSION AROUND CULVERT WORKS (DETAIL A/C)

NOT FOR CONSTRUCTION

REV	DATE	DES.	DRN.	APP.	REVISION DETAILS	DRAWING STATUS		North	CLIENT	PROJECT TITLE	DRAWING TITLE			
						DESIGN BY	A.M. / A.J.B.			 PO Box 1098, Bowral, NSW, 2576 Suites 9 & 10, Bowral Mall Cnr. Bowley & Station Streets, Bowral. (I) 02 4862 1633 (F) 02 4862 3088 email: reception@seec.com.au WWW.SEEC.COM.AU	PRIMARY EROSION AND SEDIMENT CONTROL PLAN CH7700 TO CH8200			
					DRAWN BY	A.J.B.								
					FINAL APPROVAL									
						SCALE:	1:2000				PROJECT NO.	SUB-PR NO.	DRAWING NO.	REV
A	29/05/14	A.J.B.	A.J.B.		DRAFT - SEDIMENT BASIN/TRAP LOCATIONS - FOR CONSULTATION	DRAFT					13000157	P02	ESCP102	A

EROSION AND SEDIMENT CONTROL PLAN - GENERAL NOTE

THESE PLANS ARE PRIMARY ESCPs USING BLUE BOOK (LANDCOM, 2004) DEFAULT VALUES BASED ON SURROUNDING LOCATIONS. THE CONTROLS SHOWN ONLY INCLUDE MAJOR SEDIMENT BASINS/TRAPS AND CLEAN WATER DIVERSIONS. DETAILED PROGRESSIVE ESCPs MUST BE COMPLETED PRIOR TO CONSTRUCTION WORKS IN CONSULTATION WITH RMS, EPA AND OTHER RELEVANT REGULATORY AUTHORITIES.



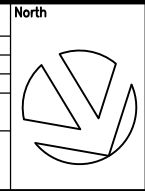
LEGEND

-  NATURAL/EXISTING CREST LOCATION
-  PROPOSED ROAD CREST LOCATION
-  SEDIMENT BASIN (SB) - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX FOR SEDIMENT BASIN VOLUMES)
-  SEDIMENT TRAP (ST) / TEMPORARY ONLINE BASIN - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX)
-  TEMPORARY WATERWAY DIVERSION AROUND CULVERT WORKS (DETAIL A/C)

NOT FOR CONSTRUCTION

REV	DATE	DES.	DRN.	APP.	REVISION DETAILS
A	29/05/14	A.J.B.	A.J.B.		DRAFT - SEDIMENT BASIN/TRAP LOCATIONS - FOR CONSULTATION

DRAWING STATUS	
DESIGN BY	A.M. / A.J.B.
DRAWN BY	A.J.B.
FINAL APPROVAL	
SCALE:	1:2000
(on A3 Original)	
DRAFT	



CLIENT

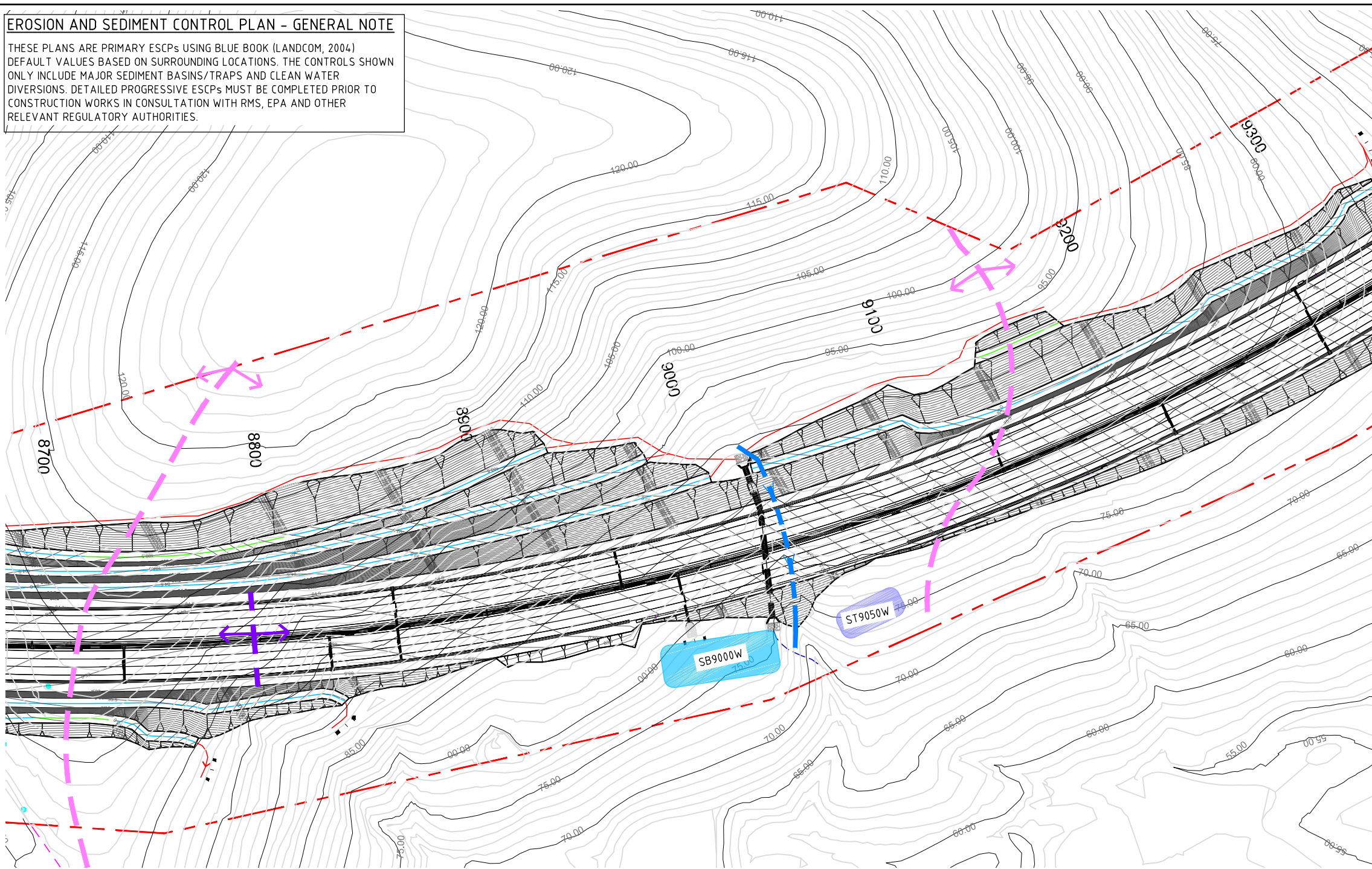


PROJECT TITLE
**HW1 PRINCES HIGHWAY
 FOXGROUND AND BERRY BY-PASS
 TOOLIJOOA ROAD TO
 SCHOFIELDS LANE**






DRAWING TITLE			
PRIMARY EROSION AND SEDIMENT CONTROL PLAN CH8200 TO CH8700			
PROJECT NO.	SUB-PR NO.	DRAWING NO.	REV
13000157	P02	ESCP103	A

EROSION AND SEDIMENT CONTROL PLAN - GENERAL NOTE

THESE PLANS ARE PRIMARY ESCPs USING BLUE BOOK (LANDCOM, 2004) DEFAULT VALUES BASED ON SURROUNDING LOCATIONS. THE CONTROLS SHOWN ONLY INCLUDE MAJOR SEDIMENT BASINS/TRAPS AND CLEAN WATER DIVERSIONS. DETAILED PROGRESSIVE ESCPs MUST BE COMPLETED PRIOR TO CONSTRUCTION WORKS IN CONSULTATION WITH RMS, EPA AND OTHER RELEVANT REGULATORY AUTHORITIES.



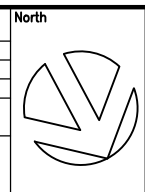
LEGEND

-  NATURAL/EXISTING CREST LOCATION
-  PROPOSED ROAD CREST LOCATION
-  SEDIMENT BASIN (SB) - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX FOR SEDIMENT BASIN VOLUMES)
-  SEDIMENT TRAP (ST) / TEMPORARY ONLINE BASIN - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX)
-  TEMPORARY WATERWAY DIVERSION AROUND CULVERT WORKS (DETAIL A/C)

NOT FOR CONSTRUCTION

REV	DATE	DES.	DRN.	APP.	REVISION DETAILS
A	29/05/14	A.J.B.	A.J.B.		DRAFT - SEDIMENT BASIN/TRAP LOCATIONS - FOR CONSULTATION

DRAWING STATUS	
DESIGN BY	A.M. / A.J.B.
DRAWN BY	A.J.B.
FINAL APPROVAL	
SCALE:	1:2000
(on A3 Original)	
DRAFT	



CLIENT

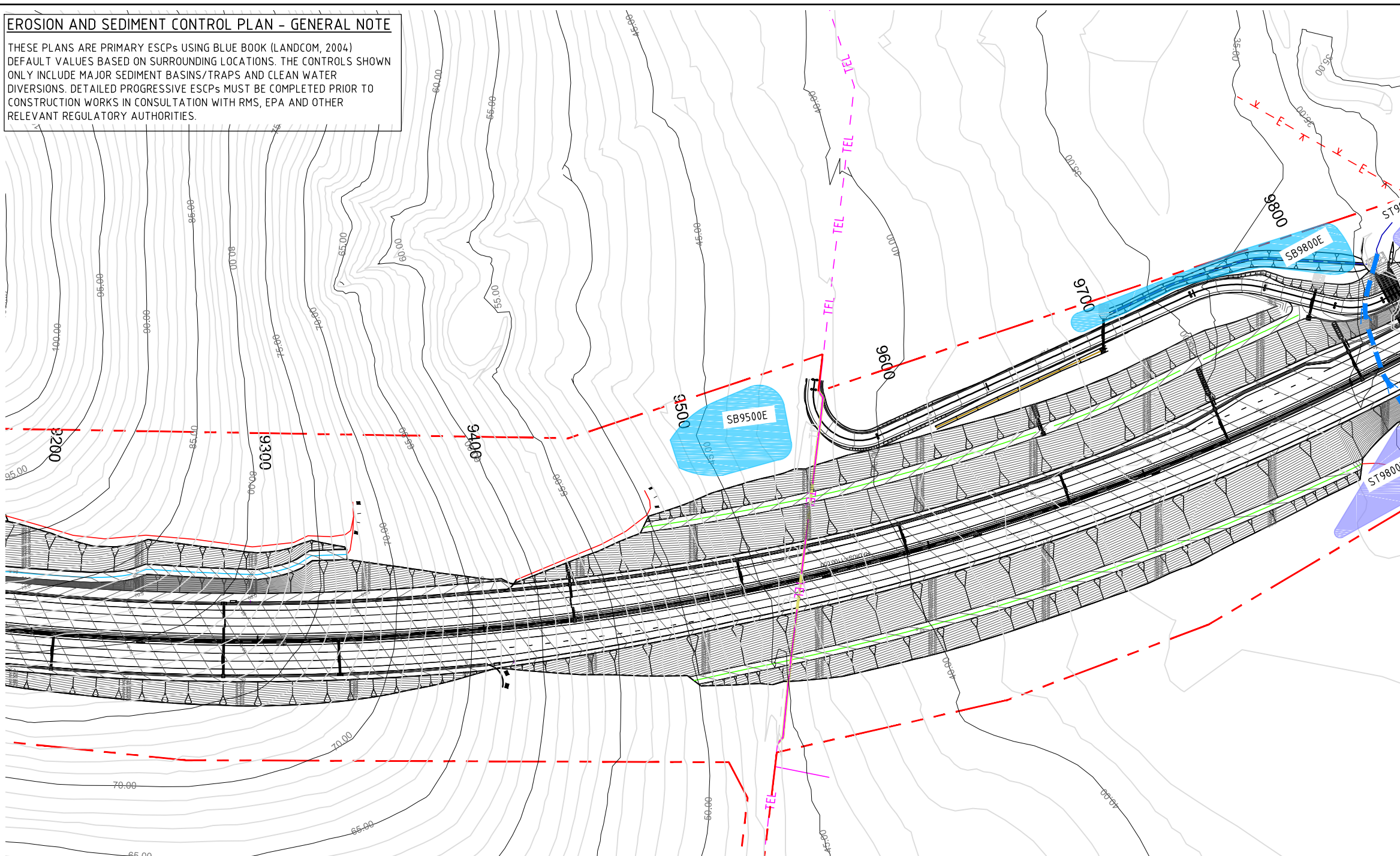


PROJECT TITLE
**HW1 PRINCES HIGHWAY
 FOXGROUND AND BERRY BY-PASS
 TOOLIJOOA ROAD TO
 SCHOFIELDS LANE**






DRAWING TITLE			
PRIMARY EROSION AND SEDIMENT CONTROL PLAN CH8700 TO CH9200			
PROJECT NO.	SUB-PR NO.	DRAWING NO.	REV
13000157	P02	ESCP104	A

EROSION AND SEDIMENT CONTROL PLAN - GENERAL NOTE

THESE PLANS ARE PRIMARY ESCPs USING BLUE BOOK (LANDCOM, 2004) DEFAULT VALUES BASED ON SURROUNDING LOCATIONS. THE CONTROLS SHOWN ONLY INCLUDE MAJOR SEDIMENT BASINS/TRAPS AND CLEAN WATER DIVERSIONS. DETAILED PROGRESSIVE ESCPs MUST BE COMPLETED PRIOR TO CONSTRUCTION WORKS IN CONSULTATION WITH RMS, EPA AND OTHER RELEVANT REGULATORY AUTHORITIES.



LEGEND

-  NATURAL/EXISTING CREST LOCATION
-  PROPOSED ROAD CREST LOCATION
-  SEDIMENT BASIN (SB) - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX FOR SEDIMENT BASIN VOLUMES)
-  SEDIMENT TRAP (ST) / TEMPORARY ONLINE BASIN - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX)
-  TEMPORARY WATERWAY DIVERSION AROUND CULVERT WORKS (DETAIL A/C)

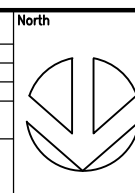
ADDITIONAL REQUIREMENTS FOR FLOOD PRONE LANDS AND LANDS WHERE HIGH GROUND WATER IS ENCOUNTERED WHERE APPLICABLE)

- ACCESS/HAUL ROADS TO BE FORMED USING ROCK WITH GEOTEXTILE UNDERLAY (THIS CAN BE INCORPORATED AS PART OF THE ROAD BRIDGING LAYER WHERE APPLICABLE)
- MINIMISE STRIPPING OF GRASS VEGETATION AND TOPSOIL AS MUCH AS POSSIBLE. CONSTRUCT WORKS OVER THE TOP OF EXISTING GRASS WHERE POSSIBLE
- EXPOSED FILL BATTERS TO BE STABILISED (LOCKED DOWN WITH SOIL STABILISERS OR COVERED WITH FABRIC/MATTING) PRIOR TO RAINFALL, SITE CLOSURE OR WHEN WORKS ARE ON HOLD
- PERMANENT STABILISATION OF FILL BATTERS IS TO OCCUR PROGRESSIVELY
- TOP EDGES OF THE FILLS ARE TO HAVE WINDROWS/BUNDS WITH REGULAR BATTER CHUTES
- CULVERTS AND CLEAN DIVERSIONS TO BE CONSTRUCTED AS EARLY WORKS
- TURKEYS NEST SEDIMENT BASINS WILL BE REQUIRED IN AREAS OF HIGH GROUND WATER. THESE BASINS ARE TO BE BUILT UP PROGRESSIVELY AS THE FILL COMES UP OR BASIN INLETS PROGRESSIVELY RAISED AS THE FILL COMES UP. SUPPLEMENTARY SEDIMENT TRAPS ON-LINE AND INCREASED EROSION CONTROLS ARE TO BE EMPLOYED UNTIL THE FULL SEDIMENT BASIN VOLUMES ARE ACHIEVED
- BASINS TO BE BUILT AS LARGE IN SURFACE AREA AS POSSIBLE TO LIMIT THE BASIN HEIGHT AND LEVEL OF EXCAVATION
- UNTIL SUCH TIME THAT FULL SIZE SEDIMENT BASINS CAN BE EMPLOYED OR IN LOCATIONS WHERE SEDIMENT BASIN CONSTRUCTION IS NOT SUITABLE, SEDIMENT FILTRATION SUMPS/TRAPS TO BE PROVIDED IN LOW POINTS ARE AROUND LOWER EDGES OF WORKS (E.G. ROCK FILTER DAMS OR EQUIVALENT SEDIMENT FILTRATION DEVICE)
- SEDIMENT BASINS WILL REQUIRE ARMoured WALLS
- ANY WORKS WITHIN WATERCOURSES ARE TO BE SCHEDULED FOR LOW RAINFALL AND RAINFALL EROSION TIMES OF THE YEAR AND WORKS ARE TO BE STAGED AS MUCH AS POSSIBLE TO MINIMISE EXPOSURE

NOT FOR CONSTRUCTION

REV	DATE	DES.	DRN.	APP.	REVISION DETAILS
A	29/05/14	A.J.B.	A.J.B.		DRAFT - SEDIMENT BASIN/TRAP LOCATIONS - FOR CONSULTATION

DRAWING STATUS	
DESIGN BY	A.M. / A.J.B.
DRAWN BY	A.J.B.
FINAL APPROVAL	
SCALE:	1:2000
(on A3 Original)	
DRAFT	



CLIENT



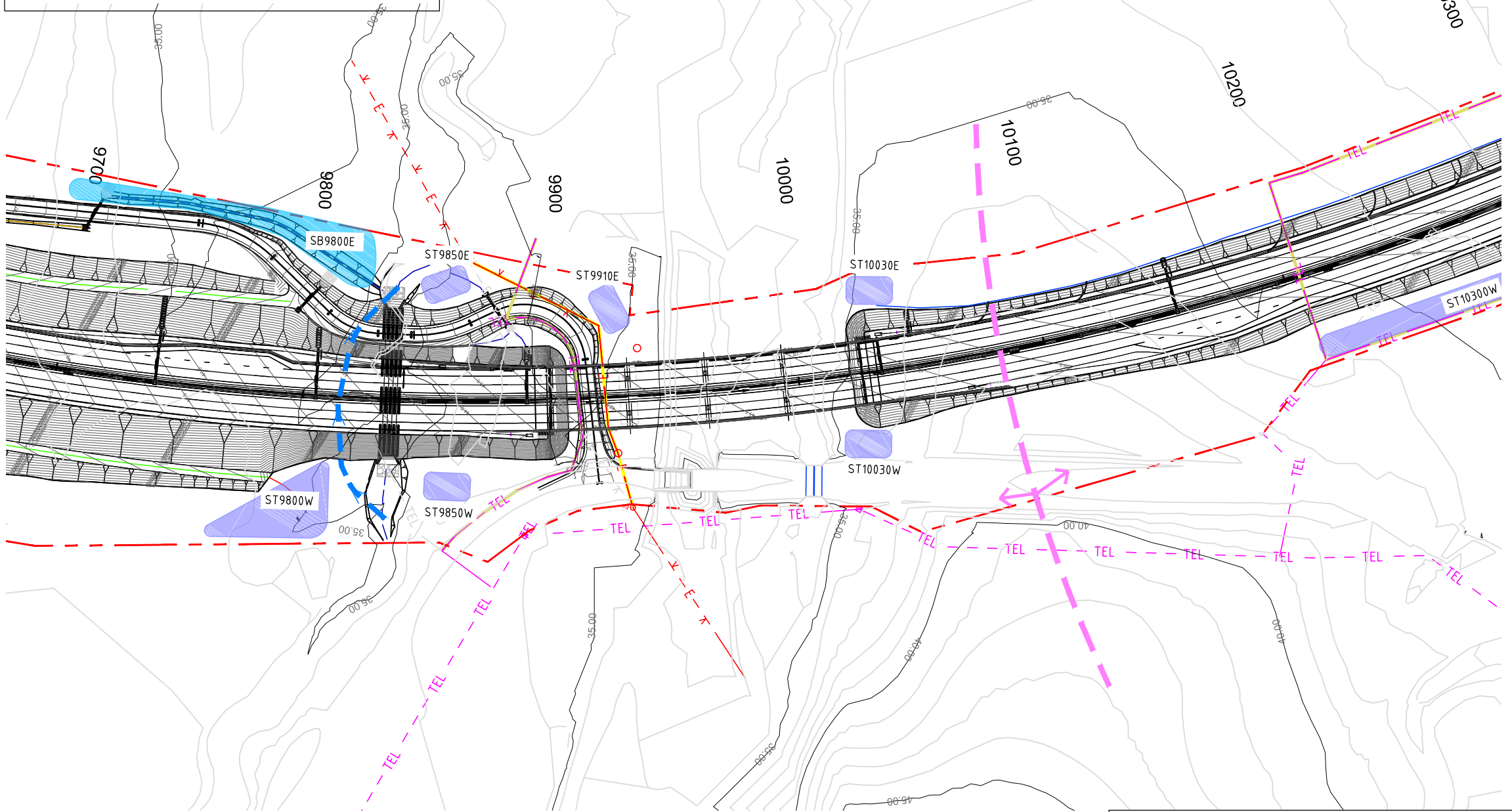
PO Box 1098, Bowral, NSW, 2576
 Suites 9 & 10, Bowral Mall
 Cnr. Bowley & Station Streets, Bowral.
 (t) 02 4862 1633
 (f) 02 4862 3088
 email: reception@seec.com.au
 WWW.SEEC.COM.AU

PROJECT TITLE
 HW1 PRINCES HIGHWAY
 FOXGROUND AND BERRY BY-PASS
 TOOLIJOOA ROAD TO
 SCHOFIELDS LANE






DRAWING TITLE			
PRIMARY EROSION AND SEDIMENT CONTROL PLAN CH9200 TO CH9700			
PROJECT NO.	SUB-PR NO.	DRAWING NO.	REV
13000157	P02	ESCP105	A

EROSION AND SEDIMENT CONTROL PLAN - GENERAL NOTE

THESE PLANS ARE PRIMARY ESCPs USING BLUE BOOK (LANDCOM, 2004) DEFAULT VALUES BASED ON SURROUNDING LOCATIONS. THE CONTROLS SHOWN ONLY INCLUDE MAJOR SEDIMENT BASINS/TRAPS AND CLEAN WATER DIVERSIONS. DETAILED PROGRESSIVE ESCPs MUST BE COMPLETED PRIOR TO CONSTRUCTION WORKS IN CONSULTATION WITH RMS, EPA AND OTHER RELEVANT REGULATORY AUTHORITIES.



LEGEND

-  NATURAL/EXISTING CREST LOCATION
-  PROPOSED ROAD CREST LOCATION
-  SEDIMENT BASIN (SB) - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX FOR SEDIMENT BASIN VOLUMES)
-  SEDIMENT TRAP (ST) / TEMPORARY ONLINE BASIN - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX)
-  TEMPORARY WATERWAY DIVERSION AROUND CULVERT WORKS (DETAIL A/C)

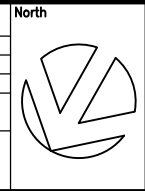
ADDITIONAL REQUIREMENTS FOR FLOOD PRONE LANDS AND LANDS WHERE HIGH GROUND WATER IS ENCOUNTERED WHERE APPLICABLE

- ACCESS/HAUL ROADS TO BE FORMED USING ROCK WITH GEOTEXTILE UNDERLAY (THIS CAN BE INCORPORATED AS PART OF THE ROAD BRIDGING LAYER WHERE APPLICABLE)
- MINIMISE STRIPPING OF GRASS VEGETATION AND TOPSOIL AS MUCH AS POSSIBLE. CONSTRUCT WORKS OVER THE TOP OF EXISTING GRASS WHERE POSSIBLE
- EXPOSED FILL BATTERS TO BE STABILISED (LOCKED DOWN WITH SOIL STABILISERS OR COVERED WITH FABRIC/MATTING) PRIOR TO RAINFALL, SITE CLOSURE OR WHEN WORKS ARE ON HOLD
- PERMANENT STABILISATION OF FILL BATTERS IS TO OCCUR PROGRESSIVELY
- TOP EDGES OF THE FILLS ARE TO HAVE WINDROWS/BUNDS WITH REGULAR BATTER CHUTES
- CULVERTS AND CLEAN DIVERSIONS TO BE CONSTRUCTED AS EARLY WORKS
- TURKEYS NEST SEDIMENT BASINS WILL BE REQUIRED IN AREAS OF HIGH GROUND WATER. THESE BASINS ARE TO BE BUILT UP PROGRESSIVELY AS THE FILL COMES UP OR BASIN INLETS PROGRESSIVELY RAISED AS THE FILL COMES UP. SUPPLEMENTARY SEDIMENT TRAPS ON-LINE AND INCREASED EROSION CONTROLS ARE TO BE EMPLOYED UNTIL THE FULL SEDIMENT BASIN VOLUMES ARE ACHIEVED
- BASINS TO BE BUILT AS LARGE IN SURFACE AREA AS POSSIBLE TO LIMIT THE BASIN HEIGHT AND LEVEL OF EXCAVATION
- UNTIL SUCH TIME THAT FULL SIZE SEDIMENT BASINS CAN BE EMPLOYED OR IN LOCATIONS WHERE SEDIMENT BASIN CONSTRUCTION IS NOT SUITABLE, SEDIMENT FILTRATION SUMPS/TRAPS TO BE PROVIDED IN LOW POINTS ARE AROUND LOWER EDGES OF WORKS (E.G. ROCK FILTER DAMS OR EQUIVALENT SEDIMENT FILTRATION DEVICE)
- SEDIMENT BASINS WILL REQUIRE ARMoured WALLS
- ANY WORKS WITHIN WATERCOURSES ARE TO BE SCHEDULED FOR LOW RAINFALL AND RAINFALL EROSIONITY TIMES OF THE YEAR AND WORKS ARE TO BE STAGED AS MUCH AS POSSIBLE TO MINIMISE EXPOSURE

NOT FOR CONSTRUCTION

REV	DATE	DES.	DRN.	APP.	REVISION DETAILS
A	29/05/14	A.J.B.	A.J.B.		DRAFT - SEDIMENT BASIN/TRAP LOCATIONS - FOR CONSULTATION

DRAWING STATUS	
DESIGN BY	A.M. / A.J.B.
DRAWN BY	A.J.B.
FINAL APPROVAL	
SCALE:	1:2000
(on A3 Original)	
DRAFT	



CLIENT




PO Box 1098, Bowral, NSW, 2576
 Suites 9 & 10, Bowral Mall
 Cnr. Bowley & Station Streets, Bowral.
 (t) 02 4862 1633
 (f) 02 4862 3088
 email: reception@seec.com.au
 WWW.SEEC.COM.AU

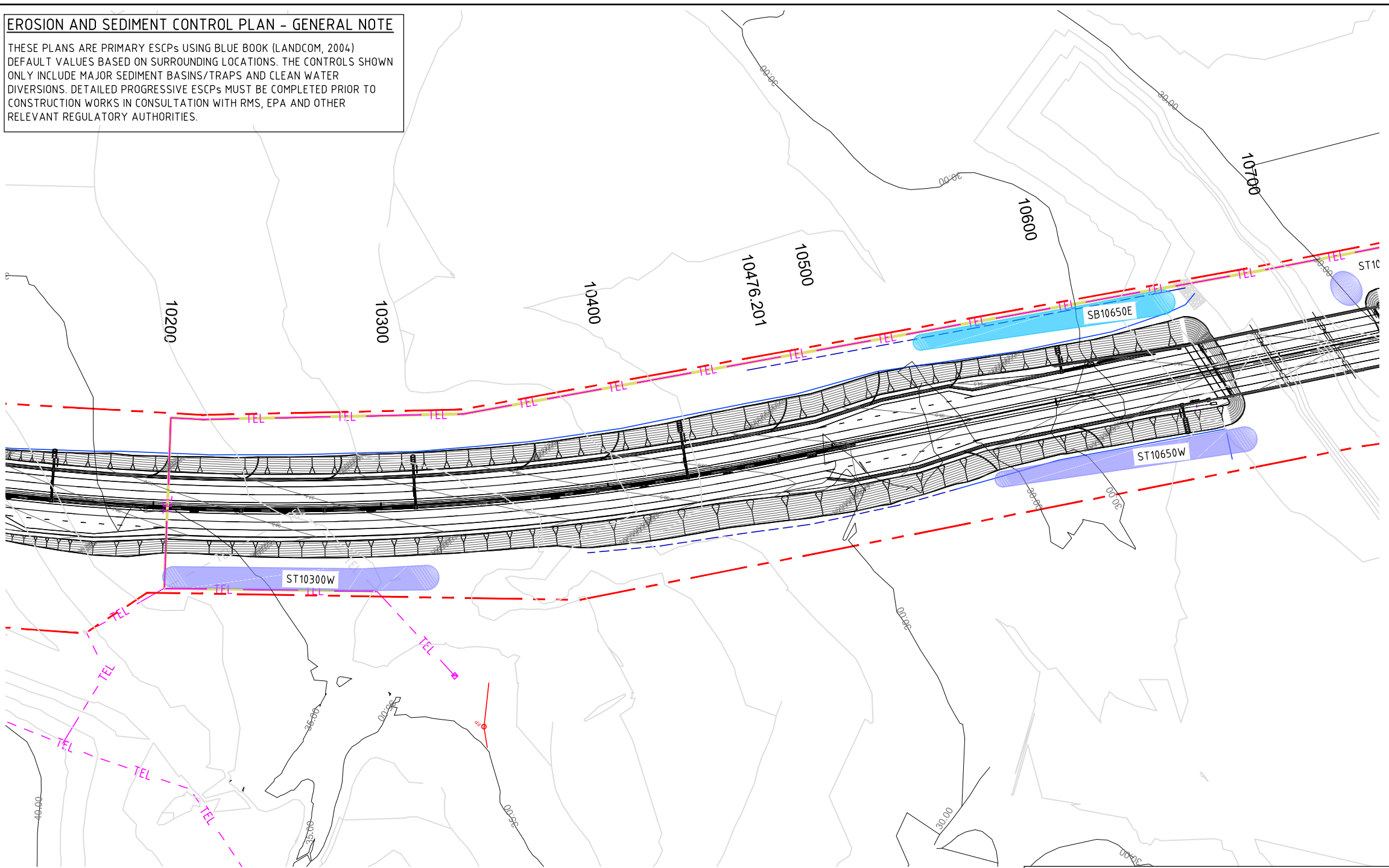
PROJECT TITLE

**HW1 PRINCES HIGHWAY
 FOXGROUND AND BERRY BY-PASS
 TOOLIJOOA ROAD TO
 SCHOFIELDS LANE**






DRAWING TITLE			
PRIMARY EROSION AND SEDIMENT CONTROL PLAN CH9700 TO CH10200			
PROJECT NO.	SUB-PR NO.	DRAWING NO.	REV
13000157	P02	ESCP106	A

EROSION AND SEDIMENT CONTROL PLAN - GENERAL NOTE

THESE PLANS ARE PRIMARY ESCPs USING BLUE BOOK (LANDCOM, 2004) DEFAULT VALUES BASED ON SURROUNDING LOCATIONS. THE CONTROLS SHOWN ONLY INCLUDE MAJOR SEDIMENT BASINS/TRAPS AND CLEAN WATER DIVERSIONS. DETAILED PROGRESSIVE ESCPs MUST BE COMPLETED PRIOR TO CONSTRUCTION WORKS IN CONSULTATION WITH RMS, EPA AND OTHER RELEVANT REGULATORY AUTHORITIES.



LEGEND

-  NATURAL/EXISTING CREST LOCATION
-  PROPOSED ROAD CREST LOCATION
-  SEDIMENT BASIN (SB) - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX FOR SEDIMENT BASIN VOLUMES)
-  SEDIMENT TRAP (ST) / TEMPORARY ONLINE BASIN - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX)
-  TEMPORARY WATERWAY DIVERSION AROUND CULVERT WORKS (DETAIL A/C)

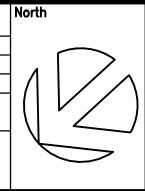
ADDITIONAL REQUIREMENTS FOR FLOOD PRONE LANDS AND LANDS WHERE HIGH GROUND WATER IS ENCOUNTERED WHERE APPLICABLE)

- ACCESS/HAUL ROADS TO BE FORMED USING ROCK WITH GEOTEXTILE UNDERLAY (THIS CAN BE INCORPORATED AS PART OF THE ROAD BRIDGING LAYER WHERE APPLICABLE)
- MINIMISE STRIPPING OF GRASS VEGETATION AND TOPSOIL AS MUCH AS POSSIBLE. CONSTRUCT WORKS OVER THE TOP OF EXISTING GRASS WHERE POSSIBLE
- EXPOSED FILL BATTERS TO BE STABILISED (LOCKED DOWN WITH SOIL STABILISERS OR COVERED WITH FABRIC/MATTING) PRIOR TO RAINFALL, SITE CLOSURE OR WHEN WORKS ARE ON HOLD
- PERMANENT STABILISATION OF FILL BATTERS IS TO OCCUR PROGRESSIVELY
- TOP EDGES OF THE FILLS ARE TO HAVE WINDROWS/BUNDS WITH REGULAR BATTER CHUTES
- CULVERTS AND CLEAN DIVERSIONS TO BE CONSTRUCTED AS EARLY WORKS
- TURKEYS NEST SEDIMENT BASINS WILL BE REQUIRED IN AREAS OF HIGH GROUND WATER. THESE BASINS ARE TO BE BUILT UP PROGRESSIVELY AS THE FILL COMES UP OR BASIN INLETS PROGRESSIVELY RAISED AS THE FILL COMES UP. SUPPLEMENTARY SEDIMENT TRAPS ON-LINE AND INCREASED EROSION CONTROLS ARE TO BE EMPLOYED UNTIL THE FULL SEDIMENT BASIN VOLUMES ARE ACHIEVED
- BASINS TO BE BUILT AS LARGE IN SURFACE AREA AS POSSIBLE TO LIMIT THE BASIN HEIGHT AND LEVEL OF EXCAVATION
- UNTIL SUCH TIME THAT FULL SIZE SEDIMENT BASINS CAN BE EMPLOYED OR IN LOCATIONS WHERE SEDIMENT BASIN CONSTRUCTION IS NOT SUITABLE, SEDIMENT FILTRATION SUMPS/TRAPS TO BE PROVIDED IN LOW POINTS ARE AROUND LOWER EDGES OF WORKS (E.G. ROCK FILTER DAMS OR EQUIVALENT SEDIMENT FILTRATION DEVICE)
- SEDIMENT BASINS WILL REQUIRE ARMOURED WALLS
- ANY WORKS WITHIN WATERCOURSES ARE TO BE SCHEDULED FOR LOW RAINFALL AND RAINFALL EROSION TIMES OF THE YEAR AND WORKS ARE TO BE STAGED AS MUCH AS POSSIBLE TO MINIMISE EXPOSURE

NOT FOR CONSTRUCTION

REV	DATE	DES.	DRN.	APP.	REVISION DETAILS
A	29/05/14	A.J.B.	A.J.B.		DRAFT - SEDIMENT BASIN/TRAP LOCATIONS - FOR CONSULTATION

DRAWING STATUS	
DESIGN BY	A.M. / A.J.B.
DRAWN BY	A.J.B.
FINAL APPROVAL	
SCALE:	1:2000
(on A3 Original)	
DRAFT	



CLIENT




PO Box 1098, Bowral, NSW, 2576
 Suites 9 & 10, Bowral Mall
 Cnr. Bowley & Station Streets, Bowral.
 (f) 02 4862 1633
 (f) 02 4862 3088
 email: reception@seec.com.au
 WWW.SEEC.COM.AU

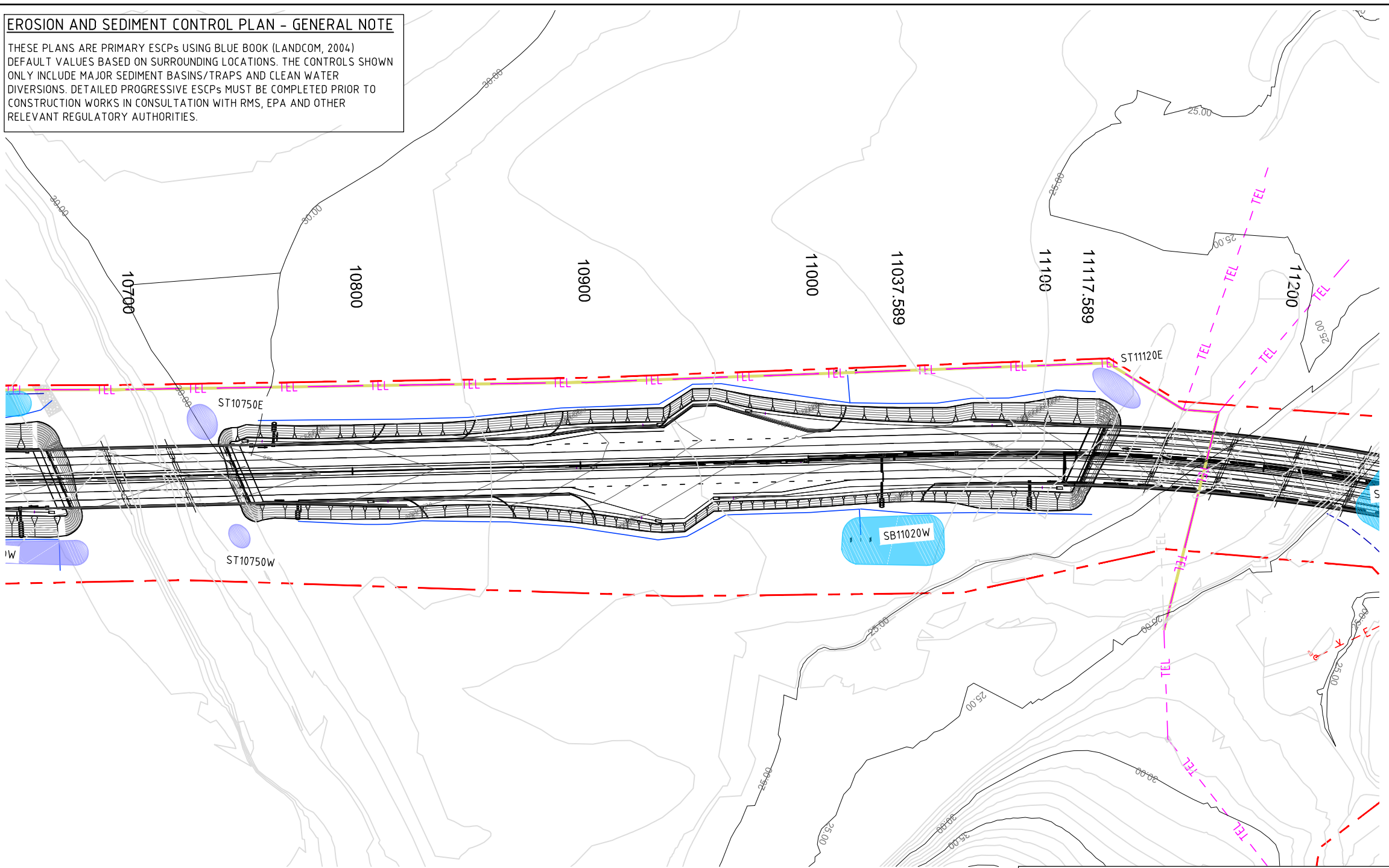
PROJECT TITLE

**HW1 PRINCES HIGHWAY
 FOXGROUND AND BERRY BY-PASS
 TOOLIJOOA ROAD TO
 SCHOFIELDS LANE**






DRAWING TITLE			
PRIMARY EROSION AND SEDIMENT CONTROL PLAN CH10200 TO CH10700			
PROJECT NO.	SUB-PR NO.	DRAWING NO.	REV
13000157	P02	ESCP107	A

EROSION AND SEDIMENT CONTROL PLAN - GENERAL NOTE

THESE PLANS ARE PRIMARY ESCPs USING BLUE BOOK (LANDCOM, 2004) DEFAULT VALUES BASED ON SURROUNDING LOCATIONS. THE CONTROLS SHOWN ONLY INCLUDE MAJOR SEDIMENT BASINS/TRAPS AND CLEAN WATER DIVERSIONS. DETAILED PROGRESSIVE ESCPs MUST BE COMPLETED PRIOR TO CONSTRUCTION WORKS IN CONSULTATION WITH RMS, EPA AND OTHER RELEVANT REGULATORY AUTHORITIES.



LEGEND

-  NATURAL/EXISTING CREST LOCATION
-  PROPOSED ROAD CREST LOCATION
-  SEDIMENT BASIN (SB) - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX FOR SEDIMENT BASIN VOLUMES)
-  SEDIMENT TRAP (ST) / TEMPORARY ONLINE BASIN - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX)
-  TEMPORARY WATERWAY DIVERSION AROUND CULVERT WORKS (DETAIL A/C)

ADDITIONAL REQUIREMENTS FOR FLOOD PRONE LANDS AND LANDS WHERE HIGH GROUND WATER IS ENCOUNTERED

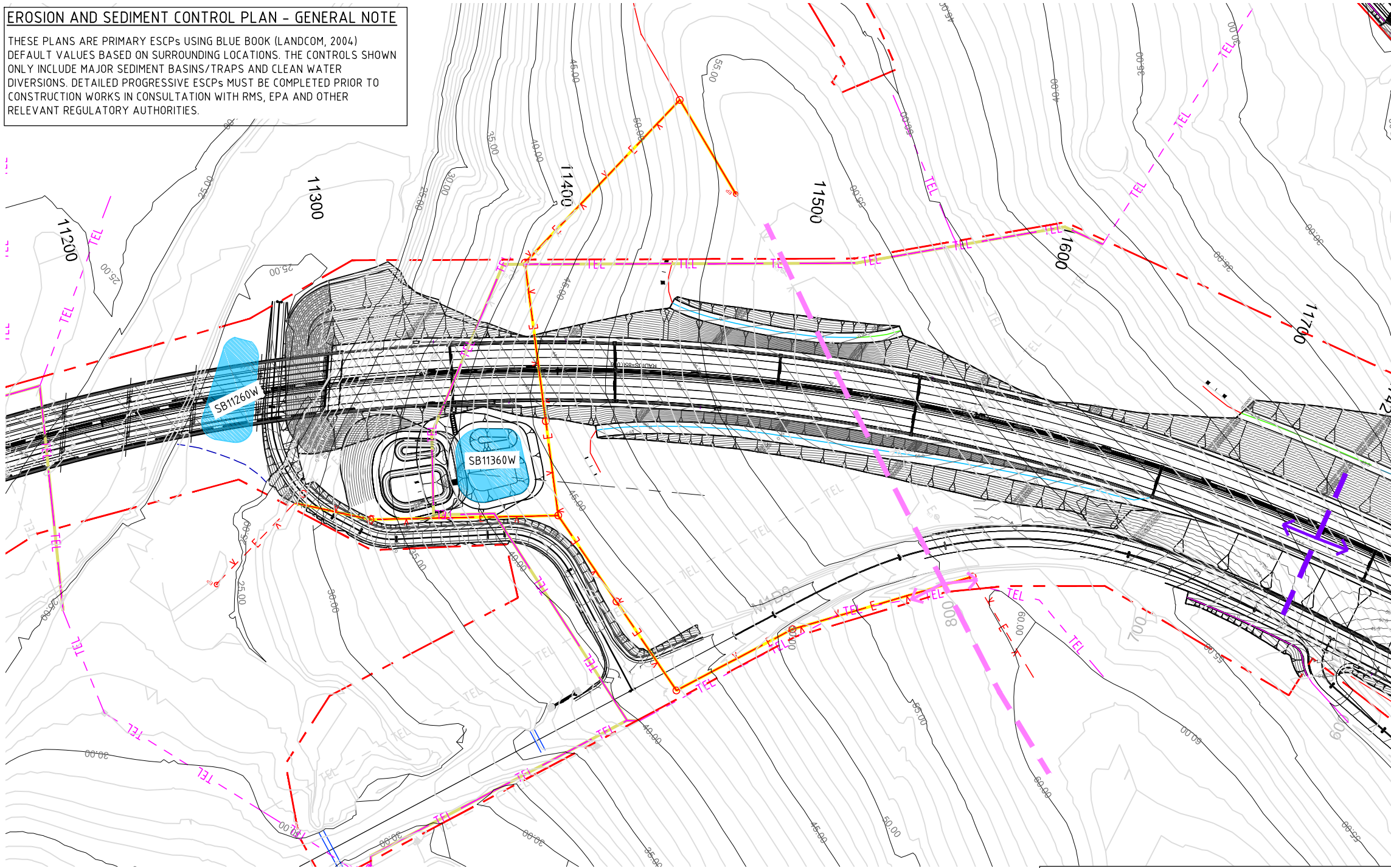
- ACCESS/HAUL ROADS TO BE FORMED USING ROCK WITH GEOTEXTILE UNDERLAY (THIS CAN BE INCORPORATED AS PART OF THE ROAD BRIDGING LAYER WHERE APPLICABLE)
- MINIMISE STRIPPING OF GRASS VEGETATION AND TOPSOIL AS MUCH AS POSSIBLE. CONSTRUCT WORKS OVER THE TOP OF EXISTING GRASS WHERE POSSIBLE
- EXPOSED FILL BATTERS TO BE STABILISED (LOCKED DOWN WITH SOIL STABILISERS OR COVERED WITH FABRIC/MATTING) PRIOR TO RAINFALL, SITE CLOSURE OR WHEN WORKS ARE ON HOLD
- PERMANENT STABILISATION OF FILL BATTERS IS TO OCCUR PROGRESSIVELY
- TOP EDGES OF THE FILLS ARE TO HAVE WINDROWS/BUNDS WITH REGULAR BATTER CHUTES
- CULVERTS AND CLEAN DIVERSIONS TO BE CONSTRUCTED AS EARLY WORKS
- TURKEYS NEST SEDIMENT BASINS WILL BE REQUIRED IN AREAS OF HIGH GROUND WATER. THESE BASINS ARE TO BE BUILT UP PROGRESSIVELY AS THE FILL COMES UP OR BASIN INLETS PROGRESSIVELY RAISED AS THE FILL COMES UP. SUPPLEMENTARY SEDIMENT TRAPS ON-LINE AND INCREASED EROSION CONTROLS ARE TO BE EMPLOYED UNTIL THE FULL SEDIMENT BASIN VOLUMES ARE ACHIEVED
- BASINS TO BE BUILT AS LARGE IN SURFACE AREA AS POSSIBLE TO LIMIT THE BASIN HEIGHT AND LEVEL OF EXCAVATION
- UNTIL SUCH TIME THAT FULL SIZE SEDIMENT BASINS CAN BE EMPLOYED OR IN LOCATIONS WHERE SEDIMENT BASIN CONSTRUCTION IS NOT SUITABLE, SEDIMENT FILTRATION SUMPS/TRAPS TO BE PROVIDED IN LOW POINTS ARE AROUND LOWER EDGES OF WORKS (E.G. ROCK FILTER DAMS OR EQUIVALENT SEDIMENT FILTRATION DEVICE)
- SEDIMENT BASINS WILL REQUIRE ARMURED WALLS
- ANY WORKS WITHIN WATERCOURSES ARE TO BE SCHEDULED FOR LOW RAINFALL AND RAINFALL EROSIIVITY TIMES OF THE YEAR AND WORKS ARE TO BE STAGED AS MUCH AS POSSIBLE TO MINIMISE EXPOSURE

NOT FOR CONSTRUCTION






REV	DATE	DES.	DRN.	APP.	REVISION DETAILS	DRAWING STATUS		North	CLIENT	PROJECT TITLE	DRAWING TITLE								
						DESIGN BY	A.M. / A.J.B.				PO Box 1098, Bowral, NSW, 2576 Suites 9 & 10, Bowral Mall Cnr. Bowley & Station Streets, Bowral. (f) 02 4862 1633 (f) 02 4862 3088 email: reception@seec.com.au WWW.SEEC.COM.AU	HW1 PRINCES HIGHWAY FOXGROUND AND BERRY BY-PASS TOOLIJOOA ROAD TO SCHOFIELDS LANE				PRIMARY EROSION AND SEDIMENT CONTROL PLAN CH10700 TO CH11200			
						DRAWN BY	A.J.B.									PROJECT NO.	SUB-PR NO.	DRAWING NO.	REV
						FINAL APPROVAL						13000157	P02	ESCP108	A				
A	29/05/14	A.J.B.	A.J.B.		DRAFT - SEDIMENT BASIN/TRAP LOCATIONS - FOR CONSULTATION	SCALE: (on A3 Original)	1:2000												

EROSION AND SEDIMENT CONTROL PLAN - GENERAL NOTE

THESE PLANS ARE PRIMARY ESCPs USING BLUE BOOK (LANDCOM, 2004) DEFAULT VALUES BASED ON SURROUNDING LOCATIONS. THE CONTROLS SHOWN ONLY INCLUDE MAJOR SEDIMENT BASINS/TRAPS AND CLEAN WATER DIVERSIONS. DETAILED PROGRESSIVE ESCPs MUST BE COMPLETED PRIOR TO CONSTRUCTION WORKS IN CONSULTATION WITH RMS, EPA AND OTHER RELEVANT REGULATORY AUTHORITIES.



LEGEND

-  NATURAL/EXISTING CREST LOCATION
-  PROPOSED ROAD CREST LOCATION
-  SEDIMENT BASIN (SB) - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX FOR SEDIMENT BASIN VOLUMES)
-  SEDIMENT TRAP (ST) / TEMPORARY ONLINE BASIN - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX)
-  TEMPORARY WATERWAY DIVERSION AROUND CULVERT WORKS (DETAIL A/C)

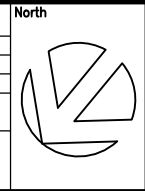
ADDITIONAL REQUIREMENTS FOR FLOOD PRONE LANDS AND LANDS WHERE HIGH GROUND WATER IS ENCOUNTERED WHERE APPLICABLE

- ACCESS/HAUL ROADS TO BE FORMED USING ROCK WITH GEOTEXTILE UNDERLAY (THIS CAN BE INCORPORATED AS PART OF THE ROAD BRIDGING LAYER WHERE APPLICABLE)
- MINIMISE STRIPPING OF GRASS VEGETATION AND TOPSOIL AS MUCH AS POSSIBLE. CONSTRUCT WORKS OVER THE TOP OF EXISTING GRASS WHERE POSSIBLE
- EXPOSED FILL BATTERS TO BE STABILISED (LOCKED DOWN WITH SOIL STABILISERS OR COVERED WITH FABRIC/MATTING) PRIOR TO RAINFALL, SITE CLOSURE OR WHEN WORKS ARE ON HOLD
- PERMANENT STABILISATION OF FILL BATTERS IS TO OCCUR PROGRESSIVELY
- TOP EDGES OF THE FILLS ARE TO HAVE WINDROWS/BUNDS WITH REGULAR BATTER CHUTES
- CULVERTS AND CLEAN DIVERSIONS TO BE CONSTRUCTED AS EARLY WORKS
- TURKEYS NEST SEDIMENT BASINS WILL BE REQUIRED IN AREAS OF HIGH GROUND WATER. THESE BASINS ARE TO BE BUILT UP PROGRESSIVELY AS THE FILL COMES UP OR BASIN INLETS PROGRESSIVELY RAISED AS THE FILL COMES UP. SUPPLEMENTARY SEDIMENT TRAPS ON-LINE AND INCREASED EROSION CONTROLS ARE TO BE EMPLOYED UNTIL THE FULL SEDIMENT BASIN VOLUMES ARE ACHIEVED
- BASINS TO BE BUILT AS LARGE IN SURFACE AREA AS POSSIBLE TO LIMIT THE BASIN HEIGHT AND LEVEL OF EXCAVATION
- UNTIL SUCH TIME THAT FULL SIZE SEDIMENT BASINS CAN BE EMPLOYED OR IN LOCATIONS WHERE SEDIMENT BASIN CONSTRUCTION IS NOT SUITABLE, SEDIMENT FILTRATION SUMPS/TRAPS TO BE PROVIDED IN LOW POINTS AROUND LOWER EDGES OF WORKS (E.G. ROCK FILTER DAMS OR EQUIVALENT SEDIMENT FILTRATION DEVICE)
- SEDIMENT BASINS WILL REQUIRE ARMoured WALLS
- ANY WORKS WITHIN WATERCOURSES ARE TO BE SCHEDULED FOR LOW RAINFALL AND RAINFALL EROSION TIMES OF THE YEAR AND WORKS ARE TO BE STAGED AS MUCH AS POSSIBLE TO MINIMISE EXPOSURE

NOT FOR CONSTRUCTION

REV	DATE	DES.	DRN.	APP.	REVISION DETAILS
A	29/05/14	A.J.B.	A.J.B.		DRAFT - SEDIMENT BASIN/TRAP LOCATIONS - FOR CONSULTATION

DRAWING STATUS	
DESIGN BY	A.M. / A.J.B.
DRAWN BY	A.J.B.
FINAL APPROVAL	
SCALE:	1:2000
(on A3 Original)	
DRAFT	



CLIENT




PO Box 1098, Bowral, NSW, 2576
 Suites 9 & 10, Bowral Mall
 Cnr. Bowley & Station Streets, Bowral.
 (t) 02 4862 1633
 (f) 02 4862 3088
 email: reception@seec.com.au
 WWW.SEEC.COM.AU

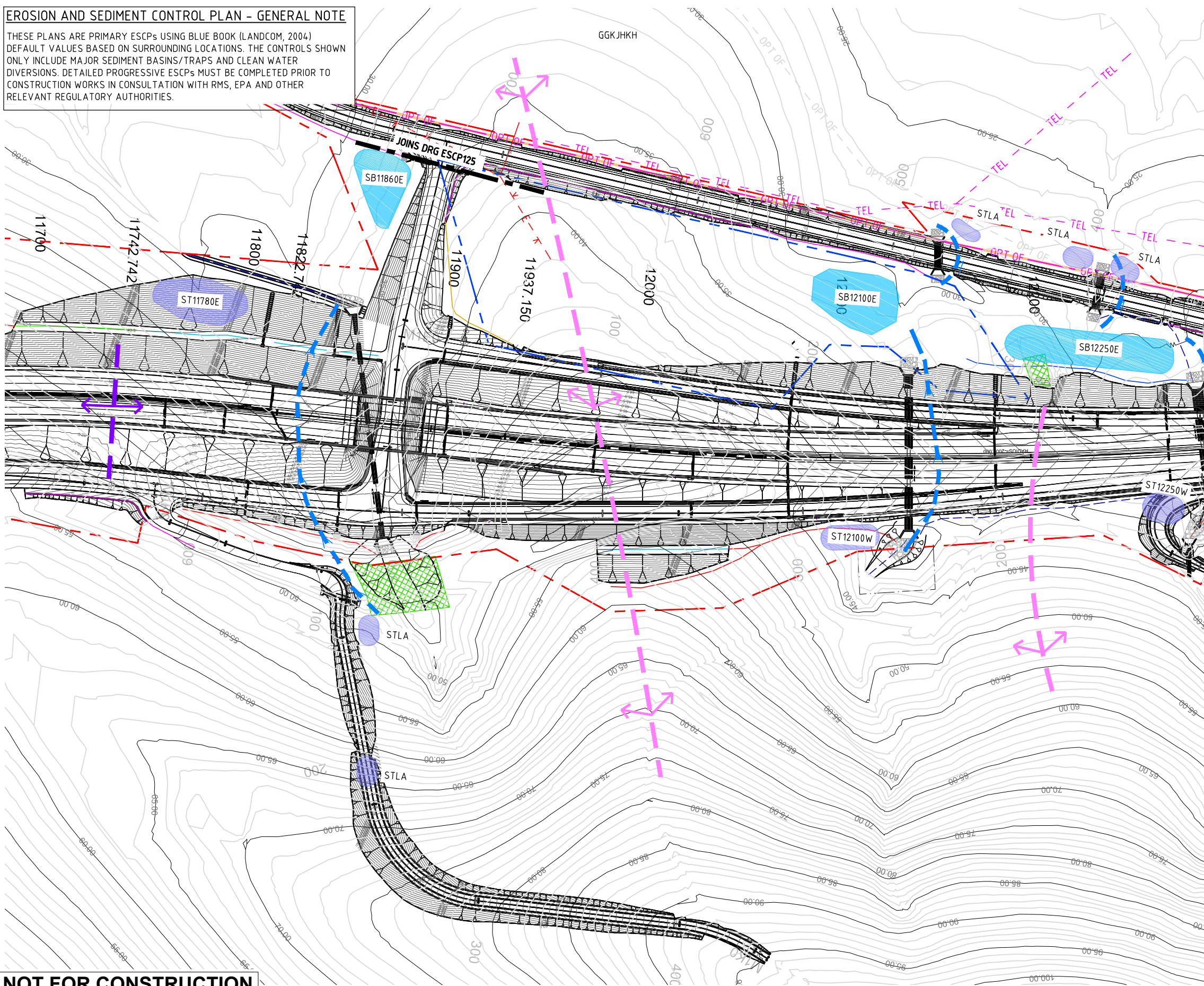
PROJECT TITLE

**HW1 PRINCES HIGHWAY
 FOXGROUND AND BERRY BY-PASS
 TOOLIJOOA ROAD TO
 SCHOFIELDS LANE**

DRAWING TITLE			
PRIMARY EROSION AND SEDIMENT CONTROL PLAN CH11200 TO CH11700			
PROJECT NO.	SUB-PR NO.	DRAWING NO.	REV
13000157	P02	ESCP109	A

EROSION AND SEDIMENT CONTROL PLAN - GENERAL NOTE

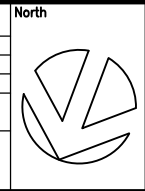
THESE PLANS ARE PRIMARY ESCPs USING BLUE BOOK (LANDCOM, 2004) DEFAULT VALUES BASED ON SURROUNDING LOCATIONS. THE CONTROLS SHOWN ONLY INCLUDE MAJOR SEDIMENT BASINS/TRAPS AND CLEAN WATER DIVERSIONS. DETAILED PROGRESSIVE ESCPs MUST BE COMPLETED PRIOR TO CONSTRUCTION WORKS IN CONSULTATION WITH RMS, EPA AND OTHER RELEVANT REGULATORY AUTHORITIES.



NOT FOR CONSTRUCTION

REV	DATE	DES.	DRN.	APP.	REVISION DETAILS
A	29/05/14	A.J.B.	A.J.B.		DRAFT - SEDIMENT BASIN/TRAP LOCATIONS - FOR CONSULTATION

DRAWING STATUS	
DESIGN BY	A.M. / A.J.B.
DRAWN BY	A.J.B.
FINAL APPROVAL	
SCALE:	1:2000
(on A3 Original)	
DRAFT	



CLIENT



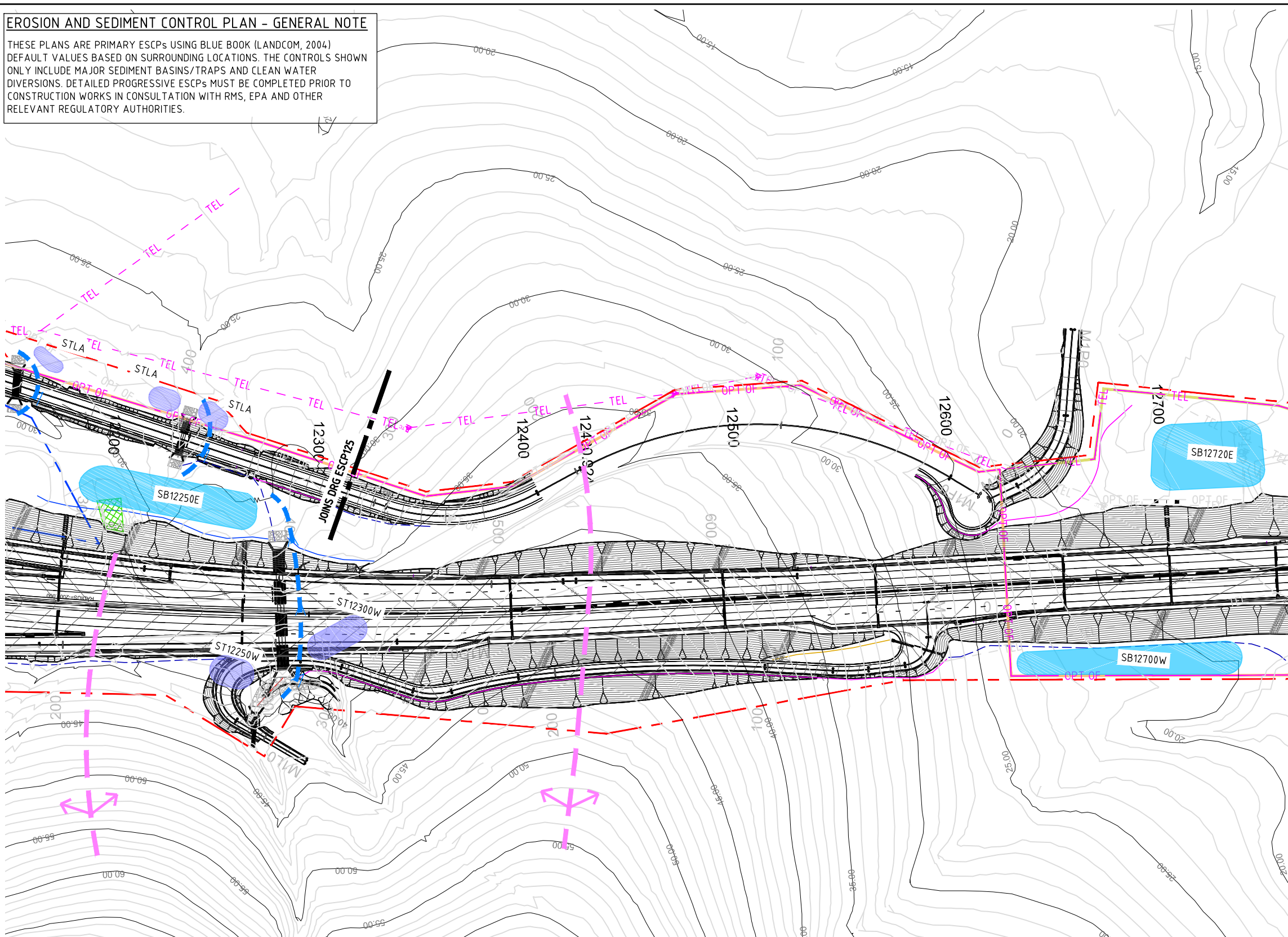
PO Box 1098, Bowral, NSW, 2576
 Suites 9 & 10, Bowral Mall
 Cnr. Bowley & Station Streets, Bowral.
 (I) 02 4862 1633
 (F) 02 4862 3088
 email: reception@seec.com.au
 WWW.SEEC.COM.AU

PROJECT TITLE
**HW1 PRINCES HIGHWAY
 FOXGROUND AND BERRY BY-PASS
 TOOLIJOOA ROAD TO
 SCHOFIELDS LANE**






DRAWING TITLE			
PRIMARY EROSION AND SEDIMENT CONTROL PLAN CH11700 TO CH12200			
PROJECT NO.	SUB-PR NO.	DRAWING NO.	REV
13000157	P02	ESCP110	A

EROSION AND SEDIMENT CONTROL PLAN - GENERAL NOTE

THESE PLANS ARE PRIMARY ESCPs USING BLUE BOOK (LANDCOM, 2004) DEFAULT VALUES BASED ON SURROUNDING LOCATIONS. THE CONTROLS SHOWN ONLY INCLUDE MAJOR SEDIMENT BASINS/TRAPS AND CLEAN WATER DIVERSIONS. DETAILED PROGRESSIVE ESCPs MUST BE COMPLETED PRIOR TO CONSTRUCTION WORKS IN CONSULTATION WITH RMS, EPA AND OTHER RELEVANT REGULATORY AUTHORITIES.



LEGEND

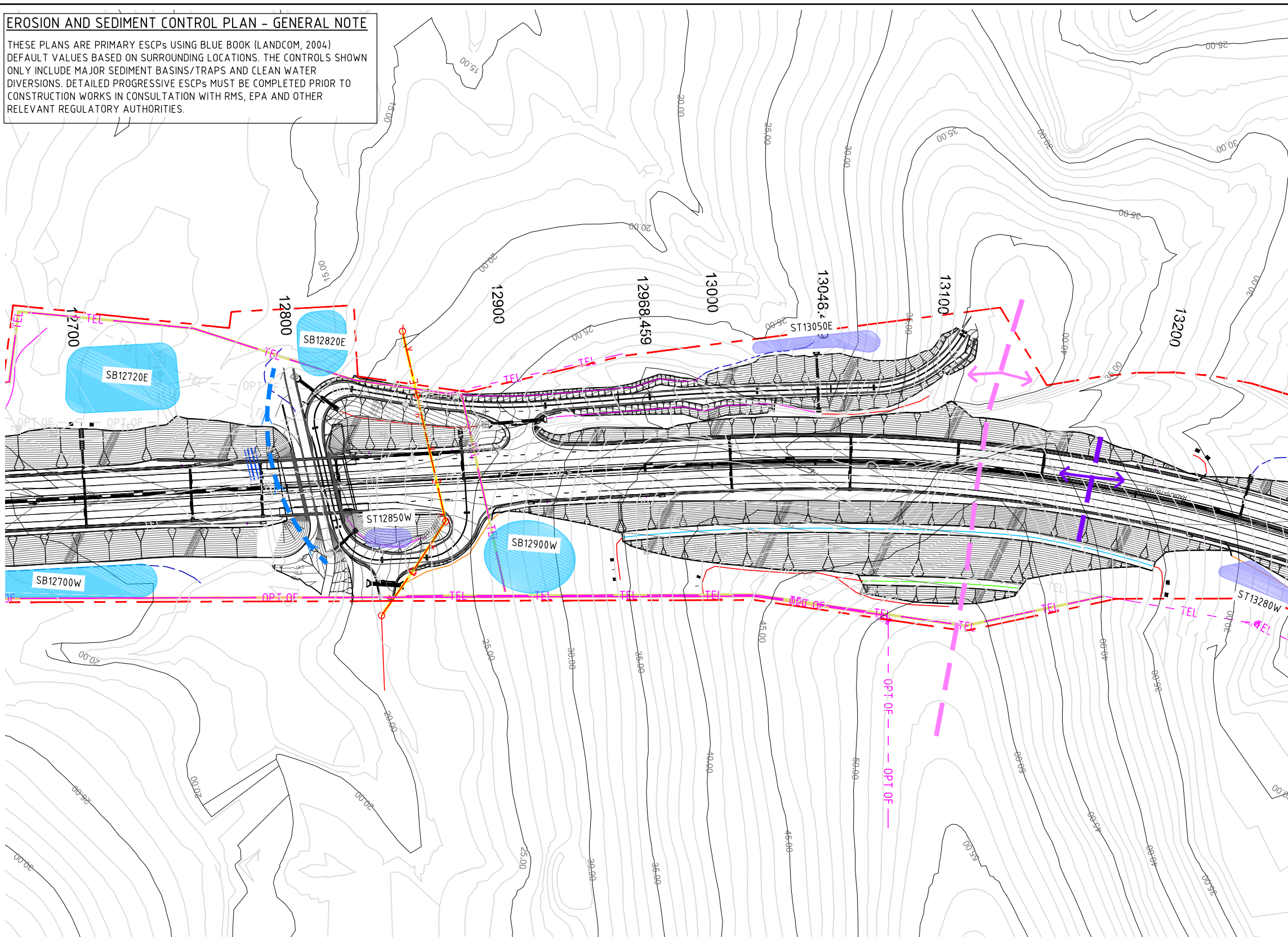
-  NATURAL/EXISTING CREST LOCATION
-  PROPOSED ROAD CREST LOCATION
-  SEDIMENT BASIN (SB) - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX FOR SEDIMENT BASIN VOLUMES)
-  SEDIMENT TRAP (ST) / TEMPORARY ONLINE BASIN - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX)
-  TEMPORARY WATERWAY DIVERSION AROUND CULVERT WORKS (DETAIL A/C)

NOT FOR CONSTRUCTION






REV	DATE	DES.	DRN.	APP.	REVISION DETAILS	DRAWING STATUS		North	CLIENT	 	PROJECT TITLE HW1 PRINCES HIGHWAY FOXGROUND AND BERRY BY-PASS TOOLIJOOA ROAD TO SCHOFIELDS LANE	DRAWING TITLE			
					DESIGN BY	A.M. / A.J.B.	SCALE: (on A3 Original) 1:2000 DRAFT					PRIMARY EROSION AND SEDIMENT CONTROL PLAN CH12200 TO CH12700			
A	29/05/14	A.J.B.	A.J.B.		DRAFT - SEDIMENT BASIN/TRAP LOCATIONS - FOR CONSULTATION	DRAWN BY		A.J.B.		PO Box 1098, Bowral, NSW, 2576 Suites 9 & 10, Bowral Mall Cnr. Bowliway & Station Streets, Bowral. (f) 02 4862 1633 (f) 02 4862 3088 email: reception@seec.com.au WWW.SEEC.COM.AU	PROJECT NO. 13000157	SUB-PR NO. P02	DRAWING NO. ESCP111	REV A	
							PROJECT NO. 13000157 SUB-PR NO. P02 DRAWING NO. ESCP111 REV A								

EROSION AND SEDIMENT CONTROL PLAN - GENERAL NOTE

THESE PLANS ARE PRIMARY ESCPs USING BLUE BOOK (LANDCOM, 2004) DEFAULT VALUES BASED ON SURROUNDING LOCATIONS. THE CONTROLS SHOWN ONLY INCLUDE MAJOR SEDIMENT BASINS/TRAPS AND CLEAN WATER DIVERSIONS. DETAILED PROGRESSIVE ESCPs MUST BE COMPLETED PRIOR TO CONSTRUCTION WORKS IN CONSULTATION WITH RMS, EPA AND OTHER RELEVANT REGULATORY AUTHORITIES.



LEGEND

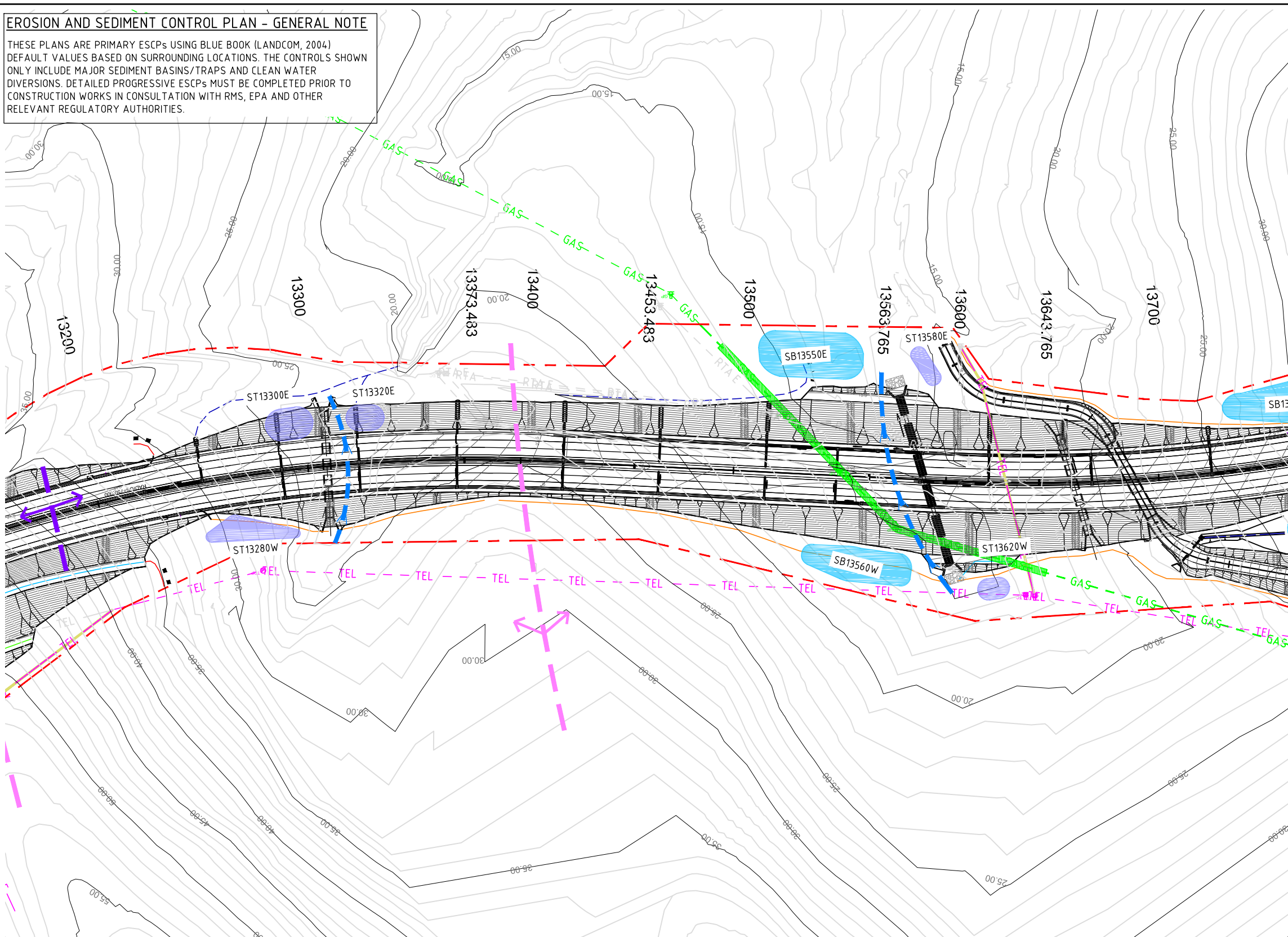
-  NATURAL/EXISTING CREST LOCATION
-  PROPOSED ROAD CREST LOCATION
-  SEDIMENT BASIN (SB) - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX FOR SEDIMENT BASIN VOLUMES)
-  SEDIMENT TRAP (ST) / TEMPORARY ONLINE BASIN - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX)
-  TEMPORARY WATERWAY DIVERSION AROUND CULVERT WORKS (DETAIL A/C)

NOT FOR CONSTRUCTION






REV	DATE	DES.	DRN.	APP.	REVISION DETAILS	DRAWING STATUS		North	CLIENT	 	PROJECT TITLE HW1 PRINCES HIGHWAY FOXGROUND AND BERRY BY-PASS TOOLIJOOA ROAD TO SCHOFIELDS LANE	DRAWING TITLE			
					DESIGN BY	A.M. / A.J.B.	SCALE: (on A3 Original) 1:2000					DRAFT	PRIMARY EROSION AND SEDIMENT CONTROL PLAN CH12700 TO CH13200		
A	29/05/14	A.J.B.	A.J.B.		DRAFT - SEDIMENT BASIN/TRAP LOCATIONS - FOR CONSULTATION	DRAWN BY		A.J.B.						PROJECT NO.	SUB-PR NO.
						FINAL APPROVAL						13000157	P02	ESCP112	A

EROSION AND SEDIMENT CONTROL PLAN - GENERAL NOTE

THESE PLANS ARE PRIMARY ESCPs USING BLUE BOOK (LANDCOM, 2004) DEFAULT VALUES BASED ON SURROUNDING LOCATIONS. THE CONTROLS SHOWN ONLY INCLUDE MAJOR SEDIMENT BASINS/TRAPS AND CLEAN WATER DIVERSIONS. DETAILED PROGRESSIVE ESCPs MUST BE CLEANED PRIOR TO CONSTRUCTION WORKS IN CONSULTATION WITH RMS, EPA AND OTHER RELEVANT REGULATORY AUTHORITIES.



LEGEND

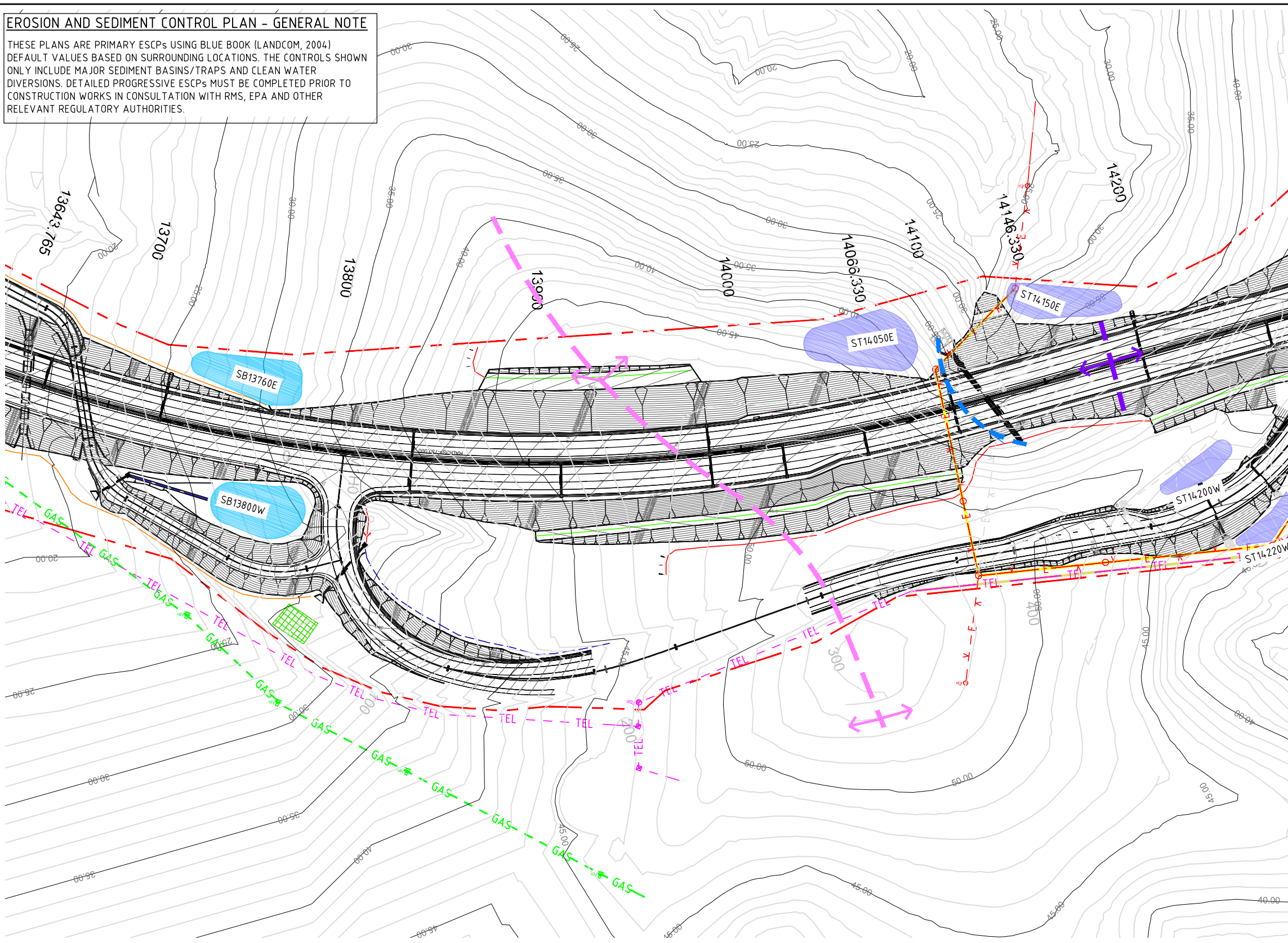
-  NATURAL/EXISTING CREST LOCATION
-  PROPOSED ROAD CREST LOCATION
-  SEDIMENT BASIN (SB) - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX FOR SEDIMENT BASIN VOLUMES)
-  SEDIMENT TRAP (ST) / TEMPORARY ONLINE BASIN - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX)
-  TEMPORARY WATERWAY DIVERSION AROUND CULVERT WORKS (DETAIL A/C)

NOT FOR CONSTRUCTION

REV	DATE	DES.	DRN.	APP.	REVISION DETAILS	DRAWING STATUS		North	CLIENT	PROJECT TITLE	DRAWING TITLE				
						DESIGN BY	A.M. / A.J.B.			 PO Box 1098, Bowral, NSW, 2576 Suites 9 & 10, Bowral Mall Cnr. Bowley & Station Streets, Bowral. (f) 02 4862 1633 (f) 02 4862 3088 email: reception@seec.com.au WWW.SEEC.COM.AU	PRIMARY EROSION AND SEDIMENT CONTROL PLAN CH13200 TO CH13700				
					DRAWN BY	A.J.B.	SCALE:								1:2000
A	29/05/14	A.J.B.	A.J.B.		DRAFT - SEDIMENT BASIN/TRAP LOCATIONS - FOR CONSULTATION	DRAFT							13000157	P02	ESCP113

EROSION AND SEDIMENT CONTROL PLAN - GENERAL NOTE

THESE PLANS ARE PRIMARY ESCPs USING BLUE BOOK (LANDCOM, 2004) DEFAULT VALUES BASED ON SURROUNDING LOCATIONS. THE CONTROLS SHOWN ONLY INCLUDE MAJOR SEDIMENT BASINS/TRAPS AND CLEAN WATER DIVERSIONS. DETAILED PROGRESSIVE ESCPs MUST BE COMPLETED PRIOR TO CONSTRUCTION WORKS IN CONSULTATION WITH RMS, EPA AND OTHER RELEVANT REGULATORY AUTHORITIES.



LEGEND

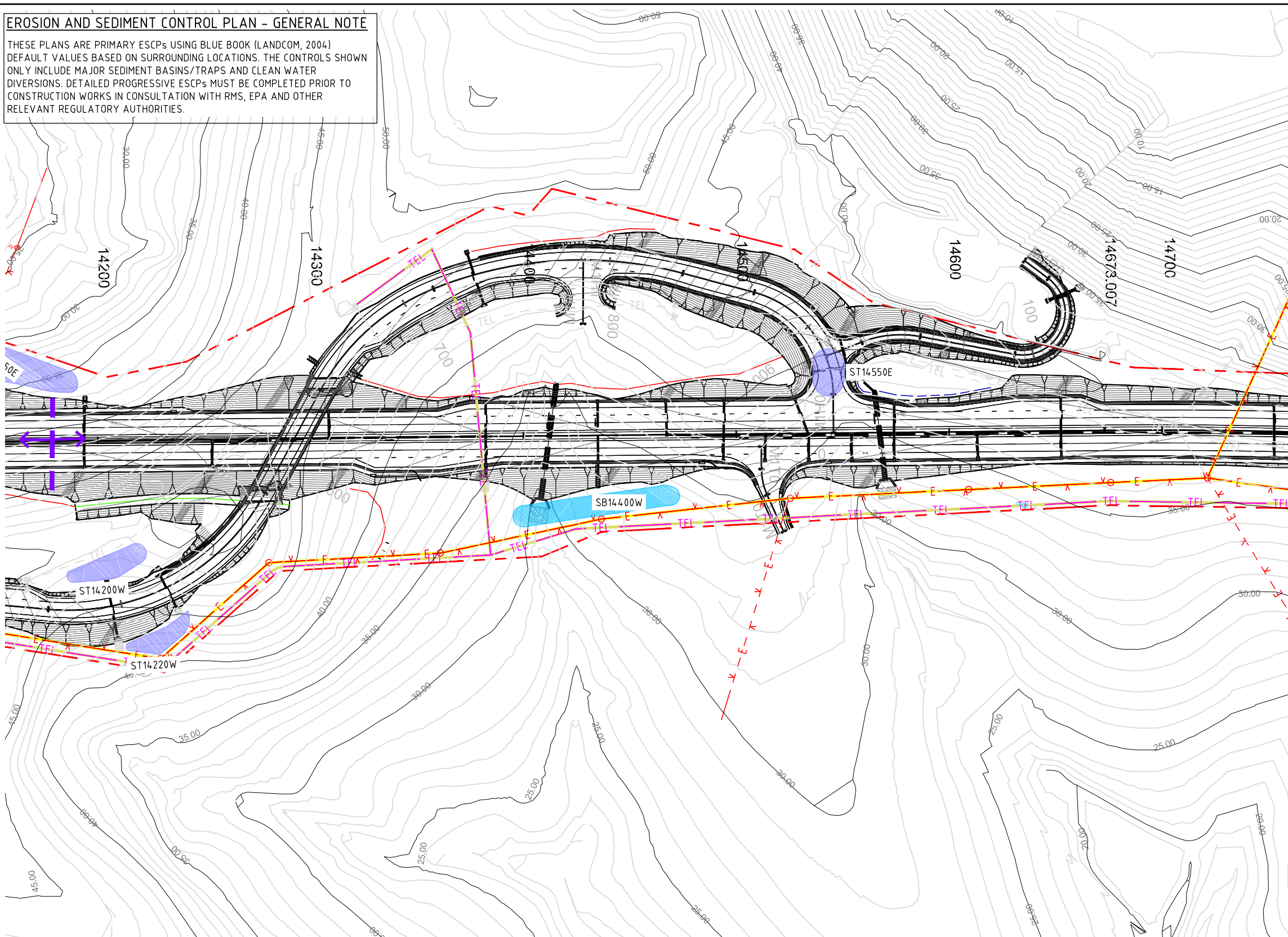
- NATURAL/EXISTING CREST LOCATION
- PROPOSED ROAD CREST LOCATION
- SEDIMENT BASIN (SB) - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX FOR SEDIMENT BASIN VOLUMES)
- SEDIMENT TRAP (ST) / TEMPORARY ONLINE BASIN - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX)
- TEMPORARY WATERWAY DIVERSION AROUND CULVERT WORKS (DETAIL A/C)

NOT FOR CONSTRUCTION






REV	DATE	DES.	DRN.	APP.	REVISION DETAILS	DRAWING STATUS		North	CLIENT		 PO Box 1098, Bowral, NSW, 2576 Suites 9 & 10, Bowral Mall Cnr. Bowley & Station Streets, Bowral. (I) 02 4862 1633 (F) 02 4862 3088 email: reception@seec.com.au WWW.SEEC.COM.AU	PROJECT TITLE		DRAWING TITLE	
					SCALE: (on A3 Original)	1:2000	DRAFT					HW1 PRINCES HIGHWAY FOXGROUND AND BERRY BY-PASS TOOLIJOOA ROAD TO SCHOFIELDS LANE		PRIMARY EROSION AND SEDIMENT CONTROL PLAN CH13700 TO CH14200	
A	29/05/14	A.J.B.	A.J.B.		DRAFT - SEDIMENT BASIN/TRAP LOCATIONS - FOR CONSULTATION							PROJECT NO.	SUB-PR NO.	DRAWING NO.	REV
												13000157	P02	ESCP114	A

EROSION AND SEDIMENT CONTROL PLAN - GENERAL NOTE

THESE PLANS ARE PRIMARY ESCPs USING BLUE BOOK (LANDCOM, 2004) DEFAULT VALUES BASED ON SURROUNDING LOCATIONS. THE CONTROLS SHOWN ONLY INCLUDE MAJOR SEDIMENT BASINS/TRAPS AND CLEAN WATER DIVERSIONS. DETAILED PROGRESSIVE ESCPs MUST BE COMPLETED PRIOR TO CONSTRUCTION WORKS IN CONSULTATION WITH RMS, EPA AND OTHER RELEVANT REGULATORY AUTHORITIES.



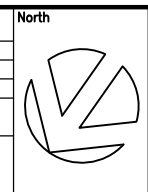
LEGEND

-  NATURAL/EXISTING CREST LOCATION
-  PROPOSED ROAD CREST LOCATION
-  SEDIMENT BASIN (SB) - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX FOR SEDIMENT BASIN VOLUMES)
-  SEDIMENT TRAP (ST) / TEMPORARY ONLINE BASIN - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX)
-  TEMPORARY WATERWAY DIVERSION AROUND CULVERT WORKS (DETAIL A/C)

NOT FOR CONSTRUCTION

REV	DATE	DES.	DRN.	APP.	REVISION DETAILS
A	29/05/14	A.J.B.	A.J.B.		DRAFT - SEDIMENT BASIN/TRAP LOCATIONS - FOR CONSULTATION

DRAWING STATUS	
DESIGN BY	A.M. / A.J.B.
DRAWN BY	A.J.B.
FINAL APPROVAL	
SCALE:	1:2000
(on A3 Original)	
DRAFT	



CLIENT



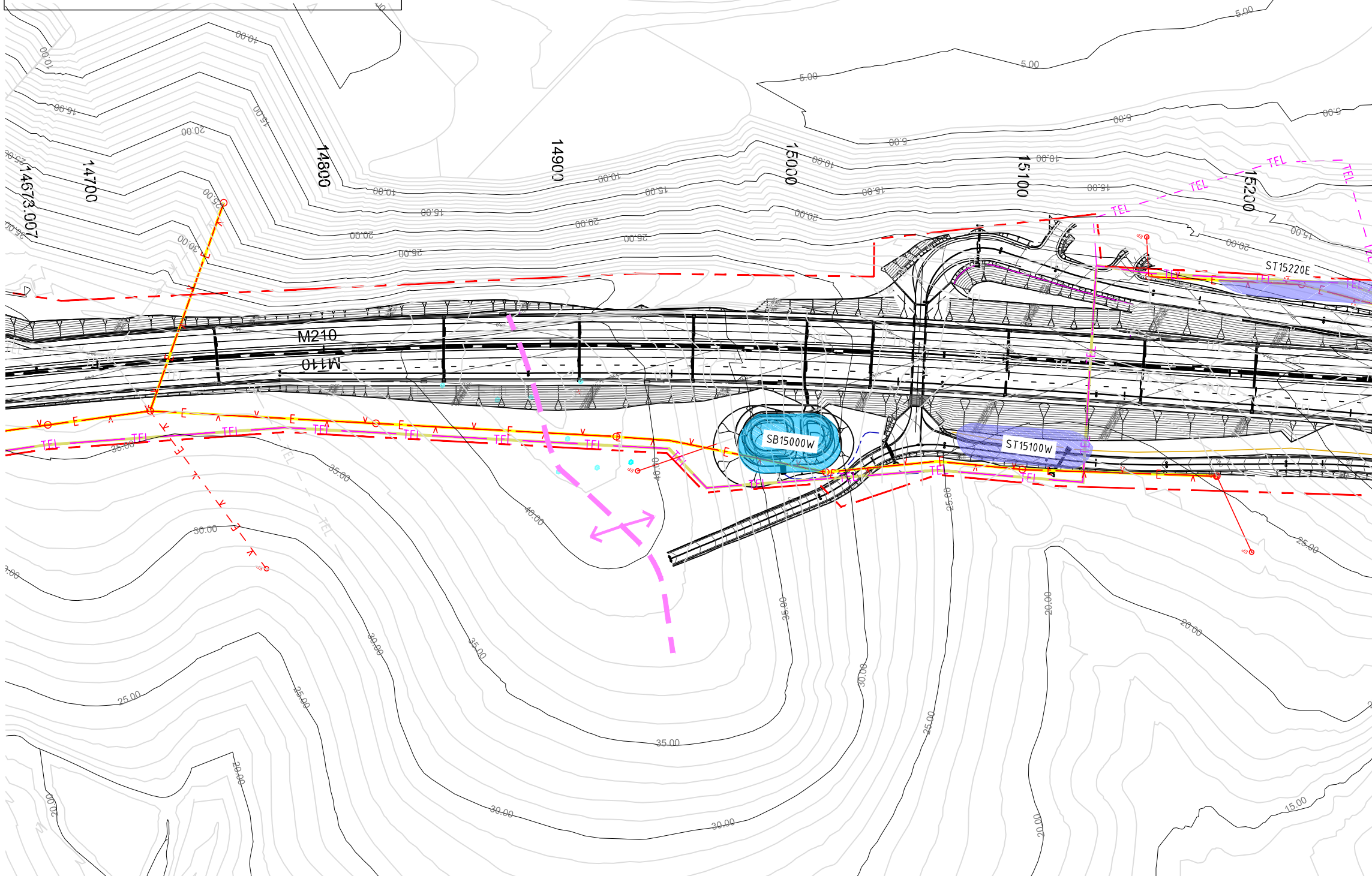
PO Box 1098, Bowral, NSW, 2576
 Suites 9 & 10, Bowral Mall
 Cnr. Bowley & Station Streets, Bowral.
 (I) 02 4862 1633
 (F) 02 4862 3088
 email: reception@seec.com.au
 WWW.SEEC.COM.AU

PROJECT TITLE
**HW1 PRINCES HIGHWAY
 FOXGROUND AND BERRY BY-PASS
 TOOLIJOOA ROAD TO
 SCHOFIELDS LANE**






DRAWING TITLE			
PRIMARY EROSION AND SEDIMENT CONTROL PLAN CH14200 TO CH14700			
PROJECT NO.	SUB-PR NO.	DRAWING NO.	REV
13000157	P02	ESCP115	A

EROSION AND SEDIMENT CONTROL PLAN - GENERAL NOTE

THESE PLANS ARE PRIMARY ESCPs USING BLUE BOOK (LANDCOM, 2004) DEFAULT VALUES BASED ON SURROUNDING LOCATIONS. THE CONTROLS SHOWN ONLY INCLUDE MAJOR SEDIMENT BASINS/TRAPS AND CLEAN WATER DIVERSIONS. DETAILED PROGRESSIVE ESCPs MUST BE COMPLETED PRIOR TO CONSTRUCTION WORKS IN CONSULTATION WITH RMS, EPA AND OTHER RELEVANT REGULATORY AUTHORITIES.



LEGEND

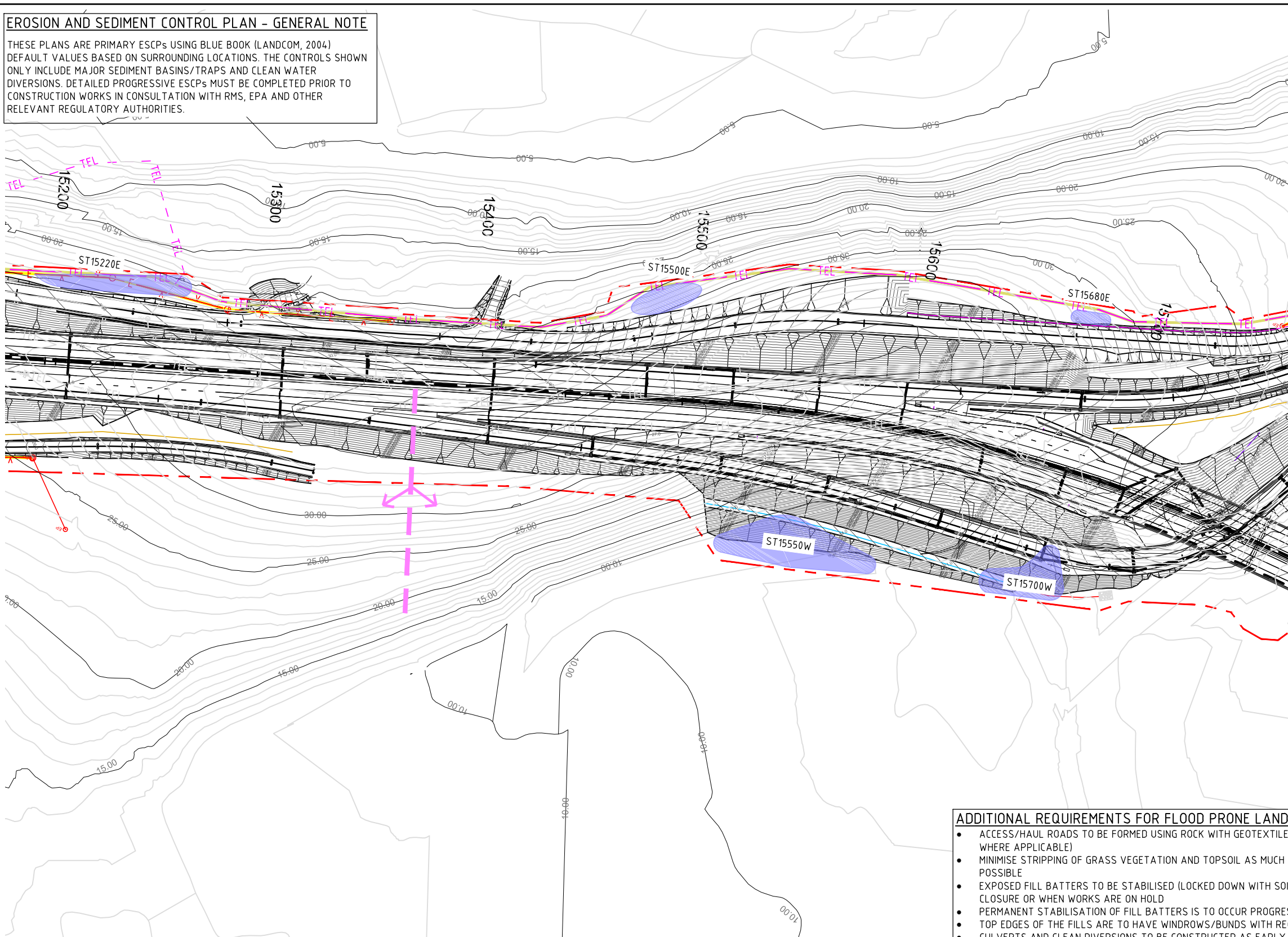
-  NATURAL/EXISTING CREST LOCATION
-  PROPOSED ROAD CREST LOCATION
-  SEDIMENT BASIN (SB) - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX FOR SEDIMENT BASIN VOLUMES)
-  SEDIMENT TRAP (ST) / TEMPORARY ONLINE BASIN - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX)
-  TEMPORARY WATERWAY DIVERSION AROUND CULVERT WORKS (DETAIL A/C)

NOT FOR CONSTRUCTION

REV	DATE	DES.	DRN.	APP.	REVISION DETAILS	DRAWING STATUS		North	CLIENT	 	PROJECT TITLE HW1 PRINCES HIGHWAY FOXGROUND AND BERRY BY-PASS TOOLIJOOA ROAD TO SCHOFIELDS LANE	DRAWING TITLE			
					DESIGN BY	A.M. / A.J.B.	SCALE: (on A3 Original) 1:2000					PROJECT NO. 13000157	SUB-PR NO. P02	DRAWING NO. ESCP116	REV A
					DRAWN BY	A.J.B.									
A	29/05/14	A.J.B.	A.J.B.		DRAFT - SEDIMENT BASIN/TRAP LOCATIONS - FOR CONSULTATION	DRAFT				PO Box 1098, Bowral, NSW, 2576 Suites 9 & 10, Bowral Mall Cnr. Bowley & Station Streets, Bowral. (f) 02 4862 1633 (f) 02 4862 3088 email: reception@seec.com.au WWW.SEEC.COM.AU					

EROSION AND SEDIMENT CONTROL PLAN - GENERAL NOTE

THESE PLANS ARE PRIMARY ESCPs USING BLUE BOOK (LANDCOM, 2004) DEFAULT VALUES BASED ON SURROUNDING LOCATIONS. THE CONTROLS SHOWN ONLY INCLUDE MAJOR SEDIMENT BASINS/TRAPS AND CLEAN WATER DIVERSIONS. DETAILED PROGRESSIVE ESCPs MUST BE COMPLETED PRIOR TO CONSTRUCTION WORKS IN CONSULTATION WITH RMS, EPA AND OTHER RELEVANT REGULATORY AUTHORITIES.



LEGEND

-  NATURAL/EXISTING CREST LOCATION
-  PROPOSED ROAD CREST LOCATION
-  SEDIMENT BASIN (SB) - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX FOR SEDIMENT BASIN VOLUMES)
-  SEDIMENT TRAP (ST) / TEMPORARY ONLINE BASIN - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX)
-  TEMPORARY WATERWAY DIVERSION AROUND CULVERT WORKS (DETAIL A/C)

ADDITIONAL REQUIREMENTS FOR FLOOD PRONE LANDS AND LANDS WHERE HIGH GROUND WATER IS ENCOUNTERED WHERE APPLICABLE

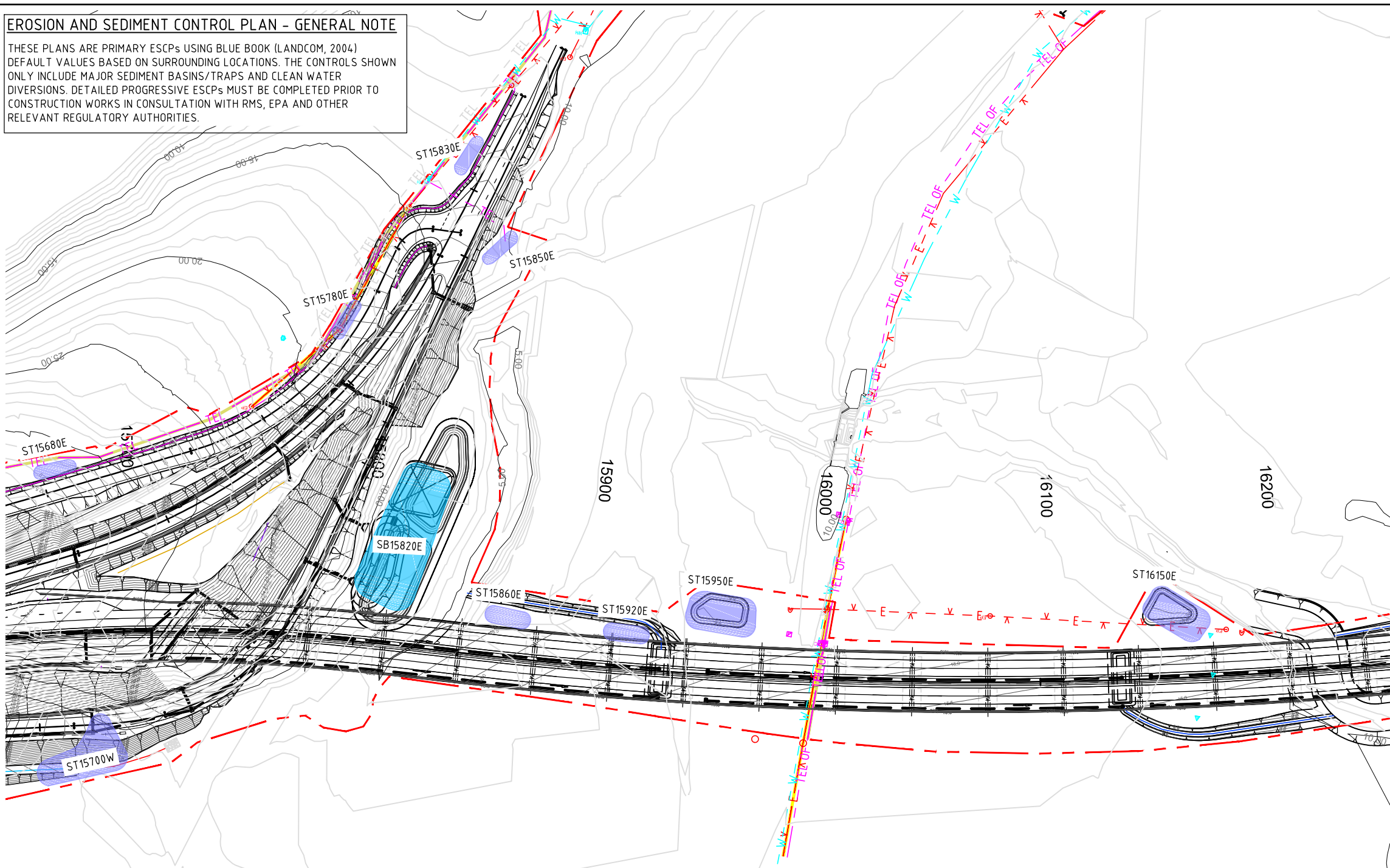
- ACCESS/HAUL ROADS TO BE FORMED USING ROCK WITH GEOTEXTILE UNDERLAY (THIS CAN BE INCORPORATED AS PART OF THE ROAD BRIDGING LAYER WHERE APPLICABLE)
- MINIMISE STRIPPING OF GRASS VEGETATION AND TOPSOIL AS MUCH AS POSSIBLE. CONSTRUCT WORKS OVER THE TOP OF EXISTING GRASS WHERE POSSIBLE
- EXPOSED FILL BATTERS TO BE STABILISED (LOCKED DOWN WITH SOIL STABILISERS OR COVERED WITH FABRIC/MATTING) PRIOR TO RAINFALL, SITE CLOSURE OR WHEN WORKS ARE ON HOLD
- PERMANENT STABILISATION OF FILL BATTERS IS TO OCCUR PROGRESSIVELY
- TOP EDGES OF THE FILLS ARE TO HAVE WINDROWS/BUNDS WITH REGULAR BATTER CHUTES
- CULVERTS AND CLEAN DIVERSIONS TO BE CONSTRUCTED AS EARLY WORKS
- TURKEYS NEST SEDIMENT BASINS WILL BE REQUIRED IN AREAS OF HIGH GROUND WATER. THESE BASINS ARE TO BE BUILT UP PROGRESSIVELY AS THE FILL COMES UP OR BASIN INLETS PROGRESSIVELY RAISED AS THE FILL COMES UP. SUPPLEMENTARY SEDIMENT TRAPS ON-LINE AND INCREASED EROSION CONTROLS ARE TO BE EMPLOYED UNTIL THE FULL SEDIMENT BASIN VOLUMES ARE ACHIEVED
- BASINS TO BE BUILT AS LARGE IN SURFACE AREA AS POSSIBLE TO LIMIT THE BASIN HEIGHT AND LEVEL OF EXCAVATION
- UNTIL SUCH TIME THAT FULL SIZE SEDIMENT BASINS CAN BE EMPLOYED OR IN LOCATIONS WHERE SEDIMENT BASIN CONSTRUCTION IS NOT SUITABLE, SEDIMENT FILTRATION SUMPS/TRAPS TO BE PROVIDED IN LOW POINTS AROUND LOWER EDGES OF WORKS (E.G. ROCK FILTER DAMS OR EQUIVALENT SEDIMENT FILTRATION DEVICE)
- SEDIMENT BASINS WILL REQUIRE ARMoured WALLS
- ANY WORKS WITHIN WATERCOURSES ARE TO BE SCHEDULED FOR LOW RAINFALL AND RAINFALL EROSIONITY TIMES OF THE YEAR AND WORKS ARE TO BE STAGED AS MUCH AS POSSIBLE TO MINIMISE EXPOSURE

NOT FOR CONSTRUCTION

REV	DATE	DES.	DRN.	APP.	REVISION DETAILS	DRAWING STATUS		North	CLIENT	PROJECT TITLE	DRAWING TITLE								
						DESIGN BY	A.M. / A.J.B.				PO Box 1098, Bowral, NSW, 2576 Suites 9 & 10, Bowral Mall Cnr. Bowley & Station Streets, Bowral. (t) 02 4862 1633 (f) 02 4862 3088 email: reception@seec.com.au WWW.SEEC.COM.AU	HW1 PRINCES HIGHWAY FOXGROUND AND BERRY BY-PASS TOOLIJOOA ROAD TO SCHOFIELDS LANE				PRIMARY EROSION AND SEDIMENT CONTROL PLAN CH15200 TO CH15700			
						DRAWN BY	A.J.B.									PROJECT NO.	SUB-PR NO.	DRAWING NO.	REV
						FINAL APPROVAL										13000157	P02	ESCP117	A
A	29/05/14	A.J.B.	A.J.B.		DRAFT - SEDIMENT BASIN/TRAP LOCATIONS - FOR CONSULTATION	SCALE: (on A3 Original)	1:2000												

EROSION AND SEDIMENT CONTROL PLAN - GENERAL NOTE

THESE PLANS ARE PRIMARY ESCPs USING BLUE BOOK (LANDCOM, 2004) DEFAULT VALUES BASED ON SURROUNDING LOCATIONS. THE CONTROLS SHOWN ONLY INCLUDE MAJOR SEDIMENT BASINS/TRAPS AND CLEAN WATER DIVERSIONS. DETAILED PROGRESSIVE ESCPs MUST BE COMPLETED PRIOR TO CONSTRUCTION WORKS IN CONSULTATION WITH RMS, EPA AND OTHER RELEVANT REGULATORY AUTHORITIES.



LEGEND

-  NATURAL/EXISTING CREST LOCATION
-  PROPOSED ROAD CREST LOCATION
-  SEDIMENT BASIN (SB) - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX FOR SEDIMENT BASIN VOLUMES)
-  SEDIMENT TRAP (ST) / TEMPORARY ONLINE BASIN - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX)
-  TEMPORARY WATERWAY DIVERSION AROUND CULVERT WORKS (DETAIL A/C)

ADDITIONAL REQUIREMENTS FOR FLOOD PRONE LANDS AND LANDS WHERE HIGH GROUND WATER IS ENCOUNTERED WHERE APPLICABLE

- ACCESS/HAUL ROADS TO BE FORMED USING ROCK WITH GEOTEXTILE UNDERLAY (THIS CAN BE INCORPORATED AS PART OF THE ROAD BRIDGING LAYER WHERE APPLICABLE)
- MINIMISE STRIPPING OF GRASS VEGETATION AND TOPSOIL AS MUCH AS POSSIBLE. CONSTRUCT WORKS OVER THE TOP OF EXISTING GRASS WHERE POSSIBLE
- EXPOSED FILL BATTERS TO BE STABILISED (LOCKED DOWN WITH SOIL STABILISERS OR COVERED WITH FABRIC/MATTING) PRIOR TO RAINFALL, SITE CLOSURE OR WHEN WORKS ARE ON HOLD
- PERMANENT STABILISATION OF FILL BATTERS IS TO OCCUR PROGRESSIVELY
- TOP EDGES OF THE FILLS ARE TO HAVE WINDROWS/BUNDS WITH REGULAR BATTER CHUTES
- CULVERTS AND CLEAN DIVERSIONS TO BE CONSTRUCTED AS EARLY WORKS
- TURKEYS NEST SEDIMENT BASINS WILL BE REQUIRED IN AREAS OF HIGH GROUND WATER. THESE BASINS ARE TO BE BUILT UP PROGRESSIVELY AS THE FILL COMES UP OR BASIN INLETS PROGRESSIVELY RAISED AS THE FILL COMES UP. SUPPLEMENTARY SEDIMENT TRAPS ON-LINE AND INCREASED EROSION CONTROLS ARE TO BE EMPLOYED UNTIL THE FULL SEDIMENT BASIN VOLUMES ARE ACHIEVED
- BASINS TO BE BUILT AS LARGE IN SURFACE AREA AS POSSIBLE TO LIMIT THE BASIN HEIGHT AND LEVEL OF EXCAVATION
- UNTIL SUCH TIME THAT FULL SIZE SEDIMENT BASINS CAN BE EMPLOYED OR IN LOCATIONS WHERE SEDIMENT BASIN CONSTRUCTION IS NOT SUITABLE, SEDIMENT FILTRATION SUMPS/TRAPS TO BE PROVIDED IN LOW POINTS ARE AROUND LOWER EDGES OF WORKS (E.G. ROCK FILTER DAMS OR EQUIVALENT SEDIMENT FILTRATION DEVICE)
- SEDIMENT BASINS WILL REQUIRE ARMoured WALLS
- ANY WORKS WITHIN WATERCOURSES ARE TO BE SCHEDULED FOR LOW RAINFALL AND RAINFALL EROSIONIVITY TIMES OF THE YEAR AND WORKS ARE TO BE STAGED AS MUCH AS POSSIBLE TO MINIMISE EXPOSURE

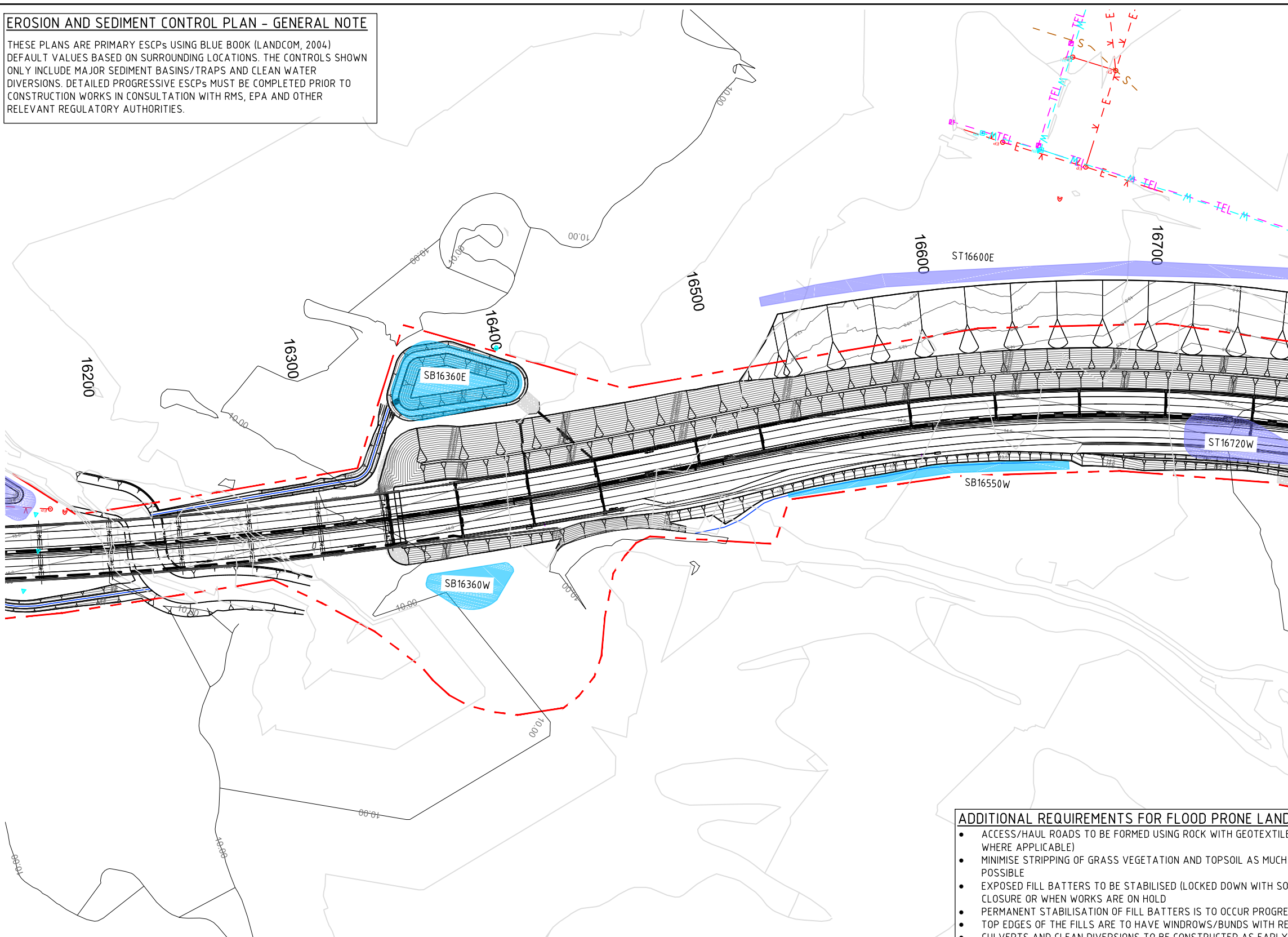
NOT FOR CONSTRUCTION

REV	DATE	DES.	DRN.	APP.	REVISION DETAILS	DRAWING STATUS		North	CLIENT	PROJECT TITLE	DRAWING TITLE				
						DESIGN BY	A.M. / A.J.B.				PO Box 1098, Bowral, NSW, 2576 Suites 9 & 10, Bowral Mall Cnr. Bowley & Station Streets, Bowral. (t) 02 4862 1633 (f) 02 4862 3088 email: reception@seec.com.au WWW.SEEC.COM.AU	PRIMARY EROSION AND SEDIMENT CONTROL PLAN CH15700 TO CH16200			
					DRAWN BY	A.J.B.									
					FINAL APPROVAL										
						SCALE:	1:2000								
						DRAFT									
A	29/05/14	A.J.B.	A.J.B.		DRAFT - SEDIMENT BASIN/TRAP LOCATIONS - FOR CONSULTATION					HW1 PRINCES HIGHWAY FOXGROUND AND BERRY BY-PASS TOOLIJOOA ROAD TO SCHOFIELDS LANE	PROJECT NO. 13000157	SUB-PR NO. P02	DRAWING NO. ESCP118	REV A	

This drawing is subject to COPYRIGHT ©. The information on this drawing remains the property of SEEC.

EROSION AND SEDIMENT CONTROL PLAN - GENERAL NOTE

THESE PLANS ARE PRIMARY ESCPs USING BLUE BOOK (LANDCOM, 2004) DEFAULT VALUES BASED ON SURROUNDING LOCATIONS. THE CONTROLS SHOWN ONLY INCLUDE MAJOR SEDIMENT BASINS/TRAPS AND CLEAN WATER DIVERSIONS. DETAILED PROGRESSIVE ESCPs MUST BE COMPLETED PRIOR TO CONSTRUCTION WORKS IN CONSULTATION WITH RMS, EPA AND OTHER RELEVANT REGULATORY AUTHORITIES.



LEGEND

- NATURAL/EXISTING CREST LOCATION
- PROPOSED ROAD CREST LOCATION
- SEDIMENT BASIN (SB) - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX FOR SEDIMENT BASIN VOLUMES)
- SEDIMENT TRAP (ST) / TEMPORARY ONLINE BASIN - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX)
- TEMPORARY WATERWAY DIVERSION AROUND CULVERT WORKS (DETAIL A/C)

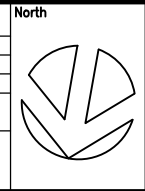
ADDITIONAL REQUIREMENTS FOR FLOOD PRONE LANDS AND LANDS WHERE HIGH GROUND WATER IS ENCOUNTERED WHERE APPLICABLE

- ACCESS/HAUL ROADS TO BE FORMED USING ROCK WITH GEOTEXTILE UNDERLAY (THIS CAN BE INCORPORATED AS PART OF THE ROAD BRIDGING LAYER WHERE APPLICABLE)
- MINIMISE STRIPPING OF GRASS VEGETATION AND TOPSOIL AS MUCH AS POSSIBLE. CONSTRUCT WORKS OVER THE TOP OF EXISTING GRASS WHERE POSSIBLE
- EXPOSED FILL BATTERS TO BE STABILISED (LOCKED DOWN WITH SOIL STABILISERS OR COVERED WITH FABRIC/MATTING) PRIOR TO RAINFALL, SITE CLOSURE OR WHEN WORKS ARE ON HOLD
- PERMANENT STABILISATION OF FILL BATTERS IS TO OCCUR PROGRESSIVELY
- TOP EDGES OF THE FILLS ARE TO HAVE WINDROWS/BUNDS WITH REGULAR BATTER CHUTES
- CULVERTS AND CLEAN DIVERSIONS TO BE CONSTRUCTED AS EARLY WORKS
- TURKEYS NEST SEDIMENT BASINS WILL BE REQUIRED IN AREAS OF HIGH GROUND WATER. THESE BASINS ARE TO BE BUILT UP PROGRESSIVELY AS THE FILL COMES UP OR BASIN INLETS PROGRESSIVELY RAISED AS THE FILL COMES UP. SUPPLEMENTARY SEDIMENT TRAPS ON-LINE AND INCREASED EROSION CONTROLS ARE TO BE EMPLOYED UNTIL THE FULL SEDIMENT BASIN VOLUMES ARE ACHIEVED
- BASINS TO BE BUILT AS LARGE IN SURFACE AREA AS POSSIBLE TO LIMIT THE BASIN HEIGHT AND LEVEL OF EXCAVATION
- UNTIL SUCH TIME THAT FULL SIZE SEDIMENT BASINS CAN BE EMPLOYED OR IN LOCATIONS WHERE SEDIMENT BASIN CONSTRUCTION IS NOT SUITABLE, SEDIMENT FILTRATION SUMPS/TRAPS TO BE PROVIDED IN LOW POINTS AROUND LOWER EDGES OF WORKS (E.G. ROCK FILTER DAMS OR EQUIVALENT SEDIMENT FILTRATION DEVICE)
- SEDIMENT BASINS WILL REQUIRE ARMoured WALLS
- ANY WORKS WITHIN WATERCOURSES ARE TO BE SCHEDULED FOR LOW RAINFALL AND RAINFALL EROSION TIMES OF THE YEAR AND WORKS ARE TO BE STAGED AS MUCH AS POSSIBLE TO MINIMISE EXPOSURE

NOT FOR CONSTRUCTION

REV	DATE	DES.	DRN.	APP.	REVISION DETAILS
A	29/05/14	A.J.B.	A.J.B.		DRAFT - SEDIMENT BASIN/TRAP LOCATIONS - FOR CONSULTATION

DRAWING STATUS	
DESIGN BY	A.M. / A.J.B.
DRAWN BY	A.J.B.
FINAL APPROVAL	
SCALE:	1:2000
(on A3 Original)	
DRAFT	



CLIENT

PO Box 1098, Bowral, NSW, 2576
 Suites 9 & 10, Bowral Mall
 Cnr. Bowley & Station Streets, Bowral.
 (t) 02 4862 1633
 (f) 02 4862 3088
 email: reception@seec.com.au
 WWW.SEEC.COM.AU

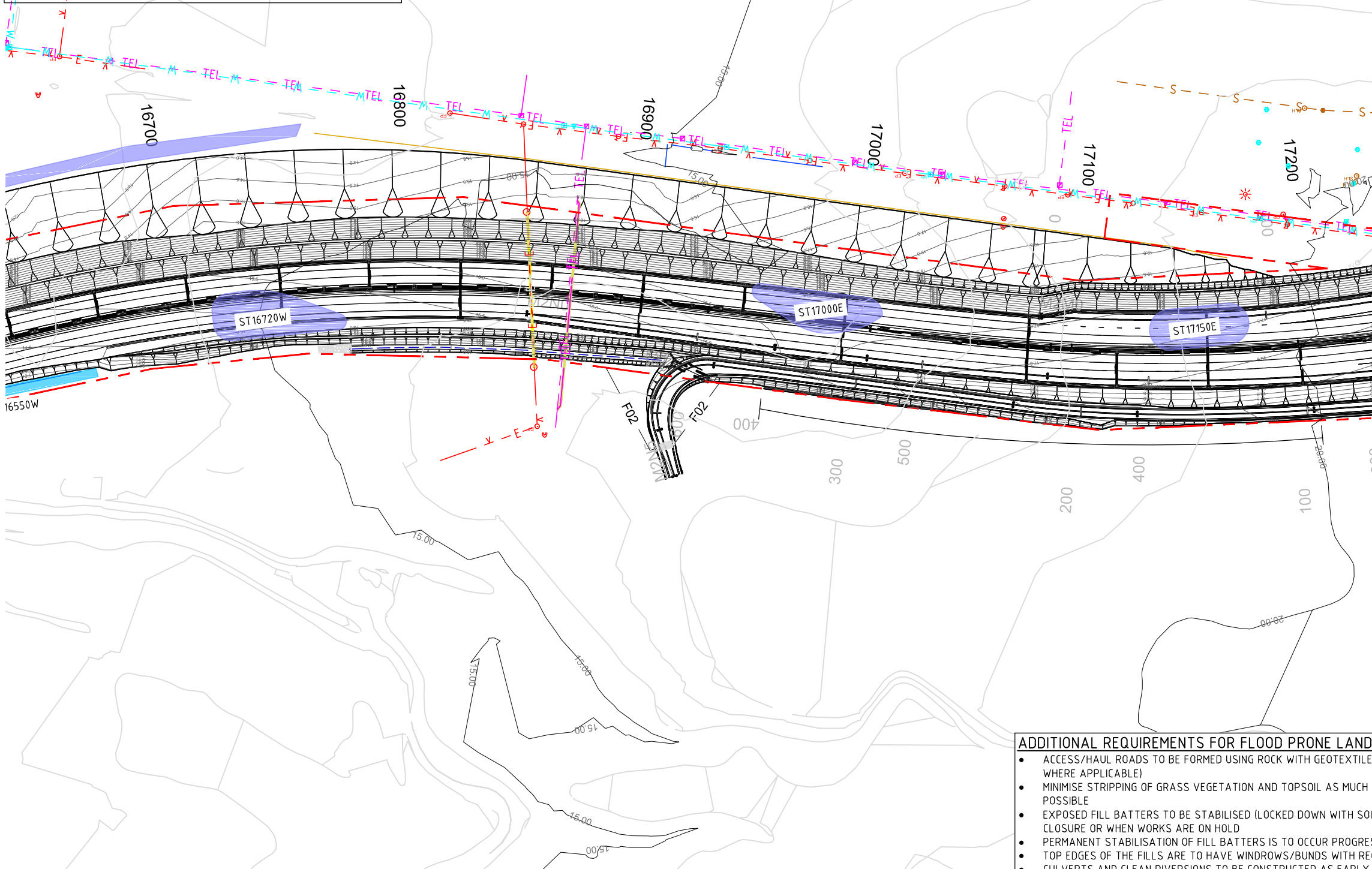
PROJECT TITLE

**HW1 PRINCES HIGHWAY
 FOXGROUND AND BERRY BY-PASS
 TOOLIJOOA ROAD TO
 SCHOFIELDS LANE**

DRAWING TITLE			
PRIMARY EROSION AND SEDIMENT CONTROL PLAN CH16200 TO CH16700			
PROJECT NO.	SUB-PR NO.	DRAWING NO.	REV
13000157	P02	ESCP119	A

EROSION AND SEDIMENT CONTROL PLAN - GENERAL NOTE

THESE PLANS ARE PRIMARY ESCPs USING BLUE BOOK (LANDCOM, 2004) DEFAULT VALUES BASED ON SURROUNDING LOCATIONS. THE CONTROLS SHOWN ONLY INCLUDE MAJOR SEDIMENT BASINS/TRAPS AND CLEAN WATER DIVERSIONS. DETAILED PROGRESSIVE ESCPs MUST BE COMPLETED PRIOR TO CONSTRUCTION WORKS IN CONSULTATION WITH RMS, EPA AND OTHER RELEVANT REGULATORY AUTHORITIES.



LEGEND

- NATURAL/EXISTING CREST LOCATION
- PROPOSED ROAD CREST LOCATION
- SEDIMENT BASIN (SB) - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX FOR SEDIMENT BASIN VOLUMES)
- SEDIMENT TRAP (ST) / TEMPORARY ONLINE BASIN - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX)
- TEMPORARY WATERWAY DIVERSION AROUND CULVERT WORKS (DETAIL A/C)

ADDITIONAL REQUIREMENTS FOR FLOOD PRONE LANDS AND LANDS WHERE HIGH GROUND WATER IS ENCOUNTERED WHERE APPLICABLE

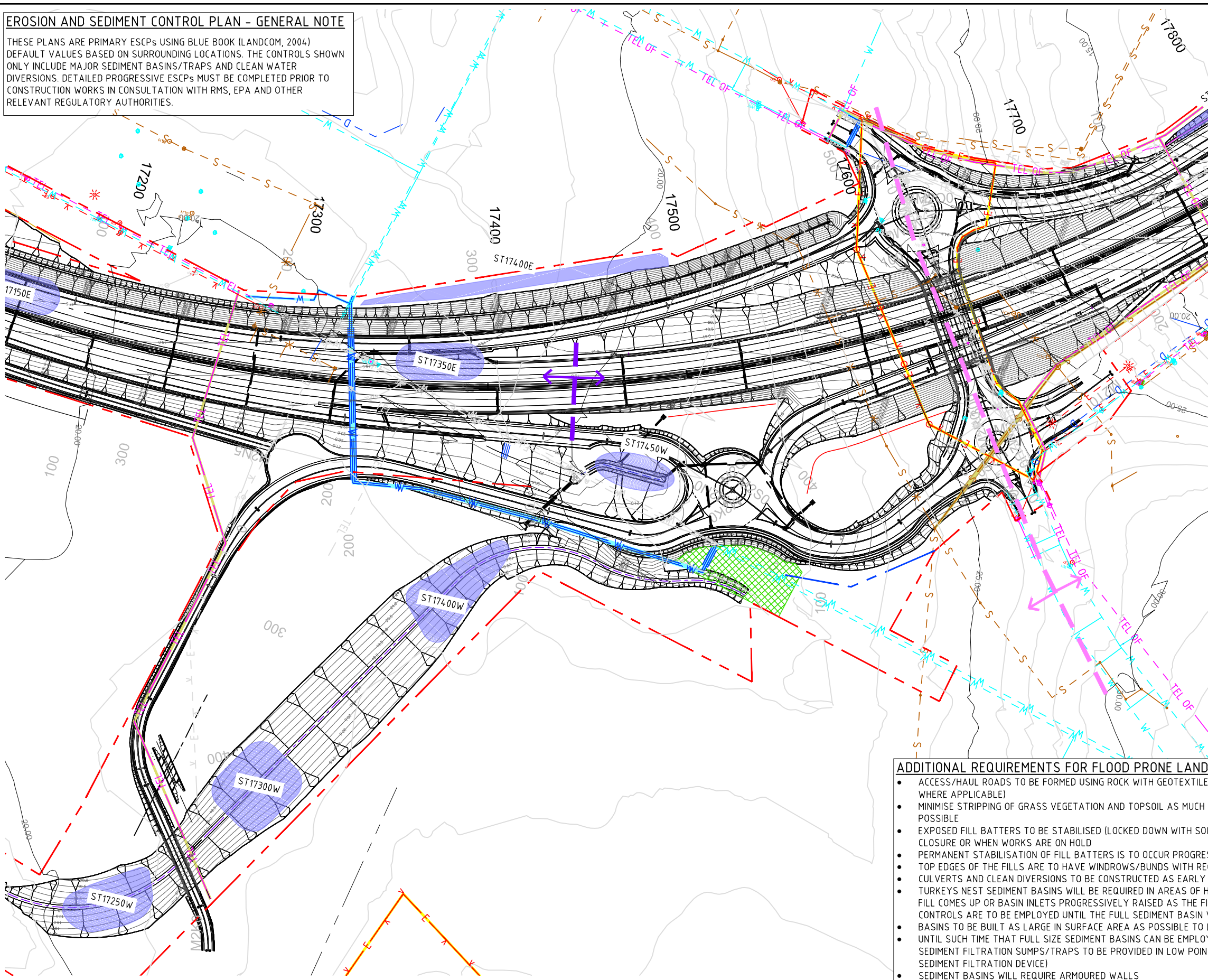
- ACCESS/HAUL ROADS TO BE FORMED USING ROCK WITH GEOTEXTILE UNDERLAY (THIS CAN BE INCORPORATED AS PART OF THE ROAD BRIDGING LAYER WHERE APPLICABLE)
- MINIMISE STRIPPING OF GRASS VEGETATION AND TOPSOIL AS MUCH AS POSSIBLE. CONSTRUCT WORKS OVER THE TOP OF EXISTING GRASS WHERE POSSIBLE
- EXPOSED FILL BATTERS TO BE STABILISED (LOCKED DOWN WITH SOIL STABILISERS OR COVERED WITH FABRIC/MATTING) PRIOR TO RAINFALL, SITE CLOSURE OR WHEN WORKS ARE ON HOLD
- PERMANENT STABILISATION OF FILL BATTERS IS TO OCCUR PROGRESSIVELY
- TOP EDGES OF THE FILLS ARE TO HAVE WINDROWS/BUNDS WITH REGULAR BATTER CHUTES
- CULVERTS AND CLEAN DIVERSIONS TO BE CONSTRUCTED AS EARLY WORKS
- TURKEYS NEST SEDIMENT BASINS WILL BE REQUIRED IN AREAS OF HIGH GROUND WATER. THESE BASINS ARE TO BE BUILT UP PROGRESSIVELY AS THE FILL COMES UP OR BASIN INLETS PROGRESSIVELY RAISED AS THE FILL COMES UP. SUPPLEMENTARY SEDIMENT TRAPS ON-LINE AND INCREASED EROSION CONTROLS ARE TO BE EMPLOYED UNTIL THE FULL SEDIMENT BASIN VOLUMES ARE ACHIEVED
- BASINS TO BE BUILT AS LARGE IN SURFACE AREA AS POSSIBLE TO LIMIT THE BASIN HEIGHT AND LEVEL OF EXCAVATION
- UNTIL SUCH TIME THAT FULL SIZE SEDIMENT BASINS CAN BE EMPLOYED OR IN LOCATIONS WHERE SEDIMENT BASIN CONSTRUCTION IS NOT SUITABLE, SEDIMENT FILTRATION SUMPS/TRAPS TO BE PROVIDED IN LOW POINTS AROUND LOWER EDGES OF WORKS (E.G. ROCK FILTER DAMS OR EQUIVALENT SEDIMENT FILTRATION DEVICE)
- SEDIMENT BASINS WILL REQUIRE ARMoured WALLS
- ANY WORKS WITHIN WATERCOURSES ARE TO BE SCHEDULED FOR LOW RAINFALL AND RAINFALL EROSIONITY TIMES OF THE YEAR AND WORKS ARE TO BE STAGED AS MUCH AS POSSIBLE TO MINIMISE EXPOSURE

NOT FOR CONSTRUCTION

REV	DATE	DES.	DRN.	APP.	REVISION DETAILS	DRAWING STATUS		North	CLIENT	PROJECT TITLE	DRAWING TITLE								
						DESIGN BY	A.M. / A.J.B.				PO Box 1098, Bowral, NSW, 2576 Suites 9 & 10, Bowral Mall Cnr. Bowliway & Station Streets, Bowral. (t) 02 4862 1633 (f) 02 4862 3088 email: reception@seec.com.au WWW.SEEC.COM.AU	HW1 PRINCES HIGHWAY FOXGROUND AND BERRY BY-PASS TOOLIJOOA ROAD TO SCHOFIELDS LANE				PRIMARY EROSION AND SEDIMENT CONTROL PLAN CH16700 TO CH17200			
						DRAWN BY	A.J.B.									PROJECT NO.	SUB-PR NO.	DRAWING NO.	REV
						FINAL APPROVAL										13000157	P02	ESCP120	A
A	29/05/14	A.J.B.	A.J.B.		DRAFT - SEDIMENT BASIN/TRAP LOCATIONS - FOR CONSULTATION	SCALE:	1:2000												

EROSION AND SEDIMENT CONTROL PLAN - GENERAL NOTE

THESE PLANS ARE PRIMARY ESCPs USING BLUE BOOK (LANDCOM, 2004) DEFAULT VALUES BASED ON SURROUNDING LOCATIONS. THE CONTROLS SHOWN ONLY INCLUDE MAJOR SEDIMENT BASINS/TRAPS AND CLEAN WATER DIVERSIONS. DETAILED PROGRESSIVE ESCPs MUST BE COMPLETED PRIOR TO CONSTRUCTION WORKS IN CONSULTATION WITH RMS, EPA AND OTHER RELEVANT REGULATORY AUTHORITIES.



LEGEND

- NATURAL/EXISTING CREST LOCATION
- PROPOSED ROAD CREST LOCATION
- SEDIMENT BASIN (SB) - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX FOR SEDIMENT BASIN VOLUMES)
- SEDIMENT TRAP (ST) / TEMPORARY ONLINE BASIN - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX)
- TEMPORARY WATERWAY DIVERSION AROUND CULVERT WORKS (DETAIL A/C)

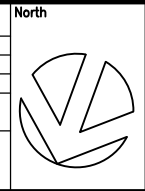
ADDITIONAL REQUIREMENTS FOR FLOOD PRONE LANDS AND LANDS WHERE HIGH GROUND WATER IS ENCOUNTERED WHERE APPLICABLE

- ACCESS/HAUL ROADS TO BE FORMED USING ROCK WITH GEOTEXTILE UNDERLAY (THIS CAN BE INCORPORATED AS PART OF THE ROAD BRIDGING LAYER WHERE APPLICABLE)
- MINIMISE STRIPPING OF GRASS VEGETATION AND TOPSOIL AS MUCH AS POSSIBLE. CONSTRUCT WORKS OVER THE TOP OF EXISTING GRASS WHERE POSSIBLE
- EXPOSED FILL BATTERS TO BE STABILISED (LOCKED DOWN WITH SOIL STABILISERS OR COVERED WITH FABRIC/MATTING) PRIOR TO RAINFALL, SITE CLOSURE OR WHEN WORKS ARE ON HOLD
- PERMANENT STABILISATION OF FILL BATTERS IS TO OCCUR PROGRESSIVELY
- TOP EDGES OF THE FILLS ARE TO HAVE WINDROWS/BUNDS WITH REGULAR BATTER CHUTES
- CULVERTS AND CLEAN DIVERSIONS TO BE CONSTRUCTED AS EARLY WORKS
- TURKEYS NEST SEDIMENT BASINS WILL BE REQUIRED IN AREAS OF HIGH GROUND WATER. THESE BASINS ARE TO BE BUILT UP PROGRESSIVELY AS THE FILL COMES UP OR BASIN INLETS PROGRESSIVELY RAISED AS THE FILL COMES UP. SUPPLEMENTARY SEDIMENT TRAPS ON-LINE AND INCREASED EROSION CONTROLS ARE TO BE EMPLOYED UNTIL THE FULL SEDIMENT BASIN VOLUMES ARE ACHIEVED
- BASINS TO BE BUILT AS LARGE IN SURFACE AREA AS POSSIBLE TO LIMIT THE BASIN HEIGHT AND LEVEL OF EXCAVATION
- UNTIL SUCH TIME THAT FULL SIZE SEDIMENT BASINS CAN BE EMPLOYED OR IN LOCATIONS WHERE SEDIMENT BASIN CONSTRUCTION IS NOT SUITABLE, SEDIMENT FILTRATION SUMPS/TRAPS TO BE PROVIDED IN LOW POINTS AROUND LOWER EDGES OF WORKS (E.G. ROCK FILTER DAMS OR EQUIVALENT SEDIMENT FILTRATION DEVICE)
- SEDIMENT BASINS WILL REQUIRE ARMoured WALLS
- ANY WORKS WITHIN WATERCOURSES ARE TO BE SCHEDULED FOR LOW RAINFALL AND RAINFALL EROSION TIMES OF THE YEAR AND WORKS ARE TO BE STAGED AS MUCH AS POSSIBLE TO MINIMISE EXPOSURE

NOT FOR CONSTRUCTION

REV	DATE	DES.	DRN.	APP.	REVISION DETAILS
A	29/05/14	A.J.B.	A.J.B.		DRAFT - SEDIMENT BASIN/TRAP LOCATIONS - FOR CONSULTATION

DRAWING STATUS	
DESIGN BY	A.M. / A.J.B.
DRAWN BY	A.J.B.
FINAL APPROVAL	
SCALE:	1:2000
(on A3 Original)	
DRAFT	



CLIENT

PO Box 1098, Bowral, NSW, 2576
 Suites 9 & 10, Bowral Mall
 Cnr. Bowley & Station Streets, Bowral.
 (t) 02 4862 1633
 (f) 02 4862 3088
 email: reception@seec.com.au
 WWW.SEEC.COM.AU

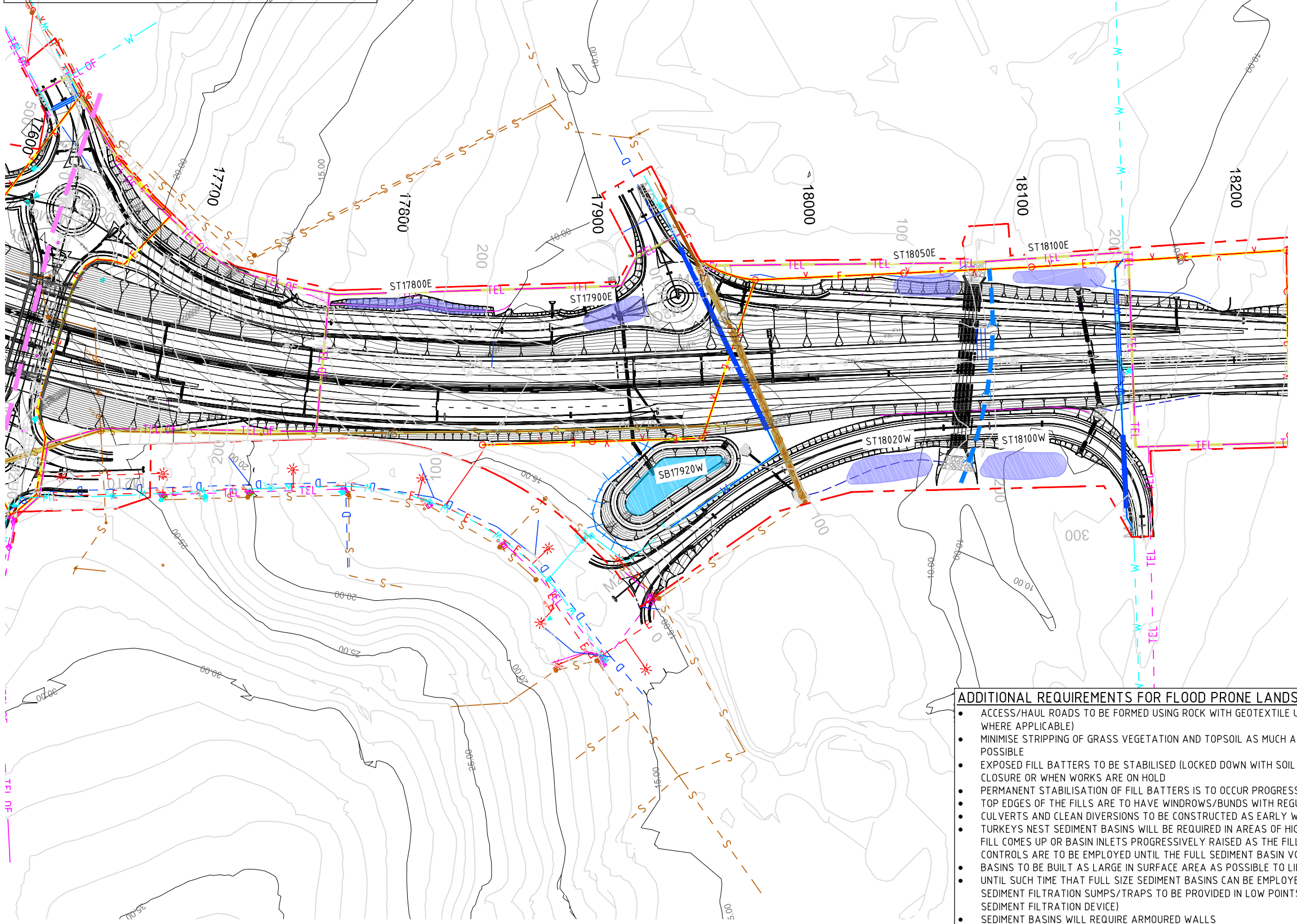
PROJECT TITLE
**HW1 PRINCES HIGHWAY
 FOXGROUND AND BERRY BY-PASS
 TOOLIJOOA ROAD TO
 SCHOFIELDS LANE**

DRAWING TITLE			
PRIMARY EROSION AND SEDIMENT CONTROL PLAN CH17200 TO CH17700			
PROJECT NO.	SUB-PR NO.	DRAWING NO.	REV
13000157	P02	ESCP121	A

This drawing is subject to COPYRIGHT ©. The information on this drawing remains the property of SEEC.

EROSION AND SEDIMENT CONTROL PLAN - GENERAL NOTE

THESE PLANS ARE PRIMARY ESCPs USING BLUE BOOK (LANDCOM, 2004) DEFAULT VALUES BASED ON SURROUNDING LOCATIONS. THE CONTROLS SHOWN ONLY INCLUDE MAJOR SEDIMENT BASINS/TRAPS AND CLEAN WATER DIVERSIONS. DETAILED PROGRESSIVE ESCPs MUST BE COMPLETED PRIOR TO CONSTRUCTION WORKS IN CONSULTATION WITH RMS, EPA AND OTHER RELEVANT REGULATORY AUTHORITIES.



LEGEND

- NATURAL/EXISTING CREST LOCATION
- PROPOSED ROAD CREST LOCATION
- SEDIMENT BASIN (SB) - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX FOR SEDIMENT BASIN VOLUMES)
- SEDIMENT TRAP (ST) / TEMPORARY ONLINE BASIN - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX)
- TEMPORARY WATERWAY DIVERSION AROUND CULVERT WORKS (DETAIL A/C)

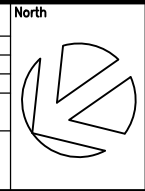
ADDITIONAL REQUIREMENTS FOR FLOOD PRONE LANDS AND LANDS WHERE HIGH GROUND WATER IS ENCOUNTERED WHERE APPLICABLE

- ACCESS/HAUL ROADS TO BE FORMED USING ROCK WITH GEOTEXTILE UNDERLAY (THIS CAN BE INCORPORATED AS PART OF THE ROAD BRIDGING LAYER WHERE APPLICABLE)
- MINIMISE STRIPPING OF GRASS VEGETATION AND TOPSOIL AS MUCH AS POSSIBLE. CONSTRUCT WORKS OVER THE TOP OF EXISTING GRASS WHERE POSSIBLE
- EXPOSED FILL BATTERS TO BE STABILISED (LOCKED DOWN WITH SOIL STABILISERS OR COVERED WITH FABRIC/MATting) PRIOR TO RAINFALL, SITE CLOSURE OR WHEN WORKS ARE ON HOLD
- PERMANENT STABILISATION OF FILL BATTERS IS TO OCCUR PROGRESSIVELY
- TOP EDGES OF THE FILLS ARE TO HAVE WINDROWS/BUNDS WITH REGULAR BATTER CHUTES
- CULVERTS AND CLEAN DIVERSIONS TO BE CONSTRUCTED AS EARLY WORKS
- TURKEYS NEST SEDIMENT BASINS WILL BE REQUIRED IN AREAS OF HIGH GROUND WATER. THESE BASINS ARE TO BE BUILT UP PROGRESSIVELY AS THE FILL COMES UP OR BASIN INLETS PROGRESSIVELY RAISED AS THE FILL COMES UP. SUPPLEMENTARY SEDIMENT TRAPS ON-LINE AND INCREASED EROSION CONTROLS ARE TO BE EMPLOYED UNTIL THE FULL SEDIMENT BASIN VOLUMES ARE ACHIEVED
- BASINS TO BE BUILT AS LARGE IN SURFACE AREA AS POSSIBLE TO LIMIT THE BASIN HEIGHT AND LEVEL OF EXCAVATION
- UNTIL SUCH TIME THAT FULL SIZE SEDIMENT BASINS CAN BE EMPLOYED OR IN LOCATIONS WHERE SEDIMENT BASIN CONSTRUCTION IS NOT SUITABLE, SEDIMENT FILTRATION SUMPS/TRAPS TO BE PROVIDED IN LOW POINTS AROUND LOWER EDGES OF WORKS (E.G. ROCK FILTER DAMS OR EQUIVALENT SEDIMENT FILTRATION DEVICE)
- SEDIMENT BASINS WILL REQUIRE ARMoured WALLS
- ANY WORKS WITHIN WATERCOURSES ARE TO BE SCHEDULED FOR LOW RAINFALL AND RAINFALL EROSIvITY TIMES OF THE YEAR AND WORKS ARE TO BE STAGED AS MUCH AS POSSIBLE TO MINIMISE EXPOSURE

NOT FOR CONSTRUCTION

REV	DATE	DES.	DRN.	APP.	REVISION DETAILS
A	29/05/14	A.J.B.	A.J.B.		DRAFT - SEDIMENT BASIN/TRAP LOCATIONS - FOR CONSULTATION

DRAWING STATUS	
DESIGN BY	A.M. / A.J.B.
DRAWN BY	A.J.B.
FINAL APPROVAL	
SCALE:	1:2000
(on A3 Original)	
DRAFT	



CLIENT



SEEC

PO Box 1098, Bowral, NSW, 2576
 Suites 9 & 10, Bowral Mall
 Cnr. Bowley & Station Streets, Bowral.
 (t) 02 4862 1633
 (f) 02 4862 3088
 email: reception@seec.com.au
 WWW.SEEC.COM.AU

PROJECT TITLE

**HW1 PRINCES HIGHWAY
 FOXGROUND AND BERRY BY-PASS
 TOOLIJOOA ROAD TO
 SCHOFIELDS LANE**

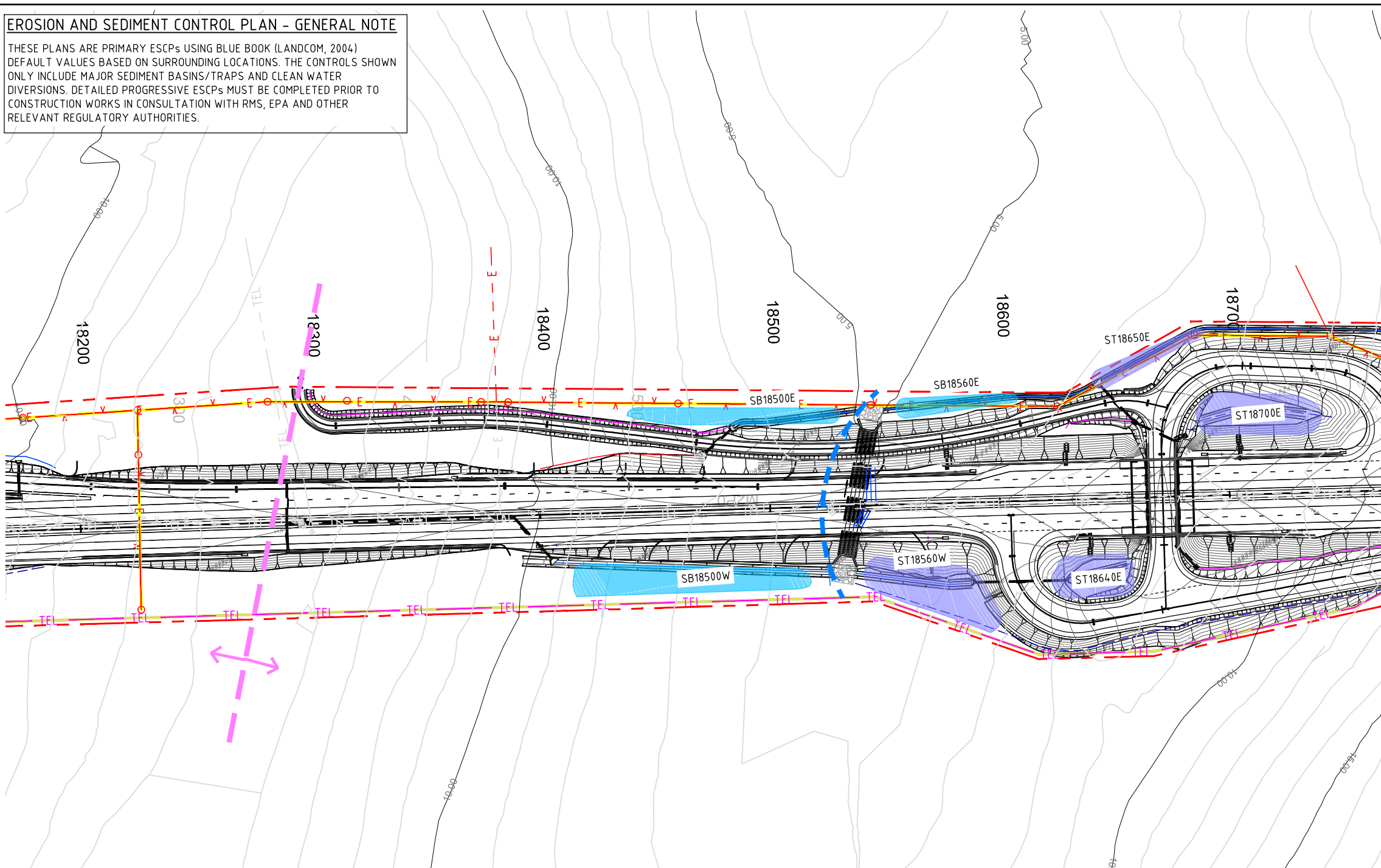
DRAWING TITLE			
PRIMARY EROSION AND SEDIMENT CONTROL PLAN CH17700 TO CH18200			
PROJECT NO.	SUB-PR NO.	DRAWING NO.	REV
13000157	P02	ESCP122	A

EROSION AND SEDIMENT CONTROL PLAN - GENERAL NOTE

THESE PLANS ARE PRIMARY ESCPs USING BLUE BOOK (LANDCOM, 2004) DEFAULT VALUES BASED ON SURROUNDING LOCATIONS. THE CONTROLS SHOWN ONLY INCLUDE MAJOR SEDIMENT BASINS/TRAPS AND CLEAN WATER DIVERSIONS. DETAILED PROGRESSIVE ESCPs MUST BE COMPLETED PRIOR TO CONSTRUCTION WORKS IN CONSULTATION WITH RMS, EPA AND OTHER RELEVANT REGULATORY AUTHORITIES.

LEGEND

-  NATURAL/EXISTING CREST LOCATION
-  PROPOSED ROAD CREST LOCATION
-  SEDIMENT BASIN (SB) - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX FOR SEDIMENT BASIN VOLUMES)
-  SEDIMENT TRAP (ST) / TEMPORARY ONLINE BASIN - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX)
-  TEMPORARY WATERWAY DIVERSION AROUND CULVERT WORKS (DETAIL A/C)



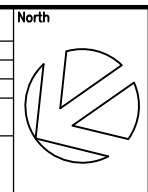
ADDITIONAL REQUIREMENTS FOR FLOOD PRONE LANDS AND LANDS WHERE HIGH GROUND WATER IS ENCOUNTERED WHERE APPLICABLE)

- ACCESS/HAUL ROADS TO BE FORMED USING ROCK WITH GEOTEXTILE UNDERLAY (THIS CAN BE INCORPORATED AS PART OF THE ROAD BRIDGING LAYER WHERE APPLICABLE)
- MINIMISE STRIPPING OF GRASS VEGETATION AND TOPSOIL AS MUCH AS POSSIBLE. CONSTRUCT WORKS OVER THE TOP OF EXISTING GRASS WHERE POSSIBLE
- EXPOSED FILL BATTERS TO BE STABILISED (LOCKED DOWN WITH SOIL STABILISERS OR COVERED WITH FABRIC/MATTING) PRIOR TO RAINFALL, SITE CLOSURE OR WHEN WORKS ARE ON HOLD
- PERMANENT STABILISATION OF FILL BATTERS IS TO OCCUR PROGRESSIVELY
- TOP EDGES OF THE FILLS ARE TO HAVE WINDROWS/BUNDS WITH REGULAR BATTER CHUTES
- CULVERTS AND CLEAN DIVERSIONS TO BE CONSTRUCTED AS EARLY WORKS
- TURKEYS NEST SEDIMENT BASINS WILL BE REQUIRED IN AREAS OF HIGH GROUND WATER. THESE BASINS ARE TO BE BUILT UP PROGRESSIVELY AS THE FILL COMES UP OR BASIN INLETS PROGRESSIVELY RAISED AS THE FILL COMES UP. SUPPLEMENTARY SEDIMENT TRAPS ON-LINE AND INCREASED EROSION CONTROLS ARE TO BE EMPLOYED UNTIL THE FULL SEDIMENT BASIN VOLUMES ARE ACHIEVED
- BASINS TO BE BUILT AS LARGE IN SURFACE AREA AS POSSIBLE TO LIMIT THE BASIN HEIGHT AND LEVEL OF EXCAVATION
- UNTIL SUCH TIME THAT FULL SIZE SEDIMENT BASINS CAN BE EMPLOYED OR IN LOCATIONS WHERE SEDIMENT BASIN CONSTRUCTION IS NOT SUITABLE, SEDIMENT FILTRATION SUMPS/TRAPS TO BE PROVIDED IN LOW POINTS ARE AROUND LOWER EDGES OF WORKS (E.G. ROCK FILTER DAMS OR EQUIVALENT SEDIMENT FILTRATION DEVICE)
- SEDIMENT BASINS WILL REQUIRE ARMoured WALLS
- ANY WORKS WITHIN WATERCOURSES ARE TO BE SCHEDULED FOR LOW RAINFALL AND RAINFALL EROSION TIMES OF THE YEAR AND WORKS ARE TO BE STAGED AS MUCH AS POSSIBLE TO MINIMISE EXPOSURE

NOT FOR CONSTRUCTION

REV	DATE	DES.	DRN.	APP.	REVISION DETAILS
A	29/05/14	A.J.B.	A.J.B.		DRAFT - SEDIMENT BASIN/TRAP LOCATIONS - FOR CONSULTATION

DRAWING STATUS	
DESIGN BY	A.M. / A.J.B.
DRAWN BY	A.J.B.
FINAL APPROVAL	
SCALE:	1:2000
(on A3 Original)	
DRAFT	



CLIENT



PO Box 1098, Bowral, NSW, 2576
 Suites 9 & 10, Bowral Mall
 Cnr. Bowley & Station Streets, Bowral.
 (t) 02 4862 1633
 (f) 02 4862 3088
 email: reception@seec.com.au
 WWW.SEEC.COM.AU

PROJECT TITLE
 HW1 PRINCES HIGHWAY
 FOXGROUND AND BERRY BY-PASS
 TOOLIJOOA ROAD TO
 SCHOFIELDS LANE

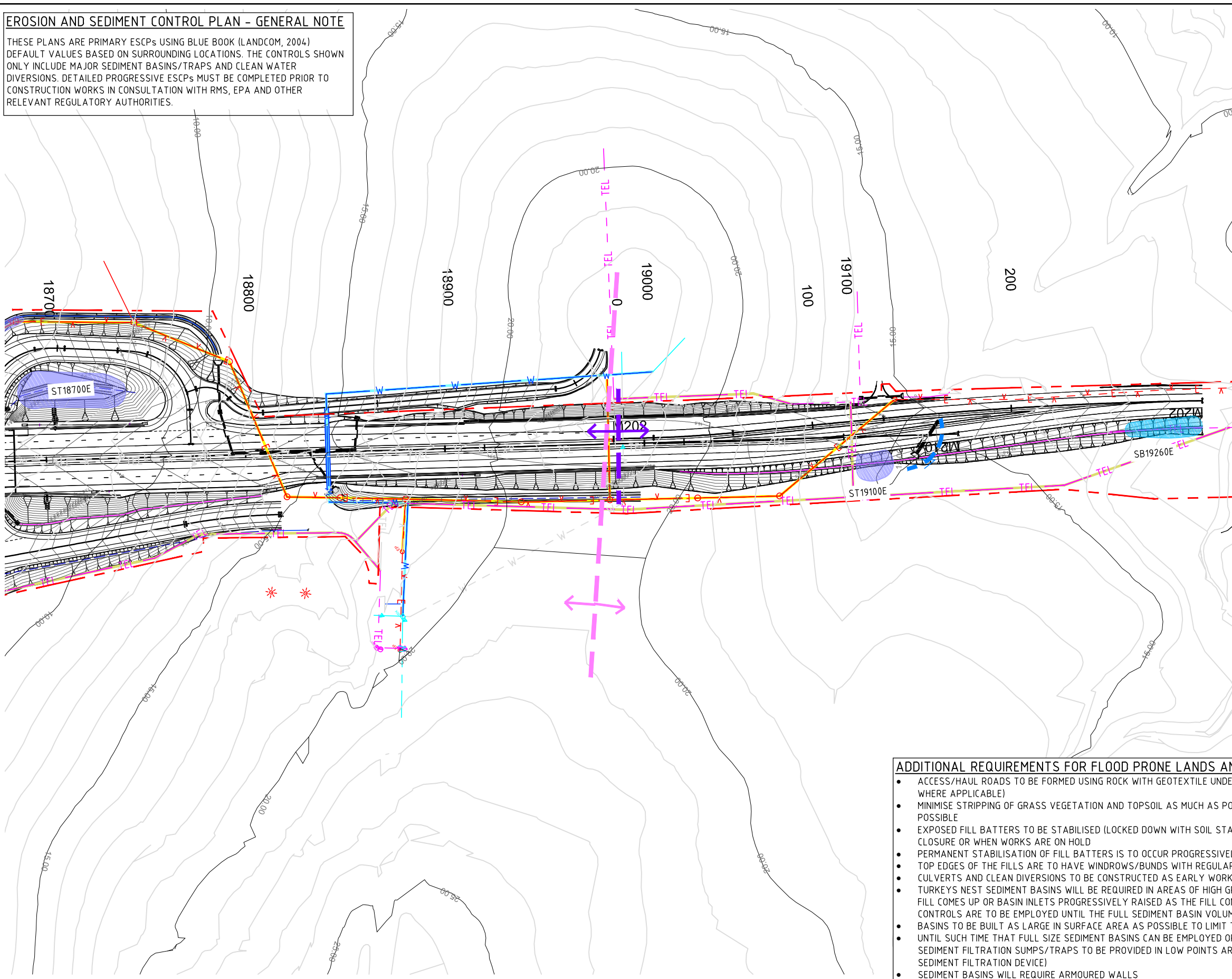
DRAWING TITLE			
PRIMARY EROSION AND SEDIMENT CONTROL PLAN CH18200 TO CH18700			
PROJECT NO.	SUB-PR NO.	DRAWING NO.	REV
13000157	P02	ESCP123	A

EROSION AND SEDIMENT CONTROL PLAN - GENERAL NOTE

THESE PLANS ARE PRIMARY ESCPs USING BLUE BOOK (LANDCOM, 2004) DEFAULT VALUES BASED ON SURROUNDING LOCATIONS. THE CONTROLS SHOWN ONLY INCLUDE MAJOR SEDIMENT BASINS/TRAPS AND CLEAN WATER DIVERSIONS. DETAILED PROGRESSIVE ESCPs MUST BE COMPLETED PRIOR TO CONSTRUCTION WORKS IN CONSULTATION WITH RMS, EPA AND OTHER RELEVANT REGULATORY AUTHORITIES.

LEGEND

-  NATURAL/EXISTING CREST LOCATION
-  PROPOSED ROAD CREST LOCATION
-  SEDIMENT BASIN (SB) - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX FOR SEDIMENT BASIN VOLUMES)
-  SEDIMENT TRAP (ST) / TEMPORARY ONLINE BASIN - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX)
-  TEMPORARY WATERWAY DIVERSION AROUND CULVERT WORKS (DETAIL A/C)



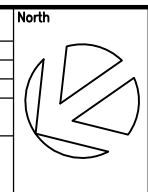
ADDITIONAL REQUIREMENTS FOR FLOOD PRONE LANDS AND LANDS WHERE HIGH GROUND WATER IS ENCOUNTERED WHERE APPLICABLE

- ACCESS/HAUL ROADS TO BE FORMED USING ROCK WITH GEOTEXTILE UNDERLAY (THIS CAN BE INCORPORATED AS PART OF THE ROAD BRIDGING LAYER WHERE APPLICABLE)
- MINIMISE STRIPPING OF GRASS VEGETATION AND TOPSOIL AS MUCH AS POSSIBLE. CONSTRUCT WORKS OVER THE TOP OF EXISTING GRASS WHERE POSSIBLE
- EXPOSED FILL BATTERS TO BE STABILISED (LOCKED DOWN WITH SOIL STABILISERS OR COVERED WITH FABRIC/MATTING) PRIOR TO RAINFALL, SITE CLOSURE OR WHEN WORKS ARE ON HOLD
- PERMANENT STABILISATION OF FILL BATTERS IS TO OCCUR PROGRESSIVELY
- TOP EDGES OF THE FILLS ARE TO HAVE WINDROWS/BUNDS WITH REGULAR BATTER CHUTES
- CULVERTS AND CLEAN DIVERSIONS TO BE CONSTRUCTED AS EARLY WORKS
- TURKEYS NEST SEDIMENT BASINS WILL BE REQUIRED IN AREAS OF HIGH GROUND WATER. THESE BASINS ARE TO BE BUILT UP PROGRESSIVELY AS THE FILL COMES UP OR BASIN INLETS PROGRESSIVELY RAISED AS THE FILL COMES UP. SUPPLEMENTARY SEDIMENT TRAPS ON-LINE AND INCREASED EROSION CONTROLS ARE TO BE EMPLOYED UNTIL THE FULL SEDIMENT BASIN VOLUMES ARE ACHIEVED
- BASINS TO BE BUILT AS LARGE IN SURFACE AREA AS POSSIBLE TO LIMIT THE BASIN HEIGHT AND LEVEL OF EXCAVATION
- UNTIL SUCH TIME THAT FULL SIZE SEDIMENT BASINS CAN BE EMPLOYED OR IN LOCATIONS WHERE SEDIMENT BASIN CONSTRUCTION IS NOT SUITABLE, SEDIMENT FILTRATION SUMPS/TRAPS TO BE PROVIDED IN LOW POINTS AROUND LOWER EDGES OF WORKS (E.G. ROCK FILTER DAMS OR EQUIVALENT SEDIMENT FILTRATION DEVICE)
- SEDIMENT BASINS WILL REQUIRE ARMoured WALLS
- ANY WORKS WITHIN WATERCOURSES ARE TO BE SCHEDULED FOR LOW RAINFALL AND RAINFALL EROSION TIMES OF THE YEAR AND WORKS ARE TO BE STAGED AS MUCH AS POSSIBLE TO MINIMISE EXPOSURE

NOT FOR CONSTRUCTION

REV	DATE	DES.	DRN.	APP.	REVISION DETAILS
A	29/05/14	A.J.B.	A.J.B.		DRAFT - SEDIMENT BASIN/TRAP LOCATIONS - FOR CONSULTATION

DRAWING STATUS	
DESIGN BY	A.M. / A.J.B.
DRAWN BY	A.J.B.
FINAL APPROVAL	
SCALE:	1:2000
(on A3 Original)	
DRAFT	



CLIENT



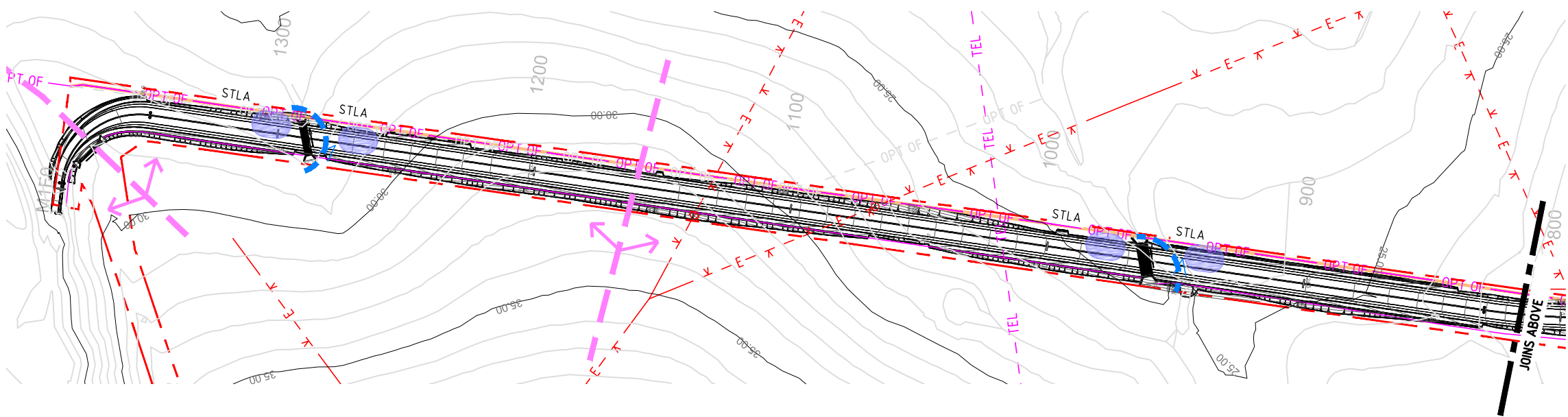
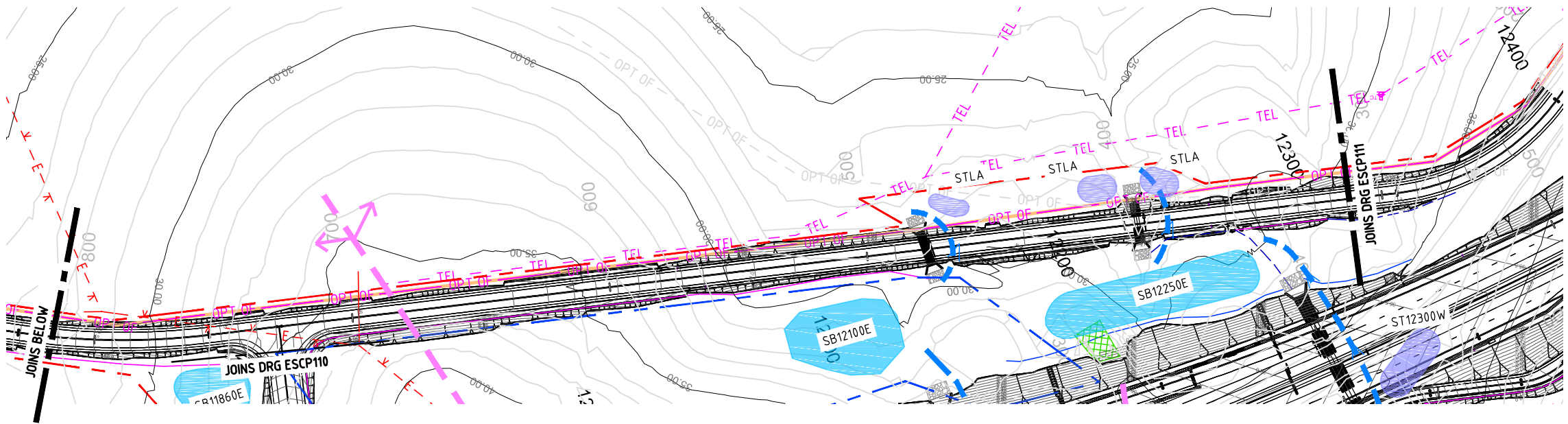
PO Box 1098, Bowral, NSW, 2576
 Suites 9 & 10, Bowral Mall
 Cnr. Bowley & Station Streets, Bowral.
 (t) 02 4862 1633
 (f) 02 4862 3088
 email: reception@seec.com.au
 WWW.SEEC.COM.AU

PROJECT TITLE
 HW1 PRINCES HIGHWAY
 FOXGROUND AND BERRY BY-PASS
 TOOLIJOOA ROAD TO
 SCHOFIELDS LANE






DRAWING TITLE			
PRIMARY EROSION AND SEDIMENT CONTROL PLAN CH18700 TO LIMIT OF WORKS			
PROJECT NO.	SUB-PR NO.	DRAWING NO.	REV
13000157	P02	ESCP124	A

EROSION AND SEDIMENT CONTROL PLAN - GENERAL NOTE

THESE PLANS ARE PRIMARY ESCPs USING BLUE BOOK (LANDCOM, 2004) DEFAULT VALUES BASED ON SURROUNDING LOCATIONS. THE CONTROLS SHOWN ONLY INCLUDE MAJOR SEDIMENT BASINS/TRAPS AND CLEAN WATER DIVERSIONS. DETAILED PROGRESSIVE ESCPs MUST BE COMPLETED PRIOR TO CONSTRUCTION WORKS IN CONSULTATION WITH RMS, EPA AND OTHER RELEVANT REGULATORY AUTHORITIES.



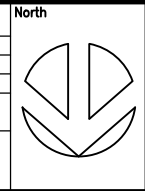
LEGEND

-  NATURAL/EXISTING CREST LOCATION
-  PROPOSED ROAD CREST LOCATION
-  SEDIMENT BASIN (SB) - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX FOR SEDIMENT BASIN VOLUMES)
-  SEDIMENT TRAP (ST) / TEMPORARY ONLINE BASIN - (INDICATIVE FOOTPRINT ONLY) - (SEE TABLE XX)
-  TEMPORARY WATERWAY DIVERSION AROUND CULVERT WORKS (DETAIL A/C)

NOT FOR CONSTRUCTION

REV	DATE	DES.	DRN.	APP.	REVISION DETAILS
A	29/05/14	A.J.B.	A.J.B.		DRAFT - SEDIMENT BASIN/TRAP LOCATIONS - FOR CONSULTATION

DRAWING STATUS	
DESIGN BY	A.M. / A.J.B.
DRAWN BY	A.J.B.
FINAL APPROVAL	
SCALE:	1:2000
(on A3 Original)	
DRAFT	



CLIENT



SEEC

PO Box 1098, Bowral, NSW, 2576
 Suites 9 & 10, Bowral Mall
 Cnr. Bowley & Station Streets, Bowral.
 (t) 02 4862 1633
 (f) 02 4862 3088
 email: reception@seec.com.au
 WWW.SEEC.COM.AU

PROJECT TITLE

**HW1 PRINCES HIGHWAY
 FOXGROUND AND BERRY BY-PASS
 TOOLIJOOA ROAD TO
 SCHOFIELDS LANE**

DRAWING TITLE			
PRIMARY EROSION AND SEDIMENT CONTROL PLAN CH12200 TO CH12700			
PROJECT NO.	SUB-PR NO.	DRAWING NO.	REV
13000157	P02	ESCP125	A

Appendix B

Water Quality Monitoring Program

Including the:

Surface Water and Groundwater Sampling Protocol

Water Quality Monitoring Surface Water Monitoring Plan

Water Quality Monitoring Groundwater Monitoring Plan

To be provided as separate files



Roads and Maritime Services

Berry to Foxground Water Quality Management

Surface Water and Groundwater Sampling Protocol

July 2014

Table of contents

1.	Introduction.....	1
1.1	Background.....	1
1.2	Objectives of the monitoring program	1
2.	Sampling Methodologies.....	2
2.1	Surface water sampling methodology.....	2
2.2	Groundwater sampling methodology	3
3.	Quality Management	4
3.1	Quality control samples.....	4
3.2	Quality assurance documentation.....	5
4.	Sample Parameters	7
4.1	In-situ water quality parameters.....	7
4.2	Laboratory water quality parameters	7
5.	Sampling Locations and Access	8
5.1	Surface water site sampling locations	9
5.2	Groundwater site sampling locations	17

Table index

Table 1 – QAQC samples and procedures.....	4
Table 2 – Water quality parameters	7
Table 3 – Laboratory analysis schedule	7
Table 4 – Surface water sampling locations.....	8
Table 5 – Groundwater sampling locations	8

Appendices

- Appendix A – Surface Water Sampling Sheet
- Appendix B – Groundwater Sampling Sheet
- Appendix C – Chain of Custody Document

1. Introduction

1.1 Background

GHD Pty Ltd (GHD) was engaged by Roads and Maritime Services (RMS) to undertake a water quality management assessment for the proposed upgrade of the Princes Highway between Foxground and Berry.

RMS is proposing to upgrade 11.6 kilometres of the Princes Highway between Toolijooa Road north of Foxground and Schofield's Lane south of Berry on the NSW South Coast. The project works will include upgrading parts of the existing highway and developing some new alignment sections. The upgrade includes the installation of a number of bridges crossing surface water features and cuttings that will dissect the existing landscape and potentially intersect groundwater.

As part of the project approval conditions CoA B15 and CoA B16, RMS are required to prepare and implement a Water Quality Monitoring Program (WQMP) and undertake groundwater modelling on the concept design.

These works must provide a monitoring framework that will allow RMS to identify and mitigate any impacts pre-construction, during construction and once the project is in operation; or alternatively to demonstrate that the environmental methods adopted for design, construction and operation have been effective at preventing/minimising impacts to surface water and groundwater quality.

1.2 Objectives of the monitoring program

The overall objectives of the surface water and groundwater monitoring program have been defined to provide a clear direction for the study and include:

- Assessing the potential impact of the project on the water quality to protect aquatic ecology and ecosystems in all the adjacent catchments and water courses.
- Assessing the potential impact of the program on groundwater hydrology in order to protect licensed bores, dams, watercourses, water bodies and groundwater dependent ecosystems in adjacent catchments.

The primary objective of this document is to detail the water quality sampling protocols that will be adopted to effectively meet the overall project objects outlined above

This document should be read in conjunction with the Water Quality and Groundwater Monitoring Plans.

2. Sampling Methodologies

All fieldwork will be conducted in general accordance with GHD's Standard Field Operating Procedures which are aimed at ensuring that all environmental samples are collected by a set of uniform and systematic methods, as required by GHD's Quality Assurance system.

2.1 Surface water sampling methodology

2.1.1 Collection of in-situ water quality data

The collection of water quality parameters will be undertaken prior to the collection of the surface water sample at each location. Parameters will be measured using a calibrated water quality meter for the parameters listed in **Table 2 (Section 4)**. The water quality meter will be placed approximately 0.5 metres below the water surface or in the middle of the water column, whichever is deeper. The readings will be allowed to stabilise before recording onto GHD's standard sampling sheets (**Appendix A**).

The sampling contractor will develop a site specific OH&S Plan for the surface water sampling as part of an overall commitment to provide a healthy and safe working environment for staff and contractors. All staff will wear appropriate personal protection equipment (PPE). In the event that sampling in-stream is unsafe, sampling and measurements may be undertaken on the stream bank (or subsequent safe location) from an area consistent with in stream flow conditions. Where this is undertaken it will be recorded on the sampling record sheets.

Equipment used for the monitoring of water quality parameters will be calibrated prior to conducting sampling and will be re-calibrated for each subsequent day of use (where required). Equipment calibration certificates supplied by the equipment rental company should be kept with the sampling record sheets.

The sampling contractor will undertake decontamination procedures between sampling locations to minimise any cross contamination. Where non-dedicated equipment is used, including the water quality meter and surface water sampler, these will be decontaminated with phosphate-free detergent (Decon N) and rinsed using clean water. In addition, the use of new disposable gloves for the collection of each sample will be used by the sampling staff.

2.1.2 Collection of samples for laboratory analysis

Surface water samples collected for laboratory analysis will be collected using a grab sample methodology. The analytes and parameters to be undertaken are listed in **Table 3 (Section 4)**. The sampling contractor will collect surface water samples using an extendable water sampler using a dedicated plastic container for each location. The surface water sampler will be constructed from materials which do not contaminate the sample. Similarly, care will be taken to minimise contact time between the sample and the sampling equipment before transferring to the laboratory containers.

The sample will be collected from just below the water surface, and care will be taken to prevent disturbance and contamination of the sample from sediments and surface debris. Following collection the sample will be transferred immediately into laboratory supplied containers with sufficient volume to satisfy the requirements for all parameters and placed into a chilled ice-chest for transport to the nominated laboratory. Where required for some laboratory containers, the water sample will also be field filtered using a 0.45 µm water filter to remove fine suspended particles.

Decontamination of all sampling equipment will be undertaken between sampling locations, using phosphate-free detergent (Decon N) and clean water. Prior to taking the surface water

sample, the equipment will be rinsed downstream in the sampling water of the sampling location (where applicable).

2.2 Groundwater sampling methodology

2.2.1 Groundwater levels and purging

The static groundwater level within each groundwater monitoring well will be measured prior to purging or sampling of monitoring wells. The water level will be measured using a groundwater level dip meter from the Top of Casing (TOC). The measurement will be taken to the nearest millimetre. Similarly, the Bottom of Casing (BOC) will be measured as well by lowering the meter to the base of the well until it touches the bottom of the casing. These levels will be recorded on groundwater standard sampling record sheets (**Appendix B**).

Following the initial measurements of water level, the groundwater monitoring well will be purged prior to sampling. Purging ensures that stagnant water within the well casing is removed and a representative sample is able to be taken. The purging of the well will be undertaken with a bladder pump using a low flow method. The pump will be attached to a water quality meter with a flow through cell, which allows the observation of water quality parameters (temperature, dissolved oxygen, pH, oxidation and reduction potential and electrical conductivity) during purging. The flow rate of the pump will be regulated (where possible) to match the recharge rate of the groundwater well if possible.

The groundwater monitoring well will be considered to be purged when one of the following criteria is achieved (whichever occurs first):

- Three well volumes of water have been purged; or
- The well is purged until no more water can be removed (considered dry); or
- The water quality parameters are stabilised within 10% over three consecutive recorded measurements.

While not anticipated, in the event that low-flow sampling methods are not feasible, a disposable plastic bailer will be used for purging and sampling.

During purging, abstracted water will also be observed for colour, odour, the presence of sheens (that may be representative of the presence of petroleum related constituents) and sediment content.

All equipment will be calibrated prior to commencing purging and sampling and re-calibrated for each subsequent day of sampling (if required). Copies of laboratory calibration certificates and field calibration events will be kept with the groundwater sampling record sheets.

2.2.2 Collection of samples for laboratory analysis

At the completion of purging, groundwater samples will be collected directly into dedicated laboratory supplied sampling bottles with sufficient volume to satisfy the requirements for all analytes. The samples will be placed into a chilled ice-chest for transport to the nominated laboratory(s). The analytes and parameters to be undertaken are listed in **Table 3 (Section 4)**. Where required for some laboratory containers (metal analysis), the water sample will also be field filtered using a dedicated 0.45 µm water filter to remove fine suspended particles.

To prevent cross-contamination, dedicated tubing for the low-flow pump will be used at each sampling location. Non-dedicated equipment will be decontaminated with phosphate-free detergent and clean water between sampling locations. A new pair of disposal nitrile gloves will also be used between sampling locations.

3. Quality Management

3.1 Quality control samples

The collection of quality assurance and control samples during sampling will be undertaken to ensure the integrity of the dataset. Field quality control procedures for use during the project shall comprise the collection and analysis presented in **Table 1**.

Table 1 – QAQC samples and procedures

Type	Purpose and Description	Frequency
Rinsate Blank (Equipment blank)	A sample of analyte free water poured over decontaminated field sampling equipment prior to the collection of samples. The rinsate sample is used to assess the adequacy of the decontamination process.	One scheduled per day of sampling, where sampling methods use the same equipment between locations.
Blind Duplicate (Intra-lab Replicate)	Comprises a single sample that is divided into two separate sampling containers. Both samples are sent anonymously to the project laboratory. Blind duplicates provide an indication of the analytical precision of the laboratory as well as sampling procedures, but are inherently influenced by other factors such as sampling techniques and sample media heterogeneity.	Collected and analysed at a rate of not less than 20%.
Split Duplicate (Inter-laboratory replicate)	Comprises a single sample that is divided into two separate sampling containers. Each sample will be sent to a different project laboratory. Split duplicates provide an indication of the analytical proficiency of the laboratories as well as sampling procedures.	Collected and analysed at a rate of not less than 20%.
Trip Spike	A sample is prepared by the testing laboratory, containing known quantities of volatile contaminants. The trip spike accompanies the samples between the site and laboratory. The trip spike is analysed for benzene, toluene, ethyl benzene and xylene (BTEX) and Total recoverable hydrocarbons (TRH) C6-C9 compounds and results are used to assess the loss of volatile contaminants during transport of the samples.	Not considered necessary for this program. Reasons for this are presented in the following report text.
Trip Blank	A sample of laboratory supplied deionised water is bottled and accompanies the other samples over the course of the fieldworks and submitted to the laboratory for analyses. Trip blanks provide an indication of contamination introduced during sample transport and handling, and also ensure that the testing laboratory is not reporting “false positives”. Trip blanks should not indicate concentrations of the chemicals of potential concern (CoPC) above the laboratory detection limit.	Not considered necessary for this program. Reasons for this are presented in the following report text.

Field (trip) blanks have not been collected and/or are not recommended as part of the sampling program. While these can be useful components of a QA/QC program, their omission is not considered to affect the outcome of the sampling program. The rationale for this omission is summarised below.

The role of trip blanks is to detect potential contamination during sample transport and nominally comprise deionised water. Given that the samples are sealed immediately following collection, it would not be expected that cross contamination of samples would have occurred. In order for contamination to occur during transit the bottles would have to be compromised (i.e. break or be

open), which is recorded by the laboratory upon receipt and subsequently reported on laboratory results and would act as a suitable indicator of the sample bottles being compromised.

Samples reporting concentrations of metals and TRH below the laboratory detection limit may also be considered representative of surrogate trip blanks, demonstrating no introduction of contaminants during the sample handling procedure. Initial sampling results suggest that a number of these results exist.

Field (trip) spikes have not been collected and/or are not recommended as part of the sampling program. While these can be useful components of a QA/QC program, their omission is not considered to affect the outcome of the sampling program. The rationale for this omission is summarised below.

Trip spikes are samples of well graded sand that are spiked with known concentrations of BTEX compounds. While the NSW OEH states that these samples can be collected, there is no guidance regarding how results from the analysis of these samples are to be evaluated. Further, given that volatile loss could occur immediately after the trip spike is prepared and may in fact continue to occur whilst the sample is in transit from the laboratory to the field (before reaching site), it is not considered that trip spike results would reliably assist in evaluating the potential loss of volatiles from samples collected in the field.

Further to the above, volatile hydrocarbons (which includes BTEX) are likely to be significantly retarded/impacted by exposure to air in surface water samples, suggesting that surface water samples are unlikely to produce representative and realistic results for these analytes. Trip spike analysis is unlikely to significantly improve this inherent uncertainty.

Rinsate blanks can provide an indication of the thoroughness of decontamination of sampling equipment and may be taken to evaluate whether cross contamination between sampling points has occurred. The absence of rinsate blanks will result in false positives if cross contamination occurs during the sampling program, which means that not taking rinsate blanks is inherently conservative.

With regard to surface water sampling, the recommended sampling method adopts dedicated sampling equipment for each site, such that there is no potential for cross-contamination during sampling and therefore rinsate samples are not required. If the proposed sampling method is changed to non-dedicated equipment during construction and operation then rinsate samples may be required during construction and operation.

With regard to groundwater sampling, the recommended sampling method uses non-dedicated sampling equipment for each site, such that there will be potential for cross-contamination. Rinsate sampling for pre-construction sampling program is not considered necessary as the potential for cross-contamination is considered to be low due to an overall absence of contaminated areas in the vicinity of the selected groundwater sampling locations and because the sampling method will result in significant dilution of low level residual contaminants remaining on the sampling equipment. However, with the advent of construction and operational activities the potential for acute contamination in individual groundwater samples and hence cross-contamination will be present. As such, rinsate sample collection and analysis will be required once construction commences.

3.2 Quality assurance documentation

3.2.1 Sample identification and records

At each sampling location for surface water and groundwater, a sampling record sheet is completed to accurately note information associated with the collection of the samples.

Examples for the field record sheets are supplied in **Appendices A** and **B**. As a minimum the sample record sheets will include the following information:

- Location of sampling site;
- Details of sampling location (location ID);
- Date and time of sampling;
- Method of sampling;
- Name of sampler;
- General environmental / climatic conditions (if applicable);
- Nature of sample pre-treatment (if applicable);
- Any duplicate samples taken at the sampling location (if applicable);
- Preservation procedure; and
- Any other information which may assist with results interpretation and analysis.

The sample containers used for surface water and groundwater sampling are supplied by the nominated analytical laboratory and have the appropriate preservation within the bottles prior to filling. To prevent misidentification of samples, each sample is labelled with a unique identification (sampling location), and as a minimum the following will be written on the label:

- Unique sample ID;
- Date and time of sampling;
- Samplers name or initials; and
- Unique job / project number

3.2.2 Chain of custody

Following the completion of sampling, a chain of custody (CoC) record will be completed to document the sample history and to schedule the relevant analyses. The CoC accompanies the samples to the laboratory at all times. An example of the laboratory CoC is supplied in **Appendix C**. As a minimum the CoC must have the following information:

- Laboratory reference number;
- Site identification;
- Contact details of sampler and project manager;
- Sample type;
- Sample collection time and date;
- Analyses to be performed by the laboratory;
- Sample preservation (if applicable);
- Dispatch information and signature; and
- Any comments or details about the samples which may assist in analysis.

3.2.3 Sampling personnel

All fieldworks will be undertaken by nominated staff with appropriate qualifications and experience in similar investigations. Where nominated staff vary from that proposed, they will be appropriately trained by staff familiar with the project. The name of staff undertaking the sampling will be recorded on the sampling record sheets for each sampling location and event.

4. Sample Parameters

4.1 In-situ water quality parameters

The water quality parameters to be measured during the surface water and groundwater sampling are listed below in **Table 2**. The water quality parameters will be measured using a handheld water quality meter (surface water) or a water quality meter with a flow through cell (groundwater). In addition to the measured parameters, any visual and olfactory observations will also be noted, including colour, odour, sheen and sediments. Sampling and measuring of these parameters will be undertaken in accordance with the procedures specified in **Section 3**.

Table 2 – Water quality parameters

Surface Water and Groundwater Parameters
Dissolved oxygen (DO) (mg/L)
Electrical conductivity (EC) (µs/cm)
pH
Oxidation reduction potential (ORP) (mv)
Temperature (°C)

4.2 Laboratory water quality parameters

The analysis of water quality parameters and potential contaminants of concern (CoPC) will be tested at the nominated NATA accredited laboratory. The analysis for surface water and groundwater samples are listed below in **Table 3**. Sampling and measuring of these parameters will be undertaken in accordance with the procedures specified in **Section 3**.

The rationale for selecting these parameters is provided in the surface water and groundwater monitoring plan documents.

The sampling regime for these parameters is also detailed in the surface water and groundwater sampling documents.

Table 3 – Laboratory analysis schedule

Surface water analytes	Groundwater analytes
Turbidity	Total Petroleum Hydrocarbons (TPH)
Total suspended solids	Benzene, Toluene, Ethylbenzene and Xylene (BTEX)
Visual oil and grease	Polycyclic Aromatic Hydrocarbons (PAH)
Total Petroleum Hydrocarbons (TPH)	Heavy metals (As, Cd, Cr, Cu, Ni, Pb, Zn, Hg)
Heavy metals (Al, Cd, Cu, Pb, Zn)	
Total phosphorus	
Total Nitrogen	

5. Sampling Locations and Access

The sampling locations for surface water and groundwater are listed below in **Table 4** and **Table 5** and are presented in **Figure 1** to **Figure 5**. The coordinates of the locations are supplied to ensure a consistent data set is collected. The relocation of sampling points may need to occur due to changes in the detailed design or due to access changes. If this occurs, it will be noted in the sampling record sheet and the new locations will be required to maintain data continuity and meet the objectives of the project.

The sampling regimes for the locations identified below are detailed in the groundwater and surface water monitoring plan documents. GHD note that MW14 and MW15 are currently not considered necessary to meet the monitoring objectives and will not be installed.

The below coordinates are supplied in MGA 94 Zone 56.

Table 4 – Surface water sampling locations

Site	Easting	Northing
SW01	294866	6152836
SW02	294321	6151308
SW03	291809	6150384
SW04	290124	6150052
SW05	290335	6149775
SW06	289512	6149948
SW07	289679	6149398
SW08	288634	6150068
SW09	289844	6149845
SW10	288317	6149798
SW11	288551	6149647
SW12	287979	6149325
SW13	288147	6149181
SW14	287682	6148955
SW15	287861	6148828
SW16	287274	6148310
SW17	297496	6148065

Table 5 – Groundwater sampling locations

Site	Easting	Northing	Screen intervals (m bgl)	Total Depth (m bgl)
MW01	296502	6152405	10 - 22	22
MW02	296340	6152814	16 – 27.8	27.8
MW03	296088	6152729	15 – 21	21
MW04	296013	6153045	4 - 7	7
MW05	295907	6152745	16 - 40	40
MW06	295490	6152884	10 - 25	25
MW07	293054	6151387	17.5 – 29.6	45.21

Site	Easting	Northing	Screen intervals (m bgl)	Total Depth (m bgl)
MW08	293436	6151265	3 – 9.1	9.1
MW09	293164	6151156	4 – 10	10
MW10	292543	6150913	10 – 14	14
MW11	292349	6151199	18.2 – 36.2	36.2
MW12	292329	6150763	7 – 10	10
MW13	291458	6150812	8 – 14	14
MW14 (proposed)	291744	6150679	-	-
MW15 (proposed)	291499	6150706	-	-
MW16	288320	6149813	4 – 10	10

Notes: MW14 and MW15 were proposed locations that have not been installed

5.1 Surface water site sampling locations

The tables and figures below present the locations of the surface water locations for water quality measurements and sampling.

Site ID: SW01



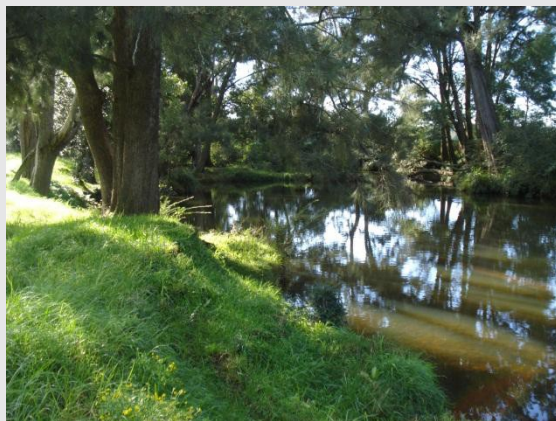
Comments: Drive through gate located on the left about 30 metres from the bridge heading North on the Princes Hwy. Park near the far fence line and squeeze under fence to reach the creek. Sample near riffle.

Site ID: SW02



Comments: Driveway on eastern side of Princes Highway at the top of the hill. Drive down the driveway until reaching the causeway. Sampled from southwest of causeway.

Site ID: SW03



Comments: Go through drive way with cattle grid and drive down to collection of farm sheds. Continue driving through sheds along dirt track until you come to the hay shed near the creek. Drive another 30 metres down the road, park and travel under fence to creek. Sample just down from riffle where accessible.

Site ID: SW04



Comments: Drive north across first bridge on Woodhill mountain Road (where SW09 is sampled) and go into the first driveway on the right. Follow driveway around Turfco paddock until you come to an access road. Park and walk along road until you come to a channel crossing (road is very rocky). Sample above this crossing.

Site ID: SW05



Comments: Access from Beach Road into Galls Lane. Follow car tracks in grass located to the left of the house around the pond until you come to the entrance of the breeze-way between two large paddocks. Drive through gate, and continue driving until you come to the end of the breeze-way. Walk through gates and walk to the right following the creek until you can access. Sample at riffle.

Site ID: SW06



Comments: Access from North Street, park in car park near the oval and skate park and follow path located to the left of the tennis courts. Follow till you come to a groundwater well located on grass directly ahead. Turn left and follow the creek until you come to the confluence of two streams. Sample downstream from this.

Site ID: SW07



Comments: Access from behind Berry Bowling Club off the Princes Highway. Go right to the end of car park and walk around black pool fence. Creek is directly behind building.

Site ID: SW08



Comments: Drive down Rawlings Lane to the end where the road meets the water. Sampled near bricks in the water.

Site ID: SW09



Comments: Sample on Turfco side of bridge to the west. Go through dirt driveway on the left just up from the bridge and follow the dirt road to the left around paddocks. Park near creek and sample close to the bridge; watch for stinging nettle.

Site ID: SW10



Comments: Access from North Street just up from the causeway by squeezing under wooden fence (same location as groundwater well MW 16).

Site ID: SW11



Comments: Park at dead end of Albert Street. and walk to the left following the creek. After about 20 metres a collection of conifer trees are located next to the creek. Walk through these to access.

Site ID: SW12



Comments: Park in Victoria Street opposite entrance to the Arbour. Carefully cross the Princes Highway and walk through gap in fence. Follow the highway south until you come to the creek and sample where access available.

Site ID: SW13



Comments: Sampled on the eastern side of bridge crossing the creek line along Pepper Farm Drive.

Site ID: SW14



Comments: Access from Schofields Lane, be aware there may be cows in paddock. Sampled where there was water near the only tree in the adjacent paddock.

Site ID: SW15



Comments: Enter through Bupa retirement village to the right at the end of Pepper Farm Drive. Beware of construction in this area. Walk down to the creek; beware of long grass in this area. May potentially be dry.



Comments: Access via gate along Andersons Lane (can only partially open). Walk to creek and sample downstream of the two tributaries.

Site ID: SW17



Comments: Call property owner prior to entry (cows and horses in the paddock). Driveway to property off Mullers Lane. Go through gate directly at end of dirt section of driveway and turn right and walk through stables. Go through second gate and travel past paddocks until you come to an access lane on the left. Go through gate at end and sample above coral tree located on creek.

5.2 Groundwater site sampling locations

The tables and figures below indicate the locations of the groundwater monitoring wells for water quality measurements and sampling. These locations will be monitored during the pre-construction and construction phase of the monitoring program. Comments are provided where specific access provisions or sampling requirements apply.



Comments: Access from 402 Princes Highway. Drive up the driveway and go through gate on left. Turn left and follow fence line to another gate. Follow vehicle tracks to well.

Site ID: MW02



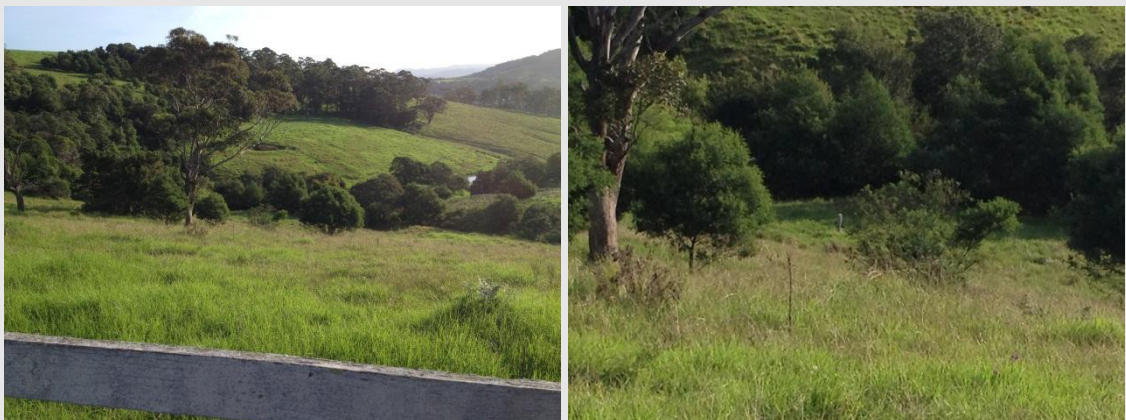
Comments: Access from 368 Princes Highway and enter gate (press button on left) with Horse sign (furthest to the west). Enter by silage bails and cross over via the dam all. Southern paddock is steep and wet after rain.

Site ID: MW03



Comments: Access from 403 Princes Highway. Drive up the driveway and go through gate on left. Follow fence line around the house and drive up the hill.

Site ID: MW04



Comments: Access from 455 Princes Highway. Need key to unlock gate. Drive up to the house and turn right through gate before house. Turn right again and go through gate. Stay up high in the first paddock and go down towards the creek in second paddock.

Site ID: MW05



Comments: Access from 455 Princes Highway. Need key to unlock gate. Drive up to the house and turn right through gate before house. Follow path over hill and then go right between two paddocks. Drive about half way along and then a gate on the right. Well located at top of hill.

Site ID: MW06



Comments: Same access as MW05 but continue along to the end of the paddocks. Go straight and half way down the hill.

Site ID: MW07



Comments: Access from neighbours' property at 437 Princes Highway (opposite Austral Park Road – Western driveway). Go to the crest of the hill and there is a bush gate on the right.

Site ID: MW08



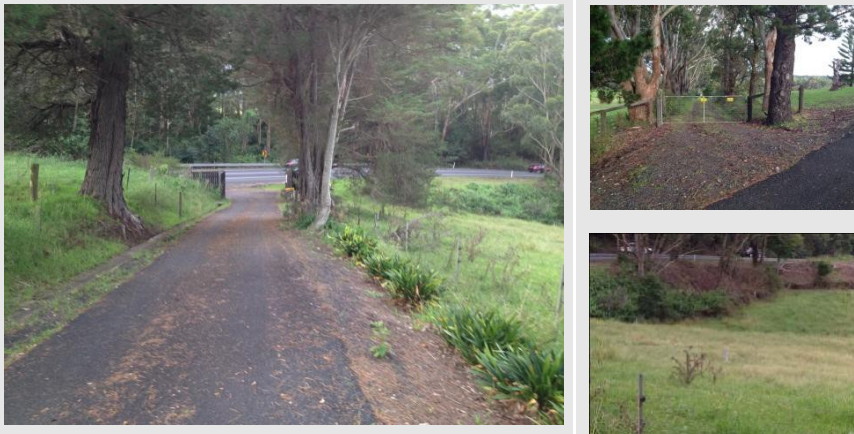
Comments: Access from Austral Park Road and half way along road there is a bush gate to the right.

Site ID: MW09



Comments: Access from Austral Park Road and take first driveway on right. Follow down and turn right at the orange handle gate. Follow along until paddock gate on right.

Site ID: MW10



Comments: Access from 350 Princes Highway and drive up the driveway and take the first gate on the left. Drive straight to the end of road and open gate and drive back around to the well.

Site ID: MW11



Comments: Access from 371 Princes Highway (two white rocks marking driveway). Take gate immediately on left with orange handles. Follow vehicle tracks up the hill and open next gate. Drive through vegetation and follow track north along crest of the hill until well.

Site ID: MW12



Comments: Access is the same as MW10. Turn right between the stock feeds and open two gates into the paddock. Stay high near the fence line and the well is located in the middle of the paddock.

Site ID: MW13

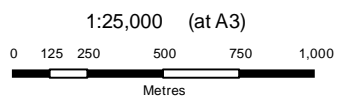


Comments: Access from 185 Princes Highway (White sign with MARIGOLD written on it). Take the first gate on the right.

Site ID: MW16



Comments: Access from Rawlings Lane. Follow the driveway to the dairy and turn right. Go straight and turn right with vehicle track and take the second gate on the right. Can be access by foot from North Street.



Map Projection: Transverse Mercator
 Horizontal Datum: Geocentric Datum of Australia (GDA)
 Grid: Map Grid of Australia 1994, Zone 56



LEGEND

- Groundwater Sampling Locations
- Proposed Groundwater Sampling Locations
- Surface Water Sampling Locations
- Berry to Foxground upgrade alignment
- Roads
- Railways
- Waterways
- Lakes and dams



Roads and Maritime Services
 Water Quality Monitoring

Surface water and
 Groundwater Sampling Locations

Job Number 21-23174
 Revision 0
 Date 09 Jul 2014

Figure 1

Z:\TEMP GIS\berry to foxground\GIS\Maps\MXD\21_23174_2014_BERRY_SurfaceWaterandGroundwaterSamplingLocations.mxd
 © 2010. While GHD has taken care to ensure the accuracy of this product, GHD and DATA CUSTODIAN, make no representations or warranties about its accuracy, completeness or suitability for any particular purpose.
 GHD and DATA CUSTODIAN, cannot accept liability of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred as a result of the product being inaccurate, incomplete or unsuitable in any way and for any reason.
 Data Source: NSW Department of Lands: DTDB and DCDB - 2012. Created by: pmcdougall



1:8,000 (at A3)

0 50 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56



LEGEND	
	Surface Water Sampling Locations
	Groundwater Sampling Locations
	Proposed Groundwater Sampling Locations
	Sampling location site access
	Roads
	Railways
	Waterways
	Lakes and dams



Roads and Maritime Services
Water Quality Monitoring

Sampling Location Site Access North Eastern Areas of Alignment

Job Number	21-23174
Revision	0
Date	09 Jul 2014

Figure 2

Z:\TEMP GIS\berry to foxground\GIS\Maps\MXD\21_23174_2015_BERRY_SamplingLocationSiteAccess.mxd
© 2010. While GHD has taken care to ensure the accuracy of this product, GHD and DATA CUSTODIAN, make no representations or warranties about its accuracy, completeness or suitability for any particular purpose.
GHD and DATA CUSTODIAN, cannot accept liability of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred as a result of the product being inaccurate, incomplete or unsuitable in any way and for any reason.
Data Source: NSW Department of Lands: DTDB and DCDB - 2012. Created by: pmcdougall



1:8,000 (at A3)

0 50 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56



LEGEND	
	Surface Water Sampling Locations
	Groundwater Sampling Locations
	Proposed Groundwater Sampling Locations
	Sampling location site access
	Roads
	Railways
	Waterways
	Lakes and dams



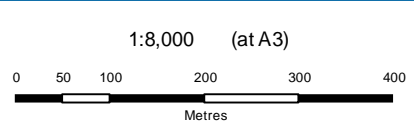
Roads and Maritime Services
Water Quality Monitoring

Sampling Location Site Access Central Areas of Alignment

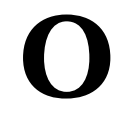
Job Number	21-23174
Revision	0
Date	09 Jul 2014

Figure 3

Z:\TEMP GIS\berry to foxground\GIS\Maps\MXD\21_23174_2015_BERRY_SamplingLocationSiteAccess.mxd
© 2010. While GHD has taken care to ensure the accuracy of this product, GHD and DATA CUSTODIAN, make no representations or warranties about its accuracy, completeness or suitability for any particular purpose.
GHD and DATA CUSTODIAN, cannot accept liability of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred as a result of the product being inaccurate, incomplete or unsuitable in any way and for any reason.
Data Source: NSW Department of Lands: DTDB and DCDB - 2012. Created by: pmcdougall



Map Projection: Transverse Mercator
 Horizontal Datum: Geocentric Datum of Australia (GDA)
 Grid: Map Grid of Australia 1994, Zone 56



LEGEND	
	Surface Water Sampling Locations
	Groundwater Sampling Locations
	Proposed Groundwater Sampling Locations
	Sampling location site access
	Roads
	Railways
	Waterways
	Lakes and dams



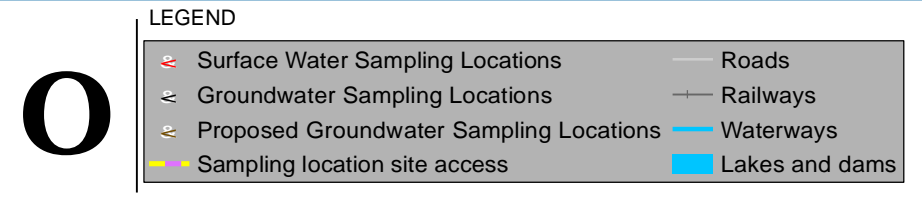
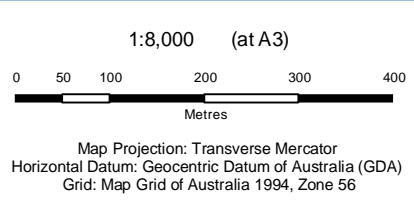
Roads and Maritime Services
 Water Quality Monitoring

Sampling Location Site Access North Eastern Berry Area of Alignment

Job Number	21-23174
Revision	0
Date	09 Jul 2014

Figure 4

Z:\TEMP GIS\berry to foxground\GIS\Maps\MXD\21_23174_2015_BERRY_SamplingLocationSiteAccess.mxd
 © 2010. While GHD has taken care to ensure the accuracy of this product, GHD and DATA CUSTODIAN, make no representations or warranties about its accuracy, completeness or suitability for any particular purpose.
 GHD and DATA CUSTODIAN, cannot accept liability of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred as a result of the product being inaccurate, incomplete or unsuitable in any way and for any reason.
 Data Source: NSW Department of Lands: DTDB and DCDB - 2012. Created by: pmcdougall



Roads and Maritime Services
Water Quality Monitoring

**Sampling Location Site Access
South Western Berry Area of Alignment**

Job Number	21-23174
Revision	0
Date	09 Jul 2014

Figure 5

Z:\TEMP GIS\berry to foxground\GIS\Maps\MXD\21_23174_2015_BERRY_SamplingLocationSiteAccess.mxd
© 2010. While GHD has taken care to ensure the accuracy of this product, GHD and DATA CUSTODIAN, make no representations or warranties about its accuracy, completeness or suitability for any particular purpose.
GHD and DATA CUSTODIAN, cannot accept liability of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred as a result of the product being inaccurate, incomplete or unsuitable in any way and for any reason.
Data Source: NSW Department of Lands: DTDB and DCDB - 2012. Created by: pmcdougall

Appendices

Appendix A – Surface Water Sampling Sheet



SURFACE WATER SAMPLING RECORD

PROJECT NO. _____ DATE: _____

PROJECT NAME: _____ TIME: _____

CLIENT: _____ SAMPLING OFFICERS: _____

SITE: _____

COORDINATES/GPS (If Applicable) _____

SAMPLING METHOD (ie grab, bucket) _____

DETAILED SAMPLE LOCATION DESCRIPTION _____

ENVIRONMENTAL OBSERVATIONS

WEATHER _____

VEGETATION _____

SLOPE _____

EROSION _____

OTHER _____

FIELD MEASUREMENTS

TEMPERATURE (°C) _____

CONDUCTIVITY (uS/cm) _____

pH _____

DO (ppm) _____

REDOX (mV) _____

HYDROLOGICAL DATA

FLOW MEASUREMENT
(or stream height if rating table available) _____

CROSS SECTION WIDTH (m) _____

DEPTH (m) _____

OTHER _____

SAMPLE NO.	NO. OF CONTAINERS	PRESERVATIVE	DUPLICATE	COMMENTS
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

FIELD SUPERVISOR

CHECKED (SIGN & DATE)

Appendix B – Groundwater Sampling Sheet

Appendix C – Chain of Custody Document



Sydney
 Unit F3 - 6 Building F, 16 Mars Road, Lane Cove
 Phone: +612 9900 8400
 Email: enviro.syd@mgtlabmark.com.au

Brisbane
 Unit 1-21 Smallwood Place, Murrarie
 Phone: +617 3902 4600
 Email: enviro.bris@mgtlabmark.com.au

Melbourne
 2 Kingston Town Close, Oakleigh, VIC 3166
 Phone: +613 8564 5000 Fax: +613 8564 5090
 Email: enquiries.melb@mgtlabmark.com.au

CHAIN OF CUSTODY RECORD

CLIENT DETAILS Page _____ of _____

Company Name : GHD Pty Ltd	Contact Name :	Purchase Order :	COC Number :
Office Address :	Project Manager :	PROJECT Number :	Eurofins mgt quote ID :
133 Castlereagh Street, Sydney, NSW 2000	Email for results :	PROJECT Name :	Data output format :

Special Directions & Comments:	Analytes										Some common holding times (with correct preservation). For further information contact the lab			
	Waters					Soils								
												BTEX, MAH, VOC	14 days	BTEX, MAH, VOC
											TRH, PAH, Phenols, Pesticides	7 days	TRH, PAH, Phenols, Pesticides	14 days
											Heavy Metals	6 months	Heavy Metals	6 months
											Mercury, CrVI	28 days	Mercury, CrVI	28 days
											Microbiological testing	24 hours	Microbiological testing	72 hours
											BOD, Nitrate, Nitrite, Total N	2 days	Anions	28 days
											Solids - TSS, TDS etc	7 days	SPOCAS, pH Field and FOX, CrS	24 hours
											Ferrous iron	7 days	ASLP, TCLP	7 days

Eurofins mgt DI water batch number:																				Containers:							Sample comments:		
Sample ID	Date	Matrix																	1LP	250P	125P	1LA	40mL vial	125mL A	Jar				
1																													
2																													
3																													
4																													
5																													
6																													
7																													
8																													
9																													
10																													
11																													
12																													
13																													
14																													
15																													
16																													

Relinquished By:	Received By:	Laboratory Staff	Turn around time	Method Of Shipment	Temperature on arrival:
Date & Time::	Date & Time:	1 DAY <input type="checkbox"/> 2 DAY <input type="checkbox"/> 3 DAY <input type="checkbox"/> 5 DAY <input checked="" type="checkbox"/> 10 DAY <input type="checkbox"/> Other:		<input checked="" type="checkbox"/> Courier <input type="checkbox"/> Hand Delivered <input type="checkbox"/> Postal Courier Consignment #:	Report number:
Signature:	Signature:				

GHD

133 Castlereagh St Sydney NSW 2000

-



T: +61 2 9239 7100 F: +61 2 9239 7199 E: sydmail@ghd.com.au

© GHD 2014

This document is and shall remain the property of GHD. The document may only be used for the purpose for which it was commissioned and in accordance with the Terms of Engagement for the commission. Unauthorised use of this document in any form whatsoever is prohibited.

n:\au\sydney\projects\21\23174\WP\196781.docx

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
Draft	S Charteris	J Hallchurch		J Hallchurch		9/04/2014
1	N. Rosen	J Hallchurch		J Hallchurch		23/04/2014
2	N. Rosen	S.Charteris		J Hallchurch		01/07/2014

www.ghd.com





Roads and Maritime Services

Princes Highway Upgrade - Foxground to Berry Bypass Project

Water Quality Monitoring Surface Water Monitoring Plan

July 2016

Table of contents

1.	Introduction	1
1.1	Background	1
1.2	Project overview	1
2.	Regulatory context	5
2.1	Environmental assessment	5
2.2	Conditions of Approval	6
2.3	Statement of commitments.....	8
3.	Overview of environmental risks	13
3.1	Sources of risk	13
3.2	Catchment overview	15
3.3	Management of environmental risks	21
4.	Consideration of groundwater interaction	26
5.	Monitoring objectives	27
5.1	Performance objectives	27
5.2	RMS water policy	27
6.	Performance standards	28
6.1	Protection of surface water quality	28
6.2	Environmental Protection Licence	29
6.3	Development of project specific performance standards	30
6.4	Proposed performance standards	30
6.5	Control charts	31
7.	Measurement and assessment criteria	33
7.1	Trigger criteria	33
7.2	Statistical analysis	33
7.3	Pollutant loads	34
8.	Monitoring program	36
8.1	Monitoring Program Criteria	36
8.2	Water quality monitoring sites	36
8.3	Monitoring parameters	40
8.4	Sample collection	40
8.5	Sampling regime (time and frequency)	40
8.6	Sampling protocol	42
8.7	Sample analysis	42
9.	Data analysis and interpretation	43
9.1	Analysis of Pre-construction phase data	43
9.2	Analysis of construction phase data	43
9.3	Analysis of operational phase data	46

10.	Management actions	48
10.1	Construction phase	48
10.2	Operational phase	49
11.	Management framework	51
11.1	Adaptive management approach	51
11.2	Roles and responsibilities	51
11.3	Reporting and auditing	53
12.	Management of acute impacts	55
12.1	Acute risks to surface water quality	55
12.2	Consideration of acute impacts	55
13.	Consultation	56
13.1	Consultation undertaken during development of the SWMP	56
14.	References	62

Table index

Table 1:	Condition of approval B16 (NSW DPI, 2013)	7
Table 2:	Statement of commitments – surface water and groundwater quality.....	9
Table 3:	Summary of environmental risks (adapted from Aurecon, 2010)	15
Table 4:	Performance objectives for the monitoring program (adapted from Aurecon 2012).	27
Table 5:	Construction and operational phase monitoring parameters	40
Table 6:	Construction Phase Roles and Responsibilities	51
Table 7:	Operation Phase Roles and Responsibilities	52
Table 8:	Summary of reporting requirements (adapted from Aurecon, 2010a)	54
Table 9:	Stakeholder Comments and Response	57

Figure index

Figure 1:	Overview of the Foxground to Berry Princes Highway Upgrade Alignment.....	4
Figure 2:	Surface Water Catchments Along the Alignment.....	16
Figure 3:	Overview of Typical Catchment Conditions	17
Figure 4:	Overview of Typical Catchment Conditions – North Road, Berry	17
Figure 5:	Overview of Typical Catchment Conditions	18
Figure 6:	Overview of Typical Catchment Conditions – Broughton Creek	18
Figure 7:	Overview of Typical Catchment Conditions – Berry Township	19
Figure 8:	Proposed Sediment/Water Quality Basins along the Upgrade	25
Figure 9:	Example control chart (Aurecon 2010a)	32

Figure 10: Surface Water Sampling Locations	39
Figure 11: Construction phase water quality impact assessment procedure (Aurecon, 2010)	44
Figure 12: Operational phase water quality assessment (Aurecon, 2010)	47
Figure 13: Construction phase management framework (adapted from Aurecon, 2010)	49
Figure 14: Operational phase management framework (adapted from Aurecon, 2010)	50

Appendices

Appendix A – Stakeholder Comments

Appendix B – Environmental Protection Licence

1. Introduction

1.1 Background

The Foxground to Berry bypass (FBB) upgrade of the Princes Highway is the next section of upgrades between Gerringong and Bomaderry. The FBB comprises an 11.6 km upgrade of the Princes Highway between Toolijoola Road north of Foxground and Schofields Lane south of Berry.

The existing FBB section of the Princes Highway requires upgrading to the standard that is being applied over the broader Princes Highway Upgrade Program. The existing highway primarily comprises a two lane single carriageway.

The proposed upgrade of the Foxground to Berry section of the Princes Highway would have substantial benefits for improved road safety and traffic efficiency for local and regional movements including freight (RMS, 2013).

1.2 Project overview

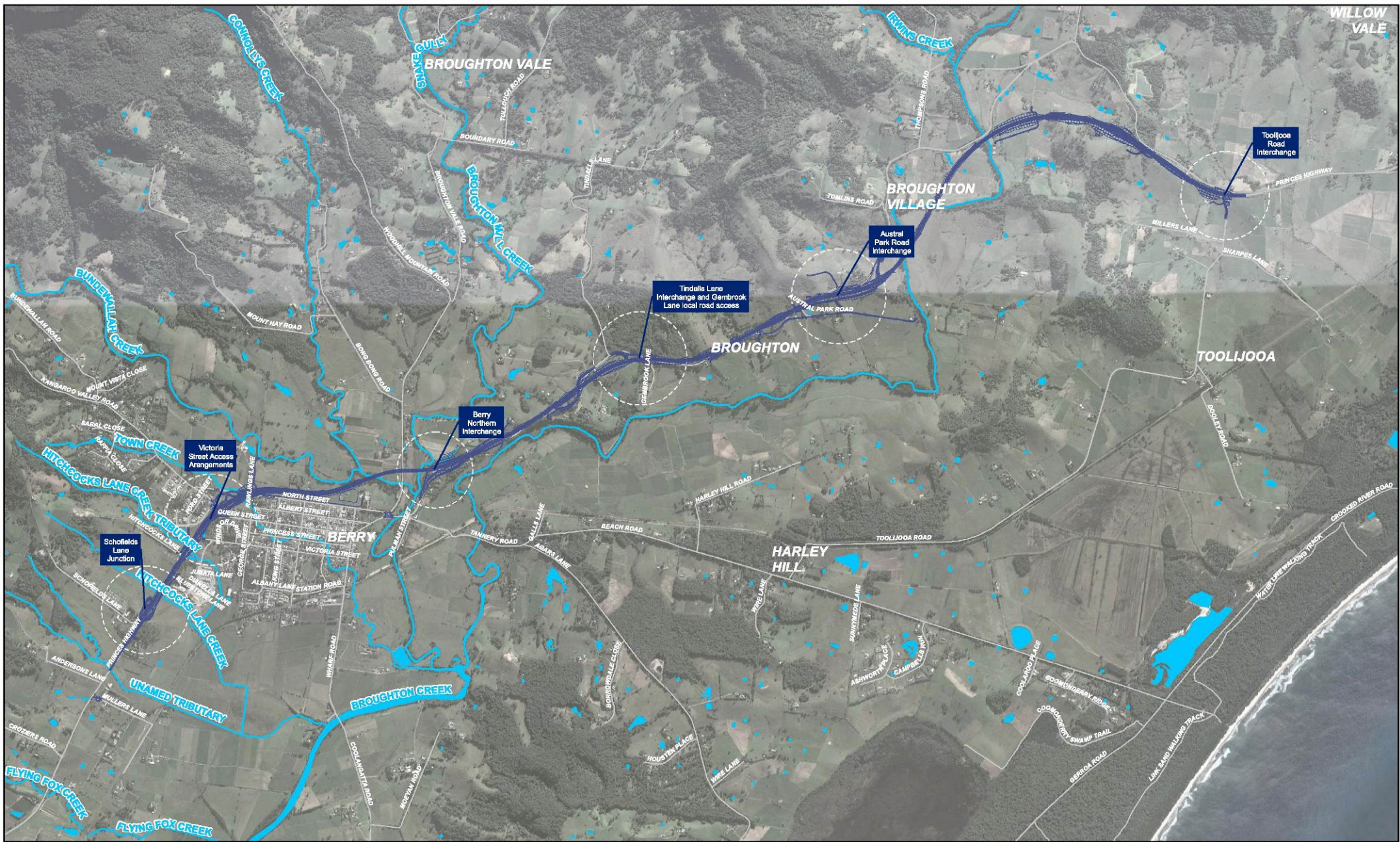
The proposed FBB Princes Highway upgrade will extend for 11.6 km from where Toolijoola Road intersects the current Princes Highway (north eastern end of the alignment) to where Schofields Lane intersects the current Princes Highway south west of Berry township. An overview of the FBB Princes Highway upgrade alignment is provided in Figure 1.

The general features of the proposed upgrade, as approved, are presented in the Director General's Environmental Assessment Report (AECOM, 2012) and are as follows:

- Construction of a four lane divided highway (two lanes in each direction) with median separation (wire rope barriers or concrete barriers where space is constrained, such as at bridge locations)
- Bypasses of the Foxground bends and Berry township
- Construction of around 6.6 kilometres of new highway where the project deviates from the existing highway alignment at Toolijooa Ridge, the Foxground bends and the Berry township
- Provision for the possible widening of the highway (if required in the future) to six lanes within the road corridor and, in some areas, construction of the road formation to accommodate future additional lanes where safety considerations, traffic disruption and sub-optimal construction practices are to be avoided
- Grade-separated interchanges at:
 - Toolijoola Road
 - Austral Park Road
 - Tindalls Lane
 - East of Berry at the existing Princes Highway, referred to as the northern interchange for Berry
 - West of Berry at Kangaroo Valley Road, referred to as the southern interchange for Berry
- A major cutting at Toolijooa Ridge (around 900 metres long and up to 26 metres deep)
- Six lanes (two lanes plus a climbing lane in each direction) through the cutting at Toolijooa Ridge for a distance of around 1.5 kilometres

- Four new highway bridges:
 - Broughton Creek bridge 1, a four span concrete structure around 170 metres in length and nine metres in height
 - Broughton Creek bridge 2, a three span concrete structure around 75 metres in length and eight metres in height
 - Broughton Creek bridge 3, a six span concrete structure around 190 metres long and 13 metres in height
 - A bridge at Berry, a 19 span concrete structure around 600 metres long and up to 12 metres in height
- Three highway overbridges:
 - Austral Park Road interchange, providing southbound access to the highway
 - Tindalls Lane interchange, providing southbound access to and from the highway
 - Southern interchange for Berry, providing connectivity over the highway for Kangaroo Valley Road along its existing alignment
- Eight underpasses including roads, drainage structures and fauna underpasses:
 - Toolijoola Road interchange, linking Toolijoola Road to the existing highway and providing northbound access to the upgrade
 - Property access underpass in the vicinity of Toolijoola Ridge at chainage 8400
 - Dedicated fauna underpass in the vicinity of Toolijoola Ridge at chainage 8450
 - Property access underpass between Toolijoola Ridge and Broughton Creek at chainage 9475
 - Combined drainage and fauna underpass in the vicinity of Austral Park Road at chainage 12800
 - Combined drainage and fauna underpass in the vicinity of Tindalls Lane at chainage 13320
 - Dedicated fauna underpass in the vicinity of Tindalls Lane at chainage 13675
 - Property access underpass between the Tindalls Lane interchange and the northern interchange for Berry in the vicinity of at chainage 15100
- Modifications to local roads, including Toolijoola Road, Austral Park Road, Gembrook Lane, Tindalls Lane, North Street, Queen Street, Kangaroo Valley Road, Hitchcocks Lane and Schofields Lane
- Diversion of Town Creek into Bundewallah Creek upstream of its confluence with Connollys Creek and to the north of the project at Berry
- Modification to about 47 existing property accesses
- Provision of a bus stop at Toolijoola Road and retention of the existing bus stop at Tindalls Lane
- Dedicated u-turn facilities at Mullers Lane, the existing highway at the Austral Park Road interchange, the extension to Austral Park Road and Rawlings Lane
- Roundabouts at the southern interchange for Berry and the Woodhill Mountain Road junction with the exiting Princes Highway
- Two culs-de-sac on North Street and the western end of Victoria Street in Berry
- Tie-in with the existing highway about 75 metres north of Toolijoola Road and about 440 metres south of Schofields Lane
- Left in/left out only provisions for direct property accesses to the upgraded highway

- Dedicated public space with shared pedestrian/cycle facilities along the southern side of the upgraded highway from the playing fields on North Street to Kangaroo Valley Road
- Ancillary operational facilities, including permanent detention basins, stormwater treatment facilities and a permanent ancillary facility site for general road maintenance



1:30,000 (A3)

0 150 300 600 900 1,200

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric DabJm of Australia (GOA)
Grid: Map Grid of Australia 1994, Zone 56



LEGEND

- Berry to Foxground upgrade alignment - Railways
- Alignment location of interest
- Roads
- ~ Waterways
- Lakes and dams



Roads and Maritime Services
Water Quality Monitoring

Job Number 121-23174
Revision 0
Date 09 Jul2014

Overview of the
Berry to Foxground upgrade

Z:\TEMP GISU\ry to foxground\GISMa\MXD\21_23174_201_0_BERRY_Orni\FBBUpgr11da.mxd
© 2010, While GHD has consent to this use of the asset for the project, GHD and DATA CUSTODIAN, male no rapraMntdInl or wa1T81tial about baeuracy, eomplallM or utability for any park:urporuosa.
GHD and DATA CUSTODIAN, cannot accept liability of any kind (whilfrin: onraet, tortoroU, rwm for any P: Pilli. to. -d -sIM and for eon (Including Indirect or: collNI: Juanbl damagJ while ar or may
blneurada a ...ultofleproductbalnginaeeu111ta.lnr: omplataoaur. utabiMnary and for any r.w.aon.
Data Source: NSW Dept of Lands, DTDB mid DCDB -2012. Cra#ld by: pmodougall

2. Regulatory context

2.1 Environmental assessment

The FBB Princess Highway upgrade project has been assessed as a transitional project under Part 3A of the Environmental Planning and Assessment Act 1979 (EP&A Act). The Director-General's requirements (DGR's) for the FBB Princes Highway upgrade were issued on 11 February 2011.

The DGR's for surface water and groundwater required the assessment of:

- *“Water quality taking into account impacts from both accidents and runoff and considering relevant environmental water quality criteria specified in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000. The assessment must describe measures to control erosion and sedimentation during construction activities and measures to capture and treat runoff from the site during the operational phase*
- *“Identify potential risks of the project on groundwater resources including: characterising existing local and regional hydrology; potential risks of drawdown; impacts to groundwater quality; discharge requirements; and implications for groundwater-dependent surface flows (including springs and drinking water catchments), groundwater-dependent ecological communities and groundwater users*
- *Identifying potential impacts of the project on existing flood regimes, consistent with the Floodplain Development Manual (Department of Natural Resources, 2005), including impacts to existing receivers and infrastructure and the future development potential of affected land, demonstrating consideration of the changes to rainfall frequency and/or intensity as a results of climate change on the project. The assessment shall demonstrate due consideration of flood risk in the project design*
- *Waterways to be modified as a result of the project, including ecological, hydrological and geomorphic impacts (as relevant) and measures to rehabilitate the waterways to pre-construction conditions or better”*

The assessment of surface water impacts presented in the Environmental Assessment (EA) Report (AECOM, 2012) was prepared in accordance with the above DGR's. The EA was subsequently exhibited for consultation and a Submissions Report (RMS, 2013) prepared in response to the concerns raised.

Approval for the project was issued by the Minister for Planning and Infrastructure on 22 July 2013.

In terms of surface water monitoring, the EA (Appendix H, AECOM, 2012) provided an outline of the surface water monitoring that would be adopted for the project. The key components of the program recommended from construction and operation in the EA are summarised below:

- The program approach is based on the surface water monitoring program for the Tintenbar to Ewingsdale Pacific Highway upgrade (T2E upgrade) as this had extensive consultation with the Office of Environment and Heritage (OEH) and Department of Investment, Regional Infrastructure and Services (NOW and Fisheries) and has been approved by RMS and the Department of Planning and Infrastructure.
- In terms of performance standards, the water quality monitoring program should focus on site specific issues rather than on pre-determined guideline values.

- The water quality monitoring program should focus on impacts associated with the project rather than the wider catchment which may create background impacts. Subsequently monitoring should be localised to areas immediately up and down gradient of the project.
- Statistical methods for assessing impacts would be based on the development of control charts (up-stream sites) which would be compared against test sites (down-stream sites). During construction statistical methods for assessing impacts will be based on data collected from upstream sites compared to data collected from downstream sites in accordance with agency guidance. A trigger would be deemed to have occurred when the median concentration of independent samples taken at a test site exceeds the eightieth percentile of the same indicator at a suitably chosen reference site. The development of suitable median and 80th percentile values would require the collection of suitable amount/period of baseline data. The statistical significance of the changes/trigger would be assessed further using a paired t-Test or Sign Test methods.
- Monitoring for the following key parameters:
 - In situ monitoring of dissolved oxygen (DO), Electrical Conductivity (EC), Oxygen Reduction Potential (ORP), pH, Temperature and Turbidity.
 - Total Suspended Solids (TSS).
 - Oils and Grease.
 - Total Petroleum Hydrocarbons (TPH).
 - Total Phosphorus (TP).
 - Total Nitrogen (TN).
 - Ammonia.
 - Metals (aluminium, cadmium, copper, lead, zinc).
- Construction sampling frequencies would focus on:
 - Wet weather events (i.e. greater than 15 mm of rainfall in 24 hours). One sample would be taken from upstream and downstream sites and compared immediately. If downstream is more than 10% greater than upstream, two more pairs of samples 15 min apart would be collected and compared.
 - Event based sampling of major wet weather events (i.e. greater than 50 mm in 24 hours)
- Operation sampling frequencies would focus on:
 - Sampling of minor wet weather events (as defined above) for one, or 12 sampling events per year, whichever is greater.

2.2 Conditions of Approval

The Project Approval was issued subject to a range of conditions, which included conditions for environmental monitoring and auditing. In relation to the monitoring of surface water, Condition of Approval number B16 (CoA No. B16) specifies that:

"The Proponent shall prepare and implement a Water Quality Monitoring Program to monitor the impacts of the project on surface water and groundwater quality and resources and wetlands, during construction and operation"

The Water Quality Monitoring Program (WQMP) is required to be developed in consultation with the Office of Environment and Heritage (OEH), Environmental Protection Authority (EPA), Department of Primary Industries (DPI) (Fishing and Aquaculture) and NSW Office of Water (NOW). Table 1 outlines the specific requirements of CoA B16 and provides section references where each criteria is addressed within this monitoring program.

Table 1: Condition of approval B16 (NSW DPI, 2013)

Condition of approval B16	WQMP section reference where addressed
(a) identification of surface and groundwater quality monitoring locations (including watercourse, water bodies and SEPP 14 wetlands), which are representative of the potential extent of impacts from the project	Surface water – Section 3, 4 and 9 Groundwater is in the groundwater quality monitoring document
(b) the results of the groundwater modelling undertaken under condition B15	Within the groundwater quality monitoring plan document
(c) identification of works and activities during construction and operation of the project, including emergencies and spill events, that have the potential to impact on surface water quality of potentially affected waterways	Section 3
(d) development and presentation of parameters and standards against which any changes to water quality will be assessed, having regard to Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000 (ANZECC, 2000)	Sections 7 and 8
(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 Director General	Section 4 and Section 9. Initial monitoring data to be provided to RMS as ongoing monitoring data updates separate to this report
(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)	Operation criteria discussed in Sections 9 to 13
(g) contingency and ameliorative measures in the event that adverse impacts to water quality are identified	Section 9 and 10
(h) reporting of the monitoring results to the Department, OEH, EPA and NOW	To be supplied as monitoring reports to RMS and subsequently to OEH, EPA and NOW

The Program must also be submitted to the Director General for approval six (6) months prior to the commencement of construction of the project, or as otherwise agreed by the Director General. A copy of the Program must also be submitted to OEH, EPA, DPI (Fishing and Aquaculture) and NOW prior to its implementation.

The conditions of approval outlined above form the objectives for the Water Quality Monitoring Plan (WQMP). This document provides the Surface Water Monitoring Plan (SWMP) component of the WQMP. A Groundwater Monitoring Program (GWMP) (GHD, 2014a) and a groundwater sampling protocol (GHD, 2014b) have also been prepared to meet other aspects of CoA No. B16 and should be read in conjunction with this document.

2.3 Statement of commitments

RMS has committed to a range of surface water quality protection measures as part of the environmental assessment under Part 3A of the EP&A Act. The primary objective of the measures proposed is to minimise the impacts to downstream surface water quality. The statement of commitments for surface water quality, as outlined in the Submission report (AECOM, 2013), is provided in Table 2. These commitments have been considered in the preparation of this SWMP and would also be taken into account in the development of the detailed design and project environmental management plans.

Table 2: Statement of commitments – surface water and groundwater quality

Ref No	Commitment	Key Action	Timing	Reference Document
SG1	Minimise impacts to water quality during construction and operation	Water quality measures such as water quality basins, swales or bioretention systems at sensitive receiving environments will be designed and installed to respond to the project water quality design criteria.	Pre-construction and construction	Managing Urban Stormwater: Council Handbook (EPA, 1997) Section 7.4 of the environmental assessment
SG2	Minimise water quality impacts and impacts to the flow regimes of Town Creek and Bundewallah Creek	A design and re-vegetation strategy for the Town Creek diversion will be developed during detailed design and will include measures to: Maintain flushing efficiency. Mitigate erosion risk at the connection with Bundewallah Creek. The design of the diversion will be finalised in consultation with directly affected landowners. The Town Creek diversion will be stabilised to mitigate erosion risk prior to operation.	Pre-construction and construction	Managing Urban Stormwater – Volume 1 (Soils and Construction) (Landcom (2004)) Managing Urban Stormwater – Soils and Construction, Volume 2D – Main Road Construction (known as the Blue Book) (DECCW 2008) Guidelines for In stream Works on Waterfront Land (NSW Office of Water, 2012) Section 7.4 of the environmental assessment Section 2.11 of the response to submissions
SG3	Minimise impacts on farm dams	Permanent losses to farm dam catchments and inflows will be identified during detailed design. Mitigation strategies will be developed in consultation with affected landowners and implemented where reasonable and feasible.	Pre-construction	Section 7.4 of the environmental assessment
SG4 and SG5	Minimise impacts on drinking water supply	Drinking water drawn from Broughton Creek will be maintained through measures identified in commitment AQ1. In the event that water drawn from Broughton Creek does not meet existing drinking water quality standards, an appropriate source of potable water will be made available to affected residents, following consultation.	SG4 – Construction SG5 - Pre-construction	Section 2.11 of the response to submissions

Ref No	Commitment	Key Action	Timing	Reference Document
		RMS will consult with landholders along the existing Town Creek alignment, below the proposed diversion, to confirm that there are no Basic Landholder Rights (under the Water Management Act 2000) to access water for domestic or stock purposes.		
SG6	Minimise changes in current flow regimes	Waterway structures will be designed to maintain existing flow regimes, where practicable.	Pre-construction	Section 7.5 of the environmental assessment
SG7 and SG8	Manage the impacts associated with changes to flooding and drainage	Detailed design will seek to minimise increases in peak flood levels in the 1 in 100 year flood event. Changes to flood impacts on property will be identified as part of detailed design. Where increased flood impacts to structures, such as residences, are identified, mitigation measures will be proposed and implemented where reasonable and feasible.	Pre-construction (SG7) Pre-construction and construction.(SG8)	Section 7.5 of the environmental assessment
SG9	Minimise impacts on channel structure	Impacts on stream channel structure diversion will be minimised during detailed design. Measures to be considered may include culvert sizing, energy dissipation measures, scour protection and other design features to control flow intensity and direction.	Preconstruction	Section 7.5 of the environmental assessment
SG10	Minimise the impact on groundwater levels	Groundwater monitoring of water levels and water quality will be undertaken. Where levels and/or quality indicate that the project is potentially having an adverse impact, mitigation measures will be considered and implemented where reasonable and feasible.	Construction	Section 7.4 of the environmental assessment
SG11	Conservation of water	Water efficient work practices, such as water reuse and recycling for road construction and re-vegetation irrigation will be implemented, where feasible. In the event that surface water from watercourses or groundwater is required to supply water to the project, a site specific impact assessment will be carried out in consultation	Construction	Section 7.4 of the environmental assessment Section 2.11 of the response to submissions

Ref No	Commitment	Key Action	Timing	Reference Document
		with the NSW Office of Water and potentially affected stakeholders.		
SW4	Avoid contamination of waterways	<p>Monitoring of water quality upstream and downstream of the project site will be undertaken before and during construction.</p> <p>Also refer to SG4.</p>	Preconstruction and construction	<p>Section 7.4 and 8.1 of the environmental assessment</p> <p>Erosion and Sedimentation Management Procedure (RTA, 2008)</p> <p>Managing Urban Stormwater – Soils and Construction Volume 1 (Landcom, 2004)</p> <p>Managing Urban Stormwater – Soils and Construction, Volume 2D – Main Road Construction (DECCW, 2008)</p> <p>RMS QA Specification G38 Soil and Water Management</p> <p>RMS QA Specification G39 Soil and Water Management (Erosion and Sediment Control Plan)</p>

The statement of commitments presented in the above table that are relevant to the SWMP and hence this document includes SG4 and SW4. Other commitments are either not associated specifically with water quality monitoring or will be dealt with in the groundwater monitoring plan document accompanying this report.

Further to the above it is noted that this water quality monitoring document is primarily focused on developing a monitoring program for pre-construction monitoring when there is a general absence of construction and operational water quality infrastructure such as sediment dams. The monitoring locations and frequency may have to be expanded to include monitoring at these locations once this infrastructure has been developed.

3. Overview of environmental risks

Potential impacts of the FBB Princes Highway upgrade on water quality were investigated as part of the project approval assessments under Part 3A of the EP&A Act and are discussed in detail in Chapter 7.4.3 of the EA Report (AECOM, 2012). An understanding of the risks to surface water quality associated with the construction and operational phases of the project is critical in developing an adequate monitoring program.

The following sections provide an overview of the key sources of risk and associated impacts to guide the development and assessment of performance objectives, standards and measurement criteria.

3.1 Sources of risk

The key sources of risk can be divided into two distinct areas - chronic water quality risks and acute water quality risks. Chronic risks refer to those which may cause detrimental effects after a prolonged period, while acute risks relate to those which cause immediate effect. These risks can be further refined to those associated with either the construction phase or operational phase of the project. The risks associated with these sources, and subsequent impacts, differ significantly between construction and operation and as such have been reviewed independently in the following sections. The review of construction and operational risks below is provided to identify the potential sources of risk and does not discuss management of these risks or represent the residual risk to water quality following implementation of mitigation measures (Aurecon, 2010).

A review of the potential sources of risk rather than the significance of the impact on water quality is made at this stage of the project. This approach has been adopted to ensure that the surface water monitoring program considers all potential sources of risk not just those with the highest risk (Aurecon, 2010).

3.1.1 Construction phase

Construction works and activities

There are a range of works and activities with the potential to impact on surface water quality if not managed correctly that must be recognised in order to understand the likely sources of risk during the construction phase of the project, including:

- Clearing, cut and fill operations (earthmoving activities)
- Sediment release from stockpiles
- Chemical and fuel spills
- Exposure of acid sulphate soils
- General waste generated during construction
- Increase in surface runoff due to use of site compounds, stockpiles and ancillary sites
- Clearing and grubbing including riparian vegetation
- Construction of Town Creek diversion

Each of these construction phase works and activities may result in chronic and acute risks to surface water quality. A summary of the potential sources of risk associated with these activities is provided in the following sections.

Chronic risks

The EA Report (AECOM, 2012) identified that 'clearing, cut and fill operations along the project alignment, including the construction of permanent and temporary creek crossings, represent the primary risk to surface water quality during and following construction'. The project site requires areas of cut and fill to be undertaken during construction of the FBB Princes Highway upgrade. Consequently there would be large areas of exposed soils, resulting in the potential for sediment laden runoff to enter the catchment if not managed correctly. An increase in sedimentation of watercourses could smother and kill aquatic habitats and organism. There is also a potential to increase the concentration of nutrients, metals and other potential toxicants that attach to sediment particles in surrounding waterways. Also, litter and gross pollutants resulting from general construction activities may enter the catchment.

Acute risks

In addition to an increase in sediment loads, the EA Report (AECOM, 2012) also identified the potential for chemical or fuel spills to enter the catchment. These risks are primarily associated with spills and leakages from plant or storage facilities on the construction site. If spills are not contained and managed correctly, these contaminants have the potential to impact on the catchment.

3.1.2 Operational phase

Operational works and activities

There are a range of works and activities with the potential to impact on surface water quality if not managed correctly that must be recognised in order to understand the likely sources of risk during the operational phase of the project, including:

- General operation of the highway (i.e. oil and grease)
- Traffic accidents (i.e. fuel and chemical spills)
- Motorist associated pollutants (i.e. non-biodegradable litter)
- Atmospheric deposition of nutrients
- Drainage of road surface and surrounds
- Erosion of the roadway and road shoulders

Chronic risks

The key sources of risk during operation of the FBB Princes Highway upgrade are associated with the increase surface runoff generated from the paved surface of the road. The EA Report (AECOM, 2012) concluded that 'road runoff is likely to be contaminated with nutrients, heavy metals, hydrocarbons, gross pollutants and suspended solids from the highway operations'.

Acute risks

Whilst the likelihood is expected to be low there is a risk of a chemical or fuel spill associated with a traffic accident entering waterways. Spills may be from vehicles carrying hazardous or dangerous goods or from general motor vehicle accidents.

3.1.3 Summary of environmental risks sources

A summary of the chronic and acute environmental risks associated with the construction and operation of the FBB Princes Highway upgrade is provided in Table 3

Table 3: Summary of environmental risks (adapted from Aurecon, 2010)

Project phase	Chronic/acute	Source of risk	Potential Environmental Impact
Construction	Chronic	Sediment laden runoff	<ul style="list-style-type: none"> • Increase in turbidity resulting in potential smothering of aquatic flora and fauna and disruption of ecological processes • Increased pollutant loads from contaminants and nutrients bound to sediment • Potential impact on drinking water and water treatment works
	Acute	Spills/leakages from plant and storages	<ul style="list-style-type: none"> • Potential for fuels and other chemicals to enter the catchment
Operation	Chronic	Runoff from paved surfaces	<ul style="list-style-type: none"> • Potential for contaminants (nutrients, heavy metals, hydrocarbons, suspended soils and pathogens) to enter the catchment • Increase in turbidity from batter slope runoff resulting in potential smothering of aquatic flora and fauna and disruption of ecological processes and habitat
	Acute	Spills from vehicles	<ul style="list-style-type: none"> • Potential for pollutants to enter the catchment from a dangerous goods spill • Potential for pollutants (hydrocarbons etc) to enter the catchment from a motor vehicle accident

3.2 Catchment overview

3.2.1 Catchment overview

The alignment of the FBB Princes Highway upgrade would pass through the six major and three minor catchments identified in this section. The location of the upgrade alignment in relation to the catchments is shown in Figure 2, with catchment overview photographs provided in Figure 3 to Figure 7.

Crooked River catchment

A small section of the project area is located within the upper Crooked River catchment, near Toolijooa Ridge. The creeks and streams that form part of the Crooked River catchment start at Currys Mountain and flow in a south-easterly direction into a coastal floodplain before discharging into the ocean via the estuarine Crooked River Lagoon. No significant or ephemeral waterways within the Crooked River catchment are located within the project footprint.

Broughton Creek catchment

Broughton Creek is the main watercourse in the project area and starts just below the Illawarra plateau at around 500 metres AHD (Australian height datum). The Broughton Creek catchment lies next to and south of the Crooked River catchment, and is separated by the ridge that extends from Currys Mountain to Toolijooa Hill, Moeyan Hill and eventually Coolangatta Mountain. After crossing the existing Princes Highway corridor, Broughton Creek flows in a south west direction. At Berry, Broughton Creek is joined by Broughton Mill Creek at the entrance of a coastal floodplain and eventually discharges into the lower Shoalhaven River. The Broughton Creek catchment upstream of Berry is around 30 square kilometres in area.



1:25,000 (at A3)

0 125 250 500 750 1,000

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric DabJm of Australia (GOA)
Grid: Map Grd of Australia 1994, Zone 56



LEGEND

- | | |
|--|----------------|
| Catchment Boundaries | --- Railways |
| - Berry to Foxground upgrade alignment | Waterways |
| Roads | Lakes and dams |



Roads and Maritime Services
Water Quality Monitoring

Job Number 121-23174
Revision 0
Date 09 Jul 2014

Surface Water Catchments

Figure 2

Z:\TEMP GIS\ry to foxground\GIS\Map MXD\21_23174_2011_BERRY_SurfaceWaterCatchment.mxd
© 2010, While GHD has created this product, GHD and DATA CUSTODIAN, male nor apra MntdInI or w17811tal about llaeeu111ey, eomplamM or Utlitllity for any Pllrk; uderpurpaa.
GHD and DATA CUSTODIAN, cannot accept llthllity of any kind (whllwllrn: connet, tort or otharwll) for any P: Plllll, lo, * damagM and for eollt (llnclllng llndractor COlll, e-Ulnbl dnmagJ whllh "or m'y
blneurad _atMultloffe product baIngnaeu1111ta, lneomplatao un f Utlitllity and for any wll, lOn.
o, tlll Source: NSW Dpartllmllnt of llnd: DTDB and DCDB -2012. Cra#ld by: pmoedoglll



Figure 3: Overview of Typical Catchment Conditions



Figure 4: Overview of Typical Catchment Conditions – North Road, Berry



Figure 5: Overview of Typical Catchment Conditions



Figure 6: Overview of Typical Catchment Conditions – Broughton Creek



Figure 7: Overview of Typical Catchment Conditions – Berry Township

Broughton Mill Creek, Bundewallah and Connollys Creek catchment

To the north and north-west of Berry are the Broughton Mill Creek, Connollys Creek and Bundewallah Creek catchments, respectively. Broughton Mill Creek originates underneath the Illawarra plateau as a number of secondary streams. It flows south through Broughton Vale and crosses the existing Princes Highway near the Woodhill Mountain Road intersection on the eastern edge of Berry, around two kilometres upstream of its confluence with Broughton Creek.

Town Creek catchment

Town Creek is a small ephemeral watercourse that passes directly through Berry township. It has a catchment area of 70 hectares upstream of Berry. Town Creek crosses the undeveloped section of North Street, on the north west edge of Berry, before crossing the town between Princess Street and Queen Street and exiting via Prince Alfred Street. Town Creek flows south east before joining Broughton Mill Creek near its confluence with Broughton Creek. The reach of Town Creek through Berry is in poor condition.

Minor catchments

Hitchcocks Lane Creek, its tributary and an unnamed tributary of Broughton Creek flow across the existing highway, south of Berry. These watercourses join southwest of the existing highway and eventually discharge into the estuarine reach of Broughton Creek. Hitchcocks Lane Creek and its tributary have a catchment area of 68 hectares and 75 hectares respectively. The unnamed tributary of Broughton Creek has a catchment area of 6.2 hectares.

3.2.2 Land-use and Vegetation

The following excerpt from Appendix H of the EA (AECOM, 2012) summarises the land use and riparian vegetation within the primary project catchments.

“The reach of Broughton Creek upstream of Berry is surrounded by cleared agricultural land although there are significant sections with relatively intact native riparian vegetation dominated by river oak (Casuarina cunninghamiana subsp. Cunninghamiana and Eucalyptus spp.) (Cardno Ecology Lab, 2011).”

The land surrounding Broughton Mill Creek has largely been cleared for agricultural use, with existing riparian vegetation containing a mixture of native and exotic trees and shrubs. Similarly, the land surrounding Bundewallah Creek had been cleared for agricultural use and recreation. Riparian vegetation is relatively continuous and composed of native trees (river oak) and exotic shrubs, climbers and annuals (Cardno Ecology Lab, 2011).

Broughton Creek, Broughton Mill Creek and Bundewallah Creek were all classed as Category 1 Riparian Habitats (Environmental Corridor), this classification representing the objective to provide biodiversity linkages by maintaining connectivity for the movement of aquatic species along the riparian corridor and between key destinations (for example, the bottom and the top of the catchment) (Cardno Ecology Lab, 2011)."

3.2.3 Catchment water quality

The following extract for water quality in waterways from the conclusions of the EA report (AECOM, 2012) is provided below:

"The long term agricultural land use in the region has resulted in significant pollution that is greater than the water quality levels that are considered to be sustainable for maintaining ecosystem integrity. The values of total phosphorus within the Crooked River and Broughton Creek catchments are regularly above the ANZECC guidelines. The applications of fertilisers and manure from stock are the likely sources of the high nutrient levels (The Ecology Lab, 1999, 2007). Broughton Creek, Broughton Mill Creek, Connollys Creek and Bundewallah Creek are considered to be sensitive receiving environments owing to the ecological values of these waterways.

Previous studies within the Crooked River and Broughton Creek catchments have also found that water quality was generally within the ANZECC threshold limits for pH and conductivity, and to a lesser extent, turbidity (The Ecology Lab, 1999; 2007). Sampling carried out in 2007 during a period of low rainfall found that sites within Crooked River and Broughton Creek catchments were frequently below ANZECC lower limits for dissolved oxygen (The Ecology Lab, 2007). Low dissolved oxygen values can be caused by low flow conditions and/or high in-stream organic loads.

Crooked River, Broughton Creek and Broughton Mill Creek have previously been found to be within ANZECC aquatic ecosystem threshold limits for a range of organochlorine pesticides, oxides of nitrogen and trace elements, although all were above the ANZECC guidelines for chloride. Crooked River was also above the ANZECC guidelines for copper and recorded concentrations of oil and grease, and suspended solids, that were much higher than samples taken from sites within the Broughton Creek catchment (The Ecology Lab, 2007).

The existing highway, which has no water quality controls, is also likely to be contributing pollutant loads to nearby waterbodies particularly at or near creek crossings. This would include oil, grease and other hydrocarbon products, generated by general vehicular use of the highway.

The water quality within Town Creek is expected to be characteristic of a watercourse with a developed residential and agricultural catchment. The long-term urban and agricultural land use in the area has likely lead to elevated nutrient levels (for example from fertilisers and livestock manure), low dissolved oxygen and raised suspended solids resulting from the erosion of soils."

3.2.4 Existing aquatic habitats

The appendix H of the environmental assessment (AECOM, 2012) provides an overview of the studies undertaken by Cardno Ecology Lab (2012) which state that:

"Broughton Creek is a Class 1 waterway providing major fish habitat, Broughton Mill Creek and Bundewallah Creek are Class 2 waterways providing moderate fish habitat and Connollys Creek is a Class 3 waterway with minimal fish habitat. These creeks are considered sensitive receiving environments with respect to this project. Town Creek is a Class 4 waterway unlikely to provide fish

habitat. The waterway is ephemeral at the proposed route crossing and much of the watercourse channel is undefined and has been colonised by pasture grasses and annual weeds (Cardno Ecology Lab, 2012)."

Appendix H of the EA (AECOM, 2012) also noted that:

"Downstream of the project at the confluence of Broughton Creek and the Shoalhaven River there are a variety of important estuarine wetland habitats such as seagrass beds, tidal flats, saltmarsh and mangroves which are important for seabirds and migratory waders. There are a number of State Environmental Planning Policy No. 14 Coastal Wetlands (SEPP 14 wetlands) in this locality, including the Comerong Island Nature Reserve, which are sensitive receiving environments.

Coomonderry Swamp, to the southeast of the study area near the coast, is a freshwater coastal wetland and sensitive receiving environment that is also protected under SEPP14 and represents one third of all semi-permanent coastal freshwater wetland habitat in NSW (NPWS, 1998)."

3.2.5 Existing surface water use

Communications with the NSW Office of water suggest that there is likely to be water supplies abstracted from all surface water features located with the catchment as part of basic landholder rights. This water may be used for stock water and domestic used including potable water supply.

Other uses in the area are anticipated to be for irrigation and dairy wash down supplies. These supplies are required to be registered with NOW.

3.3 Management of environmental risks

RMS recognise the importance of, and is committed to, ensuring that water quality within the multiple catchments is not significantly impacted by the construction and operational activities of the FBB Princes Highway.

3.3.1 Construction phase management

As per the requirement of CoA B16, implementation of appropriate mitigation and management measures to prevent soil erosion and the discharge of sediments and pollutants from the project during construction phases of the project would be undertaken to be compliant with Section 120 of the Protection of the Environment Operations (POEO) Act 1997 and the EPL for the project.

Section 7.44 of the EA Report (AECOM, 2012) outlines the proposed mitigation and management measures that would be undertaken during the construction phase of the project in order to meet the conditions of approval and to minimise the impact on the environment. A Construction Environmental Management Plan (CEMP) has been developed and was issued by RMS in February 2014. Appendix B4 of this document details the soil and water quality management procedures for the construction of the highway upgrade with Table 7.1 of this appendix detailing the soil and water management mitigation measures that will be adopted for the highway upgrade.

The CEMP includes mitigation measures similar to those outlined within the EA (AECOM, 2012) which included:

- Construct temporary drainage structures in accordance with the 'Technical Guideline – Temporary stormwater drainage for road construction' (RMS, 2011). Locate sedimentation basins during construction in areas as determined during detailed design. These would be in addition to the permanent operational water quality basins that may be used during construction for temporary sedimentation control.
- Include 'at source' management measures in areas of residual high risk erosion and sedimentation areas. These areas are where basins are not feasible due to topographical

constraints or small catchment areas. Measures would include small scale sedimentation capture devices, designed in consultation with a specialist soil conservationist

- Carry out construction in sequence to minimise the extent of disturbed areas and rehabilitate as soon as practicable
- Install permanent clean water diversions and top of cut drains at the start of construction to limit the volume of water on site
- Construct sediment and water quality basins prior to clearing activities in each area
- Establish water quality swales before or concurrently with clearing activities to enable their use during construction
- Stabilise fill batters progressively as they are constructed
- Manage vegetation stockpiles to minimise the impact of tannins leaching into the surrounding environment. Manage stockpiles in accordance with *Environmental Guidance – Management of Tannins from Vegetation Mulch* (RMS, 2012)
- Use dust management techniques, such as water spraying, to suppress dust
- Manage and use treated effluent in accordance with RMS' Environmental Direction No: 19 - Use of Reclaimed Water (RTA 2006) and RMS' Tip Sheet – Use of Reclaimed Water (RTA 2006)
- Minimise the depth of excavations in areas of alluvium
- Limit the need to dewater during construction
- Implement a communications procedure to educate construction personnel on groundwater issues
- Minimise disturbance and control runoff from construction areas
- Provide bunding and spill kits around fuel depots and stockpile areas. Develop response plans to address fuel leaks and spills at machinery compounds or during refuelling, including a hazardous materials plan and spill emergency procedure
- Establish a groundwater monitoring network along the project to monitor groundwater quality within each lithology and to establish background groundwater quality
- Detail the establishment of a groundwater monitoring network along the route to adequately characterise groundwater quality and establish background water quality within the alluvial/colluvial aquifers and Shoalhaven Group Sediments, including the Broughton Sandstone and latite
- Install monitoring wells adjacent to major cuts to confirm existing groundwater levels and to monitor the effect on groundwater levels by construction activity, where groundwater is encountered
- Implement a groundwater monitoring plan that would assess the performance of groundwater mitigation measures during and after construction. This plan would provide an assessment of groundwater level and quality trends and identification of exceedances (if any)
- During the initial works onsite, undertake further testing for ASS across the Broughton Creek floodplains
- Should the presence of ASS be confirmed, avoid or minimise disturbance, and/or activities that may lower the watertable in these areas

- Prepare an ASSMP if required, to identify strategies to remove or reduce the risks associated with ASS. This has been completed and is provided as a sub-plan within Appendix B4 of the CEMP
- Undertake staged construction of the Town Creek diversion to reduce the exposure of soils
- Stabilise banks of the constructed channel prior to diversion of flows from the upper catchment of Town Creek
- Maintain flushing efficiency and mitigate erosive forces at the discharge location into Bundewallah Creek through the design of the diversion. This could be achieved by increasing the channel roughness to reduce flow velocities. Revegetate the banks of the diversion channel to stabilise and reduce the risk of erosion

The control measures outlined above are based on the conceptual design developed as part of the environmental assessment. Further development of environmental controls would be undertaken during the detailed design stage of the project with the aim of improving the treatment performance. In addition to meeting the requirements of the conditions of approval, further development of control measures would also be guided by the RTA's *Erosion and Sedimentation Control Procedure* (RTA Procedure PN 143P). This procedure provides the administrative framework to guide the development of erosion and sediment controls through each of the key design phases from concept through to full detailed design.

State of Commitment SW2 states that:

"A specialist soil conservation consultant will be engaged to provide advice on erosion and sedimentation control during pre-construction and construction".

It would also help to deliver a range of best management practice techniques as well as continued onsite innovation.

3.3.2 Operational phase management

The risk to water quality during the operational phase of the project would come primarily from the increase of road surface runoff through impervious surfaces and drainage infrastructure or from traffic accident spills. Management of these sources of impact are discussed separately below.

Road surface run-off

Surface water quality modelling undertaken for previous assessments (AECOM, 2012) suggested incorporating treatment measures such as swales and permanent operational water quality basins would reduce pollutant loads to receiving environments and improve existing water quality. As such it was recommended that the water quality strategy includes a combination of swales and water quality basins to treat road runoff and protect downstream receiving environments, in accordance with the following:

- Swales: As a minimum these swale sizes would meet the total area requirements of 140 metres long by two metres wide, per hectare of upstream catchment
- Basins: Providing 300 cubic metres of working volume per hectare of road Catchment are recommended. Based on the current concept design, up to 18 operational water quality basins will treat run-off prior to discharge to the environment. The proposed locations of operational sediment quality basins are presented in Figure 8. It is expected that water quality basins will be designed to capture a rainfall event equal to or less than 42 mm over a 24 hour period.

Additionally, the cut batters could be managed as separate catchments with multiple small sediment capture devices to reduce reliance on the end of line water quality basin. It should be

noted that the actual operational water quality requirements, including number and location of basins, would be refined and finalised during detailed design (AECOM, 2012).

Capture and spills

The upgraded highway alignment would likely provide for safer transportation of vehicles compared with the existing alignment. This would reduce the total number of accidents along the upgraded section and therefore the potential of a spill of hazardous substances would also reduce.

Any spills that do occur would be directed to the permanent water quality basins and swales, all of which would have the capacity to receive a spill with a volume corresponding to that of a typical transport truck.

Both water quality basins and swales have potential for spillage control or containment. These water quality treatment measures provide capacity to treat first flush from the pavement surface and reduce the risk of spills discharging onto adjacent land or watercourses. The potential for spillage control or containment would be based on the hydrologic conditions prevailing at the time of the spill.

Additional treatment measures for sensitive receiving environments

Basins capturing runoff from pavements that drain to sensitive receiving environments would be designed with special outlet configurations to reduce the likelihood of overflow into the sensitive environment. For example:

- Water quality basins would have a permanent pool which a volume of spill would have to displace before passing through the entire basin
- Bioretention systems would have extended detention depths that would have to be breached before overflowing into the downstream environment

These simple yet effective arrangements would be incorporated into the design of water treatment systems as mentioned above with capacity to accommodate a typical transport truck.

In addition to swales and water quality basins, other treatment measures would be considered to further reduce nutrient loads from road runoff (primarily targeting nitrogen).

With the implementation of the management measures discussed above it is anticipated that the risk of surface water impact will generally be reduced relative to the existing highway and are anticipated to result in improved overall catchment water quality.



1:25,000 (at A3)

0 125 250 500 750 1,000

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric DabJmol of Australia (GOA)
Grid: Map Grid of Australia 1994, Zone 56



LEGEND

- Water quality basins
- Berry to Foxground upgrade alignment
- Roads
- Railways
- Waterways
- Lakes and dams



Roads and Maritime Services
Water Quality Monitoring

Job Number 121-23174
Revision 0
Date 09 Jul2014

Proposed water quality basins

Figure 8

Z:\TEMP GIS\ry to foxground\GIS\AMXD\21_23174_2012_BERRY_Propo as5.dwg_LW aiaQualityBa r.mxd
© 2010, While GHD is a consultant to the project, GHD and DATA CUSTODIAN, make no representation or warranty in relation to the accuracy or reliability of any information provided by any third party.
GHD and DATA CUSTODIAN, cannot accept liability of any kind (whether in contract, tort or otherwise) for any P, PI, II, L, or damage and/or loss (including indirect or consequential loss) of any kind arising from the use of any information provided by any third party.
Data Source: NSW Department of Land, DTDB and DCDB -2012. Created by: pmodougill

4. Consideration of groundwater interaction

Condition of Approval B16 requires that 'The Proponent shall prepare and implement a Water Quality Monitoring Program to monitor the impacts of the project on surface and groundwater quality and resources and wetlands, during construction and operation. The surface water and groundwater monitoring programs have been divided into two separate reports.

A monitoring program has subsequently been developed for groundwater quality and is presented in the *Groundwater Monitoring Program – Berry to Foxground Princes Highway Upgrade* (GHD, 2014b). The groundwater monitoring plan details the results of groundwater modelling works that have been completed which characterise the relationships between surface water and groundwater, in particular the contribution of groundwater to surface water baseflow and the potential changes to these flows associated with dewatering of groundwater systems around cuttings along the alignment.

5. Monitoring objectives

5.1 Performance objectives

When developing a monitoring program, performance objectives must be clearly stated to identify the goals of the monitoring program – i.e. what does the monitoring program aim to achieve.

The performance objectives for the FBB Princes Highway upgrade SWMP are based on the findings of the Environmental Assessment investigations, which reflect the intent of the Director General's Conditions of Approval, which require that:

"The Proponent shall prepare and implement a Water Quality Monitoring Program to monitor the impacts of the project on surface water and groundwater quality and resources and wetlands, during construction and operation"

The performance objectives are outlined in Table 4, which reflect the performance criteria adopted for the T2E Upgrade.

Table 4: Performance objectives for the monitoring program (adapted from Aurecon 2012).

Performance Objective
1. To monitor for the potential impact of the Upgrade on surface water and groundwater quality to protect the existing and ongoing human, horticultural and agricultural uses of that water
2. To monitor for potential impact of the Upgrade on water quality to protect existing and future status of aquatic ecology and ecosystem characteristics in all catchments intersected by, and downstream of, the Upgrade

5.2 RMS water policy

The above performance objectives also support the RMS water policy (RTA, 1999):

'The Roads and Traffic Authority¹ will use the most appropriate water management practices in the planning, design, construction, operation and maintenance of the roads and traffic system in order to:

- *conserve water*
- *protect the quality of water resources*
- *preserve ecosystems*

¹ Now referred to as Roads and Maritime Services (RMS)

6. Performance standards

In accordance with recommendations provided in the EA this section mimics that presented in the water quality monitoring documents for the T2E project developed by Aurecon in 2010.

6.1 Protection of surface water quality

6.1.1 Water quality guidelines

There are several water quality standards of relevance to a project of this nature and each have been reviewed in determining an appropriate performance standard for the FBB Princes Highway upgrade.

The standards include:

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000).
- Managing Urban Stormwater: Council Handbook (EPA, 1997).

A brief summary of these documents and discussion of their relevance to the project is provided below.

6.1.2 ANZECC guidelines

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC guidelines) provide a management framework, guideline water quality triggers, protocols and strategies to assist water resource managers in assessing and maintaining aquatic ecosystems. The guidelines are intended to provide government, industry, consultants and community groups with a sound set of tools that would enable the assessment and management of ambient water quality in a wide range of water resource types, and according to designated environmental values.

The primary objective of the ANZECC guidelines is:

'To provide an authoritative guide for setting water quality objectives required to sustain current or likely future environmental values for natural and semi-natural water resources in Australia and New Zealand'.

The ANZECC guidelines provide the following water quality management framework:

1. Identify the environmental values that are to be protected in a particular water body and the spatial designation of the environmental values (i.e. decide what values will apply where).
2. Identify management goals and then select the relevant water quality guidelines for measuring performance. Based on these guidelines, set water quality objectives that must be met to maintain the environmental values.
3. Develop statistical performance criteria to evaluate the results of the monitoring programs (e.g. statistical decision criteria for determining whether the water quality objectives have been exceeded or not).
4. Develop tactical monitoring programs focusing on the water quality objectives.
5. Initiate appropriate management responses to attain (or maintain if already achieved) the water quality objectives.

The guidelines recommend numerical and descriptive water quality guidelines to help managers establish water quality objectives that would maintain the environmental values of water resources.

They are not standards, and should not be regarded as such (ANZECC, 2000). It should also be noted that they are not suitable for direct application to stormwater quality. Rather, the guidelines have been derived to apply to the ambient waters that receive stormwater discharges, and to protect the environmental values that they support.

Of particular importance is the philosophical approach for using the ANZECC guidelines of:

'protect environmental values by meeting management goals that focus on concerns or potential problems' (ANZECC, 2000).

That is, development of a monitoring program, including the performance objectives, standards and measurement criteria, should focus on specific issues not on pre-determined guideline values.

The philosophy, management framework and guiding principles outlined in the ANZECC guidelines have formed the basis for development of project specific performance standards for the FBB Princes Highway upgrade Surface Water Monitoring Program.

The framework and management approach outlined above have been taken from the Australian Guidelines for Water Quality Monitoring and Reporting (ANZECC, 2000a), which are also referenced in Section 9 of the Australian Drinking Water Guidelines (NHMRC, 2011) in regard to development of monitoring programs. As such this framework is considered to be applicable for assessing drinking water catchments.

6.1.3 NSW DECCW Stormwater Quality Guidelines

The NSW Department of Environment, Climate Change and Water (DECCW)² introduced stormwater quality guidelines as part of the 'Draft - *Managing Urban Stormwater: Council Handbook*'. The handbook was developed to assist councils in preparing catchment wide stormwater management plans and is aimed at reducing the pollutant loads from stormwater that enter rivers and estuaries.

The guidelines outlined in the Council Handbook are presented as proposed treatment objectives and are formulated on a retention based approach. That is, they aim to retain a percentage of the annual average load for a range of parameters during operation of a stormwater system. They also provide specific concentration targets for suspended solids during construction works. These guidelines are a useful tool for assessing a development in isolation from the catchment by determining the removal efficiency of treatment measures for parameters such as Total Phosphorus, Total Nitrogen and Total Suspended Solids. They do not, however allow for an assessment of the potential impacts on the environmental water quality as the standard relates to removal efficiency only.

These guidelines have been developed for urban catchments and not strictly applicable to rural catchments. The recommended treatments objectives have been used as a basis for developing appropriate design criteria for the project.

6.2 Environmental Protection Licence

The FBB Princes Highway upgrade, as a freeway or tollway greater than 5 kilometres outside a metropolitan area, is classified as a scheduled activity (Schedule 1 – 35 Road Construction) under the *Protection of the Environment Operations Act 1997* (POEO Act). As such, an Environmental Protection Licence (EPL) will be required for construction under Part 3 of the POEO Act.

Under section 75(V) of the EP&A Act, such a licence cannot be refused, however a range of licence conditions may be imposed. Typically an EPL for a similar project would include licence conditions for parameters such as Oil and Grease, pH and Total Suspended Solids. Allowances for exceedance of these criteria are based on the requirement to capture rainfall events up to a set

² Currently known as the NSW Office of Environment and Heritage

recurrence as defined in the licence conditions – i.e. the concentrations of these parameters may only be exceeded where discharges from a sediment basin are a result of a rainfall event in excess of a prescribed magnitude.

The licence conditions of the EPL for this project will be determined by the EPA, and issued to the construction contractor. These conditions would form part of the water quality performance standards for the project during the construction phase.

6.3 Development of project specific performance standards

While the performance objectives identify the goals of the monitoring program, the performance standards define the benchmark and measures against which the performance is assessed. It is critical that the performance standards adopted provide a meaningful and quantifiable measure of 'performance'.

The FBB Princes Highway upgrade passes through the six main and three minor catchments (as identified in Section 3.2). It is important to protect the quality of water within these catchments. Protection of water quality in these areas is important in the development of performance standards for the monitoring program.

The nature of the land use within the catchment has potential to impact the water quality of the creeks and rivers. This should be recognised in the development of performance standards. The performance standard and monitoring approach must be capable of quantifying the impact that is directly attributable to the FBB Princes Highway upgrade – i.e. the assessment should be based on the impacts associated with the upgrade, not on the overall health of the catchment upstream.

6.4 Proposed performance standards

The potential impacts on water quality during the construction and operational phases of the FBB Princes Highway upgrade are outlined in Section 3. Whilst the key sources of risk associated with each phase of the project differ, the performance standards developed would follow the same approach, as outlined in the following sections.

6.4.1 Construction phase

For most road upgrades the approach to monitoring during construction involves sampling water quality upstream and downstream of the construction activity. This approach would be utilised for the FBB Princes Highway upgrade as it allows for an assessment of impacts that are directly attributable to the construction activities rather than the impacts related to the overall catchment.

During the construction phase of the project, the greatest risk to water quality is from the mobilisation of exposed sediments. A range of erosion and sediment control procedures would be implemented to reduce the risk of mobilised sediments entering the waterway, however appropriate monitoring standards are required to determine the performance of the control measures.

During large storm events, discharge will occur from on-site treatment/capture systems. However, with appropriate control measures in place the impact to water quality would be low. Impacts are most likely to be detected during wet weather as a result of exceedance of the control measure or from the failure of the control measures installed to adequately capture/remove pollutants.

The results of wet weather sampling undertaken during construction would be compared against upstream samples taken during the same sampling events in accordance with agency guidance.. Control charts present a 'baseline' data set (refer Section 7.4) and are developed based on data from a reference site, in this case upstream of the construction works. The control chart for each site provides the performance standard for that site. In addition to the comparison of data against the control chart, construction phase data will also be assessed against the EPL criteria for the project. The EPL for the project, which forms part of the construction phase performance standards, will be included in an Appendix once it has been issued by EPA.

6.4.2 Operational standards

During the operational phase, the greatest risk to water quality is increased pollutant loads resulting from road surface runoff. The runoff from the road surface may potentially contain a range of contaminants, including heavy metals and hydrocarbons.

A range of containment measures, including gross pollutant traps and water quality basins would be included to reduce the pollutant load entering the downstream creeks. The proposed treatment measures will be designed to capture the 'first flush' of pollutants, which has the potential to result in a significant reduction in pollutant loads.

Sampling would be undertaken upstream and downstream of the highway, with the downstream sampling site below the water quality basins. Sampling would also be undertaken within the outlet pipe of the water quality basins. Sampling would be undertaken during wet weather, as during dry weather there should be no measurable difference between the upstream and downstream sampling sites, with pollutants mobilised during wet weather only.

The wet weather sampling undertaken upstream and downstream of the highway during the operational phase would be compared against site specific control charts. Where any significant difference is identified (refer Section 8), additional investigation will be undertaken to ascertain whether the difference in the upstream and downstream data can be attributable to the FBB Princes Highway upgrade.

6.5 Control charts

Controls charts will not be used to assess construction impacts. Feedback from regulators on the first year of monitoring included a request to remove the use of control charts during construction water quality monitoring.

The Australian Guidelines for Water Quality Monitoring and Reporting (Water Quality Monitoring Guidelines) (ANZECC, 2000b), provide guidance for the development of monitoring programs and assessment of water quality. They form Volume 7 of the National Water Quality Management Strategy (ANZECC, 2000a) of which the ANZECC guidelines are also part.

The Water Quality Monitoring guidelines provide the following discussion of control charts:

'Control charting techniques used for the last 70 years in industry have an important role to play in an environmental context. They are particularly relevant to water quality monitoring and assessment. Regulatory agencies are moving away from the 'command and control' mode of water quality monitoring, and recognising that, in monitoring, the data generated from environmental sampling are inherently 'noisy'. The data's occasional excursion beyond a notional guideline value may be a chance occurrence or may indicate a potential problem. This is precisely the situation that control charts target. They not only provide a visual display of an evolving process, but also offer 'early warning' of a shift in the process level (mean) or dispersion (variability).'

The advantages of the use of control charts are identified as:

- minimal processing of data is required
- they are graphical: trends, periodicities and other features are easily detected
- they have early warning capability: the need for remedial action can be seen at an early stage

This ability to recognise 'noise' in the water quality data and the early detection of changing trends makes the use of control charts a powerful tool for assessing the impact of the FBB Princes Highway upgrade within a sensitive catchment where other land use factors may be contributing to a change in water quality.

6.5.1 Development of site specific control charts

For each of the proposed monitoring sites, a site specific control chart would be developed to provide a suitable reference criteria and performance standard. The control chart is produced by plotting the median concentration from the assessment site (i.e. downstream of the highway alignment) against the 80th percentile of the reference site (i.e. upstream of the highway alignment). Ideally, the 80th percentile at the reference site would be based on the most recent 24 monthly observations.

The Water Quality Monitoring Guidelines (ANZECC, 2000b) recommends the following procedure for calculating the 80th percentile of the data set:

- arrange the 24 data values in ascending order (i.e. lowest to highest)
- take the simple average (mean) of the 19th and 20th observation in the ordered set

The reference criteria may be kept up-to-date by recalculating the 80th percentile each month with the most recent 24 monthly observations. This would be of particular importance during the operational phase of the project, where gradual upstream catchment changes may influence the analysis of the water quality data.

An example control chart is provided in Figure 9.

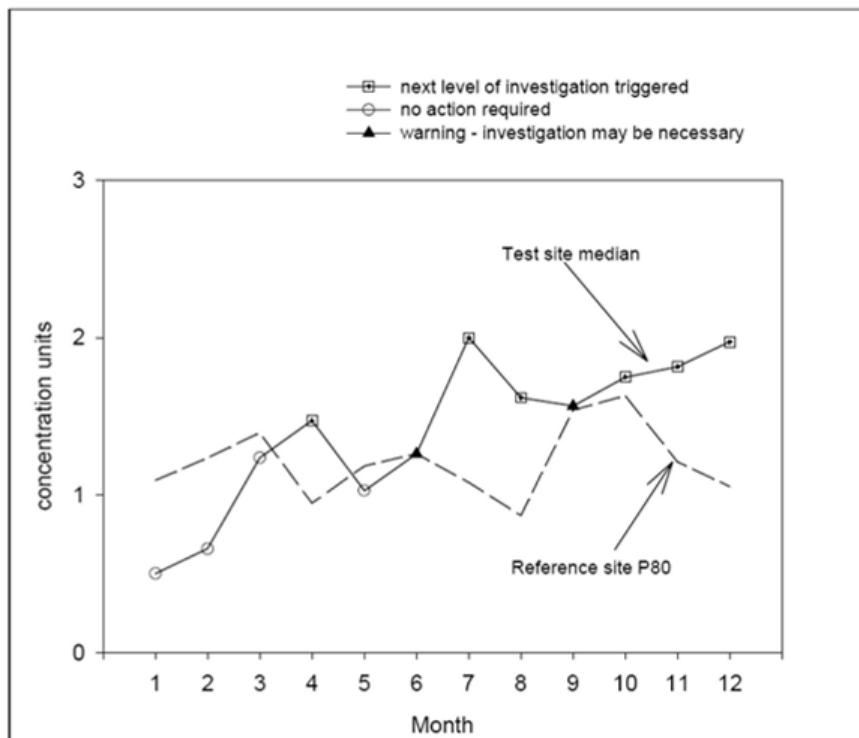


Figure 9: Example control chart (Aurecon 2010a)

Availability of data for development of control charts would be dependent on the project program and on reaching an agreement with stakeholders on the proposed approach early in the planning process.

This would allow the current background monitoring program to focus on collecting wet weather samples at the locations required to develop control charts for each site. Data collected during the construction phase of the project would also be used for reference data during the operational phase.

In accordance with agency guidance, control charts will be used during the operational monitoring but will not be used during the construction phase.

7. Measurement and assessment criteria

The following measurement and assessment criteria have been adapted from those agreed and approved with key stakeholders for similar projects in NSW and are considered to be applicable to the FBB project. They mimic those adopted for the T2E Upgrade (Aurecon, 2010).

Measurement criteria provide the 'trigger' for a management response, are related to the risks associated with the FBB Princes Highway upgrade and allow for assessment against the performance standards. The following sections provide an overview of the measurement criteria, while the processes for assessment that would result in the triggering of a management action are presented in Section 10.

7.1 Trigger criteria

The ANZECC guidelines (ANZECC, 2000a) provide a framework for setting trigger criteria. In the development of this framework the following criteria were considered:

- explicit recognition of the inherent (and usually large) variability of natural systems
- robustness under a wide range of operating conditions and environments
- no, or only weak, distributional assumptions about the population of values from which the assessment and reference data are obtained
- known statistical properties, consistent with and supporting the monitoring objectives [of the ANZECC guidelines]
- ease of implementation and interpretation
- suitability for visual display and analysis
- intuitive appeal

The trigger criteria recommended by the ANZECC guidelines for physio-chemical stressors, and subsequently adopted for the assessment of water quality impacts of the FBB Princes Highway upgrade is stated as:

"A trigger for further investigation will be deemed to have occurred when the median concentration of n independent samples taken at a test site [i.e. downstream of the highway] exceeds the eightieth percentile of the same indicator at a suitably chosen reference site [i.e. upstream of the highway]".

The above trigger criterion does not define or represent a point where an ecologically significant impact would occur. This approach is intended as an early warning mechanism to alert the catchment manager of a potential or emerging change that would require further investigation (ANZECC, 2000a).

The ANZECC guidelines also note that 'the statistical significance associated with a change in condition equal to or greater than a measurable perturbation [i.e. median of downstream sample exceeding 80th percentile of upstream sample] would require a separate analysis (ANZECC, 2000a). This analysis is discussed in the following sections.

7.2 Statistical analysis

In addition to the assessment against the above trigger criteria, a statistical analysis would also be used to test the significance of any observed difference between the upstream and downstream samples. Both a Paired t-Test and a Sign Test would be used in determining statistical significance. These are discussed further in the following sections.

7.2.1 Paired t-Test

A paired t-Test would be used to test the null hypothesis that there is no difference in the pairs (i.e. upstream and downstream samples at each time step) of data. The paired t-Test assumes that the paired differences (i.e. the difference between the upstream and downstream samples) are normally distributed around their mean. The two groups of data are assumed to have the same variance and shape. As such, if they differ, it is only in their mean. The null hypothesis can be stated as:

$$H_0: \mu = \mu_0$$

i.e. the means for group x (upstream) and y (downstream) are identical

If the differences are not normal and especially when they are not symmetric, the probability (i.e. p -values) from the t-Test would not be accurate. The primary consequence of overlooking the normality assumption underlying the t-Test is a loss of power to detect differences which may truly be present. The second consequence is an unfounded assumption that the mean difference is a meaningful description of the differences between the two groups (Helsel and Hirsch, 2002). Consequently, when assessing results of a t-Test, any large variance of significant outliers in either the upstream or downstream data set may influence the results.

7.2.2 Sign Test

A Sign Test would also be used to test for significant difference between the upstream and downstream samples. The Sign Test is used for pairs of data to determine whether one data set (upstream) is generally larger, smaller or different than the other (downstream).

$$H_0: P(x > y) = 0.5$$

Two paired groups of data are compared, to determine if one group tends to produce larger (or different) values than the other group. No assumptions about the distribution of the differences are required. This means that no assumption is made that all pairs are expected to differ by about the same amount. Numerical values for the data are also not necessary, as long as their relative magnitudes may be determined (Helsel and Hirsch, 2002). As such, the Sign Test is non-parametric and can be used regardless of distribution. The hypothesis, however, is more general than the t-Test.

The t-Test and Sign Test have both been proposed as each has strengths and weaknesses. The t-Test is a more powerful parametric test that uses all the information available while the Sign Test makes no assumption of distribution and is less affected by outlying data or significant variance.

7.3 Pollutant loads

During the operational phase of the FBB Princes Highway upgrade, monitoring would be undertaken on the outlet of some water quality basins between the upstream and downstream sample points (refer Section 9). This would allow for an assessment of the magnitude of pollutants entering the waterway by calculating pollutant loads. Pollutant loads can be calculated using the following formula:

$$Li = \frac{\sum (C_1Q_1 + C_2Q_2 + \dots + C_nQ_n)}{n}$$

- Where:
- L_i is the average pollutant load for event i (mg/s)
 - C_n is the pollutant concentration at time n (mg/L)
 - Q_n is the discharge at the same time n (L/s)

The pollutant load reductions will be compared against design criteria and the Managing Urban Stormwater Council handbook (NSW EPA, 1997) treatment objectives to test the efficiency of management systems.

8. Monitoring program

8.1 Monitoring Program Criteria

The monitoring regime is focused on collectively addressing the conditions of approval and statement of commitments and the surface water monitoring regime recommended in the EA, which are outlined in Section 2.

Further to this the monitoring program has been developed to:

- Monitor for the key environmental risks outlined in Section 3. Which can be separated in into:
 - Construction related impacts primarily associated with spills of chemicals and release of sediment laden water from active site areas and site sediment dams.
 - Operation related impacts primarily associated with chemicals from spills and generally impacted surface water run-off discharging from water quality basins.
- Meet the monitoring objectives outlined in Section 5, the performance standards outlined in Section 6 and the measurement and assessment criteria presented in Section 7, which are In particular this includes:
 - Adopting the interpretation of the ANZECC (2000) water quality guidance used for the T2E upgrade.
 - Isolating impacts of the site from broader catchment conditions/impacts.
 - Developing reference sites (upstream) and assessment sites (down-stream sites) on which standard statistical techniques (recommended in the ANZECC 2000 guidance) can be used to establish the presence of any impacts and the significance of the impacts identified.

The remainder of this section details the program developed to meet these criteria.

8.2 Water quality monitoring sites

8.2.1 Pre-construction

The RMS commenced pre-construction background monitoring of surface water quality in December 2013 at sites along the existing Princes Highway.

The Conditions of Approval for the FBB Princes Highway upgrade require ‘background monitoring of surface water quality parameters for twelve months prior to the commencement of relevant works or activities’. RMS will continue to monitor background conditions to provide a greater understanding of the catchment conditions and to provide a suitable baseline dataset for the assessment of performance of the environmental control measures during construction and operation of the FBB Princes Highway upgrade (refer Section 7).

Seventeen locations have been identified for baseline monitoring of water quality along the alignment. The sites characterise the baseline water quality in all surface water features identified in the EA that cross the alignment (at locations immediately up and down gradient).

Locating sampling sites directly up-gradient and down-gradient of where the alignment crosses water ways generally only accounts for impacts associated with the development of the alignment in those particular locations and has inherent limitations, which are outlined below.

- Sediment dams and water quality basins (the locations of which are currently unknown for construction) may discharge to locations down gradient of where the alignment crosses creeks and these need to be captured by the baseline and ongoing sampling. This approach

is unlikely to result in significant potential for influence from activities not associated with the alignment.

- Broughton Creek flanks and essentially lies down gradient of approximately 5 km of the alignment making it particularly difficult to isolate specific site activities from broader catchment activities. For example there is 5 km of catchment that lies between the immediately upgradient point and the immediately downgradient point.

In light of the above limitations, the sites have been located:

- where required further down gradient than the alignment to account for potential discharge from sediment and water quality basins; and
- to provide broad characterisation of the conditions along Broughton Creek with recognition that isolating specific site activities is not feasible in this area.

The sampling locations are presented in Figure 10 and are summarised below.

- **SW01 to SW03 and SW05** are located along Broughton Creek: Monitoring site SW01 is located immediately upgradient of the alignment. SW02 is located immediately down gradient of a number of creek crossings and of the cuts at Toolijooa Ridge. SW03 and SW05 are further downstream on Broughton Creek. SW03 is located toward central areas of the alignment, while SW05 represents the only true downgradient location for Broughton Creek.
- **SW04** is located on Broughton Mill Creek upstream of the alignment.
- **SW06** is located at the confluence of Bundewallah and Connollys Creeks upstream of the alignment.
- **SW07** is located on Broughton Mill Creek downstream of the alignment and of SW04, SW06, SW08
- **SW08** is located on Bundewallah Creek upstream of the alignment and just upstream of the proposed location of the Town Creek diversion to Bundewallah Creek.
- **SW09** is located downstream the alignment and of SW06 and SW08 on Bundewallah Creek.
- **SW10 and SW11** are located upstream and downstream of the alignment along Town Creek. Town Creek downgradient of the diversions and hence SW11 is likely to have significantly different characteristics after the diversion.
- **SW12 and SW13** are located upstream and downstream of the alignment along Hitchcocks Lane Creek Tributary
- **SW14 and SW15** are located upstream and downstream of the alignment along Hitchcocks Lane Creek.
- **SW16 and SW17** are located upstream and downstream of the alignment along an unnamed tributary of Broughton Creek.

8.2.2 Construction phase

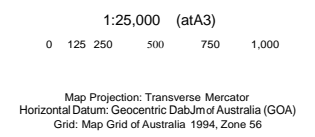
During the construction phase of the project, water quality would be monitored at the same location as for background conditions. Additional sampling would be required to the background monitoring undertaken to characterise the water quality of discharge from the proposed sediment basins. The locations of these dams are currently unknown. This monitoring would only be conducted if the trigger criteria were exceeded in the existing monitoring network or as part of assessing the efficiency of treatment systems implemented under the CEMP.

Additional sampling will also be required at construction phase in areas of dewatering at major cuts and bridges along the Upgrade alignment before this water can be discharged into receiving waters.

Additional sampling may be required at sites down gradient of other construction activities such as stockpile areas, however, it is recommended that this only occurs when the existing system identifies exceedance of the trigger criteria within the existing sampling regime.

8.2.3 Operational phase

During the operational phase of the project, water quality would be monitored at the same locations as the pre-construction phase, but with subsequent additional monitoring of water quality basins discharge similar to the construction phase if exceedances of the trigger criteria are identified in the existing monitoring network. Appendix H of the EA (AECOM, 2012) suggests that construction sediment quality basins could be converted to water quality basins for the operational phase of the project.



LEGEND

● Surface Water Sampling Locations	— Railways
— Berry to Foxground upgrade alignment	— Waterways
— Roads	— Lakes and dams



Roads and Maritime Services
Water Quality Monitoring

Job Number 121-23174
Revision 0
Date 09 Jul2014

Surface water sampling locations **Figure 10**

Z:\TEMP GISU.rwy to foxground\GISMa MXD\21_23174_2013_BERRY_Surfic.W_rumpplinglocations.mxd
© 2010. While GHD has consented to this use of the data, the product is the property of GHD and is not to be used or reproduced without the prior written consent of GHD. GHD and DATA CUSTODIAN, cannot accept liability of any kind (whenever caused, in any way) for any loss or damage of any kind (including indirect or consequential loss or damage) arising from the use of the product or the information contained in it. This information is provided for your information only and does not constitute an offer or a contract.

Data Source: NSW Department of Lands, DTDB and DCDB - 2012. Created by: pmodoug.

8.3 Monitoring parameters

The monitoring parameters proposed, as outlined in Table 5, are based on the review of potential pollutant sources and reflect those selected for background monitoring by RMS (Project Brief, 2013) and those in the EA.

Table 5: Construction and operational phase monitoring parameters

Parameter	Unit	Analysis
Dissolved oxygen	mg/L	Insitu
Electrical conductivity	µS/cm	Insitu
Oxygen Reduction Potential	mV	Insitu
pH		Insitu
Temperature	°C	Insitu
Turbidity	NTU	Laboratory
Total suspended solids	mg/L	Laboratory
Oils and Grease	mg/L	Laboratory (visual)
Total Petroleum Hydrocarbons	mg/L	Laboratory
Total Phosphorus	mg/L	Laboratory
Total Nitrogen	mg/L	Laboratory
Heavy Metals (As, Cd, Cr, Cu, Pb, Hg, Ni, Zn)	mg/L	Laboratory

8.4 Sample collection

The collection approach proposed differs between the pre-construction and other phases of the project. During the pre-construction phase samples would be collected at upstream and downstream sites in accordance with the sampling protocol outlined in the sampling protocol document (GHD, 2014a).

8.5 Sampling regime (time and frequency)

As discussed in the preceding sections, the primary impact to water quality during both the construction phase and the operational phase is during wet weather where sediments and pollutants may be mobilised and enter the receiving water. They are most likely to enter surface water via treatment trains that include sediment basins/water quality basin and swales or as diffuse incidental run-off from uncaptured areas or inappropriately designed construction areas.

Diffuse run-off from impacted areas may occur under low level rainfall events when general run-off is initiated from the catchment, but when water quality basins are not discharging. The EA suggested a rainfall event of 15 mm in a 24 hour period would be suitable to characterise these conditions. A review of Broughton Creek flow data against rainfall data suggests that a 15 mm, 24 hour event generally results in increased flows in Broughton Creek (and hence catchment run-off) and would therefore be suitable for catching diffusely impacted run-off from the alignment.

Sediment and water quality basin discharge would generally only occur when their storage capacity is reached which would generally be under extreme rainfall events. Extreme rainfall events were estimated to be 50 mm in a 24 hour period in the EA, which is understood to be greater than the storage capacity of operation water quality basins for the project and hence discharge would be occurring from the basins under these conditions.

Based on the above, the following sampling will be implemented for pre-construction, construction and operational phases:

Pre-construction Phase

- Monthly sampling of minor wet weather events (ie, where greater than 15 millimetres of rainfall is recorded in a 24 hour period).
- Event based sampling of major wet weather events (ie where greater than 50 millimetres of rainfall is recorded in a 24 hour period).

Construction Phase

- Monthly sampling of minor wet weather events (ie where greater than 15 millimetres of rainfall is recorded in a 24 hour period). One sample would be taken from upstream and downstream sites and compared immediately. If downstream is more than 10% greater than upstream, two more pairs of samples 15 min apart would be collected and compared
- Event based sampling of major wet weather events (ie where greater than 50 millimetres of rainfall is recorded in a 24 hour period). One sample would be taken from upstream and downstream sites and compared immediately. If downstream is more than 10% greater than upstream, two more pairs of samples 15 min apart would be collected and compared. A maximum of three major events would be sampled per year for the duration of the construction phase.
- During construction the primary impacts would be associated with sediment laden water discharging from the site. Other parameters would not expect to be as prevalent as they would generally be associated with incidental spills and would be stringently managed under the CEMP. As such, during construction turbidity and total suspended solids would be the primary constituents analysed at the laboratory. Other laboratory analytes would be sampled on a quarterly basis as opposed to the event based sampling outlined above for the appearance of broad scale impacts.
- Increases in monitoring associated with construction dewatering activities will be dealt with as part of the specific construction management practices.

Operation Phase

- Monthly sampling of minor wet weather events (ie where greater than 15 millimetres of rainfall is recorded in a 24 hour period). One sample would be taken from upstream and downstream sites and compared immediately. If downstream is more than 10% greater than upstream, two more pairs of samples 15 min apart would be collected and compared.
- Event based sampling of major wet weather events (ie where greater than 50 millimetres of rainfall is recorded in a 24 hour period). One sample would be taken from upstream and downstream sites and compared immediately. If downstream is more than 10% greater than upstream, two more pairs of samples 15 min apart would be collected and compared. A maximum of three major events would be sampled per year.

This sampling regime will allow repeatability between each phase and hence provide the best potential for characterisation of impacts.

It should be recognised that this is an adaptive monitoring program and this sampling regime may be modified based on the findings of early monitoring results. Further discussion on the review and adaptation of this monitoring plan is provided in Section 11.

8.6 Sampling protocol

To reduce the risk of sampling error, all sampling would be undertaken in accordance with the following standards:

- Australian Standard AS/NZS 5667.1 1998 Water quality – Sampling Part 1: Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples
- Approved Methods for the Sampling and Analysis of Water Pollutants in NSW (EPA, 2004)

A Chain of Custody (CoC) form would also be used to ensure chronological documentation of data collection, transfer and analysis. A sampling procedure manual; Surface Water and Groundwater Sampling Protocol (GHD, 2014) has been developed to ensure consistency in the sampling technique and methodology adopted during each sampling event and should be referred for additional detail on this topic.

8.7 Sample analysis

The following key points should be noted for the analysis of water quality data:

- To reduce the potential for error resulting from sample analysis, a laboratory NATA accredited for the analysis undertaken would be used to ensure a high standard of analysis
- Where an in-situ measurement is taken, the water quality sonde should be calibrated prior to each sampling event. A copy of the calibration certificate should be included with the copy of all sample results

Further detail on this is provided within the sampling protocol document (GHD, 2014a).

9. Data analysis and interpretation

9.1 Analysis of Pre-construction phase data

Analysis for preconstruction data will be limited and as the focus of this data collection is provide baseline information on which any changes during construction and operation can be compared. The data collected will be compared against relevant water quality guidelines to establish the overall conditions of water quality. The data will also be compared against the relevant surface flow data and rainfall data to provide and understanding of the flow and rainfall events that have been characterised by the sampling event undertaken. The data will also be used to develop the baseline control charts on which the operational water quality can be compared.

9.2 Analysis of construction phase data

During the construction phase, the water quality monitoring program would focus on assessing whether the erosion and sediment control procedures are effectively managing the impact from the construction works. An overview of the process for assessing the performance against the agreed objectives and standards is provided in the following sections and summarised in the flowchart in Figure 11. The management response to any observed impacts are outlined in Section 11.

9.2.1 Step 1: Data collection and collation

All water quality samples would be collected in accordance with the procedures outlined in sampling protocol document (GHD, 2014a). This includes the use of a hand-held water quality probe for in-situ assessment of a range of parameters, while other parameters would be assessed by collecting samples for analysis at a NATA certified laboratory.

9.2.2 Step 2: Analysis and interpretation

The second stage of the assessment process includes review of upstream variability, review of the data against upstream water quality and an assessment of the statistical significance of any observed change. Whilst the majority of steps in this methodology allow for a clear process to be followed, the objectivity and understanding of the user in reviewing the findings would be important.

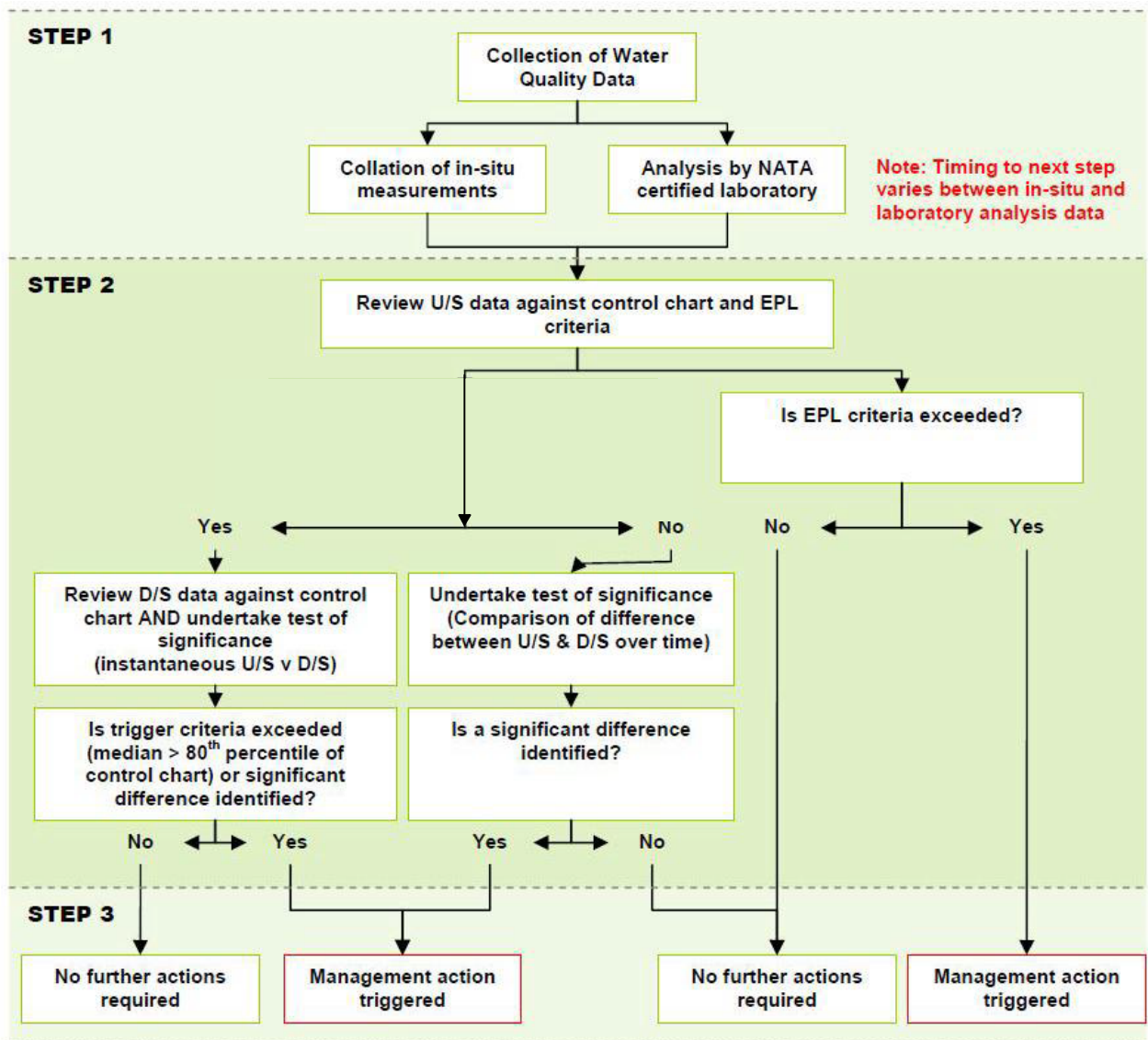


Figure 11: Construction phase water quality impact assessment procedure (Aurecon, 2010)

Notes:

CL = Confidence limit

U/S = Upstream

D/S – Downstream

Assessment against Environment Protection Licence (EPL)

An EPL will be required for construction under Part 3 of the POEO Act. The results of the monitoring program will be reviewed against the licence conditions of the EPL. Should the licence conditions be exceeded a management action would be triggered.

Assessment of significance

To ensure a robust assessment of the water quality data is completed, a test of significance would be undertaken to compare the samples upstream and downstream of the highway collected during each sampling event. The significance would be tested using both a t-Test and Sign Test as described in Section 7.2. The methodology would allow an assessment of the pollutants that are directly attributable to the highway during each event and is independent of the variable influences such as the volume of rainfall or time since last rain event. This process provides a direct comparison and assessment of impacts.

Comparison of long term differences

Where the assessment of upstream variability has identified that a particular sample event falls outside the expected range (i.e. where a significant change to upstream catchment influences has occurred), an assessment of the differences (i.e. U/S to D/S paired data) over time should be undertaken. When undertaking the above tests of significance, the paired data (i.e. upstream and downstream) from each event is used. For this analysis, however, the median value for each event should be used. By assessing the relative difference between each sample event, any trends or unexpected variance can be identified.

9.3 Analysis of operational phase data

During the operational phase of the project, the water quality monitoring program would focus on assessing whether the treatment processes (e.g. gross pollutant traps and water quality basins) are effectively mitigating the impact of the highway operation. An overview of the process for assessing the performance against the agreed objectives and standards is provided in the following sections and summarised in the flowchart in Figure 12. The management response to any observed impacts is outlined in Section 11.

9.3.1 Step 1 and Step 2 methodology

The majority of processes for the analysis and interpretation of the operational phase data are the same as for the construction phase of the FBB Princes Highway upgrade and as such the description of these steps has not been repeated.

The difference in methodologies relates to the process where the trigger criterion is exceeded or an impact of statistical significance is identified. An overview of this process is described below.

Assessment of basin outflow

During the operational phase, there will be monitoring of an estimated 18 representative water quality basins outflow (refer Section 3). Measuring the concentrations of pollutants that are leaving the basins allows for a more comprehensive assessment of any differences between upstream and downstream data.

The first stage of this process is to calculate the pollutant loads associated with the basin outflow. This requires details of the pollutant concentrations and discharge volumes and would be calculated using the formula presented in Section 8.3. By calculating the pollutant loads of the discharge leaving the basins, an assessment can be made to determine whether the observed difference between upstream and downstream samples can be attributed to the highway runoff.

The results of the MUSIC modelling presented in Chapter 7 of the EA Report (AECOM, 2012), indicate that the likely loads of pollutants entering the waterway will increase without any water quality treatment. By measuring the pollutants leaving the basins, the assumption of this modelling and the detailed design investigation can be confirmed and the actual performance of the treatment process assessed.

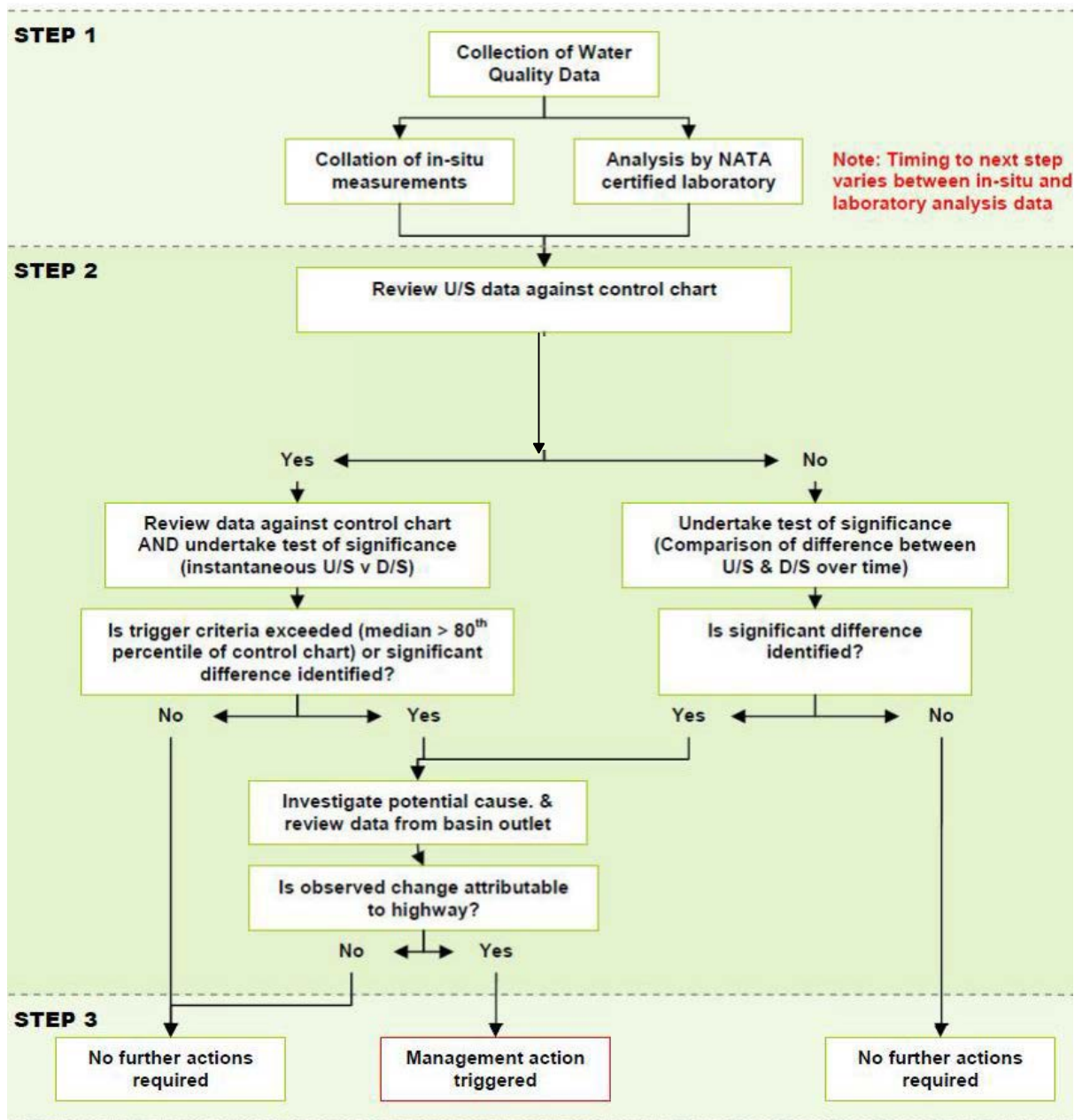


Figure 12: Operational phase water quality assessment (Aurecon, 2010)

10. Management actions

The management actions have adapted from the Surface Water monitoring programs from similar NSW projects (Aurecon, 2010a) which have been approved by all relevant stakeholders and is applicable to this project.

For a monitoring program to be effective, the performance objectives, performance standards and measurement criteria trigger must be linked to management actions. The management actions outlined in this section relate specifically to where the monitoring program has identified a potential impact. Management actions and responses for all other environmental impacts would be covered under the Construction and Operational Environmental Management Plans.

Section 6 outlines the criteria for triggering a management action, and Section 7 provides an overview of the process for assessment against these criteria. The following sections describe the management actions to be undertaken during the construction and operational phases of the project, should a trigger criteria be exceeded.

10.1 Construction phase

Best practice environmental management and control procedures would be used for the management of impacts during the construction phase of the project. The greatest risk to water quality during construction would arise in the event that these environmental control measures will not be sufficient or are inadequately installed/maintained to prevent sediment laden runoff from entering the receiving water.

The flow chart presented in Figure 13 provides an overview of the key steps in the assessment of construction phase environmental controls in the event of a management action being triggered. This is a guide only and should not be considered the only path for a management response. All management actions should include an investigation of the reasons for exceedance of the trigger and ensure that all practicable actions have been undertaken to prevent further incident.

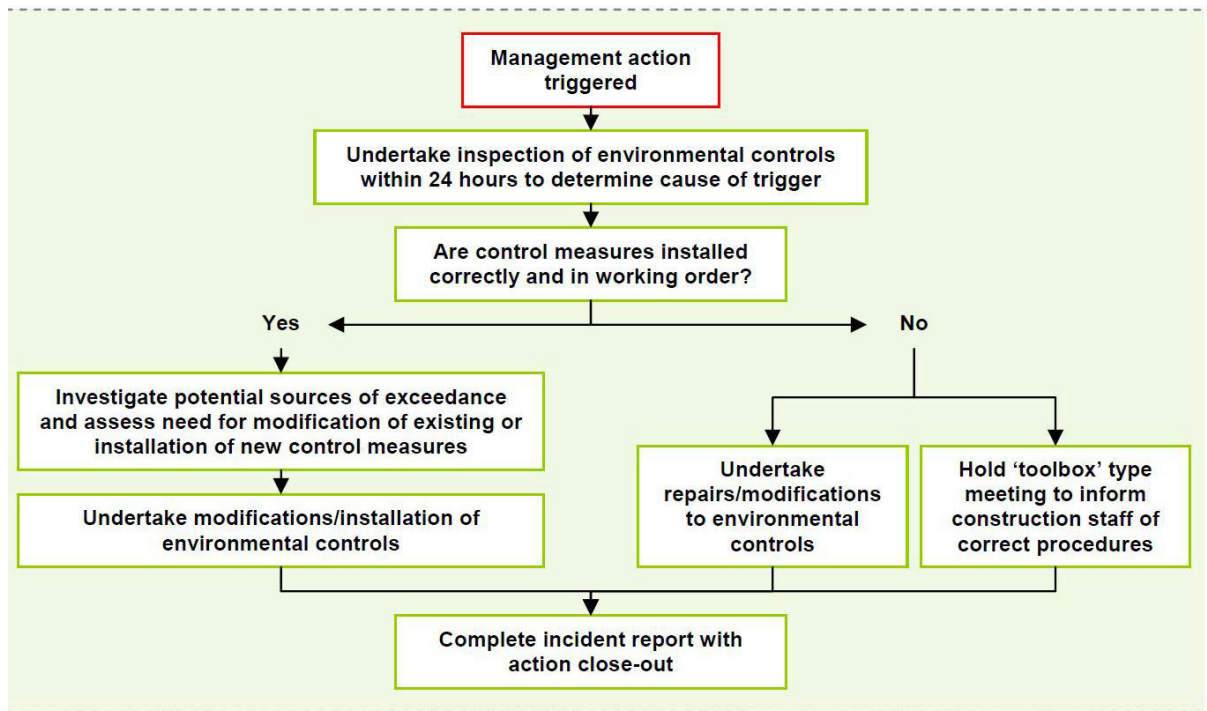


Figure 13: Construction phase management framework (adapted from Aurecon, 2010)

During the construction phase, the timing of the management actions is critical. Any trigger as a result of exceedance of a performance standard would most likely be a result of increased sediment loads following rainfall. The investigation should commence within 6 hours of the management action trigger and subsequent response should be undertaken within 24 hours to ensure that any repairs, modification or additional measures are incorporated into the environmental controls before subsequent rainfall events.

A key aspect of the management response is to ensure that the findings of any investigation are communicated to the project team. This communication process would ensure that the team are aware of the correct procedures for installation and maintenance of environmental controls and would be included in the Construction Environmental Management Plan.

Reporting following the triggering of a management action would be undertaken in accordance with the processes outlined in Section 11.

10.2 Operational phase

The operational phase environmental controls proposed for the FBB Princes Highway Upgrade are outlined in the EA Report (AECOM, 2012). Should the environmental controls perform as predicted there should be no measurable effect as a result of the operation of the FBB Princes Highway upgrade and consequently no management actions would be triggered.

Management actions are only likely to be triggered where the treatment process fails to perform as expected (i.e. a lower removal efficiency than modelled is observed), or where additional pollutants beyond those normally associated with an operational highway are recorded. As a result of the complexity of these issues, the management actions following exceedance of a performance standard during the operational phase of the project would require considerable investigation and may require further monitoring before the action can be closed out.

The flow chart presented in Figure 14 provides an overview of the key steps in the assessment of operational phase impacts in the event of a management action being triggered. As for the construction phase actions, the flow chart is provided as a guide only and should not be considered the only path for the investigation of management responses. All management triggers during the

operational phase would include an investigation of the reasons for exceedance of the trigger and ensure that all practicable actions have been undertaken to prevent further incident.

Reporting following the triggering of a management action would be undertaken in accordance with the processes outlined in Section 11.

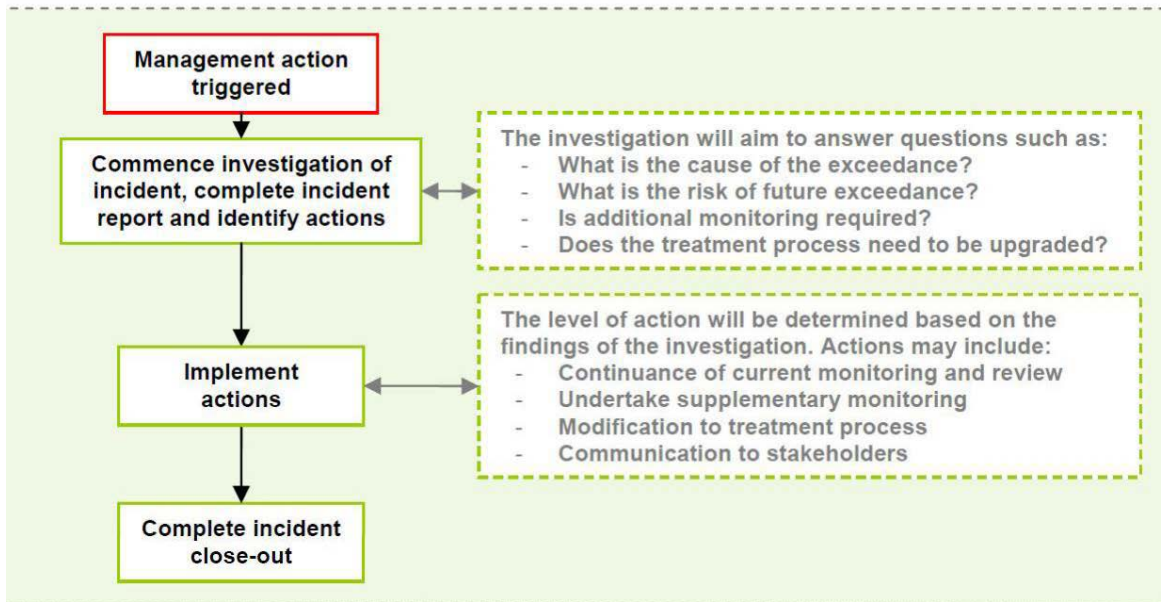


Figure 14: Operational phase management framework (adapted from Aurecon, 2010)

11. Management framework

The implementation of the proposed environmental controls, in combination with effective monitoring and management, would ensure that the risk from the FBB Princes Highway upgrade on the water quality of the local catchments would be significantly reduced. The following sections provide the framework for implementation, adaptation, review and management of the FBB SWMP. These mimic those adopted for the T2E upgrade developed by Aurecon, 2010.

11.1 Adaptive management approach

RMS recognises the importance of undertaking environmental management using an adaptive management approach and as such the SWMP would be a working document. The nature of water quality monitoring is such that there is no simple solution that provides a monitoring and management response to all scenarios.

Whilst this monitoring program has been developed based on the best available information at the time, it must be recognised that an adaptive approach is required to deliver an effective monitoring program into the future. Where the review and audit process identify opportunities for improvement, or areas where the monitoring approach may be refined, the FBB SWMP would be reviewed and updated. This would ensure that the monitoring program outlined within this surface water monitoring plan is capable and would continue to be capable of assessing the performance of the construction and operational phase environmental controls against the defined performance objectives and standards.

11.2 Roles and responsibilities

For the FBB Surface Water Monitoring Program to be implemented effectively, the roles and responsibilities for the implementation, management, review and auditing, must be clearly defined. Separate responsibilities are defined for the construction (refer Table 6) and operational (refer Table 7) phases of the project.

Table 6: Construction Phase Roles and Responsibilities

Organisation	Responsibility	Personnel and Contact Details
RMS	<ul style="list-style-type: none"> Implementation of the SWMP Assessment against performance objectives and standards Ensuring a CEMP is developed and implemented effectively Ensuring appropriate measures are implemented for management of acute impacts Investigation of any potential or observed impacts Identification and implementation of management actions as required Review and updating of SWMP Reporting 	<ul style="list-style-type: none"> Ron De Rooy Senior Project Manager Ph: 02 4221 2585 Email: Ron.DE.ROOY@rms.nsw.gov.au

Organisation	Responsibility	Personnel and Contact Details
NOW	Review of Annual Progress Report and Incident Reports. Provide feedback as necessary.	Bob Britten Water Regulation Officer Ph: 6491 8209 Email: Bob.Britten@water.nsw.gov.au
NSW DP&I - Fisheries	Review of Annual Progress Report and Incident Reports. Provide feedback as necessary.	Dr Trevor Daly Fisheries Conservation Manager – South Coast. Ph: 02 4478 9103 Email: trevor.daly@dpi.nsw.gov.au
NSW EPA	Review of Annual Progress Report and Incident Reports. Provide feedback as necessary.	Julian Thompson Unit Head - South East Region Ph: (02) 6229 7002 Email: julian.thompson@epa.nsw.gov.au
OEH	Review of Annual Progress Report and Incident Reports. Provide feedback as necessary.	Peter Marczan A/manager noise policy Ph: (02) 9995 6059 Email: peter.marczan@epa.nsw.gov.au

Table 7: Operation Phase Roles and Responsibilities

Organisation	Responsibility	Personnel and Contact Details
RMS	Implementation of the SWMP Assessment against performance objectives and standards Ensuring appropriate measures are implemented for management of acute impacts Regular inspection of treatment measures (water quality basins) Maintenance of treatment measures Investigation of any potential or observed impacts Identification and implementation of management actions as required Review and updating of SWMP Reporting Consultation	Ron De Rooy Senior Project Manager Ph: 02 4221 2585 Email: Ron.DE.ROOY@rms.nsw.gov.au

Organisation	Responsibility	Personnel and Contact Details
NOW	Review of Annual Progress Report and Incident Reports. Provide feedback as necessary.	Bob Britten Water Regulation Officer Ph: 6491 8209 Email: Bob.Britten@water.nsw.gov.au
NSW DP&I - Fisheries	Review of Annual Progress Report and Incident Reports. Provide feedback as necessary.	Dr Trevor Daly Fisheries Conservation Manager – South Coast. Ph: 02 4478 9103 Email: trevor.daly@dpi.nsw.gov.au
NSW EPA	Review of Annual Progress Report and Incident Reports. Provide feedback as necessary.	Julian Thompson Unit Head - South East Region Ph: (02) 6229 7002 Email: julian.thompson@epa.nsw.gov.au
OEH	Review of Annual Progress Report and Incident Reports. Provide feedback as necessary.	Peter Marczan A/manager noise policy Ph: (02) 9995 6059 Email: peter.marczan@epa.nsw.gov.au

11.3 Reporting and auditing

Condition of Approval B16(g) requires 'reporting of the monitoring results to the Department, OEH, EPA and NOW'. The following sections outline the reporting process to be implemented during the construction and operational phases of the project to meet this requirement and to ensure the delivery of an effective monitoring program.

11.3.1 Reporting

Regular reporting would be undertaken to allow assessment against the surface water objectives and performance standards. A brief factual monitoring report would be prepared after each sampling event, to present the data collected and ensure the environmental controls are effective.

A more comprehensive progress report would be prepared annually. The review and preparation of the progress report would not only report on the data collected during the year, but would also allow for an assessment of gradual trends and changes within the system – i.e. this review would provide early detection of any potential impacts and allow management actions to be triggered to address them before an impact occurs.

Incident reporting would also be undertaken where a performance standard has not been met. Exceedance of a performance standard does not necessarily mean that an impact has occurred, but provides a trigger for further review. The preparation of an incident report would be the first step in this process and would identify the management approach to be adopted to resolve any potential concerns.

Following all audits (internal and external), a close-out report would be prepared. Where non-conformances are noted, the report would include a summary of the actions undertaken to address the non-conformance and the steps that have been put in place to prevent further occurrence.

A summary of the reporting for the FBB Surface Water Monitoring Program is presented in Table 8.

Table 8: Summary of reporting requirements (adapted from Aurecon, 2010a)

Report	Condition of Approval Reference	Content	Timing	Circulation
Monitoring Report	B16 (h)	Following each sampling event a brief report would be prepared that describes water quality performance against the agreed objectives and standards for that particular event.	All phases until monitoring no longer required.	EPA, NOW, OEHD DPI.
Annual Progress Report	B16 (h) B29 (c), (g)	As a minimum the progress report would include: <ul style="list-style-type: none"> • A summary of the monitoring results recorded during the previous 12 months; • An assessment of performance against defined objectives, standards and measurement criteria; • An overview of any environmental incidents recorded and the corresponding action taken; • Details and rationale for any modification to the surface water sampling program; • An outline of any changes to the environmental controls; • Findings of all audits and details of any corrective actions required; • Recommendations for any changes to the monitoring program or control measures; and • Review of any complaints and actions from the ERG. 	Annual – No long operational period specified in COA	EPA, NOW, OEHD DPI.
Incident Report	A5, B29 (e), (f), (g)	In the event of an exceedance in water quality performance standards, a brief report would be prepared to examine all relevant data and to determine a likely source and appropriate management action. An action plan would be developed and would include a timeframe for implementation.	Initial notification to DG in 24 hours with report provided within 7 days	EPA, NOW, OEHD DPI.

12. Management of acute impacts

12.1 Acute risks to surface water quality

An assessment of acute impacts during the construction is summarised in Section 3.

During the construction phase the primary source of risk is from spills and leakages from plant or storage facilities on the construction site. If these spills are not contained and managed correctly, the contaminants have the potential to enter the catchment. The CEMP developed for the Project includes a range of control measures to significantly reduce this risk (Aurecon, 2012).

Risks during the operational phase of the project relate primarily to spills from road accidents.

The risk of pollutants entering the waterway as a result of a spill during the construction or operational phase of the project is low, however it is pertinent that this risk is acknowledged and managed accordingly. The nature of a risk such as a spill is that the location of the spill cannot be predicted. Also, while an assessment of potential pollutants can be made, the exact contaminant would not be known until after the spill has occurred.

12.2 Consideration of acute impacts

As discussed, for monitoring to be effective and meaningful, the program must produce quantifiable results that can be attributed to a source. That is, if contaminants are detected they must be attributable to the highway construction or operation before a management response can be implemented. Monitoring to assess the potential impacts of such spills it is not considered practical.

Acute impacts are best managed through the implementation of effective Construction and Operational Environmental Management Plans (CEMP and OEMP), as required by Condition of Approval B35 and D1. Good environmental management as a preventative measure would be far more effective in preventing impacts on catchment water quality than implementing a monitoring program.

In the event that an accident does occur and a spill results from that accident, the management response would be directed by the emergency response plan. Development of emergency response plans for both the construction and operational phase of the project would significantly reduce the risk of an impact on water quality and is a requirement of the project Conditions of Approval. An emergency response plan is required within condition of approval B35 for the CEMP.

In addition to these management solutions and emergency response procedures, a range of environmental controls would be in place to prevent spills from entering the waterway. This would include factors such as sizing water quality basin to capture the occurrence of acute impacts.

With the implementation of the management measures discussed above it is anticipated that the risk of surface water impact will generally be reduced relative to the existing highway and are anticipated to result in improved overall catchment water quality.

13. Consultation

13.1 Consultation undertaken during development of the SWMP

The Conditions of Approval for the project require that the SWMP is 'developed in consultation with the OEH, EPA, DPI (Fishing and Aquaculture) and NOW.

Contacts from these organisations have been contacted and have been supplied with the brief for the project as a means of providing familiarity with the project prior.

A copy of this document, the sampling protocol document and groundwater management plan have also been provided to the key stakeholders for comment prior to finalisation of the documents.

A summary of the comments submitted on this document and how these have been dealt with are presented in the Table 9. Additional correspondence is provided in Appendix A.

Table 9: Stakeholder Comments and Response

Organisation	Date submitted to stakeholder	Contact	Document section and document page number	Comments	Comment date	GHD response	Response Date
Fisheries NSW - DPI	14/04/2014, Rev 2 submitted 23/04/14	Trevor Daly	General comment	Think it could be better focussed to address the key risk – which is sediment coming from the site during rainfall events during the construction phase	4/03/2014	The sampling requirements during construction have now been changed to focus sampling during wet events as recommended by DPI and the EA and focusing on Turbidity and TSS (i.e. sediment in discharge)	13/06/2014
			General comment	More wet weather sampling at the expense of dry weather sampling (especially during large rainfall events eg >25mm/day in addition to the >10mm/day events currently proposed)	4/03/2014	Dry weather sampling has been removed and ongoing sampling will focus on wet weather events. The wet weather event sampling is now based on that recommended in the EA and focuses on first flush run-off capture and then high events when discharge from sediment and water quality basins will be occurring.	13/06/2014
			General comment	Analysis focus should be TSS or turbidity during construction phase. EC, temperature, pH, DO and heavy metals could be sampled less as I doubt they will show much response. Sampling of TN and TP could be minimised as well as they are likely to be closely correlated with TSS anyway. Minimising the low risk items could allow more funding to be used for more wet weather sampling (eg after hours and weekends)	4/03/2014	Construction based sampling has been revised accordingly to reduce laboratory parameters other than TSS and Turbidity to quarterly events. Inset parameters will be collected as part of adopting standard sampling protocols.	13/06/2014
			General comment	More emphasis put on the need to have paired sampling sites – ie 1 in the waterway upstream of construction activities and a 2nd in the waterway downstream of construction activities	4/03/2014	This has been undertaken where possible; however, there are limitations to adopting this approach due to catchment conditions. These limitations relate to capturing impacts from sediment dam discharges and general run off from the site, particularly into Broughton Creek. Section 8.2.1 discusses these limitations and how they have been managed.	13/06/2014
			General comment	Due to the possible presence of Australian Grayling (threatened fish species) in Broughton Creek, the construction sediment basins need to be designed for the 90th% rain event for the Gerringong-Berry section. This is consistent with what RMS have done elsewhere in NSW for threatened fish habitat waterways.	4/03/2014	Acknowledged. This will be dealt with in the CEMP and is not discussed further in this document.	13/06/2014

Organisation	Date submitted to stakeholder	Contact					
			Figure 2, pg 20	Broughton Mill Creek catchment boundary is incorrect. Should be further west	24/04/2014	This has been corrected.	13/06/2014
			Section 6.4.1 (construction phase), pg 34	What will the design standards be for the control measure (retention basins)	24/04/2014	Details of the design will be provided in the CEMP and design documents.	13/06/2014
			Section 6.4.1 (construction phase), pg 34	Statement about impact on water quality doesn't make sense. If the controls are being exceeded because the storm is larger than the Design Standard, then the control measures will not be having much effect. The impacts could be very significant if large quantities of sediment are deposited into streams.	24/04/2014	Wording has been revised to clarify this further and now states that "During large storm events, discharge will occur from on-site treatment/capture systems. However, with appropriate control measures in place the impact to water quality would be low".	13/06/2014
		Trevor Daly (and Allan Lugg)	Section 6.4.1 (construction phase), pg 34	Why not just sample upstream and downstream of the works and compare the 2 results? Any discrepancies would most likely be attributable to the works. A Control Chart sounds like an unnecessary distraction.	24/04/2014	This section essentially describes up and down gradient comparison. Reference sites are essentially upgradient sites, while assessment sites are essentially down gradient sites. The control charts allow reasonable boundaries to be established for some variability between up and down gradient sites before triggering a response. For example, there might be a slight increase in a parameter between up and down gradient, which could trigger an exceedance without the control charts, but which would be rationalised as acceptable using the control chart approach.	13/06/2014
			Section 6.5.2, pg 36	This section is an exact duplicate (highlighted yellow) of 6.5.1	24/04/2014	This section has been removed.	13/06/2014

Organisation	Date submitted to stakeholder	Contact					
			Section 7.1 (trigger criteria), pg 38	ANZECC guidelines for physio-chemical stressors over complicating the issue. It will require collection of lots of samples and statistical analysis of those samples. The reality is that most of the samples will come from dry weather periods when impacts are unlikely - ie they will tell us nothing. In fact they will give the impression that everything is good. It would be much better to concentrate on comparing paired samples (upstream and downstream) taken during or shortly after rainfall events.	24/04/2014	Sampling has been revised to include wet weather sampling only.	13/06/2014
			Section 8.1.1	grammatical error	24/04/2014	This section has been revised.	13/06/2014
			Figure 10, pg 42	SW01 site location too far upstream	24/04/2014	This site has now been moved to just upgradient of the alignment.	13/06/2014
			Figure 10, pg 42	Five points where crossing of Broughton Creek and Princes Highway should have paired upstream and downstream sites	24/04/2014	This is not considered necessary for the reasons outlined in section 8.2.1. It is based on the fact that SW01 is the only real upgradient site and SW05 is really the only down gradient site. Additional sites are just places in between. Further immediately up and down gradient of the alignment would really only account for construction works crossing Broughton Creek rather than all other sources of impact that will be present along the Creek from the alignment.	13/06/2014
			Figure 10, pg 42	Should be several paired upstream and downstream sites in the minor creeks that cross the alignment.	24/04/2014	Please see the comments above. Where the sites are genuinely up and down gradient of the alignment this method has been adopted.	13/06/2014
			Section 8.2 Table 5, pg 43	Temperature is irrelevant. The works will not affect temperature.	24/04/2014	Agreed. Temperature will be taken as a part of standard sampling protocol with insitu readings.	13/06/2014
			Section 8.2 Table 5, pg 43	Drop all the dry episodes to save money. 99% of the risk is during wet weather.	24/04/2014	This has been undertaken.	13/06/2014
			Section 8.2 Table 5, pg 43	Highly unlikely that there will be any impact upon Electrical Conductivity.	24/04/2014	Acknowledged. This will be dealt with in the CEMP and is not discussed further in this document.	13/06/2014

Organisation	Date submitted to stakeholder	Contact					
			Section 9.2.2 (Analysis of construction phase data), pg 48	Don't agree that should data fall outside the 95% confidence interval a significant change is likely to have occurred upstream. The pre commencement monitoring is limited in terms of frequency and duration so it is reasonable to expect that extreme values will not be detected.	24/04/2014	Acknowledged. The text is confusing and the methods proposed are potentially inappropriate. The text has been revised to make this section more relevant and clearer. It now focuses on a subjective assessment for the impacts of upgradient changes in the wider catchment on the comparison between up and down gradient sites using control charts.	13/06/2014
			Section 12.1, pg 58	"Risks during the operational phase of the project relate primarily to spills from road accidents" But arguably these risks are less than under the current situation. The new road will be safer.	24/04/2014	Acknowledged. Text has been added to sections 3 and 12 to make this point clearer.	13/06/2014
NSW office Water	14/04/2014, Rev 2 submitted 23/04/14	Bob Britten		The report has been provided and no comments have been provided.		Bob Britten has been communicated with on a number of occasions via telephone. We understand that NOW is focused on groundwater issues associated with the Project. Bob has provided feedback on the groundwater modelling and GWMP documents which is included within the GWMP report.	13/06/2014
OEH	Not submitted.	James Dawson		The report has not been provided to OEH.		An informal face to face meeting was held with James Dawson on the 3 April 2014. During that meeting James stated that he was currently dealing with Toby Lambert from Parsons Brinkerhoff who were developing the monitoring plan for instream ecology. He noted that this was more relevant to biodiversity and threatened species. As such, it was considered that the surface water monitoring plan was of lower importance. James noted that Peter Marczan and Tim Pritchard of the OEH Water and Coastal team may have some interest in the project. At this time contact has not been made with Tim or Peter.	13/06/2014

Organisation	Date submitted to stakeholder	Contact					
		Peter Marczan		The report has not been provided to OEH.	19/06/2014	Email received from Peter Marczan detailing that he is currently in a different position and forwarded the email to Penny Vella of OEH who is currently acting team leader for Water Quality.	30/06/2014
		Penny Villa		The report has not been provided to OEH.	20/06/2014	Email received from Penny Villa of OEH stating the "she can confirm that OEH does not need to review the surface water and groundwater monitoring plan document, or the sampling protocol." She acknowledged that the EPA are already engaged on this issue.	30/06/2014
EPA	14/04/2014	Julian Thompson	Table 9, pg 53-54	Details the roles and responsibilities for management in the operational phase of the Foxground Berry Bypass. The NSW EPA is listed in this table as having part responsibility for the review of the Annual Progress Reports and Incident Reports, and to provide feedback as necessary. It should be noted that while the project will be licensed by the EPA during the construction phase, the Environment Protection Licence will not be required during the operational phase of the project. The EPA will therefore not have a formal management role post-construction, except for its general Appropriate Regulatory Authority Role for RMS under section 6 of the Protection of the Environment Operations Act 1997.	20/05/2014	The reference to EPL for operational phases of the project has been removed from the document text.	13/06/2014

14. References

- AECOM (2012); *Foxground and Berry Bypass, Princes highway Upgrade, Environmental Assessment*.
- Aurecon (2010a) *Surface Water Monitoring Program Rev 4 – Tintenbar to Ewingsdale Road Upgrade*, prepared for the Roads and Traffic Authority, 2010
- Aurecon (2010b) *Groundwater Monitoring Program Rev 4– Tintenbar to Ewingsdale Road Upgrade*, prepared for the Roads and Traffic Authority, 2010
- Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (2000); *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, Australian Water Association, Artarmon, NSW.
- ANZECC (Australia and New Zealand Environment and Conservation Council) and ARMCANZ (Agriculture and Resource Management Council of Australia and New Zealand) (2000a). *Australian Guidelines for Water Quality Monitoring and Reporting*. National Water Quality Management Strategy Paper No. 7, ANZECC and ARMCANZ, Canberra.
- Cardno (2011) *Pacific Highway Upgrade - Tintenbar to Ewingsdale Surface Water and Groundwater Sampling Protocol*.
- Cardno Ecology Lab (2012); *Foxground and Berry Bypass Princes highway Upgrade, Volume 2 – Appendix G, Technical Paper: Aquatic Ecology and Water Quality Management*.
- DECCW (2008); *Managing Urban Stormwater – Soils and Construction, Volume 2D – Main Road Construction (known as the Blue Book)*.
- GHD (2014a); *Roads and Maritime Services, Foxground to Berry Bypass Water Quality Management, Surface Water and Groundwater Sampling Protocol*.
- GHD (2014b); *Roads and Maritime Services, Foxground to Berry Bypass Water Quality Management, Groundwater Quality Management Plan*.
- Helsel, D.R. and Hirsch, R.M. (2002) *Statistical Methods in Water Resources: Techniques of Water Resources Investigations of the United States Geological Survey*, Book 4, Chapter A3, USGS.
- National Health and Medical Research Council (NHMRC) and Natural Resource Management Ministerial Council (NRMMC), 2011; *Australian Drinking Water Guidelines 6, 2011*; Australian Government.
- NSW Department of Planning and Infrastructure (DPI), (2013); *Project Approval Section 75J of the Environmental Planning and Assessment Act 1979*.
- NSW EPA, (1997): *Managing Urban Stormwater: Council Handbook*.
- EPA (2004); *Approved Methods for the Sampling and Analysis of Water Pollutants in New South Wales*, published by the NSW Department of Environment, Climate Change and Water (formerly DEC), March 2004.
- Roads Transport Authority (2006); *Guidelines for Construction Water. Quality Monitoring*
- Roads and Maritime Services (RMS) (2013): *Foxground and Berry Bypass, Princes Highway Upgrade, Submissions Report*.

Roads and Maritime Services (RMS) (2013): *Foxground and Berry bypass Attachment A Project Brief – Preparation and implementation of Water Quality Monitoring Program and Groundwater Modelling.*

Roads and Maritime Services (RMS) (2014): *Construction and Environmental Management Plan, Toolijooa Road Fill Works Stage of Foxground and Berry Bypass.*

Roads and Traffic Authority (1999), *RTA's Water Policy*, <http://www.rta.nsw.gov.au>, accessed August 2010

Appendices

Appendix A – Stakeholder Comments

Stefan Charteris

From: trevor.daly@dpi.nsw.gov.au
Sent: Tuesday, 4 March 2014 12:22 PM
To: Stefan Charteris
Subject: Re: Berry to foxground bypass project - Water quality monitoring program
Attachments: Attachment A FBB_WQM_Brief 1729.pdf

CompleteRepository: 2123174
Description: Berry to Foxground Water Quality Monitoring
JobNo: 23174
OperatingCentre: 21
RepoEmail: 2123174@ghd.com
RepoType: Job

Hi Stefan

Fisheries NSW has reviewed the brief from RMS and these are our initial comments.

Overall its fine but we think it could be better focussed to address the key risk – which is sediment coming from the site during rainfall events during the construction phase.

Our preference would be for more wet weather sampling at the expense of dry weather sampling. We would especially like to see some sampling during large rainfall events (eg >25mm/day when controls are most likely to be exceeded) in addition to the >10mm/day events currently proposed. Dry weather sampling is not very useful and can be minimised or largely be dispensed with (as low risk).

Similarly, the main focus, especially during the construction phase should be TSS or turbidity. EC, temperature, pH, DO and heavy metals could be sampled less as I doubt they will show much response. Sampling of TN and TP could be minimised as well as they are likely to be closely correlated with TSS anyway. Minimising the low risk items could allow more funding to be used for more wet weather sampling (eg after hours and weekends).

We would also like more emphasis put on the need to have paired sampling sites – ie 1 in the waterway upstream of construction activities and a 2nd in the waterway downstream of construction activities.

Pls send the draft WQMP to us for review when ready.

Thanks

Trevor

Dr Trevor Daly | Fisheries Conservation Manager – South Coast | Aquatic Habitat Protection
Fisheries NSW - Department of Primary Industries | PO Box 17 | Batemans Bay NSW 2536
T: 02 4478 9103 | F: 02 4472 7542 | M: 0408 487 083 | E: trevor.daly@dpi.nsw.gov.au
W: www.dpi.nsw.gov.au

Achieving results on the NSW south coast for over 10 years

From: Stefan Charteris <Stefan.Charteris@ghd.com>
To: "trevor.daly@dpi.nsw.gov.au" <trevor.daly@dpi.nsw.gov.au>
Date: 28/02/2014 03:09 PM
Subject: Berry to foxground bypass project - Water quality monitoring program

Trevor,

Thanks for talking with me today.

I have attached the project brief that was prepared by RMS for this project.

The director general's requirements for this project require us to engage with DPI fisheries with regard to development of a water quality monitoring program to monitor for impacts to surface water and groundwater quality.

Basically we are planning to forward a draft water quality monitoring plan to you towards the middle of March for your comment.

If you have any queries and/or would like to know more please get back to me at your earliest convenience. I am keen to get NOW input as early as possible to minimise the potential for changes to the documents we produce for your review.

If you would like I can be available to discuss sampling locations and rationale behind these.

Regards,

Stefan Charteris
Principal Hydrogeologist

GHD

T: 61 2 9239 7472 | F: 61 2 9239 7199 | V: 217472 | M: 61 451 576 222 | E: Stefan.Charteris@ghd.com
Level 15 133 Castlereagh St Sydney NSW 2000 Australia | <http://www.ghd.com/>
[Water](#) | [Energy & Resources](#) | [Environment](#) | [Property & Buildings](#) | [Transportation](#)

Please consider the environment before printing this email

This email and all attachments are confidential. For further important information about emails sent to or from GHD or if you have received this email in error, please refer to <http://www.ghd.com/emaildisclaimer.html>

This e-mail has been scanned for viruses

This message is intended for the addressee named and may contain confidential information.
If you are not the intended recipient, please delete it and notify the sender.
Views expressed in this message are those of the individual sender, and are not necessarily the views of their organisation.

This e-mail has been scanned for viruses

Stefan Charteris

From: Jacqui Hallchurch
Sent: Wednesday, 23 April 2014 3:44 PM
To: trevor.daly@dpi.nsw.gov.au
Subject: Berry to Foxgroud n Bypass groundwater and Surfacewater Sampling Protocol
Attachments: 196781_rev2_22_04_2014.pdf

CompleteRepository: 2123174
Description: Berry to Foxground Water Qaulity Monitoring
JobNo: 23174
OperatingCentre: 21
RepoEmail: 2123174@ghd.com
RepoType: Job

Good afternoon Trevor,

Please see attached the groundwater and surface water sampling protocol for the berry to foxground bypass for your comment.

Kind Regards,
Jacqui

Jacqui Hallchurch
Senior Environmental Scientist
Service Group Manager – Contamination Assessment and Remediation

GHD

T: 61 2 9239 7046 | F: 61 2 9239 7199 | V: 217046 | M: 61 447 202 580 | E: jacqui.hallchurch@ghd.com
Level 15, 133 Castlereagh Street Sydney, 2000 Australia | <http://www.ghd.com/>

[Water](#) | [Energy & Resources](#) | [Environment](#) | [Property & Buildings](#) | [Transportation](#)

Please consider the environment before printing this email

Stefan Charteris

From: trevor.daly@dpi.nsw.gov.au
Sent: Thursday, 24 April 2014 12:21 PM
To: Jacqui Hallchurch
Cc: Nicole Rosen; Stefan Charteris
Subject: Re: Foxground to Berry Bypass - Surface water Quality Plan
Attachments: Foxground Berry Bypass Water Quality Monitoring plan Luggs comments.pdf

CompleteRepository: 2123174
Description: Berry to Foxground Water Quality Monitoring
JobNo: 23174
OperatingCentre: 21
RepoEmail: 2123174@ghd.com
RepoType: Job

Hi Jacqui

Myself and Allan Lugg have reviewed. See detailed comments in attached.

Overall we think the monitoring could be made simpler and focus more on the main risk to WQ from the roadworks which is sediment during rainfall events. The sampling sites need to be closely paired (upstream of works and downstream of works) so that any discrepancies can be confidently attributed to the road building project. There are also quite a few minor creeks not shown on the map which should have paired sites on them.

Generally we would like more sampling of rainfall events and no or much less dry weather sampling as this is unlikely to show anything useful relating to the road project.

Thanks

Trevor

Dr Trevor Daly | Aquatic Ecosystems – South Coast
Fisheries NSW - Department of Primary Industries | PO Box 17 | Batemans Bay NSW 2536
T: 02 4478 9103 | F: 02 4472 7542 | M: 0408 487 083 | E: trevor.daly@dpi.nsw.gov.au
W: www.dpi.nsw.gov.au

Achieving results on the NSW south coast for over 10 years

From: Jacqui Hallchurch <Jacqui.Hallchurch@ghd.com>
To: "trevor.daly@dpi.nsw.gov.au" <trevor.daly@dpi.nsw.gov.au>
Cc: Stefan Charteris <Stefan.Charteris@ghd.com>, Nicole Rosen <Nicole.Rosen@ghd.com>
Date: 14/04/2014 01:38 PM
Subject: Foxground to Berry Bypass - Surface water Quality Plan

Good afternoon Trevor

GHD was engaged by RMS to undertake water quality monitoring associated with the Foxground to Berry Bypass upgrade of the Princes Highway. Please find attached the draft surface water quality plan document for your comment.

Stefan Charteris, Principal Hydrogeologist and GHD's Project Manager for these works, is currently on annual leave but if you have any questions or comments please do not hesitate to contact me.

Kind Regards,

Jacqui Hallchurch
Senior Environmental Scientist
Service Group Manager – Contamination Assessment and Remediation

GHD

T: 61 2 9239 7046 | F: 61 2 9239 7199 | V: 217046 | M: 61 447 202 580 | E: jacqui.hallchurch@ghd.com
Level 15, 133 Castlereagh Street Sydney, 2000 Australia | <http://www.ghd.com/>
[Water](#) | [Energy & Resources](#) | [Environment](#) | [Property & Buildings](#) | [Transportation](#)

Please consider the environment before printing this email

This email and all attachments are confidential. For further important information about emails sent to or from GHD or if you have received this email in error, please refer to <http://www.ghd.com/emaildisclaimer.html>

This e-mail has been scanned for viruses

This message is intended for the addressee named and may contain confidential information.
If you are not the intended recipient, please delete it and notify the sender.
Views expressed in this message are those of the individual sender, and are not necessarily the views of their organisation.

This e-mail has been scanned for viruses

Stefan Charteris

From: Stefan Charteris
Sent: Wednesday, 5 February 2014 3:20 PM
To: michael.heinz@epa.nsw.gov.au
Subject: Stakeholder engagement for the Berry to Foxground Bypass Princess Highway Upgrade for Roads and Maritime Services.
Attachments: Attachment A FBB_WQM_Brief 1729.pdf

CompleteRepository: 2123174
Description: Berry to Foxground Water Quality Monitoring
JobNo: 23174
OperatingCentre: 21
RepoEmail: 2123174@ghd.com
RepoType: Job

Michael,

Thanks for talking with me today.

I have attached the project brief that was prepared by RMS for this project.

The director general's requirements for this project require us to engage with EPA with regard to the following:

1. Groundwater modelling works to assess the construction and operational impacts of the concept design on the groundwater resources, groundwater quality, groundwater hydrology and GDE's and provide details of contingency and management measures that should be adopted to manage impacts. We have committed to
2. Development of a water quality monitoring program to monitor for impacts to surface water and groundwater quality.

Basically we are planning to forward draft water quality monitoring plan to you towards the end of February for your comment.

If you have any queries and/or would like to know more please get back to me at your earliest convenience. I am very keen to keep you as informed as you would like to be on this project.

Regards,

Stefan Charteris
Principal Hydrogeologist

GHD

T: 61 2 9239 7472 | F: 61 2 9239 7199 | V: 217472 | M: 61 451 576 222 | E: Stefan.Charteris@ghd.com
Level 15 133 Castlereagh St Sydney NSW 2000 Australia | <http://www.ghd.com/>
[Water](#) | [Energy & Resources](#) | [Environment](#) | [Property & Buildings](#) | [Transportation](#)

Please consider the environment before printing this email

Stefan Charteris

From: Jacqui Hallchurch
Sent: Wednesday, 23 April 2014 3:43 PM
To: julian.thompson@epa.nsw.gov.au
Subject: Berry to Foxground Bypass Groundwater and Surface Water Sampling Protocol
Attachments: 196781_rev2_22_04_2014.pdf

CompleteRepository: 2123174
Description: Berry to Foxground Water Quality Monitoring
JobNo: 23174
OperatingCentre: 21
RepoEmail: 2123174@ghd.com
RepoType: Job

Good afternoon Julian,

Please see attached the groundwater and surface water sampling protocol for the berry to foxground bypass for your comment.

Kind Regards,
Jacqui

Jacqui Hallchurch
Senior Environmental Scientist
Service Group Manager – Contamination Assessment and Remediation

GHD

T: 61 2 9239 7046 | F: 61 2 9239 7199 | V: 217046 | M: 61 447 202 580 | E: jacqui.hallchurch@ghd.com
Level 15, 133 Castlereagh Street Sydney, 2000 Australia | <http://www.ghd.com/>

[Water](#) | [Energy & Resources](#) | [Environment](#) | [Property & Buildings](#) | [Transportation](#)

Please consider the environment before printing this email

Stefan Charteris

From: Julian Thompson <Julian.Thompson@epa.nsw.gov.au>
Sent: Wednesday, 23 April 2014 3:43 PM
To: Jacqui Hallchurch
Cc: Stefan Charteris; Nicole Rosen; Michael Heinze
Subject: RE: Foxground to Berry Bypass - Surface Water Quality Plan

CompleteRepository: 2123174
Description: Berry to Foxground Water Quality Monitoring
JobNo: 23174
OperatingCentre: 21
RepoEmail: 2123174@ghd.com
RepoType: Job

Jacqui,
Michael Heinze from EPA is reviewing this. He is currently on leave until 5 May and will be in contact shortly thereafter.
Regards

JulianThompson

UnitHead-SouthEastRegion | [NSWEnvironmentProtectionAuthority](#)
✆: (02) 6229 7002 | ☎: (02) 6229 7006 | ✉: julian.thompson@epansw.gov.au

From: Jacqui Hallchurch [<mailto:Jacqui.Hallchurch@ghd.com>]
Sent: Monday, 14 April 2014 1:24 PM
To: Thompson Julian
Cc: Stefan Charteris; Nicole Rosen
Subject: Foxground to Berry Bypass - Surface Water Quality Plan

Good afternoon Julian,

GHD was engaged by RMS to undertake water quality monitoring associated with the Foxground to Berry Bypass upgrade of the Princes Highway. Please find attached the draft surface water quality plan document for your comment.
Stefan Charteris, Principal Hydrogeologist and GHD's Project Manager for these works, is currently on annual leave but if you have any questions or comments please do not hesitate to contact me.

Kind Regards,

Jacqui Hallchurch
Senior Environmental Scientist
Service Group Manager – Contamination Assessment and Remediation

GHD

T: 61 2 9239 7046 | F: 61 2 9239 7199 | V: 217046 | M: 61 447 202 580 | E: jacqui.hallchurch@ghd.com
Level 15, 133 Castlereagh Street Sydney, 2000 Australia | <http://www.ghd.com/>

[Water](#) | [Energy & Resources](#) | [Environment](#) | [Property & Buildings](#) | [Transportation](#)

Please consider the environment before printing this email

This email and all attachments are confidential. For further important information about emails sent to or from GHD or if you have received this email in error, please refer to

<http://www.ghd.com/emaildisclaimer.html>

This e-mail has been scanned for viruses

This email is intended for the addressee(s) named and may contain confidential and/or privileged information.

If you are not the intended recipient, please notify the sender and then delete it immediately.
Any views expressed in this email are those of the individual sender except where the sender expressly and with authority states them to be the views of the Environment Protection Authority.

PLEASE CONSIDER THE ENVIRONMENT BEFORE PRINTING THIS EMAIL

This e-mail has been scanned for viruses

Stefan Charteris

From: Stefan Charteris
Sent: Friday, 28 February 2014 3:12 PM
To: David Zerafa
Subject: RE: Foxground to berry bypass - water quality monitoring program.

CompleteRepository: 2123174
Description: Berry to Foxground Water Quality Monitoring
JobNo: 23174
OperatingCentre: 21
RepoEmail: 2123174@ghd.com
RepoType: Job

Thanks David

From: David Zerafa [<mailto:David.Zerafa@water.nsw.gov.au>]
Sent: Friday, 28 February 2014 2:37 PM
To: Stefan Charteris
Subject: Re: Foxground to berry bypass - water quality monitoring program.

Hi Stefan,

Just a note to let you know that I have received your email and will get back to you in due course.

Regards David

David Zerafa
Senior Water Regulation Officer
NSW Office of Water

NSW Government Offices, 5 O'Keefe St, PO Box 309 Nowra 2541
T: (02) 4429 4441 **M:** 0427 663187 **F:** (02) 4429 4458
E: david.zerafa@water.nsw.gov.au
W: www.water.nsw.gov.au

>>> Stefan Charteris <Stefan.Charteris@ghd.com> 28/02/2014 2:29 pm >>>
David,

Thanks for talking with me today.

I have attached the project brief that was prepared by RMS for this project.

The director general's requirements for this project require us to engage with NOW with regard to the following:

1. Groundwater modelling works to assess the construction and operational impacts of the concept design on the groundwater resources, groundwater quality, groundwater hydrology and GDE's and provide details of contingency and management measures that should be adopted to manage impacts. We have committed to
2. Development of a water quality monitoring program to monitor for impacts to surface water and groundwater quality.

Basically we are planning to forward a draft water quality monitoring plan to you towards the middle of March for your comment.

If you have any queries and/or would like to know more please get back to me at your earliest convenience. I am keen to get NOW input as early as possible to minimise the potential for changes to the documents we produce for your review.

If you would like I can be available to discuss sampling locations and rationale behind these.

Regards,

Stefan Charteris
Principal Hydrogeologist

GHD

T: 61 2 9239 7472 | F: 61 2 9239 7199 | V: 217472 | M: 61 451 576 222 | E: Stefan.Charteris@ghd.com
Level 15 133 Castlereagh St Sydney NSW 2000 Australia | <http://www.ghd.com/>
[Water](#) | [Energy & Resources](#) | [Environment](#) | [Property & Buildings](#) | [Transportation](#)

Please consider the environment before printing this email

This email and all attachments are confidential. For further important information about emails sent to or from GHD or if you have received this email in error, please refer to <http://www.ghd.com/emaildisclaimer.html>

This e-mail has been scanned for viruses

This e-mail has been scanned for viruses

Stefan Charteris

From: Jacqui Hallchurch
Sent: Wednesday, 23 April 2014 3:43 PM
To: bob.britten@water.nsw.gov.au
Subject: Berry to Foxground Sampling Protocol
Attachments: 196781_rev2_22_04_2014.pdf

CompleteRepository: 2123174
Description: Berry to Foxground Water Quality Monitoring
JobNo: 23174
OperatingCentre: 21
RepoEmail: 2123174@ghd.com
RepoType: Job

Good afternoon Bob,

Please see attached the groundwater and surface water sampling protocol for the berry to foxground bypass for your comment.

Kind Regards,
Jacqui

Jacqui Hallchurch
Senior Environmental Scientist
Service Group Manager – Contamination Assessment and Remediation

GHD

T: 61 2 9239 7046 | F: 61 2 9239 7199 | V: 217046 | M: 61 447 202 580 | E: jacqui.hallchurch@ghd.com
Level 15, 133 Castlereagh Street Sydney, 2000 Australia | <http://www.ghd.com/>

[Water](#) | [Energy & Resources](#) | [Environment](#) | [Property & Buildings](#) | [Transportation](#)

Please consider the environment before printing this email

Stefan Charteris

From: Jacqui Hallchurch
Sent: Monday, 14 April 2014 1:23 PM
To: bob.britten@water.nsw.gov.au
Cc: Stefan Charteris; Nicole Rosen
Subject: Foxground to Berry Bypass - Surface Water Quality Plan
Attachments: 196933 - SWMP-5 09042014.pdf

CompleteRepository: 2123174
Description: Berry to Foxground Water Quality Monitoring
JobNo: 23174
OperatingCentre: 21
RepoEmail: 2123174@ghd.com
RepoType: Job

Good afternoon Bob,

GHD was engaged by RMS to undertake water quality monitoring associated with the Foxground to Berry Bypass upgrade of the Princes Highway. Please find attached the draft surface water quality plan document for your comment.

Stefan Charteris, Principal Hydrogeologist and GHD's Project Manager for these works, is currently on annual leave but if you have any questions or comments please do not hesitate to contact me.

Kind Regards,

Jacqui Hallchurch
Senior Environmental Scientist
Service Group Manager – Contamination Assessment and Remediation

GHD

T: 61 2 9239 7046 | F: 61 2 9239 7199 | V: 217046 | M: 61 447 202 580 | E: jacqui.hallchurch@ghd.com
Level 15, 133 Castlereagh Street Sydney, 2000 Australia | <http://www.ghd.com/>

[Water](#) | [Energy & Resources](#) | [Environment](#) | [Property & Buildings](#) | [Transportation](#)

Please consider the environment before printing this email



Our reference: DOC14/56571-01
Contact: Julian Thompson 02 6229 7002

Ms Jacqui Hallchurch
Senior Environmental Scientist
Service Group Manager – Contamination Assessment and Remediation
GHD Pty Ltd
Level 15, 133 Castlereagh Street
SYDNEY NSW 2000

20 May 2014

Dear Ms Hallchurch,

Re: Draft Berry to Foxground Water Quality Management – Surface Water and Groundwater Sampling Protocol

Thank you for your email of 23 April 2014 inviting the Environment Protection Authority (EPA) to comment on GHD's draft *Surface Water and Groundwater Sampling Protocol* and *Surface Water Monitoring Plan* (the plans) for the Berry to Foxground bypass, prepared for Roads and Maritime Services (RMS) as required under the Project Approval.

As you are aware, RMS is proposing to upgrade 11.6 km of the Princess Highway between Toolijooa Road north of Foxground and Schofield's Lane south of Berry on the NSW South Coast. As part of the project approval conditions (CoA B15 and CoA B16), RMS is required to prepare and implement a Water Quality Monitoring Program and undertake groundwater modelling on the concept design in consultation with the Office of Environment and Heritage (OEH), EPA, Department of Primary Industries (DPI) (Fishing and Aquaculture) and NSW Office of Water (NOW).

The primary objectives of these plans are to detail the water quality sampling protocols and management measures in order to effectively meet the overall project objectives, which are:

- Assess the potential impact of the project on the water quality to protect aquatic ecology and ecosystems in all the adjacent catchments and water courses; and
- Assess the potential impact of the program on groundwater hydrology in order to protect licensed bores, dams, watercourses, water bodies and groundwater dependent ecosystems in adjacent catchments.

These steps will help to ensure that appropriate mitigation and management measures are implemented in order to prevent soil erosion and the discharge of sediments and pollutants from the project during construction and operational phases to be compliant with Section 120 of the *Protection of the Environment Operations Act 1997* and the Environment Protection Licence (EPL) for the project.

The EPA encourages the development of such plans to ensure that proponents have determined how they will meet their statutory obligations and environmental objectives as specified by any project/development approvals and/or the conditions of the operator's EPL. However, it is not the role of the EPA to approve or endorse such management plans. The EPA's role is to set conditions for environmental protection and management through an environment protection licence and regulate compliance with those conditions.

Notwithstanding this, the EPA has conducted a brief review of the draft Surface Water and Groundwater Sampling Protocol prepared by GHD Pty Ltd for Roads and Maritime Services.

The plans appear adequate and the EPA has only one comment to make at this stage. Table 9 (pages 53-54) details the roles and responsibilities for management in the *operational* phase of the Foxground Berry Bypass. The NSW EPA is listed in this table as having part responsibility for the review of the Annual Progress Reports and Incident Reports, and to provide feedback as necessary. It should be noted that while the project will be licensed by the EPA during the *construction* phase, the Environment Protection Licence will not be required during the operational phase of the project. The EPA will therefore not have a formal management role post-construction, except for its general Appropriate Regulatory Authority Role for RMS under section 6 of the *Protection of the Environment Operations Act 1997*.

As a management tool, such plans should assist RMS in meeting their commitment to statutory compliance and wider environmental management and, where appropriate, should be integrated with other operational or management plans. The EPA recommends that these plans be audited to an industry standard or certified to the ISO 14001 standard (if applicable) as part of any overall environmental management system. The collection of quality assurance and control samples during sampling is an important measure in order to ensure the integrity of the datasets. Additionally, the EPA endorses the use of a nominated NATA accredited laboratory to analyse water quality parameters and contaminants of potential concern.

The EPA reminds RMS that the person or organisation that will manage the construction phase of the project is required to apply for an Environment Protection Licence under the *Protection of the Environment Operations Act 1997* (POEO Act) prior to the commencement of any scheduled development work for the Berry to Foxground Bypass. This is different and separate from holding a development consent issued by a planning authority such as the Department of Planning or your local council.

I trust this information is of assistance. Should you have any queries or wish to discuss the EPA's response, please contact me on Ph: 6229 7002.

Yours sincerely,



JULIAN THOMPSON
Unit Head – South East Region
NSW Environment Protection Authority

Nicole Rosen

From: Stefan Charteris
Sent: Monday, 30 June 2014 9:34 AM
To: Nicole Rosen
Subject: FW: Berry to Foxground Bypass Princes Highway Upgrade

CompleteRepository: 2123174
Description: Berry to Foxground Water Quality Monitoring
JobNo: 23174
OperatingCentre: 21
RepoEmail: 2123174@ghd.com
RepoType: Job

From: Peter Marczan [mailto:Peter.Marczan@epa.nsw.gov.au]
Sent: Thursday, 19 June 2014 5:06 PM
To: Stefan Charteris
Cc: Graham.Roche@rms.nsw.gov.au
Subject: RE: Berry to Foxground Bypass Princes Highway Upgrade

Stefan, apologies for this, I have just spoken to Graham. I received your message a week or so ago and while on leave but had actioned it. I am currently in a different position and am not the contact for an issue like this. I have forwarded your email to Penny Vella in OEH who is currently acting Team Leader Water Quality and will speak to her in the morning. While I cannot provide firm advice, it is unlikely that OEH will have an interest in this other than any work it has done to provide advice to the EPA. I will ask Penny to confirm a position as soon as possible.

Peter

Peter Marczan

A/Manager Noise Policy | **NSW Environment Protection Authority** |
☎: (02) 9995 6059 | Mobile ☎: 0429 944 451 | ☎: (02) 9995 5935 | ✉: peter.marczan@environment.nsw.gov.au

From: Stefan Charteris [mailto:Stefan.Charteris@ghd.com]
Sent: Thursday, 19 June 2014 4:46 PM
To: Pritchard Tim; Marczan Peter; james.dawson@environment.gov.au
Cc: Graham.Roche@rms.nsw.gov.au; saman.liyanaarachchi@rms.nsw.gov.au; ZHIVANOVICH Steve (Steve.ZHIVANOVICH@rms.nsw.gov.au)
Subject: Berry to Foxground Bypass Princes Highway Upgrade

Tim, Peter, James,

As part of developing the groundwater and surface water monitoring network for Roads and Maritime Services (RMS) for the Foxground to Berry Bypass Princes Highway Upgrade we are obliged (as part of the conditions of approval) to consult with OEH.

I spoke on an informal basis with James on 3 April 2014 re-the project and he mentioned that he was having input with the project from a biodiversity and threatened species perspective with the ecological monitoring plan being developed by Toby Lambert from Parsons Brinkerhoff. As such he was of the opinion that our work was not of major significance in regards to biodiversity and threatened species for OEH. James noted however, that both Tim and Peter may have an interest in the project outcomes.

I would like to obtain written feedback from you on whether you are satisfied with the existing level of OEH contact with the project (i.e. with the contact that James has had with the project) or subsequently whether you would like to obtain the surface water and groundwater monitoring plan documents and the sampling protocol document for comment.

For the purposes of understanding the level of consultation that has been undertaken to date, the documents have been provided to the EPA, NOW and DPI from which we've had varying degrees of response. The EPA and DPI have been detailed in their response, while NOW, after a number of teleconferences, have preferred to take an overarching position based on the degree of risk posed to groundwater dependent systems/resources.

If you could get back to me as soon as possible with a preferred position/approach of OEH for consultation on this project that would be much appreciated.

Regards,

Stefan Charteris
Principal Hydrogeologist

GHD

T: 61 2 9239 7472 | F: 61 2 9239 7199 | V: 217472 | M: 61 451 576 222 | E: Stefan.Charteris@ghd.com
Level 15 133 Castlereagh St Sydney NSW 2000 Australia | <http://www.ghd.com/>
[Water](#) | [Energy & Resources](#) | [Environment](#) | [Property & Buildings](#) | [Transportation](#)

Please consider the environment before printing this email

This email and all attachments are confidential. For further important information about emails sent to or from GHD or if you have received this email in error, please refer to <http://www.ghd.com/emaildisclaimer.html>

This e-mail has been scanned for viruses

This email is intended for the addressee(s) named and may contain confidential and/or privileged information.

If you are not the intended recipient, please notify the sender and then delete it immediately. Any views expressed in this email are those of the individual sender except where the sender expressly and with authority states them to be the views of the Environment Protection Authority.

PLEASE CONSIDER THE ENVIRONMENT BEFORE PRINTING THIS EMAIL

This e-mail has been scanned for viruses

Nicole Rosen

From: Stefan Charteris
Sent: Monday, 30 June 2014 9:34 AM
To: Nicole Rosen
Subject: FW: Berry to Foxground Bypass Princes Highway Upgrade

CompleteRepository: 2123174
Description: Berry to Foxground Water Quality Monitoring
JobNo: 23174
OperatingCentre: 21
RepoEmail: 2123174@ghd.com
RepoType: Job

From: Penny Vella [mailto:Penny.Vella@environment.nsw.gov.au]
Sent: Friday, 20 June 2014 4:34 PM
To: Stefan Charteris; Graham.Roche@rms.nsw.gov.au
Cc: Michael Heinze; Anthony Pik; James Dawson; Kylie McClelland; Tim Pritchard; Marlene Van Der Sterren; Peter Marczan
Subject: FW: Berry to Foxground Bypass Princes Highway Upgrade

Dear Stefan and Graham,

I can confirm that OEH does not need to review the surface water and groundwater monitoring plan documents, or the sampling protocol. As you point out, the EPA is engaging on this issue.

Please continue to keep in touch with OEH regarding the ecological monitoring work.

Kind regards,

Penny Vella
Acting Team Leader - Water Quality
(Working Tuesday - Friday)
Regional Operations Group
Office of Environment and Heritage
PO Box A290 Sydney South, NSW 1232
T: 02 9995 6058
W: www.environment.nsw.gov.au

From: Stefan Charteris [mailto:Stefan.Charteris@ghd.com]
Sent: Thursday, 19 June 2014 4:46 PM
To: Pritchard Tim; Marczan Peter; james.dawson@environment.gov.au
Cc: Graham.Roche@rms.nsw.gov.au; saman.liyanaarachchi@rms.nsw.gov.au; ZHIVANOVICH Steve (Steve.ZHIVANOVICH@rms.nsw.gov.au)
Subject: Berry to Foxground Bypass Princes Highway Upgrade

Tim, Peter, James,

As part of developing the groundwater and surface water monitoring network for Roads and Maritime Services (RMS) for the Foxground to Berry Bypass Princes Highway Upgrade we are obliged (as part of the conditions of approval) to consult with OEH.

I spoke on an informal basis with James on 3 April 2014 re-the project and he mentioned that he was having input with the project from a biodiversity and threatened species perspective with the ecological monitoring plan being developed by Toby Lambert from Parsons Brinkerhoff. As such he was of the opinion that our work was not of major significance in regards to biodiversity and

threatened species for OEH. James noted however, that both Tim and Peter may have an interest in the project outcomes.

I would like to obtain written feedback from you on whether you are satisfied with the existing level of OEH contact with the project (i.e. with the contact that James has had with the project) or subsequently whether you would like to obtain the surface water and groundwater monitoring plan documents and the sampling protocol document for comment.

For the purposes of understanding the level of consultation that has been undertaken to date, the documents have been provided to the EPA, NOW and DPI from which we've had varying degrees of response. The EPA and DPI have been detailed in their response, while NOW, after a number of teleconferences, have preferred to take an overarching position based on the degree of risk posed to groundwater dependent systems/resources.

If you could get back to me as soon as possible with a preferred position/approach of OEH for consultation on this project that would be much appreciated.

Regards,

Stefan Charteris
Principal Hydrogeologist

GHD

T: 61 2 9239 7472 | F: 61 2 9239 7199 | V: 217472 | M: 61 451 576 222 | E: Stefan.Charteris@ghd.com
Level 15 133 Castlereagh St Sydney NSW 2000 Australia | <http://www.ghd.com/>
[Water](#) | [Energy & Resources](#) | [Environment](#) | [Property & Buildings](#) | [Transportation](#)

Please consider the environment before printing this email

This email and all attachments are confidential. For further important information about emails sent to or from GHD or if you have received this email in error, please refer to <http://www.ghd.com/emaildisclaimer.html>

This e-mail has been scanned for viruses

This email is intended for the addressee(s) named and may contain confidential and/or privileged information.

If you are not the intended recipient, please notify the sender and then delete it immediately.

Any views expressed in this email are those of the individual sender except where the sender expressly and with authority states them to be the views of the NSW Office of Environment and Heritage.

PLEASE CONSIDER THE ENVIRONMENT BEFORE PRINTING THIS EMAIL

This e-mail has been scanned for viruses

Appendix B – Environmental Protection Licence

Currently blank pending issue of EPL

GHD

133 Castlereagh St Sydney NSW 2000

-

T: +61 2 9239 7100 F: +61 2 9239 7199 E: sydmail@ghd.com.au

© GHD 2014

This document is and shall remain the property of GHD. The document may only be used for the purpose for which it was commissioned and in accordance with the Terms of Engagement for the commission. Unauthorised use of this document in any form whatsoever is prohibited.

n:\au\sydney\projects\21\23174\WP\196933.docx

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
Draft	S Charteris	J Hallchurch		J Hallchurch		9/4/2014
1	N. Rosen	S. Charteris		J Hallchurch		30/06/2014

www.ghd.com





Roads and Maritime Services

Princes Highway Upgrade - Foxground to Berry Bypass Project

Water Quality Monitoring Groundwater Monitoring Plan

July 2014

Table of contents

1.	Introduction	1
1.1	Background	1
1.2	Project Overview	1
2.	Regulatory context	5
2.1	Environmental assessment	5
2.2	Conditions of Approval	6
2.3	Statement of commitments	8
3.	Regional setting and layout	13
3.1	Climate	13
3.2	Groundwater Recharge	15
3.3	Topography and drainage	15
3.4	Geology	19
3.5	Hydrogeological Conditions	22
3.6	Groundwater Elevations	25
3.7	Acid Sulphate Soils	27
4.	Overview of environmental impacts	30
4.1	Background	30
4.2	Sources of Impact	30
4.3	Sensitive Receptors	33
4.4	Assessment of Impacts	40
4.5	Management of environmental risks	42
5.	Consideration of surface water interactions	46
6.	Monitoring Objectives	47
6.1	Performance objectives	47
6.2	RMS water policy	47
7.	Performance standards	48
7.1	Protection of groundwater quality	48
7.2	Protection of groundwater hydrology and groundwater dependent ecosystems	50
7.3	Proposed performance standards	50
7.4	Control charts	51
8.	Measurement and assessment criteria	53
8.1	Groundwater quality trigger criteria	53
8.2	Groundwater hydrology trigger criteria	53
8.3	Groundwater dependent ecosystem trigger criteria	54
8.4	Statistical analysis	54
9.	Monitoring program	56
9.1	Monitoring sites	56

9.2	Groundwater quality monitoring parameters.....	58
9.3	Sampling frequency.....	59
9.4	Visual observations	60
9.5	Sampling protocol.....	60
9.6	Sample analysis	61
10.	Data analysis and interpretation	62
10.1	Analysis of groundwater quality and groundwater hydrology data.....	62
11.	Management actions	64
12.	Management framework.....	65
12.1	Adaptive management approach	65
12.2	Roles and responsibilities.....	65
12.3	Reporting and auditing	67
13.	Consultation.....	69
	Consultation undertaken during development of the GWMP	69
14.	References	73

Table index

Table 1:	Condition of approval B16 (NSW DPI, 2013).....	7
Table 2:	Statement of commitments – surface water and groundwater quality.....	9
Table 3:	Average annual rainfall recharge (NSW Office of Water, 2011)	15
Table 4:	Assessment of Potential Impacts at Cuttings (adapted from Coffey, 2010, Table 8).....	31
Table 5:	Proposed water quality basin locations	33
Table 6:	Summary of registered groundwater bores within 1 km of the project alignment	34
Table 7:	Summary of creeks crossing the project alignment.....	38
Table 8:	Performance objectives for the monitoring program (adapted from Aurecon 2012).	47
Table 9:	Construction and operational phase monitoring parameters and sampling schedule.....	58
Table 10:	Construction Phase Roles and Responsibilities.....	65
Table 11:	Operation Phase Roles and Responsibilities.....	66
Table 12:	Summary of reporting requirements (adapted from Aurecon, 2010a).....	68
Table 13:	Stakeholder Comments and Response	70

Figure index

Figure 1: Overview of Project	4
Figure 2: Mean temperature and rainfall for Nowra Ran Air Station (068072)	14
Figure 3: Mean temperature and rainfall for Kiama Bowling Club (068038)	14
Figure 4: Surface Water Catchments Along the Alignment.....	18
Figure 5: Geology Map.....	21
Figure 6: Surface Water and Groundwater Sampling Locations	24
Figure 7: Existing Groundwater Elevation Monitoring Wells	26
Figure 8: Acid Sulphate Soils Map.....	28
Figure 9: Sensitive Groundwater Receptors.....	37
Figure 10: Example control chart.....	52
Figure 11: Groundwater quality /hydrology assessments (Aurecon 2010b)	62
Figure 12: Management action framework (Aurecon 2010b).....	64

Appendices

- Appendix A – Groundwater Modelling Report
- Appendix B – Pumping Test Results
- Appendix C – Summary of Groundwater Levels
- Appendix D – Stakeholder Comments

1. Introduction

1.1 Background

Roads and Maritime Services (RMS) is undertaking a series of upgrades to sections of the Princes Highway between Gerringong and Bomaderry in order to provide a continuous four lane divided highway. The Foxground and Berry Bypass comprises of an 11.6 km upgrade of the existing Princes Highway between Toolijooa Road north of Foxground and Schofields Lane south of Berry which includes bypasses of Foxground and Berry (Appendix 2). The project will result in improved road safety and traffic efficiency, including for freight.

An Environmental assessment including appendices and submissions report has been prepared which identifies and assesses potential water quality impacts associated with the project. The project approval was granted on 22 July 2013, under Part 3A of the Environmental Planning and Assessment Act 1979 with conditions of approval (CoA).

These conditions (CoA B15 and CoA B16) require RMS to prepare and implement a water quality monitoring program (WQMP) and undertake groundwater modelling on the concept design. The WQMP will establish baseline water quality data prior to construction, guide monitoring during construction to ensure mitigation measures are effective and guide monitor post construction to ensure permanent measures are effective. The groundwater modelling will assess the construction and operational impact of the concept design on groundwater resources, quality, hydrology, groundwater dependent ecosystems and provide details of contingency and management measures to be implemented in the construction soil and water quality management subplan (COA B26 (d)).

1.2 Project Overview

Roads and Maritime Services (RMS) proposes to upgrade 11.6 kilometres of the Princes Highway between Toolijooa Road north of Foxground and Schofields Lane south of Berry, in New South Wales (NSW) (the project), to achieve a four lane divided highway (two lanes in each direction) with median separation. The project includes bypasses of Foxground and Berry.

The general features of the proposed upgrade, as approved, are presented in the Director General's Environmental Assessment Report (AECOM, 2012) and are as follows:

- Construction of a four lane divided highway (two lanes in each direction) with median separation (wire rope barriers or concrete barriers where space is constrained, such as at bridge locations).
- Bypasses of the Foxground bends and the Berry township.
- Construction of around 6.6 kilometres of new highway where the project deviates from the existing highway alignment at Toolijooa Ridge, the Foxground bends and the Berry township.
- Provision for the possible widening of the highway (if required in the future) to six lanes within the road corridor and, in some areas, construction of the road formation to accommodate future additional lanes where safety considerations, traffic disruption and sub-optimal construction practices are to be avoided.
- Grade-separated interchanges at:
 - Toolijoola Road.
 - Austral Park Road.
 - Tindalls Lane.

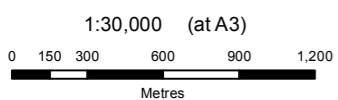
- East of Berry at the existing Princes Highway, referred to as the northern interchange for Berry.
- West of Berry at Kangaroo Valley Road, referred to as the southern interchange for Berry.
- A major cutting at Toolijooa Ridge (around 900 metres long and up to 26 metres deep).
- Six lanes (two lanes plus a climbing lane in each direction) through the cutting at Toolijooa Ridge for a distance of 1.5 kilometres.
- Four new highway bridges:
 - Broughton Creek bridge 1, a four span concrete structure around 170 metres in length and nine metres in height.
 - Broughton Creek bridge 2, a three span concrete structure around 75 metres in length and eight metres in height.
 - Broughton Creek bridge 3, a six span concrete structure around 190 metres long and 13 metres in height.
 - A bridge at Berry, a 19 span concrete structure around 600 metres long and up to 12 metres in height.
- Three highway overbridges:
 - Austral Park Road interchange, providing southbound access to the highway.
 - Tindalls Lane interchange, providing southbound access to and from the highway.
 - Southern interchange for Berry, providing connectivity over the highway for Kangaroo Valley Road along its existing alignment.
- Eight underpasses including roads, drainage structures and fauna underpasses:
 - Toolijoola Road interchange, linking Toolijooa Road to the existing highway and providing northbound access to the upgrade.
 - Property access underpass in the vicinity of Toolijooa Ridge at chainage 8400.
 - Dedicated fauna underpass in the vicinity of Toolijooa Ridge at chainage 8450.
 - Property access underpass between Toolijooa Ridge and Broughton Creek at chainage 9475.
 - Combined drainage and fauna underpass in the vicinity of Austral Park Road at chainage 12800.
 - Combined drainage and fauna underpass in the vicinity of Tindalls Lane at chainage 13320.
 - Dedicated fauna underpass in the vicinity of Tindalls Lane at chainage 13675.
 - Property access underpass between the Tindalls Lane interchange and the northern interchange for Berry in the vicinity of at chainage 15100.
- Modifications to local roads, including Toolijooa Road, Austral Park Road, Gembrook Lane, Tindalls Lane, North Street, Queen Street, Kangaroo Valley Road, Hitchcocks Lane and Schofields Lane.
- Diversion of Town Creek into Bundewallah Creek upstream of its confluence with Connollys Creek and to the north of the project at Berry.
- Modification to about 47 existing property accesses.
- Provision of a bus stop at Toolijoola Road and retention of the existing bus stop at Tindalls Lane.

- Dedicated u-turn facilities at Mullers Lane, the existing highway at the Austral Park Road interchange, the extension to Austral Park Road, and Rawlings Lane.
- Roundabouts at the southern interchange for Berry and the Woodhill Mountain Road junction with the exiting Princes Highway.
- Two culs-de-sac on North Street and the western end of Victoria Street in Berry.
- Tie-in with the existing highway about 75 metres north of Toolijooa Road and about 440 metres south of Schofields Lane.
- Left in/left out only provisions for direct property accesses to the upgraded highway.
- Dedicated public space with shared pedestrian/cycle facilities along the southern side of the upgraded highway from the playing fields on North Street to Kangaroo Valley Road.
- Ancillary operational facilities, including permanent detention basins, stormwater treatment facilities and a permanent ancillary facility site for general road maintenance.

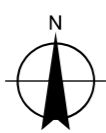
As a result of the community consultation during the display of the environmental assessment the following changes have been made to the project:

- Change of ownership status of property access road between chainage 9450 to chainage 9880 about 500 metres north of Broughton Creek crossing number one.
- Removal of turnaround facility on the Austral Park Road extension.
- Property access and boundary adjustment between chainage 11800 and chainage 12300, opposite Austral Park Road.
- Changed property access arrangement at chainage 12260, opposite Austral Park Road.
- Property access adjustment and flood mitigation between chainage 12820 and chainage 13150 about 550 metres south of the Austral Park Road interchange.
- Changed local road access arrangement for Gembrook Lane, opposite the Tindalls Lane interchange.
- Increased curve radius to optimise alignment at the Tindalls Lane interchange, chainage 13850.
- Changed property access at chainage 14430 at the southern end of the Tindalls Lane interchange.
- Removal of retaining wall and reshaping of a constructed dam at the northern interchange for Berry, between chainage 15500 and 15650.
- Realignment of the Town Creek diversion.
- Adoption of Victoria Street option 3 with the modifications presented in Chapter 4 of this report.
- Modified Schofields Lane intersection with the provision of an underpass with connecting property accesses.

An overview of the project is shown in **Figure 1**. A more detailed description of the project is available in Volume 1 Foxground and Berry bypass environmental assessment prepared for RMS by AECOM in November 2012.



Map Projection: Transverse Mercator
 Horizontal Datum: Geocentric Datum of Australia (GDA)
 Grid: Map Grid of Australia 1994, Zone 56



LEGEND

- Berry to Foxground upgrade alignment
- Alignment location of interest
- Roads
- Railways
- Waterways
- Lakes and dams



Roads and Maritime Services
 Water Quality Monitoring

Job Number | 21-23174
 Revision | 0
 Date | 09 Jul 2014

Overview of the
 Berry to Foxground upgrade

Figure 1

Z:\TEMP GIS\berry to foxground\GIS\Maps\MXD\21_23174_2010_BERRY_OverviewFBBUpgrade.mxd
 © 2010. While GHD has taken care to ensure the accuracy of this product, GHD and DATA CUSTODIAN, make no representations or warranties about its accuracy, completeness or suitability for any particular purpose.
 GHD and DATA CUSTODIAN, cannot accept liability of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred as a result of the product being inaccurate, incomplete or unsuitable in any way and for any reason.
 Data Source: NSW Department of Lands: DTDB and DCDB - 2012. Created by: pmcdougall

2. Regulatory context

2.1 Environmental assessment

The FBB Princess Highway upgrade project has been assessed as a transitional project under Part 3A of the Environmental Planning and Assessment Act 1979 (EP&A Act). The Director-General's requirements (DGR's) for the FBB Princes Highway upgrade were issued on 11 February 2011.

The DGR's for surface water and groundwater required the assessment of:

- *“Water quality taking into account impacts from both accidents and runoff and considering relevant environmental water quality criteria specified in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000. The assessment must describe measures to control erosion and sedimentation during construction activities and measures to capture and treat runoff from the site during the operational phase*
- *“Identify potential risks of the project on groundwater resources including: characterising existing local and regional hydrology; potential risks of drawdown; impacts to groundwater quality; discharge requirements; and implications for groundwater-dependent surface flows (including springs and drinking water catchments), groundwater-dependent ecological communities and groundwater users*
- *Identifying potential impacts of the project on existing flood regimes, consistent with the Floodplain Development Manual (Department of Natural Resources, 2005), including impacts to existing receivers and infrastructure and the future development potential of affected land, demonstrating consideration of the changes to rainfall frequency and/or intensity as a results of climate change on the project. The assessment shall demonstrate due consideration of flood risk in the project design*
- *Waterways to be modified as a result of the project, including ecological, hydrological and geomorphic impacts (as relevant) and measures to rehabilitate the waterways to pre-construction conditions or better”*

The assessment of groundwater impacts presented in the Environmental Assessment (EA) Report (AECOM, 2012) was prepared in accordance with the above DGR's. The EA was subsequently exhibited for consultation and a Submissions Report (RMS, 2013a) prepared in response to the concerns raised.

Approval for the project was issued by the Minister for Planning and Infrastructure on 22 July 2013.

2.1.1 Proposed Groundwater Monitoring

Section 7.4.4 of the Environmental Assessment states that the groundwater monitoring plan undertaken at the site should:

“Establish a groundwater monitoring network along the project to monitor groundwater quality within each lithology and to establish background groundwater quality.

Detail the establishment of a groundwater monitoring network along the route to adequately characterise groundwater quality and establish background water quality within the alluvial/colluvial aquifers and Shoalhaven Group Sediments, including the Broughton Sandstone and latite.

Install monitoring wells adjacent to major cuts to confirm existing groundwater levels and to monitor the effect on groundwater levels by construction activity, where groundwater is encountered.

Implement a groundwater monitoring plan that would assess the performance of groundwater mitigation measures during and after construction. This plan would provide an assessment of groundwater level and quality trends and identification of exceedances (if any)."

Further to the general text in the EA, Appendix H of the EA states the following in regard groundwater monitoring:

"Groundwater monitoring would be required to monitor potential impacts to groundwater quality and levels during and after construction. A detailed sampling, analysis and quality plan outlining the groundwater monitoring programs would be compiled in consultation with the OEH and NOW in accordance with the Guidelines for the Assessment and Management of Groundwater Contamination (NSW DEC, 2007). The results of, and any recommendations from the monitoring would be reported to these agencies. The timing of sampling would be more frequent during the construction phase due to the higher risk of contamination to the local aquifers.

The monitoring program would be required to monitor groundwater level fluctuations and groundwater quality parameters within the existing groundwater monitoring network. During the field program the following field parameters and laboratory analyses would be collected from a minimum of four monitoring wells.

- *pH, dissolved oxygen, redox, electrical conductivity and temperature (field parameters).*
- *Total petroleum hydrocarbons/benzene, toluene, ethylbenzene, xylene (TPH/BTEX), PAH, heavy metals (As, Cd, Cr, Cu, Pb, Hg, Ni, Zn).*
- *Installation of dataloggers in four key monitoring wells to monitor groundwater levels on a daily schedule.*

Groundwater sampling protocols would be defined in the Sampling Analysis and Quality Plan (SAQP) however in summary all monitoring wells would be purged a minimum of three well volumes prior to sampling and metals are to be field filtered. Field meters would be calibrated daily and water samples collected for metals analysis would be field filtered prior to transportation to a NATA accredited laboratory in a chilled cooler.

The ANZECC 2000a Fresh and Marine Water Guidelines are considered the appropriate groundwater investigation levels for the protection of aquatic systems. The 95 per cent level of protection is considered the most appropriate in this sensitive fresh water ecosystem.

Groundwater monitoring should be undertaken and reported on a three monthly basis during construction."

Appendix H also states that:

"During operation groundwater monitoring would be carried out every six months with a review after two years to assess data trends and assess if further monitoring is warranted. The framework for monitoring would be set out in the SAQP. The objectives of the groundwater monitoring program would be established in consultation with NOW and the EPA as appropriate and would likely include an assessment of groundwater level data trends and comparison with rainfall data, and an assessment of water quality trends and exceedances, if any."

2.2 Conditions of Approval

The Project Approval was issued subject to a range of conditions, which included conditions for environmental monitoring and auditing. In relation to the monitoring of groundwater, Condition of Approval number B16 (CoA No. B16) specifies that:

"The Proponent shall prepare and implement a Water Quality Monitoring Program to monitor the impacts of the project on surface water and groundwater quality and resources and wetlands, during construction and operation"

The Water Quality Monitoring Program (WQMP) is required to be developed in consultation with the Office of Environment and Heritage (OEH), Environmental Protection Authority (EPA), Department of Primary Industries (DPI) (Fishing and Aquaculture) and NSW Office of Water (NOW). Table 1 outlines the specific requirements of CoA B16 and provides section references where each criteria is addressed within this monitoring program.

Table 1: Condition of approval B16 (NSW DPI, 2013)

Condition of approval B16	WQMP section reference where addressed
(a) identification of surface and groundwater quality monitoring locations (including watercourse, water bodies and SEPP 14 wetlands), which are representative of the potential extent of impacts from the project	Surface water – Section 3, 4 and 9 Groundwater is in the groundwater quality monitoring document
(b) the results of the groundwater modelling undertaken under condition B15	Within the groundwater quality monitoring plan document
(c) identification of works and activities during construction and operation of the project, including emergencies and spill events, that have the potential to impact on surface water quality of potentially affected waterways	Section 3
(d) development and presentation of parameters and standards against which any changes to water quality will be assessed, having regard to Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000 (ANZECC, 2000a)	Sections 7 and 8
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 Director General	Section 4 and Section 9. Initial monitoring data to be provided to RMS as ongoing monitoring data updates separate to this report
(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)	Operation criteria discussed in Sections 9 to 13
(g) contingency and ameliorative measures in the event that adverse impacts to water quality are identified	Section 11 and 13
(h) reporting of the monitoring results to the Department, OEH, EPA and NOW	To be supplied as monitoring reports to RMS and subsequently to OEH, EPA and NOW

CoA B15 is referenced as part of CoA B16 and is stated below.

“Prior to the commencement of construction, unless otherwise agreed by the Director General, the Proponent shall in consultation with the EPA and NOW, undertake groundwater modelling on the concept design for the project, subject to the modelling being revised should the detailed design have a significantly different impact on groundwater than the concept design.

The modelling shall be undertaken by a suitably qualified and experienced groundwater expert and assess the construction and operational impacts of the proposal on the groundwater resources, groundwater quality, groundwater hydrology and groundwater dependent ecosystems and provide details of contingency and management measures in the groundwater management strategy required under condition B36(d).”

The Program must also be submitted to the Director General for approval six (6) months prior to the commencement of construction of the project, or as otherwise agreed by the Director General. A copy of the Program must also be submitted to OEH, EPA, DPI (Fishing and Aquaculture) and NOW prior to its implementation. This Groundwater Monitoring Program (GWMP) and a separate Surface Water Monitoring Program (SWMP) (GHD, 2014b) have been prepared to meet the requirements of CoA No. B16.

2.3 Statement of commitments

RMS has committed to a range of surface water and groundwater quality protection measures as part of the environmental assessment under Part 3A of the EP&A Act. The primary objective of the measures proposed is to minimise the impacts to downstream surface water quality. The statement of commitments for surface water and groundwater quality, as outlined in the Submission report (RMS, 2013), is provided in Table 2. These commitments have been considered in the preparation of this GWMP and would also be taken into account in the development of the detailed design and project environmental management plans.

Table 2: Statement of commitments – surface water and groundwater quality

Ref No	Commitment	Key Action	Timing	Reference Document
SG1	Minimise impacts to water quality during construction and operation	Water quality measures such as water quality basins, swales or bioretention systems at sensitive receiving environments will be designed and installed to respond to the project water quality design criteria.	Pre-construction and construction	Managing Urban Stormwater: Council Handbook (EPA, 1997) Section 7.4 of the environmental assessment
SG2	Minimise water quality impacts and impacts to the flow regimes of Town Creek and Bundewallah Creek	A design and re-vegetation strategy for the Town Creek diversion will be developed during detailed design and will include measures to: Maintain flushing efficiency. Mitigate erosion risk at the connection with Bundewallah Creek. The design of the diversion will be finalised in consultation with directly affected landowners. The Town Creek diversion will be stabilised to mitigate erosion risk prior to operation.	Pre-construction and construction	Managing Urban Stormwater – Volume 1 (Soils and Construction) (Landcom (2004)) Managing Urban Stormwater – Soils and Construction, Volume 2D – Main Road Construction (known as the Blue Book) (DECCW 2008) Guidelines for In stream Works on Waterfront Land (NSW Office of Water, 2012) Section 7.4 of the environmental assessment Section 2.11 of the response to submissions
SG3	Minimise impacts on farm dams	Permanent losses to farm dam catchments and inflows will be identified during detailed design. Mitigation strategies will be developed in consultation with affected landowners and implemented where reasonable and feasible.	Pre-construction	Section 7.4 of the environmental assessment
SG4 and SG5	Minimise impacts on drinking water supply	Drinking water drawn from Broughton Creek will be maintained through measures identified in commitment AQ1. In the event that water drawn from Broughton Creek does not meet existing drinking water quality standards, an appropriate source of potable water will be made available to affected residents, following consultation.	SG4 – Construction SG5 - Pre-construction	Section 2.11 of the response to submissions

Ref No	Commitment	Key Action	Timing	Reference Document
		RMS will consult with landholders along the existing Town Creek alignment, below the proposed diversion, to confirm that there are no Basic Landholder Rights (under the Water Management Act 2000) to access water for domestic or stock purposes.		
SG6	Minimise changes in current flow regimes	Waterway structures will be designed to maintain existing flow regimes, where practicable.	Pre-construction	Section 7.5 of the environmental assessment
SG7 and SG8	Manage the impacts associated with changes to flooding and drainage	Detailed design will seek to minimise increases in peak flood levels in the 1 in 100 year flood event. Changes to flood impacts on property will be identified as part of detailed design. Where increased flood impacts to structures, such as residences, are identified, mitigation measures will be proposed and implemented where reasonable and feasible.	Pre-construction (SG7) Pre-construction and construction.(SG8)	Section 7.5 of the environmental assessment
SG9	Minimise impacts on channel structure	Impacts on stream channel structure diversion will be minimised during detailed design. Measures to be considered may include culvert sizing, energy dissipation measures, scour protection and other design features to control flow intensity and direction.	Preconstruction	Section 7.5 of the environmental assessment
SG10	Minimise the impact on groundwater levels	Groundwater monitoring of water levels and water quality will be undertaken. Where levels and/or quality indicate that the project is potentially having an adverse impact, mitigation measures will be considered and implemented where reasonable and feasible.	Construction	Section 7.4 of the environmental assessment
SG11	Conservation of water	Water efficient work practices, such as water reuse and recycling for road construction and re-vegetation irrigation will be implemented, where feasible. In the event that surface water from watercourses or groundwater is required to supply water to the project, a site specific impact assessment will be carried out in consultation	Construction	Section 7.4 of the environmental assessment Section 2.11 of the response to submissions

Ref No	Commitment	Key Action	Timing	Reference Document
		with the NSW Office of Water and potentially affected stakeholders.		
SW4	Avoid contamination of waterways	<p>Monitoring of water quality upstream and downstream of the project site will be undertaken before and during construction.</p> <p>Also refer to SG4.</p>	Preconstruction and construction	<p>Section 7.4 and 8.1 of the environmental assessment</p> <p>Erosion and Sedimentation Management Procedure (RTA, 2008)</p> <p>Managing Urban Stormwater – Soils and Construction Volume 1 (Landcom, 2004)</p> <p>Managing Urban Stormwater – Soils and Construction, Volume 2D – Main Road Construction (DECCW, 2008)</p> <p>RMS QA Specification G38 Soil and Water Management</p> <p>RMS QA Specification G39 Soil and Water Management (Erosion and Sediment Control Plan)</p>

The statement of commitments within the Submission report list the outcomes for soil and water quality and surface water and groundwater. The outcomes that relate to the WQMP and are outline in the brief are SW4, SG4 and SG10.

3. Regional setting and layout

3.1 Climate

The project area is subject to an oceanic climate characterised by a relatively narrow annual temperature range and evenly dispersed rainfall throughout the year (i.e. lacking a dry season). Climate statistics for the area are based on the two nearest weather stations registered with the Bureau of Meteorology being Nowra Ran Air Station (068072) and Kiama Bowling Club (068038). The Nowra weather station is located approximately 24 km southwest of Berry and 35 km southwest of Gerringong. The Kiama weather station is located approximately 9 km north of Gerringong and 18 km northeast of Berry. A comparison of the data from these two locations is considered representative of the project area that lies central to them.

Temperatures between the two weather stations are comparable and thus considered representative of the project area. Summer temperatures are warm ranging 15-30 °C and winter temperatures are mild ranging 5-20 °C.

Average annual rainfall approximates 870 mm inland (Nowra, approximately 27 km from the coast) and 1250 mm at the coast (Kiama). Average annual rainfall at the project area is considered to lie within this range. Rainfall is dispersed throughout the year with no distinct dry season (Figure 2 and Figure 3).

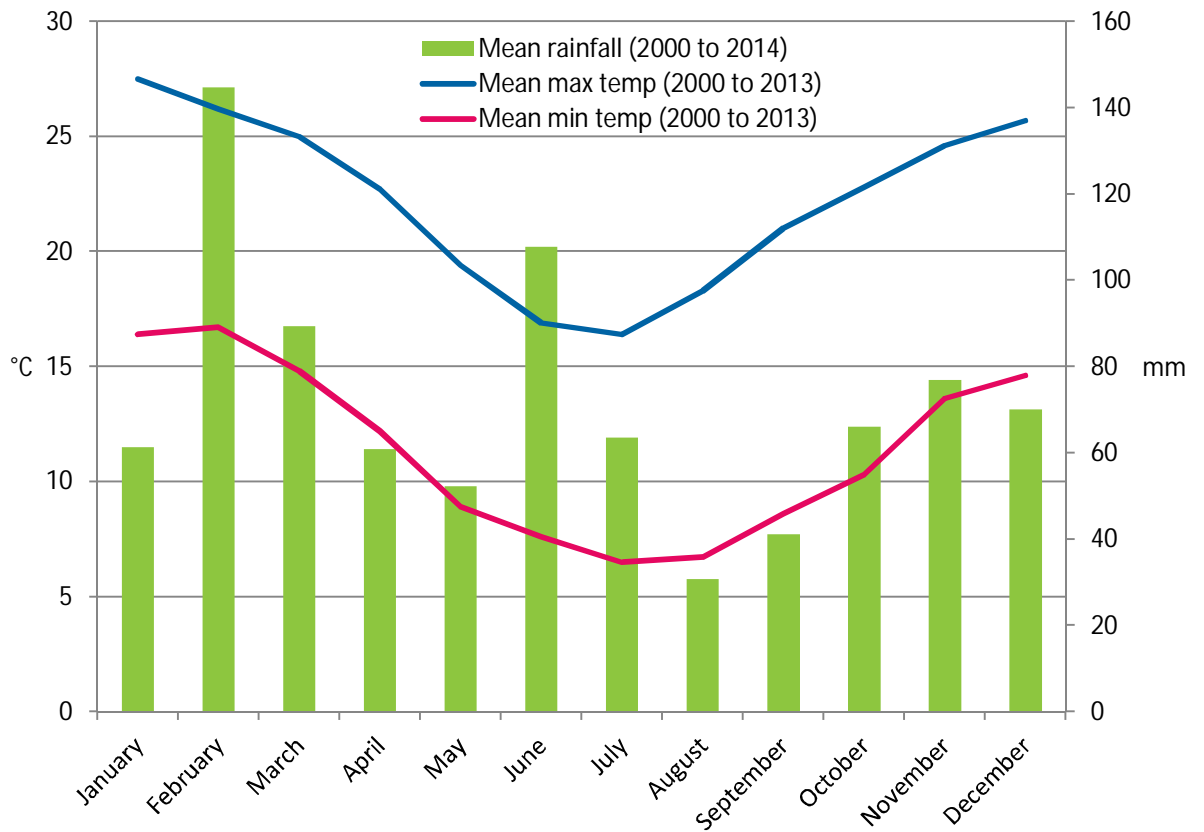


Figure 2: Mean temperature and rainfall for Nowra Ran Air Station (068072)

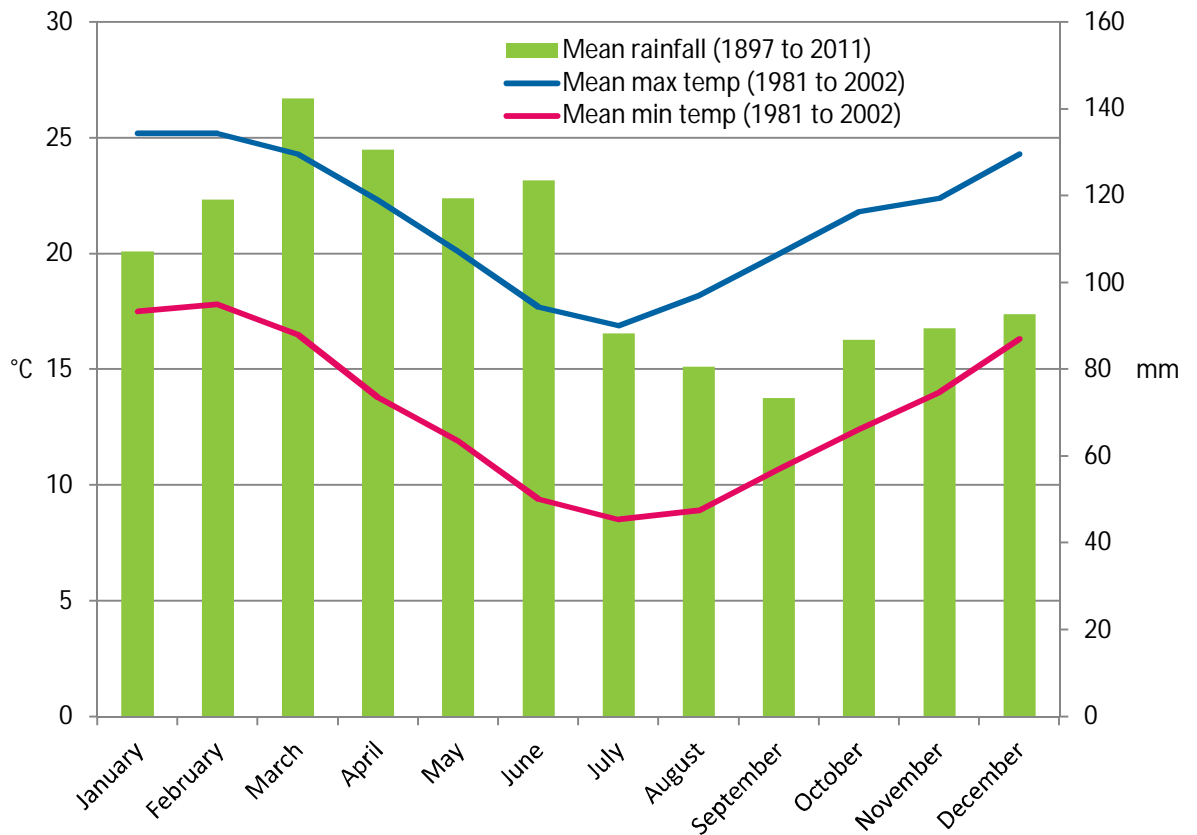


Figure 3: Mean temperature and rainfall for Kiama Bowling Club (068038)

Evaporation rates were not recorded at either weather station. Relative humidity lies around 60% being more variable inland and moderated at the coast.

3.2 Groundwater Recharge

Recharge is expected to occur predominantly via direct infiltration of rainfall. Additional recharge sources are likely to include surface waters (Broughton Creek and tributaries) and through flow within sedimentary sequences of the Shoalhaven Group. Upward flow from underlying basement rock is considered unlikely.

The NSW Office of Water (2011) provides regional estimates of recharge in the area based on a 6% infiltration of rainfall.

Table 3: Average annual rainfall recharge (NSW Office of Water, 2011)

Water Source	Area (km ²)	Average Annual Rainfall (ML)	Infiltration (%)	Estimated Average Annual Rainfall Recharge (ML/yr)#
Sydney Basin South	3034.83	3,755,436	6	225,326

#Average annual rainfall recharge (ML/yr) = [(water source area (ha)*mean rainfall (mm)) /100]*% infiltration rate.

The average annual recharge was calculated using rainfall data between 1921 and 1995.

3.3 Topography and drainage

3.3.1 Overview

The topographic setting of the investigation area traverses low relief ridges and alluvial soils near the interface between the foot slopes of the nearby Illawarra escarpment and the low lying Shoalhaven River Floodplain area. A number of secondary streams and creeks migrate from higher elevations from the Cambewarra Range into a dendritic drainage pattern and then flow onwards to the southeast into Broughton Creek (Coffey, *Geotechnical Interpretive Report*, 2 August 2012).

3.3.2 Topography

The nature of the terrain varies greatly between four primary landscape character units. These are described as the steep slopes of the Toolijooa Ridge through to the floodplains of the Broughton Creek and progresses to variable slopes of Berry and flatter land around the northern and western Berry township.

These landscapes are described in more detail as follows:

Toolijooa Ridge: This area is located at the northern end of the site and extends south from Currys mountain. Open pastoral landscape is present along the existing highway until the eastern spur of the Toolijooa Ridge which separates the coastal plain from Broughton Creek to the west.

Broughton Creek: The creek and surrounding floodplains form the valley between the western side of Toolijooa Ridge and the east facing slopes of Camberwarra Range. The creek valley runs north-south with the creek meandering throughout this floodplain. Remnant vegetation is present along the creek line and separates the creek from open pasture and small rural farm dams.

North Berry: The existing highway follows the ridgeline that separates catchments to the east and west from east of the Broughton Creek floodplain. This landscape comprises open pasture, remnant vegetation with variable terrain including undulating to steep slopes.

Berry: The town encompasses flood free land upstream of Broughton Creek and Broughton Mill Creek and flat land within the established section of Berry. It is noted that development of the town and structures such as the railway line forms a physical barrier between the flood prone pastures and flat land of Berry.

3.3.3 Drainage Catchments

The prominent high points within the study area include Mount Pleasant (RL 200 m), Toolijooa Hill (RL130 m), Harley Hill (RL 140 m) Foxground (RL 120 m) and Tomlins Hill (RL 136 m). A ridge of moderate elevation from Foxground to Toolijooa Hill and a flatter ridge to the southeast of Toolijooa Hill separates the Broughton Creek floodplain from the Crooked River floodplain.

Many high sinuosity secondary streams and creeks migrate from higher elevations within the Cambewarra range in a dendritic drainage pattern. These secondary creeks and streams generally flow to the southeast where they merge with either Crooked River in the north or Broughton Creek in the south.

North of Berry township there is a large area of near level land including some low lying areas near the watercourses, with slopes gradually increasing to the north and west. This near level is underlain by alluvial deposits. The existing highway initially follows a narrow ridge to the northeast of Berry then crosses hills and ridges of moderate elevation to Broughton Creek and Foxground Valley which comprises a large area of near level to gently sloping land over the valley floor. The highway passes through a valley and undulating slopes before crossing another high ridge near the southern side of Gerringong township.

The Shoalhaven lowland plain with a surface elevation generally less than RL 5 m includes the Crooked River floodplain and Broughton Creek floodplain (from Coffey, 2007).

The alignment of the FBB Princes Highway upgrade would pass through the six major and three minor catchments identified in this section. The location of the upgrade alignment in relation to the catchments is shown in Figure 4.

Broughton Creek floodplain

The Broughton Creek floodplain and tributary valley floor areas occupy a large portion of the study area to the south and southeast of Berry (mainly floodplains) and tributary valleys to the north and northeast of Berry. Broughton Creek is the dominant watercourse in this area extending back to the escarpment slopes to the north and northeast in the areas of Broughton, Broughton Vale, Bundewallah, Jaspers Brush and Meroo Meadow areas to the south and southeast of Berry. Broughton Creek flows across a broad floodplain in a southerly direction, flowing into the Shoalhaven River about 5 km west of Shoalhaven Heads.

Broughton Mill Creek, Bundewallah and Connollys Creek catchment

To the north and north-west of Berry are the Broughton Mill Creek, Connollys Creek and Bundewallah Creek catchments, respectively. Broughton Mill Creek originates underneath the Illawarra plateau as a number of secondary streams. It flows south through Broughton Vale and crosses the existing Princes Highway near the Woodhill Mountain Road intersection on the eastern edge of Berry, around two kilometres upstream of its confluence with Broughton Creek.

Town Creek catchment

Town Creek is a small ephemeral watercourse that passes directly through Berry township. It has a catchment area of 70 hectares upstream of Berry. Town Creek crosses the undeveloped section of North Street, on the north west edge of Berry, before crossing the town between Princess Street and Queen Street and exiting via Prince Alfred Street. Town Creek flows south

east before joining Broughton Mill Creek near its confluence with Broughton Creek. The reach of Town Creek through Berry is in poor condition.

Minor catchments

Hitchcocks Lane Creek, its tributary and an unnamed tributary of Broughton Creek flow across the existing highway, south of Berry. These watercourses join southwest of the existing highway and eventually discharge into the estuarine reach of Broughton Creek. Hitchcocks Lane Creek and its tributary have a catchment area of 68 hectares and 75 hectares respectively. The unnamed tributary of Broughton Creek has a catchment area of 6.2 hectares.

Crooked River floodplain

The Crooked River floodplain where it occurs within the study area includes the low lying areas to the southwest of Gerringong, generally between Toolijooa Road or the Princes Highway and the Illawarra railway. Crooked River originates in the Broughton Vale highlands and flows southeast across the Crooked River floodplain and into Crooked River coastal lagoon.

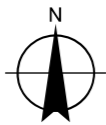
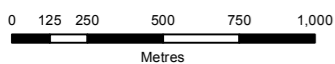
The crooked river catchment only intersects the very north eastern end of the project alignment.

Farm dams

There are 29 farm dams have catchments that intersect with the project footprint. The locations of these dams are shown in **Figure 4**. Majority of dams would be fed by surface water runoff but some could be through springs.



1:25,000 (at A3)



LEGEND

- Catchment Boundaries
- Berry to Foxground upgrade alignment
- Waterways
- Lakes and dams
- Roads
- Railways



Roads and Maritime Services
Water Quality Monitoring

Job Number | 21-23174
Revision | 0
Date | 09 Jul 2014

Surface Water Catchments

Figure 4

Z:\TEMP GIS\berry to foxground\GISMaps\MXD\21_23174_2011_BERRY_SurfaceWaterCatchments.mxd
© 2010. While GHD has taken care to ensure the accuracy of this product, GHD and DATA CUSTODIAN, make no representations or warranties about its accuracy, completeness or suitability for any particular purpose.
GHD and DATA CUSTODIAN, cannot accept liability of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred as a result of the product being inaccurate, incomplete or unsuitable in any way and for any reason.
Data Source: NSW Department of Lands: DTDB and DCDB - 2012. Created by: pmcdougall

3.4 Geology

The regional geology of the area comprises Middle to Late Permian sedimentary sequences of the southern part of the Sydney Basin with minor interbedded lithic volcanics. Unconsolidated Quaternary sediments are deposited on the Broughton Creek and Crooked River Floodplains.

A map presenting the geology of the alignment is presented in Figure 5.

The Sydney Basin is a major structural basin containing a Palaeozoic, Permian-Triassic sedimentary sequence overlying older basement rocks of the Lachlan Fold Belt. The regional dip of the rock strata grades gently to the north and northwest with the oldest rocks generally occurring along the coast in the southeast.

Located within the southern part of the Sydney Basin, the stratigraphy encountered in the study area forms part of the Shoalhaven Group. The Shoalhaven group is of Permian age and comprises the Nowra Sandstone, Berry Siltstone and the Broughton Formation. The Broughton formation includes the Gerringong volcanics, which consist of Bumbo latite and Kiama Trachytic Tuff. This Formation is also the geologically youngest Formation.

Rocks encountered in the study area belong to the Berry Siltstone. This undifferentiated member comprises a series of alternating lithology of siltstone with fine grained sandstones and interbedded shales. The Berry Siltstone consists predominantly of massive, indistinctly bedded (as a result of bioturbation) to horizontally bedded, mid to dark-grey siltstone and very fine feldspathic litharenite. Fine-grained, light-grey, sublithic interbedded sandy phases occur especially towards the top where the rock grades to laminate in parts and form a coarsening upwards trends. Pebbles up to 20 mm in diameter of quartzite, quartz, and basic igneous material occur sporadically throughout the unit with shell fossils also a common constituent. When fresh and slightly weathered, the siltstone is generally of high or very high strength and without significant joints. When weathered, the siltstone and shale beds within this rock mass generally break down and become iron stained and clayey. Much of the unit is not fossiliferous, although at some locations high concentrations of fossils such as brachiopods are found.

The site is located away from other major structural features such as synclines, anticlines, thrusts and faults that are known within the Sydney Basin. It is assessed that the rocks in this area have not been subject to major folding or tectonic forces. However, minor faults can still be present within the overall rock mass, with a normal fault observed in the Berry Siltstone in a cutting just north of Berry (from Coffey, *Geotechnical Interpretive Report*, 2 August 2012, GEOTWOLL03387AA-AB).

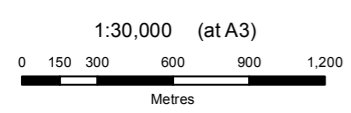
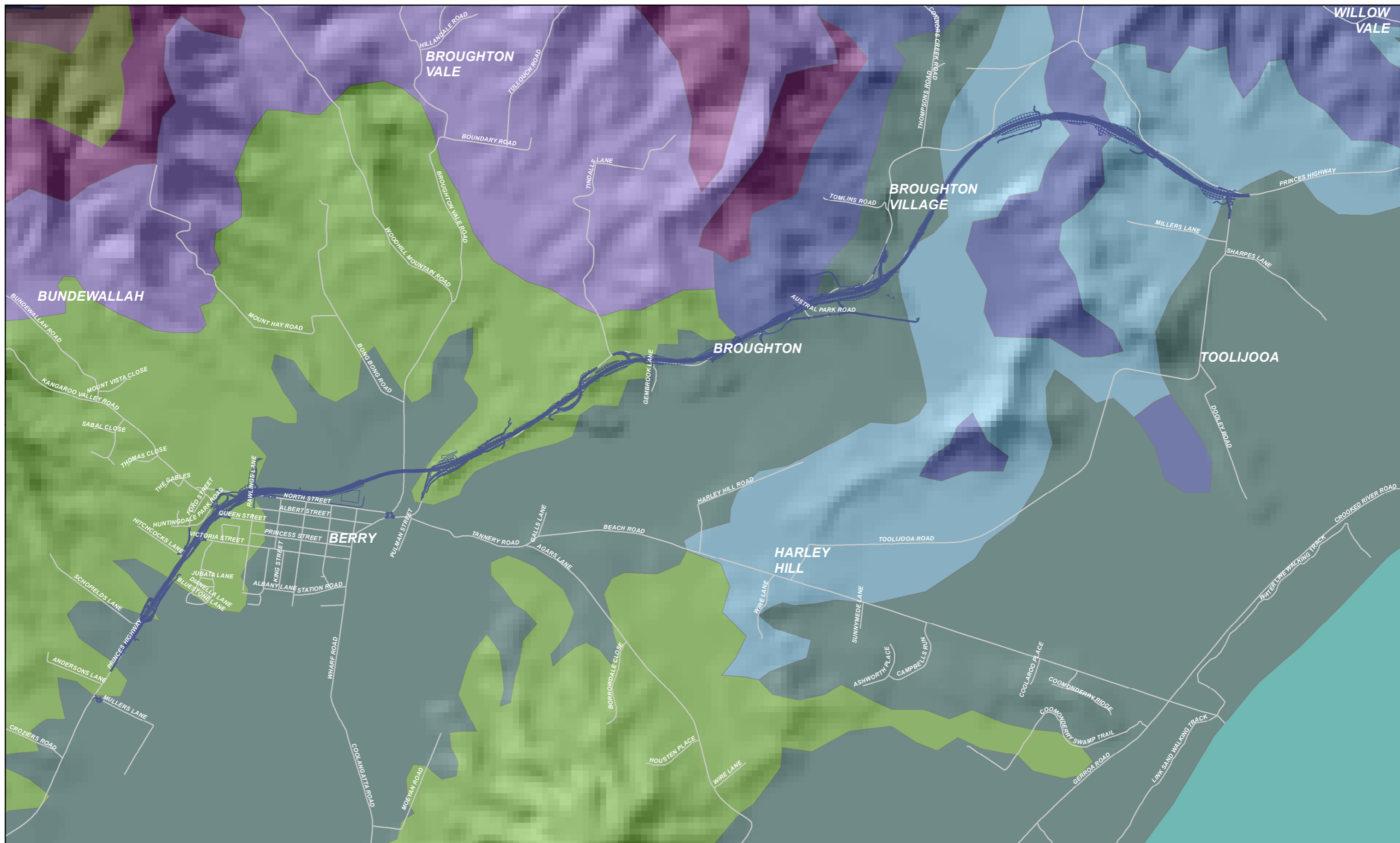
Significant deposits of coarser alluvium are present at the site and have been observed during previous investigations. Reference to the 1:250,00 Geological Sheet for Wollongong (Sheet SI/56-9) suggest some areas of the alignment to be underlain by Quaternary Alluvium of gravel, swamp deposits and sand dunes, overlying undifferentiated Berry Formation as described and shown on Figure 5.

3.4.1 Drilling Observations

Fourteen drill holes were advanced as part of setting up the groundwater monitoring network for this project. The drill/well locations are presented in Figure 6. The wells are numbered MW01 to MW16 and include proposed wells MW14 and MW15, which have not been drilled. MW14 and MW15 are currently not considered necessary to meet the monitoring objectives and will not be installed.

The air rotary drilling methods adopted were primarily for the purpose of installing monitoring wells and did not concentrate of geological characterisation as there is already extensive

geological information available for alignment. As such, geological interpretation from the drilling works undertaken has not been included here.



LEGEND			
Berry to Foxground upgrade alignment	Pbb	Pgc	Qal
Roads	Pbc	Pi	Rh
Railways	Pgb	Pps	Tek

Map Projection: Transverse Mercator
 Horizontal Datum: Geocentric Datum of Australia (GDA)
 Grid: Map Grid of Australia 1994, Zone 56



Roads and Maritime Services
 Water Quality Monitoring

Job Number | 21-23174
 Revision | 0
 Date | 09 Jul 2014

Geology of the
 Berry to Foxground upgrade

Figure 5

Z:\TEMP GIS\berry to foxground\GISMaps\MXD\21_23174_Z016_BERRY_Overview_Geology.mxd
 © 2010. While GHD has taken care to ensure the accuracy of this product, GHD and DATA CUSTODIAN, make no representations or warranties about its accuracy, completeness or suitability for any particular purpose.
 GHD and DATA CUSTODIAN, cannot accept liability of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred as a result of the product being inaccurate, incomplete or unsuitable in any way and for any reason.
 Data Source: NSW Department of Lands: DTDB and DCDB - 2012. Created by: pmdougall

3.5 Hydrogeological Conditions

Two main aquifer systems are present along the project alignment. These include unconsolidated and unconfined alluvial/colluvial aquifers and deeper systems within the Shoalhaven group sediments.

The alluvial aquifer occurs as sand, silt, clay and gravel flanking the creek systems and as more widespread floodplain deposits. Groundwater flow within the alluvial aquifer is via pathways of higher permeability. Within the flood plain sediments, localised perched groundwater is expected above interbedded clay horizons. Due to the limited information available online in regards to the alluvial aquifers, it is considered that groundwater available for abstraction within the alluvial aquifer is limited and local land holders use other water supply options. Groundwater movement within the alluvial aquifer and flood plain sediments is expected to flow towards low lying topographical features discharging into local creek systems or as springs.

Groundwater within the Shoalhaven Group sediments within the study area is present within the volcanoclastic Broughton Sandstone as well as within latite and underlying Berry Siltstone. Groundwater within the Shoalhaven Group sediments occurs in perched horizons within the weathered sandstone, siltstone and latite and within the deeper regional aquifer. Groundwater flow within the generally shallow perched horizon is limited and dominated by intergranular flow in the weathered sedimentary rocks. Groundwater in the deeper aquifers is along both primary features, such as less well cemented zones within the rocks and secondary structural features such as joints, shear zones, faults and bedding plane partings.

Licensed bores in the area constructed within the Shoalhaven Group sediments indicate variable yields with deeper aquifers accessed by the majority of licensed bores extracting water from depths ranging from 30 and 50 metres below ground level.

3.5.1 Aquifer Parameters

The primary aquifer parameters characterising intrinsic ability of an aquifer to store and transmit water are hydraulic conductivity and storativity. The data collated to describe these parameters are provided below.

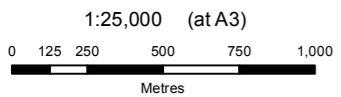
Preliminary groundwater modelling has been undertaken as part of this project where values for hydraulic conductivity, storativity and specific yield have been predicted for the different geological units as part of model calibration. The values adopted for the groundwater modelling are presented in the groundwater modelling report, which is located in **Appendix A**. Horizontal hydraulic conductivity values for the calibrated model ranged between $3.2E^{-4}$ m/day and $4.8E^{-3}$ m/day with an average of $3E^{-3}$ m/day. A value of 1 m/day was adopted for alluvial soils. Storage values were not required in the model as it was run under steady state conditions.

Hydraulic testing of installed wells was undertaken on site between the 8 and 14 April 2014. This included undertaking short term pumping tests using a submersible pump and data logger with subsequent analysis of the groundwater elevation recovery using the Theis recovery analytical method in the AQTESOLV software. A summary table, analytical outputs and field sheets are presented in Appendix B. A total of ten tests were completed successfully with nine of the tests on wells screened within bedrock material (MW01, MW03, MW07, MW08, MW09, MW11, MW12, MW13, MW16) and one well screened in residual soils (MW04). The locations of the bores are presented on Figure 6. The calculated hydraulic conductivities ranged between $2.8E^{-3}$ m/day and $5.5E^{-2}$ m/day with an average of $1.6E^{-2}$ m/day. This is generally higher than the values established by model calibration although there is some overlap in the two data sets. A value of 0.02 m/day was calculated for the residual soils at MW04.

The pumping test methods adopted used cannot be used to establish storage values. Specific yields for fractured bedrock aquifers, which broadly corresponds with storativity under

unconfined aquifer conditions are generally less than 0.05 (dimensionless). Unconsolidated alluvial systems generally have specific yields between 0.1 and 0.3 (dimensionless).

The aquifer parameters outlined above suggest that the aquifer systems in this area have overall low permeability, which will result in relatively slow groundwater migration.



LEGEND

- Groundwater Sampling Locations
- Proposed Groundwater Sampling Locations
- Surface Water Sampling Locations
- Berry to Foxground upgrade alignment
- Roads
- Railways
- Waterways
- Lakes and dams



Roads and Maritime Services
Water Quality Monitoring

**Surface water and
Groundwater Sampling Locations**

Job Number | 21-23174
Revision | 0
Date | 09 Jul 2014

Figure 6

Z:\TEMP GIS\berry to foxground\GISMaps\MXD\21_23174_2014_BERRY_SurfaceWaterandGroundwaterSamplingLocations.mxd
© 2010. While GHD has taken care to ensure the accuracy of this product, GHD and DATA CUSTODIAN, make no representations or warranties about its accuracy, completeness or suitability for any particular purpose.
GHD and DATA CUSTODIAN, cannot accept liability of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred as a result of the product being inaccurate, incomplete or unsuitable in any way and for any reason.
Data Source: NSW Department of Lands: DTDB and DCDB - 2012. Created by: pmdougall

3.6 Groundwater Elevations

3.6.1 Overview

Coffey (2010) suggested that groundwater levels were elevated in topographical ridge areas, with lower elevations in valley floors. Groundwater levels are expected to generally increase and decline in accordance with topography, following a subdued image of the ground surface. As such, groundwater is expected to flow from elevated ridges to valley floors.

The depth to groundwater along the route is influenced by positioning in the landscape and proximity to discharge features. Shallow groundwater has been identified within the Broughton Creek floodplain immediately north of Berry where a number of water courses converge. This is supported through previous groundwater investigations conducted between November 2009 and January 2010.

Monitoring of groundwater levels undertaken by Coffey in 2010 indicated that groundwater was shallow and less than ten metres below ground level across all lithologies. This investigation also indicated that the water table naturally oscillates in response to climatic variation. However, the groundwater response was variable and dependent upon landscape position and aquifer type (AECOM, *Foxground and Berry bypass Volume 2- Appendix H*, November 2012).

3.6.2 Groundwater Levels

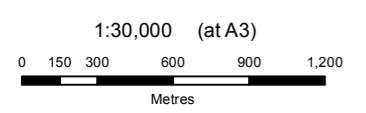
Coffey Geotechnics conducted a geotechnical investigation in October 2007 which included the installation of eleven groundwater monitoring wells as part of a broad assessment of groundwater levels. They were installed within alluvial and residual soils as well as weathered rocks. On average, the wells positioned on the elevated ridgelines (CBH15, CBH16, CBH19 and CBH20) had standing groundwater occurring at depths between 3.297 m to 6.995 m bgl. These wells demonstrated slower recharge rates although it was noted the water targeted may have been perched groundwater. The wells installed in the alluvial floodplains and low lying estuarine floodplains (CBH5, CBH6, CBH8, CBH11 and CBH17) recorded levels between 0.369 m and 2.541 m bgl. Continuous recharge rates were recorded at all locations except CBH8 and CBH11.

Groundwater level monitoring was carried out in four boreholes as detailed in the RMS *Geotechnical Investigation – Factual Report* completed in May 2013 (P1, P3, BH12 and BH13).

A map presenting the previous groundwater wells along the alignment is presented in Figure 7.

It was noted in this investigation that groundwater levels respond to changes in rainfall, rising during heavy rainfall and falling in dryer periods. Groundwater levels have also shown to vary seasonally. The lowest groundwater level recorded during a dry period was approximately 9 m bgl (BH12) and the highest level after a rain event was approximately 0.15 bgl (P3). The average groundwater over this period of monitoring was around 4 to 6 m bgl.

A summary of groundwater levels are presented in **Appendix C**.



LEGEND	
	Existing groundwater observation wells
	Berry to Foxground upgrade alignment
	Roads
	Waterways
	Lakes and dams

Map Projection: Transverse Mercator
 Horizontal Datum: Geocentric Datum of Australia (GDA)
 Grid: Map Grid of Australia 1994, Zone 56



Roads and Maritime Services
 Water Quality Monitoring

Job Number	21-23174
Revision	0
Date	09 Jul 2014

Berry to Foxground upgrade Existing groundwater wells

Figure 7

Z:\TEMP GIS\berry to foxground\GIS\Maps\MXD\21_23174_2017_BERRY_Overview_ExistingGroundwaterWells.mxd
 © 2010. While GHD has taken care to ensure the accuracy of this product, GHD and DATA CUSTODIAN, make no representations or warranties about its accuracy, completeness or suitability for any particular purpose.
 GHD and DATA CUSTODIAN, cannot accept liability of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred as a result of the product being inaccurate, incomplete or unsuitable in any way and for any reason.
 Data Source: NSW Department of Lands: DTDB and DCDB - 2012. Created by: pmcdougall

3.7 Acid Sulphate Soils

A preliminary Acid Sulphate Soils (ASS) assessment was carried out by Coffey Geotechnics Pty Ltd for the upgrade of the Princess Highway from Gerringong to Bomaderry in 2007 and has been summarised below.

ASS is a naturally occurring soil and sediment containing iron sulfides which when exposed to oxygen can generate sulfuric acid. ASS generally occurs in marine or estuarine sediments of recent geological age (Holocene), within soil horizons typically less than 5 m above Australian Height Datum (AHD).

3.7.1 ASS Risk mapping

ASS risk maps for the NSW coastline have been prepared by the Soil Conservation Service of NSW. The mapping was designed to provide information on ASS distribution and indicate land uses which are likely to create environmental risk by exposing ASS to air.

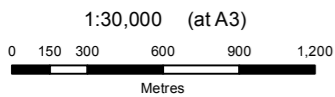
The majority of the study area is covered by three maps (Kiama, Burrier / Berry and Gerroa). A copy of these maps showing the study area is presented in Figure 8.

Reference to the Kiama 1:25,000 Acid Sulphate Soil Risk Map (1997) Edition 2, indicates that a section of the site where the Princes Highway intersects with Ooaree Creek (Rose Valley) is an area of high probability of ASS occurrence being described as low alluvial plains, estuarine sandplains, estuarine swamps, backswamp and supratidal flats, alluvial plains, alluvial swamps, alluvial levees and sandplains in estuarine reaches of catchments.

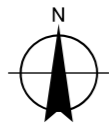
ASS, if present, are considered to be widespread or sporadic in occurrence and pose a severe environmental risk if disturbed. The map shows areas immediately to the east of this section of the study area as having a low to high probability of ASS occurrence.

Reference to the Burrier / Berry 1:25,000 Acid Sulphate Soil Risk Map (1997) Edition 2, indicates that land on the western side of the South Coast railway includes areas of low probability of ASS occurrence. These areas are described as elevated alluvial plains and levees dominated by fluvial sediments, plains and dunes dominated by aeolian sands, pleistocene plains and lacustrine and alluvium bottom sediment. ASS, if present, are considered to be sporadic and may be buried by alluvium and windblown sediments. Areas on the eastern side of the railway line that are encompassed by the study area are in areas of high probability of ASS occurrence being described as estuarine swamps, intertidal flats, supratidal flats, low alluvial plains, estuarine sandplains, estuarine swamps, backswamps, surpatidal flats, alluvial plains, alluvial swamps, alluvial levees, sandplains, elevated levees and sandplains in occurrence and pose a severe environmental risk if disturbed.

Reference to the Gerroa 1:25,000 Acid Sulphate Soil Risk Map (1997) Edition 2, indicates that a section of the site between the southern side of the Princes Highway and the Crooked River is an area of high probability of ASS occurrence being described as low alluvial plains, estuarine sandplains, estuarine swamps, backswamp and supratidal flats, alluvial plains, alluvial swamps, alluvial levees, sandplains and elevated levees in estuarine reaches of catchments. ASS, if present, are considered to be widespread or sporadic in occurrence and pose a severe environmental risk if disturbed. The map shows land immediately to the west of this area at Toolijooa as having a low probability of ASS occurrence.



Map Projection: Transverse Mercator
 Horizontal Datum: Geocentric Datum of Australia (GDA)
 Grid: Map Grid of Australia 1994, Zone 56



LEGEND

- Berry to Foxground upgrade alignment
- Disturbed soils
- High risk
- Low risk
- Roads
- Railways
- Waterways
- Lakes and dams



Roads and Maritime Services
 Water Quality Monitoring

Job Number | 21-23174
 Revision | 0
 Date | 09 Jul 2014

**Berry to Foxground upgrade
 Acid sulphate soils**

Figure 8

Z:\TEMP GIS\berry to foxground\GIS\Maps\MXD\21_23174_2018_BERRY_Overview_AcidSulphateSoils.mxd
 © 2010. While GHD has taken care to ensure the accuracy of this product, GHD and DATA CUSTODIAN, make no representations or warranties about its accuracy, completeness or suitability for any particular purpose.
 GHD and DATA CUSTODIAN, cannot accept liability of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred as a result of the product being inaccurate, incomplete or unsuitable in any way and for any reason.
 Data Source: NSW Department of Lands: DTDB and DCDB - 2012. Created by: pmcdougall

3.7.2 Limited ASS field investigation

Based on the desktop assessment and the findings of the ASS risk maps, Coffey undertook limited field testing as part of the broader geotechnical investigation.

A total of 25 samples were collected from 30 test pits and 20 boreholes throughout the area and were screened using the field pH and peroxide test.

A field pH below 4 can indicate that actual acid sulphate soils are present (i.e. soils in which oxidation of iron sulfides has occurred and have produced acid). Generally a pH drop below 3 following oxidation with hydrogen peroxide indicates the probable presence of unoxidised sulfides in the samples, and for the purposes of the screening test, is taken as an indication of the probable presence of potential acid sulphate soils.

3.7.3 Conclusion of preliminary ASS investigation

Based on the results of the desk studies and fieldwork, Coffey 2007 concluded that portions of the study area are likely to be affected by ASS.

Soils showing typical characteristics normally associated with ASS and located in lower lying parts of the study area (less than about 10 m AHD) were identified at locations south and south west of Berry and north of Gerringong. These soils were typically limited to the upper parts of the soil profile in the upper 1.5 m to 3 m. Both locations have been identified as 'high probability' of the occurrence of ASS at or near the ground surface.

In general, field screening results confirmed the field observations and correlated well with the ASS risk map.

Lower lying areas in the eastern parts of the study area have a high likelihood of being ASS, particularly within the alluvial and estuarine units. Other geotechnical units in the study area generally have a low likelihood of potential acid sulphate occurrence.

Appropriate identification of potential high hazard and high risk ASS zones should be carried out along the preferred route at the planning and design stage. Activities such as creek culverts, drainage works, and stormwater basins become a high risk if they are likely to intersect zones with a high ASS hazard rating. Proper planning may avoid placing these high risk activities in areas of high ASS hazard.

4. Overview of environmental impacts

4.1 Background

Potential impacts of the FBB Princes Highway upgrade on water quality were investigated as part of the project approval assessments under Part 3A of the EP&A Act and are discussed in detail in Chapter 7.4.3 of the EA Report (AECOM, 2012). An understanding of the risks to groundwater quality associated with the construction and operational phases of the project is critical in developing an adequate monitoring program.

The following sections provide an overview of the key sources of impact and associated impacts to guide the development and assessment of performance objectives, standards and measurement criteria.

4.2 Sources of Impact

The key sources of risk can differ significantly between construction and operation and as such have been reviewed independently in the following sections. The review of construction and operational risks below is provided to identify the potential sources of risk and does not discuss management of these risks or represent the residual risk to water quality following implementation of mitigation measures (Aurecon, 2010b).

This section reviews the potential sources of risk rather than the significance of the impact on water quality, a subsequent interpretation of the significance of those risks and measures to mitigate the risks are provided in following sections.

4.2.1 Construction impact sources

Construction impacts may include potential changes to groundwater quality and groundwater levels. Further detail on these impacts is provided below.

Reduced groundwater recharge

The construction of access roads, tracks and the isolation of areas for stockpiling of construction materials can alter groundwater recharge. Compaction of shallow soils due to construction works may be caused in areas of unconsolidated alluvial sediments which can also result in reduced groundwater recharge. Excavation of road cuttings can also locally reduce groundwater recharge and lower the water table, which may impact surrounding groundwater dependent systems.

Groundwater drawdown

Deep excavations (such as for bridge footings) and cuttings may require temporary localised dewatering during the construction phase and the drawdown associated with this can affect groundwater elevations and yields/flows at key receptors such as the surface water features, groundwater dependent ecosystems and groundwater users.

Localised dewatering would temporarily alter groundwater flow conditions but after dewatering is completed original groundwater flows would be re-established.

Should dewatering be required during the construction of road cuttings, the impacts will depend on the local hydraulic conductivity of the aquifer matrix and secondary water bearing structural features. This drawdown would be permanent and would remain after construction as cuttings would act as an ongoing groundwater discharge point.

Table 4 summarises the expected drawdowns at cuttings along the alignment.

Table 4: Assessment of Potential Impacts at Cuttings (adapted from Coffey, 2010, Table 8)

Chainage of Cutting (m)	Degree of Impact or Risk	Comment
07980 to 08420 (Up to 9 m deep)	Low to Moderate	This cutting may slightly modify groundwater levels in its vicinity and result in localised drawdown of up to 3 m.
08480 to 09400 (Up to 27 m deep)	Moderate	Existing groundwater levels will be affected by this cutting and may result in localised drawdown of up to approximately 15 m.
11360 to 11700 (Up to 12 m deep)	Low	Existing groundwater levels are unlikely to be affected by this cutting.
11920 to 12160 (Up to 7 m deep)	Moderate	This cutting will have an impact on groundwater, causing a localised drawdown of up to 4 m.
12200 to 12580 (Up to 12 m deep)	Moderate	Groundwater levels will experience localised drawdown of up to 2 m.
12880 to 13280 (Up to 12 m deep)	Moderate	This cutting will impact existing groundwater levels, causing potential localised drawdown of up to 5 m.
13780 to 14150 (Up to 11 m deep)	Low to Moderate	This cutting will have an impact on groundwater, causing a localised drawdown of up to 3 m.
14580 to 14980 (Up to 4 m deep)	Low	Existing groundwater levels are unlikely to be affected by this cutting.
15300 to 15820 (Up to 13 m deep)	Low	Existing groundwater levels are unlikely to be affected by this cutting.
17540 to 17760 (Up to 7 m deep)	Low	Existing groundwater levels are unlikely to be affected by this cutting.
18220 to 19160 (Up to 5 m deep)	No data	No groundwater level data is available for the two cuttings.
20020 to 20300 (Up to 5 m deep)	No data	No groundwater level data is available for the two cuttings.

In addition to the above impacts, groundwater elevation impacts can also be created by extraction for water supply during construction.

Lowering the groundwater table may also have other impacts such as exposing ASS, if present, which can impact the water quality at sensitive receptors. It may also result in the settlement of unconsolidated soils which may result in movement and damage of existing structures.

Groundwater quality

Potential groundwater quality risks include spills and accidents throughout construction and through diffuse impacts associated with general site activities. Contaminants of primary concern generally consist of hydrocarbon contamination and other residual chemicals associated with the use of explosives for blasting. Impact is likely to occur through the infiltration of spilt or diffuse contamination through surfaces or treatment facilities (such as sediment dams) to the underlying groundwater systems.

The location of construction sediment dams is currently unknown.

4.2.2 Operational impact sources

On-going impacts may also occur during the long-term operation phase of the project. These impacts may include changes to groundwater quality and groundwater levels. Further detail on these impacts is provided below.

Reduced Groundwater Recharge

Increasing the hard surface roads and associated project infrastructure area will increase runoff and decrease groundwater recharge. This may reduce groundwater elevations resulting in potential impacts to surrounding groundwater dependent systems on a permanent basis.

Interception of groundwater and groundwater drawdown

Significant drawdown will occur during construction of cuttings which will remain after construction and throughout the lifetime of the upgrade. This may impact result in potential impacts to surrounding groundwater dependent systems on a permanent basis

The deepest road cutting is up to 27 metres below ground surface through the Toolijooa Ridge cut, bypassing Broughton Village. Preliminary assessments indicate that groundwater would seep into the cutting from the latite and Kiama Sandstone.

Other cuts along the alignment are no deeper than 13 metres and may also be subject to groundwater inflows. Inflow to the cuttings may reduce groundwater recharge (as through flow), lower the local watertable and alter groundwater flow paths. Cuttings in fractured rock may intersect water bearing fractures which are likely to seep.

Groundwater quality

Road runoff can contain pollutants associated with vehicular movement and normal use due to leaks, spills and accidents. The contaminants can include hydrocarbons (petrol, diesel and oils), metals, suspended solids and other compounds.

It is noted that the current environment included Princes Highway runs through this area and as such the groundwater environment will already be reflective of this type of land-use.

Operational water quality basins and roadside swales are to be established to remove suspended solids to meet surface water quality criteria. They may be responsible for infiltration of low level diffuse contamination to groundwater, however, the improved designs will result in less infiltration than the current highway.

The locations of roadside swales are currently unknown but are assumed to be located along the alignment where conditions are suitable for directing run-off to swales. A total of 18 operational water quality basins are planned along the project highway alignment. Locations of the water quality basins are summarised in Table 5.

Table 5: Proposed water quality basin locations

Proposed Water Quality Basin	Chainage
1A	7700
2A	7950
3A	9800
4A	9425
5A	11000
6A	11350
7A	12100
8A	12700
8B	13450
9A	13500
9B	13750
9C	14350
10A	15000
11A	15800
12A	15950
13A	16150
14A	16400
15	18000

4.3 Sensitive Receptors

Sensitive receptors associated with groundwater related impacts on linear alignment projects in an area similar to the current project generally include:

- groundwater users and the existing beneficial use of the aquifer systems in this area;
- surface water features;
- farm dams;
- groundwater dependent ecosystems (GDE's);
- acid sulphate soils (while this not a specific sensitive receptor, it represents a point or location where exposure may initiate impacts to the range of sensitive receptors listed above); and
- existing structures located on areas prone to dewatering settlement.

Further details on the locations and characteristics of these potential receptors along the alignment are provided below.

4.3.1 Groundwater Users

A review of water bores registered with NOW indicates there are 33 registered bores within 1 km of the project. Although the data within the database are limited, analysis indicates that groundwater along the alignment is used predominantly for stock, domestic and agricultural purposes to supplement surface water supplies collected in farm dams and pumped from creeks. Groundwater is extracted from a variety of aquifers including latite, gravels, sandstone, shale and fractured rock. The groundwater yield is variable but typically less than two litres per second.

There are no drinking water catchments in the project area. Groundwater has low use within the region because the area receives a relatively high rainfall and Shoalhaven Water provides a reticulated water supply to Berry. North of Berry water users are more reliant on tank water and groundwater.

Table 6 summarises the registered groundwater bores within a 1 km radius of the project alignment.

Table 6: Summary of registered groundwater bores within 1 km of the project alignment

Work No	Completed depth (m bgl)	Date completed	Licensed Purpose (Status)	Yield (L/s)	Salinity (ppm or description)	Other Comments
GW047344	45.80	01/04/1979	Stock (cancelled)		Good	
GW072784	36.00	02/02/1995	(Unknown)		Good	
GW054770	12.20		Domestic (active)			Site visited, owner informed that well had collapsed. No longer used.
GW107697	30.00	07/12/2005	Domestic	5.0	360	
GW015286	25.90	01/01/1957	Recreation – Groundwater (cancelled)		0-500	Site walk over conducted, well no longer appears to exist. Now owned by RMS.
GW011451	27.40	01/02/1956	Domestic (active)		0-500	Site visited, well not in use and no plans to use it in future.
GW010826	22.90		(Unknown)		(Unknown)	
GW028887	28.60	01/04/1962	Stock (active)		(Unknown)	
GW065515	48.80	13/09/1991	(Unknown)		Good	Spoke with owner, well no longer exists.
GW025595	6.00	01/01/1965	Irrigation (cancelled)		(Unknown)	Site visited and found not be used and unlikely to be usable.
GW042994	36.30	01/01/1970	Irrigation		(Unknown)	

Work No	Completed depth (m bgl)	Date completed	Licensed Purpose (Status)	Yield (L/s)	Salinity (ppm or description)	Other Comments
			(lapsed)			
GW016425	25.20	01/01/1942	Farming (active)		(Unknown)	
GW100567	24.00	03/04/1997	Domestic (active)		Good	
GW101971	24.00	13/03/1997	Stock (active)	1.11	Good	
GW108622	36.00	31/10/2006	Domestic (active)	1.67		
GW105826		27/04/2005	Stock (active)			Site visited, pump still present and suggests this well could be being used.
GW109881	36.00	01/01/1999	Stock (active)	0.30		
GW015221	9.70		Stock (active)		(Unknown)	
GW013536	36.10	01/12/1957	Stock (active)		(Unknown)	
GW103006	90.00	23/02/2000	Domestic (active)			
GW102017		17/03/1999	Stock (active)			
GW029638	30.40	01/10/1968	Stock (active)		(Unknown)	
GW028837	32.30	01/08/1968	Farming (active)			
GW015223	15.20	01/02/1957	Stock (active)		0-500	Site visited and found not be used. Now owned by RMS.
GW103077	36.00	13/06/2000	Stock (active)		240	
GW054712	44.00		Stock (active)		(Unknown)	Site visited, pump still present but very old. Could be being used. Now owned by RMS.
GW023627	25.60	01/11/1965	Not known (cancelled)		(Unknown)	
GW102391	36.60	01/01/1975	Stock (active)	1.26		
GW103007	17.98	01/01/1950	Domestic (active)			
GW049981	38.00	01/03/1979	Stock (active)		Good	
GW102335	15.24	01/01/1990	Stock (active)	1.30		
GW101850	33.50	01/01/1977	Domestic	12.6		

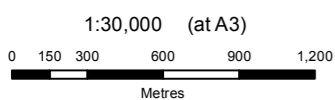
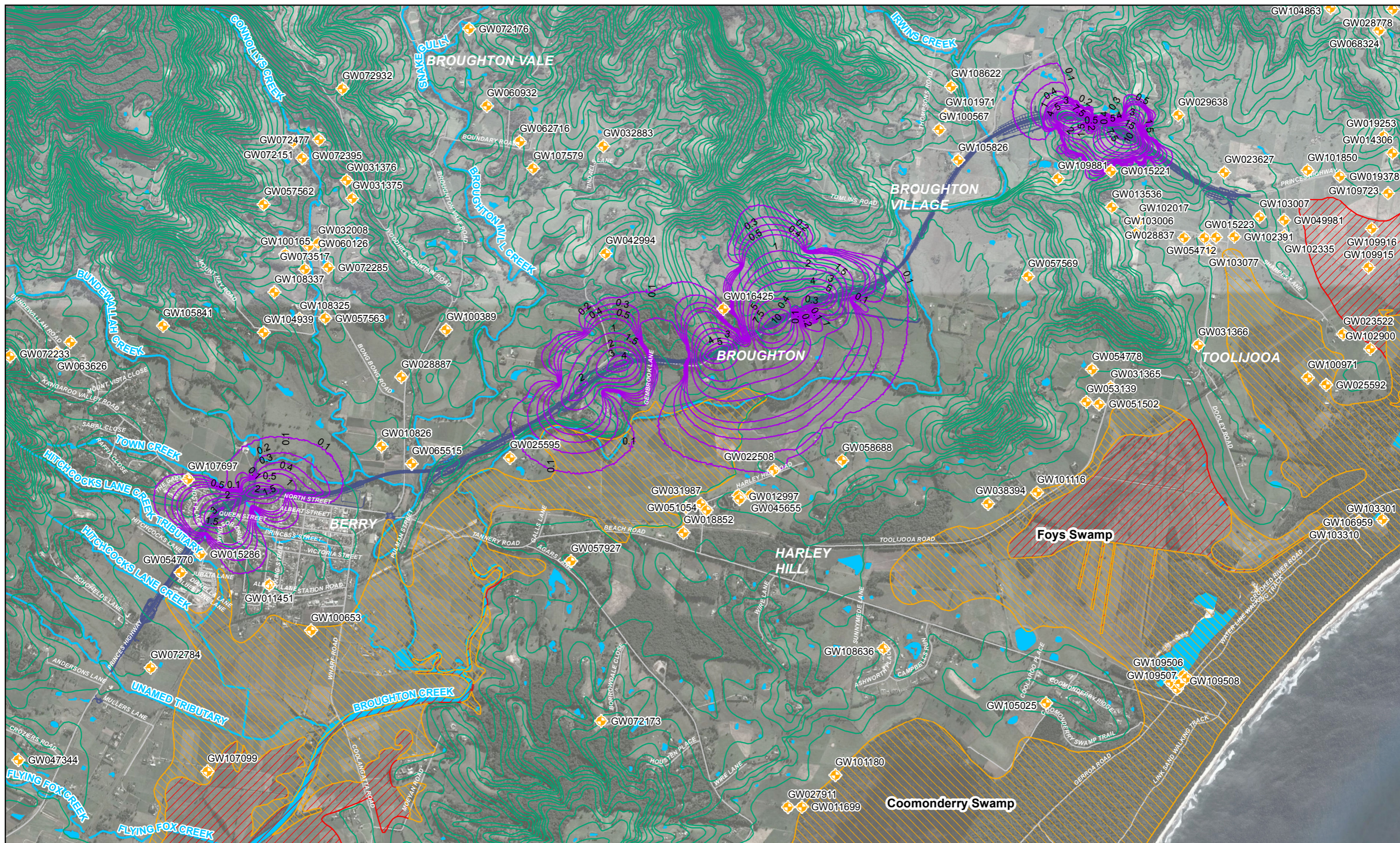
Work No	Completed depth (m bgl)	Date completed	Licensed Purpose (Status)	Yield (L/s)	Salinity (ppm or description)	Other Comments
			(active)	0		
GW019378	20.10	01/09/1961	Stock (active)		Hard	

Figure 9 presents the location of the registered groundwater bores alignment. These wells could potentially be impacted by project related groundwater drawdown impacts.

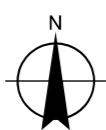
Based on the topographical and groundwater conditions along alignment, the wells located within 1 km of the alignment that are interpreted to be potentially down gradient of alignment include:

- GW102391, which is currently registered as being active for stock purposes.
- GW054712, which is present in a potentially suitable condition but does not appear to be being used.
- GW015223, which is present in a potentially suitable condition but does not appear to be being used.
- GW028837, which is currently registered as being active for farming purposes.
- GW023627, which has a registered status of being cancelled and is there not anticipated to be used.
- GW105826, which may currently be being used. Given the proximity of this well to the alignment it would appear likely that RMS now own this well which would provide flexibility to decommission the well if it as considered to be negatively impacted.
- GW065515, which after discussions with site owners appears to no longer exist.
- GW011451, which site visits suggest is no longer used and will not be used in future.
- GW015286, which site visits suggest no longer exists.
- GW054770, which site visits suggest is no longer used and has collapsed.

The five wells are interpreted to still be used or to be potentially used in the list above wells may potentially be impacted by changes in groundwater quality associated with the project.



Map Projection: Transverse Mercator
 Horizontal Datum: Geocentric Datum of Australia (GDA)
 Grid: Map Grid of Australia 1994, Zone 56



LEGEND

- | | | |
|--------------------------------------|-----------------|----------------|
| Registered Groundwater Wells | Disturbed soils | Railways |
| Simulated Groundwater Drawdown | High risk | Waterways |
| Elevation Contours | Low risk | Lakes and dams |
| Berry to Foxground upgrade alignment | Roads | |



Roads and Maritime Services
 Water Quality Monitoring

**Berry to Foxground upgrade
 Overview of Groundwater
 Receptors and Project Impacts**

Job Number | 21-23174
 Revision | 0
 Date | 09 Jul 2014

Figure 9

Z:\TEMP GIS\berry to foxground\GIS\Maps\MXD\21_23174_2019_BERRY_Overview_GWRceptors.mxd
 © 2010. While GHD has taken care to ensure the accuracy of this product, GHD and DATA CUSTODIAN, make no representations or warranties about its accuracy, completeness or suitability for any particular purpose.
 GHD and DATA CUSTODIAN, cannot accept liability of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred as a result of the product being inaccurate, incomplete or unsuitable in any way and for any reason.
 Data Source: NSW Department of Lands: DTDB and DCDB - 2012. Created by: pmcdougall

4.3.2 Farm Dams, watercourses and water bodies

Most surface water bodies (streams, lakes, reservoirs, wetlands, and estuaries) interact with groundwater to some degree. Groundwater-surface water interactions may take place where streams gain water due to the inflow of groundwater through the streambed or where streams lose water to groundwater due to outflow through the streambed. A combination of both inflows and outflows may occur along various stream reaches. For example, a stream may be gaining water along selected reaches while losing water along other reaches. As such, surface water features potentially in hydraulic connection with groundwater passing beneath the alignment may be impacted by changes to groundwater elevations and quality at the alignment.

The project alignment also crosses several surface water catchment areas. From north to south these are: The Crooked River Catchment, Broughton Creek Catchment, Broughton Mill Creek Catchment, Connollys Creek Catchment, Bundewallah Creek Catchment, Town Creek Catchment, Hitchcocks Lane Creek Catchment, and the unnamed Tributary of Broughton Creek Catchment.

The majority of the alignment is located within the Broughton Creek Catchment, with Broughton Creek crossing the alignment three times. Broughton Creek also runs parallel to the alignment between chainage CH 14600 and CH 15700, coming as close as 40 m towards the boundary of the alignment.

Minor ephemeral surface water runoff lines are located within grass paddocks of bordering farms. These water courses are believed to only contain any flow after major rainfall events, discharging into the major creeks within the catchment systems.

Table 7 summarises the major creeks that cross the project alignment.

Table 7: Summary of creeks crossing the project alignment

Creek	Chainage
Broughton Creek	CH 9950; CH 10750; CH 11200
Broughton Mill Creek	CH 15850
Connollys Creek (including Bundewallah Creek)	CH 16250
Town Creek	CH 17450
Hitchcocks Lane Creek Tributary	CH 18100
Hitchcocks Lane Creek	CH 18580
Unnamed Tributary of Broughton Creek	End of chainage

The flows and water quality in these surface features may be impacted by project construction and operation at the point of crossing.

Approximately 29 farm dams have been identified along the alignment (AECOM, 2012). The farm dams are anticipated to be primarily reliant on surface water run-off harvesting and are unlikely to have significant connections to groundwater systems. Contact with groundwater for the farm dams is therefore likely to be negligible, however, with the current conceptual understanding interaction of farm dams with groundwater cannot be ruled out.

4.3.3 Groundwater dependent ecosystems

The NSW State Groundwater Dependent Ecosystems Policy (DLWC, 2002) is specifically designed to protect valuable ecosystems which rely on groundwater for survival so that, wherever possible, the ecological processes and biodiversity of these dependent ecosystems are maintained or restored for the benefit of present and future generations. The policy defines GDEs, as “communities of plants, animals and other organisms whose extent and life processes

are dependent on groundwater.” A GDE may either be entirely dependent on groundwater for survival or it may use groundwater opportunistically or for a supplementary source of water (Hatton and Evans, 1998). GDEs often occur in low lying areas with shallow groundwater close to the surface, however they are also associated with perched swamps, springs, karsts and base-flow to creeks and estuaries.

Five management principles establish a framework by which groundwater is managed in ways that ensure, whenever possible, that ecological processes in dependent ecosystems are maintained or restored. A summary of the principles are as follows:

- GDEs have important values. Threats should be identified and action taken to protect them.
- Groundwater extractions should be managed within the sustainable yield of aquifers.
- Priority should be given to ensure that sufficient groundwater is available at all time to identified GDEs.
- Where scientific knowledge is lacking, the precautionary principle should be applied to protect GDEs.
- Planning, approval and management of developments should aim to minimise adverse effects on groundwater by maintaining natural patterns, not polluting or causing changes to groundwater quality and rehabilitating degraded groundwater systems.

Groundwater from the alluvial aquifer systems associated with the Broughton Creek floodplain discharges into Broughton Creek. Riparian vegetation associated with Broughton Creek is likely to be dependent upon groundwater in some capacity. Local shallow groundwater flow systems also exist within elevated parts of the catchment within the Berry Sandstone and latite. Groundwater discharge is via springs, seeps or spring fed dams may also sustain local small communities.

Coomonderry Swamp and Foys Swamp are coastal freshwater wetlands, located east of Broughton Creek (See Figure 9). Due to their distance from the alignment and the intervening geological and topographical conditions, these systems are not expected to be in significant hydraulic connection with groundwater flowing beneath the alignment. The Sydney Basin Southern management zone of the Greater Metropolitan Region Water Sharing Plan for the project area identifies Coomonderry Swamp as a high priority GDE in Schedule 4 of the Plan (NOW, 2011a). Coomonderry Swamp is a large (429 hectare) semi-permanent freshwater swamp, northeast of Nowra that is listed on the register of the National Estate. Foys Swamp is not listed in the Water Sharing Plan.

Floodplain swamp forest is a low, dense forest tolerant of brackish groundwater that was identified along Toolijooa Road and the railway line between Berry and Gerringong (Maunsell, 2007). This community may grade into estuarine fringe forest with increasing groundwater salinity. Due to their distance from the alignment and the intervening geological and topographical conditions, these systems are not expected to be in significant hydraulic connection with groundwater flowing beneath the alignment.

No groundwater springs of significance have been identified to be potentially impacted by the alignment.

4.3.4 Acid sulphate soils

There is a low risk that ASS may be present near to the alignment in low lying areas around Broughton Creek (see Figure 9). Should the water table be lowered where ASS is present, ASS may become exposed and oxidation of sulphide minerals could result. This process generates sulphuric acid and increases metal concentrations in solution, which can lead to degradation of

groundwater quality. Rainfall runoff could cause low pH water to migrate within the shallow groundwater system and discharge into surface water systems and groundwater receptors.

According to the ASS risk maps (Coffey, 2007), no known occurrence has been reported for ASS along the project alignment north of Berry.

Low probability of ASS occurrence within 1 and 3 metres below ground surface is reported for the area to the south and south east of Berry and in a number of areas extending along Broughton Creek to central areas of the alignment around Tindalls lane.

4.3.5 Existing structures on soils prone to settlement

There is a potential risk associated with settlement of unconsolidated sediments where they have been dewatered. This may result integrity issues to existing structures located on these sediments. Figure 9 of Coffey Geotechnics, Maunsell Aecom (2007) suggests that soft soils of generally less than 3 m in thickness are generally located between Broughton Creek and the proposed alignment, Austral Park Road and Berry. These sediments are also located in southern areas of Berry Township.

4.4 Assessment of Impacts

This section further characterises the significance of groundwater quality and groundwater elevation/drawdown changes associated with the project on the groundwater receptors identified above.

The section focuses on the primary sources of risk discussed in Section 4.2 and the impacts that these sources may have on the identified receptors discussed in Section 4.3.

4.4.1 Recharge Reduction Impacts

Recharge reduction impacts resulting in lowering of the groundwater table are expected to have a very small impact on overall groundwater elevations yields/flows at the identified receptors. This is because reduction in recharge associated with compaction, paved surfaces and infrastructure during construction and operation are very insignificant compared to the overall size of the catchments contributing to groundwater recharge. As such, this is not considered to represent a significant impact.

The reduction in recharge may contribute slightly to cumulative impacts associated with groundwater drawdown around cuttings, however, these would be relatively insignificant compared with the large changes created by cuttings.

4.4.2 Groundwater Drawdown Impacts

Localised drawdown during construction associated with bridge footing installation will mainly occur in the vicinity of existing surface water features where bridge construction is occurring. The extent of overall drawdown would be limited as dewatering would be temporary in nature and localised to small footprints. Surface water flows will have the potential to be impacted by drawdown and management measures will be required to limit this impact. Acid sulphate soils maps suggest that acid sulphate soils are unlikely to be intercepted by the localised and temporary drawdown impacts. There are no identified sensitive groundwater wells identified within the vicinity of these localised drawdowns. There may be some potential for settlement of sediments in the vicinity of any bridge footing near surface water structures.

A numerical groundwater model has been developed to assess the impact of the project on groundwater users and groundwater dependent systems associated with drawdown around cuttings, which represent the primary source of groundwater elevation changes. The groundwater modelling report is presented in **Appendix A**.

The modelling approach and complexity was based on that undertaken prior to construction for other major road upgrade projects in NSW where groundwater is considered to be sensitive.

Changes in groundwater recharge due to the development of the project and associated increases in sealed and compacted surfaces have not been simulated by groundwater modelling. This is because these impacts are expected to be small given that sealed and compacted areas are likely to represent a small percentage of the overall catchment recharge.

The predicted impacts to identified receptors are presented in Figure 9 and summarised below:

- Significant drawdown impacts have been identified to occur at five main locations including the Toolijooa Ridge cut, at three separate locations between Austral Park Road and Tomlins Lane and at the western end of Berry Township.
- The impacts are likely to develop during construction with subsequent stabilisation during operation of the project.
- Impacts to surrounding registered groundwater wells are simulated to be within acceptable ranges, with the maximum predicted drawdown within impacted registered groundwater wells approximating less than 0.2 m.
- The drawdowns are expected to result in a less than 1 % reduction in the base flow component of catchment surface water features. This is anticipated to have negligible impacts on in-stream aquatic ecology and existing surface water users' supplies; however, further consultation with ecological specialists is required to validate this.
- Impacts to sensitive surface water features such as Coomonderry Swamp and Foys swamp are simulated to be negligible.
- The zones of drawdown influence created by the cuttings near to Tindalls Lane and Tomlins Road are simulated to intersect areas where there is low potential for the presence of Acid Sulphate soils. The exposure of acid sulphate soils in these areas could result in pH and metals impacts within Broughton Creek.
- The zones of drawdown influence created by the cuttings extend under isolated developments along the alignment, particularly in the Berry area, that are potentially situated on unconsolidated materials.
- Ten farm dams are intersected by the zone of drawdown influence of which six are interpreted to be within zones of drawdown greater than 0.2 m. Given that the farm dams rely primarily on surface water harvesting it is considered unlikely that they will be impacted by groundwater drawdown unless they have significant contact with groundwater, which is currently unknown.

Given the current understanding of design and construction of the alignment it is recommended that the modelling is revised when there is more certainty on the design levels and construction program. At this time more detailed assessment of non-uniqueness in the modelling outcomes should be considered.

It is not expected that groundwater extraction for water supply will be required during construction and or operation as such no impacts are considered likely. If this need is identified during detailed design, further investigation would be required to be undertaken to quantify the impacts and develop appropriate mitigation measures.

4.4.3 Groundwater Quality Impacts

The sources for groundwater quality impacts differ between construction and operation however, ultimately the impacts will arise from infiltration of residual or spilt chemicals during the construction and operation phases.

Based on the current understanding of aquifer properties and likely groundwater migration rates it is expected that the impacts will emerge slowly as impacted groundwater migrates down hydraulic gradient.

This does not include impacts associated with the generation of acid sulphate soils which may be more rapid and have been discussed previously.

The primary receptors potentially down gradient of the alignment include all surface water features located down gradient particularly Broughton Creek, farm dams and the five registered groundwater wells GW102391 , GW054712 (owned by RMS), GW015223 (owned by RMS), GW028837 and GW105826 (owned by RMS). The wells owned by RMS are not considered likely to be adversely impacted. There are no other identified sensitive groundwater dependent ecosystems down gradient of the alignment and other receptors identified in Section 4.3 (i.e. structures and acid sulphate soils) are not expected to be affected by water quality impacts.

Any emerging impacts are expected to be diffuse and minor/low level in nature as mitigation measures will be adopted during construction and operation to prevent infiltration of chemicals to groundwater, appropriately treat infiltrating surface water and/or prevent contact of surface water run-off with groundwater. These mitigation measures are discussed further in the following sections.

Water quality impacts to farm dams are expected to be negligible because connection with groundwater is expected to be limited if at all present and because the primary water inputs to the dams are from surface water harvesting.

Water quality impacts to down gradient groundwater users may be compounded by pumping at these wells which will result in increased capture zone size and a greater potential to draw in diffuse impacts associated with the alignment.

The existing highway will have already resulted in low level impact to the groundwater system. The adoption of more advance capture and treatment systems for the upgrade is anticipated to result in a reduction in any existing low level contaminant infiltration to groundwater, which may improve current groundwater quality along the alignment.

Groundwater monitoring will be required to assess whether diffuse impacts associated with construction and operation are creating an adverse impact that needs to be mitigated.

4.5 Management of environmental risks

The assessment of potential impacts presented in Section 4.4 suggests that mitigation measures will be required to:

- Prevention of drawdown impacts including:
 - temporary impacts associated with construction works for bridge footings.
 - reduced flow to farm dams.
 - exposure of acid sulphate soils, especially within the vicinity of cuts located near to Tindalls Lane.
 - settlement along the alignment and hence impacts to building structures during both construction and operation.

- Minimise potential for contamination to underlying groundwater during both construction and operation.

The mitigation measures to be adopted to manage/mitigate these impacts are discussed below.

4.5.1 Management of Drawdown Impacts

Temporary drawdown during construction

Should dewatering of the alluvial aquifer be required during the construction of bridge footings, groundwater drawdown will be limited to the base of the footing, and the zone of influence or induced cone of depression (which is expected to be limited due to the more transmissive nature of an alluvial aquifer soils).

The management of the impacts will be dealt with in the construction and environmental management plan (CEMP) and/or with the adoption of construction methods/design that limit interaction with groundwater. Any requirement to monitor for the effectiveness of the methods implemented would be dealt with in the CEMP.

This drawdown will most likely occur within the immediate vicinity of surface water features and targeted flow monitoring at surface water locations will likely deal with these issues.

Additional groundwater modelling may be required to assist in quantifying the amount of groundwater drawdown and any potential impacts.

Dewatered groundwater, if impacted by construction activities, may require appropriate treatment primary to re-infiltration back into the groundwater system. This would be dealt with in the CEMP.

Management of flow to farm dams

Given the low probability of impacts to farm dam water supply, if impacts to farm dams were to become apparent an additional groundwater supply well would be provided.

While the potential for impacts to farm dams is expected to be very low infiltration of dewatered groundwater during construction and operation up gradient of farm dams would further minimise the potential for groundwater related impacts.

Management of Acid Sulphate Soil Exposure

It is expected that the overall likelihood of impact from acid sulphate soil exposure is low as cut induced drawdowns are only expected to intersect zones of low probability acid sulphate soils. Further consideration of this potential impact has been recommended by the EPA to be undertaken at detailed design phase. The following additional management measures will be considered:

- investigations to delineate the presence of acid sulphate soils and hence the presence of an actual risk.
- re-infiltrating dewatered groundwater upgradient of potential acid sulphate soil areas. There would be an opportunity to optimise construction mitigation using the existing groundwater model.

If all groundwater is returned to the groundwater system down gradient of the cut it would be expected that drawdown impacts would be limited to the immediate area around the cuts upgradient of seepage zones and would minimise the development of drawdown impacts down gradient of the seepage zone.

A strategically placed groundwater elevation monitoring bore would be useful to assess the effectiveness of implemented solutions to mitigate this potential impact. It could also act as an

early warning mechanism for the presence of emerging impacts and hence a requirement to investigate and implement additional mitigation measures.

Settlement Related Impacts

At present there is a predicted risk of groundwater drawdown to intersect soft soil sediments that have the potential to settle and damage overly structures especially in Berry Township. Further investigation is required by an appropriately qualified professional in characterising settlement issues to determine in this intersection actually represents a settlement risk. Subject to a settlement risk being identified the design and construction methods will be required to negate impacts.

Given the potential cost associated with the mitigating these impacts after they occur. Groundwater monitoring will be required to assess the adequacy of mitigation measures and act as a trigger to that additional actions can be taken of impacts were to emerge.

4.5.2 Management of Groundwater Quality Impacts

Construction

It is expected that the risk posed by this type of source would be low due to stringent management measures imposed during construction as part of the CEMP. The CEMP will provide methods and procedures for:

- storage and handling of site chemicals.
- spill management and clean-up.

Further to the above, site practices will be adopted to prevent interaction of surface water with groundwater by diverting groundwater seepage away from construction activities and surface water run-off and capture systems and re-infiltrating the unimpacted groundwater back to the groundwater system downgradient of the site.

Groundwater monitoring will be required to assess the overall effectiveness of these management measures.

Operation

The upgraded highway alignment would likely provide for safer transportation of vehicles compared with the existing alignment. This would reduce the total number of accidents along the upgraded section and therefore the potential of a spill of hazardous substances would also reduce.

In the event that any spills that do occur the spill would be directed to the permanent water quality basins and swales, all of which would have the capacity to receive a spill with a volume corresponding to that of a typical transport truck.

Both water quality basins and swales will have potential for spillage control or containment. These water quality treatment measures provide capacity to treat first flush from the pavement surface and reduce the risk of spills discharging onto adjacent land or watercourses. The potential for spillage control or containment would be based on the hydrologic conditions prevailing at the time of the spill. These structures will be design to limit the potential for infiltration to the underlying groundwater system.

The system will be designed to reduce infiltration of contaminants to groundwater by redirecting any rainfall and associated run-off from the project through a treatment train of swales and water quality basins that will have limited connection to the underlying groundwater systems. The systems will be appropriately designed to facilitate this. The small quantity of run-off that

may ultimately enter the groundwater system would have a low risk of impact to the existing groundwater quality beyond the immediate road corridor.

Further to this groundwater seepage will be kept separate from interaction with surface water and re-directed within separate infrastructure to down gradient locations where it will be re-infiltrated to the groundwater system.

Groundwater monitoring will be required to assess the overall effectiveness of these management mitigation measures. However, the mitigation measures implemented are expected to result in a reduction on potential contaminant infiltration to groundwater compared to the current highway system.

5. Consideration of surface water interactions

Condition of Approval B16 requires that 'The Proponent shall prepare and implement a Water Quality Monitoring Program to monitor the impacts of the project on surface and groundwater quality and resources and wetlands, during construction and operation. The surface water and groundwater monitoring programs have been divided into two separate reports.

A monitoring program has subsequently been developed for surface water quality and is presented in the *Surface Water Monitoring Program – Berry to Foxground Princes Highway Upgrade* (GHD, 2014b).

The groundwater modelling report presented in **Appendix A** outlines the interactions between groundwater and surface water.

6. Monitoring Objectives

6.1 Performance objectives

When developing a monitoring program, performance objectives must be clearly stated to identify the goals of the monitoring program – i.e. what does the monitoring program aim to achieve. It is important the performance objectives are identified early and are agreed by stakeholders to ensure that the monitoring plan is focused on meeting these objectives.

The performance objectives for the FBB Princes Highway upgrade GWMP are based on the findings of the Environmental Assessment investigations, take into account the key concerns of stakeholders, and reflect the intent of the Director General's Conditions of Approval.

The performance objectives are outlined in Table 8, which reflect the performance criteria adopted for the T2E Upgrade.

Table 8: Performance objectives for the monitoring program (adapted from Aurecon 2012).

Performance Objective
1. To monitor for the potential impact of the Upgrade on surface water and groundwater quality to protect the existing and ongoing human, horticultural and agricultural uses of that water
2. To monitor for the potential impact of the Upgrade on water quality to protect existing and future status of aquatic ecology and ecosystem characteristics in all catchments intersected by, and downstream of, the Upgrade

6.2 RMS water policy

The above objectives also support the RMS water policy (RTA, 2010):-

'The Roads and Traffic Authority would use the most appropriate water management practices in the planning, design, construction, operation and maintenance of the roads and traffic system in order to:-

- *conserve water;*
- *protect the quality of water resources; and*
- *preserve ecosystems'.*

7. Performance standards

The performance objectives of this monitoring plan focus on three key areas – that is, protection of groundwater quality; protection of groundwater hydrology; protection of licensed bores and dams and protection of groundwater dependent ecosystems. The proposed performance standards provide a framework against which the protection of these aspects can be assessed.

In accordance with recommendations provided in the EA this section mimics that presented in the water quality monitoring documents for the T2E project developed by Aurecon, in 2010.

7.1 Protection of groundwater quality

7.1.1 Water quality guidelines

There are several water quality standards of relevance to a project of this nature and each have been reviewed in determining an appropriate performance standard for the FBB Princes Highway upgrade. The standards include:-

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000a);
- Australian Drinking Water Guidelines (NHMRC, 2004); and
- Guidelines for Groundwater Protection in Australia (ANZECC, 1995).

A brief summary of these documents and discussion of their relevance to the project is provided below.

ANZECC guidelines

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC guidelines) provide a management framework, guideline water quality triggers, protocols and strategies to assist water resource managers in assessing and maintaining aquatic ecosystems. The guidelines are intended to provide government, industry, consultants and community groups with a sound set of tools that would enable the assessment and management of ambient water quality in a wide range of water resource types, and according to designated environmental values.

The primary objective of the ANZECC guidelines is:-

To provide an authoritative guide for setting water quality objectives required to sustain current or likely future environmental values for natural and semi-natural water resources in Australia and New Zealand.

The ANZECC guidelines provide the following water quality management framework:-

1. Identify the environmental values that are to be protected in a particular water body and the spatial designation of the environmental values (i.e. decide which values would apply where).
2. Identify management goals and then select the relevant water quality guidelines for measuring performance. Based on these guidelines, set water quality objectives that must be met to maintain the environmental values.
3. Develop statistical performance criteria to evaluate the results of the monitoring programs (e.g. statistical decision criteria for determining whether the water quality objectives have been exceeded or not).

4. Develop tactical monitoring programs focusing on the water quality objectives.
5. Initiate appropriate management responses to attain (or maintain if already achieved) the water quality objectives.

The guidelines recommend numerical and descriptive water quality guidelines to help managers establish water quality objectives that would maintain the environmental values of water resources. They are not standards, and should not be regarded as such (ANZECC, 2000a).

Of particular importance to note is the philosophical approach for using the ANZECC guidelines of: *'protect environmental values by meeting management goals that focus on concerns or potential problems'* (ANZECC, 2000a). That is, development of a monitoring program, including the objectives, standards and measurement criteria, should focus on specific issues not on pre-determined guideline values.

The philosophy, management framework and guiding principles outlined in the ANZECC guidelines have formed the basis for development of project specific performance standards for the FBB Groundwater Monitoring Program.

The following guidance is provided for the application of the ANZECC guidelines to groundwater management:

Groundwater is an essential water resource for many aquatic ecosystems, and for substantial periods it can be the sole source of water to some rivers, streams and wetlands. Groundwater is also very important for primary and secondary industry as well as for domestic drinking water, particularly in low rainfall areas with significant underground aquifers.

Generally these Guidelines should apply to the quality both of surface water and of groundwater since the environmental values which they protect relate to above-ground uses (e.g. irrigation, drinking water, farm animal or fish production and maintenance of aquatic ecosystems). Hence groundwater should be managed in such a way that when it comes to the surface, whether from natural seepages or from bores, it would not cause the established water quality objectives for these waters to be exceeded, nor compromise their designated environmental values.

As a cautionary note the reader should be aware that different conditions and processes operate in groundwater compared with surface waters and these can affect the fate and transport of many organic chemicals. This may have implications for the application of guidelines and management of groundwater quality.

Australian Drinking Water Guidelines

The Australian Drinking Water Guidelines (ADWG), published by the National Health and Medical Research Council, 'provide the authoritative Australian reference for use within Australia's administrative and legislative framework to ensure the accountability of drinking water suppliers (as managers) and of state/territory health authorities (as auditors of the safety of water supplies)' (ADWG, 2004).

With appropriate consultation with the community, the ADWG may be used directly as agreed levels of service or they may form the basis for developing local levels of service. In the case of health-related water quality characteristics there is less latitude for variation because the safety of drinking water is paramount. However, with regard to aesthetic characteristics, what is acceptable or unacceptable depends on public expectations and can therefore be determined by water authorities in consultation with consumers, taking into account the costs and benefits of further treatment of the water. The ADWG provide a starting point for that process (ADWG, 2004).

The ADWG include both health-related and aesthetic guideline values to guide the short and long term management of drinking water quality. The guidelines do not provide a framework for the management of environmental and catchment values and as such cannot be directly applied to this project. The guidelines do, however, provide a number of principles that have been considered in the preparation of project specific performance standards for the FBB Princes Highway upgrade.

There are no drinking water catchments in the project area (AECOM 2012) and reference to the ADWG (2004) will only be made in the event that groundwater is identified to be used as a potable source.

Guidelines for Groundwater Protection in Australia

The *Guidelines for Groundwater Protection in Australia* form part of the National Water Quality Management Strategy and have been developed with the primary objective of providing 'a national framework for the protection of groundwater from contamination'.

The guidelines 'are intended to address a broader range of basin/catchment management issues than are currently considered in groundwater protection strategies elsewhere, and allow for integration of groundwater planning with surface water planning. The guidelines are based on a planning approach. They adopt the principle of beneficial use of groundwater classification and risk assessment to derive appropriate protection measures' (ANZECC, 1995).

The guidelines do not provide trigger criteria, but rather provide the framework for development of groundwater management plans. For trigger criteria the ANZECC (currently ANZECC, 2000b) water quality guidelines are referenced.

7.2 Protection of groundwater hydrology and groundwater dependent ecosystems

While the performance objectives identify the goals of the monitoring program, the performance standards define the benchmark and measures against which the performance is assessed. It is critical that the performance standards adopted provide a meaningful and quantifiable measure of 'performance'. Setting performance standards for the protection of groundwater hydrology and subsequent impacts on licensed bores, dams and groundwater dependent ecosystems that are capable of quantifying the impact that is directly attributable to the FBB Princes Highway upgrade is complex. For groundwater quality the performance standards allow for an assessment based on changes in quality up-gradient and down-gradient of the project alignment. For groundwater hydrology, the impact must be assessed by review against a baseline data set and, as such, is more open to outside influences such as changing weather, climate or local groundwater resource use. For groundwater dependent ecosystems, any changes in composition or distribution may also be affected by external factors and, as such, would be difficult to attribute to the FBB upgrade.

To assist in the analysis of impacts that can be attributed to the construction and operation of the alignment, hydrology data may be compared to control sites. It is proposed to monitor sites up-gradient of a number of cuts (See Section 9).

7.3 Proposed performance standards

The potential impacts on groundwater water quality, groundwater hydrology, licensed bores and dams and groundwater dependent ecosystems of the FBB upgrade are outlined in Section 4.4. Consideration must be given to external drivers of change in groundwater when determining appropriate performance standards. As discussed above, factors such as groundwater extraction by local users or variability in rainfall and climatic patterns have the

potential to impact on groundwater hydrology and groundwater dependent ecosystems, while changes in catchment condition or land use have the potential to impact on groundwater quality. The nature of each of the potential impacts requires a varied approach to setting performance standards.

For the assessment of impacts on groundwater quality and hydrology, the sampling results for each sample event would be compared against site specific control charts. Control charts present a 'baseline' data set (refer Section 7.4) and are developed based on data from a reference site. The baseline will be comprised of data collected in the 12 months prior to the commencement of construction activities. The control chart for each site provides the performance standard for that site.

For the assessment of impacts on groundwater dependent ecosystems, the performance standards would be based on changes in species (floristic) composition, abundance and distribution/extent over time. These assessments are not part of this monitoring plan.

7.4 Control charts

The Australian Guidelines for Water Quality Monitoring and Reporting (Water Quality Monitoring Guidelines) (ANZECC, 2000b), provide guidance for the development of monitoring programs and assessment of water quality. They form Volume 7 of the National Water Quality Management Strategy (ANZECC, 2000a) of which the ANZECC guidelines are also part.

The Water Quality Monitoring guidelines provide the following discussion of control charts:-

Control charting techniques used for the last 70 years in industry have an important role to play in an environmental context. They are particularly relevant to water quality monitoring and assessment. Regulatory agencies are moving away from the 'command and control' mode of water quality monitoring, and recognising that, in monitoring, the data generated from environmental sampling are inherently 'noisy'. The data's occasional excursion beyond a notional guideline value may be a chance occurrence or may indicate a potential problem. This is precisely the situation that control charts target. They not only provide a visual display of an evolving process, but also offer 'early warning' of a shift in the process level (mean) or dispersion (variability).

The advantages of the use of control charts are identified as:-

- minimal processing of data is required;
- they are graphical: trends, periodicities and other features are easily detected; and
- they have early warning capability: the need for remedial action can be seen at an early stage.

This ability to recognise 'noise' in the water quality data and the early detection of changing trends makes the use of control charts a powerful tool for assessing the impact of the FBB upgrade within a drinking water catchment where other land use factors may be contributing to a change in water quality.

The use of control charts is also suitable for the assessment of impacts on groundwater hydrology. The control chart includes plots of data over time (refer Figure 8) and as such would allow for the assessment of impacts on groundwater hydrology to incorporate potential seasonal variability in the data set.

7.4.1 Development of site specific control charts

For each of the proposed monitoring sites, a site specific control chart would be developed to provide a suitable reference criterion and performance standard. The control chart is produced by plotting the median concentration from the test site against the 80th percentile of the reference site/reference data (i.e. pre-construction data).

The Water Quality Monitoring Guidelines (ANZECC, 2000b) recommend the following procedure for calculating the 80th percentile of the data set:

- arrange the 24 data values in ascending order (i.e. lowest to highest); then
- take the simple average (mean) of the 19th and 20th observation in the ordered set.

An example control chart is provided in Figure 10.

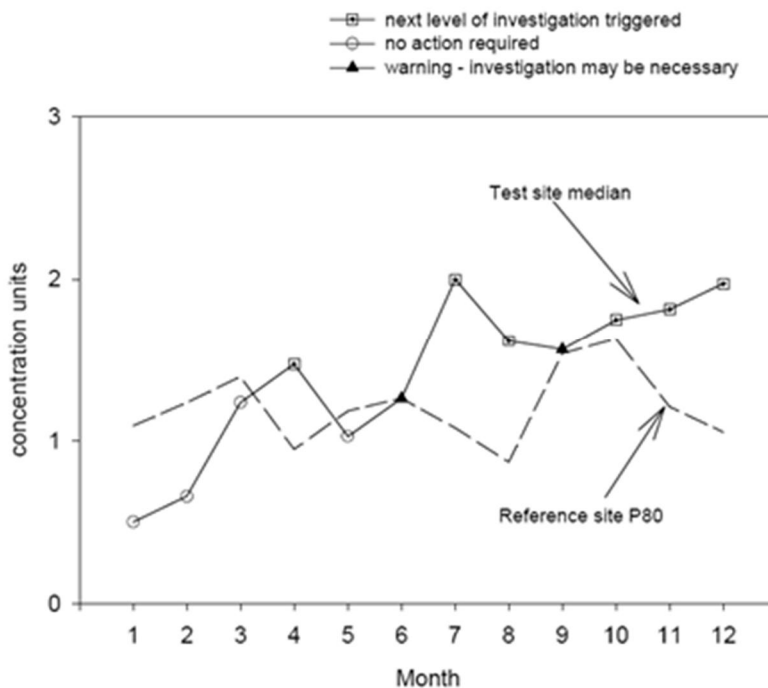


Figure 10: Example control chart

8. Measurement and assessment criteria

Measurement criteria provide the 'trigger' for a management response, are related to the risks associated with the FBB Princes Highway upgrade and allow for assessment against the performance standards. They mimic those adopted for the T2E Upgrade (Aurecon, 2010).

The following sections provide an overview of the measurement criteria, while the processes for assessment that would result in the triggering of a management action are presented in Section 11.

8.1 Groundwater quality trigger criteria

The ANZECC guidelines (ANZECC, 2000a) provide a framework for setting trigger criteria. In the development of this framework the following criteria were considered:-

- explicit recognition of the inherent (and usually large) variability of natural systems;
- robustness under a wide range of operating conditions and environments;
- no, or only weak, distributional assumptions about the population of values from which the test and reference data are obtained;
- known statistical properties, consistent with and supporting the monitoring objectives [of the ANZECC guidelines];
- ease of implementation and interpretation;
- suitability for visual display and analysis; and
- intuitive appeal.

The trigger criterion recommended by the ANZECC guidelines for physio-chemical stressors, and subsequently adopted for the assessment of groundwater quality impacts of the FBB Princes Highway upgrade is stated as:

“A trigger for further investigation would be deemed to have occurred when the median concentration of n independent samples taken at a test site [i.e. down-gradient of the highway] exceeds the eightieth percentile of the same indicator at a suitably chosen reference site [i.e. up-gradient of the highway].”

The above trigger criterion does not define or represent a point where an ecologically significant impact would occur. This approach is intended as an early warning mechanism to alert the catchment manager of a potential or emerging change that would require further investigation (ANZECC, 2000a).

The ANZECC guidelines also note that 'the statistical significance associated with a change in condition equal to or greater than a measurable perturbation [i.e. median of down-gradient sample exceeding 80th percentile of up-gradient sample] would require a separate analysis (ANZECC, 2000a). This analysis is discussed in the following sections.

8.2 Groundwater hydrology trigger criteria

Changes in groundwater hydrology would be assessed using a statistical analysis to test for significant change. The trigger for a management action in relation to groundwater hydrology would be when a statistically significant difference in groundwater levels or flow from groundwater springs (refer Section 9) is shown in the analysis. An overview of the statistical analysis approach is provided in Section 8.4.

In areas impacted by cut drawdown, a comparison of observed and simulated elevations from modelling will be undertaken, observations outside those predicted would represent a trigger for further investigation/characterisation works.

8.3 Groundwater dependent ecosystem trigger criteria

As discussed in Section 7.3, the assessment of impacts on groundwater dependent ecosystems would be based on changes in species/floristic composition, abundance and distribution over time and, as such, a specific trigger criterion may not be set. Sampling would then be undertaken at intervals throughout the operational phase of the project and the data assessed against the baseline. This requires a more subjective assessment and would be undertaken by an ecologist with experience in the assessment of groundwater dependent ecosystems. These assessments are not dealt with as part of this plan.

8.4 Statistical analysis

For the assessment of impacts on groundwater hydrology, the following statistical analysis would be used for the trigger of management actions. For groundwater quality the statistical analysis would be used in addition to the assessment against the trigger criteria outlined in Section 8.1. The statistical analysis would be used to test the significance of any observed difference between the baseline data set and test data for groundwater quality and elevations hydrology. Both a Paired t-Test and a Sign Test would be used in determining statistical significance.

8.4.1 Paired t-Test

A paired t-Test would be used to test the null hypothesis that there is no difference in the pairs (i.e. up- gradient and down-gradient samples at each time step or between the baseline and test data for groundwater hydrology) of data. The paired t-Test assumes that the paired differences (i.e. the difference between the up-gradient and down-gradient samples) are normally distributed around their mean. The two groups of data are assumed to have the same variance and shape. As such, if they differ, it is only in their mean. The null hypothesis can be stated as:-

$$H_0 : \mu_x = \mu_y$$

i.e. the means for group x (upstream) and y (downstream) are identical.

If the differences are not normally distributed and especially when they are not symmetric, the probability (i.e. p-values) from the t-Test would not be accurate. The primary consequence of overlooking the normality assumption underlying the t-Test is a loss of power to detect differences which may truly be present. The second consequence is an unfounded assumption that the mean difference is a meaningful description of the differences between the two groups (Helsel and Hirsch, 2002). Consequently, when assessing results of a t-Test, any large variance of significant outliers in either the up-gradient or down-gradient data set may influence the results.

8.4.2 Sign Test

A Sign Test would also be used to test for significant difference between the up-gradient and down-gradient samples or between the baseline and test data for groundwater hydrology. The Sign Test is used for pairs of data to determine whether one data set (up-gradient) is generally larger, smaller or different than the other (down-gradient). The null hypothesis can be stated as:

$$H_0 : PROB[x > y] = 0.5$$

Two paired groups of data are compared, to determine if one group tends to produce larger (or different) values than the other group. No assumptions about the distribution of the differences are required. This means that no assumption is made that all pairs are expected to differ by about the same amount. Numerical values for the data are also not necessary, as long as their relative magnitudes may be determined (Helsel and Hirsch, 2002). As such, the Sign Test is non-parametric and can be used regardless of distribution. The hypothesis, however, is more general than the t-Test.

The t-Test and Sign Test have both been proposed as each has strengths and weaknesses. The t- Test is a more powerful parametric test that uses all the information available while the Sign Test makes no assumption of distribution and is less affected by outlying data or significant variance.

9. Monitoring program

9.1 Monitoring sites

9.1.1 Site selection criteria

The selection of groundwater monitoring sites for monitoring for impacts has been based on the monitoring recommendations made in the EA outlined in Section 2.1.1 and the outcomes of the assessment and modelling of impacts outlined in Section 4.

For the purpose of clarifying the monitoring recommendations outlined in the EA, the key requirements have been summarised below:

- *“Establish a groundwater monitoring network along the project to monitor groundwater quality within each lithology and to establish background groundwater quality.”*
- *“Detail the establishment of a groundwater monitoring network along the route to adequately characterise background water quality within the alluvial/colluvial aquifers and Shoalhaven Group Sediments, including the Broughton Sandstone and latite.”*
- *“Install monitoring wells adjacent to major cuts to confirm existing groundwater levels and to monitor the effect on groundwater levels by construction activity, where groundwater is encountered.”*
- *“Implement a groundwater monitoring plan that would assess the performance of groundwater mitigation measures during and after construction. This plan would provide an assessment of groundwater level and quality trends and identification of exceedances (if any).”*
- *“The monitoring program would be required to monitor groundwater level fluctuations and groundwater quality parameters within the existing groundwater monitoring network. During the field program the following field parameters and laboratory analyses would be collected from a minimum of four monitoring wells.”*
 - *pH, dissolved oxygen, redox, electrical conductivity and temperature (field parameters).*
 - *Total petroleum hydrocarbons/benzene, toluene, ethylbenzene, xylene (TPH/BTEX), PAH, heavy metals (As, Cd, Cr, Cu, Pb, Hg, Ni, Zn).*
 - *Installation of dataloggers in four key monitoring wells to monitor groundwater levels on a daily schedule.”*

The assessment of potential impacts outlined in Section 4 suggests that monitoring is undertaken to:

- Assess the effectiveness of management measures developed for installation of bridge footings during construction. This monitoring would be dealt with in the CEMP and is not considered to form part of the broader groundwater monitoring regime outlined in this document.
- Assess drawdown at potential acid sulphate soil areas surrounding cuts near Tindalls Lane. Further investigations should be undertaken during construction to assess if the acid sulphate soils identified to have a low probability of occurrence actually represent a risk in this area. Subsequently, management measures would be implemented to mitigate these impacts. Monitoring would be implemented during construction to assess the effectiveness of any management solutions adopted to mitigate the impact.

- Assess drawdown in soft soils resulting in settlement and hence movement/damage to structures. Further investigation is required to assess if this represents an issue. Subject to the outcomes of this assessment, design changes will be required to mitigate this impact. Groundwater elevation monitoring maybe required to assess the adequacy of adopted mitigation measures.
- Assess the effectiveness of water quality management mitigation measures implemented during construction and operation and to monitor for the emergence of diffuse low level contamination infiltrating from the site and from surface water capture and treatment infrastructure.

9.1.2 Monitoring locations

Monitoring of groundwater quality and groundwater level will be undertaken via suitably designed and installed monitoring bores. The monitoring bore sites have been selected to:

- meet the recommended parameters outlined in the EA including:
 - establish baseline water quality in a range of lithological units;
 - establish baseline water quality along the entire alignment;
 - characterisation of groundwater elevations around cuttings;
 - assess groundwater mitigation measures along the alignment;
 - includes monitoring of a minimum of four wells; and
 - groundwater elevation monitoring in four wells using data loggers.
- monitor for groundwater quality impacts to potentially impacted receptors down gradient of the alignment, particularly including Broughton Creek and currently used groundwater bores.
- monitoring for settlement and acid sulphate soils is not currently recommended as it dependent on further investigation. Subsequent to the findings of these investigations it may necessitate the expansion of the monitoring program.

It is noted that Appendix H of the EA suggests a minimum of four wells should be sampled. The sampling of four wells is considered unlikely to provide a suitable amount of information to address the criteria listed above. As such, an expanded monitoring network has been recommended and is detailed below.

Fourteen wells have been installed along the alignment to meet the listed criteria. The well locations are presented in Figure 6. The wells are numbered MW01 to MW16 and include proposed wells MW14 and MW15, which were not installed. The wells have been screened at depths, and across water bearing units, that enable characterisation of groundwater drawdown as wells as migration of contamination downgradient of the cuttings.

The monitoring wells have been installed in the three major areas impacted by cut drawdown:

- **Near Foxground Road:** Monitoring wells MW01 to MW06 are located at the north eastern end of the project within the Broughton Creek Catchment and Crooked River Catchment (refer to Figure 6). These sites are up-gradient (MW02, MW04) and down-gradient (MW01, MW03, MW05, MW06) of road cuts 1 and 2.
- **Near Tindalls Lane and Tomlins Road:** Monitoring wells MW07 to MW12 are located near Austral Park Road (refer Figure 6) within the Broughton Creek Catchment. These sites are up-gradient (MW07 and MW11) and down-gradient (MW08, MW09, MW10 and

MW12) of road cuts 4 and 5). MW13 is located near to Tindalls Lane and located up-gradient of Cut 6 and is located within the Broughton Mill Creek Catchment.

- **Berry Town:** Monitoring well MW16 is located within Berry Town near North Street. It is located on the up-gradient of cut 9 and is located within the Town Creek Catchment.

Of these wells, MW01, MW02, MW03, MW04, MW06, MW08, MW09, MW12 and MW16 are generally located downgradient of the alignment and can be used for the purposes of assessing broad scale baseline groundwater quality.

It was noted during drilling works undertaken in February and March 2014 that locations MW02 and MW06 were dry at depths greater than 10 m below the alignment and have remained dry since installation. MW01 is considered to be best for assessing emergence of broad scale impacts between the alignment and the four potentially impacted registered groundwater wells down gradient of the alignment in this area. Other wells in the area, not owned by RMS, are not considered to be potentially impacted. Well GW105826 (see Figure 9), which is located on an RMS property, has no upgradient monitoring well to monitor for emerging water quality impacts. As such, this well should be decommissioned (or prevented from being used), or if on-going use is intended, then this well should be added to the groundwater quality monitoring schedule.

The wells have been distributed along the length of the alignment to provide an understanding of groundwater elevations and water quality. Based on the geological information presented in Figure 5 the wells are also interpreted to be screened within a range of different lithologies associated with the Shoalhaven Group lithology. This includes Gerringong Volcanics and Berry Formation sandstones, siltstones and shales. MW04 is also screen within residual/colluvial soils.

It is noted that these wells do not monitor for potential impacts associated with the acid sulphate soil exposure. Additional wells may be required for this purpose and should be considered if the infiltration of groundwater in the identified areas cannot be included in the design of the road.

Additional monitoring wells maybe required to monitor for settlement impacts which will be subject to the outcomes of a settlement assessment associated with groundwater drawdown along the alignment.

To meet the recommendations made in the EA and monitor for the key impacts identified by impact assessment presented in Section 4, the following groundwater sampling strategy has been implemented at the site.

- Groundwater elevation sampling of all fourteen wells along the alignment; and
- Groundwater quality sampling of six wells including MW01, MW04, MW09, MW12 and MW16.

9.2 Groundwater quality monitoring parameters

The proposed monitoring parameters, as outlined in Table 9, are based on a review of potential pollutant sources and reflect those recommended in the EA.

Table 9: Construction and operational phase monitoring parameters and sampling schedule

Parameter	Unit	Locations	Frequency
Groundwater elevation	m bgl	MW01, MW04, MW09, MW10, MW12 and MW16.	Monthly for baseline, Quarterly during construction and six monthly during operation.

Parameter	Unit	Locations	Frequency
		MW03, MW08, MW13, MW16 (groundwater level loggers installed)	Loggers to be installed and set at daily sampling rate during construction and operation.
Dissolved oxygen	mg/L	MW01, MW04, MW09, MW10, MW12 and MW16	Monthly for baseline, Quarterly during construction and six monthly during operation.
Electrical conductivity	µS/cm	MW01, MW04, MW09, MW10, MW12 and MW16	Monthly for baseline, Quarterly during construction and six monthly during operation.
Oxygen Reduction Potential	mV	MW01, MW04, MW09, MW10, MW12 and MW16	Monthly for baseline, Quarterly during construction and six monthly during operation.
pH		MW01, MW04, MW09, MW10, MW12 and MW16	Monthly for baseline, Quarterly during construction and six monthly during operation.
Temperature	°C	MW01, MW04, MW09, MW10, MW12 and MW16	Monthly for baseline, Quarterly during construction and six monthly during operation.
Total Petroleum Hydrocarbons (TPH) & Benzene, Toluene, Ethylbenzene and Xylene (BTEX)	mg/L	MW01, MW04, MW09, MW10, MW12 and MW16	Monthly for baseline, Quarterly during construction and six monthly during operation.
Heavy Metals (As, Cd, Cr, Cu, Pb, Hg, Ni, Zn)	mg/L	MW01, MW04, MW09, MW10, MW12 and MW16	Monthly for baseline, Quarterly during construction and six monthly during operation.

9.3 Sampling frequency

As outlined in Section 2 the conditions of approval and the EA require/recommend:

- *“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 Director General”.*
- Quarterly monitoring of groundwater elevations and water quality during construction.
- Six monthly monitoring during operation for a minimum of two years.

Based on this the sampling regime outlined in Table 9 is proposed to be undertaken to collect a baseline data set for groundwater quality and levels prior to construction and to assess impacts during the construction and operational phases of the project.

A monthly monitoring program will be undertaken for baseline monitoring to provide an expanded data set that characterises the range of potential climatic conditions. The baseline data gathering exercise will focus on the collection of data under a range of climatic conditions (wet and dry periods) on which construction and operation can be compared. This approach is considered to provide a better representation of the range in groundwater conditions expected

along the alignment as opposed to adopting the seasonal characterisation approach recommended in the conditions of approval.

The EA also recommends the installation of data loggers in four wells along the alignment to monitor for daily changes in groundwater elevations. It is expected that these loggers will be preferentially located in wells MW03, MW08, MW13 and MW16 to monitor for groundwater elevation impacts outside of those simulated by groundwater modelling around major cuts. Consideration will be given to changing these locations during construction to facilitate a more comprehensive characterisation of groundwater elevations around specific cuts as construction occurs..

9.4 Visual observations

During the construction phase of the project, records of visual observation will be kept and photographs taken where groundwater flows are observed from cuts during construction. While this data will not form part of the assessment methodology, it will aid in the interpretation of data collected from adjacent bores in determining the potential impacts of the construction works on groundwater hydrology.

9.5 Sampling protocol

The potential for significant variability exists within each of the monitoring locations. The source of this variability may be natural or it may be as a result of sampling error – i.e. where the sample collection process has influenced the observed pollutant concentration or groundwater level.

To reduce the risk of sampling error, all sampling would be undertaken in accordance with the following standards and appropriate groundwater sampling techniques:-

- Australian Standard AS/NZS 5667.11: 1998 Water quality – Sampling Part 11: Guidance on sampling groundwaters
- Australian Standard AS/NZS 5667.1 1998: Water quality – Sampling Part 1: Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples; and
- Approved Methods for the Sampling and Analysis of Water Pollutants in NSW (EPA, 2004).

A Chain of Custody (CoC) form would also be used to ensure chronological documentation of data collection, transfer and analysis. The following is an overview of the key procedures that are proposed for the groundwater sampling methodology:-

- Depth to water table would be measured using an electric calibrated water level meter.
- Prior to sample collection, monitoring wells would be purged. The groundwater monitoring well will be considered to be purged when one of the following criteria is achieved (whichever occurs first):
 - Three well volumes of water have been purged; or
 - The well is purged until no more water can be removed (considered dry); or
 - The water quality parameters are stabilised within 10% over three consecutive recorded measurements.
- The groundwater will be purged and sampled using a submersible pump, foot-valve pump or a down-hole bailer. Purged groundwater would be disposed of into nearby drains or onto adjacent land.

- Physico-chemical parameters would be recorded during the purging of each monitoring well using a calibrated water quality (multi-parameter) meter.
- Groundwater samples would be collected following the purging of groundwater from each well. Effective purging is demonstrated by the stabilisation of physico-chemical water quality parameters.
- Groundwater sampling devices should be comprised of dedicated (i.e. Waterra footvalve pump) and/or disposable down-hole bailers.
- Groundwater samples would be collected in laboratory supplied water sampling containers that would be appropriately dosed with preservative for the analysis required.

A Surface Water and Groundwater Sampling Protocol (GHD, 2014a) has been developed to ensure consistency in the sampling technique and methodology adopted during each sampling event and should be referred for additional detail on this topic.

9.6 Sample analysis

The following key points are noted for the analysis of water quality data:-

- To reduce the potential for error resulting from sample analysis, a laboratory NATA accredited for the analysis undertaken would be utilised for analysis of water quality samples to ensure a high standard of analysis.
- Where an in-situ measurement is taken, the water quality sonde would be calibrated prior to each sampling event. A copy of the calibration certificate would be included with the copy of all sample results.
- A qualified ecologist with experience in monitoring groundwater dependent ecosystems would be used for the monitoring of floristic composition and distribution.

10. Data analysis and interpretation

10.1 Analysis of groundwater quality and groundwater hydrology data

During the construction and operational phases, the monitoring program would focus on assessing whether any changes in groundwater quality and groundwater hydrology have occurred in comparison to the baseline dataset and also whether this change is attributable to the FBB Princess Highway upgrade. An overview of the process for assessing the performance against the agreed objectives and standards is provided in the following sections and summarised in the flowchart in Figure 11. The management response to any observed impacts are outlined in Section 11.

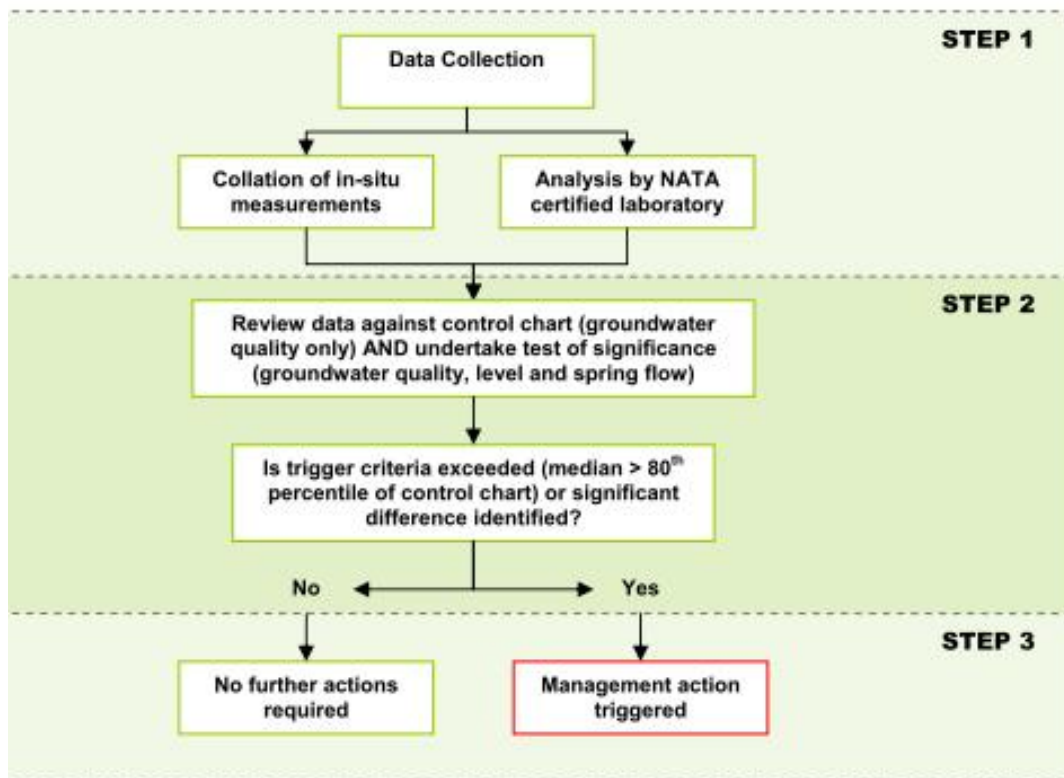


Figure 11: Groundwater quality /hydrology assessments (Aurecon 2010b)

10.1.1 Step 1: Data collection and collation

Groundwater quality and level samples would be collected in accordance with the procedures outlined in Section 9. This would include the use of a water quality probe for assessment of a range of field parameters, while other parameters would be assessed by collecting samples for analysis at a NATA certified laboratory.

The timing between receipt of results and proceeding to the next step in the process would vary between those samples collected using in-situ measurements and those samples collected for measurement at a laboratory.

10.1.2 Step 2: Analysis and interpretation

The second stage of the assessment process would include a review of the data against control charts and an assessment of the statistical significance of any observed change. Whilst the majority of steps in this methodology allow for a clear process to be followed, the objectivity

and understanding of the user in reviewing the findings would play a significant part in the assessment of potential impacts.

Review against control chart

There would be two stages in the assessment of the data against the control chart. Firstly, the data would be assessed to determine whether the trigger criterion has been exceeded. That is, does the median of the test site exceed the 80th percentile value of the control chart (long term data). Where the trigger criterion is exceeded a management action is triggered.

Secondly, the control chart would be reviewed to assess for any trends. While the trigger criteria may not be exceeded, the control chart has the ability to facilitate the early identification of potential catchment impacts that may require further investigation. A gradual increase in the up-gradient/baseline data may be the result of increasing pressures on the catchment. Whilst these impacts would not be attributable to the FBB Princes Highway upgrade, they would be of interest to catchment managers. Review of data against the control chart would be undertaken for the assessment of impacts on groundwater quality only.

Assessment of significance

A test of significance would be undertaken to compare the samples against the pre-construction baseline. The significance would be tested using both a t-Test and Sign Test as described in Section 8.4, or in the case of groundwater drawdown, comparison of observed levels against levels predicted by modelling. The methodology would allow an assessment of the pollutants that are directly attributable to the highway during each event and is independent on the variable influences such as the volume of rainfall or time since last rain event. This process provides a direct comparison and assessment of impacts. An assessment of significance using statistical analysis would also be undertaken for groundwater level measurements.

11. Management actions

For a monitoring program to be effective, the performance objectives, performance standards and measurement criteria trigger must be linked to management actions. The management actions outlined in this section relate specifically to where the monitoring program has identified a potential impact. Management actions and responses for all other environmental impacts would be covered under the Construction Environmental Management Plans (CEMPs) and operational environmental management systems.

Section 8 outlines the criteria for triggering a management action, and Section 10 provides an overview of the process for assessment against these criteria. The following sections describe the management actions to be undertaken during the construction and operational phases of the project, should a trigger criteria be exceeded.

The environmental controls proposed in the EA Report (AECOM 2012) for treatment of surface water runoff from the FBB Princes Highway upgrade would significantly reduce the risks of pollutants entering the groundwater system. Should the environmental controls perform as predicted there should be no measurable effect as a result of the operation of the FBB project and consequently no management actions would be triggered.

The flow chart presented in Figure 12 provides an overview of the key steps in the assessment of construction and operational phase impacts in the event of a management action being triggered. The flow chart is provided as a guide only and should not be considered the only path for the investigation of management responses. All management triggers would include an investigation of the reasons for exceedance of the trigger and ensure that all practicable actions have been undertaken to prevent further incident.

In the event that management actions are triggered any short term solutions will be implemented where possible to prevent ongoing impacts while detailed investigations are being undertaken to isolate the source.

Subsequent to the identification of the source of the issues, long term solutions will be developed to mitigate the impact or appropriately manage the ongoing impact.

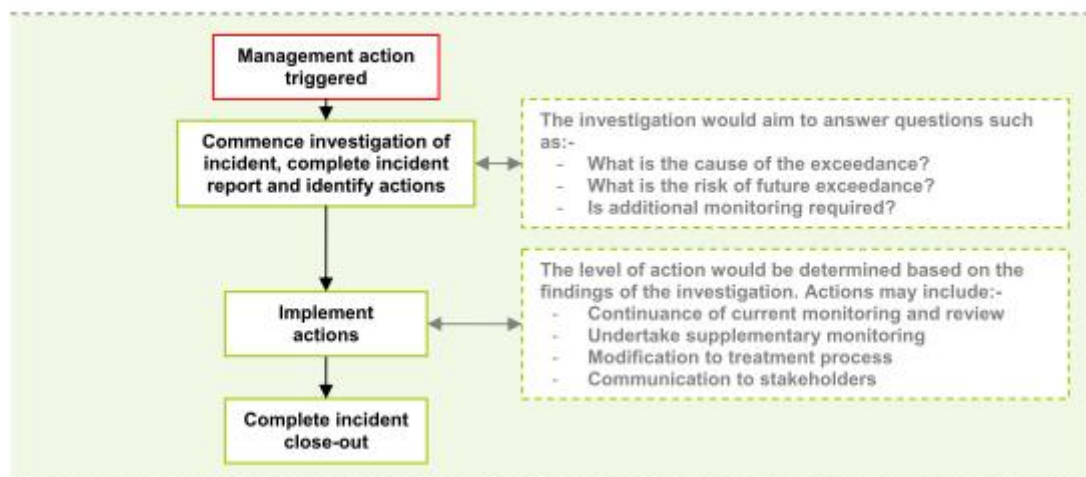


Figure 12: Management action framework (Aurecon 2010b)

Reporting following the triggering of a management action would be undertaken in accordance with the processes outlined in Section 12.

12. Management framework

The implementation of the proposed environmental controls, in combination with effective monitoring and management, would ensure that the risk from the FBB Princes Highway upgrade on the water quality of the local catchments would be significantly reduced. The following sections provide the framework for implementation, adaptation, review and management of the FBB GWMP. These mimic those adopted for the T2E upgrade developed by Aurecon in 2010.

12.1 Adaptive management approach

RMS recognises the importance of undertaking environmental management using an adaptive management approach and as such the GWMP would be a working document. The nature of groundwater quality monitoring is such that there is no simple solution that provides a monitoring and management response to all scenarios.

Whilst this monitoring program has been developed based on the best available information at the time, it must be recognised that an adaptive approach is required to deliver an effective monitoring program into the future. Where the review and audit process identify opportunities for improvement, or areas where the monitoring approach may be refined, the FBB GWMP would be reviewed and updated. This would ensure that the monitoring program outlined within this groundwater monitoring plan is capable and would continue to be capable of assessing the performance of the construction and operational phase environmental controls against the defined performance objectives and standards.

12.2 Roles and responsibilities

For the FBB groundwater monitoring program to be implemented effectively, the roles and responsibilities for the implementation, management, review and auditing, must be clearly defined. Separate responsibilities are defined for the construction (refer Table 10) and operational (refer Table 11) phases of the project.

Table 10: Construction Phase Roles and Responsibilities

Organisation	Responsibility	Personnel and Contact Details
RMS	Implementation of the GWMP Assessment against performance objectives and standards Ensuring a CEMP is developed and implemented effectively Ensuring appropriate measures are implemented for management of acute impacts Investigation of any potential or observed impacts Identification and implementation of management actions as required Review and updating of GWMP Reporting	Ron De Rooy Senior Project Manager Ph: 02 4221 2585 Email: Ron.DE.ROOY@rms.nsw.gov.au
NOW	Review of Annual Progress Report and Incident Reports. Provide feedback as necessary.	Bob Britten Water Regulation Officer Ph: 6491 8209 Email: Bob.Britten@water.nsw.gov.au
NSW DP&I - Fisheries	Review of Annual Progress Report and Incident Reports.	Dr Trevor Daly Fisheries Conservation Manager –

Organisation	Responsibility	Personnel and Contact Details
	Provide feedback as necessary.	South Coast. Ph: 02 4478 9103 Email: trevor.daly@dpi.nsw.gov.au
NSW EPA	Review of Annual Progress Report and Incident Reports. Provide feedback as necessary.	Julian Thompson Unit Head - South East Region Ph: (02) 6229 7002 Email: julian.thompson@epa.nsw.gov.au
OEH	Review of Annual Progress Report and Incident Reports. Provide feedback as necessary.	Peter Marczan A/manager noise policy Ph: (02) 9995 6059 Email: peter.marczan@epa.nsw.gov.au

Table 11: Operation Phase Roles and Responsibilities

Organisation	Responsibility	Personnel and Contact Details
RMS	Implementation of the GWMP Assessment against performance objectives and standards Ensuring appropriate measures are implemented for management of acute impacts Regular inspection of treatment measures (water quality basins) Maintenance of treatment measures Investigation of any potential or observed impacts Identification and implementation of management actions as required Review and updating of GWMP Reporting Consultation	Ron De Rooy Senior Project Manager Ph: 02 4221 2585 Email: Ron.DE.ROOY@rms.nsw.gov.au
NOW	Review of Annual Progress Report and Incident Reports. Provide feedback as necessary.	Bob Britten Water Regulation Officer Ph: 6491 8209 Email: Bob.Britten@water.nsw.gov.au
NSW DP&I - Fisheries	Review of Annual Progress Report and Incident Reports. Provide feedback as necessary.	Dr Trevor Daly Fisheries Conservation Manager – South Coast. Ph: 02 4478 9103 Email: trevor.daly@dpi.nsw.gov.au
NSW EPA	Review of Annual Progress Report and Incident Reports. Provide feedback as necessary. The EPA have stated that while the project will be licensed by the EPA during the construction phase, the EPL will not be required during the operational phase of the project. In light of this, the EPA will not have a formal management role post construction, except in the case of	Julian Thompson Unit Head - South East Region Ph: (02) 6229 7002 Email: julian.thompson@epa.nsw.gov.au

Organisation	Responsibility	Personnel and Contact Details
	<p>pollution incidents where it assumes the role of Appropriate Regulatory Authority under section 6 of the Protection of the Environment Operations Act 1997 for the activities of RMS.</p> <p>GHD notes that the Conditions of Approval B16(h) require the reporting of monitoring results to the EPA.</p>	
OEH	<p>Review of Annual Progress Report and Incident Reports.</p> <p>Provide feedback as necessary.</p>	<p>Peter Marczan</p> <p>A/manager noise policy</p> <p>Ph: (02) 9995 6059</p> <p>Email: peter.marczan@epa.nsw.gov.au</p>

12.3 Reporting and auditing

Condition of Approval B16(g) requires ‘reporting of the monitoring results to the Department, OEH, EPA and NOW’. The following sections outline the reporting process to be implemented during the construction and operational phases of the project to meet this requirement and to ensure the delivery of an effective monitoring program.

12.3.1 Reporting

Regular reporting would be undertaken to allow assessment against the surface water objectives and performance standards. A brief factual monitoring report would be prepared after each sampling event, to present the data collected and ensure the environmental controls are effective.

A more comprehensive progress report would be prepared annually. The review and preparation of the progress report would not only report on the data collected during the year, but would also allow for an assessment of gradual trends and changes within the system – i.e. this review would provide early detection of any potential impacts and allow management actions to be triggered to address them before an impact occurs.

Incident reporting would also be undertaken where a performance standard has not been met. Exceedance of a performance standard does not necessarily mean that an impact has occurred, but provides a trigger for further review. The preparation of an incident report would be the first step in this process and would identify the management approach to be adopted to resolve any potential concerns.

Following all audits (internal and external), a close-out report would be prepared. Where non-conformances are noted, the report would include a summary of the actions undertaken to address the non-conformance and the steps that have been put in place to prevent further occurrence.

A summary of the reporting for the FBB Groundwater Monitoring Program is presented in Table 12.

Table 12: Summary of reporting requirements (adapted from Aurecon, 2010a)

Report	Condition of Approval Reference	Content	Timing	Circulation
Monitoring Report	B16 (h)	Following each sampling event a brief report would be prepared that describes water quality performance against the agreed objectives and standards for that particular event.	All phases until monitoring no longer required.	EPA, NOW, OEH DPI.
Annual Progress Report	B16 (h) B29 (c), (g)	As a minimum the progress report would include: A summary of the monitoring results recorded during the previous 12 months; An assessment of performance against defined objectives, standards and measurement criteria; An overview of any environmental incidents recorded and the corresponding action taken; Details and rationale for any modification to the surface water sampling program; An outline of any changes to the environmental controls; Findings of all audits and details of any corrective actions required; Recommendations for any changes to the monitoring program or control measures; and Review of any complaints and actions from the ERG.	Annual – No long operational period specified in COA	EPA, NOW, OEH DPI.
Incident Report	A5, B29 (e), (f), (g)	In the event of an exceedance in water quality performance standards, a brief report would be prepared to examine all relevant data and to determine a likely source and appropriate management action. An action plan would be developed and would include a timeframe for implementation.	Initial notification to DG in 24 hours with report provided within 7 days	EPA, NOW, OEH DPI.

13. Consultation

Consultation undertaken during development of the GWMP

The Conditions of Approval for the project require that the GWMP is 'developed in consultation with the OEH, EPA, DPI (Fishing and Aquaculture) and NOW.

Contacts for these have been contacted and have been supplied with the brief for the project as a means of providing familiarity with the project prior.

A copy of this document, the sampling protocol document and groundwater management plan will be provided to the key stakeholders for comment prior to finalisation of the documents.

If required additional meetings will be undertaken with stakeholders to further explain the contents of the documentation being submitted.

A summary of the comments submitted on this document and how these have been dealt with are presented in the Table 13. Additional correspondence is provided in Appendix A.

Table 13: Stakeholder Comments and Response

Organisation	Date submitted to stakeholder	Contact	Document section and document page number	Comments	Comment date	GHD response	Response Date
Fisheries NSW - DPI	10/06/2014, Rev 4 submitted	Trevor Daly	General comment	The report has been provided and no comments were provided. The groundwater model report was not provided to the DPI.	.	Trevor Daly has been communicated with on a number of occasions via telephone and has suggested that they are concerned primarily with surface water issues, which have been dealt with in the SWMP	02/07/2014
NSW office Water	08/04/2014, Rev 1 submitted 01/07/14	Bob Britten	General comment	The groundwater modelling report has been provided and a letter was received in response from Bob Britten dated 1 July 2014. This letter is included in Appendix D . All comments were in agreement with the groundwater modelling report.	01/07/2014	No response required.	02/07/2014
	GWMP_DRAFT_7_Rev4 - Submitted 03/07/2014	Bob Britten	General comment	The GWMP report has been provided and a letter was received in response from Bob Britten dated 8 July 2014. This letter is included in Appendix D . All comments were in agreement with the groundwater modelling report.	08/07/2014	No response required	09/07/2014

Organisation	Date submitted to stakeholder	Contact	Document section and document page number	Comments	Comment date	GHD response	Response Date
OEH	Not submitted.	James Dawson		The report has not been provided to OEH.		An informal face to face meeting was held with James Dawson on the 3 April 2014. During that meeting James stated that he was currently dealing with Toby Lambert from Parsons Brinkerhoff who were developing the monitoring plan for instream ecology. He noted that this was more relevant to biodiversity and threatened species. As such, it was considered that the surface water monitoring plan was of lower importance. James noted that Peter Marczan and Tim Pritchard of the OEH Water and Coastal team may have some interest in the project. At this time contact has not been made with Tim or Peter.	02/07/2014
		Peter Marczan		The report has not been provided to OEH.	19/06/2014	Email received from Peter Marczan detailing that he is currently in a different position and forwarded the email to Penny Vella of OEH who is currently acting team leader for Water Quality.	30/06/2014
		Penny Vella		The report has not been provided to OEH.	20/06/2014	Email received from Penny Villa of OEH stating the "she can confirm that OEH does not need to review the surface water and groundwater monitoring plan document, or the sampling protocol." She acknowledged that the EPA are already engaged on this issue.	30/06/2014

Organisation	Date submitted to stakeholder	Contact	Document section and document page number	Comments	Comment date	GHD response	Response Date
EPA	14/04/2014	Julian Thompson	Table 9, pg 53-54	Details the roles and responsibilities for management in the operational phase of the Foxground Berry Bypass. The NSW EPA is listed in this table as having part responsibility for the review of the Annual Progress Reports and Incident Reports, and to provide feedback as necessary. It should be noted that while the project will be licensed by the EPA during the construction phase, the Environment Protection Licence will not be required during the operational phase of the project. The EPA will therefore not have a formal management role post-construction, except in the case of pollution incidents where it assume the role of Appropriate Regulatory Authority Role for RMS under section 6 of the Protection of the Environment Operations Act 1997.	20/05/2014	The reference to EPL for operational phases of the project has been removed from the document text. EPA will still receive the annual progress reports as per the conditions of approval.	13/06/2014
	14/01/2014	Julian Thompson		Before undertaking any detailed assessments of the presence and risk of ASS, the EPA recommends seeking advice on appropriate sampling design and analytical framework from a practitioner with ASS experience. Consultation with appropriate topic specialists should also be arranged in order to assess the potential impacts of groundwater drawdown on in-stream aquatic ecology and groundwater dependent ecosystems and the risk of settlement issues.	20/05/2014	Following a telephone discussion with EPA on the acid sulphate soil issue they raised in their correspondence it was recommended by the EPA that further investigations should be undertaken in this area and that this should be undertaken as part of detailed design phase investigations. An email (dated 09/07/2014) documenting the outcomes of the conversation are provided in Appendix D. Settlement issues are currently being considered by an appropriate specialist.	08/07/2014
	14/01/2014	Julian Thompson		Groundwater well GW105826 does not have an upgradient monitoring well to monitor for emerging water quality impacts, and should therefore be decommissioned, or should be added to the groundwater quality monitoring schedule. Also, additional wells may be required to monitor for potential impacts associated with acid sulphate soil exposure and settlement impacts.	20/05/2014	Reference has been made in the text to implementing these actions as required. See Section 9.1.2 and Section 4.5.1. Monitoring Well MW16 may be suitable for settlement monitoring if further investigations of settlement highlight a potential risk.	08/07/2014

14. References

AECOM (2012); *Foxground and Berry Bypass, Princes highway Upgrade, Environmental Assessment*.

Aurecon (2010a) *Surface Water Monitoring Program Rev 4 – Tintenbar to Ewingsdale Road Upgrade*, prepared for the Roads and Traffic Authority, 2010

Aurecon (2010b) *Groundwater Monitoring Program Rev 4– Tintenbar to Ewingsdale Road Upgrade*, prepared for the Roads and Traffic Authority, 2010

Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (1995); *Guidelines for groundwater protection in Australia*. National Water Quality management Strategy

Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (2000a); *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, Australian Water Association, Artarmon, NSW

Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (2000b). *The Australian Guidelines for Water Quality Monitoring and Reporting (Water Quality Monitoring Guidelines)*, Australian Water Association, Artarmon, NSW.

Cardno (2011) *Pacific Highway Upgrade - Tintenbar to Ewingsdale Surface Water and Groundwater Sampling Protocol*.

Coffey Geotechnics, Maunsell Aecom (2007) *Princes Highway Upgrade, Route Selection Study, Geotechnical Investigation, Gerringong to Bomaderry NSW, Volume 1: Interpretation Report*. Ref: GEOTUNAN02580AA-AZ

Coffey Geotechnics (2012); *Geotechnical Interpretive Report, South Berry Option, Foxground to Berry Bypass, Berry NSW*. Ref: GEOTWOLL03387AA-AB

Coffey Geotechnics (2010); *Geotechnical factual Report for Concept Design, Gerringong to Bombaderry*. Ref: GEOTWOLL02580AE-BD

DECCW (2008); *Managing Urban Stormwater – Soils and Construction, Volume 2D – Main Road Construction (known as the Blue Book)*.

Department of Land and Water Conservation (1997) *Kiama 1:25,000 Acid Sulphate Soil Risk Map Edition 2*,

Department of Land and Water Conservation (1997) *Burrier / Berry 1:25,000 Acid Sulphate Soil Risk Map Edition 2*

Department of Land and Water Conservation (1997) *Gerroa 1:25,000 Acid Sulphate Soil Risk Map Edition 2*

DLWC (2002) NSW State Groundwater Dependent Ecosystems Policy. A Component Policy of the NSW State Groundwater Policy Framework Document

Department of Mineral Resources (1985) *1:250 000 Geological Sheet for Wollongong (Sheet SI/56-9)*

GHD (2014a); *Roads and Maritime Services, Foxground to Berry Bypass Water Quality Management, Surface Water and Groundwater Sampling Protocol*.

GHD (2014b); *Roads and Maritime Services, Foxground to Berry Bypass Water Quality Management, Surface Water Quality Management Plan.*

Helsel, D.R. and Hirsch, R.M. (2002) *Statistical Methods in Water Resources: Techniques of Water Resources Investigations of the United States Geological Survey*, Book 4, Chapter A3, USGS.

Landcom (2004); *Managing Urban Stormwater – Volume 1 (Soils and Construction).*

National Health and Medical Research Council (NHMRC) and Natural Resource Management Ministerial Council (NRMMC), 2011; *Australian Drinking Water Guidelines 6, 2011*; Australian Government.

NSW Department of Planning and Infrastructure (DPI), (2013); *Project Approval Section 75J of the Environmental Planning and Assessment Act 1979.*

NSW EPA, (1997): *Managing Urban Stormwater: Council Handbook.*

NSW EPA (2004); *Approved Methods for the Sampling and Analysis of Water Pollutants in New South Wales.*

NSW DEC (2007) *Guidelines for the Assessment and Management of Groundwater Contamination*

NSW Office of Water, 2012; *Guidelines for In stream Works on Waterfront Land*

Roads Transport Authority (2006); *Guidelines for Construction Water. Quality Monitoring*

RTA (2008); *Erosion and Sedimentation Management Procedure. RTA Procedures PN143P*

Roads and Traffic Authority (1999), *RTA's Water Policy*, <http://www.rta.nsw.gov.au>, accessed August 2010

Roads and Maritime Services (RMS) (2013a): *Foxground and Berry Bypass, Princes Highway Upgrade, Submissions Report.*

Roads and Maritime Services (RMS) (2013b): *Foxground and Berry bypass Attachment A Project Brief – Preparation and implementation of Water Quality Monitoring Program and Groundwater Modelling.*

Roads and Maritime Services (RMS) (2014): *Construction and Environmental Management Plan, Toolijooa Road Fill Works Stage of Foxground and Berry Bypass.*

Appendices

Appendix A – Groundwater Modelling Report



Roads and Maritime Services

Princes Highway Upgrade – Foxground to Berry Bypass Project

Groundwater Flow Model

July 2014

Executive summary

Roads and Maritime Services (RMS) is undertaking a series of upgrades to sections of the Princes Highway between Gerringong and Bomaderry in order to provide a continuous four lane divided highway. The Foxground to Berry Bypass (FBB) is comprised of an 11.6 km upgrade of the existing highway between Toolijooa Road north of Foxground and Schofields Lane south of Berry and includes bypasses of Foxground and Berry.

The project approval was granted on 22 July 2013 under Part 3A of the Environmental Planning and Assessment Act 1979 with conditions of approval (CoA).

CoA 15 requires that groundwater modelling on the concept design be completed to assess the construction and operational impact of the concept design on groundwater resources, quality, hydrology, groundwater dependent ecosystems and provide details of contingency and management measures to be implemented for construction.

To meet this requirement a numerical groundwater model has been developed to assess the impact of the Project on the surrounding groundwater environment and potentially dependent systems.

The modelling approach and complexity has been based on those undertaken prior to construction for other major road upgrade projects in NSW where groundwater is considered to be sensitive.

The modelling has been designed to focus on changes in groundwater elevations and flow volumes associated with the project. Impacts to groundwater quality and associated management measures are summarised in the GWMP document.

This report has been designed as a technical appendix to the GWMP and should be read in conjunction with the GWMP.

The model was developed using the Groundwater Vistas modelling Graphical User Interface (GUI) which was set up to simulate groundwater flow using MODFLOW SURFACT (Hydrogeologic, 1996). MODFLOW-SURFACT was selected for this application because it allows for improved representation of groundwater flow in the saturated and unsaturated zone.

One model domain was constructed to assess impacts along the entire alignment. Surfaces and layering in the model domain were developed using a large volume data from previous geotechnical investigations completed along the alignment and from detailed topographical data. This was used to develop a two layer model representing the inferred change between unconsolidated and consolidated sediments.

Calibration of the groundwater flow model was undertaken in steady state through comparison of observed and modelled groundwater levels at 60 borehole locations and assessed baseflow from observation data at 3 flow gauging stations. Calibration of the steady-state model was carried out using the PEST suite of software (Doherty, 2010). The calibration results had typically acceptable limits, as recommended in the Australian Groundwater Flow Modelling Guideline (National Water Commission, 2012).

The groundwater modelling results suggest that the primary impacts will be associated with drawdown around cuttings along the project alignment. The predicted impacts and proposed management measures are summarised below:

- Impacts to surrounding registered groundwater wells are simulated to be within acceptable ranges, with the maximum predicted drawdown within impacted registered groundwater wells approximating less than 0.2 m.

- The drawdowns are expected to result in a less than 1 % reduction in the base flow component of catchment surface water features. This is anticipated to have negligible impacts on in-stream aquatic ecology and existing surface water user supplies, however, further consultation with ecological specialists is required to validate this.
- Impacts to sensitive surface water features such as Coomonderry Swamp and Foys swamp are simulated to be negligible.
- The zones of drawdown influence created by the cuttings near to Tindalls Lane and Tomlins Road are simulated to intersect areas where there is low potential for the presence of Acid Sulphate soils. In terms of managing this risk there are a number of potential options, which could include either of, or a combination of:
 - Additional intrusive soil investigations to characterise the actual potential for the generation of acid sulphate soils within the simulated drawdown zone.
 - Implementation of measures to recharge dewatered groundwater from the cuttings to downgradient locations flanking acid sulphate soil areas and hence reduce drawdown impacts. This measure could be assessed within the groundwater model.
 - An assessment of road design and construction to minimise drawdown impacts at these cuttings and hence prevent the potential for the generation of adverse impacts. These measures could be assessed within the groundwater model.
 - Implementation of a monitoring regime in this area to monitor for pH impacts and provide an early warning mechanism for enhanced mitigation measures to be implemented. Sampling location SW03 would act to identify impacts in Broughton Creek. A strategically placed monitoring bore, would perhaps provide an early warning mechanism for the presence of emerging groundwater elevation impacts.
- The zones of drawdown influence created by the cuttings extend under isolated developments along the alignment, particularly in the Berry area, that are potentially situated on unconsolidated materials. This may represent a settlement risk that should be considered further by appropriate specialists.

The modelling undertaken provides an understanding of the likely impacts associated with the project based on the conceptual design, which will require further investigation at detailed design stage. At this time, further modelling should be undertaken to assess non-uniqueness in the modelling outcomes, paying particular attention to the potential variation in impacts associated with changes in storage and under high and low flow conditions. Further consideration of available hydraulic data that has become available since model development should also be undertaken at detailed design phase. It is noted that the conditions of approval only require further consideration of the model at detailed design phase where the detailed design has a significantly different impact on groundwater than the concept design.

Table of contents

1.	Introduction	1
1.1	Background	1
1.2	Objectives	1
2.	Conceptual Model	4
2.1	Geology and Hydrostratigraphic Units.....	4
2.2	Groundwater Levels, Groundwater Flow Directions and Recharge Estimates.....	4
3.	Model Construction	6
3.1	Model Grid	6
3.2	Model Code Selection	8
3.3	Model Layering.....	8
3.4	Initial Model Parameters.....	9
3.5	Boundary Conditions	11
4.	Model Calibration	13
4.1	Model Calibration Strategy	13
4.2	Calibration Targets	13
4.3	Calibration Results	14
5.	Model Predictions.....	19
5.1	Predictive Model Objectives.....	19
5.2	Predictive Model Construction	19
5.3	Predictive Model Results	20
6.	Conclusions	29
7.	Limitations.....	31
7.1	Modelling limitations	31
7.2	General Limitations	31
8.	References	33

Table index

Table 1	Recharge Estimates from Baseflow Separation	5
Table 2	Initial Hydraulic Conductivity and Permissible Range	9
Table 3	Groundwater Level Targets by Hydraulic Conductivity Zone	13
Table 4	Calibrated Horizontal and Vertical Hydraulic Conductivity	15
Table 5	Calibrated Recharge Values.....	15
Table 6	Observed and Modelled Baseflow Comparison.....	18
Table 7	Predictive Model - Storage Values.....	20
Table 8	Groundwater Level Impacts at Registered Bores	22

Table 9	Baseflow Impacts at Creeks Gauging Stations.....	27
---------	--	----

Figure index

Figure 1: Project Overview	3
Figure 2: Foxground to Berry Model Grid and Boundaries	7
Figure 3: Foxground to Berry Model - Hydraulic Conductivity Zonation	10
Figure 4: Steady State Groundwater Level Calibration Statistics.....	17
Figure 5: Predicted inflows during and after construction	21
Figure 6: Predicted Groundwater Level Impacts – Cuttings close to Foxground Road.....	24
Figure 7: Predicted Groundwater Level Impacts – Cuttings between Tindalls Lane and Tomlins Road	25
Figure 8: Predicted Groundwater Level Impacts – Cuttings nearby Berry town.....	26

Appendices

Appendix A – Stream gauging data and estimated groundwater base flows

1. Introduction

1.1 Background

Roads and Maritime Services (RMS) is undertaking a series of upgrades to sections of the Princes Highway between Gerringong and Bomaderry in order to provide a continuous four lane divided highway. The Foxground to Berry Bypass (FBB) is comprised of an 11.6 km upgrade of the existing highway between Toolijooa Road north of Foxground and Schofields Lane south of Berry and includes bypasses of Foxground and Berry. The project will result in improved road safety and traffic efficiency, including for freight. An overview of the project is provided in Figure 1.

An environmental assessment including technical appendices and a submissions report have been prepared which identify and assesses potential water quality impacts associated with the project. The project approval was granted on 22 July 2013, under Part 3A of the Environmental Planning and Assessment Act 1979 with conditions of approval (CoA).

These conditions (CoA B15 and CoA B16) require RMS to prepare and implement a water quality monitoring program (WQMP) and undertake groundwater modelling on the concept design. The WQMP will establish baseline water quality data prior to construction, guide monitoring during construction to ensure mitigation measures are effective and guide monitor post construction to ensure permanent measures are effective. The groundwater modelling will assess the construction and operational impact of the concept design on groundwater resources, quality, hydrology, groundwater dependent ecosystems and provide details of contingency and management measures to be implemented in the construction soil and water quality management sub-plan (CoA B26 (d)).

This document has been developed to describe the monitoring works undertaken to assess impacts on the surrounding groundwater system. This report has been designed as a technical document to be included as an annex to the groundwater quality monitoring plan (GQMP) document and should be read in conjunction with the GQMP. In particular the GQMP provides an overview of the existing environmental conditions and the key environmental risks associated with the project, which have been used for the assessment of the impacts by the groundwater model.

1.2 Objectives

Condition of approval CoA 15 provides the basis for the groundwater modelling objectives and is stated below.

“Prior to the commencement of construction, unless otherwise agreed by the Director General, the Proponent shall in consultation with the EPA and NOW, undertake groundwater modelling on the concept design for the project, subject to the modelling being revised should the detailed design have a significantly different impact on groundwater than the concept design.

The modelling shall be undertaken by a suitably qualified and experienced groundwater expert and assess the construction and operational impacts of the proposal on the groundwater resources, groundwater quality, groundwater hydrology and groundwater dependent ecosystems and provide details of contingency and management measures in the groundwater management strategy required under condition B36(d).”

Based on the above, the objectives for the modelling are to use the existing understanding of the concept design to develop a numerical groundwater model that assesses the *construction and operational impacts of the Project on the groundwater resources, groundwater quality,*

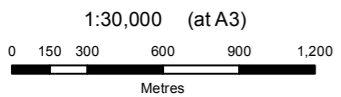
groundwater hydrology and groundwater dependent ecosystems and provide details of contingency and management measures in the groundwater management strategy.

The modelling is based on conceptual design information, which has meant that some aspects of the modelling may not represent final design conditions, particularly in regards to the staging and rates of construction works. As such, the modelling is preliminary in nature and it is recommended that further modelling is undertaken at detailed design stage.

Further to this, the groundwater modelling does not account for short term fluctuations in groundwater associated with dewatering around bridge pilings as the impact is likely to be highly localised temporally and spatially and may differ significantly due to specific design and methods adopted for construction. As such, these impacts would be best managed and assessed as part of construction management works and/or detailed design works, when there is more certainty over design and construction.

The detail of the modelling has been designed in accordance with CoA 15 and the level of modelling that has been undertaken at conceptual design stage for similar projects within NSW, such as for the Tintenbar to Ewingsdale Pacific Highway upgrade project, which is currently under construction.

Other limitations and assumptions for this report are presented in Section 7.



Map Projection: Transverse Mercator
 Horizontal Datum: Geocentric Datum of Australia (GDA)
 Grid: Map Grid of Australia 1994, Zone 56



LEGEND	
	Berry to Foxground upgrade alignment
	Alignment location of interest
	Roads
	Railways
	Waterways
	Lakes and dams



Roads and Maritime Services
 Water Quality Monitoring

Job Number	21-23174
Revision	0
Date	09 Jul 2014

Overview of the Berry to Foxground upgrade Figure 1

Z:\TEMP GIS\berry to foxground\GIS\Maps\MXD\21_23174_2010_BERRY_OverviewFBBUpgrade.mxd
 © 2010. While GHD has taken care to ensure the accuracy of this product, GHD and DATA CUSTODIAN, make no representations or warranties about its accuracy, completeness or suitability for any particular purpose.
 GHD and DATA CUSTODIAN, cannot accept liability of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred as a result of the product being inaccurate, incomplete or unsuitable in any way and for any reason.
 Data Source: NSW Department of Lands: DTDB and DCDB - 2012. Created by: pmcdougall

2. Conceptual Model

2.1 Geology and Hydrostratigraphic Units

The FBB project is located within the Broughton Creek catchment. The Project alignment is approximately parallel to the north-east to south-west flow direction of the Broughton Creek.

The superficial geology along the alignment is characterised by estuarine, alluvial and colluvial deposits. The superficial geology is dominated by sandy clay and clay deposits. Coarser deposits such as gravels and cobbles are found in areas south of the town of Berry, which is further away from the Project alignment. The superficial deposits are laterally and vertically very heterogeneous and therefore are conceptualised as a single hydrostratigraphic unit.

The solid geology in the Broughton Creek catchment is characterized by elevated sedimentary (sandstone) reliefs and igneous (latite) intrusions. The solid geology of the Broughton catchment is described in detail in other reports such as Coffey (2010). The main units present in the area are:

- The Berry Siltstone which lithology is characterised by interbedded mid grey to dark grey siltstone and fine sandstone.
- Jamberoo Sandstone, Kiama Sandstone and only marginally the Westley Park Sandstone which lithology is characterised by red, brown and grey volcanic lithic sandstones.
- Bumbo and Blow Hole Latite Members which are volcanic flow facies characterised by columnar jointing.

All the solid geology units described above outcrop to some extent within the Broughton Creek catchment. Given the dominant presence of siltstone and sandstone units, the solid rock units are conceptualised as a single hydrostratigraphic unit. Differences in hydraulic properties are likely to exist between the siltstone / sandstone units and the latite units. Different hydraulic conductivity values will be assigned to the latite and siltstone / sandstone outcrop areas.

2.2 Groundwater Levels, Groundwater Flow Directions and Recharge Estimates

Analysis of the available groundwater levels in the area suggests that the water table is likely to represent a subdued image of the ground surface. Thus groundwater levels are high in topographically elevated areas and low along the Broughton Creek valley. Groundwater flows from highland recharge areas, primarily the sandstone and latite outcrops, to discharge to the main creeks and low-lying areas.

Evidence of a topographically driven groundwater flow is provided by groundwater levels ranging from elevations in excess of 80 mAHD (boreholes BH12, BH13, P01, P02 and P03) in the outcrop highs of the Bumbo Latite to elevations lower than 5 mAHD (CBH05, B08 and CBh08) in low-lying areas to the south of Berry town.

Evidence of groundwater discharging to the main creeks is provided by the relatively large baseflow component of the total creek flow for the Broughton Mill Creek. Time series of creek flows are available for the Broughton Mill Creek at Broughton Vale (flow gauge reference number 215018), the Broughton Mill Creek at Berry (flow gauge reference number 215015) and Jaspers Creek at Jaspers Brush (flow gauge reference number 215019). However, only gauges 215018 and 215019 have a relatively long and continuous flow record and are therefore suitable

to quantify the baseflow component of the total creek flow. The dataset for flow gauge 21015, provided by The Office of Water (NSW) has a very discontinuous record and it appears that this station is not currently being maintained.

The Lyne and Hollick (1979) method was used to estimate the baseflow for the streams with suitable data. Appendix A provides plots of the estimated baseflow components for the available stream flow gauging data. Baseflow separation of creek flows recorded at gauging station 215018 suggests around 6 MI/d of baseflow or around 16% of long term average total creek flow. Baseflow separation of creek flows at gauging station 215019 suggests around 2.4 MI/d of baseflow or around 12% of long term average total creek flow. It is expected that the flows presented in the appendix are inclusive of water already abstracted for irrigation and basic landholder rights.

Given the baseflow estimates provided above and the sub-catchment areas, recharge can be estimated as described in Table 1.

Table 1 Recharge Estimates from Baseflow Separation

Zone	Creek Name	Creek Gauging Station	Baseflow Estimate (m ³ /d)	Sub-catchment Area (Km ²)	Recharge (mm/d)
215018	Broughton Mill	Broughton Vale	5,986	18.324	0.32
215019	Jaspers	Jaspers Brush	2,400	13.0904	0.18
Average Value:					0.25

The estimated recharge value of 0.25 mm/d which corresponds to around 6% of long term average rainfall at rain gauge 68003 (Berry Masonic Village) was used as initial recharge value in the steady-state model. This estimation of recharge percentage approximates that stated in the groundwater sharing plan for this area (NOW, 2011), which suggests that the method adopted to derive recharge rates (i.e. from base flow estimates) is realistic.

3. Model Construction

3.1 Model Grid

Three main considerations were taken into account during the design of the numerical model grid for the FBB, as follows:

1. The purpose of the FBB is to assess the impacts of road construction on groundwater levels as well as baseflow to the Broughton Creek and tributaries. Therefore the model should be large enough to encompass the whole Broughton Creek catchment. The model should also be oriented with the dominant south-westward groundwater flow direction which corresponds approximately to the overall drainage direction of the Broughton Creek.
2. The model boundaries should be placed at a sufficient distance from the site to minimise the interaction of model prediction results with the model boundaries. The catchment boundaries of the Broughton Creek were identified as suitable boundaries to the north and north-east. The Shoalhaven River was identified as suitable boundary to the south-west and the coastline was identified as suitable boundary to the south and south-east.
3. The model grid horizontal resolution should be fine enough in the surrounding of the proposed road reserve boundary to ensure that sufficient detail of the road design is represented in the model. Furthermore the model resolution should be fine enough for the model predictions to replicate the detail of the phreatic surface in the surrounding of the proposed road during development.

Based on these considerations the model was oriented on a north-east to south-west direction with the x-axis of the model grid approximately parallel to the main drainage direction of the Broughton Creek. The model grid was given variable resolution to ensure a resolution of 10 m by 10 m in a region of 13 Km (north-east to south-west) by 4 Km (north-west to south-east) surrounding the proposed road and coarser resolution up to 100 m by 100 m at the boundaries of the active model domain. The current model grid for the FBB groundwater model is illustrated in Figure 2.

The model comprises 558 rows by 1,397 columns with up to 779,526 model cells in each layer. Given that the hydrostratigraphic model developed is of two layer system (see Section 3.3 for details on the model layering) this gives up to 955,184 active model cells.

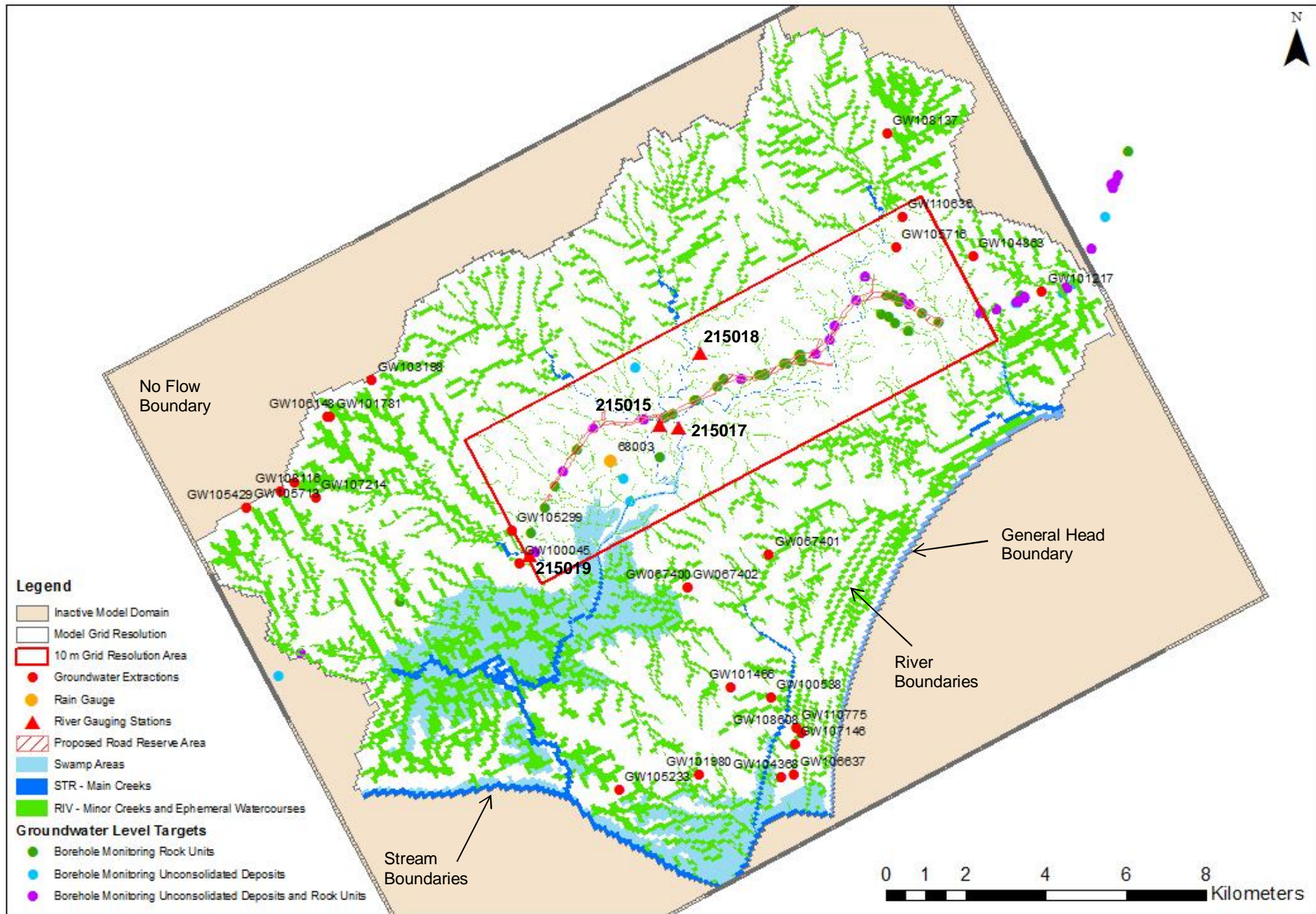


Figure 2: Foxground to Berry Model Grid and Boundaries

3.2 Model Code Selection

Numerical model development was undertaken using the Groundwater Vistas modelling Graphical User Interface (GUI) which was set up to simulate groundwater flow using MODFLOW SURFACT (Hydrogeologic, 1996). MODFLOW-SURFACT is an enhancement to the MODFLOW 96 suite of groundwater modelling code. In particular MODFLOW-SURFACT was selected for this application because it provides additional capabilities which include representation of groundwater flow in the saturated and unsaturated zone.

The numerical code selected for this model is MODFLOW-SURFACT v4 (HydroGeoLogic, 1996), a proprietary modification to the United States Geological Survey's open source MODFLOW-96 (finite difference) code. MODFLOW-SURFACT v4 provides several useful enhancements to MODFLOW-96 including:

- A more robust and flexible numerical solver (PCG5);
- Simulation of saturated and unsaturated zone flow, resolving many of the issues with cell drying and rewetting and associated numerical instabilities of standard MODFLOW;
- A more flexible and robust well boundary package (FWL4/5);
- A more flexible recharge package (RSF4), which allows for simulation of recharge rejection when groundwater levels are shallow.

3.3 Model Layering

The conceptual model identifies two main hydrostratigraphic units in the area:

1. Superficial unconsolidated deposits including alluvial and colluvial deposits, estuarine deposits.
2. Solid rock units of the Shoalhaven Group comprising Budgong Sandstone, Gerringong Volcanic Facies and Berry Siltstone.

Based on the conceptual model of the site and the NSW Department for Mines Geological Series Sheet S1 56-9 for Wollongong 1:250,000 outcrop geology map of the area a two layer representation of the system has been modelled numerically as follows:

- Layer 1 – Unconsolidated deposits.
- Layer 2 – Solid rock units.

The areal extent of the unconsolidated deposits was defined based on the 250,000 outcrop geology map. Differentiation of the various rock geological units comprising model layer 2 was obtained through parameterisation of the hydraulic conductivity (see Section 3.4).

The elevations of the rock unit and the thickness of the unconsolidated deposits was derived using a combination of:

- Topographic surface based on 1 meter resolution LIDAR data for the whole Broughton Creek catchment provided by RMS.
- Interpreted borehole logs, test pits and CPT tests for all geotechnical investigations carried out since 2007 and are primarily located in the close proximity of the Project alignment.
- Interpreted borehole logs from the NSW Groundwater Works database.

Geotechnical and geological investigations used in the construction of the three-dimensional model included data contained in the following reports provided by RMS:

- Maunsell-Aecom and Coffey Geotechnics, (October 2007), “Preliminary Geotechnical Report - Gerringong to Bomaderry Princes Highway Upgrade”.
- Coffey Geotechnics, Maunsell Aecom (16 November 2007) Princes Highway Upgrade, Route Selection Study, Geotechnical Investigation, Gerringong To Bomaderry NSW, Volume 1: Interpretation Report, Report Ref: GEOTUNAN02580AA-AZ.
- Maunsell-Aecom, (February 2009), “Gerringong to Bomaderry Princes Highway Upgrade – Geotechnical Interpretive Report”, Report ref: DEV06/04-GE-MA No: 60021933.
- Golder Associates Pty Ltd, (draft, undated), “Princes Highway Upgrade – Gerringong to Bomaderry. Additional Geotechnical Investigation – Factual Report”. Report Ref: 087622122.
- Coffey Geotechnics, (May 2010), “Geotechnical Interpretive Report for Concept Design”. Preferred Route of the Princes Highway, Gerringong to Bomaderry. Report Ref: GEOTWOLL02580AE-BL.
- Coffey Geotechnics, (February 2010), “Geotechnical Factual Report for Concept Design”. Gerringong to Bomaderry. Report Ref: GEOTWOLL02580AE-BD.
- Roads and Maritime Services, (March 2011), “HW1 – Princes Highway, Gerringong Upgrade, Mt Pleasant to Toolijooa Road. Geotechnical Overview Report” File No. 10-04.
- Coffey Geotechnics, (2 August 2012), “Geotechnical Interpretive Report, South Berry Option, Foxground to Berry Bypass, Berry NSW.” Report Ref: GEOTWOLL03387AA-AB.
- Roads and Maritime Services (21 May 2012) Foxground and Berry Bypass Project, Proposed South Berry Option, Princes Hwy (HW1), Berry NSW, Factual Geotechnical Investigation Report, Job Ref: 11- 02.
- Roads and Maritime Services, (9 May 2013), “HW1 – Princes Highway, Proposed Cutting, Foxground NSW. Geotechnical Investigation Factual Report” File No. 11-02.
- Roads and Maritime Services, (31 July 2013), “HW1 – Princes Highway Foxground and Berry Bypass, NSW. Geotechnical Information Document – Issue 3”. File No. 11-02.

3.4 Initial Model Parameters

Hydraulic conductivity was assigned as zones in the model domain based on the outcrop geology map. Given the lack of hydraulic testing data for the rock and unconsolidated units the initial model parameter values were obtained from literature (Anderson and Woessner, 1992 and Domenico and Schwartz, 1998). Table 2 summarises the initial hydraulic conductivity values as well as the range of permissible values for each zone specified in the model. Figure 3 shows the spatial extent of the hydraulic conductivity zonation as specified in the steady-state model.

Table 2 Initial Hydraulic Conductivity and Permissible Range

Zone	Geological Unit	Initial Horizontal Hydraulic Conductivity (m/d)	Lower Bound Horizontal Hydraulic Conductivity (m/d)	Upper Bound Horizontal Hydraulic Conductivity (m/d)	Ratio Kh and Kv
1	Superficial Unconsolidated Deposits	1.0×10^{-01}	1.0×10^{-02}	$1. \times 10^{+01}$	1
2	Basement Unit (general)	5.0×10^{-03}	8.6×10^{-07}	1.2×10^{-03}	10
3 & 8	Bumbo and Blow Hole Latite Members	4.0×10^{-04}	2.6×10^{-09}	5.0×10^{-01}	10

3.5 Boundary Conditions

3.5.1 Recharge and Evapotranspiration

Recharge was implemented in the model via the Modflow Recharge Package (RCH). Recharge is applied to the top active model layer.

An initial recharge value of 0.25 mm/d was assigned at different recharge zones in the model. Recharge zones were identified based on outcrop geology and qualitative analysis of groundwater level hydrographs as follow:

1. Alluvial, Colluvial deposits. Lack of time series logger data monitoring this unit does not allow a qualitative assessment of recharge in this unit, however spot readings (borehole B8 and CBH05) indicate groundwater levels close to surface and thus suggest high recharge in this unit;
2. Berry Siltstone (East of Berry). Time series logger data (boreholes BH21, BH24 and F21) suggest significant response to rainfall events with post-rainfall event groundwater level fluctuations up to 6 m. The Berry Siltstone outcrop area, east of Berry, is considered a high recharge area;
3. Berry Siltstone (West of Berry). Groundwater hydrograph for borehole F35 suggests little response to rainfall events. Conversely data for borehole BH29 located close by shows up to 1.7 m groundwater level fluctuations during intense rainfall events. The Berry Siltstone outcrop area, west of Berry, is considered a medium / low recharge area;
4. Bumbo Latite member. Time series logger data (boreholes BH12, BH13, P3) suggest significant response to rainfall events with post-rainfall event groundwater level fluctuations up to 8 m. The outcrop areas of the Bumbo Latite are considered high recharge areas;
5. Kiama Sandstone. Time series logger data (boreholes BH10) suggest moderate response to rainfall events with groundwater level fluctuations generally less than 1 m. The outcrop area of the Kiama Sandstone is considered a medium-low recharge area.

The initial recharge value assigned to each zone listed above was subsequently adjusted in the calibration process against groundwater levels and river baseflow (see Section 4).

In addition to the zones listed above a further recharge zone was specified for the low-lying swampy areas present to the south-west of Berry which are drained by Broughton Creek and its tributaries. These areas are characterised by water table close or at ground surface all year round and thus a recharge of 3.98 mm/d, equivalent to the long term average rainfall, was adopted. Given that the water table is close to ground surface it has been assumed that evapotranspiration occurs at its maximum possible rate determined by the meteorological conditions. Evapotranspiration was simulated in the model via the Modflow Evapotranspiration Package (EVT). The extinction depth was set to 0.5 m below the evapotranspiration surface which was set to coincide with the modelled topographic surface.

The recharge / evapotranspiration zone corresponding to swampy areas was not adjusted during the calibration process and thus the model parameters were kept fixed to its initial value during the calibration process.

3.5.2 Stream and River Boundaries

The Broughton Creek and Crooked River drainage systems were simulated via a combination of the Modflow Stream (STR) and River (RIV) Packages as illustrated in Figure 1 and Figure 2.

The main rivers and creeks, i.e. the Broughton Creek including the tributaries Broughton Mill Creek, the Bundewallah Creek and Jaspers Creek as well as the Shoalhaven River and the Crooked River were simulated using the Stream Package which allows for a more sophisticated simulation of surface and groundwater interactions than the simple River Package. Stream stage elevation was set to the minimum of the 10 m DEM within each model grid cell, with some manual modification to certain areas of the drainage network to guarantee the downstream flow of the main rivers. The stream bed top was set to 0.3 m below the stream stage and a thickness of 0.2 m was assigned to the stream bed. Stream conductance was set to an initial value of 100 m²/d and it was subsequently adjusted in the calibration process.

The remaining minor creeks and water courses were simulated with the River Package. The River bed has been set to have a zero thickness meaning that these River boundaries act in the same fashion as Modflow Drain boundaries, i.e. allowing baseflow out of the aquifer but not allowing leakage from watercourses to the aquifer. Similarly to the streams the river stage elevation was set to the minimum of the 10 m DEM within each model grid cell. River conductance has been set to 100 m²/d and it was subsequently adjusted in the calibration process.

3.5.3 General Head Boundaries

General head boundaries (GHB) have been applied along the coastline at the edge of the active model domain to simulate the sea (see Figure 2). The elevation of the GHBs was set consistently to the minimum stream stage specified for the Shoalhaven River.

3.5.4 No-Flow Boundaries

No flow boundaries were assigned at the edge of the northern and western edges of the Broughton Creek catchment based on the assumption that there is no significant subsurface groundwater inflow from adjacent catchments into the Broughton Creek groundwater system (see Figure 2).

3.5.5 Groundwater Extractions

According to the NSW groundwater works there are 26 groundwater extraction bores with known extraction yields within the model active domain as illustrated in Figure 2. Groundwater extraction bores in the area are primarily used for agricultural and stock and domestic purposes. According to the database yields range from 12.4 L/s in borehole GW108608 to 0.01 L/s in borehole GW103198.

Groundwater extractions were simulated using the Modflow-Surfact FWL4 package which allows a reduction in the volume of groundwater extracted if a specified in-bore target water level is achieved during the model simulation. Given the lack of information regarding the depth of the pump in the boreholes the target water level was set to the bottom elevation of each borehole.

4. Model Calibration

4.1 Model Calibration Strategy

Calibration of the groundwater flow model was undertaken in steady state through comparison of observed and modelled groundwater levels at 60 borehole locations and observed and modelled baseflow at 3 flow gauges.

Calibration of the steady-state model was carried out using the PEST suite of software (Doherty, 2010) and adopting the following overall framework:

1. The initial horizontal hydraulic conductivity was allowed to vary within suitable bounds as defined in Table 2 in each hydraulic conductivity zone defined in Section 3.4. The vertical hydraulic conductivity was 'tied' to the horizontal hydraulic conductivity in all zones but the Latite units where both the horizontal and the vertical hydraulic conductivity were allowed to vary within pre-defined bounds;
2. The initial recharge value was allowed to vary between 1 and 10 per-cent of long term average rainfall in each recharge zone defined in Section 3.5.
3. The river and stream conductances were allowed to vary between 1 m²/d and 1000 m²/d in each sub-catchment for which a river baseflow target was available.

A total of 26 parameters were adjusted in the calibration process. The use of both groundwater levels and river baseflow targets in the calibration process allowed a more robust estimation of interlinked model parameters such as hydraulic conductivity and recharge.

4.2 Calibration Targets

4.2.1 Groundwater Levels

Groundwater levels were provided by RMS in the form of logger data and manual readings. The average groundwater level elevation was calculated for the 60 groundwater bores present within the active model area and used as targets in the model calibration.

Groundwater level targets range from a maximum of around 112.3 mAHD in the Bumbo Latite outcrop highs in the north-east of the Broughton catchment to -0.2 mAHD in the low-lying swampy areas to the south-west of Berry.

Groundwater level statistics for each hydraulic conductivity zone in the model are listed in Table 3. The distribution of groundwater targets with the model domain that were used for calibration are presented in Figure 2. Groundwater levels are generally very high in the highland outcrop areas of the Bumbo Latite with a zone average value of 76.1 mAHD.

Zone average groundwater level for the Berry Siltstone (east of Berry – Zone 4) is higher than the zone west of Berry (Zone 7) suggesting that these two zones are hydrogeologically different.

Table 3 Groundwater Level Targets by Hydraulic Conductivity Zone

Zone	Geological Unit	Number of Observed Groundwater Level Targets	Zone Avg. Groundwater Level (mAHD)	Zone Min. Groundwater Level (mAHD)	Zone Max. Groundwater Level (mAHD)
1	Superficial Unconsolidated Deposits	6	21.4	-0.2	57.8

Zone	Geological Unit	Number of Observed Groundwater Level Targets	Zone Avg. Groundwater Level (mAHD)	Zone Min. Groundwater Level (mAHD)	Zone Max. Groundwater Level (mAHD)
2	Basement Unit (general)	12	19.3	1.9	41.1
3 & 8	Bumbo and Blow Hole Latite Members	11	76.1	54.9	112.3
4	Berry Siltstone (east of Berry)	10	33.8	12.1	48.0
7	Berry Siltstone (west of Berry)	7	14.3	8.1	20.3
5	Jamberoo Sandstone	4	44.1	33.9	55.3
6	Kiama Sandstone	10	30.8	17.7	62.8

4.2.2 Creek Baseflow

Time series of creek flows for Broughton Mill Creek at Broughton Vale and Jaspers Creek at Jaspers Brush suggest a baseflow component of around 6 ML/d and around 2.4 ML/d, respectively (see Section 2.2).

Flow time series are also available at gauging station 215015 (Broughton Mill Creek at Berry) but given the discontinuous dataset it was not possible to carry out a baseflow separation at this location. However, a baseflow target for Broughton Mill Creek at Berry was calculated based on the assumption that the Broughton Mill Creek sub-catchment area between Vale and Berry would produce the same amount of baseflow per unit area as the one produced by Broughton Mill Creek sub-catchment at Broughton Vale. Given that assumption, it was assumed a baseflow of around 13.4 ML/d for the Broughton Mill Creek at Berry.

The baseflow estimates provided above were used as targets in the model calibration.

4.3 Calibration Results

4.3.1 Calibrated Hydraulic Conductivity

Calibrated horizontal and vertical hydraulic conductivity values are shown in Table 4. Calibrated hydraulic conductivity for the FBB model suggest that three major changes were required to achieve a good match between modelled and observed groundwater levels and baseflows as follows:

- The initial horizontal hydraulic conductivity of the superficial unconsolidated deposits (zone 1) was increased by one order of magnitude;
- The initial horizontal hydraulic conductivity of the Kiama Sandstone (zone 6) was reduced by a factor of 0.3;
- The initial vertical hydraulic conductivity of the Bumbo Latite units was increased by a factor larger than 100.

The substantial increase in vertical hydraulic conductivity of the Bumbo Latite is consistent with the geological nature of this unit where columnar jointing is often found within these volcanic facies and thus a vertical groundwater flow direction is preferred to horizontal flow direction.

Calibrated horizontal and vertical hydraulic conductivity are well within the permissible ranges specified in Table 2 for all zones. A comparison of calibrated values and test data was not possible at this stage of the project as testing is currently being undertaken as part of on-going

fieldwork activities. The comparison with test data however will be undertaken at later stages of the project as part of the model validation phase.

Table 4 Calibrated Horizontal and Vertical Hydraulic Conductivity

Zone	Geological Unit	Calibrated Horizontal Hydraulic Conductivity (m/d)	Calibrated Vertical Hydraulic Conductivity (m/d)	Ratio Kh/Kv
1	Superficial Unconsolidated Deposits	$1.0 \times 10^{+00}$	$1.0 \times 10^{+00}$	1
2	Basement Unit (general)	4.8×10^{-03}	4.8×10^{-04}	10
3	Bumbo Latite Member	7.4×10^{-04}	6.8×10^{-03}	0.1
4	Berry Siltstone	4.8×10^{-03}	4.8×10^{-04}	10
7	Berry Siltstone	3.6×10^{-03}	3.6×10^{-04}	10
5	Jamberoo Sandstone	4.5×10^{-03}	4.5×10^{-04}	10
6	Kiama Sandstone	3.2×10^{-04}	3.2×10^{-05}	10

4.3.2 Calibrated Recharge

Calibrated recharge values for each model zone are shown in Table 5. Calibrated recharge for the FBB model suggest that two major changes were required to achieve a good match between modelled and observed groundwater levels and baseflows as follows:

- Recharge was increased from 6 per-cent to around 8 to 10 per-cent of long term average rainfall in the highland areas north of Berry;
- Recharge for the Kiama Sandstone and the Berry siltstone (west of Berry, only) was decreased from 6 per-cent to around 1 to 1.5 per-cent of long term average rainfall.

The increase of recharge in the highland catchment areas to the north of Berry (zone 2 and 6) is consistent with the relatively large baseflow component observed for Broughton Mill Creek at Vale and Berry. The calibrated recharge value for zone 2 and 6 are also consistent with the recharge estimated from baseflow for the Broughton Mill Creek at Vale sub-catchment (see Section 2.2).

Conversely the decrease of recharge in zone 7 (Berry Siltstone, west of Berry) is consistent with lower observed baseflow for Jaspers Creek catchment as well as lower observed groundwater levels west of Berry town. The calibrated recharge value for zone 7 is consistent with the recharge estimated from baseflow for the Jaspers Creek at Jaspers Brush sub-catchment (see Section 2.2).

The low recharge values for the Kiama Sandstone is associated with a lack of baseflow targets in that area and thus the calibrated recharge value is only determined matching the available observed groundwater levels in recharge zone 9.

Table 5 Calibrated Recharge Values

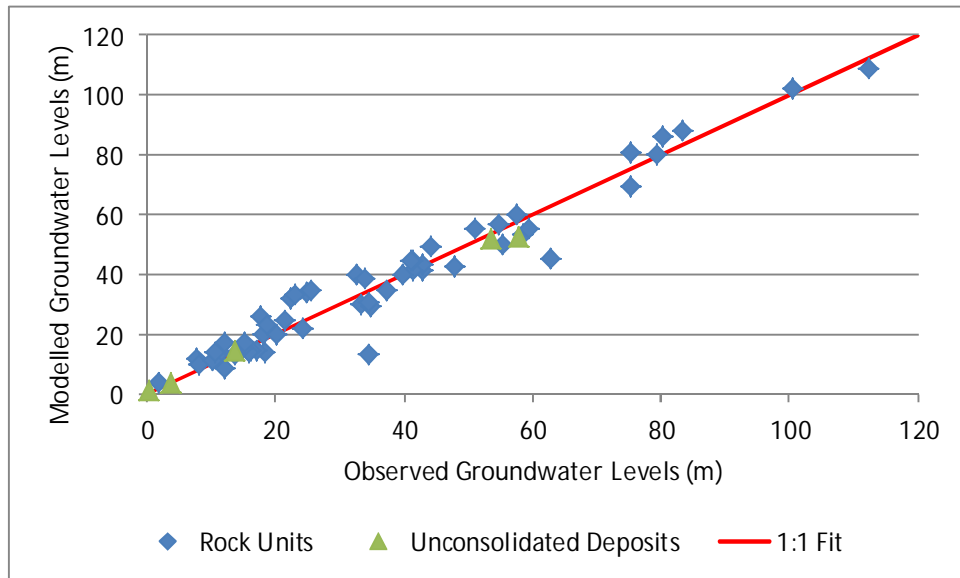
Zone	Geological Unit	Calibrated Recharge (mm/d)
1 & 4	Superficial Unconsolidated Deposits	0.398
2	Basement Unit (general)	0.33
3	Swampy Areas	3.98 *
5	Bumbo Latite	0.32

Zone	Geological Unit	Calibrated Recharge (mm/d)
6	Berry Siltstone (East of Berry)	0.398
7	Berry Siltstone (West of Berry)	0.058
9	Kiama Sandstone	0.045
* Recharge in swampy areas was not calibrated but kept fixed to long term average rainfall		

4.3.3 Comparison of Observed and Modelled Groundwater Levels

Scatter plots of modelled against observed average groundwater levels for all head targets used to calibrate the steady-state model are shown in Figure 4.

Various calibration statistics are presented in Figure 4. The scaled root mean square error (sRMS) is less than five per cent, which is within the typically accepted limits, as suggested in the Australian Groundwater Flow Modelling Guideline (National Water Commission, 2012). Calibrated model water balance errors are well below one per cent, which is also within the guidelines' suggested limits. The statistical distribution of modelled head error is approximately normal, with the greatest density of errors within the +/- 5 m error band (Figure 4), and relatively evenly spread positive and negative head errors either side of that. The mean absolute head error is 4 m, with only two bores (b01 and bh11) with head errors larger than 15 m. However, it should be noted that at both of those locations only one manual groundwater level reading was available at the time of the model calibration. It is therefore possible that the targets used for boreholes b01 and bh11 are not representative of average groundwater conditions and thus are considered of low reliability.



No Calibration Bores	60	Root Mean Square Error	5.5
Sum of Square Errors	1815	Overall Scaled RMS Error	4.9%

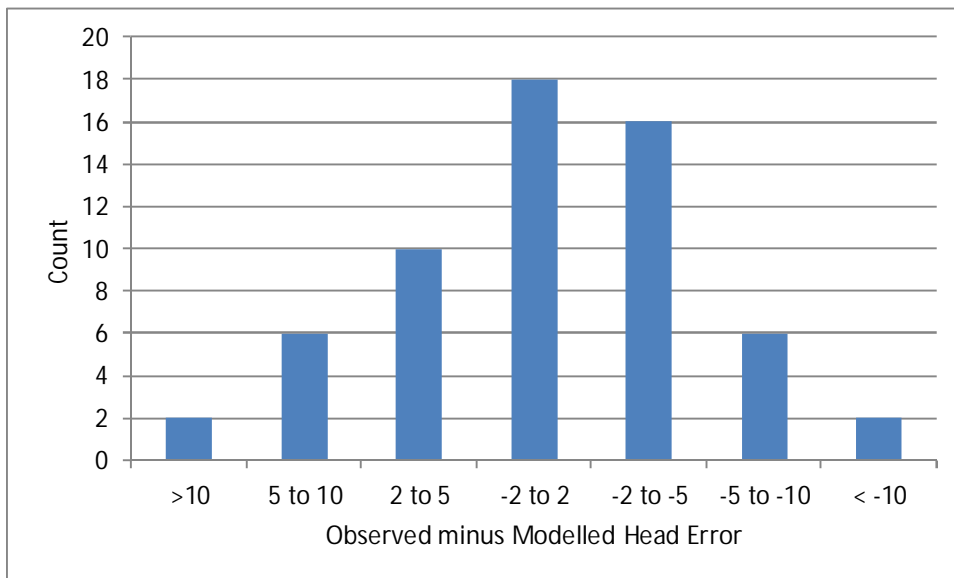


Figure 4: Steady State Groundwater Level Calibration Statistics

4.3.4 Comparison of Observed and Modelled Baseflow

Model calibration suggests a good match between observed and modelled creek baseflows as illustrated in Table 6. Calibrated model results suggest that modelled baseflow is within +/- 10 % of observed baseflow at the two Broughton Mill Creek gauging stations used in the model calibration. Model results however suggest a larger baseflow for Jaspers Creek with the calibrated value sitting outside the +/- 10 % error bar.

Modelled baseflow is also listed for Broughton Creek at the Oaks although a calibration baseflow target is not available at this location.

Table 6 Observed and Modelled Baseflow Comparison

Gauging Station ID	Catchment	Target Baseflow (MI/d)	+/- 10% of Baseflow Target	Modelled Baseflow (MI/d)	Within +/- 10% Error Bound
215018	Broughton Mill Creek at Broughton Vale	6.0	5.4 - 6.6	6.19	Yes
215015	Broughton Mill Creek at Berry	13.4	12.1 - 14.7	14.22	Yes
215019	Jaspers Creek at Jaspers Brush	2.4	2.2 - 2.6	3.01	No
215017	Broughton Creek at The Oaks	-	-	13.13	-

5. Model Predictions

5.1 Predictive Model Objectives

The primary purpose of developing a groundwater flow model for the FBB was to provide a tool to predict:

- Groundwater inflows to the Project cuttings for road construction planning;
- Groundwater level changes to the hydrogeological units present in the Broughton Creek catchment in response to dewatering of the Project workings;
- Potential baseflow impacts on local water courses; and
- Impacts on local hydrological features of environmental or economic importance, which might be sensitive to groundwater level decline.

5.2 Predictive Model Construction

Construction of the predictive model was relatively straightforward as it required minimal modification of the steady-state model input files.

5.2.1 Stress Periods and Time Steps

At the current stage of the project a detailed road construction program is not available including a start and end date of the road workings. Therefore the predictive model was set-up to assess the long term impact of the proposed development post-construction. A long term transient model comprising 120 yearly stress periods was created and the impacts are assessed once the groundwater system has re-equilibrated to steady-state conditions.

To assess the inflow changes during construction of the Project an additional model was set up with daily stress periods that simulated for a period of 10 years. The 10 year period was based on the above model design suggesting that steady state conditions would be reached within 10 years of construction completion. At the time of developing this model little information was available to characterise the staging of construction. As such, the following conditions were assumed:

- Construction occurs over a period of two years,
- Construction commences at the south western extent of the Project alignment and finishes at the north eastern extent of the Project alignment.
- Construction progresses at a constant rate.

5.2.2 Initial Groundwater levels and Model Parameters

Initial groundwater levels, hydraulic conductivity, recharge and stream / river conductances were taken from the calibrated steady state model.

Modelled storage values adopted for predictive modelling are summarised in Table 7. It should be noted that given that a transient calibration of the model was not undertaken at this stage the storage values were taken from reference groundwater modelling books including Anderson and Woessner,(1992) and Domenico and Schwartz (1998).

Confined storage values for each model layer are input to MODFLOW-SURFACT in the form of total storativity (i.e. specific storage multiplied by the layer thickness).

Table 7 Predictive Model - Storage Values

Zone	Geological Unit	Storativity	Specific Yield
1	Superficial Unconsolidated Deposits	1×10^{-01}	1×10^{-01}
2	Outcrop Basement Units	1×10^{-02}	1×10^{-02}
3	Confined Basement Units	6.9×10^{-03} *	1×10^{-02}
* Base on a specific storage value of $6.9 \times 10^{-5} \text{ m}^{-1}$ and a constant thickness of 100 m.			

5.2.3 Simulation of Road Workings

The Project has been simulated in the model using the Modflow Drain (DRN) package.

As already mentioned previously due to the lack of a construction schedule at this stage of the Project the model drains for the whole road extent are active from the first stress period of the predictive model simulation in the yearly time step model with a constant progression of construction over two years in the daily time step model.

The drain elevations were set to one meter below the elevation of the proposed road centreline. The elevations were provided directly by RMS at approximately 10 m interval for the whole road bypass. The width of the road was obtained from design drawings (60021933-xrf-10-02-rd_des_mc2a_2d_130723.dwg) provided by RMS and was generally around 25 m. The same elevations as the road centreline were specified for the whole width of the road giving therefore a flat profile to the base of the road

The drain conductance was set to a relatively large value of $1,000 \text{ m}^2/\text{d}$, which is equivalent to a vertical hydraulic conductivity value of $1 \text{ m}/\text{d}$. Thus the equivalent hydraulic conductivity value used to parameterisation of the Modflow drain cells is greater than the calibrated vertical hydraulic conductivity of the modelled layers; hence the material properties of the modelled layer will tend to control the modelled flow to drain cells rather than the modelled drain conductance.

5.3 Predictive Model Results

5.3.1 Predicted Inflows to Road Workings

Figure 5 presents the predicted inflows to the cuttings along the project alignment during construction. There are three peaks in the drain outflow in Figure 5 that correspond to the three main road cuttings detailed as follows:

- The first peak is associated with the major cutting(s) near Berry (see Figure 8), At this time flows peak at approximately 0.14 ML/day
- The second peak is associated with the major cutting(s) between Tindalls Lane and Tomlins Road (see Figure 7). At this time flows peak at approximately 0.25 ML/day
- The third peak is associated with the major cutting(s) Foxground Road (Figure 6). At this time flows peak at approximately 0.27 ML/day.

It is noted that these results represent an overview of the potential inflows based on a limited understanding of how the construction will progress. A more detailed assessment of each cutting will be required at detailed design stage when appropriate staging information for the cutting is available.

The predictive model results suggest that the groundwater system will take around 10 years to re-equilibrate to steady-state conditions. The model suggests a long-term post-construction groundwater inflow to the road cuttings of around 0.14 ML/d.

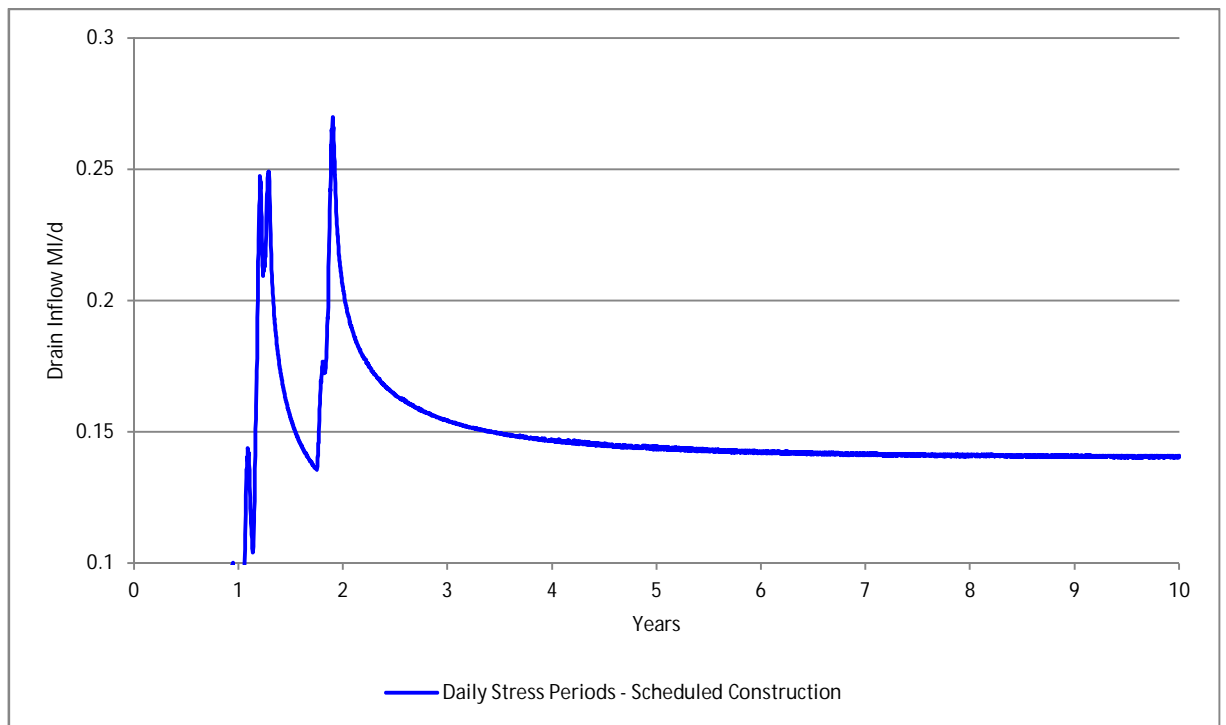


Figure 5: Predicted inflows during and after construction

5.3.2 Predicted Groundwater Level Impacts

Road elevations are generally above ground surface in areas where alluvial deposits are present. Therefore little or no groundwater level impacts are anticipated in alluvial deposits and this is confirmed by predictive model results.

Groundwater level impacts are expected in the rock unit aquifers at the location of the three main road cuttings and surrounding areas. Groundwater level impacts at the location of the three main road cuttings along the proposed road bypass are shown in Figure 6 to Figure 8. Predictive model results suggest around a 20 m impact to the water table in the road cutting close to Foxground Road. Predictive model results suggest a water table impact up to 10 m and 3 m in the Project cuttings between Tindalls Lane and Tomlins Road and the cuttings close to Berry town, respectively. Predictive model results suggest groundwater level impacts further away from the main road potentially impacting registered groundwater bores located in the area. Groundwater level impacts at specific registered bores are listed in Table 8.

Impacts to registered groundwater users

Groundwater level impacts greater than 0.1 m are predicted at three registered groundwater bores. Predictive model results also suggest a less than 0.1 m groundwater level impact at the other 20 registered groundwater bores.

Table 8 Groundwater Level Impacts at Registered Bores

Bore ID	Distance From Road (m)	Model Layer	Drawdown (m)
GW107697	383	2	0.18
GW022508	1110	2	0.13
GW016425	313	2	0.12
GW025595	163	2	0.06
GW011451	740	2	0.04
GW010826	244	2	0.01
GW015221	337	2	0.01
GW022506	1216	2	0.01
GW065515	70	2	0.01
GW015286	102	2	0.01
GW057927	1188	2	0.01
GW054770	43	2	0.01
GW108622	553	2	0.01
GW017029	1252	2	0.01
GW045655	1242	2	< 0.01
GW051054	1291	2	< 0.01
GW101971	396	2	< 0.01
GW028843	1852	2	< 0.01
GW012997	1245	2	< 0.01
GW019253	794	2	< 0.01
GW028887	809	2	< 0.01
GW031987	1226	2	< 0.01
GW105716	1171	2	< 0.01

Groundwater impacts approximating 0.18 m or less are not anticipated to represent an adverse impact to the water supply in these wells and would be considered to be negligible impact under the NSW Aquifer interference policy (NOW, 2012).

Impacts to Sensitive Surface Water Features

A number of potentially sensitive surface water features are present in the vicinity of the project alignment. This includes Foys Swamp and Coomonderry Swamp, which are located near to Seven Mile beach at distances of greater than 2 km to the south east of the Project. These systems are also likely to be hydraulically separated from the Project by the ridgeline that separates the Broughton Creek and Crooked River Catchments. Further to this the groundwater elevation changes created by the project do not intersect these surface water features. Therefore, groundwater changes associated with the project are not expected to have an adverse impact on these systems.

Impacts to Acid Sulphate Soils

The long term drawdown response created by the cuttings at Tindalls Lane and Tomlins Road (see Figure 7) are simulated to intersect potential acid sulphate soils to the south east located in low lying areas along Broughton Creek. These areas are identified as having a low potential for the presence of acid sulphate soils in Maunsell (2007).

In terms of impacts to sensitive features, the generation of acid sulphate soils in this area is unlikely to impact existing groundwater users, however, impacted groundwater is likely to discharge to Broughton Creek.

In terms of managing this risk there are a number of potential options, which could include either of, or a combination of:

- Additional intrusive soil investigations to characterise the actual potential for the generation of acid sulphate soils within the simulated drawdown zone.
- Implementation of measures to recharge dewatered groundwater from the cuttings to downgradient locations flanking acid sulphate soil areas and hence reduce drawdown impacts. This measure could be assessed within the groundwater model.
- An assessment of road design and construction to minimise drawdown impacts at these cuttings and hence prevent the potential for the generation of adverse impacts. These measures could be assessed within the groundwater model.
- Implementation of a monitoring regime in this area to monitor for pH impacts and provide an early warning mechanism for enhanced mitigation measures to be implemented. Sampling location SW03 would act to identify impacts in Broughton Creek. A strategically placed monitoring bore, would perhaps provide an early warning mechanism for the presence of emerging groundwater elevation impacts.

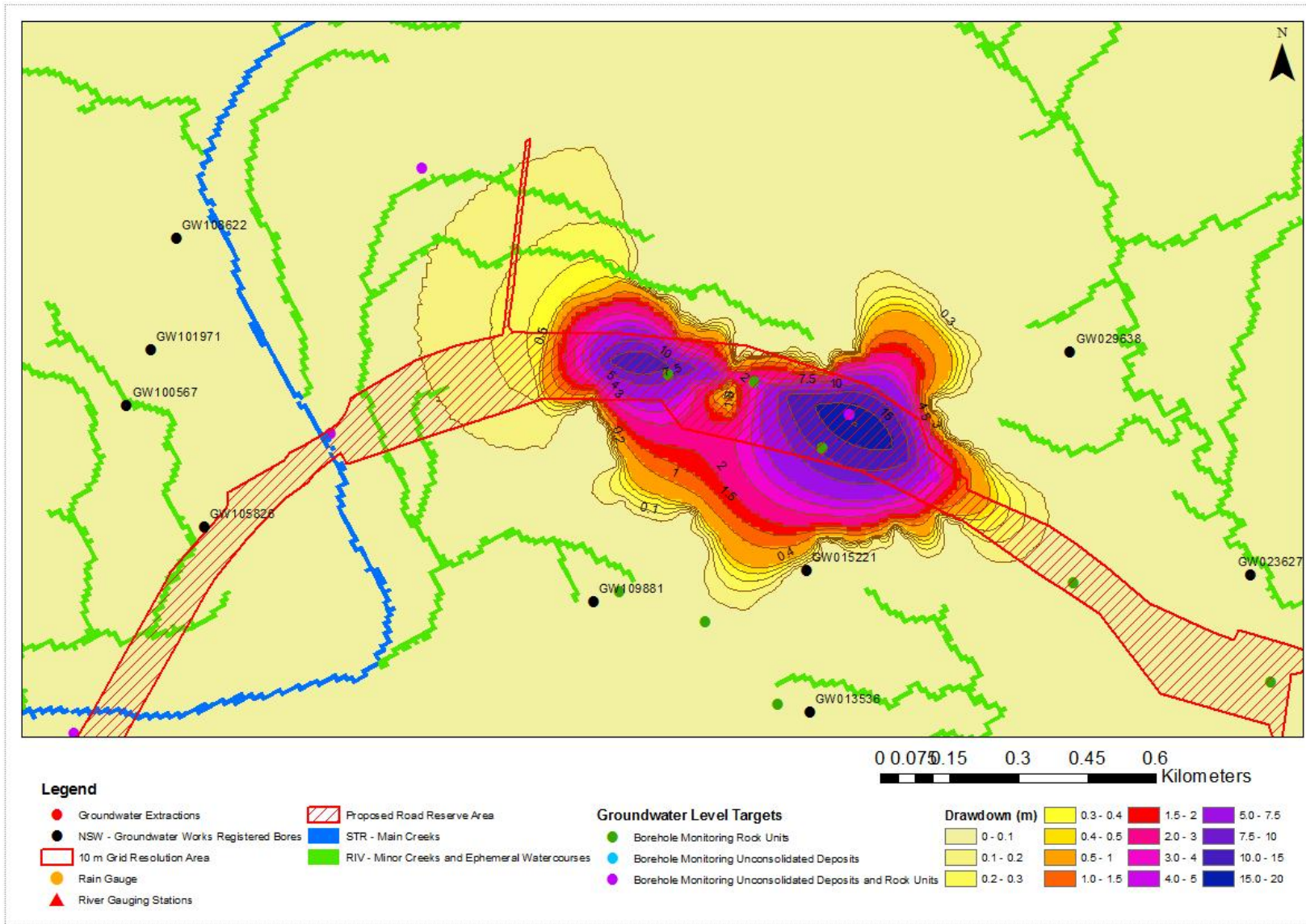


Figure 6: Predicted Groundwater Level Impacts – Cuttings close to Foxground Road

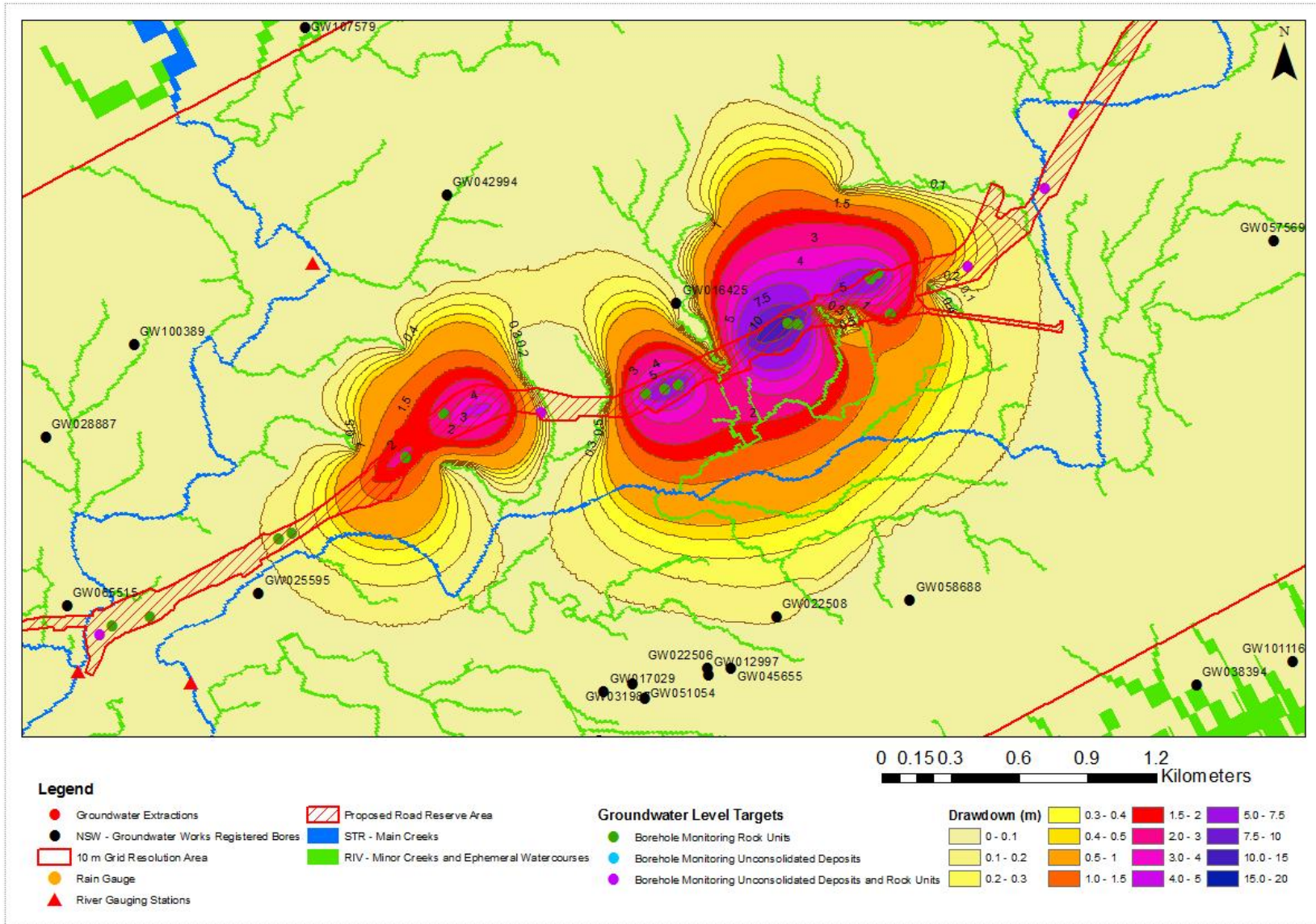


Figure 7: Predicted Groundwater Level Impacts – Cuttings between Tindalls Lane and Tomlins Road

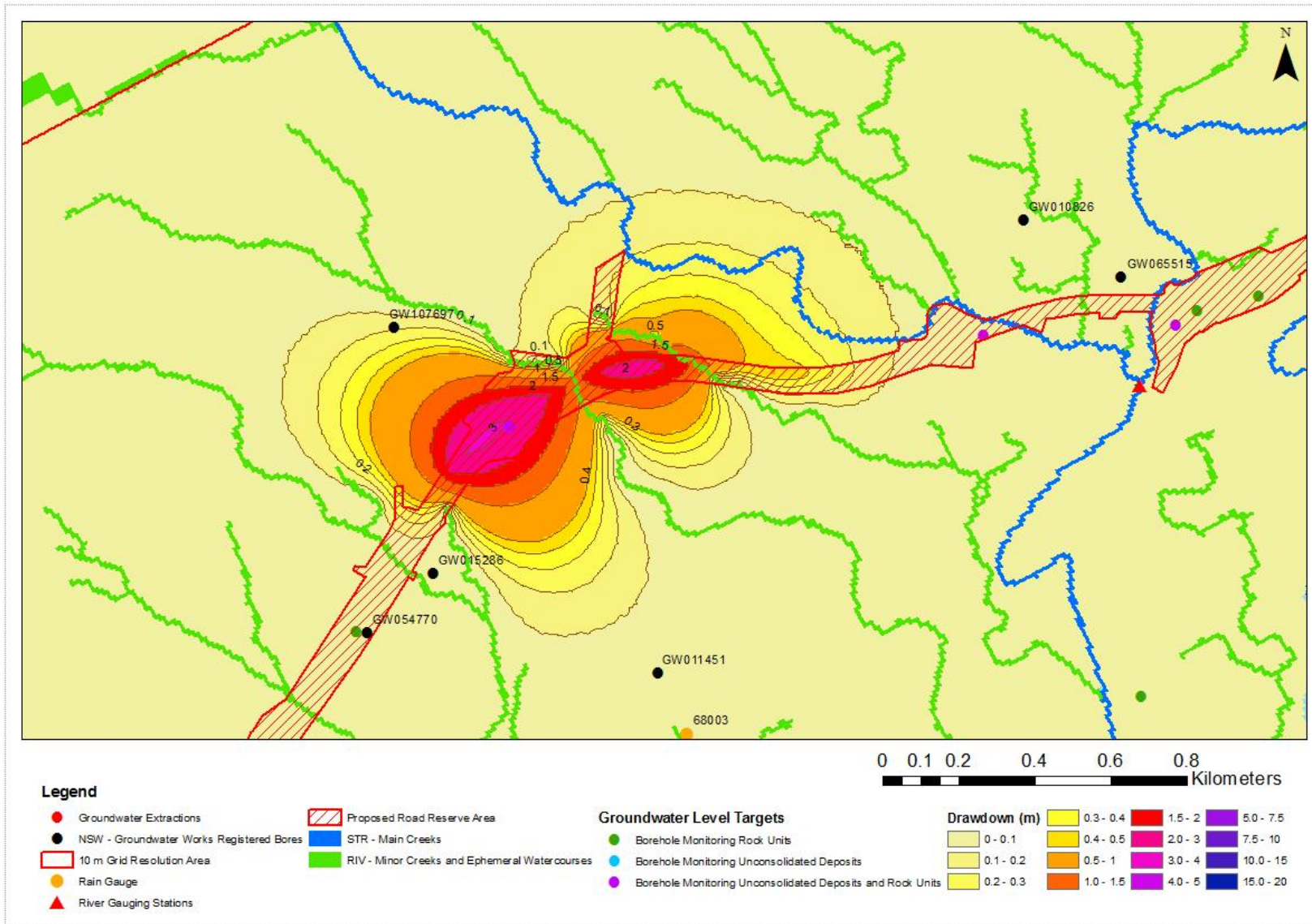


Figure 8: Predicted Groundwater Level Impacts – Cuttings nearby Berry town

5.3.3 Predicted Baseflow Impacts

Baseflow impacts at gauging stations in the Broughton Creek catchment are shown in Table 9.

Predictive model results suggest up to 0.2% baseflow reduction from the calibrated baseflow value across the whole model domain, which includes the Broughton Creek and Crooked River catchments.

The majority of baseflow impact is associated with the Broughton Creek. Predictive model results suggest up to 0.6% baseflow reduction for the Broughton Creek at The Oaks. Baseflow to the Broughton Creek is impacted by the project cuttings between Tindalls Lane and Tomlins Road as well as the major cutting close to Foxground Road.

Predictive model results suggest a small baseflow reduction for Broughton Creek at Berry caused by the project road cutting near Berry.

As expected no baseflow impacts are predicted at Jaspers Creek at Jaspers Brush and Broughton Mill Creek at Broughton Vale as the upstream reaches of these sub-catchments drain areas which are located at a significant distance from the project road cuttings.

Table 9 Baseflow Impacts at Creeks Gauging Stations

Gauging Station ID	Catchment	Calibrated Baseflow (ML/d)	Predicted Baseflow (ML/d)	Percentage Baseflow Reduction
215018	Broughton Mill Creek at Broughton Vale	6.19	6.19	No Impact
215015	Broughton Mill Creek at Berry	14.22	14.21	0.04
215019	Jaspers Creek at Jaspers Brush	3.01	3.01	No Impact
215017	Broughton Creek at The Oaks	13.13	13.05	0.6
Total (whole model active area)*		74.1	73.9	0.2

* Include Broughton Creek and Crooked River

Impacts to aquatic ecology and surface water supplies

The predicted reduction in groundwater baseflows are expected to be at percentages that are within background fluctuations and are expected to be relatively insignificant in terms of impacts to aquatic ecology and ongoing surface water supplies obtained under basic landholder rights. Despite this, further quantification of these reductions relative to existing basic landholder right abstractions and aquatic health are required.

5.3.1 Impacts to Farm Dams

There are approximately ten farm dams located along the alignment that are within the location of the zones of drawdown influence create by project alignment cuttings. Of these farm dams only four are located in zones where the drawdown influence is greater than 0.2 m.

The farm dams along the project alignment are anticipated to be primarily reliant on surface water harvesting and are unlikely to have significant connections to groundwater systems. As such, they are considered unlikely to be adversely impacted. Consideration could be given to monitoring the water level in and/or groundwater elevations surrounding the dam in the four most potentially impacted farm dams prior to construction and operation in order to monitor for groundwater related impacts after construction.

5.3.2 Settlement Impacts

The drawdown in groundwater elevations can be associated with settlement. The significance of the impacts are likely to be most pronounced in areas where there is significant development and where there are unconsolidated sediments that have the potential to settle with dewatering. Based on this it is anticipated that the drawdown cones created beneath Berry may present a settlement risk. There may also be isolated risks to housing located within zones of drawdown influence intersection unconsolidated sediments elsewhere along the alignment.

It is recommended that the results of this report are provided to appropriate settlement specialists to assess the potential for settlement. Subject to the findings of this review appropriate mitigation measures can be developed.

5.3.3 Recharge Impacts

Changes in groundwater recharge due to the development of the project and associated increases in sealed surface have not been simulated by the modelling. This is because these impacts are expected to be small given that sealed areas are likely to represent a small percentage of the overall catchment recharge.

6. Conclusions

A numerical groundwater model has been developed to assess the impact of the project on groundwater users and groundwater dependent systems.

The modelling approach and complexity has been based on that undertaken prior to construction for other major road upgrade projects in NSW where groundwater is considered to be sensitive.

The modelling has been designed to focus on changes in groundwater elevations and flow volumes associated with the project. Impacts to groundwater quality and associated management measures are summarised in the GQMP document.

The report has been designed as a technical appendix to the GQMP and should be read in conjunction with the GQMP.

The groundwater modelling results suggest that the primary impacts will be associated with drawdown around cuttings along the project alignment. The predicted impacts and proposed management measures are summarised below:

- Impacts to surrounding registered groundwater wells are simulated to be within acceptable ranges, with the maximum predicted drawdown within impacted registered groundwater wells approximating less than 0.2 m.
- The drawdowns are expected to result in a less than 1 % reduction in the base flow component of catchment surface water features. This is anticipated to have negligible impacts on in-stream aquatic ecology and existing surface water user supplies, however, further consultation with ecological specialists is required to validate this.
- Impacts to sensitive surface water features such as Coomonderry Swamp and Foy's swamp are simulated to be negligible.
- The zones of drawdown influence created by the cuttings near to Tindalls Lane and Tomlins Road are simulated to intersect areas where there is low potential for the presence of Acid Sulphate soils. In terms of managing this risk there are a number of potential options, which could include either of, or a combination of:
 - Additional intrusive soil investigations to characterise the actual potential for the generation of acid sulphate soils within the simulated drawdown zone.
 - Implementation of measures to recharge dewatered groundwater from the cuttings to downgradient locations flanking acid sulphate soil areas and hence reduce drawdown impacts. This measure could be assessed within the groundwater model.
 - An assessment of road design and construction to minimise drawdown impacts at these cuttings and hence prevent the potential for the generation of adverse impacts. These measures could be assessed within the groundwater model.
 - Implementation of a monitoring regime in this area to monitor for pH impacts and provide an early warning mechanism for enhanced mitigation measures to be implemented. Sampling location SW03 would act to identify impacts in Broughton Creek. A strategically placed monitoring bore, would perhaps provide an early warning mechanism for the presence of emerging groundwater elevation impacts.
- The zones of drawdown influence created by the cuttings extend under isolated developments along the alignment, particularly in the Berry area, that are potentially situated on unconsolidated materials. This may represent a settlement risk that should be considered further by appropriate specialists.

- Ten farm dams are intersected by the zone of drawdown influence of which four are in zones of drawdown greater than 0.2 m. Given that the farm dams rely primarily on the surface water harvesting it is considered unlikely that they will be impacted by groundwater drawdown unless they have significant contact with groundwater. Consideration could be given to monitoring the water level in and/or groundwater elevations surrounding the dams in the four most potentially impacted farm dams prior to construction and operation in order to monitor for groundwater related impacts after construction.

Given the current understanding of design and construction of the alignment it is recommended that the modelling is revised when there is more certainty on the design levels and construction program. At this time more detailed assessment of non-uniqueness in the modelling outcomes should be considered.

7. Limitations

7.1 Modelling limitations

The model has the following key assumptions/limitations.

The model has been calibrated to observed stream flow data and groundwater observations along the alignment using automatic calibration software PEST. In the absence of site specific hydraulic conductivity data a larger range, based on literature data, has been specified for the calibration. This increases the potential for the introduction of non-uniqueness into the model, which means the ability to get the same calibration with equally plausible inputs. The overall recharge to the model appears to be realistic. It is based on back calculation of base flows from stream data and compares well with rates used in the groundwater sharing plan for this area. A realistic and well constrained recharge within the model domain is likely to result in estimates of hydraulic conductivity that are also realistic in order for a reasonable calibration to stream flows and groundwater elevations to be achieved. Hydraulic data is being collected along the alignment and will be compared against values derived from automatic calibration to provide further evidence of the robustness of the calibrated model.

Geological and groundwater elevation data is primarily focused on the alignment. This means that in model areas further away from the alignment data becomes scarce and therefore the model design relative to geological layering and calibration becomes more uncertain in its ability to provide realistic outcomes. LIDAR topographical information has been used to represent topography through the model domain while detailed geological data for the alignment has been coupled with geological map information. These factors combined will provide a reasonably tight understanding of the shallow groundwater system within the model domain, which is anticipated to be the main aquifer system impacted by the alignment. The locations where potential impacts extend to greater depth are usually at cuts along the alignment. At these locations there is abundant geotechnical data to confidently constrain the model design. Given this approach uncertainties associated with model design and layering are anticipated to be relative minimal with regard to providing a realistic estimate of impacts. Nevertheless, there is inherent uncertainty in all numerical groundwater models which is reflective of the limitation of the available data on which a model is designed.

The modelling undertaken provides an understanding of the likely impacts associated with the project based on the conceptual design, which will require further investigation at detailed design stage. At this time further modelling should be undertaken to assess non-uniqueness in the modelling outcomes, paying particular attention to the potential variation in impacts associated with changes in storage and under high and low flow conditions.

7.2 General Limitations

This report has been prepared by GHD for RMS and may only be used and relied on by RMS for the purpose agreed between GHD and the RMS as part of contract no. 13.2574.1729.

GHD otherwise disclaims responsibility to any person other than RMS arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section(s) 3 to 5 of this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by RMS and others who provided information to GHD (including Government authorities)], which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

8. References

See Section 3.3 for geotechnical reports used in this groundwater modelling work.

Anderson and Woessner, 1992. Applied Groundwater Modelling – Simulation of Flow and Advective Transport.

Domenico and Schwartz, 1998. Physical and Chemical Hydrogeology, Second Edition.

Hydrogeologic, 1996. MODHMS Software (Version 2.0) Documentation. Volume I: Groundwater Flow Modules.

Lyne, V. and Hollick, M. 1979. Stochastic time-variable rainfall-runoff modelling. Proceedings of the Hydrology and Water Resources Symposium, Perth, 10-12 September, Institution of Engineers National Conference Publication, No. 79/10, pp 89-92.

Maunsell (2007), Gerringong to Bomaderry Princes Highway Upgrade, Preliminary Acid Sulphate Soil Assessment,

National Water Commission, 2012. Australian Groundwater Modelling Guidelines. Waterlines Report Series No. 82, National Water Commission, Canberra, ACT, Australia

NSW Office of Water (NOW), 2012. NSW Aquifer Interference Policy, NSW Department of Primary Industries, Office of Water.

Appendices

Appendix A – Stream gauging data and estimated groundwater base flows

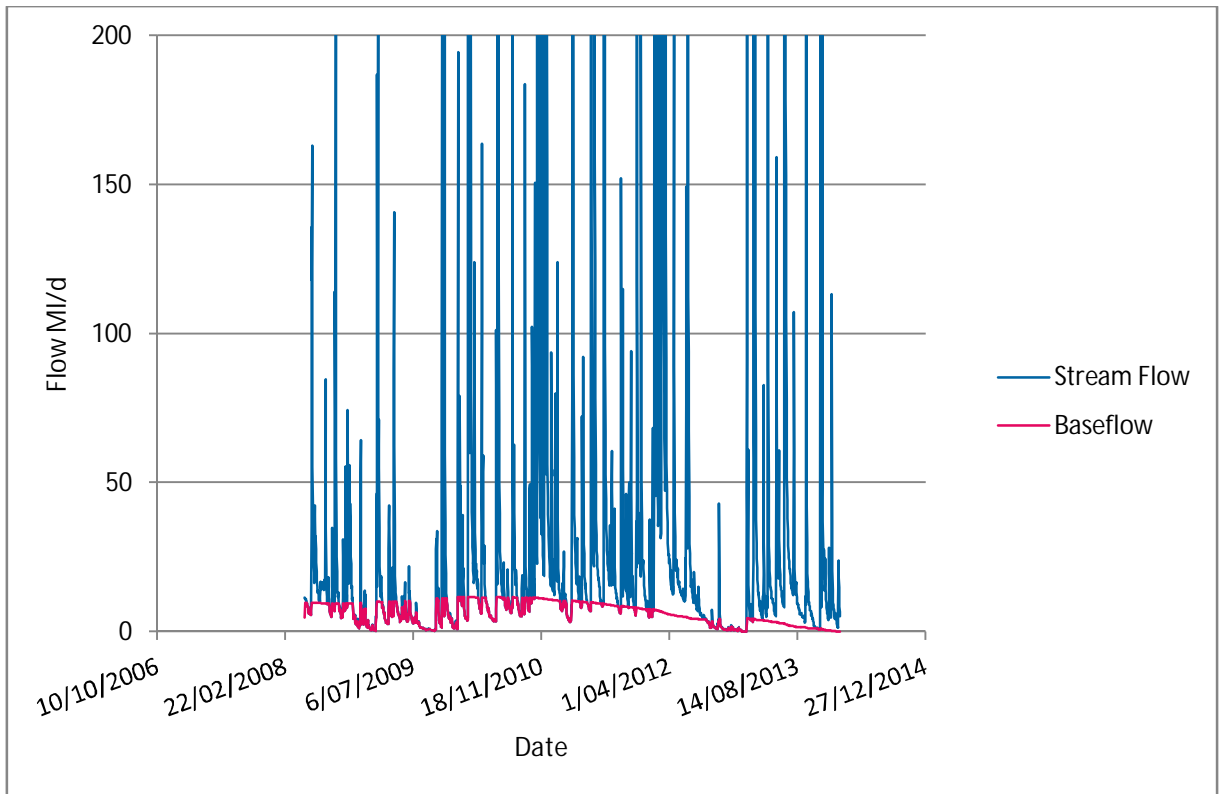


Figure A 1: Gauging data and Groundwater Baseflow Estimate for Surface Water Gauging Station 215018 (Broughton Mill Creek at Broughton Vale)

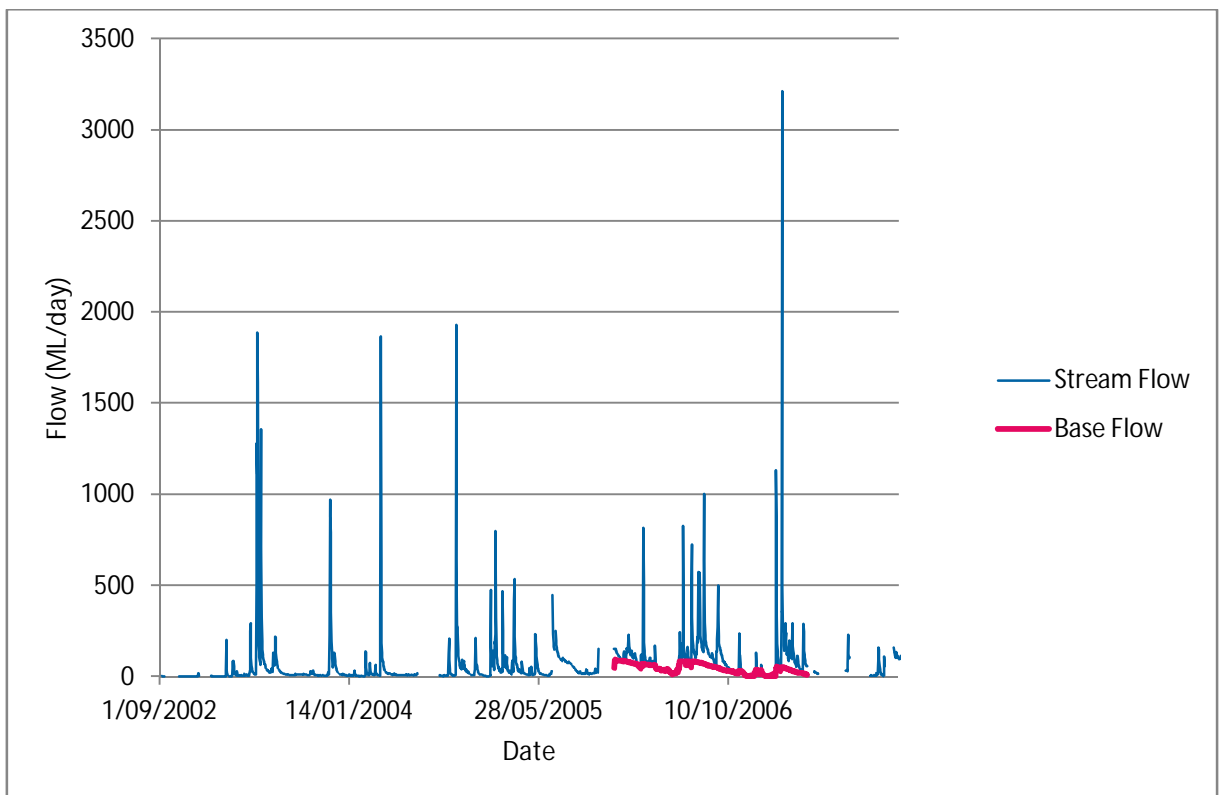


Figure A 2: Gauging data and Groundwater Baseflow Estimate for Surface Water Gauging Station 215015 (Broughton Mill Creek at Berry)

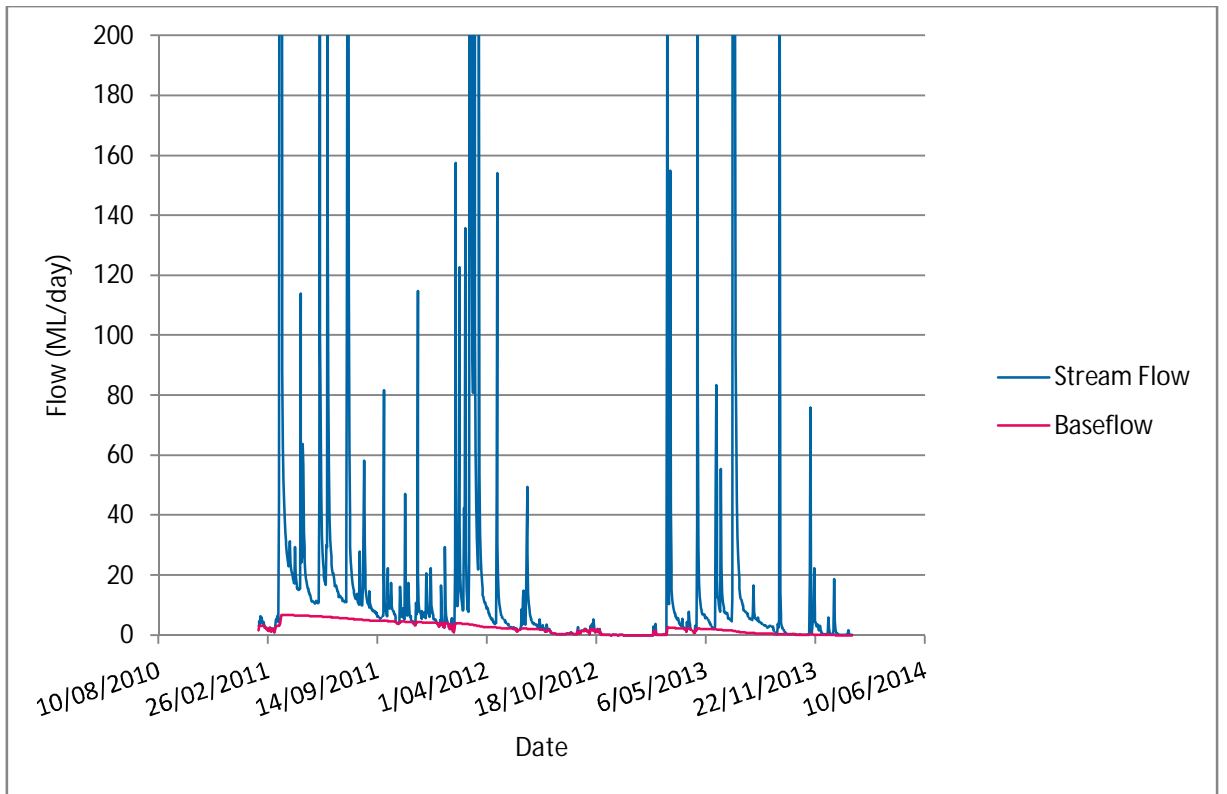


Figure A 3: Gauging data and Groundwater Baseflow Estimate for Surface Water Gauging Station 215019 (Jaspers Creek at Jaspers Brush)

GHD

145 Ann Street Brisbane QLD 4000

GPO Box 668 Brisbane QLD 4001



T: (07) 3316 3000 F: (07) 3316 3333 E: bnemail@ghd.com

© GHD 2014

This document is and shall remain the property of GHD. The document may only be used for the purpose for which it was commissioned and in accordance with the Terms of Engagement for the commission. Unauthorised use of this document in any form whatsoever is prohibited.

G:\21\23174\WP\456545.docx

Document Status

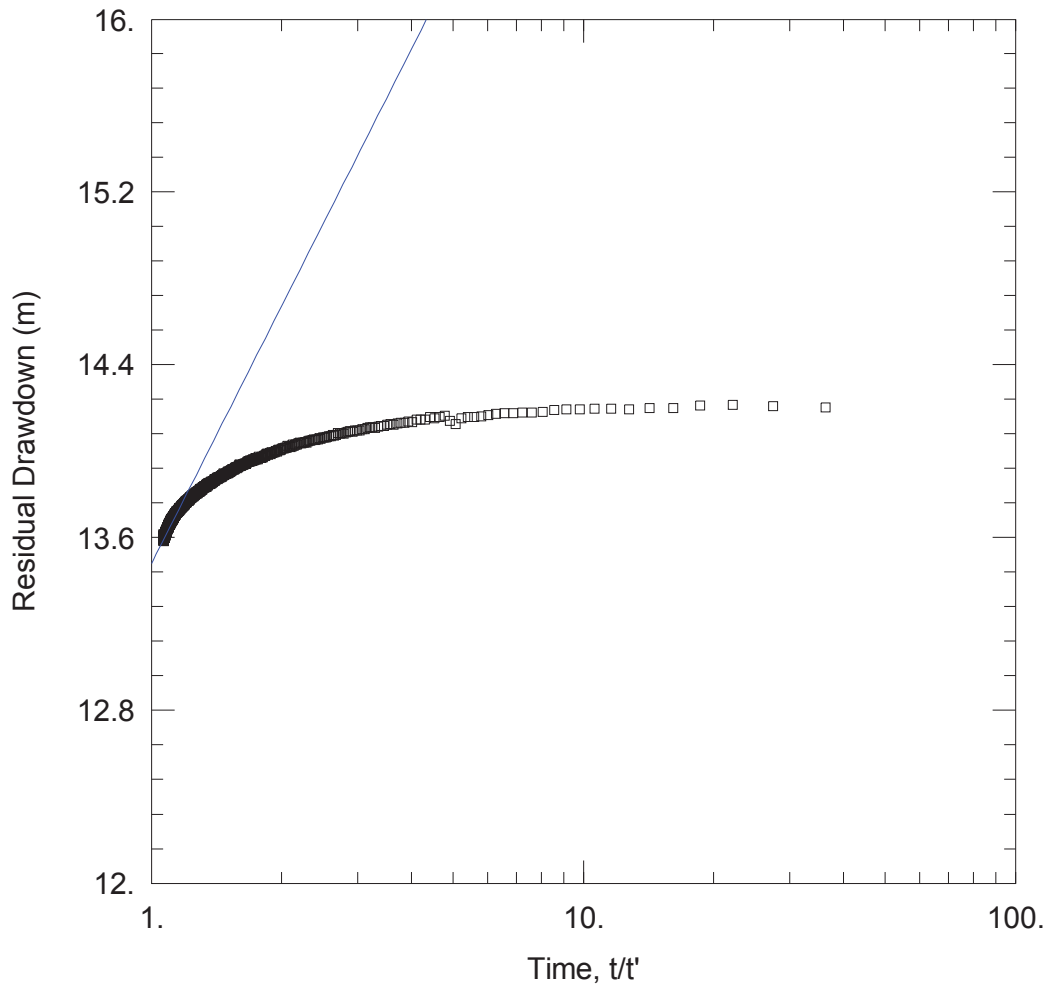
Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	L. Traverso	S. Charteris		J. Hallchurch		09/07/2014

www.ghd.com



Appendix B – Pumping Test Results

Well	Test Notes	Logger	Approx. Pumping Start Time	Approx. Pumping Finish Time	Pumping Duration (min)	Volume removed (L)	Average pumping rate (L/s)	Average pumping rate (m ³ /s)	Logger installation time	Pre-test GWL (m bgl)	Time	Well Depth (m bgl)	Water Column (m)	End test GWL reading (mbgl)	Manual reading time	GW Diff. Start to End	Trans. Est. 1 (m ² /day)	K Est. 1 (m/day)	Geology of Screen
MW08	Test completed - logger had to be inserted after pumping due to space.	118386	8/04/2014 15:19	8/04/2014 15:31	11.17	24	0.036	3.58E-05	8/04/2014 15:32	2.498	8/04/2014 15:08	10.65	8.15	2.88	8/04/2014 16:52	-0.38	0.024	0.003	Sandstone, Siltstone and Shale bands.
MW12	Test completed - logger had to be inserted after pumping due to space.	118386	14/04/2014 10:31	14/04/2014 10:36	4.32	15.5	0.060	5.98E-05	14/04/2014 10:37	6.720	14/04/2014 10:23	10.66	3.94	7.40	14/04/2014 16:25	-0.68	0.141	0.036	Weathered Shale
MW01	Test completed - logger had to be inserted after pumping due to space.	118389	8/04/2014 9:23	8/04/2014 9:50	26.42	50	0.032	3.15E-05	8/04/2014 9:51	6.745	8/04/2014 9:00	22.89	16.15	20.36	8/04/2014 16:23	-13.61	0.126	0.008	Shale/Siltstone
MW16	Test completed - logger had to be inserted after pumping due to space.	118389	9/04/2014 8:47	9/04/2014 9:11	23.88	60	0.042	4.19E-05	9/04/2014 9:12	0.761	9/04/2014 8:37	10.76	10.00	0.69	9/04/2014 13:53	0.08	0.061	0.006	Weathered to competent Siltstone
MW07	Test completed - logger had to be inserted after pumping due to space.	118529	9/04/2014 10:03	9/04/2014 10:42	38.93	75	0.032	3.21E-05	9/04/2014 10:43	11.027	9/04/2014 9:56	45.21	34.18	11.02	9/04/2014 15:05	0.01	1.894	0.055	Siltstone
MW10	Test completed - logger had to be inserted after pumping due to space. Dipper not working for manual readings. Data logger has no recovery response.	118529	14/04/2014 9:40	14/04/2014 9:58	17.58	60	0.057	5.69E-05	14/04/2014 9:59	12.141	22/04/2014 0:00	14.85	-	-	-	-	-	-	Hard Siltstone
MW04	Test completed - logger had to be inserted after pumping due to space.	122479	8/04/2014 12:56	8/04/2014 13:12	15.05	40	0.044	4.43E-05	8/04/2014 13:13	0.691	8/04/2014 12:55	7.00	6.31	0.75	8/04/2014 16:01	-0.05	0.129	0.020	Clay
MW13	Test completed - logger had to be inserted after pumping due to space. Pumped well dry.	122479	9/04/2014 14:18	9/04/2014 14:33	14.45	29	0.033	3.34E-05	9/04/2014 14:34	7.180	14/04/2014 14:15	14.80	7.62	7.11	10/04/2014 7:51	0.07	0.024	0.003	Weathered Shale
MW11	Test completed - logger had to be inserted after pumping due to space.	122487	9/04/2014 11:20	9/04/2014 11:56	35.20	43	0.020	2.04E-05	9/04/2014 11:57	11.252	9/04/2014 11:12	36.50	25.25	24.22	9/04/2014 15:37	-12.96	0.484	0.019	Siltstone
MW03	Test completed - logger had to be inserted after pumping due to space.	122491	8/04/2014 14:01	8/04/2014 14:31	29.62	60	0.034	3.38E-05	8/04/2014 14:32	11.600	8/04/2014 13:45	21.82	10.22	14.10	8/04/2014 16:37	-2.50	0.028	0.003	Shale/Siltstone
MW09	Test completed - logger had to be inserted after pumping due to space - Well balled as too dirty to pump.	122491	9/04/2014 12:48	9/04/2014 12:53	5.00	10	0.033	3.33E-05	9/04/2014 12:54	4.413	9/04/2014 12:42	10.74	6.33	4.50	9/04/2014 15:20	-0.08	0.060	0.009	Sandstone and Siltstone
MW02	Well dry no test completed.	-	-	-	-	-	-	-	-	28.160	15/04/2014 10:59	28.18	0.02	-	-	-	-	-	Siltstone
MW05	No test completed. Could not pump water out of well. It appeared the pump could not pump up the level of head required.	-	-	-	-	-	-	-	-	31.205	-	41.025	9.820	-	-	-	-	-	Siltstone
MW06	Well dry no test completed. 0.5 L of sediment in bottom of well.	-	-	-	-	-	-	-	-	25.025	-	25.855	0.830	-	-	-	-	-	Siltstone
MW14	Well not installed as yet	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MW15	Well not installed as yet	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-



MW01 PUMP TEST

Data Set: N:\AU\Sydney\Projects\21\23174\Technical\Pump tests\MW01b.aqt
 Date: 05/30/14 Time: 13:50:02

PROJECT INFORMATION

Company: GHD
 Client: RMS
 Project: 2123174
 Location: Berry to Foxground
 Test Well: MW01
 Test Date: 08/04/2014

AQUIFER DATA

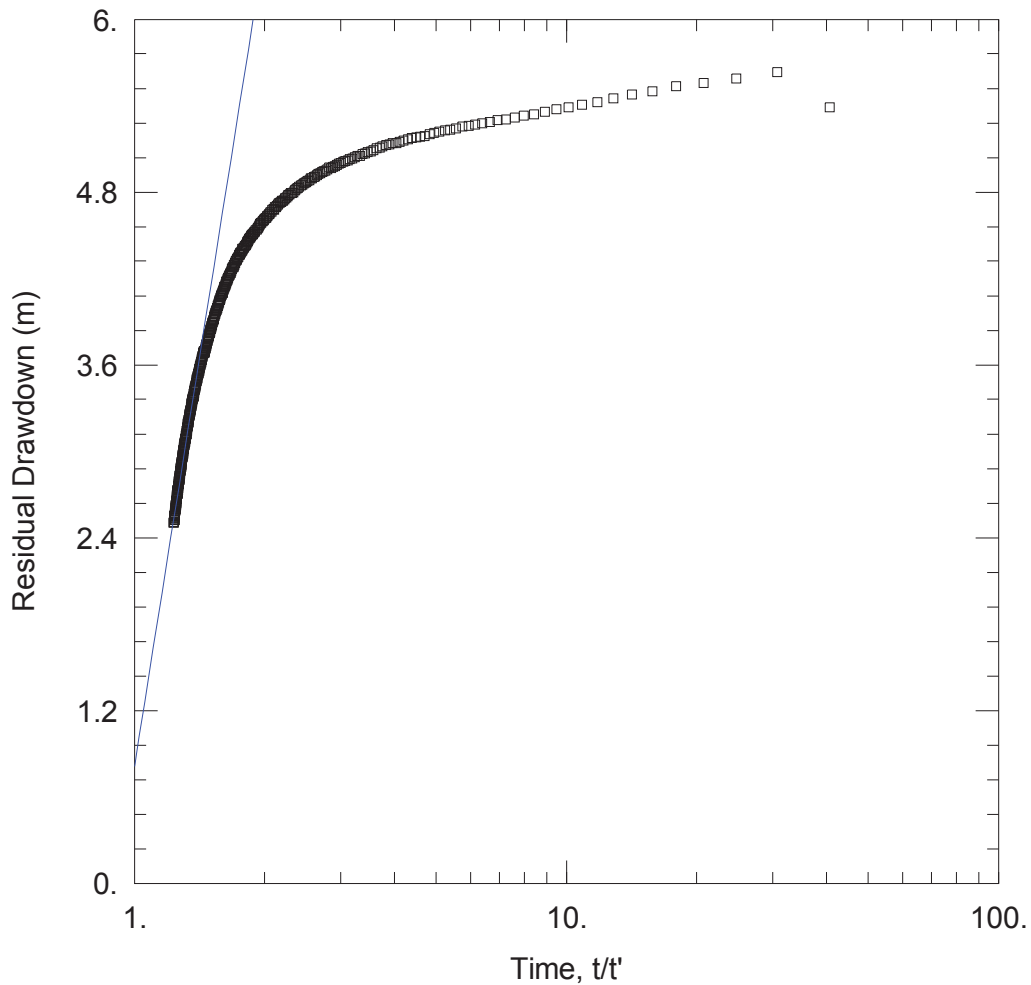
Saturated Thickness: 16.15 m Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA

Pumping Wells			Observation Wells		
Well Name	X (m)	Y (m)	Well Name	X (m)	Y (m)
MW01	0	0	□ MW01	0	0

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)
 T = 0.1262 m²/day S/S' = 0.0003934



MW03 PUMP TEST

Data Set: N:\AU\Sydney\Projects\21\23174\Technical\Pump tests\MW03a.aqt
 Date: 05/30/14 Time: 13:58:45

PROJECT INFORMATION

Company: GHD
 Client: RMS
 Project: 2123174
 Location: Berry to Foxground
 Test Well: MW03
 Test Date: 08/04/2014

AQUIFER DATA

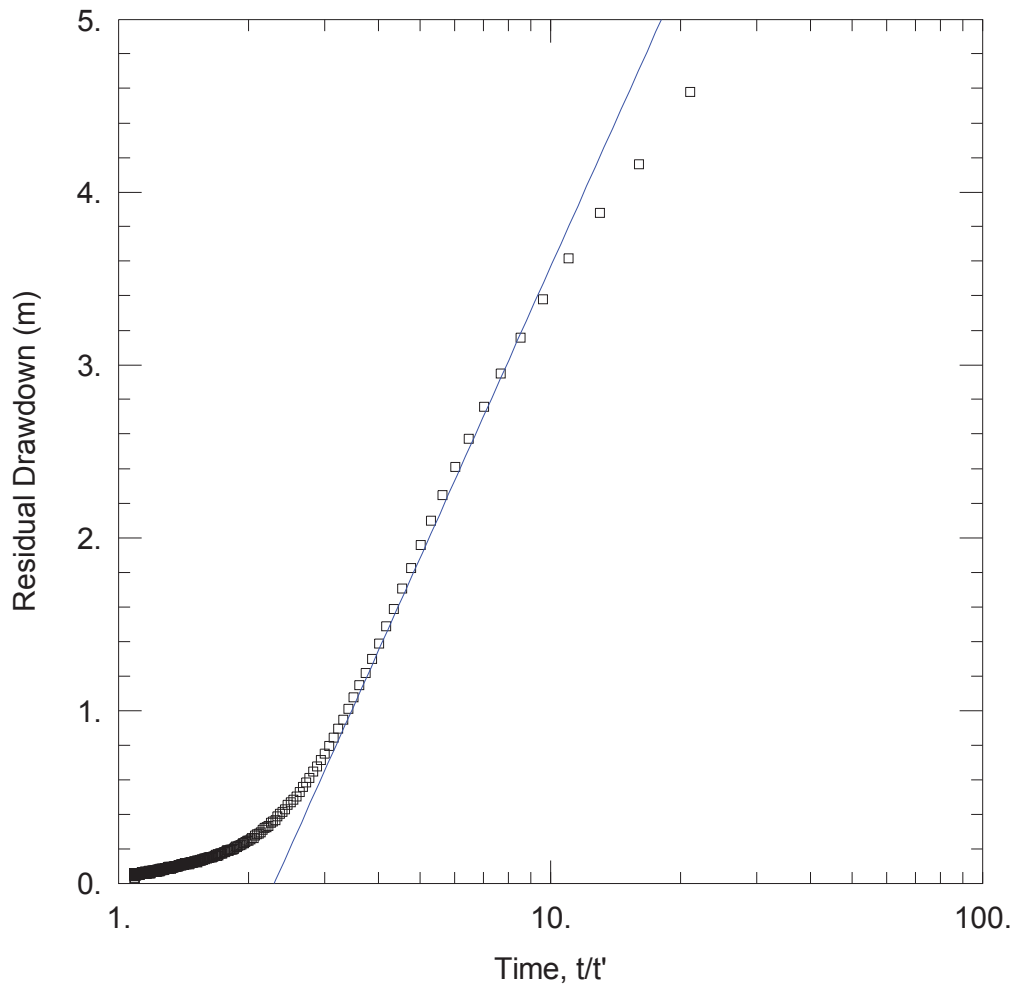
Saturated Thickness: 10.22 m Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA

Pumping Wells			Observation Wells		
Well Name	X (m)	Y (m)	Well Name	X (m)	Y (m)
MW03	0	0	□ MW03	0	0

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)
 T = 0.02833 m²/day S/S' = 0.906



MW04 PUMP TEST

Data Set: N:\AU\Sydney\Projects\21\23174\Technical\Pump tests\MW04a.aqt
 Date: 05/30/14 Time: 13:56:49

PROJECT INFORMATION

Company: GHD
 Client: RMS
 Project: 2123174
 Location: Berry to Foxground
 Test Well: MW04
 Test Date: 08/04/2014

AQUIFER DATA

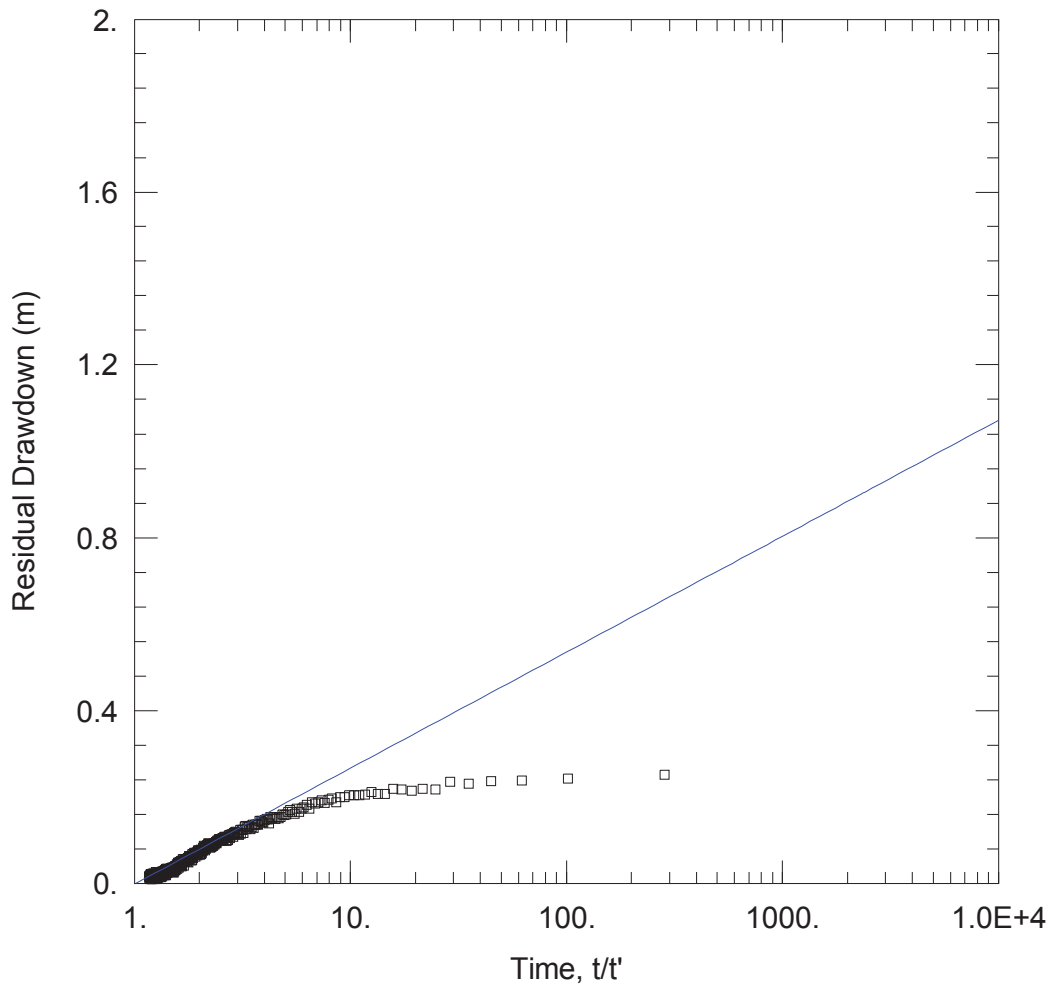
Saturated Thickness: 6.309 m Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA

Pumping Wells			Observation Wells		
Well Name	X (m)	Y (m)	Well Name	X (m)	Y (m)
MW04	0	0	□ MW04	0	0

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)
 $T = 0.1257 \text{ m}^2/\text{day}$ $S/S' = 2.295$



MW07 PUMP TEST

Data Set: N:\AU\Sydney\Projects\21\23174\Technical\Pump tests\MW07a.aqt
 Date: 05/30/14 Time: 13:54:31

PROJECT INFORMATION

Company: GHD
 Client: RMS
 Project: 2123174
 Location: Berry to Foxground
 Test Well: MW07
 Test Date: 09/04/2014

AQUIFER DATA

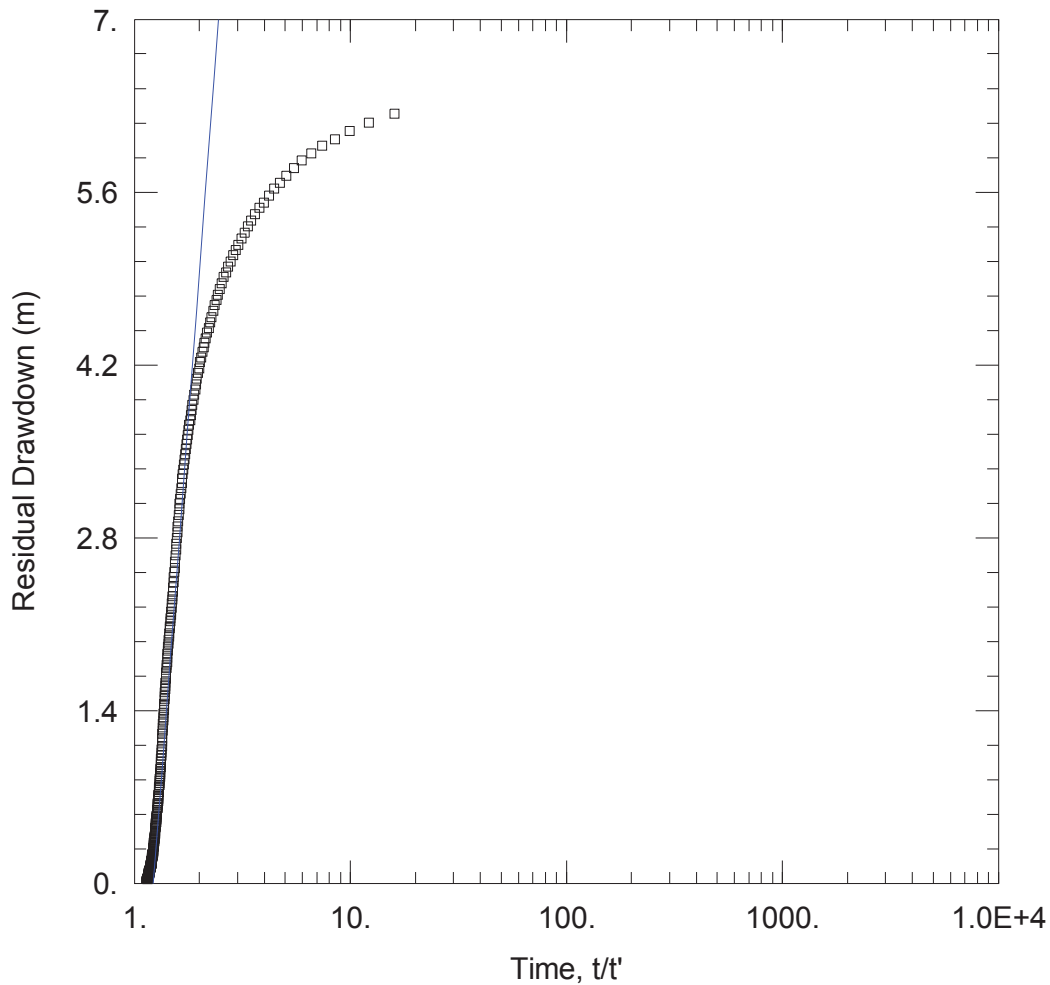
Saturated Thickness: 34.18 m Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA

Pumping Wells			Observation Wells		
Well Name	X (m)	Y (m)	Well Name	X (m)	Y (m)
MW07	0	0	□ MW07	0	0

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)
 T = 1.894 m²/day S/S' = 1.019



MW08 PUMP TEST

Data Set: N:\AU\Sydney\Projects\21\23174\Technical\Pump tests\MW08a.aqt
 Date: 05/30/14 Time: 13:51:04

PROJECT INFORMATION

Company: GHD
 Client: RMS
 Project: 2123174
 Location: Berry to Foxground
 Test Well: MW08
 Test Date: 08/04/2014

AQUIFER DATA

Saturated Thickness: 8.15 m Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA

Pumping Wells

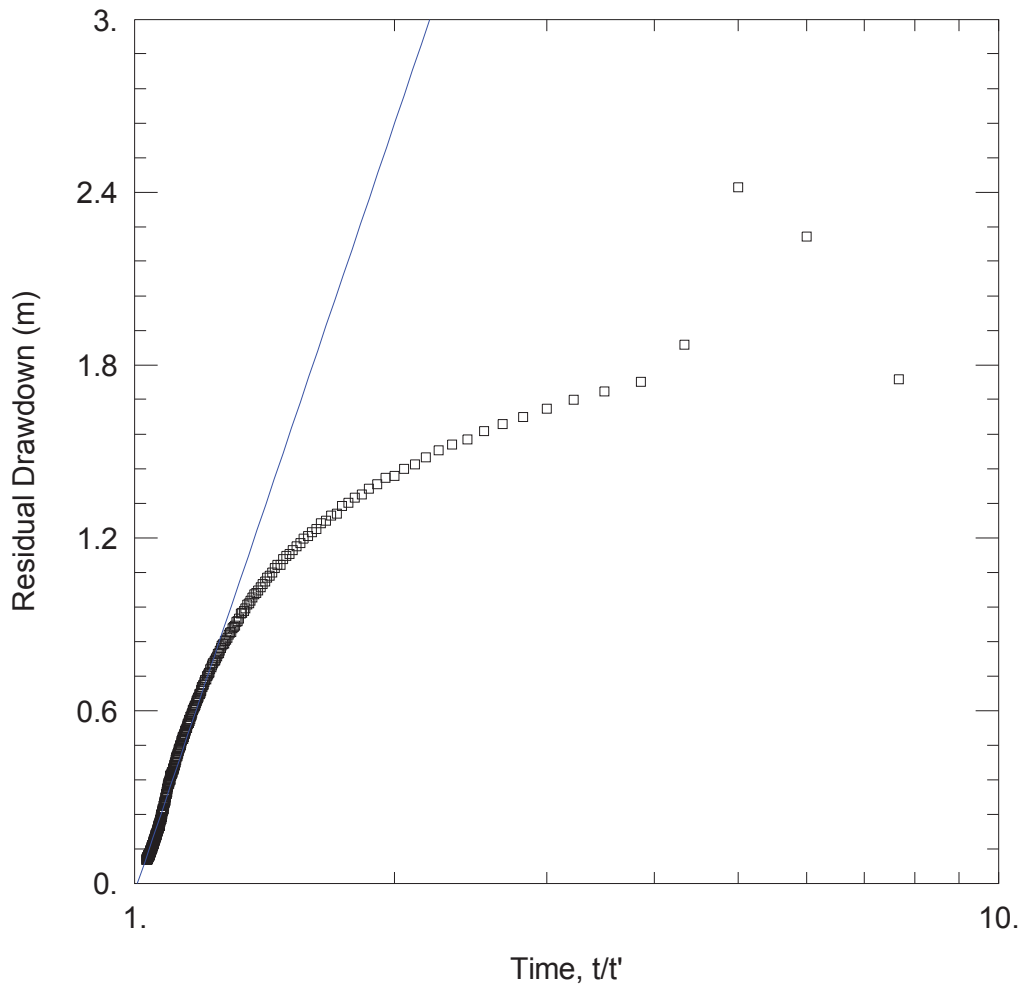
Well Name	X (m)	Y (m)
MW08	0	0

Observation Wells

Well Name	X (m)	Y (m)
□ MW08	0	0

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)
 T = 0.02433 m²/day S/S' = 1.226



MW09 PUMP TEST

Data Set: N:\AU\Sydney\Projects\21\23174\Technical\Pump tests\MW09a.aqt
 Date: 05/30/14 Time: 13:59:21

PROJECT INFORMATION

Company: GHD
 Client: RMS
 Project: 2123174
 Location: Berry to Foxground
 Test Well: MW09
 Test Date: 09/04/2014

AQUIFER DATA

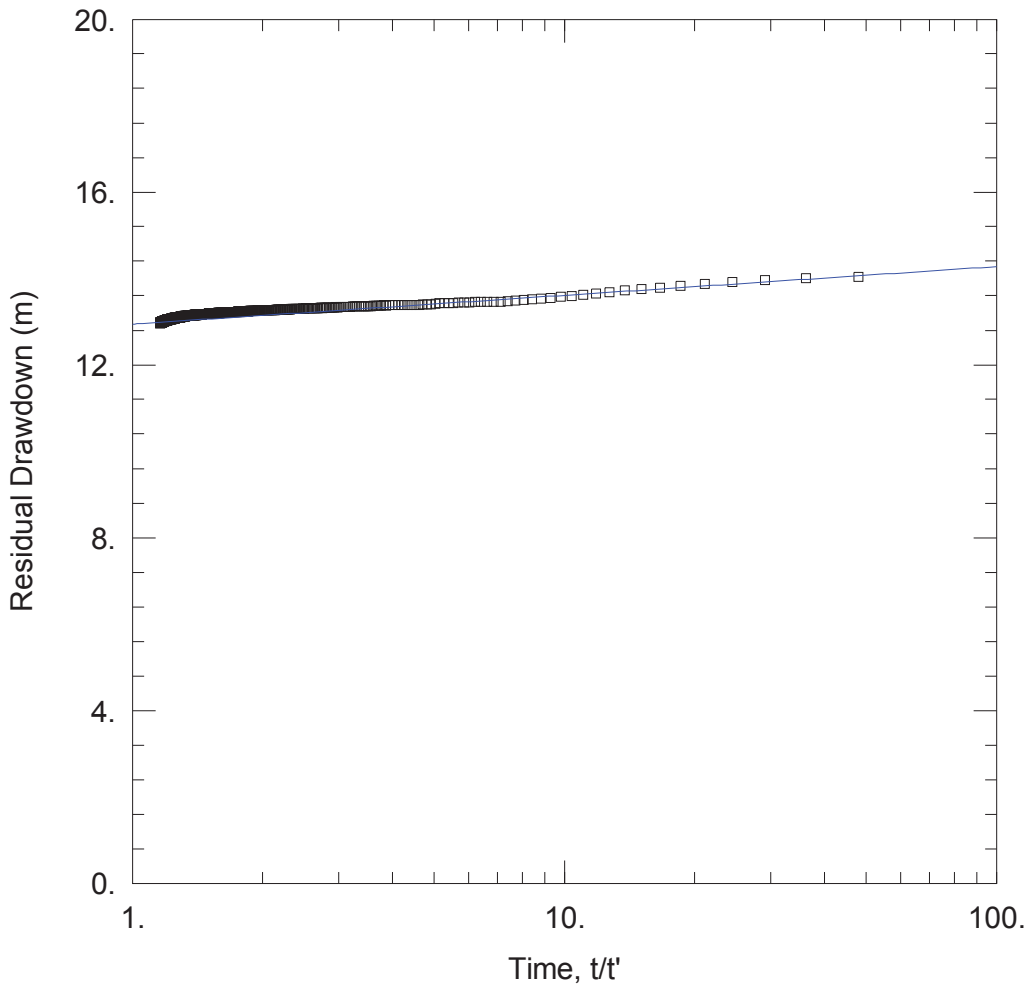
Saturated Thickness: 6.327 m Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA

Pumping Wells			Observation Wells		
Well Name	X (m)	Y (m)	Well Name	X (m)	Y (m)
MW09	0	0	□ MW09	0	0

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)
 $T = 0.0595 \text{ m}^2/\text{day}$ $S/S' = 1.009$



MW11 PUMP TEST

Data Set: N:\AU\Sydney\Projects\21\23174\Technical\Pump tests\MW11a.aqt
 Date: 05/30/14 Time: 13:58:17

PROJECT INFORMATION

Company: GHD
 Client: RMS
 Project: 2123174
 Location: Berry to Foxground
 Test Well: MW11
 Test Date: 08/04/2014

AQUIFER DATA

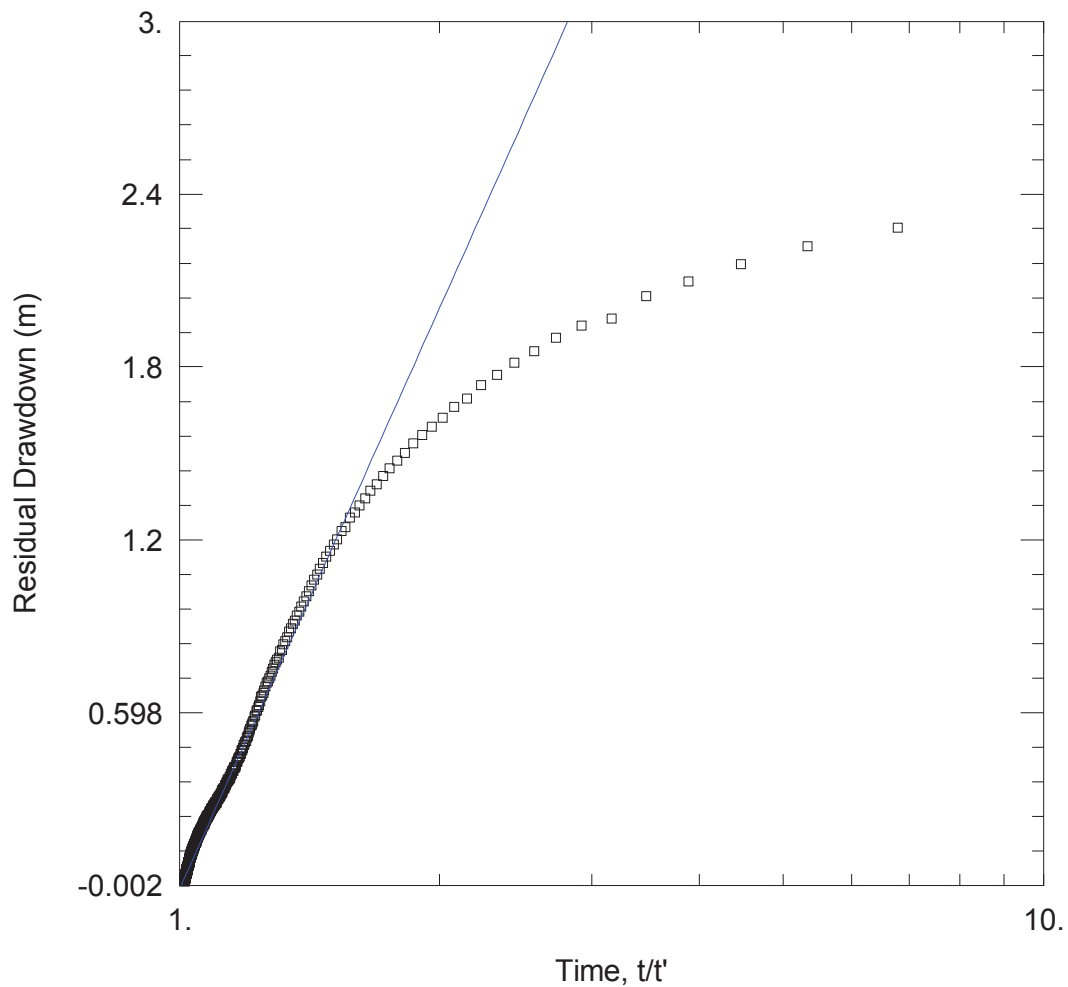
Saturated Thickness: 25.25 m Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA

Pumping Wells			Observation Wells		
Well Name	X (m)	Y (m)	Well Name	X (m)	Y (m)
MW11	0	0	□ MW11	0	0

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)
 T = 0.4844 m²/day S/S' = 3.556E-20



MW12 PUMP TEST

Data Set: N:\AU\Sydney\Projects\21\23174\Technical\Pump tests\MW12a.aqt
 Date: 05/30/14 Time: 13:51:23

PROJECT INFORMATION

Company: GHD
 Client: RMS
 Project: 2123174
 Location: Berry to Foxground
 Test Well: MW12
 Test Date: 14/04/2014

AQUIFER DATA

Saturated Thickness: 3.936 m Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA

Pumping Wells

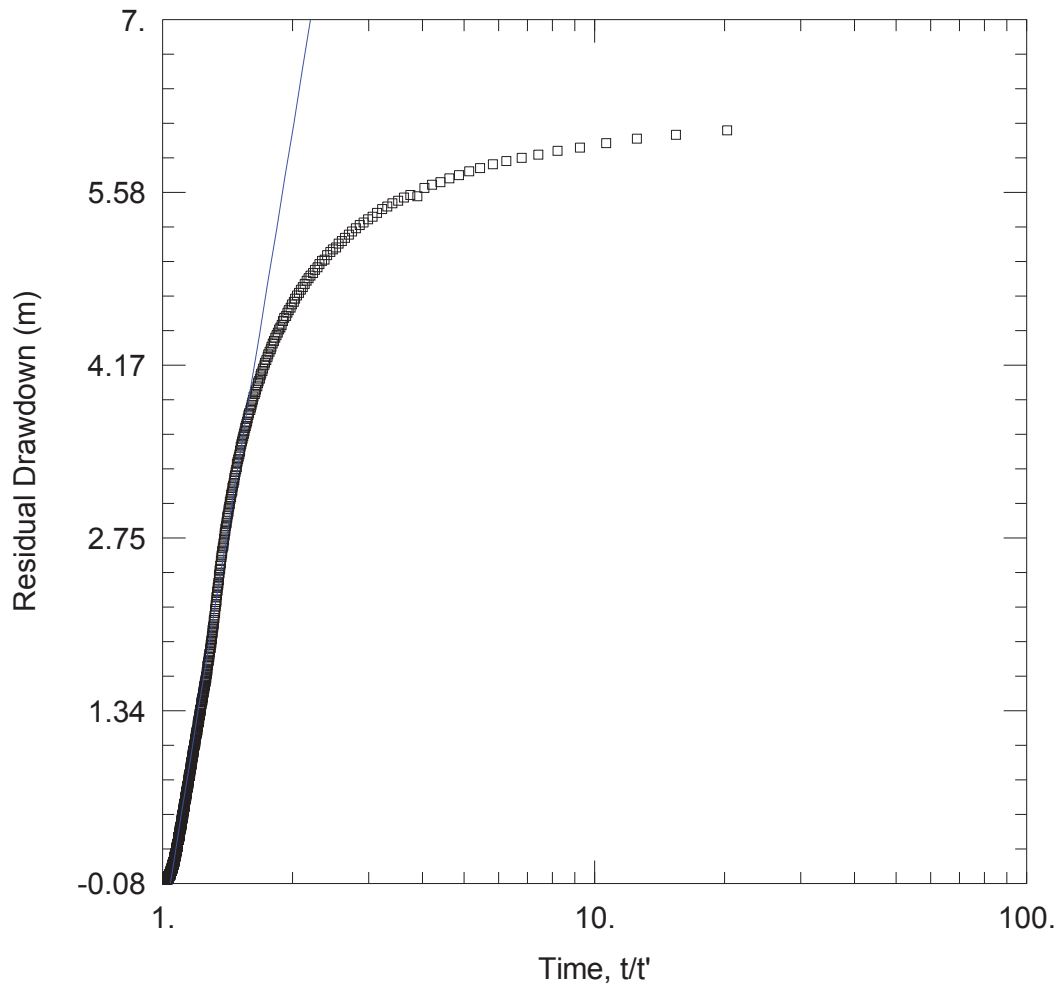
Well Name	X (m)	Y (m)
MW12	0	0

Observation Wells

Well Name	X (m)	Y (m)
□ MW12	0	0

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)
 T = 0.1413 m²/day S/S' = 1.006



MW13 PUMP TEST

Data Set: N:\AU\Sydney\Projects\21\23174\Technical\Pump tests\MW13a.aqt
 Date: 05/30/14 Time: 13:57:18

PROJECT INFORMATION

Company: GHD
 Client: RMS
 Project: 2123174
 Location: Berry to Foxground
 Test Well: MW13
 Test Date: 08/04/2014

AQUIFER DATA

Saturated Thickness: 7.62 m Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA

Pumping Wells

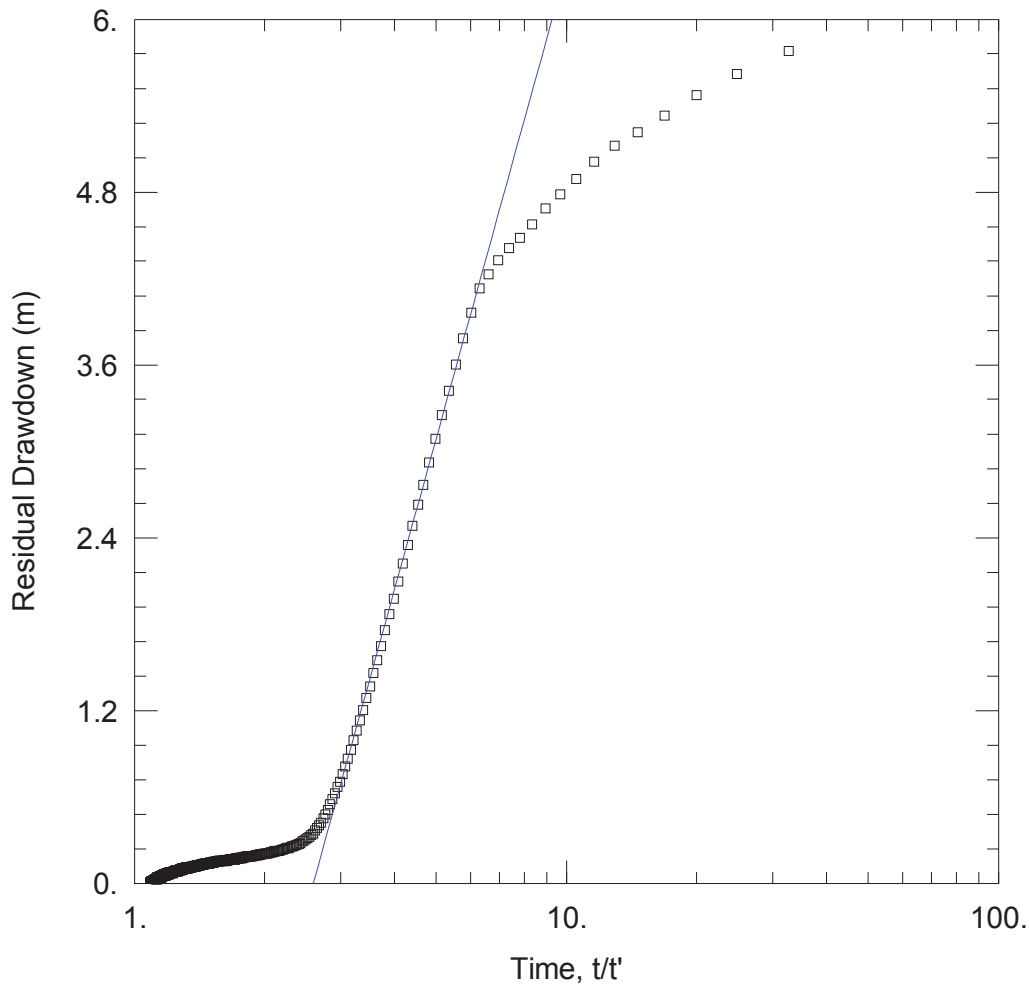
Well Name	X (m)	Y (m)
MW13	0	0

Observation Wells

Well Name	X (m)	Y (m)
□ MW13	0	0

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)
 T = 0.02433 m²/day S/S' = 1.051



MW16 PUMP TEST

Data Set: N:\AU\Sydney\Projects\21\23174\Technical\Pump tests\MW16a.aqt

Date: 05/30/14

Time: 13:52:05

PROJECT INFORMATION

Company: GHD

Client: RMS

Project: 2123174

Location: Berry to Foxground

Test Well: MW16

Test Date: 08/04/2014

AQUIFER DATA

Saturated Thickness: 10. m

Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
MW16	0	0

Observation Wells

Well Name	X (m)	Y (m)
□ MW16	0	0

SOLUTION

Aquifer Model: Confined

Solution Method: Theis (Recovery)

T = 0.06107 m²/day

S/S' = 2.595

Client: RMS	Monitoring Well ID: MW01
Project: FBB	Date: 8/4/14
Job Number: 21/23174	Logged by: NR.
Subject: Hydraulic Conductivity Testing	Checked by:
Slug Test: GHD Procedure E13. 22.890	
SWL (m) prior logger:	6.745 S/N 118389 - install
SWL (m) with logger:	6.743 @ 9.00
Depth (from TOC m) of logger:	20m
Scan Rate (Seconds):	15 sec
SLUG used:	
Conduct Test (See computer file)	Pump
SWL post test with SLUG in hole	
1min-	15L = 6.06
2min-	30L = 13.15
SWL post test with SLUG removed	
1min-	45L = 22.15
2 min-	50L = 26.25
	-well dry
Falling / Rising Head Test	
Minutes after SLUG test:	Pull up pump - disturb logger
SWL (m) pre-test with logger:	
Depth (from TOC m) of logger:	log back in @ 9:51
Litres introduced (falling head)	21.050 SWL.
Duration of pump out / litres pumped out (rising head)	20.975 956
Conduct Test (See computer file)	
SWL post test (logger still in hole)	20.355 @ 16:23
1min-	
2min-	logger removed
3min-	16:24
4min-	
5min-	
Repeat Test (if appropriate)	

Client: RMS	Monitoring Well ID: MW02
Project: FBB	Date: 15/4/14
Job Number: 21/23174	Logged by: NR.
Subject: Hydraulic Conductivity Testing	Checked by:
Slug Test: GHD Procedure E13.	
SWL (m) prior logger:	28.160m @ 10:59
SWL (m) with logger:	DT Bottom at 28.180m
Depth (from TOC m) of logger:	
Scan Rate (Seconds):	Dry - confirmed
SLUG used:	w/ bailer.
Conduct Test (See computer file)	
SWL post test with SLUG in hole	
1min-	
2min-	
SWL post test with SLUG removed	
1min-	
2 min-	
Falling / Rising Head Test	
Minutes after SLUG test:	
SWL (m) pre-test with logger:	
Depth (from TOC m) of logger:	
Litres introduced (falling head)	
Duration of pump out / litres pumped out (rising head)	
Conduct Test (See computer file)	
SWL post test (logger still in hole)	
1min-	
2min-	
3min-	
4min-	
5min-	
Repeat Test (if appropriate)	

no lock - Jane to buy one
 Access Gate → #368
 Girrakool letter box
 Push button to open gate

13:45

Client: RMS	Monitoring Well ID: MW03
Project: FBB	Date: 8/4/14
Job Number: 21/23174	Logged by: MR
Subject: Hydraulic Conductivity Testing	Checked by:
Slug Test: GHD Procedure E13.	
	S/N (2249)
SWL (m) prior logger:	11.600 21.815
SWL (m) with logger:	
Depth (from TOC m) of logger:	10C = 4.25
Scan Rate (Seconds):	20C = 19.19
SLUG used:	30C = 14.05
Conduct Test (See computer file)	40C = 19.05
SWL post test with SLUG in hole	50C = 24.27
1min-	60C = 29.46
2min-	
SWL post test with SLUG removed	Logger installed 14:32
1min-	16.913 @ 14:33
2 min-	16.800 @ 14:37
Falling / Rising Head Test	
Minutes after SLUG test:	
SWL (m) pre-test with logger:	14.103 @ 16:37
Depth (from TOC m) of logger:	
Litres introduced (falling head)	Logger removed
Duration of pump out / litres pumped out (rising head)	@ 16:38
Conduct Test (See computer file)	
SWL post test (logger still in hole)	
1min-	
2min-	
3min-	
4min-	
5min-	
Repeat Test (if appropriate)	

455
403 Princess

Client: RMS	Monitoring Well ID: MW04
Project: FBB	Date: 8/4/14
Job Number: 21123174	Logged by: NR
Subject: Hydraulic Conductivity Testing	Checked by: SN 122479
Slug Test: GHD Procedure E13. 12:55	
SWL (m) prior logger:	0.691 7.00
SWL (m) with logger:	
Depth (from TOC m) of logger:	
Scan Rate (Seconds):	
SLUG used:	10L 3:35
Conduct Test (See computer file)	15L 5:08
SWL post test with SLUG in hole	20L 7:47
1min-	30L 11:30
2min-	40L 15:03
SWL post test with SLUG removed	
1min-	Grey Turbid water thicker at depths
2 min-	
Falling / Rising Head Test	
Minutes after SLUG test:	
SWL (m) pre-test with logger:	
Depth (from TOC m) of logger:	Logger installed
Litres introduced (falling head)	13:13
Duration of pump out / litres pumped out (rising head)	3.80 @ 13:13
Conduct Test (See computer file)	
SWL post test (logger still in hole)	
1min-	
2min-	0.745 @ 16:01
3min-	logger removed 16:06
4min-	
5min-	
Repeat Test (if appropriate)	

Client:	RMS	Monitoring Well ID:	MW05.
Project:	FBB	Date:	8/4/14
Job Number:	2123174.	Logged by:	NR
Subject: Hydraulic Conductivity Testing		Checked by:	
Slug Test: GHD Procedure E13.			
SWL (m) prior logger:		31.205	41.025
SWL (m) with logger:		Couldn't pump	
Depth (from TOC m) of logger:		pump would not lift	
Scan Rate (Seconds):		water.	
SLUG used:			
Conduct Test (See computer file)			
SWL post test with SLUG in hole			
1min-			
2min-			
SWL post test with SLUG removed			
1min-			
2 min-			
Falling / Rising Head Test			
Minutes after SLUG test:			
SWL (m) pre-test with logger:			
Depth (from TOC m) of logger:			
Litres introduced (falling head)			
Duration of pump out / litres pumped out (rising head)			
Conduct Test (See computer file)			
SWL post test (logger still in hole)			
1min-			
2min-			
3min-			
4min-			
5min-			
Repeat Test (if appropriate)			

Client: <i>RMS</i>	Monitoring Well ID: <i>MW06</i>
Project: <i>FBB</i>	Date: <i>8/4/14</i>
Job Number: <i>21/23174</i>	Logged by: <i>NR.</i>
Subject: Hydraulic Conductivity Testing	Checked by:
Slug Test: GHD Procedure E13.	
SWL (m) prior logger:	<i>23.025 25.856</i>
SWL (m) with logger:	<i>dry</i>
Depth (from TOC m) of logger:	<i>no test</i>
Scan Rate (Seconds):	<i>0.5L sediment in bottom</i>
SLUG used:	<i>in bailer.</i>
Conduct Test (See computer file)	
SWL post test with SLUG in hole	
1min-	
2min-	
SWL post test with SLUG removed	
1min-	
2 min-	
Falling / Rising Head Test	
Minutes after SLUG test:	
SWL (m) pre-test with logger:	
Depth (from TOC m) of logger:	
Litres introduced (falling head)	
Duration of pump out / litres pumped out (rising head)	
Conduct Test (See computer file)	
SWL post test (logger still in hole)	
1min-	
2min-	
3min-	
4min-	
5min-	
Repeat Test (if appropriate)	

S/N 118529

Client: RMS	Monitoring Well ID: MW07
Project: FBB	Date: 9/4/14
Job Number: 21/23174	Logged by: NR
Subject: Hydraulic Conductivity Testing	Checked by:
Slug Test: GHD Procedure E13.	
SWL (m) prior logger:	11.027 @ 9:50
SWL (m) with logger:	
Depth (from TOC m) of logger:	Pump start @ 10:06
Scan Rate (Seconds):	
SLUG used:	15L @ 6:47
Conduct Test (See computer file)	30L @ 14:40
SWL post test with SLUG in hole	45L @ 22:41
1min-	60L @ 31:07
2min-	75L @ 38:56
SWL post test with SLUG removed	pump stop
1min-	
2 min-	Logger installed @ 10:43
Falling / Rising Head Test	
Minutes after SLUG test:	14.50 @ 10:43
SWL (m) pre-test with logger:	12.680 @ 10:48
Depth (from TOC m) of logger:	
Litres introduced (falling head)	11.021 @ 15:04
Duration of pump out / litres pumped out (rising head)	
Conduct Test (See computer file)	
SWL post test (logger still in hole)	Logger + baro removed
1min-	
2min-	@ 15:05
3min-	
4min-	
5min-	
Repeat Test (if appropriate)	

45.21

From neighbour lane - bush fence. 15m Sump # not stressed minimal drawdown

Client: RMS	Monitoring Well ID: MW08
Project: FB3	Date: 8/4/14.
Job Number: 21/23174	Logged by: NR.
Subject: Hydraulic Conductivity Testing	Checked by:
Slug Test: GHD Procedure E13.	
SWL (m) prior logger:	S/N 118386 10.048 2.498 @ 15:08
SWL (m) with logger:	
Depth (from TOC m) of logger:	100 @ 3:57.
Scan Rate (Seconds):	200 @ 8:24
SLUG used:	24L @ 11:10
Conduct Test (See computer file)	
SWL post test with SLUG in hole	
1min-	Logger installed @ 15:32
2min-	8.675 @ 15:32
SWL post test with SLUG removed	
1min-	
2 min-	
Falling / Rising Head Test	
Minutes after SLUG test:	2.875 @ 16:52
SWL (m) pre-test with logger:	
Depth (from TOC m) of logger:	Logger removed
Litres introduced (falling head)	
Duration of pump out / litres pumped out (rising head)	16:52.
Conduct Test (See computer file)	
SWL post test (logger still in hole)	
1min-	
2min-	
3min-	
4min-	
5min-	
Repeat Test (if appropriate)	

Client: RMS	Monitoring Well ID: MN09
Project: FBB	Date: 9/4/14
Job Number: 21/23174	Logged by: NK
Subject: Hydraulic Conductivity Testing	Checked by:
Slug Test: GHD Procedure E13. 10.740	
SWL (m) prior logger:	4.413 @ 12:42
SWL (m) with logger:	
Depth (from TOC m) of logger:	S/N 122491
Scan Rate (Seconds):	
SLUG used:	Removed 10L
Conduct Test (See computer file)	by bailing.
SWL post test with SLUG in hole	Too muddy by car
1min-	
2min-	Think bailer was getting
SWL post test with SLUG removed	caught on a join.
1min-	Logger installed @ 12:54.
2 min-	6.04 @ 12:55
Falling / Rising Head Test	
Minutes after SLUG test:	
SWL (m) pre-test with logger:	
Depth (from TOC m) of logger:	4.495 @ 15:20
Litres introduced (falling head)	
Duration of pump out / litres pumped out (rising head)	Logger removed
Conduct Test (See computer file)	15:21.
SWL post test (logger still in hole)	
1min-	
2min-	
3min-	
4min-	
5min-	
Repeat Test (if appropriate)	

Client: RMS	Monitoring Well ID: MW10
Project: FBB	Date: 14/4/14
Job Number: 21/23174	Logged by: NE
Subject: Hydraulic Conductivity Testing	Checked by:
Slug Test: GHD Procedure E13.	
SWL (m) prior logger:	24.1m Dip meter not working.
SWL (m) with logger:	
Depth (from TOC m) of logger:	10L @ 3.00
Scan Rate (Seconds):	20L @ 6.14
SLUG used:	30L @ 9:10
Conduct Test (See computer file)	40L @ 12:04.
SWL post test with SLUG in hole	50L @ 14:45
1min-	60L @ 17:35
2min-	
SWL post test with SLUG removed	S/N 118529
1min-	Clear.
2 min-	
Falling / Rising Head Test	
Minutes after SLUG test:	Logger installed @ 9:59 12.550 @ 10:00
SWL (m) pre-test with logger:	
Depth (from TOC m) of logger:	removed @ 16:17
Litres introduced (falling head)	Well dry
Duration of pump out / litres pumped out (rising head)	
Conduct Test (See computer file)	
SWL post test (logger still in hole)	
1min-	
2min-	
3min-	
4min-	
5min-	
Repeat Test (if appropriate)	

Client: RMS	Monitoring Well ID: MW11
Project: FBB	Date: 9/4/14
Job Number: 21123174	Logged by: NR
Subject: Hydraulic Conductivity Testing	Checked by:
Slug Test: GHD Procedure E13.	
SWL (m) prior logger:	11.252 @ 11:12 36.5
SWL (m) with logger:	
Depth (from TOC m) of logger:	10L @ 4:42
Scan Rate (Seconds):	20L @ 10:50
SLUG used:	30L @ 18:25
Conduct Test (See computer file)	40L @ 30:06
SWL post test with SLUG in hole	43L @ 35:12
1min-	
2min-	pump stop → no longer pumping
SWL post test with SLUG removed	
1min-	
2 min-	
Falling / Rising Head Test	
Minutes after SLUG test:	Logger installed @ 11:57
SWL (m) pre-test with logger:	24.632 @ 12:02
Depth (from TOC m) of logger:	24.610 @ 12:05
Litres introduced (falling head)	
Duration of pump out / litres pumped out (rising head)	24.215 @ 15:37
Conduct Test (See computer file)	
SWL post test (logger still in hole)	Logger removed @ 15:37
1min-	
2min-	
3min-	
4min-	
5min-	
Repeat Test (if appropriate)	

massive drawdown

MW10
removed
@ 16:17, Well
dry

Client: RMS	Monitoring Well ID: MW12
Project: FBB	Date: 14/4/14
Job Number: 21/23174	Logged by: NR
Subject: Hydraulic Conductivity Testing	Checked by:
Slug Test: GHD Procedure E13.	
SWL (m) prior logger:	6.720 @ 10:23 10.650
SWL (m) with logger:	4.3 @ 10:35 9.125m @ 10:37
Depth (from TOC m) of logger:	
Scan Rate (Seconds):	10L @ 2:24
SLUG used:	15.5 @ 4:19
Conduct Test (See computer file)	
SWL post test with SLUG in hole	S/N 118386. Logger installed.
1min-	16:25 7.398
2min-	
SWL post test with SLUG removed	Logger removed
1min-	16:25
2 min-	
Falling / Rising Head Test	
Minutes after SLUG test:	
SWL (m) pre-test with logger:	
Depth (from TOC m) of logger:	
Litres introduced (falling head)	
Duration of pump on / litres pumped out (rising head)	
Conduct Test (See computer file)	
SWL post test (logger still in hole)	
1min-	
2min-	
3min-	
4min-	
5min-	
Repeat Test (if appropriate)	

S/N 122479

Client: RMS	Monitoring Well ID: MW13
Project: FBB	Date: 8/9/14
Job Number: 21/23174	Logged by: NR.
Subject: Hydraulic Conductivity Testing	Checked by:
Slug Test: GHD Procedure E13.	
SWL (m) prior logger:	7.180 @ 14:15
SWL (m) with logger:	
Depth (from TOC m) of logger:	10L @ 4:35
Scan Rate (Seconds):	20L @ 9:29
SLUG used:	29L @ 14:27
Conduct Test (See computer file)	dry.
SWL post test with SLUG in hole	
1min-	Logger installed @ 14:34
2min-	
SWL post test with SLUG removed	13 4.465 @ 14:35
1min-	12.660 @ 14:43 - dip meter
2 min-	not working properly.
Falling / Rising Head Test	
Minutes after SLUG test:	
SWL (m) pre-test with logger:	Logger left overnight.
Depth (from TOC m) of logger:	
Litres introduced (falling head)	7.108 @ 7:51
Duration of pump out / litres pumped out (rising head)	
Conduct Test (See computer file)	logger removed
SWL post test (logger still in hole)	@ 7:52
1min-	
2min-	
3min-	
4min-	
5min-	
Repeat Test (if appropriate)	

Client: RMS	Monitoring Well ID: BW16
Project: FBD	Date: 9/14/14
Job Number: 21123174	Logged by: NR.
Subject: Hydraulic Conductivity Testing	Checked by:
Slug Test: GHD Procedure E13.	
	S/N 118389.
SWL (m) prior logger:	0.761 @ 8:37 10.761
SWL (m) with logger:	logger
Depth (from TOC m) of logger:	10L = 4:12 4:19
Scan Rate (Seconds):	20L = 8:04.
SLUG used:	30L = 12:01
Conduct Test (See computer file)	40L = 15:52
SWL post test with SLUG in hole	50L = 20:02.
1min-	60L = 23:53. @9.12
2min-	Logger installed @ 9.12
SWL post test with SLUG removed	5:98 @ 9:12
1min-	5:50 @ 9:13
2 min-	
Falling / Rising Head Test	
Minutes after SLUG test:	
SWL (m) pre-test with logger:	0.686 @ 13:53
Depth (from TOC m) of logger:	
Litres introduced (falling head)	Logger removed
Duration of pump out / litres pumped out (rising head)	13:54.
Conduct Test (See computer file)	
SWL post test (logger still in hole)	
1min-	
2min-	
3min-	
4min-	
5min-	
Repeat Test (if appropriate)	

Appendix C – Summary of Groundwater Levels

Table B1. A summary of groundwater level information

Well ID	EASTING	NORTHING	Well Depth (m bgl)	Inside of Boundary?	Average GW Level (m bgl)	Variation in GW levels (m)	Response to rainfall	Period of data
CBH02	283473.35	6145307.28	16.2	No	4.45^^			
CBH05	286506.88	6145441.04	7.5	No	0.65^^			
CBH06	286860.61	6146530	12.5	No	0.36^^			
CBH08	289214.94	6147809.01	6.6	No	2.54			
CBH11	289360.09	6151157.1	4.2	No	-			
CBH13	292004.2	6150866.61	8.95	Yes	3.47^^			
CBH15	293530.18	6151294.7	8.0	Yes	6.67^^			
CBH16	296184.46	6152071.25	9.0	No	3.74^^			
CBH17	295092.08	6153406.06	13.62	No	1.30^^			
CBH19	298874.34	6152750.34	12.0	No	5.0**	3.0**	Moderate to High	20/11/10 to 11/1/11**
CBH20	301239.56	6155714.67	8.5	No	3.30^^			
G1	295864.2	6152239.3	8.0	No	3.0**	5.5**	Negligible	27/5/10 to 07/01/11**
G2	295519.8	6152482.8	20.0	No	4.47^^			
G3	295708.3	6152417.5	40.5	No	7.75^^			
P1	296205.8	6152733.4	8.5	Yes	7.5**	2.0**	Negligible	27/5/10 to 07/01/11**
P2	295813.5	6152940.1	13.4		5.15^^			
P3	295962.6	6152796.3	30.5	Yes	7.5**	6.0**	Moderate to High	27/5/10 to 07/01/11**

Well ID	EASTING	NORTHING	Well Depth (m bgl)	Inside of Boundary?	Average GW Level (m bgl)	Variation in GW levels (m)	Response to rainfall	Period of data
BH01	301653.37	6156540.64	5.5	No	0.88	1.46	Moderate - High	20/11/09 to 3/08/10 30/10/10 to 11/1/11
BH02	301250.92	6155730.31	8.0	No	5.31	2.48	Moderate	21/11/09 to 2/06/10 30/10/10 to 11/1/11
BH03A	301104.53	6154902.29	7.5	No				
BH04B	300271.55	6153226.18	5.8	No	1.99	2.22	Moderate -high	22/12/10 to 11/1/11
BH05	300137.54	6153148.58	8.5	No	7.62	6.45	Negligible	21/11/10 to 11/1/11
BH06	300013.93	6153018.17	7.0	No	1.62	0.34	Negligible	30/10/10 to 11/1/11 and manual dip data
BH07	298991.58	6152935.28	7.0	No	8.98	1.66	Negligible	30/10/09 to 25/04/10 30/10/10 to 11/1/11
BH08	298846.28	6152746.64	10.0	No	8.10	3.59	Moderate	21/11/09 to 30/04/10 30/10/10 to 11/1/11
BH09	297999.89	6152536.68	7.0	No	4.79	6.91	Moderate (manual dip data)	21/11/10 to 1/05/10 30/10/10 to 11/1/11
BH10	296938.63	6152286.9	7.38	Yes	0.94	1.15	Moderate -High	20/11/09 to 3/08/10 30/10/10 to 11/1/11
BH11	296508.42	6152503.63	10.0	Yes				

Well ID	EASTING	NORTHING	Well Depth (m bgl)	Inside of Boundary?	Average GW Level (m bgl)	Variation in GW levels (m)	Response to rainfall	Period of data
BH12	296021.34	6152870.2	14.0	Yes	7.66	5.34	High responses, not completely related to rainfall	20/11/09 to 3/08/10 30/10/10 to 11/1/11
BH13	295628.48	6152956.87	9.7	Yes	5.81	2.59	Insufficient data to assess	21/11/09 to 14/03/10 30/10/10 to 11/1/11
BH14	294891.84	6152829.45	6.0	Yes	1.57 (++)	1.23 (++)		Nov 2009 to Jan 2010
BH15	294334.18	6152176.02	8.0	Yes	5.42 (++)	1.23 (++)		
BH16	294206.83	6151846.38	7.0	Yes	4.6 (++)	0.71 (++)		
BH18	293870.39	6151503.79	10.0	Yes	8.96 (++)	1.84 (++)		
BH19	293479.76	6151476.89	10.0	Yes	3.06 (++)	1.54 (++)		
BH20	293082.14	6151254.67	9.0	Yes	7.97 (++)	0.76 (++)		
BH21	292462.08	6150947.59	10.0	Yes	9.0**	7.00**	Delayed response for May rainfall event, quick response for June	01/05/13 to 05/07/13**
BH22	291575.71	6150861.51	15.19	Yes	6.72 (++)	0.87 (++)		
BH23	290913.91	6150339.1	7.0	Yes	7.20 (++)	1.30 (++)		
BH24	290127.48	6149931.36	10.0	Yes	6.3 (++)	3.45 (++)		
BH26	290073.85	6149892.06	10.0	Yes	6.5**	4.0**	Moderate to High	01/05/13 to 05/07/13
BH28	289566.37	6149866.52	9.5	Yes	2.64 (++)	0.80 (++)		
BH29	288315.65	6149624.85	10.0	Yes	5.0**	2.5**	Low to Moderate	01/05/13 to 05/07/13

Well ID	EASTING	NORTHING	Well Depth (m bgl)	Inside of Boundary?	Average GW Level (m bgl)	Variation in GW levels (m)	Response to rainfall	Period of data
BH30	281033.12	6144003.25	8.0	No	4.45 (++)	3.64 (++)		
BH31	280453.72	6143462.75	9.0	No	5.34 (++)	3.64 (++)		
K01	301412.74	6155949.81		No	1.14	0.28		30/10/10 to 11/1/11
K03	301334.56	6155787.03		No	0.59	1.01	High responses, not related to rainfall	30/10/10 to 11/1/11
K07	301271.11	6155625.53		No	0.84	1.36	High responses, not related to rainfall	30/10/10 to 11/1/11
K31	300752.84	6154119.86		No	1.98	0.24	Negligible	30/10/10 to 11/1/11
K33	300470.23	6153669.94		No				
K37					4.74	3.88	High responses, not related to rainfall	30/10/10 to 11/1/11
K55	299072	6152902.53		No	5.03	0.52	Moderate	30/10/10 to 11/1/11
K56	299084.78	6152874.21		No	8.73	1.13	High	30/10/10 to 11/1/11
K58	298929.77	6152773.79		No	6.47	3.72	High	30/10/10 to 11/1/11
K59	298876.64	6152790.84		No	2.52	3.01	High	30/10/10 to 11/1/11
K63	298379.67	6152587.42		No	4.13	0.61	Negligible	30/10/10 to 11/1/11

Well ID	EASTING	NORTHING	Well Depth (m bgl)	Inside of Boundary?	Average GW Level (m bgl)	Variation in GW levels (m)	Response to rainfall	Period of data
K65	297969.91	6152516.88		No	3.41	0.91	High	30/10/10 to 11/1/11
L01	302011	6156755		No				
L18	297699	6152503		No				
L20	298850	6152843		No				
B1	290290.64	6149969.46		Yes				
B4	289982.28	6148914.05		No				
B8	289070.01	6148357.54		No				
B14	287108.99	6147635.18		No				
B17	287355.24	6148169.58		Yes				
B22	286783.31	6147011.35		No				
F01	296595.74	6152458.95		Yes				
F11	293441.97	6151450.61		Yes	8.50**	2.0**	Negligible	01/05/13 to 05/07/13
F13	293128.76	6151250.77		Yes	Well pumped between 06/5/13 to 05/07/13			
F14	292603.54	6150989.12		Yes				
F15	292546.67	6150967.97		Yes	10.00**	0.8**	Negligible	Manual dip data only between 01/5/13 and 05/07/13
F21	291410.7	6150668.84		Yes	6.0**	3.0**	High	01/05/13 to 05/07/13
F22	290853.49	6150312.34		Yes				
F33	288372.45	6149660.88		Yes				

Well ID	EASTING	NORTHING	Well Depth (m bgl)	Inside of Boundary?	Average GW Level (m bgl)	Variation in GW levels (m)	Response to rainfall	Period of data
F35	287912.59	6149084.98		Yes	7.0**	1.5**	Negligible	01/05/13 to 05/07/13
F38	287551.95	6148574.66		Yes	4.0**	6.0**	High	01/05/13 to 05/07/13

** Values based on visual assessment of visualised rainfall data. No dataset available.

^^ Single data point observed either during drilling or after development

(++) Calculated by using minimum and maximum SWL (mbgl) using Table 5.3, Golder 2010

Appendix D – Stakeholder Comments



Contact: Bob Britten
Phone: 02 6491 8209
Fax: 02 6492 3019
Email: bob.britten@water.nsw.gov.au

Stefan Charteris
GHD
133 Castlereagh St
Sydney NSW 2000

Our ref: 10 ERM2014/0563
File No:
Your Ref:

8 July 2014

Dear Stefan,

**Re: Proposed Development - Princes Highway Upgrade - Foxground Berry Bypass
Review of Groundwater Monitoring Plan**

This letter is in regard of the NSW Office of Water (NOW) review of Water Quality Monitoring Groundwater Monitoring Plan dated June 2014 for the proposed Princes Highway upgrade – Foxground Berry Bypass Project. Comment is based on a review of the following information:

- GHD, June 2014, "Roads and Maritime Services, Princes Highway Upgrade – Foxground to Berry Bypass Project, Water Quality Monitoring Groundwater Monitoring Plan"

The Groundwater Monitoring Plan provides a sound basis to establish baseline groundwater hydrology and water quality data prior to construction. As previously commented the regional setting and layout as presented for the groundwater modelling is supported. The objectives of the Plan which is to monitor the potential impact of the upgrade on surface and groundwater quality ...is adequately supported in the ensuing sections 7 to 12 of the report.

The NSW Office of Water supports the current Monitoring Plan and looks forward to reviewing the ongoing outcomes as presented in the Annual progress reports

Please direct any questions or correspondence to Bob Britten, bob.britten@water.nsw.gov.au.

Yours sincerely

Bob Britten
Senior Water Regulation Officer
Office of Water - Water Regulatory Operations South



Contact: Bob Britten
Phone: 02 6491 8209
Fax: 02 6492 3019
Email: bob.britten@water.nsw.gov.au

Graham Roche
Roads and Maritime Services
Level Ground 153 Auckland Street
Bega NSW 2550

Our ref: 10 ERM2014/0563
File No:
Your Ref:

1 July 2014

Dear Graham,

**Re: Proposed Development - Princes Highway Upgrade - Foxground Berry Bypass
Review of Groundwater assessment**

This letter is in regard of the NSW Office of Water (NOW) review of groundwater assessment for the proposed Princes Highway upgrade – Foxground Berry Bypass Project. Comment is based on a review of the following information:

- GHD, 2014, "Roads and Maritime Services, Princes Highway Upgrade – Foxground to Berry Bypass Project, Groundwater Flow Model"
- Discussions with Stephan Charteris from GHD
- Roads and Maritime proposed Schedule of activities - June 2014 to April 2015

The Groundwater Flow Model provides a good representation of the groundwater hydrology and is considered a suitable tool to assess the likely impacts of the proposed highway development on the local groundwater system. The developed model provides a reasonable representation of the landscape geology, geomorphology and hydrogeology, the assumptions are reasonable and with the steady state calibration possible at this stage the model is considered a reasonable representation of the expected groundwater flow regime. The model predictions are subsequently supported. The section on "Model Limitations" is also considered a reasonable reality check/assessment of the model's abilities.

It is noted that the report identifies development/refinement of the model with the collection of ongoing monitoring data, "*paying particular attention to the potential variation in impacts associated with changes in storage under high and low flow conditions*".

With regard to the required time to undertake background monitoring, discussions have included the suitability of some reduction to the proposed 12 months monitoring/benchmarking prior to commencement of works. Notably, if selective works commencement were in areas of modelled low groundwater impact. NOW is of the view that the key, is collecting data representing the likely a range of water level /water quality parameters and that majority of the

required information would probably be achieved within the first 9 months. Ongoing review of monitoring data being collected would be able to confirm the suitability of the data set.

Please direct any questions or correspondence to Bob Britten, bob.britten@water.nsw.gov.au.

Yours sincerely



Bob Britten
Senior Water Regulation Officer
Office of Water - Water Regulatory Operations South



Our reference: DOC14/115248

Contact: Michael Heinze 6229 7002

Mr Stefan Charteris
Principal Hydrogeologist
GHD Pty Ltd
Level 15, 133 Castlereagh Street
SYDNEY NSW 2000

2 July 2014

Dear Mr Charteris,

Re: Foxground to Berry Bypass Project – Groundwater Flow Model and Water Quality Monitoring - Groundwater Monitoring Plan

Thank you for your emails on 26 May and 10 June 2014 inviting the Environment Protection Authority (EPA) to comment on GHD's draft *Groundwater Flow Model* and *Water Quality Monitoring: Groundwater Monitoring Plan* (the plans) for the Foxground to Berry bypass project, prepared for Roads and Maritime Services (RMS) as required by the Project Approval under the *Environmental Planning and Assessment Act 1979*.

As you are aware, RMS is proposing to upgrade 11.6 km of the Princess Highway between Toolijooa Road north of Foxground and Schofields Lane south of Berry on the NSW South Coast. As part of the project approval conditions (CoA B15 and CoA B16), RMS is required to prepare and implement a Water Quality Monitoring Program and undertake groundwater modelling on the concept design in consultation with the Office of Environment and Heritage (OEH), EPA, Department of Primary Industries (DPI) (Fishing and Aquaculture) and NSW Office of Water (NOW). The primary objectives of these plans are to detail the groundwater flow modelling and the monitoring plan in order to effectively meet the overall project objectives, which are:

- Assess the construction and operational impact of the concept design on groundwater resources, quality, hydrology, groundwater dependent ecosystems and provide details of contingency and management measures
- Assess the potential impact of the project on the water quality to protect aquatic ecology and ecosystems in all the adjacent catchments and water courses; and
- Assess the potential impact of the program on groundwater hydrology in order to protect licensed bores, dams, watercourses, water bodies and groundwater dependent ecosystems in adjacent catchments.

These steps will help to ensure that appropriate mitigation and management measures are implemented in order to prevent soil erosion, the discharge of sediments and pollutants from the project, and any impacts due to drawdown of groundwater during construction and operational phases to be in accordance with the *ANZECC 2000a Freshwater and Marine Water Guidelines*, and compliant with Section 120 of the *Protection of the Environment Operations Act 1997* and the future Environment Protection Licence (EPL) for the project.

The EPA encourages the development of such plans to ensure that proponents have determined how they will meet their statutory obligations and environmental objectives as specified by any project/development approvals and/or the conditions of the operator's EPL. However, it is not the role of the EPA to approve or endorse such management plans. The EPA's role is to set conditions for environmental protection and management through a licence and regulate compliance with those conditions. Notwithstanding this, the EPA has conducted a brief review of the draft Surface Water and Groundwater Sampling Protocol prepared by GHD Pty Ltd for Roads and Maritime Services.

The plans appear adequate and the EPA has only a couple of comments to make at this stage. The groundwater modelling is based on conceptual design information, which may not represent the final design conditions. As mentioned throughout the plans, the EPA agrees and recommends that the modelling be revised once there is more certainty on the design levels and construction design, and that further modelling should be undertaken to assess non-uniqueness in the modelling outcomes. Additionally, results of the comparison of current hydraulic data that is being collected along the alignment against the values derived from the automatic calibration should be included in these plans when they are complete. Any additional modelling necessary to understand potential impacts should be carried out before construction commences.

Several areas along the preferred bypass route have been identified as having a high probability of acid sulphate soils (ASS) occurrence that may pose severe environmental risks if disturbed. Before undertaking any detailed assessments of the presence and risk of ASS, the EPA recommends seeking advice on appropriate sampling design and analytical framework from a practitioner with ASS experience. Consultation with appropriate topic specialists should also be arranged in order to assess the potential impacts of groundwater drawdown on in-stream aquatic ecology and groundwater dependent ecosystems and the risk of settlement issues.

Groundwater well GW105826 does not have an upgradient monitoring well to monitor for emerging water quality impacts, and should therefore be decommissioned, or should be added to the groundwater quality monitoring schedule. Also, additional wells may be required to monitor for potential impacts associated with acid sulphate soil exposure and settlement impacts.

Finally, Table 11 (page 65) details the roles and responsibilities for management in the operational phase of the Foxground Berry Bypass. The NSW EPA is listed in this table as having part responsibility for the review of the Annual Progress Reports and Incident Reports, and to provide feedback as necessary. It should be noted that while the project will be licensed by the EPA during the construction phase, the EPL will not be required during the operational phase of the project. In light of this, the EPA will not have a formal

management role post-construction, except in the case of pollution incidents where it assumes the role of Appropriate Regulatory Authority under section 6 of the *Protection of the Environment Operations Act 1997* for the activities of RMS. The EPA recommends that this report be updated to reflect these changes before construction commences so that it may be read as a stand-alone report.

As a management tool, such plans should assist RMS in meeting its commitment to statutory compliance and wider environmental management and, where appropriate, should be integrated with other operational or management plans. The EPA recommends that these plans be audited to an industry standard or certified to the ISO 14001 standard (if applicable) as part of any overall environmental management system. The collection of quality assurance and control samples during sampling is an important measure in order to ensure the integrity of the datasets. Additionally, the EPA endorses the use of a nominated NATA accredited laboratory to analyse water quality parameters and contaminants of potential concern.

The EPA reminds RMS that the person or organisation that will manage the premises is required to apply for an environment protection licence under the *Protection of the Environment Operations Act 1997* (POEO Act) prior to the commencement of any scheduled activities or development work for the Berry to Foxground bypass. This is different and separate from holding a development consent issued by a planning authority such as the Department of Planning or your local council.

I trust this information is of assistance. Should you have any queries or wish to discuss the EPA's response, please contact me on Ph: 6229 7002.

Yours sincerely,



Julian Thompson
Unit Head – South East Region
NSW Environment Protection Authority

Stefan Charteris

From: Julian Thompson <Julian.Thompson@epa.nsw.gov.au>
Sent: Wednesday, 9 July 2014 4:57 PM
To: Stefan Charteris
Cc: Cristina Venables
Subject: RE: GHD file(s) . . .Draft groundwater monitoring plan - for you

Hi Stefan,
Your email below reflects the conversation we had yesterday clarify the EPA written comments on the matter.
Cheers
Julian.

Julian Thompson
Unit Head - South East Region | NSW Environment Protection Authority
☎: (02) 6229 7002 | 📠: (02) 6229 7006 | ✉: julian.thompson@epa.nsw.gov.au

From: Stefan Charteris [mailto:Stefan.Charteris@ghd.com]
Sent: Tuesday, 8 July 2014 5:59 PM
To: Thompson Julian
Subject: RE: GHD file(s) . . .Draft groundwater monitoring plan - for you

Hi Julian,

Further to our discussion today re-the acid sulphate soils intersection issue raised in your response letter to the review of the FBB groundwater monitoring plan I understand we came to the following conclusions.

- Whether the zone is of high or low risk is to acid sulphate soils is essentially irrelevant as from the EPA's perspective acid sulphate soil maps are for screening purposes only and have raised a potential issue of acid sulphate soil generation that needs to be considered further.
- Consultation with a specialist in acid sulphate soils is required given this risk. Subject to this consultation mitigation measures may or may not be considered necessary.
- Consultation should be undertaken at detailed design phase, with any subsequent mitigation measures built into the design if required.

If you are happy with these conclusions please let me know via email and I will forward them to RMS and include them as part of consultation documentation in the report. Otherwise, if you can provide any changes you feel are necessary to represent your understanding of our conversation that would be greatly appreciated.

Best regards,
Stefan

From: Julian Thompson [mailto:Julian.Thompson@epa.nsw.gov.au]
Sent: Tuesday, 10 June 2014 4:28 PM
To: Stefan Charteris
Subject: RE: GHD file(s) . . .Draft groundwater monitoring plan - for you

Stefan,
10MB should be OK.
Julian.

Nicole Rosen

From: Stefan Charteris
Sent: Wednesday, 2 July 2014 4:21 PM
To: Nicole Rosen
Subject: FW: File Downloaded

CompleteRepository: 2123174
Description: Berry to Foxground Water Quality Monitoring
JobNo: 23174
OperatingCentre: 21
RepoEmail: 2123174@ghd.com
RepoType: Job

From: SendThisFile Customer Service [<mailto:info@sendthisfile.com>]
Sent: Thursday, 12 June 2014 12:47 PM
To: Stefan Charteris
Subject: File Downloaded



Sender: stefan.charteris@ghd.com
Recipient: trevor.daly@dpi.nsw.gov.au
Upload Date: 2014-06-10 00:22:34.0

The following file was downloaded on 2014-Jun-11:
196955 - GWMP_DRAFT_7_Rev4.pdf

Maximum allowed downloads: 9
Total downloads so far: 5

<https://ghd.sendthisfile.com/x5BM74BocviYabQtJDZ15Hgy>

This e-mail has been scanned for viruses

Nicole Rosen

From: Stefan Charteris
Sent: Monday, 30 June 2014 9:34 AM
To: Nicole Rosen
Subject: FW: Berry to Foxground Bypass Princes Highway Upgrade

CompleteRepository: 2123174
Description: Berry to Foxground Water Quality Monitoring
JobNo: 23174
OperatingCentre: 21
RepoEmail: 2123174@ghd.com
RepoType: Job

From: Peter Marczan [mailto:Peter.Marczan@epa.nsw.gov.au]
Sent: Thursday, 19 June 2014 5:06 PM
To: Stefan Charteris
Cc: Graham.Roche@rms.nsw.gov.au
Subject: RE: Berry to Foxground Bypass Princes Highway Upgrade

Stefan, apologies for this, I have just spoken to Graham. I received your message a week or so ago and while on leave but had actioned it. I am currently in a different position and am not the contact for an issue like this. I have forwarded your email to Penny Vella in OEH who is currently acting Team Leader Water Quality and will speak to her in the morning. While I cannot provide firm advice, it is unlikely that OEH will have an interest in this other than any work it has done to provide advice to the EPA. I will ask Penny to confirm a position as soon as possible.

Peter

Peter Marczan
A/Manager Noise Policy | NSW Environment Protection Authority |
☎: (02) 9995 6059 | Mobile ☎: 0429 944 451 | 📠: (02) 9995 5935 | ✉: peter.marczan@environment.nsw.gov.au

From: Stefan Charteris [mailto:Stefan.Charteris@ghd.com]
Sent: Thursday, 19 June 2014 4:46 PM
To: Pritchard Tim; Marczan Peter; james.dawson@environment.gov.au
Cc: Graham.Roche@rms.nsw.gov.au; saman.liyanaarachchi@rms.nsw.gov.au; ZHIVANOVICH Steve (Steve.ZHIVANOVICH@rms.nsw.gov.au)
Subject: Berry to Foxground Bypass Princes Highway Upgrade

Tim, Peter, James,

As part of developing the groundwater and surface water monitoring network for Roads and Maritime Services (RMS) for the Foxground to Berry Bypass Princes Highway Upgrade we are obliged (as part of the conditions of approval) to consult with OEH.

I spoke on an informal basis with James on 3 April 2014 re-the project and he mentioned that he was having input with the project from a biodiversity and threatened species perspective with the ecological monitoring plan being developed by Toby Lambert from Parsons Brinkerhoff. As such he was of the opinion that our work was not of major significance in regards to biodiversity and threatened species for OEH. James noted however, that both Tim and Peter may have an interest in the project outcomes.

I would like to obtain written feedback from you on whether you are satisfied with the existing level of OEH contact with the project (i.e. with the contact that James has had with the project) or subsequently whether you would like to obtain the surface water and groundwater monitoring plan documents and the sampling protocol document for comment.

For the purposes of understanding the level of consultation that has been undertaken to date, the documents have been provided to the EPA, NOW and DPI from which we've had varying degrees of response. The EPA and DPI have been detailed in their response, while NOW, after a number of teleconferences, have preferred to take an overarching position based on the degree of risk posed to groundwater dependent systems/resources.

If you could get back to me as soon as possible with a preferred position/approach of OEH for consultation on this project that would be much appreciated.

Regards,

Stefan Charteris
Principal Hydrogeologist

GHD

T: 61 2 9239 7472 | F: 61 2 9239 7199 | V: 217472 | M: 61 451 576 222 | E: Stefan.Charteris@ghd.com
Level 15 133 Castlereagh St Sydney NSW 2000 Australia | <http://www.ghd.com/>
[Water](#) | [Energy & Resources](#) | [Environment](#) | [Property & Buildings](#) | [Transportation](#)

Please consider the environment before printing this email

This email and all attachments are confidential. For further important information about emails sent to or from GHD or if you have received this email in error, please refer to <http://www.ghd.com/emaildisclaimer.html>

This e-mail has been scanned for viruses

This email is intended for the addressee(s) named and may contain confidential and/or privileged information.

If you are not the intended recipient, please notify the sender and then delete it immediately.

Any views expressed in this email are those of the individual sender except where the sender expressly and with authority states them to be the views of the Environment Protection Authority.

PLEASE CONSIDER THE ENVIRONMENT BEFORE PRINTING THIS EMAIL

This e-mail has been scanned for viruses

Nicole Rosen

From: Stefan Charteris
Sent: Monday, 30 June 2014 9:34 AM
To: Nicole Rosen
Subject: FW: Berry to Foxground Bypass Princes Highway Upgrade

CompleteRepository: 2123174
Description: Berry to Foxground Water Quality Monitoring
JobNo: 23174
OperatingCentre: 21
RepoEmail: 2123174@ghd.com
RepoType: Job

From: Penny Vella [mailto:Penny.Vella@environment.nsw.gov.au]
Sent: Friday, 20 June 2014 4:34 PM
To: Stefan Charteris; Graham.Roche@rms.nsw.gov.au
Cc: Michael Heinze; Anthony Pik; James Dawson; Kylie McClelland; Tim Pritchard; Marlene Van Der Sterren; Peter Marczan
Subject: FW: Berry to Foxground Bypass Princes Highway Upgrade

Dear Stefan and Graham,

I can confirm that OEH does not need to review the surface water and groundwater monitoring plan documents, or the sampling protocol. As you point out, the EPA is engaging on this issue.

Please continue to keep in touch with OEH regarding the ecological monitoring work.

Kind regards,

Penny Vella
Acting Team Leader - Water Quality
(Working Tuesday - Friday)
Regional Operations Group
Office of Environment and Heritage
PO Box A290 Sydney South, NSW 1232
T: 02 9995 6058
W: www.environment.nsw.gov.au

From: Stefan Charteris [mailto:Stefan.Charteris@ghd.com]
Sent: Thursday, 19 June 2014 4:46 PM
To: Pritchard Tim; Marczan Peter; james.dawson@environment.gov.au
Cc: Graham.Roche@rms.nsw.gov.au; saman.liyanaarachchi@rms.nsw.gov.au; ZHIVANOVICH Steve
(Steve.ZHIVANOVICH@rms.nsw.gov.au)
Subject: Berry to Foxground Bypass Princes Highway Upgrade

Tim, Peter, James,

As part of developing the groundwater and surface water monitoring network for Roads and Maritime Services (RMS) for the Foxground to Berry Bypass Princes Highway Upgrade we are obliged (as part of the conditions of approval) to consult with OEH.

I spoke on an informal basis with James on 3 April 2014 re-the project and he mentioned that he was having input with the project from a biodiversity and threatened species perspective with the ecological monitoring plan being developed by Toby Lambert from Parsons Brinkerhoff. As such he was of the opinion that our work was not of major significance in regards to biodiversity and

threatened species for OEH. James noted however, that both Tim and Peter may have an interest in the project outcomes.

I would like to obtain written feedback from you on whether you are satisfied with the existing level of OEH contact with the project (i.e. with the contact that James has had with the project) or subsequently whether you would like to obtain the surface water and groundwater monitoring plan documents and the sampling protocol document for comment.

For the purposes of understanding the level of consultation that has been undertaken to date, the documents have been provided to the EPA, NOW and DPI from which we've had varying degrees of response. The EPA and DPI have been detailed in their response, while NOW, after a number of teleconferences, have preferred to take an overarching position based on the degree of risk posed to groundwater dependent systems/resources.

If you could get back to me as soon as possible with a preferred position/approach of OEH for consultation on this project that would be much appreciated.

Regards,

Stefan Charteris
Principal Hydrogeologist

GHD

T: 61 2 9239 7472 | F: 61 2 9239 7199 | V: 217472 | M: 61 451 576 222 | E: Stefan.Charteris@ghd.com
Level 15 133 Castlereagh St Sydney NSW 2000 Australia | <http://www.ghd.com/>
[Water](#) | [Energy & Resources](#) | [Environment](#) | [Property & Buildings](#) | [Transportation](#)

Please consider the environment before printing this email

This email and all attachments are confidential. For further important information about emails sent to or from GHD or if you have received this email in error, please refer to <http://www.ghd.com/emaildisclaimer.html>

This e-mail has been scanned for viruses

This email is intended for the addressee(s) named and may contain confidential and/or privileged information.

If you are not the intended recipient, please notify the sender and then delete it immediately.

Any views expressed in this email are those of the individual sender except where the sender expressly and with authority states them to be the views of the NSW Office of Environment and Heritage.

PLEASE CONSIDER THE ENVIRONMENT BEFORE PRINTING THIS EMAIL

This e-mail has been scanned for viruses

GHD

133 Castlereagh St Sydney NSW 2000

-



T: +61 2 9239 7100 F: +61 2 9239 7199 E: sydmail@ghd.com.au

© GHD 2014

This document is and shall remain the property of GHD. The document may only be used for the purpose for which it was commissioned and in accordance with the Terms of Engagement for the commission. Unauthorised use of this document in any form whatsoever is prohibited.

G:\21\23174\WP\Groundwater Quality Monitoring Plan\196955 - GWMP_DRAFT.docx

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	N. Rosen	J. Hallchurch		J. Hallchurch		23/04/14
1	N. Rosen	S. Charteris		S Charteris		30/05/14
2	N. Rosen	S. Charteris		J. Hallchurch		09/07/14

www.ghd.com



Appendix C

Unexpected Discovery of Contaminated Land Procedure

Unexpected Discovery of Contaminated Land Procedure

Purpose

This procedure details the actions to be taken in the event that potentially contaminated soil or material is unexpectedly encountered during excavation/construction activities.

Scope

This procedure applies to all construction activities undertaken as part of the Foxground and Berry bypass project.

Training

All Fulton Hogan personnel and subcontractors will be trained this procedure.

Procedure

1. If potential contaminated soil/material is encountered during excavation/construction activities:
 - **STOP ALL WORK** in the immediate/affected area
 - immediately notify the Environmental Manager (EM)
 - recommence works in an alternate area, where practicable.
2. Prior to any contamination investigation/management, appropriate personal protective equipment (PPE) is to be worn as per the relevant Safety Data Sheets (SDSs).
 - this may include, but not be limited to:
 - eye goggles
 - face mask
 - rubber boots
 - rubber gloves, and
 - work clothes.
3. The RMS Specification D&C G36 Hold Point for Contaminated Land must be implemented.
4. The EM will evaluate the situation and, if considered necessary, commission a suitably qualified contamination specialist to undertake a contamination investigation in the area of the find.
5. The material is to be classified in accordance with the *Waste Classification Guidelines* (DECCW 2009).
6. If necessary, the EM will liaise with the relevant authorities to determine the appropriate management options.
7. The EM (in consultation with specialists) will determine the appropriate management measures to be implemented. This may include treatment or offsite disposal. If the material is to be disposed offsite, ensure the waste facility is appropriately licensed.
8. If the material is determined to be ASS or PASS, follow *ASS Management Procedure*.
9. Remedial actions are to be incorporated into specific SWMSs and EWMSs and to be further toolboxed to project team and subcontractors.
10. Recommence works once remedial works have been implemented. The EM grants approval once Hold Point is released.

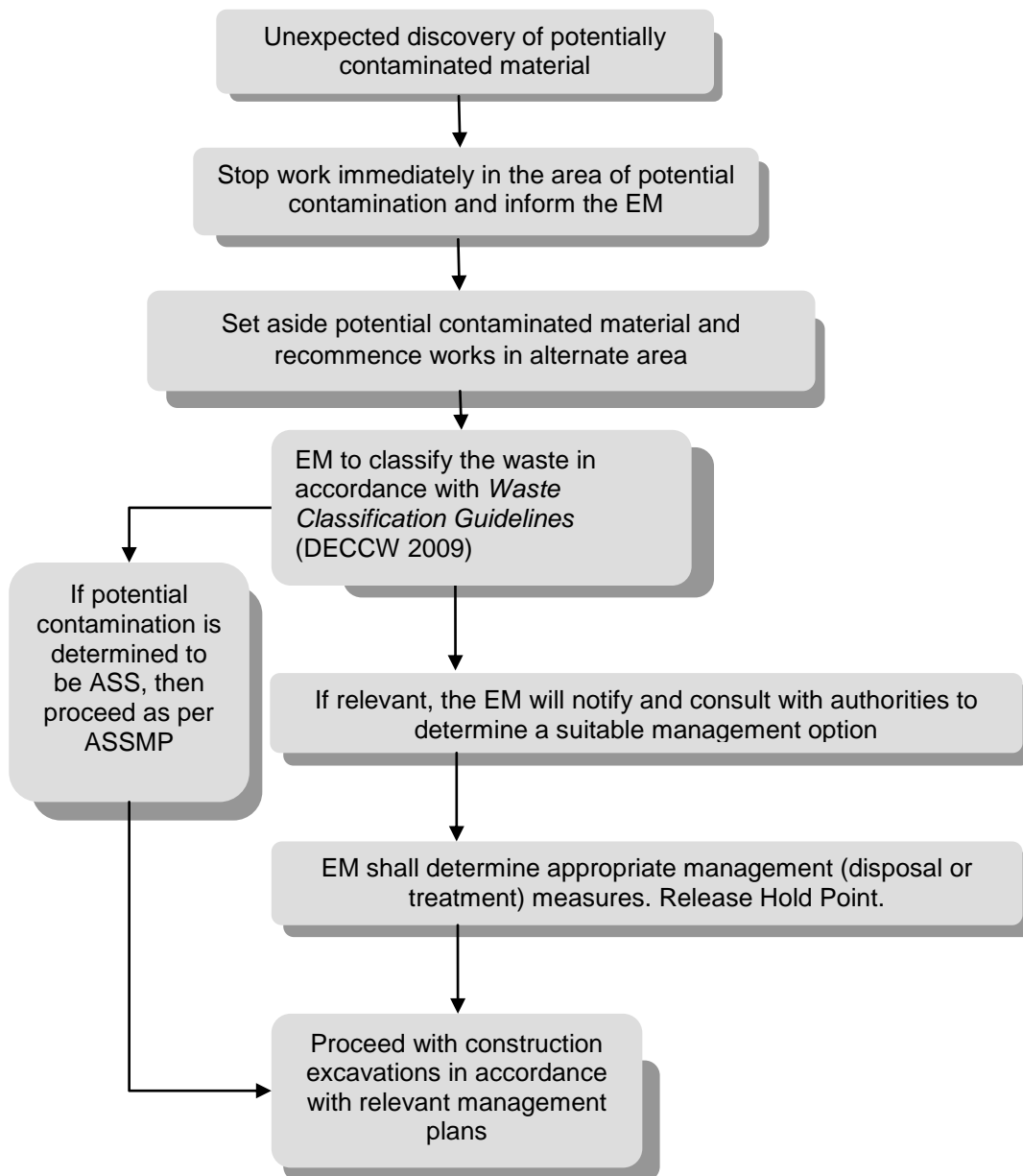


Figure C1 Unexpected Discovery of Contaminated Land Procedure Flow Chart

Appendix D

RMS Environmental Direction

Management of Tannins from Vegetation Mulch

To be provided as a separate file

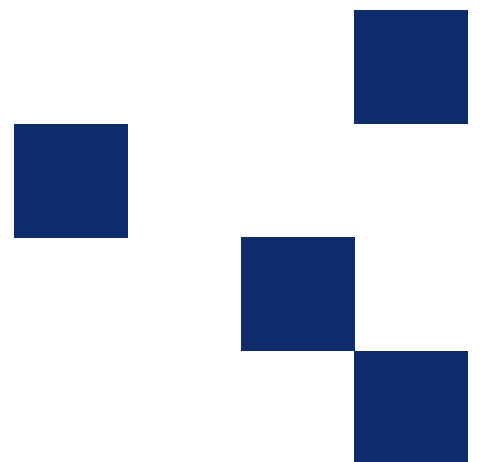


Transport
Roads & Maritime
Services

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

COPYRIGHT

© NSW Roads and Maritime Services, 2011

All intellectual property and copyright reserved.

Apart from any fair dealing for the purpose of private study, research, criticism or review, as permitted under the Copyright Act, 1968, no part of this report may be reproduced, transmitted, stored in a retrieval system or adapted in any form or by any means (electronic, mechanical, photocopying, recording or otherwise) without written permission.

CONTENTS

ABOUT THIS RELEASE	1
1 PURPOSE	2
2 MANAGEMENT MEASURES	2
2.1 General mulch management measures	2
2.1.1 Planning and works staging.....	2
2.1.2 Stockpile location and management.....	2
2.1.3 Management measures for the use of mulch on site.....	3
2.1.4 Monitoring and response.....	3
2.2 Mulch management methods for high risk sites.....	3
2.2.1 High risk sites	3
2.2.2 Stockpile management measures for high risk sites	3
2.3 Site management procedures	3
3 BACKGROUND	4
3.1 Tannin generation from vegetation mulch	4
3.2 Tannin impacts on water quality	4
3.3 Use of mulch on construction sites	4
4 ADDITIONAL RESOURCES	5
5 APPENDICES	6
Appendix 1: Plates showing tannin generation & water quality impacts.....	7
Appendix 2: Plates showing the use of mulch for erosion & sedimentation controls	10
Appendix 3: Minimum requirements for community mulch giveaways	14
Appendix 4: Community mulch giveaway information sheet	15
Appendix 5: Records template for community mulch giveaway	17

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
<ul style="list-style-type: none">• 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
<ul style="list-style-type: none">• 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
<ul style="list-style-type: none">• <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.

Appendix E

Acid Sulfate Soil Management Procedure

Acid Sulfate Soil Management Procedure

Purpose

This procedure details the actions to be taken when actual Acid Sulfate Soils (ASS) or Potential Acid Sulfate Soils (PASS) are encountered during excavation/construction activities.

Scope

This procedure applies to all construction activities undertaken as part of Foxground and Berry Bypass project that have the potential to uncover/disturb ASS/PASS.

Training

All Fulton Hogan personnel and subcontractors will be trained this procedure.

Procedure

1. Actual or Potential Acid Sulfate Soils encountered during excavation/construction activities

If ASS/PASS is encountered during excavation/construction activities the Foreman must:

- STOP ALL WORK in the immediate/affected area and contact the Environmental Officer (EO).
- Recommence works in alternate area where practicable.

The EO is responsible for testing of ASS/PASS and will undertake testing to determine the acidity (field pH test) and potential for acidity (field 30% peroxide test) of the material encountered.

2. Action Criteria for Management Intervention

Table 1 details the texture based action criteria for management of ASS disturbance. Where soils containing concentrations at or above the action criteria are disturbed, management of spoil is required. As this project may disturb spoil greater than 1000 tonnes, the two right hand columns should be used.

Table 1 Action criteria based on the ASS analysis for three broad texture categories

Type of Material	Action Criteria	Action Criteria			
		1- 1000 tonnes disturbed	> 1000 tonnes disturbed		
Texture range (McDonald et al. (1990))	Approx clay content (%<0.002 mm)	Sulphur trail % S oxidisable e.g. S _{TOS} or S _{POS}	Acid trail mol H ⁺ /tonne e.g. TPA or TSA	Sulphur trail % S oxidisable e.g. S _{TOS} or S _{POS}	Acid trail mol H ⁺ /tonne e.g. TPA or TSA
Coarse Texture Sands to loamy sands	≤5	0.03	18	0.03	18
Medium Texture Sandy loams to light clays	5 – 40	0.06	36	0.03	18
Fine Texture Medium to heavy clays and silty clays	≤40	0.1	62	0.03	18

Source: *Ahern et al. 1998*

3. Neutralisation of Excavated Acid Sulfate Materials(ASM) from Earthworks

If field tests are positive or inconclusive, laboratory analysis using the Chromium Suite will be required to determine if the material is in fact ASS and/or the required treatment rates based on the net acidity.

Neutralising agents must be incorporated within all ASS/PASS. All cut batters shall be coated with fine aglime at the rate of 5kg/m and the lime coating should be checked and re-limed as necessary on a daily basis during periods of dewatering during construction excavation. The base of all fill areas where treated material is to be placed shall be treated with a neutralising agent forming a guard layer prior to the placement of any fill soils to neutralise downward seepage of acidic drainage water. This application may need to be increased depending on stockpile height and actual and potential acidity of the ASM developed through detail assessment.

Aglime rates will be as determined through analytical assessment to establish S% to determine an indicative level of treatment as specified in Table 2. Interpretation of analytical data must be conducted by an appropriately qualified and experienced in dealing with ASS/PASS management. ASS/PASS must be sufficiently dry before neutralising is commenced so that the lime can be thoroughly mixed through the soil. Where moisture levels in soil are high, the soil must be dried by spreading and leaving open to the atmosphere. Drying can be accelerated by regular aeration by turning with an excavator or backhoe. Drying should be carried out on a guard layer and protected from stormwater ingress.

Mixing of ASS/PASS with neutralising agent shall be carried out by spreading the soil in layers of not more than 300-400mm thick using an agricultural spreader and disc plough, rotary hoe or similar. Care shall be taken to ensure that mixing occurs throughout the depth of the layer prior to placement of new material.

Following the successful treatment of the lot (as determined through the validation testing), the material shall be compacted and the next layer of excavated material to be treated shall be placed over the already treated material. This process shall be continued until the required site elevation is achieved.

Table 2 Treatment levels and aglime required to treat total weight of disturbed ASS

The tonnes (t) of pure fine aglime, CaCO₃ required to fully treat the total weight/volume of acid sulfate soils (ASS) can be read from the table at the intersection of the weight of disturbed soil [row] with the existing plus potential acidity [column]. Where the exact weight or soil analysis figure does not appear in the heading of the row or column, use the next highest value.

Disturbed ASS (tonnes) (=m ³ ×BD) †	Soil Analysis [‡] – Existing Acidity plus Potential Acidity (converted to equivalent S% units)													
	0.03	0.06	0.1	0.2	0.4	0.6	0.8	1	1.5	2	2.5	3	4	5
1	0	0	0	0	0	0.03	0.04	0.05	0.1	0.1	0.1	0.1	0.2	0.2
5	0	0	0	0.05	0.1	0.1	0.2	0.2	0.4	0.5	0.6	0.7	0.9	1.2
10	0	0.03	0.05	0.1	0.2	0.3	0.4	0.5	0.7	0.9	1.2	1.4	1.9	2.3
50	0.1	0.1	0.2	0.5	0.9	1.4	1.9	2.3	3.5	4.7	5.9	7.0	9.4	12
100	0.1	0.3	0.5	0.9	1.9	2.8	3.7	4.7	7.0	9.4	12	14	19	23
200	0.3	0.6	0.9	1.9	3.7	5.6	7.5	9.4	14	19	23	28	37	47
250	0.4	0.7	1.2	2.3	4.7	7.0	9.4	12	18	23	29	35	47	59
350	0.5	1.0	1.6	3.3	6.6	10	13	16	25	33	41	49	66	82
500	0.7	1.4	2.3	4.7	9.4	14	19	23	35	47	59	70	94	117
600	0.8	1.7	2.8	5.6	11	17	22	28	42	56	70	84	112	140
750	1.1	2.1	3.5	7.0	14	21	28	35	53	70	88	105	140	176
900	1.3	2.5	4.2	8.4	17	25	34	42	63	84	105	126	168	211
1000	1.4	2.8	4.7	9.4	19	28	37	47	70	94	117	140	187	234
2000	2.8	5.6	9.4	19	37	56	75	94	140	187	234	281	374	468
5000	7.0	14	23	47	94	140	187	234	351	468	585	702	936	1170
10000	14	28	47	94	187	281	374	468	702	936	1170	1404	1872	2340

L Low treatment: (≤0.1 tonnes lime)
M Medium treatment: (>0.1 to 1 tonne lime)
H High treatment: (>1 to 5 tonnes lime)
VH Very High treatment: (>5 to 25 tonnes lime)
XH Extra High treatment: (>25 tonnes lime)

Note: Lime rates are for pure fine aglime, CaCO₃ assuming an NV of 100% and using a safety factor of 1.5. A factor that accounts for Effective Neutralising Value is needed for commercial grade lime. (See the Information Sheets on Neutralising Agents – Neutralising Considerations).

† An approximate soil weight (tonnes) can be obtained from the calculated volume by multiplying volume (cubic m) by bulk density (t/m³). (Use 1.7 if B.D. is not known.) Dense fine sandy soils may have a BD up to 1.7, and hence 100 m³ of such soil may weigh up to 170 t. In these calculations, it is necessary to convert to dry soil masses, since analyses are reported on a dry weight basis.

‡ Potential acidity can be determined by Chromium Reducible Sulfur (S_{CR}), Peroxide Oxidisable Sulfur (S_{PO5}) and Total Oxidisable Sulfur (S_{TOD}). For samples with pH < 5.5, the existing acidity must also be determined by appropriate laboratory analysis eg. Titratable Actual Acidity (TAA). Soils with retained acidity eg. jarosite or other similar insoluble compounds have a less available acidity and will require more detailed analysis. The amount of treatment required may be reduced if the self-neutralising capacity of the soil is appropriately measured. Consult the Queensland Acid Sulfate Soils Technical Manual, Laboratory Methods Guidelines.

Source: (based on soil analysis) (Queensland Acid Sulfate Soil Technical Manual, Soil Management Guidelines 2002)

4. Neutralising Materials

For management or neutralisation of ASS/PASS soils, medium-fine Aglime will be used. Dolomitic Aglime, or magnesium-blend Aglime, will not be used. In general a finer grind is better. The Aglime purity should preferably be 90% or better, (that is, Neutralising Value [NV] > 90), unless there is a significant savings to be made by use of less pure Aglime. In the latter case, however, the individual lime dosing rates will need to be increased accordingly. The requirement for greater amounts of Aglime of lower purity should be borne in mind when assessing the supplies of this material, as the cost savings from less pure material may be offset by the need for more, and correspondingly higher total transport costs.

ASS/PASS treatment will occur within the ASS treatment area. Material which is transported to the treatment cells must be completely treated and removed from the treatment area before new material is introduced. This will ensure that treated material remains segregated and is not mixed with contaminated material. Aglime or other suitable treatment material will be stored at the treatment area in sufficient quantities to enable the treatment of all ASS/PASS material expected to be treated in the upcoming few weeks/months and will be determined by the expected delivery schedule of treatment material. The management of onsite treatment is the responsibility of the Site Foreman, with assistance from the Environmental Officer (EO).

Aglime is non-corrosive, and requires no special handling – it may be necessary to cover the stockpile with a tarpaulin or cover the stockpile with plastic, to minimise dust generation and prevent wetting, since it is then more difficult to spread. Intermittently, until such time as field testing suggests otherwise, a small quantity of Aglime will be stored on site, in the order of 200kg or so. This will enable the regular treatment of soil and cater for any unexpected occurrences of 'hotter' ASS/PASS.

Dolomitic aglime, or magnesium-blend aglime, should not be used as these materials impose environmental risks from overdosing with the potential to damage estuarine ecosystems. A reasonable quantity of calcium hydroxide solution (hydrated lime) shall be kept on site at all times for treatment of acidic waters. The supply shall be stored in a covered and bunded area to prevent accidental release to waters. Neutralising agents must be replenished and or replaced regularly to remain effective against loss by wind or water erosion.

5. Validation of Ameliorated ASS/PASS

Samples of the treated soil should be taken and laboratory analysed to demonstrate compliance with the performance criteria (ie. verification testing). These performance criteria equate to there being no net acidity in the soil following neutralisation. Soil that has been treated by neutralisation techniques and has not met these criteria must be retreated until the above performance criteria are met.

The objective of ameliorating ASS/PASS materials is to ensure that there is no chance that net acidity will be produced. Validation testing only occurs when soils have been treated (with a neutralising agent) to prevent any future acidification. If results of the validation testing indicate a failure to comply with the performance criteria, soil may need to be re-treated with an additional application of neutralising agent.

Soils that have been mixed with aglime will be analysed by either the SPOCAS or S_{CR} Suite test methods at a rate of one sample per 250m³. All validation samples are to be recorded by GPS or survey, clearly marked on a map/sketch or otherwise recorded.

Where large quantities (>1,000m³) of ameliorated soils are involved and 'net acidity' rates are generally low (18 – <125 mol H⁺/t or 0.03 – 0.20 %S), a reduced rate of sampling may be appropriate subject to approval. A rate of one sample per 1,000m³ may be suitable for example.

The following performance criteria must be attained for soil that has been treated using neutralisation:

- The neutralising capacity of the treated soil must exceed the existing plus potential acidity of the soil.
- Post-neutralisation, the soil pH is to be greater than 5.5.
- Excess neutralising agent should remain within the soil until all acid generation reactions are complete and the soil has no further capacity to generate acidity.

If ameliorated ASS is going to be reused on site, due environmental regard for areas of placement should be assessed, documented and approved by the FH EM. Assessment measures may include:

- location of proposed placement areas and potential receptors (waterways, sensitive flora and fauna, structures)
- stability and suitability of materials as select fill (especially clays), and
- suitability of soil type for plant growth.

In the unlikely event that the treated material is unable to be reused on-site for other purposes, the material will need to be disposed of to an appropriately licensed waste disposal facility. The Environment Manager/Environment Officers will liaise with a licensed waste facility and coordinate the process.

6. Large-scale dewatering or drainage

Earthworks and/or pumping that result in localised drainage or lowering of groundwater and the exposure of sulfidic soils to the ingress of oxygen may generate acidity as a function of soil type(s), sulfide contents, area exposed, and length of time the excavation remains 'dry'. The scale of the dewatering or drainage should be defined by the size of the cone of depression rather than the size of the void. Activities of this type are high-risk, and should not be undertaken without technical risk assessment by qualified personnel and the formulation of management measures sufficient to reduce risk to levels acceptable by the administering authorities.

7. Neutralising acid leachate and drain water using lime

The liming rate for treating acid water should be carefully calculated to avoid the possibility of "overshooting" the optimum pH levels of 6.5 - 8.5. This can occur quite easily if more soluble or caustic neutralising agents such as hydrated lime (pH 12) or magnesium hydroxide (pH 12) are used. It should be noted that when neutralising acid water, no safety factor is used. However, monitoring of pH should be carried out regularly during neutralisation procedures.

Agricultural lime (pH 8.2) is the safest neutralising agent. It equilibrates around a pH of 8.2 that is not generally harmful to plants, stock or humans and most aquatic ecology species. The main shortcoming associated with the use of lime is its insolubility in water.

When using alkaline materials, strict protocols must be established for the use, handling and monitoring of these materials. Prior to any ASS/PASS management, appropriate personal protective equipment (PPE) is to be worn as per relevant SDSs (e.g. for Lime). This may include:

- Eye goggles and/or face masks;
- Hard Hat;

- Rubber boots, gloves; and
- Appropriate clothing (e.g. long sleeved shirts)

8. Calculating the quantity of lime

The current pH is measured with a recently calibrated pH detector. The desired pH is usually between 6.5 and 8.5 with pH 7 is normally targeted. The volume of water can be calculated by assuming 1 cu metre of acid water is equivalent to 1 kilolitre (1000 litre) and 1,000 cu metre is equivalent to 1 megalitre (ML).

As a general guide, Table 2 shows minimum quantities of pure lime, hydrated lime or sodium bicarbonate needed to treat dams or drains of 1 ML (1,000 m³) capacity.

Table 2 Quantity of pure neutralising agent required to raise from existing pH to pH 7 for 1 megalitre of low salinity acid water

Current Water pH	[H⁺] {mol/L}	H⁺ in 1 Megalitre {mol}	Lime to neutralise 1 Megalitre {kg pure CaCO₃}	Hydr. lime to neutralise 1 Megalitre {kg pure Ca(OH)₂}	Pure NaHCO₃/ 1 Megalitre {kg }
0.5	.316	316,228	15,824	11,716	26,563
1.0	.1	100,000	5,004	3705	8390
1.5	.032	32,000	1,600	1185	2686
2.0	.01	10,000	500	370	839
2.5	.0032	3,200	160	118	269
3.0	.001	1,000	50	37	84
3.5	.00032	320	16	12	27
4.0	.0001	100	5	4	8.4
4.5	.000032	32	1.6	1.18	2.69
5.0	.00001	10	0.5	0.37	0.84
5.5	.0000032	3.2	0.16	0.12	0.27
6.0	.000001	1	0.05	0.037	0.08
6.5	.00000032	.32	0.016	0.12	0.027

Notes on Table 2: 1 m³ = 1,000 litre = 1 Kilolitre = 0.001 Megalitre

- Agricultural lime has very low solubility and may take considerable time to even partially react.
- Hydrated lime is more soluble than aglime and hence more suited to water treatment. However, as Ca(OH)₂ has a high water pH, incremental addition and thorough mixing is needed to prevent overshooting the desired pH. The water pH should be checked regularly after thorough mixing and time for equilibration before further addition of neutralising product.
- Weights of lime or hydrated lime are based on theoretical pure material and hence use of such amounts of commercial product will generally result in under treatment.
- To more accurately calculate the amount of commercial product required, the weight of lime from the table should be multiplied by a purity factor (100/ Neutralising Value for aglime) or (148/ Neutralising Value for hydrated lime).
- Calculations are based on low salinity water acidified by hydrogen ion, H⁺ (acid) and do not take into account the considerable buffering capacity or acid producing reactions of some acid salts and soluble species of aluminium and iron. For example, as the pH increases towards 4, the precipitation of soluble ferric ion occurs, liberating more acid:
- $Fe^{3+} + 3H_2O \rightarrow Fe(OH)_3 + 3H^+$
- If neutralising substantial quantities of acid sulfate soil leachate, full laboratory analysis of the water will be necessary to adequately estimate the amount of neutralising material required.

9. Application of lime to water

To increase the efficiency, lime should be mixed into a slurry before adding. A slurry can be prepared in a concrete truck, cement mixer or large vat with an agitator. Methods of application of the slurry include:

- spraying the slurry over the water with a dispersion pump
- pumping the slurry into the water body with air sparging (compressed air delivered through pipes) to improve mixing once added to water
- pouring the slurry out behind a small motorboat and letting the motor mix it in
- incorporating the slurry into the dredge line (when pumping dredge material)
- using mobile water treatment equipment such as the 'Neutra- mill' and 'Aqua Fix' to dispense neutralising reagents to large water bodies.

A change in pH will not be instantaneous. The rate of neutralisation will vary with the solubility, fineness of the lime, the application technique and the acidity (pH) of the water. The finer the lime (preferably microfine with the consistency of white dust) and the more agitated the water, the faster the lime will dissolve and become effective. The pH must be carefully monitored even after the desired pH has been reached. If the water has not reached the desired pH within two weeks, more lime may need to be added. Before additional lime is added, the lack of success should be investigated. Issues to consider may include:

- the quality of the lime being used
- the effectiveness of the application technique
- the existence of additional sources of acid leaching into the water body further acidifying the water.
- the lime has become lumpy and is sitting on the bottom

Neutralisation may be faster if higher rates are used, but is not recommended as it is expensive and resource wasteful. Moreover, over-dosing may result, though this is unlikely to be a concern with agricultural lime.

Appendix F

Stockpile Management Protocol

Stockpile Management Protocol

Purpose

This protocol provides a process for the establishment of stockpile areas within and outside the approved project boundary to ensure that environmental impacts are minimised during construction.

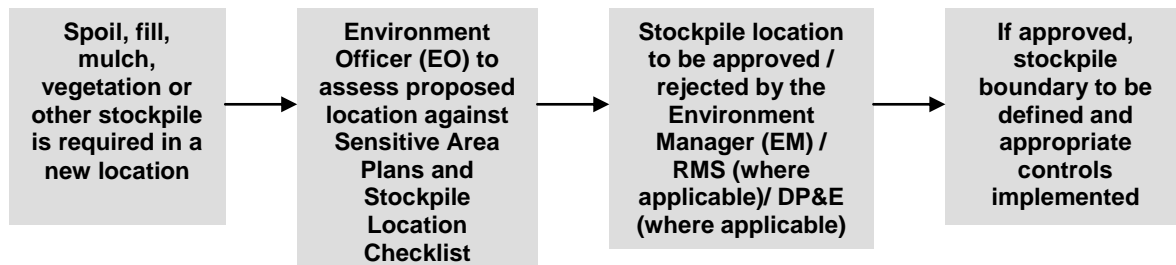
Stockpile sites may typically be required to store material including, but not limited to:

- Excavated materials to be used in fill embankments and other design features
- Acid sulfate soils subject to treatment prior to reuse
- 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, and
- Topsoil, mulch, excess timber for landscaping and revegetation works.

Scope

This protocol and associated Stockpile Location Checklist describes the environmental factors to be considered to ensure stockpiles are located in areas where potential environmental harm is minimised.

Refer to Chapter 5 of both the Construction Air Quality Management Sub-plan and the Construction Soil and Water Quality Management Sub-plan for additional mitigation measures to minimise air quality and erosion and sediment impacts from stockpiles.



Protocol

1. Proposed Stockpile Information

Prior to requesting the assessment of a stockpile location from the EO, the person requesting the new stockpile location should check approved stockpile locations to ensure nearby sites cannot be utilised. Minimise the number of stockpiles sites wherever practicable.

If existing sites cannot be used, the expected quantity of material, expected dimensions required, whether the stockpile will be permanent, whose land the stockpile will be located on and the type of material to be stockpiled shall be detailed. Once this information is known, the EO shall be contacted for an assessment of the proposed stockpile location.

2. Assessment of Stockpile Site

The EO shall utilise the **Stockpile Location Checklist** (included in this Protocol) to assess the stockpile location.

Note stockpiles within the approved project boundary are intrinsic to and undifferentiated from the bulk earthworks operations, these stockpiles are assessed in accordance with Section 3.1.

Where stockpile areas located outside the road reserve are proposed an assessment will be undertaken in accordance with CoA B35 (vi) in accordance with Section 3.2 and 3.3.

3. Approval of Stockpile Site

3.1. Stockpiles within the approved project boundary

The EO shall give the completed **Stockpile Location Checklist** to the EM for review and assessment. Following this review, the EM shall either approve or reject the proposed stockpile location and notify the EO of the decision.

A register of all stockpile sites (included in this Protocol) shall be kept on file by the EO and they shall also ensure that any additional mitigation measures are included in the relevant progressive erosion and sediment control plan (PESCP).

3.2. Stockpiles on RMS land outside the approved project boundary

Where a stockpile is proposed outside the approved project boundary but on RMS owned land, the EM will assess whether the proposal is consistent with the Project Approval and complete the Stockpile Location Checklist.

Note: As approval of stockpiles on RMS owned land outside the approved project boundary will be determined by RMS and potentially the Director-General of DP&E (where the proposal is inconsistent with the Project Approval), the timeframes for approval will be greater than through the Environmental Team.

3.3. Stockpiles not on RMS land outside the approved project boundary

Where a stockpile is proposed on land outside the approved project boundary that is not RMS owned land, the EM will assess whether the proposal is consistent with the Project Approval, complete the Stockpile Location Checklist and obtain evidence of landowner consent.

Note: As approval of stockpiles on land outside the approved project boundary will be determined by RMS and potentially the Director-General of DP&E (where the proposal is inconsistent with the Project Approval), the timeframes for approval will be greater than through the Environmental Team.

4. Preparing Stockpile Site

If the proposed stockpile site is approved, the boundaries will be agreed between the person proposing the stockpile and the EO (or RMS where required). They will be marked out and appropriate erosion and sediment controls installed. Stockpile sites will also be signposted to clearly identify and delineate between other stockpiles. The erection of signs will be agreed with the Site Foreman.

Details of stockpile management will be included in the relevant PESCP.

5. Mulch Stockpiles

Locate and manage mulch stockpiles to minimise and manage tannin generation. Refer to Appendix D of the CSWQMP *RMS Environmental Direction No.25 Management of Tannins from Vegetation Mulch*.

Stockpile Location Checklist

The location of stockpile sites will be determined following review of the following documents and requirements:

1. Sensitive Area Plans
2. CoA B35 (vi) – Stockpile Management Protocol
3. SoC AF3 – Temporary Stockpiles
4. FBB SWTC Appendix 4
5. RMS Specification D&C G36, G38 and G40

Where proposed sites do not comply with the criteria provided below justification and additional mitigation measures will be required.

Stockpile Number	
Chainage	
Location sketch attached?	
Stockpile type and Dimensions (HxWxD)	

Criteria		Does the proposed site meet the criteria?	If proposed site does not meet the criteria, provide justification / additional mitigation measures to demonstrate how potential impacts will be managed
Review Against CoA B35 (vi) and Sensitive Area Plans	Site should not impact on heritage		
	Site should not impact on flora and fauna threatened species		
	Site should not impact on threatened populations		
	Site should not impact on endangered ecological communities		
Statement of Commitment AF3	Site at least 50 metres from a waterway		
	Site outside the 10 year ARI floodplain		
	Site on relatively level ground		
Review Against Scope of Works and Technical Criteria Appendix 4 Clause 4.32	a) Site must be located at least 5 metres from all areas of possible concentrated water flow		
	b) Site to have ready access to the road network or direct access to the construction corridor		
	c) Site must not result in any clearing of native vegetation beyond that which is otherwise required for the Project and which is permitted under the Deed.		
	d) Locate, plan and manage vegetation stockpiles so as to minimise the impact of tannins leaching into the surrounding environment, in accordance with the requirements of Environmental Direction – Management of Tannins from Vegetation Mulch (RMS, 2012) included in Appendix D of the CSWQMP.		
G36 Clause 4.18.2 (e)	The toe of stockpiled material must not be any closer than 5 m to a fence or drain or within the drip line of existing trees to be retained. Place protective fencing around trees to be retained.		

Prepared by Environment Officer:

Date:

Environmental Manager:

Date:

Approved / Rejected (please circle) by:

Date:

Appendix G

Heavy Rainfall Event Procedure

Heavy Rainfall Event Procedure

Purpose

To detail the actions to be taken in the event of a 'heavy' or 'violent' rainfall forecast as defined by the Australian Government Bureau of Meteorology. The procedure outlines how to monitor rainfall forecasts and prepare site to minimise impacts as much as practicable.

References

- RMS Specification D&C G36
- RMS Specification D&C G38
- Australian Government Bureau of Meteorology website: <http://www.bom.gov.au/>
- Environment Protection Licence where applicable

Definitions of rain or showers intensity

Category	Description
Light	Up to 2 mm per hour. Individual drops easily identified, puddles form slowly, small streams may flow in gutters.
Moderate	2.2 mm to 6 mm per hour. Rapidly forming puddles, down pipes flowing freely, some spray visible over hard surfaces.
Heavy	6.2 mm to 50mm mm per hour. Falls in sheets, misty spray over hard surfaces, may cause roaring noise on roof.
Violent	Over 50mm per hour. Gutters and downpipes overflowing, spray to height of several centimeters over hard surfaces, may cause roaring noise on roof.

Source: Australian Government Bureau of Meteorology website <http://www.bom.gov.au/info/wwords>

Training

All Fulton Hogan Superintendents, Foremen and Engineers will be trained in this Procedure.

Procedure

1. Monitoring of 'heavy' or 'violent' rain or shower events (through the Australian Government Bureau of Meteorology):
 - On each working day, the Environmental Manager (EM)/ Environment Officer (EO) or delegate will log on to the Australian Government Bureau of Meteorology website <http://www.bom.gov.au/weather/nsw/>, review the weather forecast for the next three days and notify the Project team of the same by email. When rain or showers are described as 'heavy' or 'violent', the EM/EO or delegate will highlight that:
 - rain or showers are described as 'heavy' or 'violent' (as applicable)
 - the Heavy Rainfall Event Procedure must be followed.
 - The EM/ EO or delegate will keep a record of all weather forecast emails.
 - The daily weather forecast may be discussed at Prestart Meetings as deemed required by the Fulton Hogan Foreman/Superintendent.

2. When rain or showers are described as 'heavy' or 'violent' the Fulton Hogan Superintendent will notify the Project team of personnel who will monitor and maintain erosion and sediment controls if required.
3. The Foremen will ensure that there is an adequate supply of erosion and sediment control measures on site.
4. Prior to the 'heavy' or 'violent' rainfall or shower event, the Foremen and the EM/ EO or delegate will inspect erosion and sediment control measures, focusing on the critical areas first. These may include stockpile areas, chemical storage areas and sediment basins.
5. The Superintendent and Foremen will ensure maintenance is performed focusing on the critical areas first as described above.
 - EM/ EO or delegate to enter items (that cannot be immediately actioned) into the pre-rainfall inspection report.
 - EM/ EO or delegate to issue relevant part of the pre-rainfall inspection report to the responsible Engineers, Superintendent and Foremen
 - Responsible Engineers, Superintendent and Foremen to notify EM/ EO or delegate upon completion of actions
 - Completed actions to be verified by the EM/EO or delegate and actions closed out in the pre-rainfall inspection report.

Appendix H

Use of Reclaimed Water

Date: 8 December 2006

Direction No: 19

Use of Reclaimed Water

Purpose

To provide requirements for reclaimed water use for the protection of RTA and Contractor staff and the environment.

Definition of Reclaimed Water

Reclaimed water is sewage effluent that has been treated and disinfected to a standard that is suitable for reuse for non-potable purposes (non-drinking water purposes).

Background

Sewerage treatment plants (STP's) in NSW use a range of methods of sewage treatment and the quality of effluent from different plants is variable. For this reason, the reclaimed water that can be used by RTA for different activities is specifically by treated water quality criteria, not the treatment method.

RTA encourages the use of reclaimed water. However, in order to protect site staff and the environment, certain requirements need to be followed. Specifically, reclaimed water must only be used for construction purposes and only on sites where access is restricted to inducted personnel. Reclaimed water is not to be used for drinking water, cooking or used in potable bathrooms.

Actions Required

Quality of Reclaimed Water that can be used for RTA works

The National Water Quality Management Strategy (NWQMS) 2000 provides guidance on the appropriate uses of reclaimed water of different quality in the *Guidelines for Sewage Systems – Use of Reclaimed Water, Nov 2000*. For construction activities undertaken by the RTA the Guideline recommends a maximum concentration of 1,000 thermotolerant coliforms/100ml (tc/100ml) in reclaimed water to protect human health. This water quality can be achieved by secondary effluent treatment with disinfection and by tertiary treatment. Reclaimed water for various activities must meet the standards for each activity in Table I.

Quality Control of Reclaimed Water Quality for water Provider

RTA will receive water from sewage treatment plants where it can be demonstrated that the reclaimed water meets the requirements of Table I of this Direction. Regular monitoring of reclaimed water by the Water Authority is required to demonstrate compliance with RTA requirements for use. Additional information is included in the “Minimum System Requirements”, below.

Environmental Directions (continued)

Excluded Activities

This Direction refers to requirements for the use of reclaimed water for construction purposes only. Due primarily to the potential creation of concentrated flows, and subsequent direct runoff to waterways, reclaimed water is not to be used for the following activities:

- Subsoil drainage flushing.
- Pavement or structure washdown.
- Saw cutting.
- Drilling (water may contaminate groundwater and drinking water resources)

Table 1 – Reclaimed Water Standards Required for Specific Activities

Key:

√ = Water of this quality can be used for this activity in accordance with all minimum requirements

X = Water of this quality must not be used for this activity

Reclaimed Water Use	Water Quality required (Thermotolerant Coliforms – tc/100ml) *1	
	< 10	10-1000
Earthworks Construction (compaction and pavement stabilisation) *2	√	√
Dust Suppression *2	√	√
Watering Vegetation with vehicle-operated equipment (a 4 hour exclusion period may apply prior to site entry)	√	√
High Pressure Water Blasting for Pavement Re-texturing	√	X

*1 – Thermotolerant Coliforms are a group of bacteria whose presence is used as an indicator of effective treatment and the residual risk of treated wastewater.

*2 – Workers potentially exposed to spray drift from dust suppression and earthworks activities include both ground-based staff and plant operators. The SVMS for dust suppression must identify the risks for all site staff. Temporary exclusion of entry to the sprayed area, where possible, is an effective management control.

Minimum Procedural Requirements

RTA's minimum system requirements for the management of recycled water on any RTA project site are:

- I. That written information is provided to the water provider (e.g. the Council operating the STP) that:
 - Clearly states the proposed use of the reclaimed water.
 - Makes reference to the specified water quality required (from Table 1).
 - Requests written confirmation from the water provider that their reclaimed water meets the specified water quality and that regular sampling is undertaken that provides quality assurance to the requirements of the NWQMS, 2000. A minimum of weekly sampling and National Association of Testing Authorities (NATA)

Environmental Directions (continued)

accredited analysis that demonstrates compliance is the minimum standard. Records of long term monitoring results (6 months or more) should be made available by the Water Provider to demonstrate that STP consistently meets the requirements.

2. That the driver of the water cart keeps a log book or other record of information in each registered water cart to record information of deliveries that is available for audit. Details must include the following:
 - All dates of reclaimed water receipt and delivery.
 - Source of reclaimed water.
 - Customers name and delivery address.
 - Volume delivered.
 - The time of application on the site.
 - Method of delivery (i.e. was the water sprayed for dust suppression, used for watering landscaped areas).
3. That the organisation contracted to undertake services for RTA prepares appropriate safe work method statements (SWMS) for its use. Risk assessments and SWMS must identify the use of reclaimed water as a hazard and institute appropriate controls and signage commensurate with the level of risk.
4. That all site staff are made aware of the SWMS and safety controls and environmental controls required for using reclaimed water on each site prior to use.
5. That any water cart used for transporting reclaimed water is preferably not be used to transport potable water. If any water cart previously used for reclaimed water is to be used for potable water then it must be disinfected in accordance with the NSW Health Guidelines for Water Carters, 2002.
6. This Environmental Direction should be read in conjunction with the RTA OHS Tip Sheet on Reclaimed Water Use. The OHS Tip Sheet provides additional guidance on the risk assessment for use of reclaimed water and the procedures for managing exposure outside the requirements of the SWMS.

Minimum Environmental Requirements

Minimum environmental requirements for the use of reclaimed water are:

- That use of the reclaimed water does not result in any runoff from the defined work area. Application will be undertaken to prevent ponding of water on the work site.
- That water carts are fitted with sprays that do not cause spray drift of the effluent.
- That spraying activities are undertaken, with consideration of the weather conditions, so no observable spray or mist from the activity is blown from the site to adjacent properties.

Contact Officer: Chris Blake – (02) 8588 5738

General Manager Environment

Chief Executive

Supersedes: Nil