

LAKE VERMONT NORTHERN EXPANSION
EPBC REFERRAL – IESC RESPONSE

PREPARED FOR
BOWEN BASIN COAL PTY LTD

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1.0	INTRODUCTION	1
1.1	BACKGROUND	1
1.2	SCOPE OF DOCUMENT	2
1.3	REFERENCE DOCUMENTS	2
2.0	RESPONSE TO IESC FINAL ADVICE.....	4
2.1	BASILINE DATA COLLECTION AND ASSESSMENT.....	4
2.1.1	Baseline Data.....	4
2.1.1.1	Regional Surface Water Quality	6
2.1.1.2	Local Surface Water Quality.....	10
2.1.2	Lake Vermont Wetland	13
2.1.3	Geochemical Data	14
2.1.4	Further Ecological Assessment	14
2.2	CUMULATIVE IMPACTS	15
2.3	ADEQUACY OF MODELLING.....	16
2.3.1	Groundwater	16
2.3.2	Surface Water	17
2.3.3	Final Voids	21
2.4	MITIGATION MANAGEMENT AND MONITORING	22

LIST OF FIGURES

Figure 1	Proposed Groundwater Monitoring Bores	5
Figure 2	pH in Sediment Dams (Jellinbah Group 2017)	19
Figure 3	Electrical Conductivity in Sediment Dams (Jellinbah Group 2017)	20
Figure 4	Sulphate levels in Sediment Dams (Jellinbah Group 2017)	20
Figure 5	Simulated Final Void Storage Water Level.....	21

LIST OF TABLES

Table 1	Proposed Groundwater Monitoring Locations	5
Table 2	Regional Background Surface Water Quality	8
Table 3	EFMP Regional Background Surface Water Quality in the Isaac River (Deverill)	9
Table 4	Local Surface Water Quality	11
Table 5	Adopted design discharges (m ³ /s) at RP1 compared to ARR Regional Flood Frequency Estimation Model	18
Table 6	Predicted Void Water Levels	22

LIST OF APPENDICES

Appendix A	Lake Vermont Receiving Environment Monitoring Program	A
Appendix B	JBT Consulting IESC Response - Groundwater.....	B
Appendix C	WRM IESC Response – Surface Water	C
Appendix D	Geochemical Waste Rock Characterisation Study.....	D
Appendix E	Response to DoEE Information Request.....	E

LIST OF ABBREVIATIONS

AARC	AustralAsian Resource Consultants Pty Ltd
AMD	Acid Mine Drainage
CSG	Coal Seam Gas
DoEE	Department of the Environment and Energy
EA	Environmental Authority
EC	Electrical Conductivity
EFMP	Enhanced Fitzroy Monitoring Program
EHP	Queensland Department of Environment and Heritage Protection
EPBC	Environmental Protection and Biodiversity Conservation Act
EPP	Environment Protection Policy
GDE	Groundwater Dependent Ecosystem
Ha	Hectares
HCC	Hard Coking Coal
IESC	The Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development
ML	Mining Lease
MNES	Matter(s) of National Environmental Significance
PCI	Pulverised Coal Injection
REMP	Receiving Environment Monitoring Program
TSS	Total Suspended Solids
WQO	Water Quality Objective

1.0 INTRODUCTION

AustralAsian Resource Consultants Pty Ltd (AARC) was commissioned by Bowen Basin Coal Pty Ltd (BBC) to prepare this document in response to the 'Final Lake Vermont Coal Mine Northern Extension Project Advice' report provided by the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC) to the Australian Government Department of the Environment and Energy (DoEE).

This document supports the 'Matters of National Environmental Significance Assessment Report' submitted as part of the *Environmental Protection and Biodiversity Conservation (EPBC) Act* referral for the Lake Vermont Northern Extension (May 2016), and the subsequent 'Lake Vermont Northern Expansion EPBC Referral Response to Information Request' report submitted to the DoEE in November 2016.

1.1 BACKGROUND

The Lake Vermont Coal Mine is a medium size open-cut coal mine producing hard coking coal (HCC) and pulverised coal injection (PCI) coal for the export market to be used in steel production. Mining operations at the Lake Vermont site commenced in September 2008 with first coal production in January 2009.

The EPBC Referral, to which the IESC advice pertains, was lodged on 6th May 2016 with respect to the proposed Lake Vermont Coal Mine Northern Extension Project (the Project). The Project aims to extend current mining activities at the Lake Vermont Mine (the Mine) into new resource areas located directly to the north within mining lease (ML) 70528, covering an area of approximately 3,700 hectares (ha). No change in the approved mining or production rate is proposed. An application to amend the Mine's Environmental Authority (EA) (EPML00659513), pertaining to a new ML application by BBC over the subject land, was submitted to the Queensland Department of Environment and Heritage Protection (EHP) for assessment and approval in October 2014. An Information Request was received in January 2015 and a subsequent Information Response was submitted to EHP in May 2015. EHP approved the EA amendment application on 28th September 2015.

As the proposed Project had potential to impact on Matters of National Environmental Significance (MNES), it was determined by the proponent that the Project would be referred to the DoEE to determine whether it constituted a controlled action. A pre-referral meeting was held with the DoEE on 26th June 2014. Assessment of potential impacts on MNES determined that a significant impact on water resources was likely to be triggered by the Project. In response, a referral, accompanied by an MNES Assessment Report was submitted to the DoEE on 6th May, 2016.

In June 2016, the DoEE confirmed that the Project does constitute a controlled action, specifically due to the potential for impacts on a water resource in relation to a large coal mining development. In August 2016, the DoEE issued a Request for Further Information, focussed on issues including surface water hydrology, interaction between surface water and groundwater, and surface water quality impacts. A response to this information request was submitted to the DoEE on 17th November 2016.

DoEE issued a Request for Further Information on August 22, 2016, focussed on issues including surface water hydrology, interaction between surface water and groundwater, and surface water quality impacts. Bowen Basin Coal responded to this Information Request in November 2016.

Under the Commonwealth approvals process, as per section 131AB of the EPBC Act, the Minister for the Department of Environment and Energy (the Minister) must obtain advice from the IESC given that the controlled action involves a large coal mining development. The IESC submitted the 'Final Lake

Vermont Coal Mine Northern Extension Project Advice' on 11th November 2016, with the DoEE allowing BCC an opportunity to address the advice provided prior to final assessment decision by the Minister.

1.2 SCOPE OF DOCUMENT

The purpose of this document is to provide additional information, or to highlight information already provided to the DoEE in previous supporting documentation, to address issues and recommendations raised in IESC's response regarding the Project's potential impact on water resources.

The IESC's response centred on several broad themes, including:

- the collection and assessment of baseline data;
- cumulative impact assessment;
- suitability of modelling; and
- ongoing monitoring and management commitments.

This document responds to each of these themes, with reference to specific DoEE Questions and IESC Responses as appropriate. Responses refer to either the section of the MNES Assessment Report where the issue has been addressed, the subsequent response to the DoEE Request for Information, or with additional information included where required.

It is noted that the IESC's advice was issued prior to the submission of BBC's response to the DoEE Information Request. A number of the issues raised in the Information Request are similar to those raised by IESC. Where this is the case, this document summarises or refers to the relevant sections of the November 2016 Response to DoEE's Information Request. The November 2016 Response has been included with this document, as Appendix E.

1.3 REFERENCE DOCUMENTS

A number of previously submitted or supporting documents are referred to throughout, and/or appended to, this report. These documents are summarised below.

MNES Assessment Report

The MNES Assessment Report was originally submitted to DoEE in May 2016. This report summarised the potential impacts that the project may have on Matters of National Environmental Significance, and outlined management measures to be implemented by the project.

Surface Water Impact Assessment Report

The Surface Water Impact Assessment Report was prepared by WRM Water & Environment (WRM), as a supporting document appended to the MNES Assessment Report. This report included an assessment on the likely impacts from a reduction in surface catchment area, impacts to Phillips Creek and the Lake Vermont Wetland, and a proposed site water management plan.

Lake Vermont Northern Extension Groundwater Impact Assessment 2016

The Groundwater Impact Assessment Report was prepared by JBT Consulting, as a supporting document appended to the MNES Assessment Report. The report presented a summary of groundwater conditions in the project area and an assessment of the potential for the project to impact

the existing groundwater environment, existing groundwater users and any groundwater dependant ecosystems.

Geochemical Waste Rock Characterisation Study

A Geochemical Waste Rock Characterisation Study was undertaken in 2014 by MBS Environmental. The objectives of this study were to compile a waste characterisation report, evaluate the potential for acidic, neutral and metalliferous drainage (AMD), evaluate the potential for waste rock and subsoils to be dispersive, evaluate the potential for the generation of saline or metalliferous leaching, and classify waste types based on their potential to generate AMD. The Geochemical Waste Rock Characterisation Study Report is attached as Appendix D

Response to DoEE's Information Request

In August 2016, the DoEE issued a Request for Further Information, focussed on issues including surface water hydrology, interaction between surface water and groundwater, and surface water quality impacts. A response to this information request was submitted to the DoEE on 17th November 2016, and is attached as Appendix E to this report.

Surface Water Balance Modelling Report

WRM produced a Surface Water Balance Modelling Report to support the Response to DoEE's Information Request. This report provided further information on the potential impacts of the Project on the hydrology of the Lake Vermont Wetland

Lake Vermont Receiving Environment Monitoring Program

Condition C9 of the Lake Vermont Mine's Environmental Authority requires BBC to *“develop and implement a Receiving Environment Monitoring Program (REMP) to monitor, identify and describe any adverse impacts to surface water environmental values, quality and flows due to the authorised mining activity. This must include monitoring the effects of the mine on the receiving environment periodically (under natural flow conditions) and while mine affected water is being discharged from the site.*

This monitoring program will enable the detection of any adverse impacts on aquatic and riparian habitat values in the downstream receiving environment. The REMP document is attached to this report as Appendix A.

JBT Consulting IESC Response – Groundwater

JBT Consulting prepared this document in order to address specific groundwater aspects of the IESC Final Advice. JBT's response is referred to throughout this document, and attached as Appendix B.

WRM IESC Response – Surface Water

WRM prepared this document in order to address specific surface water aspects of the IESC Final Advice. WRM's response is referred to throughout this document, and attached as Appendix B.

2.0 RESPONSE TO IESC FINAL ADVICE

2.1 BASELINE DATA COLLECTION AND ASSESSMENT

In their response to DoEE's Question 1, regarding the adequacy of groundwater and surface water assessments to provide reasonable estimations of the likely impacts to water resources, IESC recommended that additional collection and analysis of site-specific baseline data is required, with consideration given to:

- Site-specific monitoring and analysis of baseline data
- Obtaining data to assess the spatial and temporal variability of the surface water/groundwater interactions within the project site over a two-year period.
- Assessing the water regime of Lake Vermont Wetland and how this may be affected throughout the life of the project and post closure.
- Characterising the nature of the final voids and assessing their potential for interaction with the alluvium of Phillips Creek, alluvium of Isaac River, flooding, faults and regional groundwater.
- Undertaking a geochemical assessment for contaminants in the waste rock material in the project area.
- Further assessing GDEs, including stygofauna and aquatic biota.

2.1.1 Baseline Data

As demonstrated by the Surface Water Impact Assessment Report, and the subsequent Surface Water Balance Modelling Report (Appendix A to the Response to DoEE's Information Request), Phillips Creek and the Lake Vermont wetland are surface water fed and ephemeral, subject to extended periods of dry conditions.

Similarly, and as outlined in the Response to DoEE's Information Request, dry conditions were consistently found in relevant geological and hydrogeological units (i.e. quaternary alluvium and tertiary sediments) during drilling and monitoring for the project's groundwater assessment, during both above average and below average rainfall years.

With these predominantly dry conditions, collection of baseline surface and groundwater data to assess spatial and temporal variability is not possible within the assessment timeframe. Therefore, a groundwater monitoring program has been proposed, and will be incorporated into the Lake Vermont Environmental Authority. The proposed monitoring bore network comprises a combination of existing vibrating wire piezometer (VWP) bores (for monitoring of water level) and standpipe bores (for monitoring of both water level and water quality). The network has been designed to monitor the major groundwater units that are to be mined or impacted at site and to give adequate spatial and vertical coverage across the site. The proposed program comprises a combination of existing vibrating wire piezometer (VWP) bores (for monitoring of water level) and standpipe bores (for monitoring of both water level and water quality). The network has been designed to monitor the major groundwater units that are to be mined or impacted at site and to give adequate spatial and vertical coverage across the site. The proposed network is illustrated in Figure 1 below and the proposed standpipe monitoring bores and target lithology are listed in Table 1.

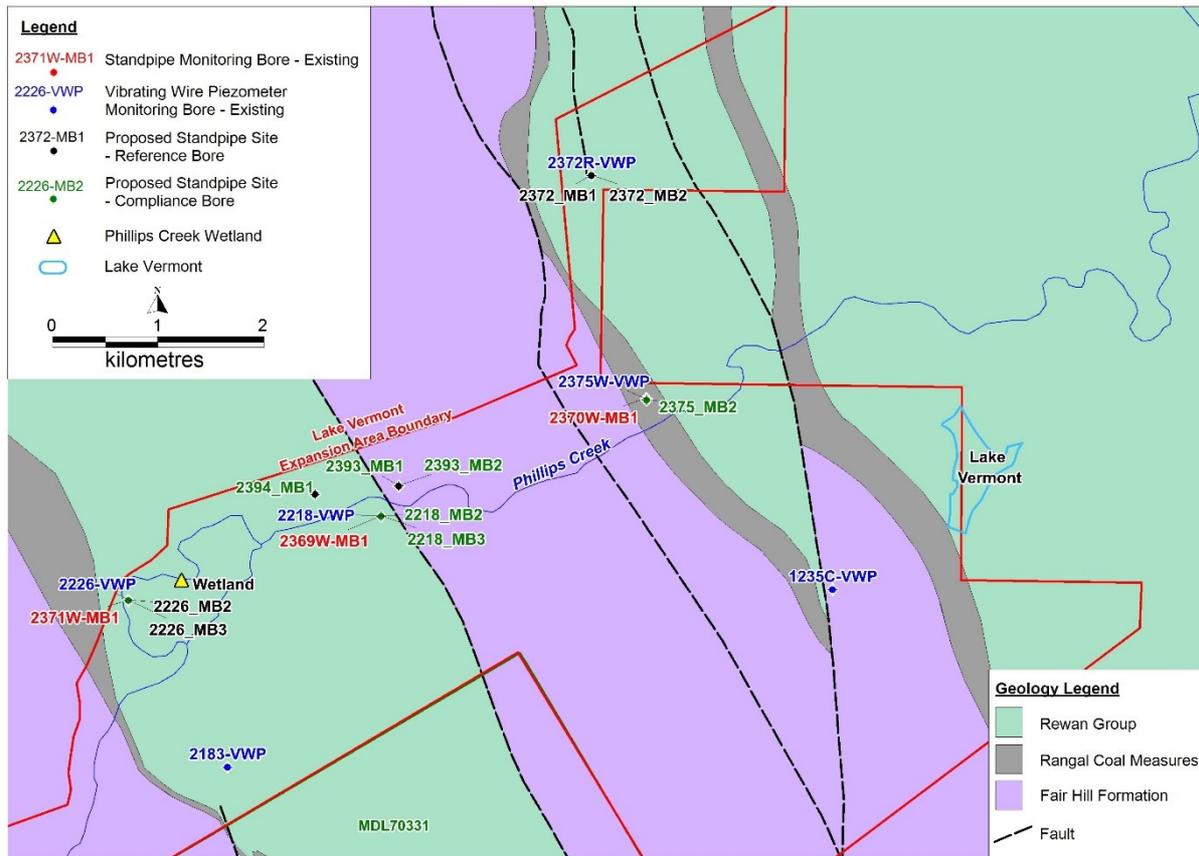


Figure 1 Proposed Groundwater Monitoring Bores

Table 1 Proposed Groundwater Monitoring Locations

Bore ID	Target Lithology	Easting (AGD84)	Northing (AGD84)	Ground Level (mAHD)
2371W-MB1	Tertiary Sediments	643131	7521947	178.92
2226-MB2	Rewan Group	643129	7521950	178.84
2226-MB3	Leichhardt Seam	643129	7521950	178.84
2372-MB1	Rewan Group	647515	7526007	166.91
2372-MB2	Vermont Seam			
2393-MB1	Leichhardt Seam	645693	7523043	173.24
2393-MB2	Vermont Lower Seam			
2394-MB1	Rewan Group	644898	7522962	173.96
2375-MB2	Vermont Seam	648040	7523865	168.36
2218-MB2	Rewan Group	645526	7522753	173.29
2218-MB3	Leichhardt Seam			

Similarly, Section 3.11.1.3 of the MNES Assessment Report acknowledges that the data collected and analysed as part of the Project’s assessment is inadequate to establish a suitable baseline data set, but was limited by the availability of surface water to sample during the assessment phase. The

Report makes the commitment that, on approval of the Project, the Receiving Environment Monitoring Program (REMP) for the site will be updated in order to establish a suitable baseline dataset for these values. Condition C9 of the Lake Vermont Mine's Environmental Authority requires BBC to *“develop and implement a Receiving Environment Monitoring Program (REMP) to monitor, identify and describe any adverse impacts to surface water environmental values, quality and flows due to the authorised mining activity. This must include monitoring the effects of the mine on the receiving environment periodically (under natural flow conditions) and while mine affected water is being discharged from the site.*

This monitoring program (Appendix A) will enable the detection of any adverse impacts on aquatic and riparian habitat values in the downstream receiving environment. Specifically, the REMP includes:

- Biological Monitoring comprising
 - macroinvertebrate analysis; and
 - aquatic and riparian vegetation health;
- Habitat assessment; and
- Water and stream sediment monitoring

For the purposes of the REMP, the Queensland Department of Environment and Heritage Protection (EHP), have identified the receiving environment as Phillips Creek and the Isaac River within 15km downstream of the release points, and the REMP has been designed to undertake monitoring in these locations. The REMP includes monitoring of water quality, riparian vegetation (species composition, canopy height and cover, stream cover, recruitment and vegetation health), macroinvertebrates (including habitat assessment), and erosion.

2.1.1.1 Regional Surface Water Quality

Regional water quality data from the Isaac River at Deverill and Phillips Creek at Tayglen (where available), has been assessed against Australian and New Zealand Environment and Conservation Council (ANZECC) (2000) guideline values and Queensland's EPP (Water) Water Quality Objectives (WQOs) for the protection of aquatic ecosystems, stock and irrigation supply water.

Physico-chemical and nutrient quality water monitoring data was sourced from the automated gauges located on the Isaac River at Deverill and on Phillips Creek at Tayglen. Median and 80th percentile values for a range of water quality parameters measured at these locations are shown in Table 2 below.

Background levels of pH, chloride and magnesium in Phillips Creek and the Isaac River were found to exceed the ANZECC (2000) Aquatic Ecosystem Guidelines values. Long term data indicates that the EPP (Water) aquatic ecosystem WQOs for turbidity, EC, total nitrogen, total phosphorous and total suspended solids (TSS) are typically exceeded at one or both monitoring points located upstream of the Lake Vermont Mine.

Water quality data collected from the Deverill monitoring location on the Isaac River as part of the Enhanced Fitzroy Monitoring Program (EFMP) has also been collated and is presented in Table 3. This table describes the background water quality (i.e. physico-chemical properties, total and dissolved metals) for the Isaac River, upstream of the Project's receiving environment. These background values have been compared to the proposed EA release limits and receiving water trigger values as well as the ANZECC guideline values and EPP (Water) WQOs. While the background water quality was typically within guideline limits a number of parameters exceeded the ANZECC guideline

values and EPP (Water) WQOs during the December 2013 monitoring event. Turbidity, aluminium and iron levels were particularly high at this time.

Table 2 Regional Background Surface Water Quality

Parameter	Units	ANZECC (2000) Guidelines		EPP (Water) WQOs			Isaac River			Phillips Creek		
		Stock Water	Aquatic Ecosystems	Aquatic Ecosystems	Livestock Watering	Irrigation Supply	Deverill			Tayglen		
							Count	Median	80 th percentile	Count	Median	80 th percentile
pH		6.5 – 8.5	6.5 – 7.5	6.5 – 8.5	6.5 – 8.5	6.5 – 9.0	44	7.6	8.2	26	8.1	8.4
Turbidity	NTU	n/a	25	50	n/a	n/a	14	46	200	3	n/a	153
Ammonia as N - soluble	mg/l	n/a	0.01	n/a	n/a	n/a	7	0	0	n/a	n/a	n/a
Nitrate + nitrate as N - soluble	mg/l	n/a	n/a	n/a	n/a	n/a	7	0	0.5	n/a	n/a	n/a
Nitrate + nitrate as N - soluble	mg/l	400	0.015	n/a	400	n/a	28	1.9	3.4	13	1.5	3.5
Bicarbonate as HCO ₃	mg/l	n/a	n/a	n/a	n/a	n/a	43	95	128	23	254	302
Hardness as CaCO ₃	mg/l	n/a	n/a	n/a	n/a	60	43	78	100	23	173	245
Calcium as Ca soluble	mg/l	1000	n/a	n/a	1000	<60	43	17.1	25.7	23	25	29.1
Carbonate as CO ₃	mg/l	n/a	n/a	n/a	n/a	n/a	33	0.3	1.3	22	2.5	n/a
Boron	mg/l	5.0	n/a	5.0	5.0	0.5	16	0.0	n/a	3	n/a	n/a
Chloride	mg/l		0.02	n/a		175	43	30	50	23	42	75
Conductivity	µS/cm	2000	350	<720 (baseflow) <250 (high flow)	2000	1300	43	241	392	26	512	847
Fluoride	mg/l	2	n/a	n/a	2	1	41	0.1	0.2	26	0.2	0.3
Iron as Fe soluble	mg/l	n/a	n/a	n/a	n/a	0.2	12	0	n/a	4	n/a	5.0
Magnesium	mg/l	n/a	n/a	n/a	n/a	0.2	43	7.7	10.9	23	22	41.6
Potassium	mg/l	n/a	n/a	n/a	n/a	n/a	40	4.7	5.5	20	4.4	6.0
Silica as SiO ₂ soluble	mg/l	n/a	n/a	n/a	n/a	n/a	41	12.0	15.0	23	13	18
Sodium	mg/l	n/a	n/a	n/a	n/a	115	43	22	40.8	23	43	74
Sulphate	mg/l	1000	n/a	25	1000	n/a	36	10	15.6	17	8	21.1
TDS	mg/l	2400	n/a	n/a	2400	n/a	41	152	224	22	300	464
TN	mg/l	n/a	0.25	0.5	n/a	5	n/a	n/a	n/a	2	n/a	1.6
TP	mg/l	n/a	0.03	0.05	n/a	0.05	7	0.20	1.10	2	n/a	1.3
TSS	mg/l	n/a	n/a	55	n/a	n/a	40	128	850	18	46	495

Key:

- XX** This parameter exceeds the ANZECC (2000) Stock Water Guidelines (upper limit, where applicable).
- XX** This parameter exceeds ANZECC (2000) Aquatic Ecosystems Guidelines (upper limit, where applicable).
- This parameter exceeds EPP (Water) WQOs (upper limit, where applicable).

Table 3 EFMP Regional Background Surface Water Quality in the Isaac River (Deverill)

Water Quality Parameter	ANZECC Trigger Values			EPP (Water) 2009			Proposed EA Limits		EFMP Water Quality Data		
	Irrigation (STV)	Freshwater Ecosystem Protection	Livestock	Irrigation (STV)	Freshwater Ecosystem Protection	Livestock	Release Limits	Receiving Water Trigger Limits	Nov-12	Dec-13	Nov-14
Physico-chemical Parameters											
Temp (°C)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	24	25	30.6
EC (µS/cm)	600	720	4475	1300	<720 (baseflow) / <250 (high flow)	n/a	10000	2000 / 8400	675	203	495
pH	6.0-9.0	6.5-8.0	n/a	6.5-9.0	6.5-8.5	n/a	6.5-9.0	6.5-9.0	7.5	6.7	8.43
DO (% Saturation)	n/a	85 to 110	n/a	n/a	n/a	n/a	n/a	n/a	9	3	7.18
Turbidity (NTU)	n/a	50	n/a	n/a	<50	n/a	n/a	n/a	4	81	17.82
Dissolved Metals (µg/L)											
Aluminium	20000	55 pH >6.5; 0.8 if pH <6.5		20000	55	n/a	n/a	416	<5	256	16
Iron	10000	300	n/a	10000	n/a	n/a	n/a	1130	53	701	130
Chromium	1000	3.3 (Cr ⁱⁱⁱ), 1 (Cr ^{vi})	n/a	1000	1	n/a	n/a	1	<0.2	0.5	<0.5
Copper	5000	1.4	n/a	5000	1.4	n/a	n/a	2	<0.5	1.3	1.3
Uranium	100	0.5	n/a	100	n/a	n/a	n/a	1	0.13	0.1	0.21
Zinc	5000	0.8	n/a	5000	8	n/a	n/a	8	<1	1	1.3
Total Metals (µg/L)											
Aluminium	n/a	n/a	5000	n/a	n/a	5000	n/a	n/a	27	3390	98
Iron	n/a	n/a	not toxic	n/a	n/a	n/a	n/a	n/a	1520	6200	780
Chromium	n/a	n/a	1000	n/a	n/a	1000	n/a	n/a	<0.2	4.7	<0.5
Copper	n/a	n/a	400	n/a	n/a	1000	n/a	n/a	<0.5	3.7	1.6
Uranium	n/a	n/a	200	n/a	n/a	200	n/a	n/a	0.13	0.11	0.23
Zinc	n/a	n/a	20000	n/a	n/a	20000	n/a	n/a	<1	8	4.8

Key:

- XX This parameter exceeds ANZECC (2000) Aquatic Ecosystems Guidelines (upper limit, where applicable).
- This parameter exceeds EPP (Water) WQOs for Aquatic Ecosystem Protection (upper limit, where applicable).

2.1.1.2 Local Surface Water Quality

Local surface water quality data has been collected during various site investigations including the Mine's ongoing Receiving Environment Monitoring Program (REMP). Data has been collated for the Isaac River, Phillips Creek, Downs Creek, Lumpy Gully, Lake Vermont, and a small palustrine wetland located adjacent to Phillips Creek. Samples were analysed for various physio-chemical parameters, metals and metalloids, and hydrocarbons. This data has been assessed against ANZECC (2000) Livestock Drinking Water and Aquatic Ecosystems Guidelines, EPP (Water) WQOs for Aquatic Ecosystems, Livestock Watering, Drinking Water and Irrigation supply, as well as the current and proposed EA Trigger Limits. Local surface water quality results were analysed using all available surface water sampling data collected from the relevant water bodies between January 2012 and August 2016, and is summarised in Table 4.

The local surface water quality data shows that pH levels in the local and regional receiving environment (e.g. Isaac River, Phillips Creek, Downs Creek) exceed both the current EA limit and the ANZECC guideline value (aquatic ecosystem protection) of pH 8.0.

Median and 80th percentile EC levels within the receiving environment typically fall within the EC range provided by the EPP water objectives for different flow events (250-750uS/cm), although levels can exceed the upper limits in low flow scenarios.

80th percentile dissolved aluminium levels in Phillips Creek are consistent with current water quality objectives while the median value is below the objective. Median and 80th percentile dissolved aluminium levels in the Isaac River are lower than objectives.

Surface water in the Isaac River typically contains dissolved copper concentrations below the water quality objective (1.4 µg/L) and the current EA trigger limit of 2 µg/L. The median dissolved copper level in Phillips Creek exceeds the water quality objective while the 80th percentile exceeds both the water quality objective and the current EA trigger limit. Other local waterbodies typically exceed the water quality objective and trigger limits for dissolved copper.

Existing water quality in the Isaac River and Phillips Creek generally consists of dissolved zinc concentrations in excess of the water quality objective (0.008 mg/L). Dissolved levels of chromium and uranium in the Project's receiving environment remain below the current water quality objectives.

Water quality in the Isaac River consists of total metal levels at or below water quality objectives. Phillips Creek and other local waterbodies have been found to contain total chromium and copper concentrations in excess of the water quality objectives for livestock drinking water. The 80th percentile for total aluminium in Phillips Creek exceeds the livestock consumption water quality objective.

Background petroleum hydrocarbon (C10 - C36) levels in Phillips Creek and the local wetlands have been found to exceed the mine's current EA release trigger limit of 100 µg/L.

Table 4 Local Surface Water Quality

Parameter	Units	LOR	Guideline and Trigger Levels								Isaac River			Phillips Creek			Downs Creek			Lumpy Gully			LVW			Wetland 1		
			ANZECC (2000)		EPP (Water) 2009				EA Trigger Limits	Proposed EA Release Conditions	Count	Median	80th percentile	Count	Median	80th percentile	Count	Median	80th Percentile	Count	Median	80th percentile	Count	Median	80th percentile	Count	Median	80th percentile
			Livestock Drinking Water	Aquatic Eco-systems	Aquatic Ecosystem Protection	Drinking Water Supply	Livestock Watering	Irrigation Supply																				
pH	pH units	n/a	n/a	6.0 - 8.0	6.5 - 8.5	6.5 - 8.5	n/a	n/a	6.5 - 8.0	6.5 - 9.0	12	7.89	8.1	14	8.07	8.3	4	8.25	8.32	4	7.44	7.6	2	7.85	8.05	2	7.41	7.59
EC	µs/cm	1	n/a	20 - 250	<720 (baseflow)	>400	n/a	n/a	1000	10,000	0	n/a	n/a	0	n/a	n/a	0	n/a	n/a	0	n/a	n/a	2	n/a	382.8	2	n/a	192
					<250 (high flow)		n/a	n/a			12	422	489	14	551	720.5	4	439	559	4	244	254	2	312	241.2	2	170	148
Turbidity	NTU	0.1	n/a	n/a	<50	>500 - >1000	n/a	n/a	n/a	n/a	12	11.4	21.9	12	121	399.6	4	34	49.1	4	39.5	46.8	2	118	186	2	27.2	38.5
Sulphate (SO4 ²⁻)	mg/L	1	1000	n/a	<25	200	1000	n/a	300	TBD	12	31.5	36.6	13	32	56	4	18	19.6	4	2.5	3.8	2	0.5	0.5	2	0.5	0.5
Suspended solids	mg/L	5	n/a	n/a	<55	n/a	n/a	n/a	1500	n/a	5	6	24.6	11	178	316	2	17	23.6	2	15.5	20	2	105	160	2	36.5	48.2
Dissolved Metals/Metalloids																												
Aluminium	mg/L	0.01	n/a	0.055	0.055	n/a	n/a	5	0.055	0.416	12	0.005	0.018	11	0.02	0.058	4	0.038	0.074	4	0.05	0.38	2	0.01	0.01	2	0.02	0.02
Chromium	µg/L	0.2	n/a	1	1	n/a	n/a	100	1	1	12	0.500	0.500	12	0.39	0.50	4	0.5	0.5	4	0.5	0.5	2	0.1	0.1	2	0.1	0.1
Copper	µg/L	0.5	n/a	1.4	1.4	n/a	n/a	200	2	2	12	0.500	1.000	12	1.99	2.4	4	2.5	3.8	4	1.5	4.8	2	3.5	5.24	2	0.68	0.93
Zinc	mg/L	0.005	n/a	0.008	0.008	n/a	n/a	2	0.008	0.008	12	0.003	0.014	12	0.01	0.023	4	0.003	0.008	4	0.003	0.021	2	0.003	0.003	2	0.006	0.008
Iron	mg/L	0.05	n/a	n/a	n/a	n/a	n/a	0.2	0.3	1.13	12	0.025	0.092	12	0.04	0.099	4	0.003	0.034	4	0.94	1.474	2	0.128	0.189	2	1.13	1.412
Uranium	mg/L	0.001	n/a	n/a	n/a	n/a	n/a	0.01	0.001	0.001	12	0.001	0.001	10	0.001	0.001	4	0.001	0.001	4	0.001	0.001	2	0.001	0.001	2	0.001	0.001
Total Metals/Metalloids																												
Aluminium	mg/L	0.01	5	n/a	n/a	n/a	5	20	n/a	n/a	12	0.215	0.604	14	2.11	7.204	4	0.87	1.39	4	1.065	2.916	2	2.155	3.43	2	0.905	1.064
Chromium	µg/L	0.2	1	n/a	n/a	n/a	1	1000	n/a	n/a	12	0.500	0.580	14	5.05	14.68	4	0.75	1.80	4	1.50	4.80	2	5.30	8.42	2	2.45	2.96
Copper	µg/L	0.5	1	n/a	n/a	n/a	1	5000	n/a	n/a	12	0.850	1.000	14	3	8	4	3.50	4.80	4	4.00	5.40	2	4.60	6.22	2	1.800	2.16
Zinc	mg/L	0.005	20	n/a	n/a	n/a	20	5	n/a	n/a	12	0.003	0.003	14	0.01	0.017	4	0.003	0.004	4	0.003	0.007	2	0.012	0.012	2	0.012	0.014

Parameter	Units	LOR	Guideline and Trigger Levels								Isaac River			Phillips Creek			Downs Creek			Lumpy Gully			LVW			Wetland 1		
			ANZECC (2000)		EPP (Water) 2009				EA Trigger Limits	Proposed EA Release Conditions	Count	Median	80th percentile	Count	Median	80th percentile	Count	Median	80th Percentile	Count	Median	80th percentile	Count	Median	80th percentile	Count	Median	80th percentile
			Livestock Drinking Water	Aquatic Eco-systems	Aquatic Ecosystem Protection	Drinking Water Supply	Livestock Watering	Irrigation Supply																				
Iron	mg/L	0.05	n/a	n/a	n/a	n/a	n/a	10	n/a	n/a	12	0.315	0.800	14	2.49	8.596	4	0.805	1.336	4	5.350	6.584	2	3.410	5.048	2	5.380	6.196
Uranium	mg/L	0.001	0.2	n/a	n/a	n/a	0.2	0.1	n/a	n/a	12	0.001	0.001	12	0.001	0.001	4	0.001	0.001	4	0.001	0.001	2	0.001	0.001	2	0.001	0.001
Petroleum hydrocarbons (C6 - C9)	µg/L	20	n/a	n/a	n/a	n/a	n/a	n/a	20	20	12	10	10	11	10	10	4	10	10	4	10	10	2	10	10	2	10	10
Petroleum hydrocarbons (C10 - C36)	µg/L	50	n/a	n/a	n/a	n/a	n/a	n/a	100	100	12	25	25	11	25	580.75	3	25	52	4	25	25	2	168	253	2	133	197

Key:

- n/a indicates no data is available for this parameter
- XX This parameter exceeds the relevant ANZECC (2000) Guidelines (upper limit, where applicable).
- This parameter exceeds EPP (Water) WQOs (upper limit, where applicable).
- This parameter exceeds the current EA trigger limit.
- XX This parameter exceeds the proposed EA release conditions

2.1.2 Lake Vermont Wetland

Assessment of the water regime of Lake Vermont Wetland was addressed in the Response to DoEE's Information Request (Appendix E). In summary, Lake Vermont wetland is an ephemeral waterbody experiencing long periods of dry conditions between periods of rainfall. The wetland is relatively shallow, and is less than 2% full about half of the time and around or above 50% full only 5% of the time.

At the peak of mining disturbance, the maximum captured catchment area during mining operations consists of approximately:

- 49% of the Lake Vermont wetland catchment area, attributable to the Northern Extension Project;
- 4% of the Phillips Creek catchment to the confluence of the Isaac River (half of which is due to the Northern Extension);
- 37% of the Lumpy Gully catchment to the confluence of Downs Creek (10% of which is due to Northern Extension Project); and
- 1% of the Downs Creek catchment to the confluence of the unnamed tributary (due to approved operations).

The impact of the change in Lake Vermont's catchment area on the frequency of filling the lake is shown in Section 4.1 of WRM's Surface Water Balance Modelling Report. In summary, the likelihood at the peak of mining disturbance of stored water levels exceeding 160.4 m AHD (approximately 0.15 m deep – i.e. at about 2% of full capacity) would temporarily decrease from approximately 60% to 42%. The likelihood of exceeding an elevation of 161.4 m AHD (1.15 m depth - i.e. at about 47% of the total storage capacity) would reduce from approximately 12% to 8%.

Post-mining, the permanently changed topography as a result of the final landform will have the following impacts on catchment areas:

- A reduction of 5.9 km² in the catchment area draining to Phillips Creek compared to pre-mining conditions. This represents a decrease of less than 1.2%;
- A reduction of 2.6 km² in the catchment area draining to Lumpy Gully compared to pre-mining conditions. This represents a reduction of approximately 2%; and
- A reduction of 1.3 km² in the catchment area draining to the Lake Vermont wetland compared to pre-mining conditions, representing a decrease in catchment area of approximately 12%.

From the information provided in both the initial Surface Water Impact Assessment and the subsequent Surface Water Balance Modelling Report, it can be concluded that the impact of the Project on the flow regimes within the wetland and its catchment is insignificant, with only slight decreases in the likelihood and frequency of water entering the lake as a result of lost catchment area. Such minor changes in hydrology are highly unlikely to impact the ecology of the ephemeral wetland, which has evolved to tolerate varied levels of water availability, in combination with impacts from cattle grazing.

2.1.3 Geochemical Data

A Geochemical Waste Rock Characterisation Study was undertaken in 2014 by MBS Environmental. The objectives of this study were to:

- Compile a waste characterisation report as part of the Project's Waste Management Plan;
- Evaluate the potential for acidic, neutral and metalliferous drainage (AMD) to form in various waste materials;
- Evaluate the potential for waste rock and subsoils to be dispersive;
- Evaluate the potential for the generation of saline or metalliferous leaching; and
- Classify waste types based on their potential to generate AMD.

The Geochemical Waste Rock Characterisation Study Report is attached as Appendix D. In summary, the study concluded that 92% of the samples were classified as non acid forming, with generally low sulphur. Potentially acid forming material found in some of the coal seam roof samples represent approximately 1.7% of the total waste rock volume. Implementation of progressive backfilling and rehabilitation will avoid long-term exposure of these materials.

Analysis of samples for total and leachable metals found no metals or metalloid concentrations of environmental significance. Seepage and surface runoff from any waste is predicted to be within ANZECC 2000 water quality guidelines for both human and livestock consumption. Salinity levels in water extracts from waste materials were found to be significantly less than local groundwater sources, and were within the range experienced by existing operations at Lake Vermont.

2.1.4 Further Ecological Assessment

As outlined in Section 2.1.9 of the Response to DoEE's Information Request, Phillips Creek and the Lake Vermont wetland are surface water fed and ephemeral, subject to long periods of dry conditions. Phillips Creek only flows to the wetland when the flow rate exceeds approximately 250 m³/s, which is less than the 1 in 5 Annual Exceedance Probability peak flood flow. This implies the wetland is only filled by Phillips Creek floodwater every 2 to 5 years. As such, the terrestrial ecosystems in the wetland and along Phillips Creek are tolerant of extended dry periods, with little or no inflow. Due to the insignificant impact from the Project on storage volumes and fill-empty cycles in the Lake Vermont wetland, changes in Phillips Creek flooding are unlikely to have impact on aquatic / ecological values of the wetland.

The Aquatic Ecology and Stream Morphology Assessment Reports, included with the initial MNES Assessment Report, discuss potential for drawdown, and with reference to the Groundwater Impact Assessment, conclude that the risk to groundwater dependent ecosystems will be low due to the depth of the regional groundwater table from the surface and the limited extent of drawdown impacts from mining. Similarly, due to the predominantly dry aquifers, the likelihood of the presence of and impact to stygofauna is expected to be low.

The site's REMP, described in Section 2.1.1 and required by the Project's approved Environmental Authority, includes monitoring of water quality, riparian vegetation (species composition, canopy height and cover, stream cover, recruitment and vegetation health), macroinvertebrates (including habitat assessment), and erosion.

2.2 CUMULATIVE IMPACTS

In their response to DoEE's Question 2 on cumulative impacts, IESC advise that there is inadequate consideration of the project's contribution to cumulative impacts associated with other mining activities. This issue was dealt with extensively in Section 2.1.7 (surface water) and Section 2.2.9 (groundwater) of the November 2016 Response to DoEE's Information Request.

For surface water impacts, nineteen relevant existing projects considered in the cumulative impact analysis, along with seven new or proposed projects.

For water quality, given that the Northern Extension is simply an extension of existing mining activities, and that mine water releases will be managed within an overarching strategic framework for management of cumulative impacts of mining activities, the proposed management approach for mine water from the Project is expected to have negligible cumulative impact on surface water quality and associated environmental values.

For flooding, none of the known projects in the planning or development phase in the vicinity of the Project are expected to result in additional structures on the floodplain. Therefore, cumulative impacts on flooding are not expected to lead to any adverse impacts on human populations, property or other environmental or social values.

For surface water flows, the Project does not require any additional raw water allocations and therefore does not contribute to cumulative impacts in relation to extraction of surface water resources from other catchments. The Project will locally impact flows in the minor tributaries of Downs Creek and the Isaac River due to water being captured within the SWMS. The impacts of these changes are expected to be minimal. No other projects have been identified which would further increase these impacts.

JBT Consulting have addressed IESC's comments regarding cumulative assessment for groundwater impacts in the attached response (Appendix B). In summary, the groundwater assessment included consideration of the projects that were known at the time, namely the Arrow Energy Bowen Gas Project and the Saraji Coal Mine. Assessment of cumulative impacts can only be undertaken with information from publicly available documents. It is not reasonable to make assumptions about impacts of other operations without data as these assumptions are likely to be highly inaccurate. With respect to the projects recommended for consideration by the IESC the following observations are made:

- In some respects, it would be possible to take into consideration the impacts of the Arrow Energy CSG wells; however the current version of the Arrow Energy Underground Water Impact Report only includes information on water level impacts to 2015 (or 2018 in some areas) and includes no water level predictions that could be used as input to an end-of-life model for Lake Vermont;
- BBC is not aware of any information in the public domain on the groundwater level impacts of the proposed Saraji underground mine. Therefore, it is not possible at this stage to make any accurate prediction as to cumulative impacts from this operation.

The assumptions made with respect to cumulative groundwater impacts at the time of the original report development are therefore judged to be reasonable.

2.3 ADEQUACY OF MODELLING

In response to DoEE's Question 3, IESC advise that the groundwater and surface water modelling does not appropriately estimate the project's environmental impacts on water resources. Bowen Basin Coal believes that the modelling undertaken for both surface and groundwater impacts is appropriate for the likely impact of the Project, its scale relative to surrounding operations, and the known subsurface and surface conditions.

2.3.1 Groundwater

For groundwater, IESC recommend that a full site-specific hydrogeological investigation is required, targeting and identifying both the local and regional groundwater systems in the vicinity of the proposed project and potential connectivity between these systems and surface water. This should include:

- a) Collection of site-specific groundwater level and quality data and testing to determine site-specific aquifer hydraulic parameters.
- b) Hydrogeological characterisation of faults including the type, severity and penetration of faults and their influence on groundwater flow
- c) The conceptualisation of the groundwater system both at local and regional scales should be revisited, with newly-collected site-specific data incorporated
- d) A 3-dimensional groundwater model should be developed following the procedure outlined in the Australian Groundwater Modelling Guidelines (Barnett et al 2012).

Points a) and b) have been addressed in Sections 2.1.1 and 2.1.3, above. In regard to points c) and d), JBT consulting have provided an extensive justification of the modelling approach used in Appendix B. In summary, a number of factors are assessed when choosing the appropriate modelling platform for a particular groundwater modelling study. Factors that are relevant to the Lake Vermont study include:

- The ability of the model to represent the essential elements of the conceptual groundwater model. At Lake Vermont this includes the ability of the model to accurately represent the complexity of the geology. This includes faulting of strata, which acts to compartmentalise the geological and hydrogeological units, as faulting has the potential to significantly impact groundwater occurrence and flow; and,
- The ability of the model to adequately address the requirements of the scope of work. At Lake Vermont this includes assessment of the extent of groundwater level impact from mining, as well as assessment of the potential impact of groundwater level changes on any connected surface water and groundwater dependant ecosystems.

Based on assessment of the model requirements, including representation of the essential elements of the conceptual groundwater model, it was concluded that 2-dimensional cross-section modelling using Seep/W would be appropriate for the Lake Vermont project, for the following reasons:

- The geology of the mining area is complex, and includes a number of local-scale and regional-scale faults which significantly disrupt the strata. It is possible within a 2-dimensional model to reproduce complex cross-sectional geology, whereas such detail could not be included practically within a 3-dimensional model;

- The existing 2-dimensional groundwater models are accurate representations of the site geology in cross-section and include distinct representation (in terms of unit thickness, hydraulic properties and displacement by faulting). The level of detail that can be represented within a 2-dimensional cross section model is far greater than can be represented within a regional 3-dimensional model;
- Seep/W is designed to simulate flow in both the saturated zone and the unsaturated zone. When mining occurs below the phreatic surface an unsaturated zone is induced in the pit walls as seepage to the excavation occurs. Seep/W is well suited to investigation of groundwater level impacts resulting from seepage to open pits, particularly for projects such as Lake Vermont where mine dewatering via bores does not occur, and seepage to the excavation is the only means via which the mine removes water from the groundwater system;
- In open cut mines groundwater storage conditions transition from confined to unconfined in the zone adjacent to the pit walls. Seep/W models the rate of drainage to an excavation via a property called the volumetric water content, which is able to accurately account for the rate of groundwater flow and the rate of change of the phreatic surface as groundwater conditions transition from confined to unconfined and gravity drainage of the groundwater unit occurs to the excavation. Seep/W is able to model this important element of the groundwater system much more accurately than many other groundwater flow models (including 3-dimensionation models such as Modflow); and,
- It was assessed that one of the main purposes of the model was to investigate the rate and extent of groundwater level drawdown in response to mining, especially in areas of potentially connected surface water and groundwater systems. This can be readily (and potentially more accurately) achieved through the use of a 2-dimensional cross section models.

The choice of 2-dimensional modelling software was assessed to be appropriate to the scale of the Lake Vermont Northern Extension project and to provide distinct advantages (especially with respect to delineation of complex geology and structure) compared to a 3-dimensional model. JBT Consulting advised that undertaking 3-dimensional modelling would be an exercise that would be unlikely to yield additional information in the areas of primary concern, that is the Phillips Creek wetland and Lake Vermont.

2.3.2 Surface Water

For Surface Water, the IESC recommends the following surface water assessments be undertaken to better estimate the project's environmental impacts:

- a) *Model the surface water regime at Lake Vermont Wetland. A model of the water regime should identify:*
 - i. *Peak inflows*
 - ii. *Volume, duration, frequency and seasonality of inflows*
 - iii. *Water depths (seasonal averages)*
 - iv. *Wetting and drying cycles over multiple years (to span the responses to different climatic conditions)*
- b) *Provide pre and post-development modelling of the surface water regime at Lake Vermont Wetland. This should include quantification of estimated impacts to the Lake Vermont Wetland*

water regime during the phase of the project that truncates the greatest portion of catchment area.

- c) Model the interaction between the pits/final voids and the flood extent of Isaac River and Phillips Creek up to the 1 in 1000
- d) Compare estimates of peak flow quantiles with area-adjusted regional flood frequency analysis, and regional methods for estimation of peak flows as outlined by Australian Rainfall and Runoff.
- e) Undertake a sensitivity analysis on the water balance model for a high inflow parameter scenario and present results of sensitivity analyses explicitly.

The surface water regime of the Lake Vermont Wetland was described in detail in WRM’s Surface Water Balance Modelling for Lake Vermont Wetland, included as Appendix A to the November 2016 Response to DoEE’s Information Request, and summarised in Section 2.1.2 of this document. The interaction of pits/final voids with floodwaters of Isaac River and Phillips Creek is addressed below in Section 2.3.3.

The remaining comments from IESC in regard to surface water modelling have been addressed in a response from WRM, attached to this report as Appendix C, and summarised below.

Comparison of Design Discharges to Australian Rainfall & Runoff

A comparison of the adopted design discharges to the Australian Rainfall & Runoff (AR&R) discharge estimates (Table 5) shows that the adopted design discharges exceed the 95% confidence limit discharges from AR&R for the 1% and 2% AEP.

Table 5 Adopted design discharges (m³/s) at RP1 compared to ARR Regional Flood Frequency Estimation Model

AEP	Adopted Design Discharge	Expected Quantile	5% lower confidence limit	95% upper confidence limit
10	427	479	270	452
5	611	580	312	686
2	928	723	361	901
1	1,207	839	395	1,150

This suggests that the modelling undertaken for the assessment of the Project includes conservatively high peak discharges and levels adjacent to the proposed levees, and that therefore, the actual impact from flooding will be lower than modelled.

Assessment of Water Quality Impacts from Overflows from Sediment Dams

Impacts to water quality from sediment dam overflows was addressed in Section 2.3.3 of the Response to DoEE’s Information Request. The design of both the on-site Surface Water Management System, to ensure mine-affected water is not discharged through the stormwater system, and the sizing of the proposed and existing sediment dams ensures that the downstream impacts from these structures will not be significant.

WRM have provided further detailed discussion of this issue in their IESC Response, attached as Appendix C. In summary, sediment dams have been located to only receive runoff from overburden

dumps and undisturbed catchments. The waste characterisation studies, and laboratory samples from existing waste dumps show that solutes in overburden runoff are unlikely to significantly affect downstream water quality.

Sediment dams have been sized in accordance with the Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland (Technical Guidelines) prepared by the former Department of Minerals and Energy (DME) in 1995 (the DME Guidelines) for the discharge of low toxicity waste. This containment standard would generally exceed the volumetric requirements for sediment basins sized in accordance with the International Erosion Control Association's (IECA) Best Practice Erosion and Sediment Control guidelines.

Water quality monitoring results from the existing Lake Vermont mine sediment dams indicate:

- Water quality is typically slightly to moderately alkaline, ranging from 7 to 9 pH units (Figure 2).
- Salinity levels are fresh and typically range between 200µS/cm to 500µS/cm (Figure 3).
- Sulphate levels are very low (<10 mg/L) in all stormwater dams (Figure 4), with the exception of a single high sulphate reading of 91 mg/L recorded in Sediment Dam 1.

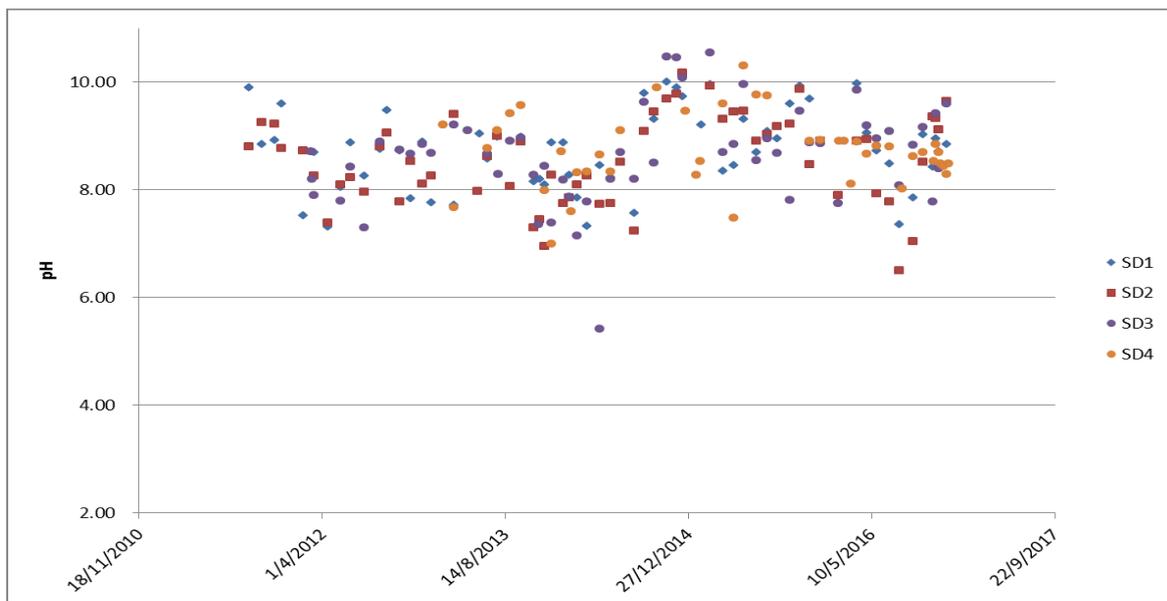


Figure 2 pH in Sediment Dams (Jellinbah Group 2017)

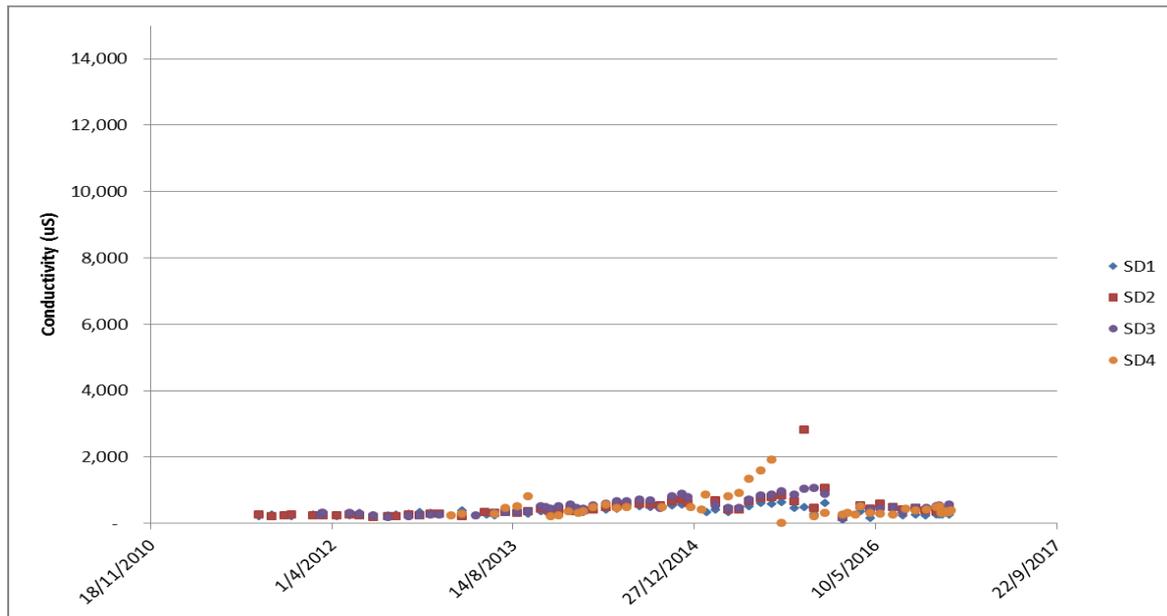


Figure 3 Electrical Conductivity in Sediment Dams (Jellinbah Group 2017)

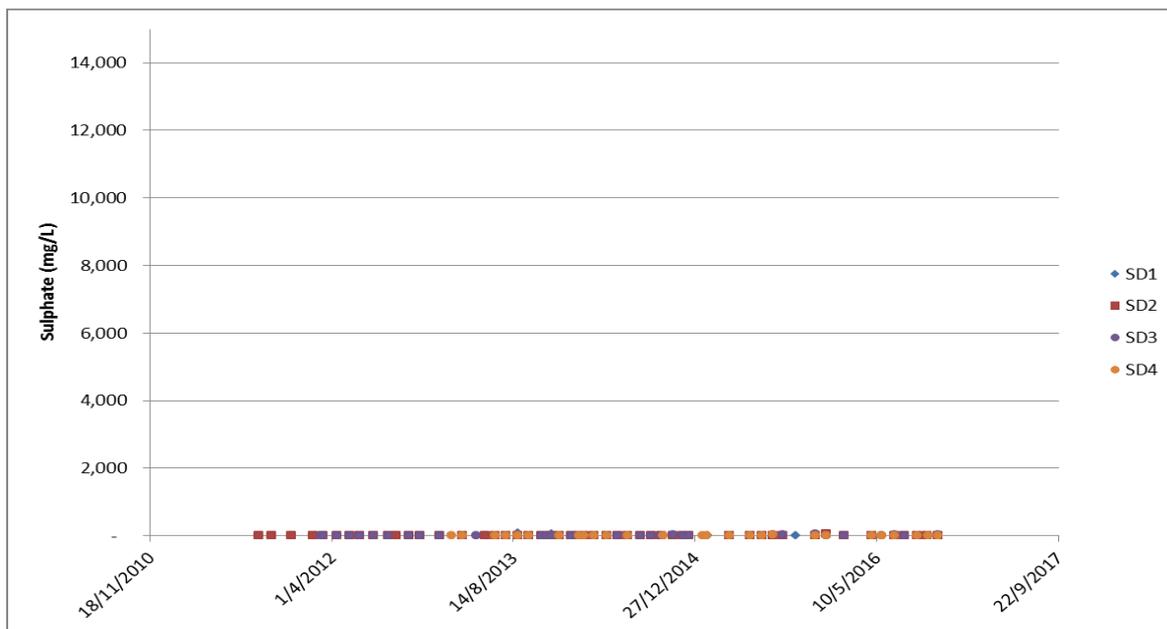


Figure 4 Sulphate levels in Sediment Dams (Jellinbah Group 2017)

Comparing the sediment dam water quality to mine affected water on the existing Lake Vermont site indicates that the site’s water management strategy is effectively separating the mine affected and clean stormwater water sources. Stormwater captured in the sediment dams is typically fresh (EC levels of 200 – 500 $\mu\text{S}/\text{cm}$), slightly to moderately alkaline, and has very low sulphate levels (typically < 10 mg/L). Mine affected water is brackish to saline (typically up to 6000 $\mu\text{S}/\text{cm}$) and slightly alkaline to alkaline with high sulphate levels (up 2000 mg/L).

Additionally, the Isaac River has a catchment area of 6,195 km² immediately downstream of the Downs Creek confluence. The total catchment area of all sediment dams in the extended project is approximately 30 km², or less than 0.5% of the Isaac River catchment area. Overflows reaching the

Isaac River are therefore likely to be diluted to the extent that their impact on water quality will be undetectable.

2.3.3 Final Voids

Section 6.3.1 of the Surface Water Impact Assessment (MNES Assessment Report – Appendix C) describes the long-term water level behaviour in the voids. In summary, due to the limited catchment area around each void, the input of surface water into the voids will essentially be limited to direct rainfall, and the voids will not fill to a level above surrounding groundwater. As such, there will be minimal interaction with the Phillips Creek or Isaac River alluvium, or regional groundwater.

Potential interaction between Phillips Creek and Isaac River floodwaters and the final voids (particularly Pit B and the Satellite Pit) is addressed in detail in the attached response from WRM Water and Environment (Appendix C). In summary, surface water and flood modelling demonstrated that it will be possible to design a final landform that will be resistant to flooding inputs from Phillips Creek and the Isaac River.

As shown in Figure 5, modelling of water levels, based on groundwater inflows and surface water inputs (which will be minimal as the voids do not have a significant catchment beyond their own boundaries), indicates that long term water levels in the Central, North, B and East Pits would be expected to stabilise between 82m AHD and 101m AHD after approximately 120 years. For the Satellite Pit void, the level stabilises at a higher level – around 121m AHD after approximately 60 years.

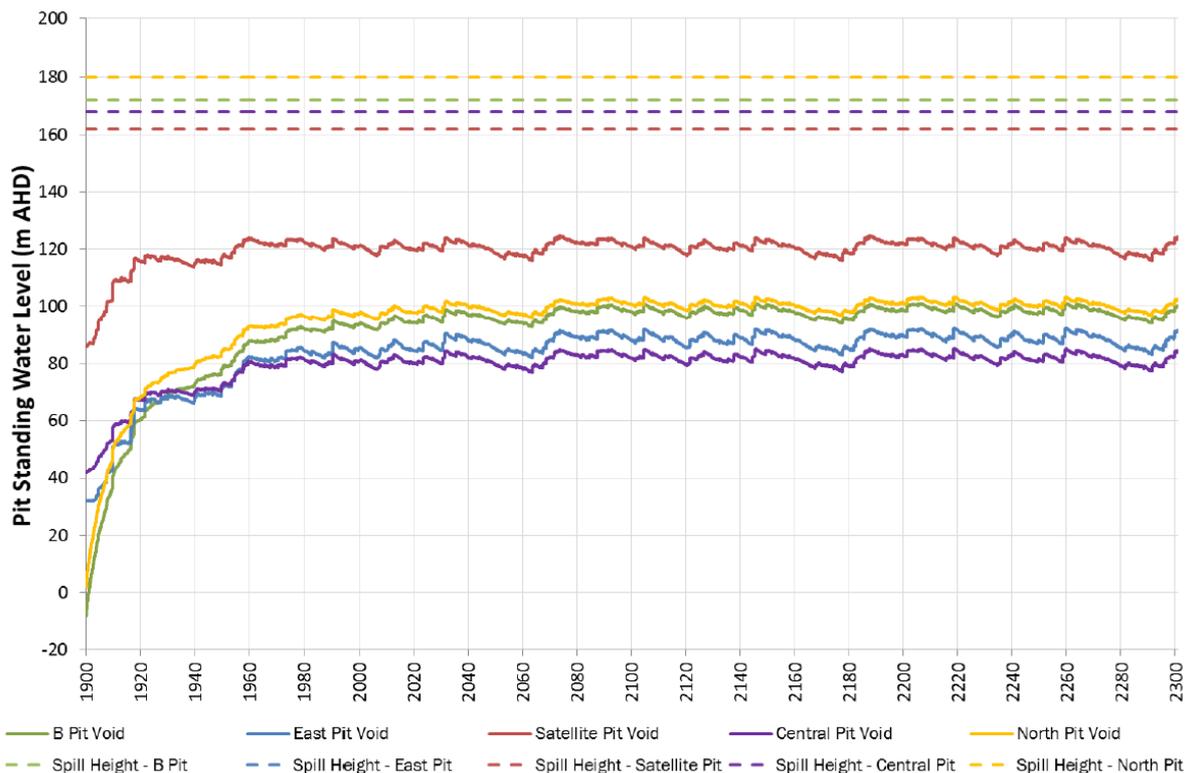


Figure 5 Simulated Final Void Storage Water Level

When compared to regional groundwater levels, it can be concluded that void water levels will remain below groundwater levels, leaving the pits to act as a sink. These comparisons are shown in Table 6 below:

Table 6 Predicted Void Water Levels

Final Void	Regional Groundwater Level (m AHD)	Modelled Long-Term Water Level (m AHD)
Central Pit	130	82
North Pit	138	101
B Pit	143	98
East Pit	140	88
Satellite Pit	146	121

Regarding the influence of faults, the nature of faulting in the Lake Vermont area has been observed from fault exposures in the existing Lake Vermont Mine. It has been observed that the faults tend to simply displace the strata and do not tend to contain infill or act as conduits for groundwater seepage. Exceptions may occur in shallow areas (generally < 50 m from surface) of the existing Lake Vermont pit, where joints and faults can be opened to some extent by relaxation of the Permian strata adjacent to the pit and minor seepage may be observed along joints and faulted contacts following west season rainfall. However within the Lake Vermont area, and Bowen Basin generally, it tends to be the coal seams that act as conduits for groundwater flow and the interburden tends to be dry; therefore faulting is interpreted to impede groundwater flow in instances where the faults displace the coal seams to the extent that the full thickness of the coal seam abuts interburden. These observations have been modelled in the existing 2-dimensional groundwater flow models, which are based on information from the site geological model within the mining area. The site geological model includes the dip and displacement of mapped faults and this fault data has been accurately represented within the 2-dimensional groundwater flow models. The individual coal seams, and the displacement of these seams due to faulting, have been accurately represented within the existing groundwater flow model and it is therefore concluded that the impacts of faults of groundwater movement and flow have already been assessed.

2.4 MITIGATION MANAGEMENT AND MONITORING

In response to DoEE’s questions regarding mitigation, management, and monitoring programs, IESC’s advice centres on the need for robust groundwater and surface water monitoring programs to establish a baseline data set and a set of trigger values, and to better inform management practices.

As described previously in this report, a Receiving Environment Monitoring Program has been developed in accordance with EA conditions, and is attached as Appendix A. This monitoring program will enable the detection of any adverse impacts on aquatic and riparian habitat values in the downstream receiving environment. Specifically, the REMP includes:

- Biological Monitoring comprising
 - macroinvertebrate analysis; and
 - aquatic and riparian vegetation health;
- Habitat assessment; and
- Water and stream sediment monitoring.

Bowen Basin Coal will also implement a groundwater monitoring program, required by the Environmental Authority. The proposed monitoring bore network comprises a combination of existing vibrating wire piezometer (VWP) bores (for monitoring of water level) and standpipe bores (for

monitoring of both water level and water quality). The network has been designed to monitor the major groundwater units that are to be mined or impacted at site and to give adequate spatial and vertical coverage across the site. This program will be implemented initially to develop baseline data and trigger levels, and to determine ongoing monitoring requirements.

Appendix A Lake Vermont Receiving Environment Monitoring Program

LAKE VERMONT MINE
RECEIVING ENVIRONMENT MONITORING PROGRAM

PREPARED FOR
Thiess Pty Ltd

APRIL 2017



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LAKE VERMONT MINE
Receiving Environment
Monitoring Program

INDEX

1.0	INTRODUCTION	1
1.1	BACKGROUND.....	1
1.2	SITE LOCATION AND DESCRIPTION.....	1
1.3	PURPOSE & SCOPE OF DOCUMENT	3
1.4	REQUIREMENTS OF THE ENVIRONMENTAL AUTHORITY	3
2.0	LAKE VERMONT MINE RECEIVING ENVIRONMENT	4
2.1	ENVIRONMENTAL VALUES	6
2.2	WATER QUALITY OBJECTIVES	6
2.2.1	EPP Guideline Water Quality Objectives.....	6
2.2.2	Site Specific Water and Sediment Quality Objectives	7
2.2.2.1	Surface Water Parameters.....	7
2.2.2.2	Sediment Parameters.....	9
3.0	MINE RELEASE	10
4.0	REMP MONITORING METHODOLOGY.....	13
4.1	TIMING AND SCHEDULING	13
4.2	REMP MONITORING SITES.....	13
4.3	WATER QUALITY	15
4.3.1	Flow Monitoring.....	15
4.4	SEDIMENT QUALITY.....	16
4.5	RIPARIAN VEGETATION	17
4.5.1	Vegetation Condition Monitoring.....	17
4.5.2	Plant Health	18
4.6	MACROINVERTEBRATES	19
4.6.1	Habitat Assessment.....	20
4.6.2	Sampling.....	20
4.7	EROSION.....	20
5.0	DATA ANALYSIS & INTERPRETATION.....	22
5.1	LABORATORY ANALYSIS.....	22
5.2	INTERPRETATION.....	22
5.3	STATISTICAL ANALYSIS.....	22

6.0 QUALITY CONTROL & ASSURANCE	23
REFERENCES	25

LIST OF FIGURES

Figure 1	Project Location	2
Figure 2	Watercourses.....	5
Figure 3	EA Release and Monitoring Points	12
Figure 4	REMP Sites.....	14

LIST OF TABLES

Table 1	Guideline Values for the protection of Aquatic Ecosystem Environmental Value	7
Table 2	Water Quality Objectives	8
Table 3	Site Specific Sediment Quality Objectives.....	9
Table 4	Mine Affected Water Release Points, Source and Receiving Waters	11
Table 5	REMP Site Locations and Status.....	13
Table 6	Gauging Station locations	16
Table 7	Riparian Condition Monitoring Methodology.....	18
Table 8	Vegetation Condition Assessment Scoring Framework*	19
Table 9	Erosion Monitoring Methods	21

LIST OF APPENDICES

Appendix A	Field Datasheets	A
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LIST OF ABBREVIATIONS

AARC	-	AustralAsian Resource Consultants
ANSIOM	-	Analysis of similarities
ANZECC	-	Australian and New Zealand Environment and Conservation Council
ARMCANZ	-	Agriculture and Resource Management Council of Australia and New Zealand
cm	-	centimetre
DBH	-	diameter at breast height
EA	-	Environmental Authority
EDL	-	ecologically dominant layer
EPP Water	-	<i>Environmental Protection (Water) Policy 2009</i>
EV	-	Environmental Values
WQO	-	Water Quality Objective
ISQG	-	Interim Sediment Quality Guideline
km	-	kilometre(s)
LVM	-	Lake Vermont Mine
m	-	metre(s)
m ³	-	cubic metre(s)
mg/L	-	Milligrams per Litre
ML	-	Mining Lease
MLA	-	Mining Lease Area
MP	-	monitoring point
Mtpa	-	million tonnes per annum
NMDS	-	Non-Metric Multidimensional Scaling
NTU	-	Nephelometric Turbidity Unit
QC/QA	-	Quality Control / Quality Assurance
QWQG	-	Queensland Water Quality Guidelines

REMP	-	Receiving Environment Monitoring Program
RP	-	Release Point
RPD	-	Relative Performance Differences
Theiss	-	Theiss Pty Ltd
WQO	-	Water Quality Objectives
$\mu\text{S/cm}$	-	microSiemens per centimetre
μm	-	micrometre(s)

1.0 INTRODUCTION

1.1 BACKGROUND

AustralAsian Resource Consultants Pty Ltd (AARC) was commissioned by Theiss Pty Ltd (Theiss) to prepare a Receiving Environment Monitoring Program (REMP) for the Lake Vermont Mine (LVM) (the Project). The Lake Vermont Mine, owned by Bowen Basin Coal Pty Ltd and operated under contract by Theiss Pty Ltd, is developing the coal reserves on Mining Leases (MLs) 70331, 70477 and 70528.

Currently, the dominant land use in the Project region is open cut coal mining and low intensity cattle grazing. The area immediately surrounding the ML can be described as pastoral land interspersed with tracts of remnant vegetation.

1.2 SITE LOCATION AND DESCRIPTION

The Lake Vermont Mine is located in the Isaac Regional Council area in central Queensland, approximately 18 kilometres (km) north-east of Dysart and 170 km south-west of Mackay (Figure 1). The Project is located on ML 70331, ML 70477 and ML 70528 and is authorised by Environmental Authority (EA) EPML00659513, which took effect on 11th October 2016. Mining activities are yet to commence on ML70528.

The Project is a medium-sized open-cut coal mine producing hard coking coal and pulverised coal injection coal, which is exported for use in steel production. The Project has a maximum production rate of 12 million tonnes per annum (Mtpa).

The topography of the area can be described as gently undulating downs country with low ridge lines trending southwest to northeast. The active mine site is drained by three minor, ephemeral, unnamed gullies. These gullies generally drain in a north-easterly direction to the floodplain of the Isaac River, which flows in a south-easterly direction. The northern portion of the active mine site drains north to Phillips Creek which in turn drains east to the Isaac River. The Isaac River is the major northern tributary of the Fitzroy River.

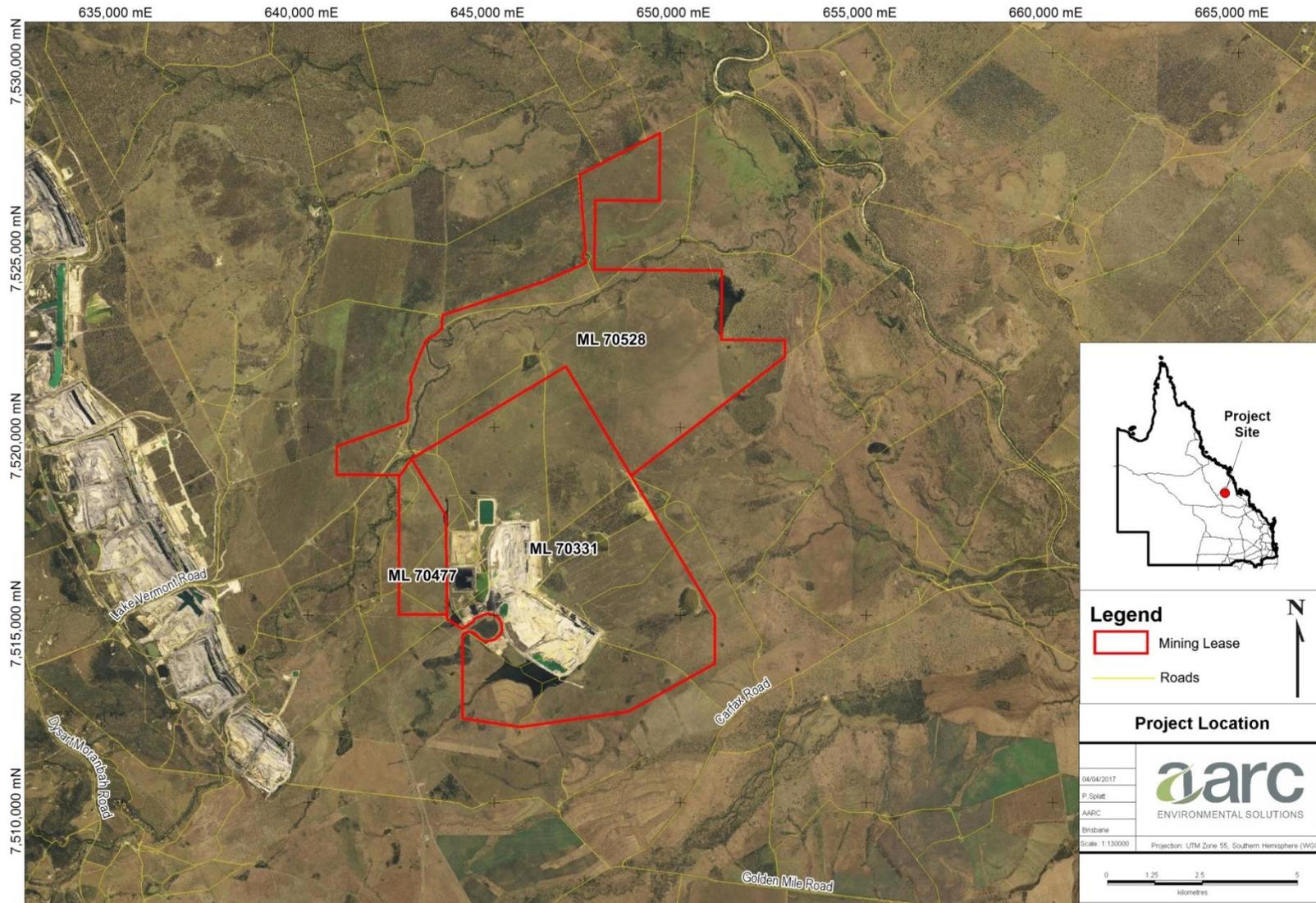


Figure 1 Project Location

1.3 PURPOSE & SCOPE OF DOCUMENT

The purpose of this report is to describe a Receiving Environment Monitoring Program (REMP) that is designed to monitor and assess the potential impacts of controlled or uncontrolled releases of wastewater and associated contaminants to the receiving environment, as a result of the authorised mining activity. The REMP also provides a basis for evaluating whether the discharge limits or other conditions relevant to the activity have been successful in maintaining or protecting receiving environment values over time.

This REMP design document defines a site specific monitoring program for Lake Vermont Mine including:

- Release characteristics (quality and quantity);
- Receiving environment attributes (including location of EVs and other releases or activities);
- Spatial extent (including the location of monitoring sites); and
- Temporal context (including timing and frequency of sampling).

1.4 REQUIREMENTS OF THE ENVIRONMENTAL AUTHORITY

The following conditions (C19, C20, C21, and C22) are outlined in the current EA (EPML00659513) and must be satisfied by the REMP.

C19 - The environmental authority holder must develop and implement a Receiving Environment Monitoring Program (REMP) to monitor, identify and describe any adverse impacts to surface water environmental values, quality and flows due to the authorised mining activity. This must include monitoring the effects of the mine on the receiving environment periodically (under natural flow conditions) and while mine affected water is being discharged from the site.

For the purposes of the REMP, the receiving environment is Phillips Creek and the Isaac River within 15km downstream of the release points. The REMP should encompass any sensitive receiving waters or environmental values downstream of the authorised mining activity that will potentially be directly affected by an authorised release of mine affected water.

C20 - A REMP Design Document that addresses the requirements of the REMP must be prepared and made available to the administering authority upon request.

C21 - A report outlining the findings of the REMP, including all monitoring results and interpretations must be prepared annually and made available on request to the administering authority. This must include an assessment of background reference water quality, the condition of downstream water quality compared against water quality objectives, and the suitability of current discharge limits to protect downstream environmental values.

C22 - All determinations of water quality and biological monitoring must be performed by an appropriately qualified person.

2.0 LAKE VERMONT MINE RECEIVING ENVIRONMENT

The receiving environment of the Lake Vermont Mine incorporates Phillips Creek and the Isaac River within 15 km downstream of the Mine's release points. The immediate receiving environment consists of Phillips Creek, the Isaac River and unnamed tributaries associated with these larger watercourses as shown in Figure 2.

The Isaac River Sub-basin surrounds the mine and is located in the upper Fitzroy Basin. Flowing north to south, the Isaac River is located west of the ML boundary. Stormwater from the mine area flows into the Isaac River directly or via Phillips Creek, eventually flowing into the Fitzroy River. Phillips Creek is typical of central Queensland watercourses with high ephemerality, steep banks and a sandy bed. The Isaac River is a major watercourse with significant upstream catchment and a large flood plain. Water typically persists in the main channels of the River for extended periods following flow. However, the river does not contain permanent base flow.

Stream flow in the rivers and tributaries of the Isaac River Sub-basin are dependent on the frequency and intensity of rainfall events within the catchment. Periods of flow are directly related to large rainfall events in the catchment.

While limited riparian vegetation exists on the mine site itself, the receiving environment of Phillips Creek and the Isaac River consists of a remnant riparian community described as River Red Gum (*Eucalyptus camaldulensis*) Woodland.

Cattle grazing and open cut coal mining are the dominant land uses surrounding the Project site and throughout the Isaac River Sub-basin.

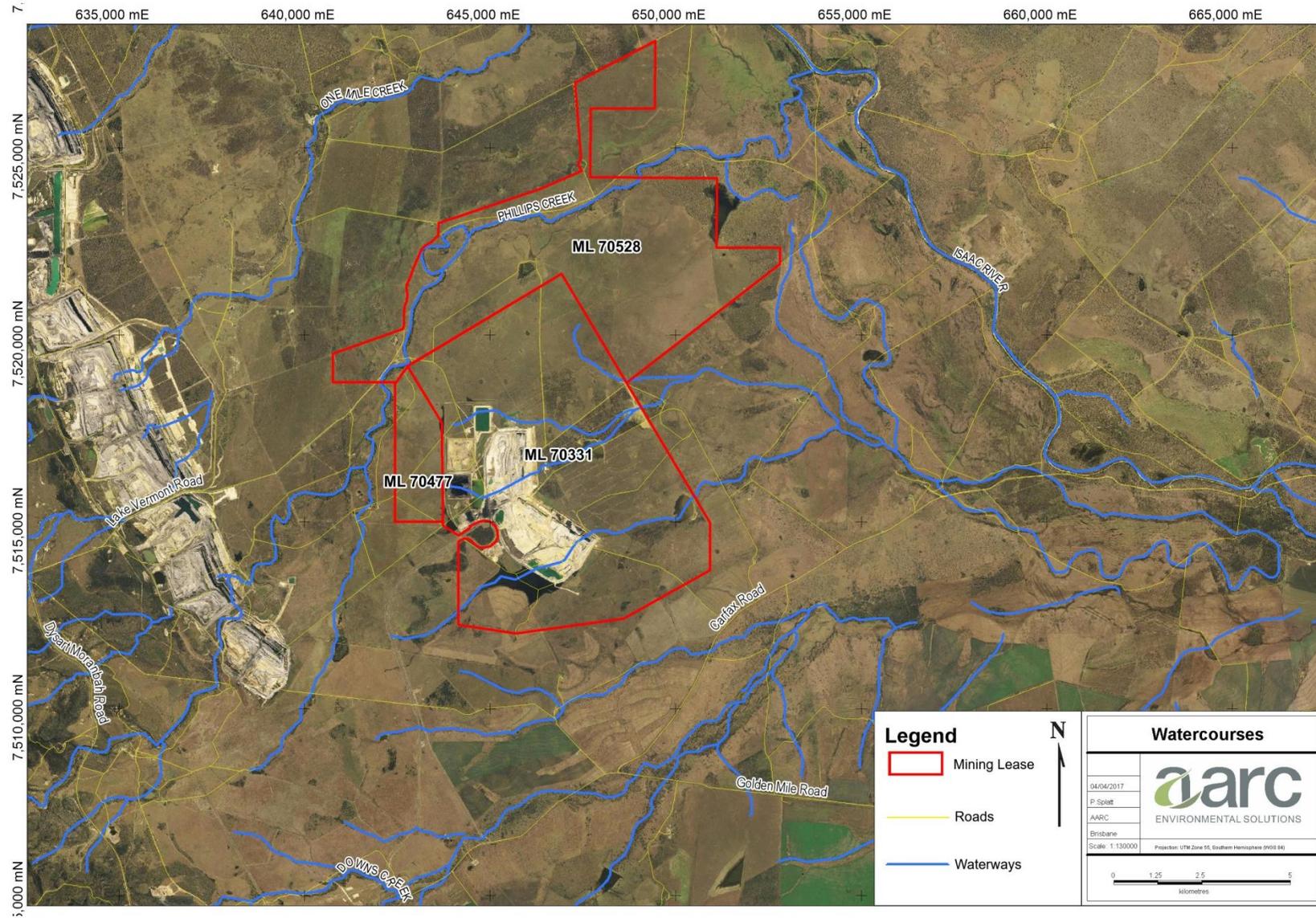


Figure 2 Watercourses

2.1 ENVIRONMENTAL VALUES

Environmental Values (EVs) are defined as the qualities of water that make it suitable for supporting aquatic ecosystems and human water uses (EHP, 2009). The *Environmental Protection (Water) Policy 2009* (EPP (Water)) for the Isaac River Sub-Basin Environmental Values (EVs) and Water Quality Objectives (WQOs) Basin No. 130 (part) provides a list of EVs for all waters within the Isaac River Sub-basin (DERM 2011).

The *EPP (Water) Central Queensland Mapping* (WQ1301 – Isaac River Sub-basin) identifies several watercourses (rivers/creeks), wetlands (palustrine) and lakes/reservoirs on and surrounding the Project site.

The waterways of the Project area fall within the Isaac western upland tributaries and the Isaac and lower Connors River main channel in the Upper Isaac River Sub-basin. The EPP (Water) specifies that the EVs for this catchment are those set out in the Isaac River Sub-basin EVs and WQOs document. The environmental values identified in the Isaac River Sub-basin EVs and WQOs for waterways in the Project region are:

- Protection of aquatic ecosystem values;
- Suitability for crop irrigation;
- Suitability for aquaculture (Isaac western upland tributaries only);
- Suitability for drinking water supplies;
- Suitability for primary contact recreation;
- Suitability for secondary contact recreation;
- Suitability for visual recreation;
- Suitability for human consumers of wild or stocked fish, shellfish or crustaceans;
- Protection of cultural and spiritual values;
- Suitability for industrial use;
- Suitability for stock watering; and
- Suitability for farm supply use.

Environmental values deemed to be relevant to the Project's defined receiving environment are aquatic ecosystem values and suitability for stock watering.

2.2 WATER QUALITY OBJECTIVES

2.2.1 EPP Guideline Water Quality Objectives

The EPP (Water) provides WQOs to support and protect the different EVs identified for waters within the Isaac and Connors Rivers catchments. WQOs are provided in two main parts,

1. For the purposes of protecting the aquatic ecosystem EV; and

2. For EVs other than aquatic ecosystems ('human use EVs' such as stock watering).

Where more than one EV applies to receiving waters (e.g. aquatic ecosystem and stock watering), the most stringent WQO for each water quality indicator will then be adopted to protect all identified EVs. Aquatic ecosystem WQOs are typically more stringent than objectives for stock watering and as such form the basis of site specific targets and criteria. Table 1 provides the guideline WQOs identified for protection of aquatic ecosystems.

Table 1 Guideline Values for the protection of Aquatic Ecosystem Environmental Value

Water area/type (refer plans WQ1301, WQ1310)	Management Intent (level of protection)	Water quality objectives to protect aquatic ecosystem EV
Upper Isaac River catchment waters	Aquatic ecosystem – moderately disturbed	<ul style="list-style-type: none"> • turbidity: <50 NTU • suspended solids: <55 mg/L • pH: 6.5–8.5 • conductivity (EC) baseflow: <720 µS/cm • conductivity (EC) high flow: <250 µS/cm • sulfate: <25 mg/L • Macroinvertebrates: <ul style="list-style-type: none"> – Taxa richness (composite): 12–21 – PET taxa richness (composite): 2–5 – SIGNAL index (composite): 3.33–3.85

2.2.2 Site Specific Water and Sediment Quality Objectives

The following site specific criteria have been developed for the Lake Vermont Mine based on a combination of guideline WQOs and site specific baseline studies. These criteria are also represented in the Project EA, as criteria for investigation of potential contamination.

2.2.2.1 Surface Water Parameters

The site specific water quality objectives, deemed appropriate for inclusion in the Lake Vermont Mine Environmental Authority (EA), are outlined in Table 2 of this report. The objectives are based on ANZECC (2000) aquatic ecosystem protection levels for Slightly to Moderately Disturbed (SMD) ecosystems and water quality data obtained during site specific baseline studies.

Table 2 Water Quality Objectives

Quality Characteristic	WQO / Trigger	Source
pH	6.5 - 8.0	Site specific baseline studies
Electrical Conductivity	1,000 µS/cm	
Suspended Solids	1,500 mg/L	
Sulphate (SO ₄ ²⁻)	300 mg/L	
Sodium	180 mg/L	
Aluminium	55 µg/L	For aquatic ecosystem protection, based on SMD guideline
Arsenic	13 µg/L	For aquatic ecosystem protection, based on SMD guideline
Cadmium	0.2 µg/L	For aquatic ecosystem protection, based on SMD guideline
Chromium	1 µg/L	For aquatic ecosystem protection, based on SMD guideline
Copper	2 µg/L	For aquatic ecosystem protection, based on LOR for ICPMS
Iron	300 µg/L	For aquatic ecosystem protection, based on low reliability guideline
Lead	4 µg/L	For aquatic ecosystem protection, based on SMD guideline
Mercury	0.2 µg/L	For aquatic ecosystem protection, based on LOR for CV FIMS
Nickel	11 µg/L	For aquatic ecosystem protection, based on SMD guideline
Zinc	8 µg/L	For aquatic ecosystem protection, based on SMD guideline
Boron	370 µg/L	For aquatic ecosystem protection, based on SMD guideline
Cobalt	90 µg/L	For aquatic ecosystem protection, based on low reliability guideline
Manganese	1900 µg/L	For aquatic ecosystem protection, based on SMD guideline
Molybdenum	34 µg/L	For aquatic ecosystem protection, based on low reliability guideline
Selenium	10 µg/L	For aquatic ecosystem protection, based on LOR for ICPMS
Silver	1 µg/L	For aquatic ecosystem protection, based on LOR for ICPMS
Uranium	1 µg/L	For aquatic ecosystem protection, based on LOR for ICPMS
Vanadium	10 µg/L	For aquatic ecosystem protection, based on LOR for ICPMS
Ammonia	900 µg/L	For aquatic ecosystem protection, based on SMD guideline
Nitrate	1,100 µg/L	For aquatic ecosystem protection, based

Quality Characteristic	WQO / Trigger	Source
		on ambient Qld WQ Guidelines (2006) for Total Nitrate
Petroleum hydrocarbons (C6-C9)	20 µg/L	
Petroleum hydrocarbons (C10-C36)	100	
Fluoride (total)	2,000	Protection of livestock and short term irrigation guideline
Sodium (mg/L)	180	Australian Drinking Water Guidelines. Trigger may require amendment if future advice from Queensland Health becomes available

Note:

1. All metals and metalloids must be measured as total (unfiltered) and dissolved (filtered). Trigger levels for metal/metalloids apply if dissolved results exceed trigger.
2. SMD – slightly moderately disturbed level of protection, guideline refers ANZECC & ARMCANZ (2000).
3. LOR – typical reporting for method stated. ICPMS/CV FIMS – analytical method required to achieve LOR.

2.2.2.2 Sediment Parameters

Stream sediment quality objectives for the Project are adopted from the Interim Sediment Quality Guideline (ISQG) values (ANZECC & ARMCANZ 2000) (Table 3).

Table 3 Site Specific Sediment Quality Objectives

Contaminant	Sediment Quality Guideline Value - Low	Sediment Quality Guideline Value - High
Arsenic	20	70
Cadmium	1.5	10
Chromium	80	370
Copper	65	270
Lead	50	220
Nickel	21	52
Mercury	0.15	1
Zinc	200	410

3.0 MINE RELEASE

Schedule C of the Project EA outlines conditions in which the Project is permitted to release mine affected water to receiving waters from ten prescribed release locations. The release locations are described in Table 4 and displayed in Figure 3.

Mine affected water includes groundwater and runoff from coal stockpiles and processing areas. It is contained within environmental dams and released only in accordance with the criteria of the EA (based on release quality and flow conditions in the receiving environment). Mine affected water is typically higher in salt content than normal stormwater runoff.

Other stormwater runoff can contain elevated sediment loads but does not come into contact with other contaminant sources. This water is intercepted by sediment dams to allow suspended sediment loads to settle out prior to release.

Release of mine affected waters must meet the strict release criteria and monitoring commitments of the EA. This is managed by Thiess through a telemetry based system of automated water level monitoring in dams and pump control for release.

Release waters are to be monitored at the release points and at six locations downstream of the release points to ensure discharged waters do not exceed the release limits listed in Table 2 for each water quality characteristic. The locations of these monitoring points (MPs) are also displayed in Figure 3. Monitoring at these points is to take place under natural flow conditions and while mine affected water is being discharged from the release points.

The REMP has been designed in accordance with the water release conditions whereby REMP site locations have been determined relative to the EA release and monitoring points.

Table 4 Mine Affected Water Release Points, Source and Receiving Waters

Release Point (RP)	Latitude (decimal degree, GDA94)	Longitude (decimal degree, GDA94)	Mine Affected Water Source and Location	Monitoring Point	Receiving Waters Description
RP1	-22.4305	148.4433	Mine Area	Pipe / Drain	Unnamed gully and Isaac River
RP2	-22.4377	148.4482	Mine Area	Pipe / Drain	Unnamed gully and Isaac River
RP3	-22.4621	148.4638	Mine Area	Pipe / Drain	Unnamed gully and Isaac River
RP4	-22.4289	148.3886	Mixed Mine Water (pumped to release site)	Pipe / Drain	Phillips Creek
RP5	-22.3905	148.4319	Mixed Mine Water (pumped to release site)	Pipe / Drain	Phillips Creek
RP6	-22.4362	148.3845	Mixed Mine Water (pumped to release site)	Pipe / Drain	Phillips Creek
RP7	-22.4436	148.3846	Mixed Mine Water (pumped to release site)	Pipe / Drain	Phillips Creek
RP8	-22.3636	148.4502	Mixed Mine Water Release	Pipe / Drain	Phillips Creek
RP9	-22.4125	148.4603	Mixed Mine Water Release	Pipe / Drain	Phillips Creek
RP10	-22.3954	148.4097	Mixed Mine Water Release	Pipe / Drain	Phillips Creek

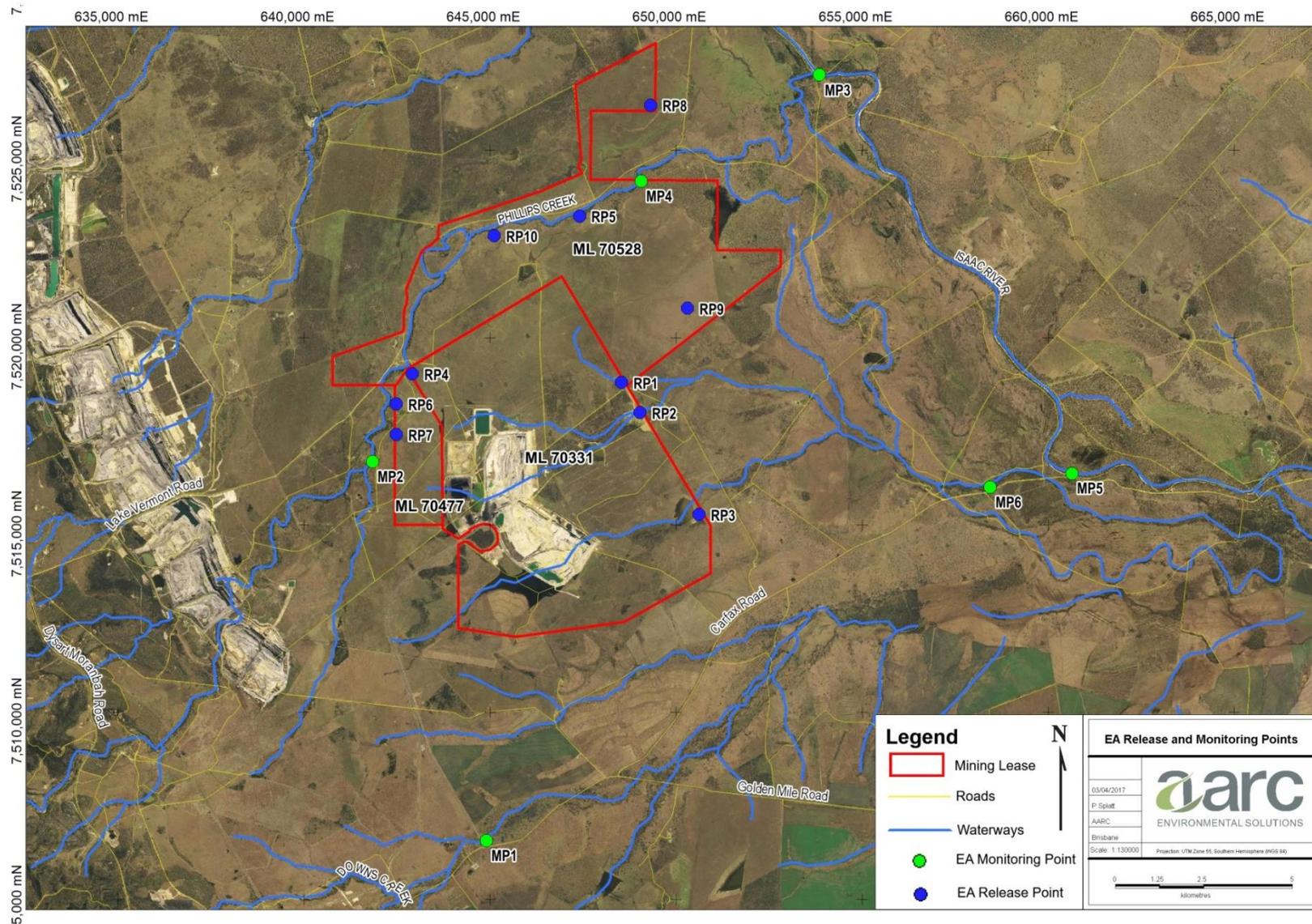


Figure 3 EA Release and Monitoring Points

4.0 REMP MONITORING METHODOLOGY

4.1 TIMING AND SCHEDULING

The frequency and scheduling of monitoring is based on the Queensland *Monitoring and Sampling Manual 2009* (EHP 2009). REMP monitoring should take place during periods of stream flow, ideally toward the end of the wet season, when safe access is available. In the event of a major flow event, REMP monitoring should be scheduled to occur approximately 4 - 6 weeks later but before base flows cease.

4.2 REMP MONITORING SITES

The REMP monitoring sites have been developed to incorporate all sampling procedures at each site location. These sites are generally consistent with water monitoring sites in the EA, with some minor variations to better suit the nature of the REMP activities.

Reference sites are those located upstream of the mining lease and are not subject to the release of mine affected water from the Lake Vermont Mine. Impact sites are those located downstream of the Release Points (RPs) and within the receiving environment. Table 5 describes the status, reference and physical locations of each REMP site. Figure 4 displays the physical location of each REMP site.

Table 5 REMP Site Locations and Status

Site Code	Licensed Monitoring Point	Status	Reference Location	Latitude (GDA 94)	Longitude (GDA 94)
REMP 1	MP1	Reference	Located 100 metres (m) upstream of mine access road	-22.5402	148.4113
REMP 2	MP2	Reference	Located west of mining lease at confluence of Phillip creek and small tributary	-22.4607	148.3565
REMP3US	MP3	Reference	Located at the confluence of Isaac River and Phillips Creek	-22.3541	148.4917
REMP3DS	MP3	Impact	Located downstream of the confluence of Phillips Creek and Isaac River	-22.3559	148.4941
REMP 4	MP4	Impact	Located on Phillips Creek at the confluence to the Isaac River	-22.3558	148.4923
REMP 5	MP5	Impact	Located adjacent to Carfax Road along the Isaac River	-22.4549	148.5855
REMP 6	MP6	Impact	Located 3 km west of REMP 5 along a small tributary	-22.4530	148.5550

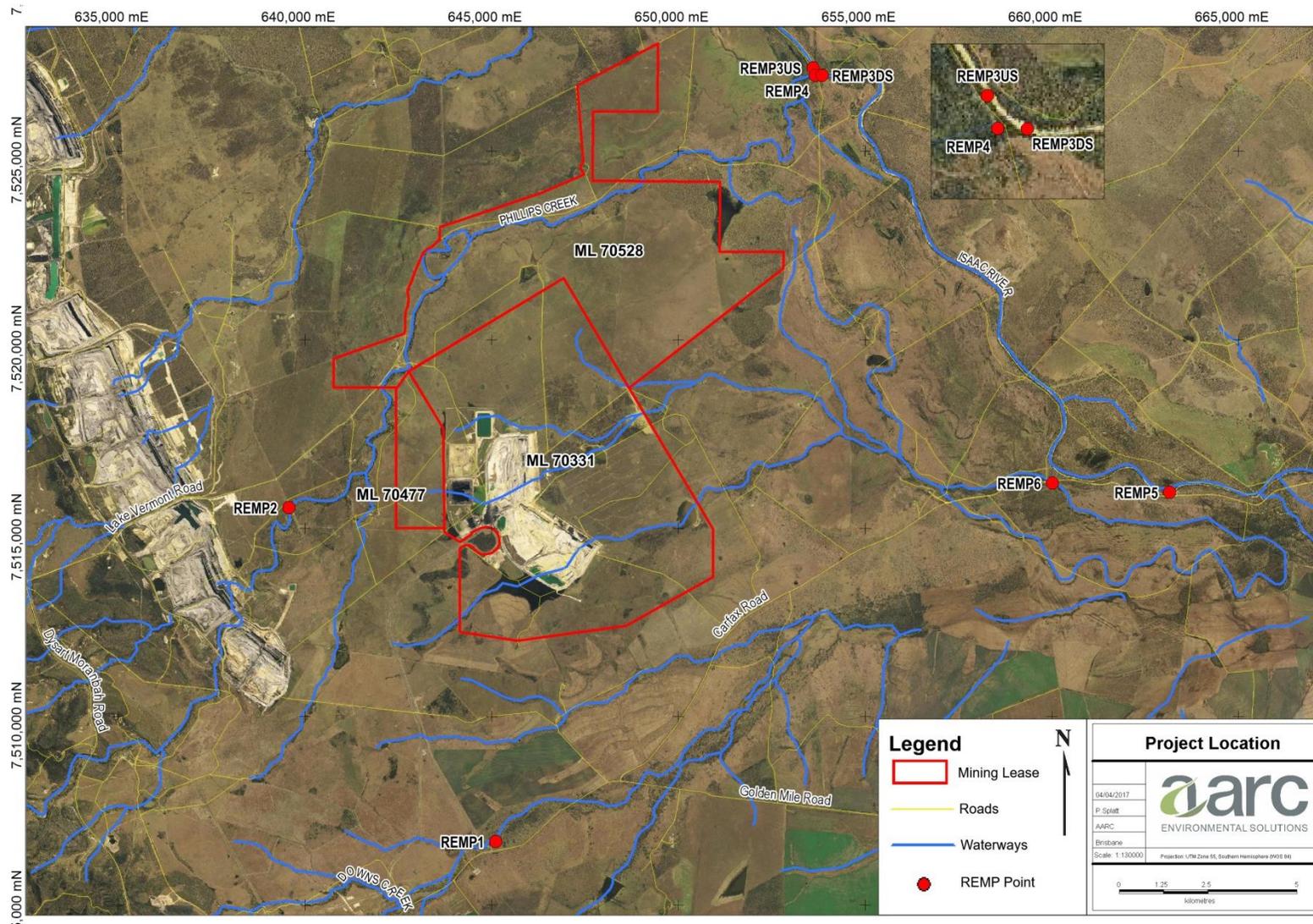


Figure 4 REMP Sites

4.3 WATER QUALITY

Water quality sampling is to be carried out in accordance with the Queensland *Monitoring and Sampling Manual 2009* (EHP 2009) methodology.

Surface water sampling should occur during flow events, where possible. Field readings of pH, Dissolved Oxygen, Turbidity, Electrical Conductivity (EC) and Temperature are to be recorded. In-situ measurements shall be collected using a multi-parameter water quality meter that is laboratory calibrated to the manufacturers' specifications.

Grab samples will be collected at a depth of 10 to 20 cm where sufficient water is available. Two water samples, one total (unfiltered) and one dissolved (field filtered) will be collected at each site. Water quality samples will be analysed under laboratory testing conditions for the parameters listed below:

- pH
- EC
- Suspended Solids
- Turbidity
- Sulphate
- Sodium
- Aluminium
- Arsenic
- Cadmium
- Chromium
- Copper
- Iron
- Lead
- Mercury
- Nickel
- Zinc
- Boron
- Cobalt
- Manganese
- Molybdenum
- Selenium
- Silver
- Uranium
- Vanadium
- Ammonia
- Nitrate
- Petroleum hydrocarbons

Samples will be collected in suitable sample collection bottles provided by the laboratory with preservative added. All water samples should be kept on ice or refrigerated during storage and transport to a National Association of Testing Authorities (NATA) accredited laboratory for analysis.

The results of the analysis will be compared to upstream water quality (reference sites), and the site specific water quality objectives. Where site specific objectives have not been set for a particular parameter, data analysis and interpretation will refer to the following regional or sub-regional guideline values where relevant:

- EPP (Water) WQO for the protection of aquatic ecosystems in the Isaac River Sub-basin; and
- Queensland *Water Quality Guideline (2009)* values for slightly to moderately disturbed uplands streams of the Central Coast QLD Region.

4.3.1 Flow Monitoring

Flow monitoring incorporates measurements of stream level (height in metres) and discharge (volume in cubic metres per second). This monitoring is important when dealing with point source releases to freshwater streams, regardless of stream ephemerality.

Flow will heavily influence water quality and biological indicators and must be considered in the interpretation of REMP data. Collection of flow information allows for the analysis of the relationship between individual water quality parameters and flow conditions, enabling more accurate characterisation of the receiving environment and informs the derivation of WQOs.

Two QLD Government gauging stations record flow rates in the Isaac River and Phillips Creek. Flow is recorded continuously at the gauging stations. Table 6 outlines the locations of the gauging stations.

Table 6 Gauging Station locations

Receiving Water	Release Point	Gauging Station	Coordinates (MGA GDA94, Z55)	Flow Recording Frequency
Isaac River	RP1 RP2 RP3	Isaac at Deverill	-22.1726, 148.3822	Continuous (min. daily)
Phillips Creek	RP4 RP5 RP6 RP7 RP8 RP9 RP10	Upstream Phillips Creek or Isaac at Deverill	-22.4502, 148.3784 or -22.1726, 148.3822	Continuous (min. daily)

Flow monitoring data recorded at existing gauging stations can be accessed online and utilised in the interpretation of REMP data. Flow monitoring data related to these specific gauging stations can be accessed through the following Queensland Government website and information portal. <https://water-monitoring.information.qld.gov.au/wini/documents/telem/TP_SURFACE.HTM>

4.4 SEDIMENT QUALITY

Sediment quality sampling will be undertaken in accordance with the Queensland *Monitoring and Sampling Manual 2009*. Sampling is undertaken at all REMP sites when access to the channel substrate is available. Sediment sampling may not be possible at all sites during the REMP surveys due to the likely presence of water. In such instances sampling can be undertaken at some future point in time when flow has ceased. Ideally, sediment sampling will be undertaken post-wet season

Five sub-samples (approximately 500g each) of the stream-bed substrate are to be taken at each REMP site along a 50 m transect in the river bed. Samples should be collected using a non-metallic shovel. The sub-samples will then be mixed in a clean plastic bucket to obtain a composite sample (approximately 500g) to be sealed in sterilised glass jars or plastic sample bags and sent to a NATA accredited laboratory for analysis of trace metals and particle size. Sediment samples will be analysed for the following parameters:

- Arsenic
- Cadmium
- Chromium
- Copper
- Lead
- Nickel

- Zinc
- Mercury
- Particle size distribution

The results of the receiving environment will be compared with upstream sites and the site specific sediment quality objectives.

4.5 RIPARIAN VEGETATION

A riparian condition monitoring program has been designed to detect, monitor and assess any impacts of mine releases on the receiving environment and document any changes in riparian condition over time. Riparian vegetation condition and plant health shall be assessed annually at each REMP monitoring site. For the purposes of the REMP, a vegetation monitoring plot (50 m x 10 m plot) will be established at each REMP site.

4.5.1 Vegetation Condition Monitoring

The BioCondition assessment framework (Eyre *et al.* 2015) has been adapted to develop vegetation condition indicators (relevant to the REMP) providing a rapid vegetation condition monitoring methodology as described in Table 7 below.

Table 7 Riparian Condition Monitoring Methodology

Community Characteristics	Monitoring Methodology
Community Structure and Composition	
Species Composition	Record all woody species and dominant non-woody species within the 50 m x 10 m plot.
Relative species dominance	Within the 50 m x 10 m plot, assign relative dominance (e.g. Dominant, Co-dominant, Sub-dominant, Associated or Occasional) for each species noted above.
Non-native plant cover	Estimate the cover of exotic species over the 50 m x 10 m plot.
Canopy height	The height of the Ecologically dominant canopy layer shall be measured during the establishment of each monitoring plot. This can be estimated during subsequent monitoring events.
Canopy cover	Assess canopy cover using the crown or line-intercept method; a measure of the percentage of living, native tree canopy that overlaps the 50 m transect line. The total length of the canopy is divided by the total length of the tape to give an estimate of percentage crown cover.
Shrub cover	Assess native and exotic shrub canopy cover using the line intercept method. Shrub canopy cover can be assessed from above the canopy if it is below eye level.
Recruitment of woody perennial species	Within the 50 m x 10 m plot, assess the proportion of dominant species present that are regenerating (presence of individuals <5 centimetre (cm) diameter at breast height (DBH)). For each dominant canopy species present, at least one individual must be present as a sapling or seedling for the species to be considered as regenerating. The presence of all dominant species in the regenerative state would make up 100 % recruitment.
Stream Cover	
Shading	Visually estimate the percentage of the stream area that would be shaded by riparian vegetation when the sun is directly overhead. The stream area is equivalent to the length of the REMP site and the width of the wetted channel (under baseflow conditions).
In-stream vegetation cover	Visually estimate the percentage of the stream area covered by instream vegetation (submerged, floating and emergent macrophytes). The stream area is equivalent to the length of the REMP site and the width of the wetted channel (under baseflow conditions).

4.5.2 Plant Health

Some metals are essential to plant metabolism in trace amounts. Of the total pool of metals present in the soil or growth substrate, plants can only access the bioavailable fraction (i.e. soluble metal in soil solution). The potential for metal contamination to cause plant toxicity arises when metals occur at excessive levels in bioavailable forms. Generally metal toxicity issues do not arise in native vegetation in natural soils (Reichman, 2001).

A visual assessment of three representative individuals of the dominant tree and shrub species at each site will be undertaken. Measures of any physiological symptoms of plant stress will be recorded.

Symptoms of visible injury to vegetation should be scored according to the semi-quantitative scoring framework outlined in Table 8 below.

Table 8 Vegetation Condition Assessment Scoring Framework*

Category	Tip necrosis or chlorosis (leaf yellowing) (% length or % cover)	Marginal necrosis or chlorosis (leaf margins - dark brown) (% width/area or % cover)	Undulation / cupping	Anthocyanin accumulation (leaf redness) (% area or % cover)
0	Nil	Nil	Nil	Nil
1	Slight < 5 %	Slight < 5 %	Slight	Slight < 5 %
2	Moderate < 20 %	Moderate < 20 %	Moderate	Moderate < 20 %
3	Marked < 50%	Marked < 50%	Marked	Marked < 50%
4	Severe <90%	Severe <90%	Severe	Severe <90%
5	Extreme > 90 %	Extreme > 90 %	Extreme	Extreme > 90 %

*Table adapted from UniQuest 2000

The assessment of plant health shall be limited to woody trees and shrubs particularly those of the genus *Eucalyptus*, *Corymbia*, *Melaleuca* and *Acacia*. These and other woody plant species will function as the primary indicators of contamination as they provide a more durable record of injury compared to herbaceous plants and grasses (UniQuest 2000).

4.6 MACROINVERTEBRATES

Macroinvertebrates have been adopted as the standard biological indicators of water quality in order to assess the condition of a waterway. Macroinvertebrates live, for at least some part of their life history, in the aquatic system and are usually large enough to be seen with the naked eye. This group includes dragonflies, caddis flies, biting flies (e.g. midges), mites, snails, mussels, prawns and crayfish (DERM 2009; Lloyd and Cook 2002).

Macroinvertebrates are chosen because of their abundance and diversity nationally, their sensitivity to changes in water quality, flow regime and habitat conditions, and relatively good taxonomic knowledge. Impacts on these animals are relatively long lasting and can be detected for some time after the impact. They are also limited in their ability to migrate from an area of watercourse that is being adversely impacted, and only have the ability to recolonise quite slowly after any pollution events. These animals have been utilised worldwide as good indicators of river and stream health and are increasingly used for rapid bio-assessment (DERM 2009; Lloyd and Cook 2002).

Macroinvertebrate sampling is common in waterway health assessments for the following reasons:

- 1) They are generally sensitive to the cumulative impacts of a wide range of disturbances and pollutants;
- 2) They are abundant in freshwater systems;
- 3) They are relatively easy to identify; and

- 4) They are easy to collect (Chessman, 2003).

Macroinvertebrate sampling will be conducted in accordance with the AusRivAS sampling and assessment methodology as outlined by the Queensland *Monitoring and Sampling Manual 2009* (EHP 2009).

4.6.1 Habitat Assessment

The AusRivAS Macroinvertebrate Sampling and Habitat Assessment field sheets (Appendix A) will be used to document the reach environs, site conditions (e.g. channel alteration, erosion, etc.), instream habitat and other relevant observations.

Photographs will be taken at each site, including the left and right banks, upstream and downstream and other relevant habitat features.

4.6.2 Sampling

Along a 10 m stretch of the waterbody, a 250 micrometre D-frame net will be used to sample macroinvertebrates at each REMP site containing sufficient suitable aquatic habitat. This procedure will target various micro-habitats including riffles, runs, pool beds and edge/backwaters. Due to the ephemeral nature of the creeks and rivers in the receiving environment, micro-habitats available for sampling are limited to pool beds and edge habitats. All macroinvertebrates sampled will be placed in a preservative solution and sent to a designated laboratory for identification. The nets will be checked thoroughly for damage before use and washed between sites to ensure no cross contamination of samples.

Data collected during this project will be assessed using a range of indices including:

- Taxa Richness;
- PET Richness;
- SIGNAL 2 Biotic Index; and
- Percentage Tolerance Taxa.

4.7 EROSION

An erosion monitoring program has been developed for the REMP. Physical degradation to the banks of the receiving waterways will be described based on their specific bank characteristics (bank shape, bank slope, artificial bank stability features etc.), quality characteristics (e.g. sediment and water oils and odours, turbidity, etc.) and erosion characteristics. This program utilises standard erosion monitoring techniques described in the following environmental sampling manuals:

- *AusRivAS Physical Assessment Protocol* (Parsons *et al.* 2002) (refer to AusRivAS Physical Assessment Protocol Field Data Sheets Page 5 in Appendix A); and
- *Australia-Wide Assessment of River Health: Northern Territory AusRivAS Sampling and Processing Manual* (Lloyd and Cook 2002).

Erosion monitoring techniques to be employed as part of the Lake Vermont Mine REMP are described in Table 9.

Table 9 Erosion Monitoring Methods

Characteristic	Monitoring Methodology
Bank Shape	Categorise the predominant shape of the left and right banks along the length of the monitoring site in accordance with the AusRivAS physical assessment categories for bank shape (i.e. concave, convex, stepped, wide lower bench or undercut) (Appendix A).
Bank Slope	Categorise the predominant slope of the left and right banks along the length of the monitoring site in accordance with the AusRivAS physical assessment categories for bank slope (i.e. vertical, steep, moderate, low or flat) (Appendix A).
Factors Affecting Bank Stability	Identify disturbance factors present that may negatively influence bank stability of either the left or right bank (refer to Appendix A).
Artificial Bank Stability Features	Note the presence of any artificial bank protection measures (refer to Appendix A).
Large Woody Debris	Visually estimate the percent cover of large woody debris within the lower embankment and channel area, along a length of stream that is equal to the length of the monitoring site. Large woody debris includes logs and branches greater than 10 cm in diameter.
Turbidity, Water and Sediment Oils and Odours	Visually assess and categorise the presence of oily residues or odours in surface water and stream sediments at the REMP monitoring site (refer to Appendix A).
Bare Ground	Note the extent of bare ground including eroded areas or those not supporting vegetation, due to some form of disturbance that would otherwise be expected to be vegetated.
Exposed Tree Roots	Note whether tree roots are exposed due to any disturbances.
Gully Erosion	Record any visible gully erosion adjacent to the watercourse.
Bank Slumping	Record any evidence of slumping banks along the watercourse.
Local Catchment Erosion	Note the erosion in the surrounding catchment on the approach to the site.

5.0 DATA ANALYSIS & INTERPRETATION

5.1 LABORATORY ANALYSIS

All REMP samples collected (macroinvertebrates, water and sediment) will be sent to a NATA certified laboratory for analysis of the recommended parameters.

5.2 INTERPRETATION

Results from the REMP will initially be compared to upstream reference water quality, and the Project's site specific water quality objectives to identify immediately obvious impacts of the mine.

Data will also be analysed for trends over time and geographic location. Consideration to common variables such as stream flow, release characteristics, upstream land uses, seasonal variation and other event specific circumstances will also be provided.

Analysis of biological indicators will assist in interpreting short and long term impacts on the ecosystem as a whole.

5.3 STATISTICAL ANALYSIS

Standard statistical methods will be employed unless event specific circumstances require more detailed assessment. The following analytical methods will be employed as a minimum:

- In relation to vegetation, water and sediment quality characteristics, the mean values +/- 2 standard deviations will be calculated for comparison of reference and impact locations;
- Temporal variation will be presented graphically with other variables. Statistical analysis will be undertaken only if required (where obvious trends are apparent);
- To gain an understanding of temporal variation in macroinvertebrate community composition, datasets from previous monitoring events will be assessed, where sufficient data is available. The following statistical analyses will be used to quantify and compare community composition in macroinvertebrates across the REMP sites:
 - Non-Metric Multidimensional Scaling (NMDS) Ordination
 - Analysis of Similarities (ANOSIM)

6.0 QUALITY CONTROL & ASSURANCE

To ensure the reliability of monitoring results, a number of quality control / quality assurance (QC/QA) procedures shall be adopted during the collection and analysis of REMP samples. All field testing and sample collection will be completed using best practice techniques and in accordance with instrument manufacturer's instructions (including calibration). All macroinvertebrate, water and sediment samples will be sent to NATA accredited laboratories for analysis. Samples shall be analysed using appropriate methods as per NATA laboratory accreditation requirements. In accordance with those requirements, the analysing laboratory will also be responsible for undertaking a range of QC/QA checks, (e.g. evaluation of sample preservation and holding times, relative performance differences (RPD) on duplicate samples, etc.). The results of these QC/QA checks will be provided with the raw quality data in the report appendices.

The following QC/QA steps shall be undertaken as part of the REMP water and sediment quality sampling procedure:

- At each REMP site, water quality measurements and water samples shall be collected prior to any other sampling to reduce sample contamination and bias of in-situ turbidity readings. Care shall be taken to prevent disturbance to the stream bed or banks when undertaking these tasks.
- Water quality meters shall be calibrated in accordance with the manufacturer's specifications prior to sampling.
- Water quality probes shall be rinsed between sampling sites to prevent contamination.
- Persons collecting water samples shall wear clean single use powder free sterile nitrile gloves at each REMP site.
- Where required, unpreserved sample bottles are to be rinsed in local water before filling.
- Prior to the collection of field filtered samples, the sampling syringe shall be rinsed twice using sampling water collected in a sample container. The entire inside surface of the syringe is to come in contact with the sample. The syringe shall then be refilled and a filter attached. The first 2 ml of the sample shall be discarded through the filter as a filter rinse, before filling the sample bottle via the filter.
- All label information on each sampling bottle shall be completed while at the REMP site and checked during the completion of the Chain of Custody (COC) forms prior to sample dispatch. Sampling bottles containing dissolved water shall be appropriately demarcated as field filtered.
- Samples are to be stored in appropriate, laboratory allocated sample bottles and sample collection is to be conducted according to appropriate methods, as advised by the analysing laboratory.
- Samples collected as part of the REMP are to be stored in coolers with ice to keep them chilled, and shall be sent to the NATA accredited laboratory for testing as soon as practically possible in order to comply with holding times.
- The COC's for each batch of samples are to be included in the coolers.
- Cooler lids shall be taped with the security tape to ensure that any tampering is evident.

- Data received from the laboratories shall be reviewed immediately following receipt to identify any anomalies that may require samples to be re-tested.

The following sampling control procedures shall be undertaken as part of the macroinvertebrate sampling procedure, to assure sample quality and data reliability:

- Dip nets and sorting trays shall be thoroughly rinsed prior to sampling at each REMP site to prevent sample contamination.
- Each sample shall be clearly labelled, with sample details to be recorded on the sample jar in permanent marker. These details will then be recorded on the COC forms prior to the samples being dispatched. This process ensures samples can be readily tracked when sent to the laboratory for processing.

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Lloyd J. and Cook S. (2002) *Australia-Wide Assessment of River Health: Northern Territory AusRivAS Sampling and Processing Manual, Monitoring River Health Initiative Technical Report no 19*. Commonwealth of Australia and Department of Lands, Planning and Environment. Available from: <http://www.environment.gov.au/water/publications/environmental/rivers/nrhp/manual-nt/pubs/manual-nt.pdf>.

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Appendix A Field Datasheets



WATER QUALITY SAMPLING FIELD SHEET

Site Number []	Sample Number []		
Site Name _____		Project Name _____	
Date [ | / | / | | ]	Time (24 hrs) [ | : | ]		
Project Code [ | | | | | ]	Submitted [A B C D E F G H I J K L M N]		
Run Code [ | | | | | ]	Received [ | | | | | ]		
Party [ | | ] [ | | ] [ | | ]			

SAMPLING LOCATION: Latitude _____ **Longitude** _____
 Reach orientation (looking downstream): N NE E SE S SW W NW Datum: _____

Parameter	Value	Quality	Variable
Conductivity <small>µS/cm@25°C</small>	[ | | | | ]	[ | | ]	2010.5
Water Temperature <small>°C</small>	[ | | . | ]	[ | | ]	2080.5
pH	[ | | . | ]	[ | | ]	2100.5
Dissolved O ₂ <small>mg/l</small>	[ | | . | ]	[ | | ]	2351.5
Turbidity <small>NTU</small>	[ | | | ]	[ | | ]	2030.5
Air Temperature <small>°C</small>	[ | | . | ]	[ | | ]	2065.5
Total Alkalinity <small>mg/l CaCO₃</small>	[ | | | . | ]	[ | | ]	2113.5
Phenol Alkalinity <small>mg/l CaCO₃</small>	[ | | | . | ]	[ | | ]	2114.5
Transparency (secchi) <small>m</small>	[ | | . | ]	[ | | ]	2046.5
Velocity <small>m/s</small>	[ | . | | ]	[ | | ]	240.0
Gauge Height <small>m</small>	[ | | | . | ]	[ | | ]	100.0
Discharge <small>m³/s</small>	[ | | | | . | ]	[ | | ]	140.0
Discharge Method: <input type="checkbox"/> measured (gauged) <input type="checkbox"/> obtained from rating curve <input type="checkbox"/> estimated: <input type="checkbox"/> no flow <input type="checkbox"/> trickle <input type="checkbox"/> >0.01 cumecs			

WEATHER: Rain in past week: Yes [] No [] Comments: _____
Today: Rain _____ Cloud cover _____ Wind _____
 Comments: _____

OBSERVATIONS AT WATER SAMPLING SITE (within 2 metres of sampling point or on closest bank)

Shading: _____ % Water Odour: _____

Water Surface Condition: Normal Slick Scum Foaming Other _____

Algae: On substrate: N L S M E In water column: N L S M E

Macrophytes: Emergent: N L S M E Submerged: N L S M E
 Floating: N L S M E

Impacts: Human N L S M E Pastoral animals N L S M E Non-pastoral animals N L S M E

N = none L = 1-10% (little) S = 10-50% (some) M = 50-75% (moderate) E = >75% (extensive)

PERCENT OF HABITAT TYPES IN 100 m REACH:

Riffle (R) [ | | ] %	Run [ | | ] %	Macrophytes [ | | ] % in: R _____ % E _____ %
Pool (rocky-K) [ | | ] %	Pool (sandy-S) [ | | ] %	K _____ % S _____ % Run _____ %
Dry [ | | ] %	Riffle + Run + Pool + Dry = 100%	Algae [ | | ] % in: R _____ % E _____ %
Edge [ | | ] %		K _____ % S _____ % Run _____ %
Edge is % of habitat available to sample from L and R banks		Blanketing silt [ | | ] %

COMMENTS: _____

(Office use only) Entered into Hydsys ____/____/____ by _____ Checked on ____/____/____ by _____
 Entered into AQEIS ____/____/____ by _____ Checked on ____/____/____ by _____

REACH OBSERVATIONS (of 100 m stream length)

Upstream landuse:

Adjacent landuse: Left bank: Score Type Right bank: Score Type

- | | |
|--|---------------------------------------|
| 0. Urban/semi-urban, industrial | 3. Light grazing, vegetation clearing |
| 1. Irrigated cropping, intensive forestry or heavy grazing | 4. Natural |
| 2. Non-irrigated cropping, moderate grazing | |

Local catchment erosion:	None	Little	Some	Moderate	Extensive
Water colour:	Clear	Green	Opaque	Tannin	Other
Sediment deposits:	None	Sand	Silt	Other	
Algae: On substrate:	None	Little	Some	Moderate	Extensive
In water column:	None	Little	Some	Moderate	Extensive
Water odour:	No	Yes	Specify		
Substrate odour:	No	Yes	Specify		
Water surface:	Normal	Slick	Scum	Foaming	Other
Variety of habitat: (circle all types)	Shallow	Deep	Pool	Run	Riffle
	Undercut bank		LWD	Macrophytes	Other

Bars: (bed surface protruding from normal water level and forming a bar) %

Flow level: (relative to 'watermark' i.e. normal inundation level shown by limit of terrestrial grasses, or by eroded area, or boundary in bank sediment types).

No flow	Low	Moderate	High	Flood
(dry/isolated)	(<watermark)	(=watermark)	(>watermark)	

RIPARIAN ZONE (to maximum 100 m width)

Width of riparian zone:		Left bank	m	Right bank	m
* Bare ground	None	Little	Some	Moderate	Extensive
* Grass	None	Little	Some	Moderate	Extensive
* Shrubs	None	Little	Some	Moderate	Extensive
* Trees <10 m high	None	Little	Some	Moderate	Extensive
* Trees >10 m high	None	Little	Some	Moderate	Extensive
Presence of exotic riparian species	None	Little	Some	Moderate	Extensive

Width of continuous tree zone from bank: Left bank m Right bank m

None = 0% Little = 1-10% Some = 10-50% Moderate = 50-75% Extensive >75% * Can add to >100%

MACROPHYTES Indicate the presence and abundance of the following common taxa in the 100 m reach:

Native											
Azolla	N	L	S	M	E	Water Ribbon (<i>Triglochin</i>)	N	L	S	M	E
Duckweed	N	L	S	M	E	Water Lettuce (<i>Pistia stratiotes</i>)	N	L	S	M	E
Hornwort (<i>Ceratophyllum</i>)	N	L	S	M	E	Water Primrose (<i>Ludwigia</i>)	N	L	S	M	E
Stoneworts (<i>Chara</i> or <i>Nitella</i>)	N	L	S	M	E	Sedge (<i>Cyperus</i>)	N	L	S	M	E
Hydrilla	N	L	S	M	E	Common Rush (<i>Juncus</i>)	N	L	S	M	E
Water Milfoil (<i>Myriophyllum</i>)	N	L	S	M	E	Cumbungi (<i>Typha</i>)	N	L	S	M	E
Pondweeds (<i>Potamogeton</i>)	N	L	S	M	E	Slender Knotweed (<i>Persicaria</i>)	N	L	S	M	E
Ribbonweed (<i>Vallisneria</i>)	N	L	S	M	E	.....	N	L	S	M	E
.....	N	L	S	M	E	.....	N	L	S	M	E
Exotic											
Water Hyacinth (<i>Eichhornia</i>)	N	L	S	M	E	Alligator Weed (<i>Alternanthera</i>)	N	L	S	M	E
Salvinia	N	L	S	M	E	Elodea	N	L	S	M	E
Para Grass (<i>Urochloa</i>)	N	L	S	M	E	<i>Egeria</i>	N	L	S	M	E
.....	N	L	S	M	E	.....	N	L	S	M	E

Comments:

N = none L = 1-10% (little) S = 10-50% (some) M = 50-75% (moderate) E = >75% (extensive)

STREAM SEDIMENT SAMPLING



Stream Sediment Sampling Field Sheet										
Site Number				Date and Time	/ / am / pm					
Coordinates										
Site Description										
Project Name				Sample Collector						
Photo No.										
Observations (circle where appropriate)										
Sediment Odour	None		Sulfides		Sewage		Petroleum		Algal	
Sediment Colour	Colourless	Green	Yellow	Red	Brown					
Composition	Cobble	Gravel	Sand	Silt	Clay					
Moisture	Dry	Damp	Standing Water			Flowing Water				
Comments										
Laboratory Analysis Required (circle appropriate)										
Filtering	Prior to Analysis		Sieve in field _____ Sieve in lab _____							
	Post Analysis		<input type="checkbox"/> Sieve <input type="checkbox"/> Hydrometer							
Physical parameters	Moisture		TOC		Nutrients					
Dissolved / Total toxicants	Ag	As	B	Ba	Be	Cd	CN	Co	Cr	Cu
	Al	Fe	Hg	Mn	Mo	Ni	Pb	Sb	Se	Zn
Other										

STREAM SEDIMENT SAMPLING

Stream Sediment Sampling Field Sheet			
Quality Control			
Duplicate Provided	Yes	No	Details:
Blank Provided	Yes	No	Details:
Quality Assurance			
<input type="checkbox"/>	Identified safety hazards and risks before commencing sampling		
<input type="checkbox"/>	Correct field equipment ie. bucket, shovel, GPS		
<input type="checkbox"/>	Correct sampling bottles / bags ie. no preservative / preservative added bottles		
<input type="checkbox"/>	Followed Environmental Monitoring Manual sampling procedure		
<input type="checkbox"/>	Field equipment calibrated		
<input type="checkbox"/>	Field Sheet completed		
<input type="checkbox"/>	Sample bottle / bag label completed		
<input type="checkbox"/>	Chain of Custody completed		

REMP RIPARIAN TRANSECT PROFORMA



Project:	Lake Vermont REMP		
Date:		Season:	
Recorder:			
Site:			
Easting:		Northing:	
Photo No:	Start (0m):		End (50m):

Site Location:	
Context:	
Notes:	

Altitude (m)	Erosion Pattern	Slope (°)	Transect Aspect

Disturbance	Severity*	Notes
Storm Damage:		
Road Works:		
Fire:		
Clearing:		
Grazing:		
Weeds	List species	
	Cover (%)	
Other:		

* 1 = minor, 2 = moderate, 3 = severe

Stream Cover	% Cover
Shading: Visually estimate the percentage of the stream area that would be shaded by riparian vegetation when the sun is directly overhead	
In-stream vegetation cover: Visually estimate the percentage of the stream area covered by instream vegetation (submerged, floating and emergent macrophytes)	

Veg Layer	E	T1	T2	T3	S1	S2	G
Height (m)*							

*measure at transect establishment, estimate during subsequent monitoring events.

REMP RIPARIAN TRANSECT PROFORMA



Recruitment	%
--------------------	---

*Proportion of ecologically dominant canopy species regenerating.

Canopy Coverage (<i>length of tape under canopy</i>)	Total (m)	%
<i>(example) 0 – 4, 8 – 13, 28 – 31, 45 – 48</i>	$= 15 / 50 * 100$	30
Canopy:		
Shrub:		

Vegetation Health*				
Dominant Species	Tip necrosis or chlorosis (leaf yellowing) (% length or % cover#)	Marginal necrosis or chlorosis (dark brown margins) (% width/area or % cover#)	Undulation / cupping	Anthocyanin accumulation (leaf redness) (% area or % cover#)
Canopy Tree species				
Shrub species				

*Visually assess three representative individuals of the dominant tree and shrub species.

#Indicate whether % leaf length or % crown cover has been assessed.

REMP RIPARIAN TRANSECT PROFORMA

Dominance (D, CD, A, O or ✓)							Species*	Sample #	Photo #
E	T1	T2	T3	S1	S2	G			
							Bare		
							Litter		
							Rock		
							1.		
							2.		
							3.		
							4.		
							5.		
							6.		
							7.		
							8.		
							9.		
							10.		
							11.		
							12.		
							13.		
							14.		
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							20.		
							21.		
							22.		
							23.		
							24.		
							25.		
							26.		
							27.		
							28.		
							29.		
							30.		
							31.		
							32.		

*Record all woody species and dominant non-woody species (50 m x 10 m plot).



MACROINVERTEBRATE SAMPLING FIELD SHEET

Site Number [ | | | | | ]	Sample Number [ | | | | | | | | | | | | | ]	
Site Name _____		
Project Code [ | | | | | ]	Date [ | / | / | | | ]	Time (24 hrs) [ | : | ]
Run Code [ | | | | | ]	Project Name _____	

EDGE/BACKWATER: Y [] N [] Collected by: [| |] Picked By: [| |] No. vials: [] QAQC Residue: Y [] N []
(average over 10 m sampled)

<p>Velocity (m/sec): max [•] min [•]</p> <p>Mean Sample Depth: [•] m</p> <p>Mean Wetted Width: [•] m</p> <p>Method: 10 m sweep [] _____ minutes random live-pick [] Other _____ []</p> <p>Canopy Cover: [] % Densiometer: [] %</p> <p>Shading: [] %</p> <p>Snags and LWD:</p> <table style="width: 100%; border-collapse: collapse;"> <tr><td>Detritus (leaves, twigs)</td><td>N</td><td>L</td><td>S</td><td>M</td><td>E</td></tr> <tr><td>Sticks (<2cm diam)</td><td>N</td><td>L</td><td>S</td><td>M</td><td>E</td></tr> <tr><td>Branches (<15cm diam)</td><td>N</td><td>L</td><td>S</td><td>M</td><td>E</td></tr> <tr><td>Logs (>15cm diam)</td><td>N</td><td>L</td><td>S</td><td>M</td><td>E</td></tr> </table>	Detritus (leaves, twigs)	N	L	S	M	E	Sticks (<2cm diam)	N	L	S	M	E	Branches (<15cm diam)	N	L	S	M	E	Logs (>15cm diam)	N	L	S	M	E	<p>Substrate Description:</p> <table style="width: 100%; border-collapse: collapse;"> <tr><td>Bedrock</td><td>[] %</td><td>Gravel (2 - 4 mm)</td><td>[] %</td></tr> <tr><td>Boulder (> 256 mm)</td><td>[] %</td><td>Sand (0.05 - 2 mm)</td><td>[] %</td></tr> <tr><td>Cobble (64 - 256 mm)</td><td>[] %</td><td>Silt/Clay (<0.05 mm)</td><td>[] %</td></tr> <tr><td>Pebble (4 - 64 mm)</td><td>[] %</td><td></td><td></td></tr> </table> <p>Habitat Attributes:</p> <table style="width: 100%; border-collapse: collapse;"> <tr><td>Periphyton</td><td>N</td><td>L</td><td>S</td><td>M</td><td>E</td></tr> <tr><td>Moss</td><td>N</td><td>L</td><td>S</td><td>M</td><td>E</td></tr> <tr><td>Filamentous algae</td><td>N</td><td>L</td><td>S</td><td>M</td><td>E</td></tr> <tr><td>Macrophytes</td><td>N</td><td>L</td><td>S</td><td>M</td><td>E</td></tr> <tr><td>Bank overhang vegetation</td><td>N</td><td>L</td><td>S</td><td>M</td><td>E</td></tr> <tr><td>Trailing bank vegetation (tree roots, vegetation, grasses, etc)</td><td>N</td><td>L</td><td>S</td><td>M</td><td>E</td></tr> <tr><td>Blanketing silt</td><td>N</td><td>L</td><td>S</td><td>M</td><td>E</td></tr> <tr><td>Substrate anoxia</td><td>N</td><td>L</td><td>S</td><td>M</td><td>E</td></tr> </table>	Bedrock	[] %	Gravel (2 - 4 mm)	[] %	Boulder (> 256 mm)	[] %	Sand (0.05 - 2 mm)	[] %	Cobble (64 - 256 mm)	[] %	Silt/Clay (<0.05 mm)	[] %	Pebble (4 - 64 mm)	[] %			Periphyton	N	L	S	M	E	Moss	N	L	S	M	E	Filamentous algae	N	L	S	M	E	Macrophytes	N	L	S	M	E	Bank overhang vegetation	N	L	S	M	E	Trailing bank vegetation (tree roots, vegetation, grasses, etc)	N	L	S	M	E	Blanketing silt	N	L	S	M	E	Substrate anoxia	N	L	S	M	E
Detritus (leaves, twigs)	N	L	S	M	E																																																																																				
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N = none L = 1-10% (little) S = 10-50% (some) M = 50-75% (moderate) E = >75% (extensive)

BED: Y [] N [] Collected by: [| |] Picked By: [| |] No. vials: [] QAQC Residue: Y [] N []
TYPE: Riffle [] Run [] Pool (rocky/gravel) [] Pool (sandy/silty) []
 (average over 10 m sampled)

<p>Velocity (m/sec): max [•] min [•]</p> <p>Mean Sample Depth: [•] m</p> <p>Mean Wetted Width: [•] m</p> <p>Method: 10 m kick only [] 10 m kick & gleaning rocks of different sizes (5) [] _____ minutes random live-pick [] Other _____ []</p> <p>Canopy Cover: [] % Densiometer: [] %</p> <p>Shading: [] %</p> <p>Snags and LWD:</p> <table style="width: 100%; border-collapse: collapse;"> <tr><td>Detritus (leaves, twigs)</td><td>N</td><td>L</td><td>S</td><td>M</td><td>E</td></tr> <tr><td>Sticks (<2cm diam)</td><td>N</td><td>L</td><td>S</td><td>M</td><td>E</td></tr> <tr><td>Branches (<15cm diam)</td><td>N</td><td>L</td><td>S</td><td>M</td><td>E</td></tr> <tr><td>Logs (>15cm diam)</td><td>N</td><td>L</td><td>S</td><td>M</td><td>E</td></tr> </table>	Detritus (leaves, twigs)	N	L	S	M	E	Sticks (<2cm diam)	N	L	S	M	E	Branches (<15cm diam)	N	L	S	M	E	Logs (>15cm diam)	N	L	S	M	E	<p>Substrate Description:</p> <table style="width: 100%; border-collapse: collapse;"> <tr><td>Bedrock</td><td>[] %</td><td>Gravel (2 - 4 mm)</td><td>[] %</td></tr> <tr><td>Boulder (> 256 mm)</td><td>[] %</td><td>Sand (0.05 - 2 mm)</td><td>[] %</td></tr> <tr><td>Cobble (64 - 256 mm)</td><td>[] %</td><td>Silt/Clay (<0.05 mm)</td><td>[] %</td></tr> <tr><td>Pebble (4 - 64 mm)</td><td>[] %</td><td></td><td></td></tr> </table> <p>Habitat Attributes:</p> <table style="width: 100%; border-collapse: collapse;"> <tr><td>Periphyton</td><td>N</td><td>L</td><td>S</td><td>M</td><td>E</td></tr> <tr><td>Moss</td><td>N</td><td>L</td><td>S</td><td>M</td><td>E</td></tr> <tr><td>Filamentous algae</td><td>N</td><td>L</td><td>S</td><td>M</td><td>E</td></tr> <tr><td>Macrophytes</td><td>N</td><td>L</td><td>S</td><td>M</td><td>E</td></tr> <tr><td>Bank overhang vegetation</td><td>N</td><td>L</td><td>S</td><td>M</td><td>E</td></tr> <tr><td>Trailing bank vegetation (tree roots, vegetation, grasses, etc)</td><td>N</td><td>L</td><td>S</td><td>M</td><td>E</td></tr> <tr><td>Blanketing silt</td><td>N</td><td>L</td><td>S</td><td>M</td><td>E</td></tr> <tr><td>Substrate anoxia</td><td>N</td><td>L</td><td>S</td><td>M</td><td>E</td></tr> </table>	Bedrock	[] %	Gravel (2 - 4 mm)	[] %	Boulder (> 256 mm)	[] %	Sand (0.05 - 2 mm)	[] %	Cobble (64 - 256 mm)	[] %	Silt/Clay (<0.05 mm)	[] %	Pebble (4 - 64 mm)	[] %			Periphyton	N	L	S	M	E	Moss	N	L	S	M	E	Filamentous algae	N	L	S	M	E	Macrophytes	N	L	S	M	E	Bank overhang vegetation	N	L	S	M	E	Trailing bank vegetation (tree roots, vegetation, grasses, etc)	N	L	S	M	E	Blanketing silt	N	L	S	M	E	Substrate anoxia	N	L	S	M	E
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N = none L = 1-10% (little) S = 10-50% (some) M = 50-75% (moderate) E = >75% (extensive)

Comments

.....

.....

.....

TOTAL NO. VIALS: _____ **OTHERS:** _____

1. LONGITUDINAL PROFILE SKETCH OF STREAM REACH

Scale: _____

Please indicate on sketch and tick off each item when completed.

- | | |
|---|---|
| <input type="checkbox"/> Biological sampling sites for each habitat type. | <input type="checkbox"/> Flow direction |
| <input type="checkbox"/> Water quality measurement and water sample collection sites. | <input type="checkbox"/> Location of cross-sectional profile sketch. |
| <input type="checkbox"/> Location from where photograph(s) taken. | <input type="checkbox"/> Riparian vegetation (include approx. heights). |
| | <input type="checkbox"/> Riparian zone width. |

2. CROSS-SECTIONAL PROFILE SKETCH OF STREAM REACH

Scale: _____

Please indicate on sketch and tick off each item when completed.

- | | | | |
|--|--|---|--------------------------------------|
| <input type="checkbox"/> Bankfull bank height | <input type="checkbox"/> Stream wetted width | <input type="checkbox"/> Riparian vegetation height | <input type="checkbox"/> Water depth |
| <input type="checkbox"/> Bankfull stream width | <input type="checkbox"/> "Normal" wetted width | <input type="checkbox"/> Riparian zone width | |

3. COMMENTS

AEF007

River Bioassessment Program



Queensland
Government
Natural Resources
and Mines

HABITAT ASSESSMENT FIELD SHEET

SITE NUMBER: [| | | | |] **SITE NAME:** _____

Date: ___/___/___ **Time (24 hrs):** [| | |] **GPS:** _____ **Project Name:** _____

Habitat Variable	CATEGORY			
	Excellent	Good	Fair	Poor
1. Bottom substrate/available cover	Greater than 50% rubble, gravel, submerged logs, undercut banks or other stable habitat. 20, 19, 18, 17, 16	30-50% rubble, gravel or other stable habitat. Adequate habitat. 15, 14, 13, 12, 11	10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. 10, 9, 8, 7, 6	Less than 10% rubble, gravel or stable habitat. Lack of habitat is obvious. 5, 4, 3, 2, 1, 0
2. Embeddedness	Gravel, cobble and boulder particles are between 0 & 25% surrounded by fine sediment. 20, 19, 18, 17, 16	Gravel, cobble and boulder particles are between 25% & 50% surrounded by fine sediment. 15, 14, 13, 12, 11	Gravel, cobble and boulder particles are between 50 & 75% surrounded by fine sediment. 10, 9, 8, 7, 6	Gravel, cobble and boulder particles are over 75% surrounded by fine sediment. 5, 4, 3, 2, 1, 0
3. Velocity/depth category	Slow deep (<0.3 m/s & >0.5 m); slow shallow; fast deep; fast shallow; habitats all present. 20, 19, 18, 17, 16	Only 3 of the four habitat categories present (missing riffles or runs receive lower score than missing pools). 15, 14, 13, 12, 11	Only two of the four habitat categories present (missing riffles/runs receive lower score). 10, 9, 8, 7, 6	Dominating by one velocity/depth category (usually pool). 5, 4, 3, 2, 1, 0
4. Channel alteration	Little or no enlargement of islands or point bars and/or no channelisation. 15, 14, 13, 12	Some new increase in bar formation, mostly from coarse gravel; and/or some channelisation present. 11, 10, 9, 8	Moderate deposition of new gravel, coarse sand, on old and new bars; pools partly filled with silt; and/or embankments on both banks. 7, 6, 5, 4	Heavy deposits of fine materials, increased bar development; most pools filled with silt; and/or extensive channelisation. 3, 2, 1, 0
5. Bottom scouring and deposition	Less than 5% of the bottom affected by scouring and deposition. 15, 14, 13, 12	5-30% affected. Scours at constrictions and where grades steepen, some deposition in pools. 11, 10, 9, 8	30-50% affected. Deposits and scours at obstructions and bends. Some deposition in pools. 7, 6, 5, 4	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. Only large rocks in riffle exposed. 3, 2, 1, 0

DU50340RSC.P45 (LM3883) 20/8/98

River Bioassessment Program



HABITAT ASSESSMENT FIELD SHEET cont.

Habitat Variable	CATEGORY			
	Excellent	Good	Fair	Poor
6. Pool/riffle, run/bend ratio. <i>(Distance between riffles divided by stream width)</i>	0-7 Variety of habitat. Deep riffles and pools. <p style="text-align: center;">15, 14, 13, 12</p>	7-15 Adequate depth in pools and riffles. Bends provide habitat. <p style="text-align: center;">11, 10, 9, 8</p>	15-25 Occasional riffle or bend. Bottom contours provide some habitat. <p style="text-align: center;">7, 6, 5, 4</p>	>25 Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. <p style="text-align: center;">3, 2, 1, 0</p>
7. Bank stability	Stable. No evidence of erosion or bank failure. Side slopes generally <30%. Little potential for future problem. <p style="text-align: center;">10, 9</p>	Moderately stable. Infrequent, small areas of erosion mostly healed over. Side slopes up to 40% on one bank. Slight potential in extreme floods. <p style="text-align: center;">8, 7, 6</p>	Moderately unstable. Moderate frequency and size of erosional areas. Side slopes up to 60% on some banks. High erosion potential during extreme/high flows. <p style="text-align: center;">5, 4, 3</p>	Unstable. Many eroded areas. Side slopes > 60% common. 'Raw' areas frequent along straight sections and bends. <p style="text-align: center;">2, 1, 0</p>
8. Bank vegetative stability	Over 80% of the streambank surfaces covered by vegetation or boulders and cobble. <p style="text-align: center;">10, 9</p>	50-79% of the streambank surfaces covered by vegetation, gravel or larger material. <p style="text-align: center;">8, 7, 6</p>	25-49% of the streambank covered by vegetation, gravel or larger material. <p style="text-align: center;">5, 4, 3</p>	Less than 25% of the streambank surfaces covered by vegetation, gravel or larger material. <p style="text-align: center;">2, 1, 0</p>
9. Streamside cover	Dominant vegetation is of tree form. <p style="text-align: center;">10, 9</p>	Dominant vegetation shrub. <p style="text-align: center;">8, 7, 6</p>	Dominant vegetation is grass, sedge, ferns. <p style="text-align: center;">5, 4, 3</p>	Over 50% of the streambank has no vegetation and dominant material is soil, rock, bridge materials, culverts, or mine tailings. <p style="text-align: center;">2, 1, 0</p>

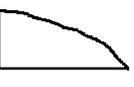
Column Totals				
----------------------	--	--	--	--

Score



Bank shape

Choose one category for each bank

		Left bank	Right bank
	Concave	<input type="checkbox"/>	<input type="checkbox"/>
	Convex	<input type="checkbox"/>	<input type="checkbox"/>
	Stepped	<input type="checkbox"/>	<input type="checkbox"/>
	Wide lower bench	<input type="checkbox"/>	<input type="checkbox"/>
	Undercut	<input type="checkbox"/>	<input type="checkbox"/>

Factors affecting bank stability

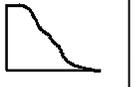
Choose one or more categories

- | | |
|--|---|
| <input type="checkbox"/> None | <input type="checkbox"/> Cleared vegetation |
| <input type="checkbox"/> Mining | <input type="checkbox"/> Irrigation draw-down |
| <input type="checkbox"/> Runoff | <input type="checkbox"/> Reservoir releases |
| <input type="checkbox"/> Stock access | <input type="checkbox"/> Seepage |
| <input type="checkbox"/> Human access | <input type="checkbox"/> Flow and waves |
| <input type="checkbox"/> Ford, culvert or bridge | <input type="checkbox"/> Drainpipes |
| <input type="checkbox"/> Feral animals | |
| <input type="checkbox"/> Other | |

Description _____

Bank slope

Choose one category for each bank

		Left bank	Right bank
	Vertical 80 - 90°	<input type="checkbox"/>	<input type="checkbox"/>
	Steep 60 - 80°	<input type="checkbox"/>	<input type="checkbox"/>
	Moderate 30 - 60°	<input type="checkbox"/>	<input type="checkbox"/>
	Low 10 - 30°	<input type="checkbox"/>	<input type="checkbox"/>
	Flat <10°	<input type="checkbox"/>	<input type="checkbox"/>

Bedrock outcrops

Assess % of each bank covered by bedrock outcrops

% bedrock outcrops Left bank _____
 Right Bank _____

Artificial bank protection measures

Choose one or more categories

- | | |
|--|---|
| <input type="checkbox"/> None | <input type="checkbox"/> Fenced stock watering points |
| <input type="checkbox"/> Fence structures | <input type="checkbox"/> Vegetation plantings |
| <input type="checkbox"/> Levee banks | <input type="checkbox"/> Logs strapped to bank |
| <input type="checkbox"/> Rock or wall layer | <input type="checkbox"/> Concrete channel lining |
| <input type="checkbox"/> Rip rap | |
| <input type="checkbox"/> Fenced human access | |
| <input type="checkbox"/> Other | |

Sediment oils

- absent light moderate profuse

Water oils

- none flecks globs sheen slick

Sediment odours

- normal/none sewage petroleum chemical
 anaerobic other _____

Water odours

- normal/none sewage petroleum chemical
 other _____

Turbidity (visual assessment)

- Clear Slight Turbid Opaque

↓ ↓ ↓
 Is water clarity reduced by:

- Suspended material (e.g mud, clay, organics) Dissolved material (e.g plant leachates)

Water level at the time of sampling

- Dry No flow Low Baseflow or near baseflow
 High Flood (don't sample)

Artificial features at the sampling site

Choose one or more categories

- Major Minor Ford Bridge Culvert Other weir

Description _____

Large woody debris

Overall % cover of logs and branches greater than 10cm in diameter
 _____ % Notes on visibility _____

REMP Erosion Observations							
Sampling Date:							
Sampling Site:							
Photo No.							
Bare Ground Note the extent of bare ground including eroded areas or those not supporting vegetation, due to some form of disturbance that would otherwise be expected to be vegetated.							
Exposed Tree Roots Note whether tree roots are exposed due to any disturbances.							
Gully Erosion Record any visible gully erosion adjacent to the watercourse.							
Bank Slumping Record any evidence of slumping banks along the watercourse.							
Local Catchment Erosion Note the erosion in the surrounding catchment on the approach to the site.							

Note: Observations to be scored according to the following categories [None, Little (1-10%), Some (10-50%), Moderate (50-75%), or Extensive (= >75%)]

Appendix B JBT Consulting IESC Response - Groundwater

Our reference: JBT01-036-005-IESC Response.docx

19 May 2017

Carl Pritchard
General Manager - Technical Services
Jellinbah Group Pty Ltd
Level 7, 12 Creek Street
Brisbane Qld 4001 Australia

Groundwater Summary – Lake Vermont Northern Extension

1. Introduction

Bowen Basin Coal Pty Ltd (BBC) received a letter¹ from the Independent Expert Scientific Committee (IESC) that provided advice to the decision maker (Department of the Environment and Energy) with respect to the Lake Vermont Coal Mine Northern Extension. BBC has commissioned JBT Consulting Pty Ltd (JBT) to prepare a response to the elements of the IESC advice that relate to groundwater.

The response is provided in Section 2 below; the numbered IESC comments/advice that relate to groundwater are provided in italics, with the JBT response provided below.

2. IESC Advice and Response

1. *Additional collection and analysis of site-specific baseline data are required to support development of robust geological and hydrogeological conceptualisation and models, and to estimate the likely impacts. Consideration should be given to:*
 - a. *Site-specific monitoring and analysis of baseline data (water levels and water quality) for surface water and groundwater*
 - b. *Obtaining data to assess the spatial and temporal variability of the surface water/groundwater interactions of Phillips Creek, Lake Vermont Wetland and Downs Creek within the project site over (ideally) a two-year period to conceptualise how these will be affected by the project*

Response

A groundwater monitoring program has been proposed that provides for an additional ten (10) standpipe monitoring bores at six sites. In addition, it is understood that BBC have committed to the construction of an additional two groundwater monitoring bores, one to monitor groundwater conditions adjacent to the Phillips Creek wetland and another to monitor groundwater adjacent to Lake Vermont.

The proposed program comprises a combination of existing vibrating wire piezometer (VWP) bores (for monitoring of water level) and standpipe bores (for monitoring of both water level and water quality). The network has been designed to monitor the major groundwater units that are to be mined or impacted at site and to give adequate spatial and vertical coverage across the site. The proposed network is illustrated in Figure 1 below and the proposed standpipe monitoring bores and target lithology are listed in Table 1.

¹ IESC document 2015-080: Lake Vermont Coal Mine Northern Expansion (EPBC2016/7701)-Expansion. Final Lake Vermont Coal Mine Northern Extension Project Advice, 11 November 2016.



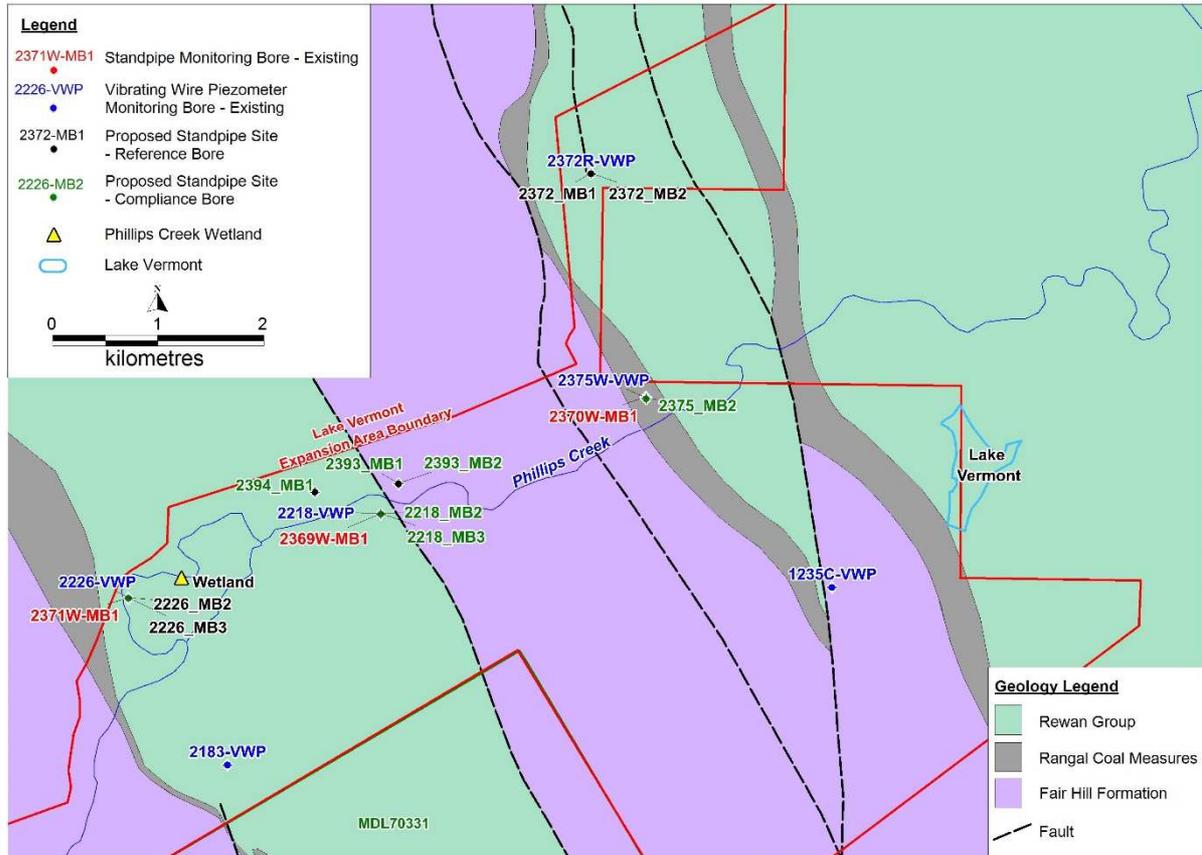


Figure 1: Proposed Groundwater Monitoring Bores

Table 1: Proposed Groundwater Monitoring Locations – Standpipe Monitoring Bores

Bore ID	Target Lithology	Easting (AGD84)	Northing (AGD84)	Ground Level (mAHD)
2371W-MB1	Tertiary Sediments	643131	7521947	178.92
2226-MB2	Rewan Group	643129	7521950	178.84
2226-MB3	Leichhardt Seam	643129	7521950	178.84
2372-MB1	Rewan Group	647515	7526007	166.91
2372-MB2	Vermont Seam			
2393-MB1	Leichhardt Seam	645693	7523043	173.24
2393-MB2	Vermont Lower Seam			
2394-MB1	Rewan Group	644898	7522962	173.96
2375-MB2	Vermont Seam	648040	7523865	168.36
2218-MB2	Rewan Group	645526	7522753	173.29
2218-MB3	Leichhardt Seam			



-
2. *Site-specific geological and hydrogeological data are required to inform the hydrogeological conceptualisation*

Response

Refer response to (1) above.

4. *The groundwater quality and level/pressure data in the assessment are inadequate to define baseline conditions. Baseline conditions for groundwater quality on site were derived from a desktop study of the Department of Natural Resources and Mines (DNRM) database and three samples from site bores. The groundwater level data presented are based on six geographical bore locations, with a maximum of four observations per bore that were taken during generally drier months. There is no identification of groundwater elevation, pressure contours or flow paths. Much of the groundwater assessment is based on inferences with little or no reference to data.*

Response

Refer response to (1) above.

5. *The conclusions about the surface water/groundwater interactions at Lake Vermont Wetland are based on inadequate data from one bore location that is approximately 300 metres to the south-west of the wetland.*

Response

Refer response to (1) above.

8. *East Pit and B Pit final voids potentially intersect faults and there is inadequate discussion in relation to the nature and hydrogeological characteristics of the relevant faults. It is unclear whether the potentially intersecting faults may enable movement of contaminated groundwater out of the final voids or promote loss of water from the aquifers*

Response

The nature of faulting in the Lake Vermont area has been observed from fault exposures in the existing Lake Vermont Mine, where it has been noted that the faults tend to be dry and do not act as conduits for groundwater seepage. Exceptions may occur in shallow areas (generally < 50 m from surface) of the existing Lake Vermont pit, where joints and faults can be opened to some extent by relaxation of the Permian strata adjacent to the pit and minor seepage may be observed along joints and faulted contacts following wet season rainfall. However, within the Lake Vermont area and the Bowen Basin generally, it tends to be the coal seams that act as conduits for groundwater flow and the interburden tends to be dry; therefore, faulting is interpreted to impede groundwater flow in instances where the faults displace the coal seams to the extent that the full thickness of the coal seam abuts interburden. These observations have been modelled in the existing 2-dimensional groundwater flow models, which are based on information from the site geological model within the mining area. The site geological model includes the dip and displacement of mapped faults and this fault data has been accurately represented within the 2-dimensional groundwater flow models. In addition, the coal seams, and the displacement of these seams due to faulting, has been accurately represented within the existing groundwater flow



model allowing the impact of faulting on groundwater flow towards the pits to be assessed. It is therefore concluded that the impacts of faults of groundwater movement and flow have already been assessed.

10. *Cumulative impacts of multiple final voids are not addressed in the groundwater model. The model does not adequately represent the interaction of all three project voids (either during mining or post-mining) as only two are included in the model construction. Additionally, differentiation is needed between the mine voids in the approved Lake Vermont mine and the proposed voids in the project area to enable assessment of potential cumulative impacts*

Response

The existing 2-dimensional groundwater flow models include representation of final voids in areas where the voids are deepest. The north-south cross section model included representation of observed conditions in the existing Lake Vermont void as part of the calibration process, with the north-south section then representing the eastward extension of the existing Lake Vermont void at its deepest location. Therefore it is considered that the impacts of the existing Lake Vermont Mine, as well as the impacts of the existing mining area at its deepest eastern extension, have already been considered by the modelling process.

Refer to the response under (14) below for additional discussion of modelling.

14. *There is inadequate consideration of the project's contribution to cumulative impacts associated with other mining activities. The proponent's assessment of cumulative impacts could be improved through:*
- a. *Consideration of the Arrow Energy Bowen Gas Project, the closed Norwich Park Coal mine and the recently proposed Saraji Underground Mine located approximately 8 km north-west of the project.*
 - b. *A quantification of the impact on groundwater levels and water quality of the three proposed project voids and the two voids associated with the approved Lake Vermont Mine.*

Response

The following comments are made with respect to the assessment of groundwater cumulative impacts:

- The groundwater assessment included consideration of the projects that were known at the time. These included:
 - The Arrow Energy Underground Water Impact Report for Authority to Prospect 1031, which covers the Lake Vermont Northern Extension project area. The report included analytical modelling of coal seam gas (CSG) well impacts for individual CSG wells but contained no detail of drawdown estimates in the Lake Vermont Northern Extension area. Therefore, there was no defined impact to assess in the case of the Arrow Energy CSG wells;
 - Mining operations located to the west of the project area. All mining operations that are located near Lake Vermont (e.g. Norwich Park to the south (now closed), the existing Saraji open cut and proposed Saraji East underground mine) to the west, mine coal from the Moranbah Coal Measures. The Moranbah Coal Measures are a stratigraphically lower sequence than the Rangal Coal Measures that are mined at Lake Vermont and the units are separated by the siltstone, mudstone and sandstone sequence of the Fort Cooper Coal Measures (Fair Hill



Formation). Therefore, whilst the Moranbah Coal Measures exist beneath the Lake Vermont Mine, they occur at significant depth (due to the overall dip of the strata to the ENE) and are separated from the overlying Rangal Coal Measures (the target unit for mining at Lake Vermont) by sediments of the Fort Cooper Coal Measures (Fair Hill Formation).

- As such it is concluded that there are no cumulative impacts to be assessed
15. *The groundwater and surface water modelling does not appropriately estimate the project's environmental impacts on water resources. All aspects of the groundwater modelling require review as the groundwater modelling is not fit for purpose. Suggested improvements to the modelling are outlined below*

Response

Refer to response under (16) below.

16. *A full site-specific hydrogeological investigation is required, targeting and identifying both the local and regional groundwater systems in the vicinity of the proposed project and potential connectivity between these systems and surface water. This should include:*
- a. *Collection of site-specific groundwater level and quality data and testing to determine site-specific aquifer hydraulic parameters. Additional groundwater modelling bores screened in the shallow sediments to identify potential shallow groundwater around the edge of Lake Vermont Wetland and along Phillips Creek. Additional bores screened within relevant hydrostratigraphic units are also required to enable water quality sampling and water level monitoring*
 - b. *Hydrogeological characterisation of faults including the type, severity and penetration of faults and their influence on groundwater flow*
 - c. *The conceptualisation of the groundwater system both at local and regional scales should be revisited, with newly-collected site-specific data incorporated*
 - d. *A 3-dimensional groundwater model should be developed following the procedure outlined in the Australian Groundwater Modelling Guidelines (Barnett et al 2012). Development and parameterisation of this model must be informed by the site-specific data collected during the hydrogeological investigation outlined above. This model can then be used to predict mining-induced changes, assess changes to surface water/groundwater interactions and to undertake a quantitative assessment of cumulative impacts*

Response

Refer the response to (1) above for point 16 (a).

Refer to the response to (8) above for point 16 (b).

With respect to points (c) and (d) and point (15) above, the following comments are made:

- To estimate the extent of water level impact from the proposed project, 2-dimensional seepage modelling has been undertaken using the program Seep/W. The choice of model code has been based on an assessment of the model platform that would be appropriate to the study requirements.



The selection of model code was discussed in the groundwater impact assessment report and relevant points are repeated and/or expanded upon below.

- A number of factors are assessed when choosing the appropriate modelling platform for a particular groundwater modelling study. Factors that are relevant to the Lake Vermont study include:
 - The ability of the model to represent the essential elements of the conceptual groundwater model. At Lake Vermont this includes the ability of the model to accurately represent the complexity of the geology. This includes faulting of strata, which acts to compartmentalise the geological and hydrogeological units, as faulting has the potential to significantly impact groundwater occurrence and flow; and,
 - The ability of the model to adequately address the requirements of the scope of work. At Lake Vermont this includes assessment of the extent of groundwater level impact from mining, as well as assessment of the potential impact of groundwater level changes on any connected surface water and groundwater dependant ecosystems.
- Based on assessment of the model requirements, including representation of the essential elements of the conceptual groundwater model, it was concluded that 2-dimensional cross-section modelling would be appropriate for the Lake Vermont project and on that basis the model Seep/W was selected. The use of a 2-dimensional Seep/W cross section model was assessed to be appropriate to this investigation for the following reasons:
 - The geology of the mining area is complex, and includes a number of local-scale and regional-scale faults which significantly disrupt the strata, including the coal seams through which groundwater flow occurs. It is possible within a 2-dimensional model to reproduce complex cross-sectional geology, whereas such detail could not be included practically within a 3-dimensional model;
 - The existing 2-dimensional groundwater models are accurate representations of the site geology in cross-section and include distinct representation (in terms of unit thickness, hydraulic properties and displacement by faulting). The level of detail that can be represented within a 2-dimensional cross section model is far greater than can be represented within a regional 3-dimensional model;
 - Seep/W is designed to simulate flow in both the saturated zone and the unsaturated zone. When mining occurs below the phreatic surface an unsaturated zone is induced in the pit walls as seepage to the excavation occurs. Seep/W is well suited to investigation of groundwater level impacts resulting from seepage to open pits, particularly for projects such as Lake Vermont where mine dewatering via bores does not occur, and seepage to the excavation is the only means via which the mine removes water from the groundwater system;
 - In open cut mines groundwater storage conditions transition from confined to unconfined in the zone adjacent to the pit walls. Seep/W models the rate of drainage to an excavation via a property called the volumetric water content, which is able to accurately account for the rate of groundwater flow and the rate of change of the phreatic surface as groundwater conditions transition from confined to unconfined and gravity drainage of the groundwater unit occurs to the excavation. Seep/W is able to model this important element of the groundwater system



much more accurately than many other groundwater flow models (including 3-dimensionation models such as Modflow); and,

- It was assessed that one of the main purposes of the model was to investigate the rate and extent of groundwater level drawdown in response to mining, especially in areas of potentially connected surface water and groundwater systems. This can be readily (and potentially more accurately) achieved through the use of a 2-dimensional cross section models;
- Each model type (2-dimensional vs. 3-dimensional) has inherent strengths and weakness and an assessment must be made at the start of the modelling process to determine the most appropriate model type for the project. The following observations are made with respect to 2-dimensional vs 3-dimensional models:
 - It is acknowledged that the representation of multiple mining pits is a 3-dimensional problem in many respects; however, the complex 3-dimensional flow patterns tend to be observed within the mining footprint and at a more regional scale (i.e. beyond the outer limits of the mining area) groundwater flow lines will tend to be directed towards the pits (i.e. there will be radial groundwater flow that is directed towards the pit voids). Therefore, at a more regional scale a 2-dimensional model that is oriented along a flow line can still provide an accurate representation of groundwater level impacts;
 - 3-dimensional groundwater models generally require simplification of the geology, both in terms of model layering and representation of structures such as faults. The complex faulted geometry, folding of strata, representation of individual coal seams (which are the main conduits for groundwater flow), truncation of coal seams by faults, etc. that is encountered at Lake Vermont can be accurately represented in a 2-dimensional model, whereas the representation of complex geology and structure is unlikely to be adequately achieved in a 3-dimensional model;
 - The geological and hydrogeological relationship in the area of surface water features can be more accurately represented in a cross-sectional model than in a 3-dimensional model;
 - The periodic wetting and drying of ephemeral surface water features, as well as flow in the unsaturated zone, can also be better studied via the use of detailed 2-dimensional cross-sectional models than regional 3-dimensional models, where surface water features may be represented by only one or two model cells;
- The choice of model should also reflect the scale of the project. The Lake Vermont Northern Extension is not a new mine in a previously unmined area; rather the project represents an extension of the existing Lake Vermont Mine. The choice of 2-dimensional modelling software was assessed to be appropriate to the scale of the Lake Vermont Northern Extension project and to provide distinct advantages (especially with respect to delineation of complex geology and structure) compared to a 3-dimensional model. It is our opinion that undertaking 3-dimensional modelling would be an exercise that would be unlikely to yield additional information in the areas of primary concern, that is the Phillips Creek wetland and Lake Vermont. Instead, it is our recommendation that the following approach be adopted:



- Additional groundwater monitoring bores be drilled as per the groundwater monitoring strategy, which should include the drilling of bores adjacent to Lake Vermont and the Phillips Creek wetland;
 - Water level monitoring be undertaken over wet season/dry season periods;
 - Data loggers should be fitted to the bores adjacent to Lake Vermont and Phillips Creek, to allow assessment of groundwater changes in response to rainfall;
 - Surface water monitoring should be undertaken at both the Phillips Creek wetland and Lake Vermont to allow correlation between surface water and groundwater levels and conditions at these features;
 - If it is assessed that the impacts of mining on these surface water features requires further assessment, additional 2-dimensional groundwater modelling should be undertaken.
19. *The proposed monitoring program is not adequate to establish onsite baseline conditions and identify potential impacts to groundwater and surface water resources. Consideration should be given to the following:*
- a. *Development of a robust onsite groundwater monitoring program that is spatially and temporally representative of the local and regional groundwater systems. This should include:*
 - (i) *Installing piezometers in all hydrostratigraphic units that have the potential to be impacted by the project. Particular areas to target and monitor include the shallow alluvium along Phillips Creek, Lake Vermont Wetland and the Isaac River alluvium adjacent to Satellite Pit. Control or reference bores should be installed and monitored in areas that will not be affected by mine activities.*
 - (ii) *Field testing for hydrogeological characteristics such as hydraulic conductivity and storativity, in relevant hydrostratigraphic units. This is needed for 3-dimensional numerical model parameterisation.*
 - (iii) *Frequent monitoring (e.g. monthly) of groundwater of levels and quality for a range of analytes including physical parameters, metal and ionic composition.*

Response

Refer the response to (1) above.

20. *In addition to the groundwater and surface water modelling updates described in the response to Question 3, information that would assist in the identification and assessment of impacts includes:*
- a. *Further assessment of the groundwater environment, particularly around Phillips Creek and the Lake Vermont Wetland. This could include the installation of additional monitoring wells targeted at identifying the nature and magnitude of the potential impacts of drawdown, and bores screened in the shallow alluvium. Data loggers could be installed to provide improved temporal resolution of changes in groundwater level.*



- b. Assessment and additional information regarding the protection of the Pit B and Satellite Pit final voids from the 1 in 1000 AEP event in Phillips Creek and Isaac River. Including geotechnical engineering studies to determine the long term integrity of the levees.*
- c. Additional information on the influence of faults on groundwater flow as this is an area of considerable uncertainty given the location and potential risks associated with the final voids.*

Response

Refer the response to (1) and (16) above for point 20 (a).

Refer to the response to (8) above for point 20 (c).

21. Responses to the previous questions indicate that the impact analysis is such that substantial uncertainty remains regarding the nature and scale of potential impacts. This uncertainty would be partly addressed by gathering additional monitoring information as recommended in the response to Question 6. Additional measures and commitments that could assist to monitor, mitigate and manage impacts to water resources include:

- a. A detailed groundwater monitoring and management plan for the project that outlines monitoring procedures and specific sampling locations, identifies appropriate groundwater level and water quality triggers, and identifies response actions for trigger exceedances.*

Response

The groundwater monitoring network and groundwater management plan is in the process of being finalised

Please contact the undersigned if you have any queries in relation to this letter.

Yours Faithfully,



John Bradley
Principal Hydrogeologist
JBT Consulting Pty Ltd

Appendix C WRM IESC Response – Surface Water

0622-19-B1

Carl Pritchard
Lake Vermont Resources
Level 7 12 Creek Street
Brisbane Qld 4001

23 June 2017

**Subject: Lake Vermont Mine Northern Extension Project -
Response to surface water advice of
Independent Expert Scientific Committee on Coal Seam
Gas and Large Coal Mining Development**

Dear Carl,

This letter responds to various issues raised by the Independent Expert Scientific Committee (IESC) on Coal Seam Gas and Large Coal Mining Development on aspects of the surface water assessment of the Lake Vermont Mine Northern Extension Project (LVNEP).

The Committee has requested additional information to assist in the identification and assessment of impacts to water resources. We understand the key surface water-related areas are as follows (from the Committee's response (20) to Question 6):

- b. Assessment and additional information regarding the protection of the Pit B and Satellite Pit final voids from the 1 in 1000 AEP event in Phillips Creek and Isaac River.*
- d. Assessment of potential changes to the water regime of the Lake Vermont Wetland as a result of the reduction in reporting catchment area.*
- e. Assessment of potential impacts on water quality in receiving waters as a result of overflows from sediment dams.*
- f. Geochemical characterisation of waste rock to enable an adequate assessment of salinity, acid-forming materials and other contaminants that have the potential to contaminate sediment dam water, which is anticipated to be released offsite.*

These issues are further clarified in response (17), which recommends the following surface water assessments be undertaken to better estimate the project's environmental impacts:

- a. Model the surface water regime at Lake Vermont Wetland. A model of the water regime should identify:
 - i. Peak inflows*
 - ii. Volume, duration, frequency and seasonality of inflows*
 - iii. Water depths (seasonal averages)*
 - iv. Wetting and drying cycles over multiple years (to span the responses to different climatic conditions)**

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b. Provide pre and post-development modelling of the surface water regime at Lake Vermont Wetland. This should include quantification of estimated impacts to the Lake Vermont Wetland water regime during the phase of the project that truncates the greatest portion of catchment area.

c. Model the interaction between the pits/final voids and the flood extent of Isaac River and Phillips Creek up to the 1 in 1000

d. Compare estimates of peak flow quantiles with area-adjusted regional flood frequency analysis, and regional methods for estimation of peak flows as outlined by Australian Rainfall and Runoff (Ball et al. 2016).

e. Undertake a sensitivity analysis on the water balance model for a high inflow parameter scenario and present results of sensitivity analyses explicitly.

We have responded to each of these issues in the following sections.

Protection of Pit B and Satellite Pit final voids from the 1 in 1000 AEP event in Phillips Creek and Isaac River

Section 6.2.4 of the surface water impact assessment report (WRM, 2016a) states that

The overflow levels of proposed final voids are above the Isaac River floodplain. Pit B void is proposed immediately south of Phillips Creek and a permanent levee structure may need to be constructed at this location to prevent flooding of the void in the long-term. However, prior to establishment of this void, a detailed assessment and mitigation strategy will need to be prepared to manage the potential geotechnical risks, and the interaction of this void and the adjacent Phillips Creek alluvium.

Flood impacts associated with the project are dealt with extensively in the Phillips Creek Diversion Functional Design Report (WRM, 2016b). Further details have been extracted from the flood model developed for this report to address the IESC's specific concerns with regard to the proposed final voids.

Figure 1 shows the locations of the proposed B Pit and Satellite Pit final voids in relation to the proposed levees and the area inundated by the 1 in 1,000 AEP design flood.

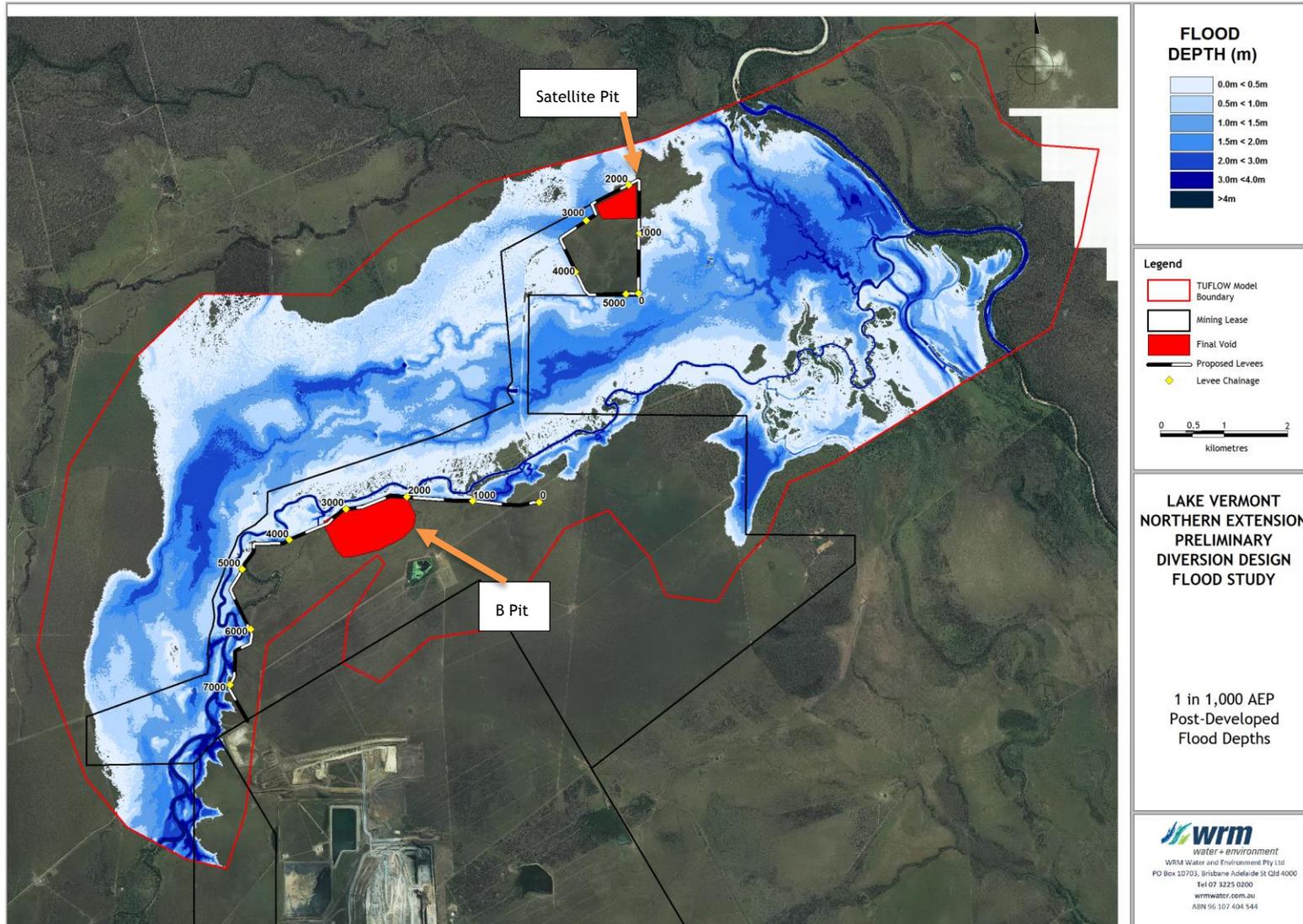


Figure 1 - Locations of proposed B Pit and Satellite Pit final voids in relation to 1 in 1,000 AEP design flood extent

B Pit

Figure 2 presents a longitudinal profile along the proposed Phillips Creek B Pit levee, showing the proposed 1 in 1,000 AEP peak design flood level before and after the construction of the levee. The figure also shows the location of the proposed B Pit void along the levee, where the peak design 1 in 1,000 AEP flood depth ranges from 0 m to approximately 1.0 m.

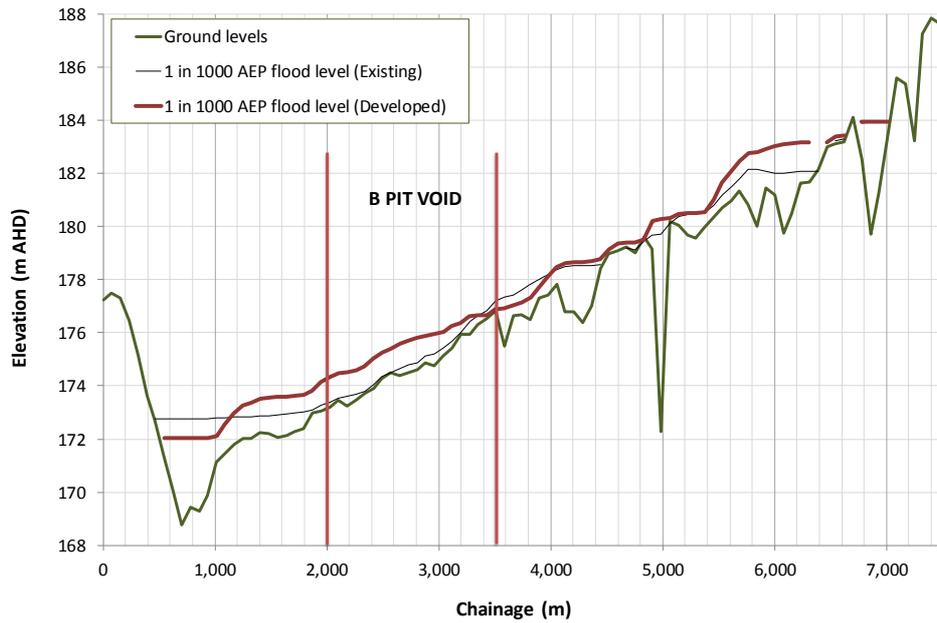


Figure 2 - 1 in 1,000 AEP design flood depths at B Pit final void

Figure 3 shows the design 1 in 1,000 AEP flood velocities along the proposed Phillips Creek B Pit levee. In the vicinity of Pit B Void, the maximum 1 in 1,000 AEP design flood velocity is approximately 1.3 m/s. The average velocity along this portion of the levee is approximately 0.7 m/s.

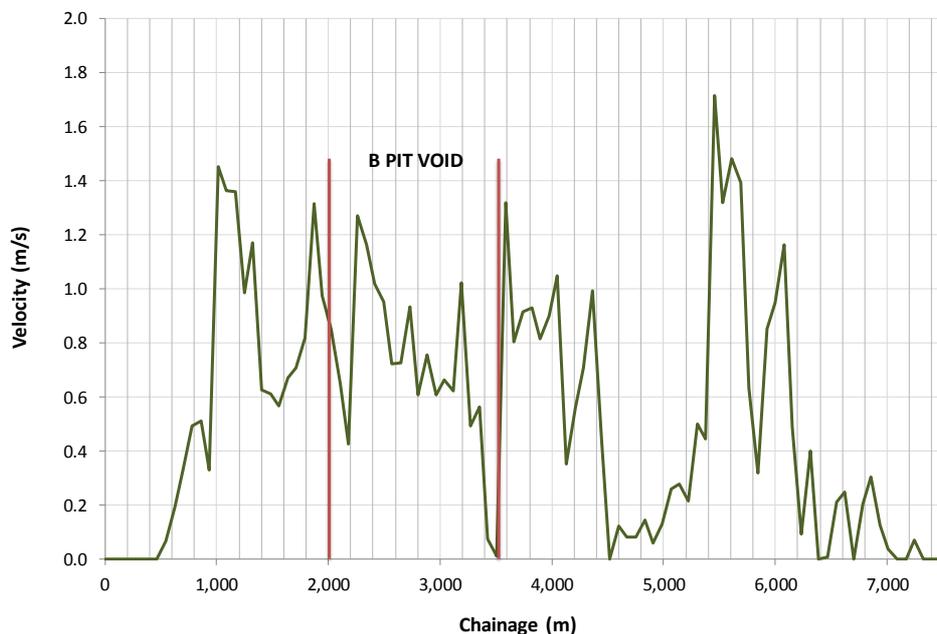


Figure 3 - 1 in 1,000 AEP design flood velocities at B Pit final void

Satellite Pit

Figure 4 presents a longitudinal profile along the proposed Satellite Pit levee, showing the proposed 1 in 1,000 AEP peak design flood level before and after the construction of the levee. Less than half of the section of levee adjacent to the Satellite Pit void is below the peak design 1 in 1,000 AEP design flood level. The design flood depth ranges from 0 m up to approximately 1.5 m.

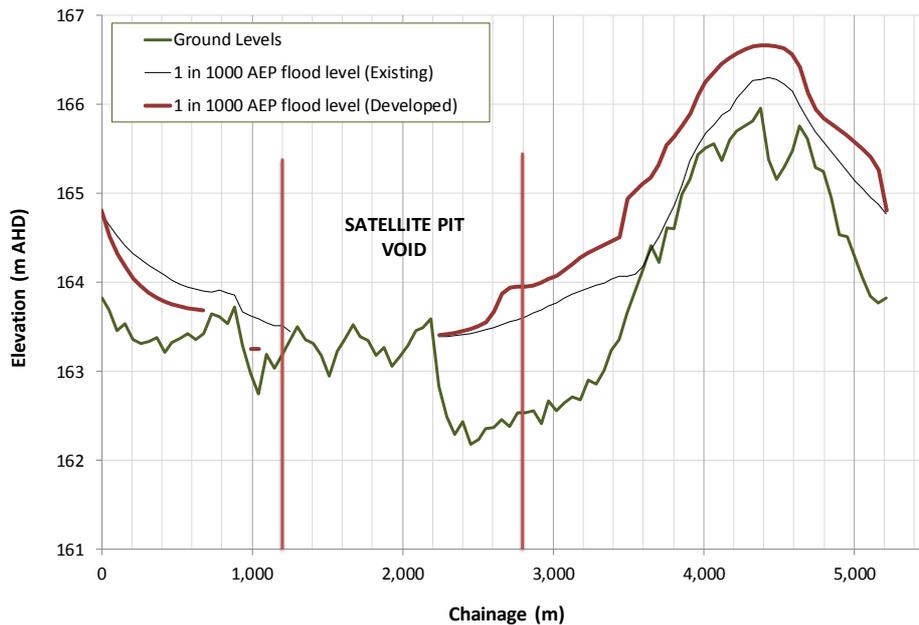


Figure 4 - 1 in 1,000 AEP design flood depths at Satellite Pit final void

Figure 5 shows the design 1 in 1,000 AEP flood velocities along the proposed levee. In the vicinity of Satellite Pit Void, the maximum 1 in 1,000 AEP flood velocity is 1.5 m/s at a localised point at chainage 2,600 m. Elsewhere velocities are minimal.

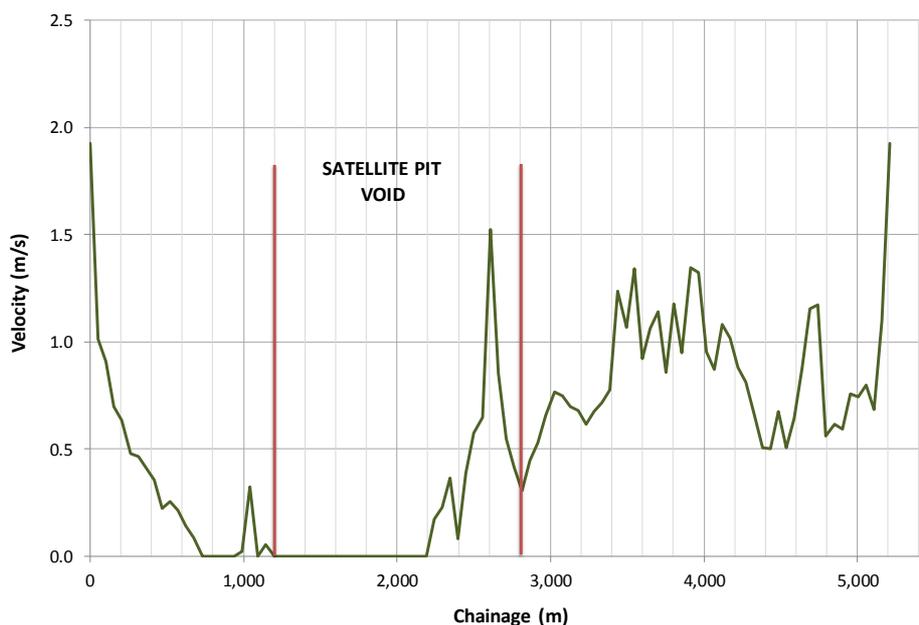


Figure 5 - 1 in 1,000 AEP design flood velocities at Satellite Pit final void

The results show that it will be possible to develop a final landform design that from a hydraulic point of view will be protected from inundation and resistant to erosion by floodwaters.

Prior to establishing the various mine voids, this design analysis will be repeated and the void and levee design will be refined to reduce the length of levee protection required, and reduce the incidence of localised high velocities where possible.

Comparison of Phillips design discharges compared to ARR Regional Flood Frequency Estimation Model

Table 1 below compares the adopted design Phillips Creek flood discharges with the Regional Flood Frequency Estimation (RFFE) Model discharge estimates (Australian Rainfall and Runoff 2016 (Ball et al, 2016)) at the proposed Phillips Creek diversion.

The results show that the adopted design discharges exceed the 95% confidence limit discharges from the RFFE for the 1% and 2% AEP. This suggests the assessment undertaken for the LVNEP provides conservatively high peak discharges and levels adjacent to the proposed levees.

Table 1 Adopted design discharges (m³/s) at RP1 compared to ARR Regional Flood Frequency Estimation Model

AEP (%)	Adopted design discharge	Expected quantile	5% lower confidence limit	95% upper confidence limit
10	427	479	270	452
5	611	580	312	686
2	928	723	361	901
1	1,207	839	395	1,150

The input data are summarised below:

Latitude (Outlet)	-22.452188
Longitude (Outlet)	148.376379
Latitude (Centroid)	-22.525394
Longitude (Centroid)	148.166665
Catchment Area (km ²)	408.0
Distance to Nearest Gauged Catchment (km)	84.35
50% AEP 6 Hour Rainfall Intensity (mm/h)	9.627322
2% AEP 6 Hour Rainfall Intensity (mm/h)	22.476134
Rainfall Intensity Source (User/Auto)	Auto
Region	East Coast
Region Version	RFFE Model 2016 v1
Region Source (User/Auto)	Auto
Shape Factor	1.14*
Interpolation Method	Natural Neighbour

Assessment of potential changes to the water regime of the Lake Vermont wetland

We have prepared a separate report outlining the results and methodology of hydrological analysis for the assessment of impacts on the Lake Vermont Wetland (WRM, 2016, Lake Vermont Mine Northern Extension Project Surface water balance modelling for Lake Vermont wetland). This document has been provided in the “November 2016 Response to DoEE’s Information Request”.

Geochemical characterisation of overburden and assessment of potential impacts on water quality in receiving waters as a result of overflows from sediment dams

Geochemical characterisation of overburden

Issue: 11. A number of sediment dams are proposed to be used to intercept runoff from spoil dumps (MNES Appendix C p. 3), and it is anticipated that there will be overflow from the sediment dams to the offsite receiving environment (MNES Appendix C p. 59). It is also stated that geochemical characterisation of the overburden material indicates that runoff from spoil dumps draining to sediment dams should have concentrations of dissolved salts and metals below guideline values (MNES Appendix C p. 4). However, there is no geochemical assessment provided for the project area and therefore the potential impact of these overflows on receiving waters and their biota is unknown.

Section 2.5.2.2 of the surface water impact assessment report (WRM,2016) includes the following information on the characterisation of surface water runoff from overburden:

The Lake Vermont overburden is typical of that overlying the Rangal coal measures (AARC, 2013). The spoil predominantly comprises weathered and unweathered Permo-Triassic sediments, containing approximately equal proportions of greyish-green sandstones, siltstones and mudstones. The Rewan Formation was deposited in an upper fluvial environment, with no marine influence. Sulphide is rarely detected, and while the coal seams do contain minor pyrite nodules, this material is not associated with the mine waste, so the risk of acid forming has been assessed as low, and no such issues have been reported during operations so far.

Weathering processes result in the dissolution of soluble minerals, partial dissolution of lower solubility minerals (mineral weathering), cation exchange, and reaction. Mining activities increase the hydraulic conductivity and surface area of naturally occurring materials resulting in a body of spoil more prone to leaching. The salts released are mainly chlorides of Na, Ca and Mg, and to a lesser extent, sulfates and carbonates.

Further, Section 6.2.5 of the surface water impact assessment report states:

The Lake Vermont Progressive Waste Characterisation Assessment (AARC, 2013) reports the majority of spoil (92 %) falls into the very low to low salinity categories. Electrical conductivity (EC) of spoil samples ranged from 132 to 642 $\mu\text{S}/\text{cm}$. More recent data provided by Lake Vermont Resources gives a weighted average overburden EC of 410 $\mu\text{S}/\text{cm}$.

The *Lake Vermont Progressive Waste Characterisation Assessment* was not appended to the submission. We understand it has since been further updated. The revised report (AARC, 2014) states that:

Analysis of samples for total and leachable metals identified no metal or metalloid concentrations of environmental significance. Seepage/surface runoff from any waste is predicted to be below Human and ANZECC 2000 Livestock Drinking Water Guidelines.

We recommend that the latest version of the *Lake Vermont Progressive Waste Characterisation Assessment* is included in any supplementary information provided to the IESC. This should also include some assessment of its applicability to the overburden to be encountered in the proposed mining areas.

Assessment of potential impacts on water quality in receiving waters as a result of overflows from sediment dams

Sediment dams have been located to only receive runoff from overburden dumps and undisturbed catchments. The waste characterisation studies, and laboratory samples from existing waste dumps show that solutes in overburden runoff are unlikely to significantly affect downstream water quality.

Sediment dams are provided to intercept overburden runoff before it leaves the site, and to remove suspended solids before they reaches the receiving waters. This further reduces the risk of downstream water quality impacts associated with overburden runoff.

For the LVNEP, sediment dams have been sized in accordance with the Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland (Technical Guidelines) prepared by the former Department of Minerals and Energy (DME) in 1995 (the DME Guidelines) for the discharge of low toxicity waste. This containment standard would generally exceed the volumetric requirements for sediment basins sized in accordance with the International Erosion Control Association's (IECA) Best Practice Erosion and Sediment Control guidelines.

As water is to be removed from the sediment dams as soon as it begins to accumulate, overflows will only occur infrequently, following periods of prolonged or heavy rainfall which will generate runoff in the surrounding catchments. A significant portion of the overburden runoff will be contained within the dam, and the portion that overflows will be significantly diluted by runoff in the receiving waters. During overflow events, sediment dams continue to effectively remove coarse sediment and thus continue to mitigate the already low risk of downstream water quality impacts.

The Isaac River has a catchment area of 6,195 km² immediately downstream of the Downs Creek confluence. The total catchment area of all sediment dams in the extended project is approximately 30 km², or less than 0.5% of the Isaac River catchment area. Overflows reaching the Isaac River are therefore likely to be diluted to the extent that their impact on water quality will be undetectable.

For and on behalf of

WRM Water & Environment Pty Ltd



Michael Batchelor

Director

References:

- AARC, 2013** *Lake Vermont Progressive Waste Characterisation Assessment, AustralAsian Resource Consultants, 2013.*
- AARC, 2014** *Lake Vermont Progressive Waste Characterisation Assessment, AustralAsian Resource Consultants, 2014.*
- WRM, 2016a** *Lake Vermont Mine Northern Extension Project Surface Water Impact Assessment, prepared by WRM Water & Environment Pty Ltd for Lake Vermont Resources, 0622-13-C5, April 2016.*
- WRM, 2016b** *Lake Vermont Northern Extension - Phillips Creek Diversion Functional Design Report, prepared by WRM Water & Environment Pty Ltd for Lake Vermont Resources, 0622-09-D3, April 2016.*
- DEHP, 2013** *Queensland Water Quality Guidelines 2009, Queensland Government Department of Environment and Heritage Protection, 2013.*

Appendix D Geochemical Waste Rock Characterisation Study

LAKE VERMONT NORTHERN EXTENSION GEOCHEMICAL WASTE ROCK CHARACTERISATION

PREPARED FOR:

AUSTRALASIAN RESOURCE CONSULTANTS

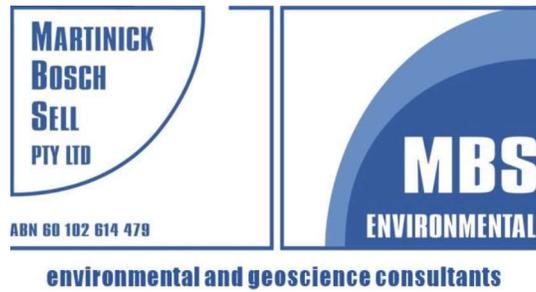


JUNE 2014

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LAKE VERMONT NORTHERN EXTENSION GEOCHEMICAL WASTE ROCK CHARACTERISATION

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TABLE OF CONTENTS

1.	INTRODUCTION	1
1.1	PROJECT BACKGROUND	1
1.2	PROJECT OBJECTIVE AND SCOPE OF WORK.....	1
2.	ENVIRONMENTAL SETTING	3
2.1	CLIMATE	3
2.2	GEOLOGY	3
2.2.1	Regional Geology.....	3
2.2.2	Project Geology and Extension	4
2.3	LANDFORM, SOILS AND WATER QUALITY	6
2.4	EXISTING MANAGEMENT STRATEGIES (AARC 2012)	6
3.	METHODOLOGY	7
3.1	ACID FORMING WASTE CLASSIFICATION METHODOLOGY	7
3.2	ACID MINE DRAINAGE ASSESSMENT.....	8
3.3	ELEMENTAL COMPOSITION.....	9
3.4	WATER LEACHATE CHARACTERISATION	9
4.	SAMPLE DESCRIPTIONS AND SELECTION	11
5.	RESULTS AND DISCUSSION	13
5.1	ACID BASE ACCOUNTING	13
5.1.1	Sulphur Forms and Distribution	13
5.1.2	Acid Neutralisation Capacity.....	14
5.1.3	Acid Production Potential	16
5.1.4	Waste Classification	18
5.2	ELEMENTAL COMPOSITION.....	20
5.3	WATER LEACHATE CHARACTERISATION	20
5.3.1	pH and Alkalinity.....	21
5.3.2	Soluble Salts and Sodicity.....	21
5.3.3	Metals and Metalloids.....	23
6.	CONCLUSIONS	25
7.	REFERENCES	27

TABLES

Table 1:	Lake Vermont Stratigraphic Units (Minserve Group 2004).....	3
Table 2:	Rangal Coal Measures Stratigraphic Units (Minserve Group 2004).....	4
Table 3:	Waste Classification Criteria.....	8
Table 4:	Sample Selection Summary	12
Table 5:	Total Sulphur by Position/Stratigraphic Unit	13
Table 6:	ANC (kg H ₂ SO ₄ /t) by Position/Stratigraphic Unit.....	14
Table 7:	NAPP by Stratigraphic Position	16
Table 8:	Summary of Waste Classification by Stratigraphic Position	19

FIGURES

Figure 1:	Location Plan.....	2
Figure 2:	Location of Extension Areas and Drill Core Samples	5

CHARTS

Chart 1:	Frequency Plot of Total Sulphur Concentrations	14
Chart 2:	Plot of ANC Versus Total Inorganic Carbon (TIC)	15
Chart 3:	Plot of NAPP Versus Stratigraphic Position.....	17
Chart 4:	Plot of Total S% (Logarithmic Scale) Versus NAGpH.....	17
Chart 5:	Plot of NAPP Versus NAGpH (Waste Classification).....	18
Chart 6:	Acid Base Accounting Plot of Lake Vermont Samples	20
Chart 7:	pH Distribution Excluding Coal	21
Chart 8:	Average EC by Strata Position	22
Chart 9:	Calculated SAR Values Versus EC	23

APPENDICES

Appendix 1:	Acid Forming Waste Classification Methodology
Appendix 2:	Collated Results
Appendix 3:	Laboratory Analysis Reports

1. INTRODUCTION

1.1 PROJECT BACKGROUND

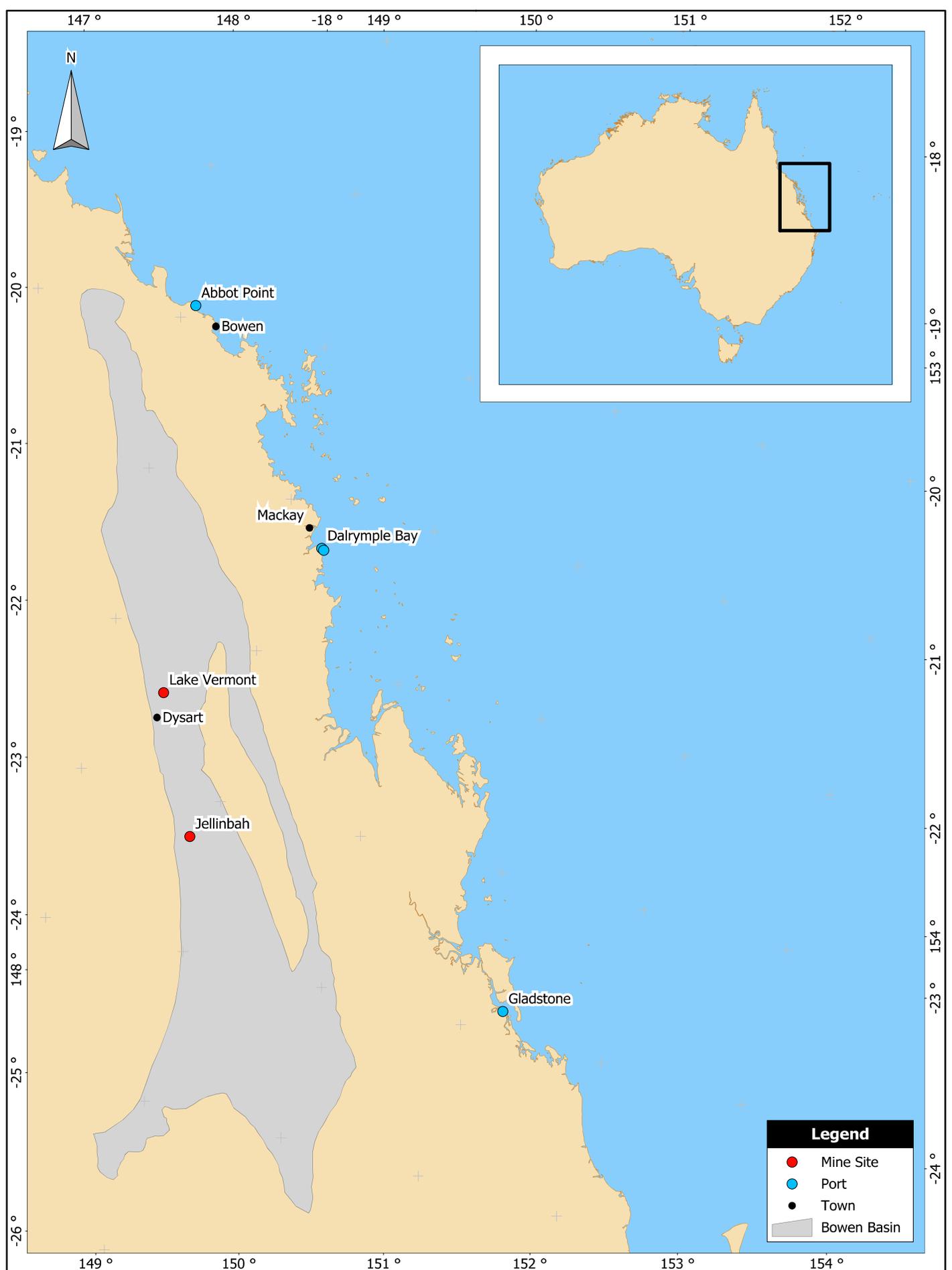
The Lake Vermont Coal Project (the project), operated by Bowen Basin Coal Pty Ltd (BBC) is developing coal reserves on Mining Lease 70331 (Figure 1). The project is located in the Queensland Bowen Basin, 20 km northeast of Dysart and 60 km southeast of Moranbah. The Lake Vermont mine has been operating since 2009 producing both coking coal and pulverised coal injection coal. It is an open cut operation with existing infrastructure including a co-disposal dam (discussed later), 800 t/h coal handling and preparation plant (CHPP), rail loading facilities, maintenance workshop, offices, run of mine (ROM) pad, product stockpiles, HV switchyard and turkey's nest dam. The project has a current Environmental Authority (MIN100736808) first granted by the Department of Environment and Heritage Protection (DEHP) in September 2005.

In 2011, extension of the project commenced to increase production from 4 to 8 Mt/a. BBC intends to extend the project area including proposed mining in two new areas to the east of Isaac Fault (see Section 2.2.2) where coal bearing seams resurface. Additional waste rock characterisation is required for the waste lithologies within the proposed extension as part of the project's Mine Waste Management Plan. AustralAsian Resource Consultants (AARC) engaged MBS Environmental (MBS) to undertake this additional waste rock characterisation.

1.2 PROJECT OBJECTIVE AND SCOPE OF WORK

Objectives of this study were to:

- Compile a waste characterisation report as part of an ongoing requirement for progressive waste characterisation as part of the project's Mine Waste Management Plan. This report is to include results from additional sampling and test work conducted as part of the present scope, previous technical reports and information derived from practical experience at the operating minesite to assess possible waste impacts of the extended project.
- Evaluate the potential for acid, neutral, and metalliferous drainage (AMD) to form in various waste materials.
- Evaluate the potential for waste rock and subsoils examined to be dispersive.
- Evaluate the potential for generation of saline or metalliferous leaching through supplementary static tests and / or kinetic column tests where necessary.
- Classify waste types based on their potential to generate AMD according to procedures published by the Federal Department of Industry, Tourism and Resources (DITR, 2007).



Scale: 1:4000000
 Original Size: A4
 Grid: Latitude / Longitude

0 100 km

AustralAsian
 Resource Consultants
 Lake Vermont
 Waste Characterisation

Figure 1

Location Plan

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 ENVIRONMENTAL

2. ENVIRONMENTAL SETTING

2.1 CLIMATE

The closest operating BOM weather station is St Lawrence Post Office, located approximately 130 km southeast of Lake Vermont. Average annual rainfall at this site is 1,020.8 mm with the highest average rainfall recorded in January (206.3 mm) and the lowest average in August (23.9 mm). Temperatures are highest in January with a mean maximum temperature of 31.7°C and lowest in July with a mean minimum temperature of 10.9°C (BOM 2013).

2.2 GEOLOGY

2.2.1 Regional Geology

Stratigraphic units present at Lake Vermont are summarised in Table 1. The coal seams of economic importance for BBC are contained within the Rangal Coal Measures and comprise the Leichhardt and Vermont Seams (AARC 2009). The deeper Fort Cooper and Moranbah coal formations will not be disturbed under current plans.

Table 1: Lake Vermont Stratigraphic Units (Minserve Group 2004)

Age	Group	Unit	Description
Cenozoic		Unnamed	Mainly unconsolidated sand and clay alluvial deposits. Some areas of thick alluvial cover towards the south west corner of the deposit. Overburden dominated by weathered Permo-Triassic sediments.
Triassic	Rewan Group	Sagittarius Sandstone	Typically 250 to 300 m thick. Approximately equal proportions of greyish green sandstones, siltstones and mudstones.
Late Permian	Blackwater Group	Rangal Coal Measures	Light grey, fine to medium grained lithic sandstone, grey to dark grey siltstone and mudstone, carbonaceous mudstone, carbonaceous claystone and three coal horizons: the Phillips, Leichhardt and Vermont seams (the Rangal Coal Measures containing the Leichhardt and Vermont seams can be broken into five distinct units as per Table 2).
		Fort Cooper Coal Measures	Approximately 400 m thick. Characterised by tuffaceous sandstones and siltstones and several thick, coaly horizons that contain interbedded high-ash coal, carbonaceous mudstone, tuffaceous mudstone and siltstone.
		Moranbah Coal Measures	Grey labile tuffaceous sandstone and siltstone, mudstone, carbonaceous mudstone and coal.
Not determined	Yarrabee Tuff Bed		0.2 to 1 m thick tuff bed believed to be volcanic ash present over much of the Bowen Basin.

The major regional structural feature is the Isaac Fault. It is a north northwest trending, east side up thrust fault (Figure 2). It has a throw in the order of 100 m.

2.2.2 Project Geology and Extension

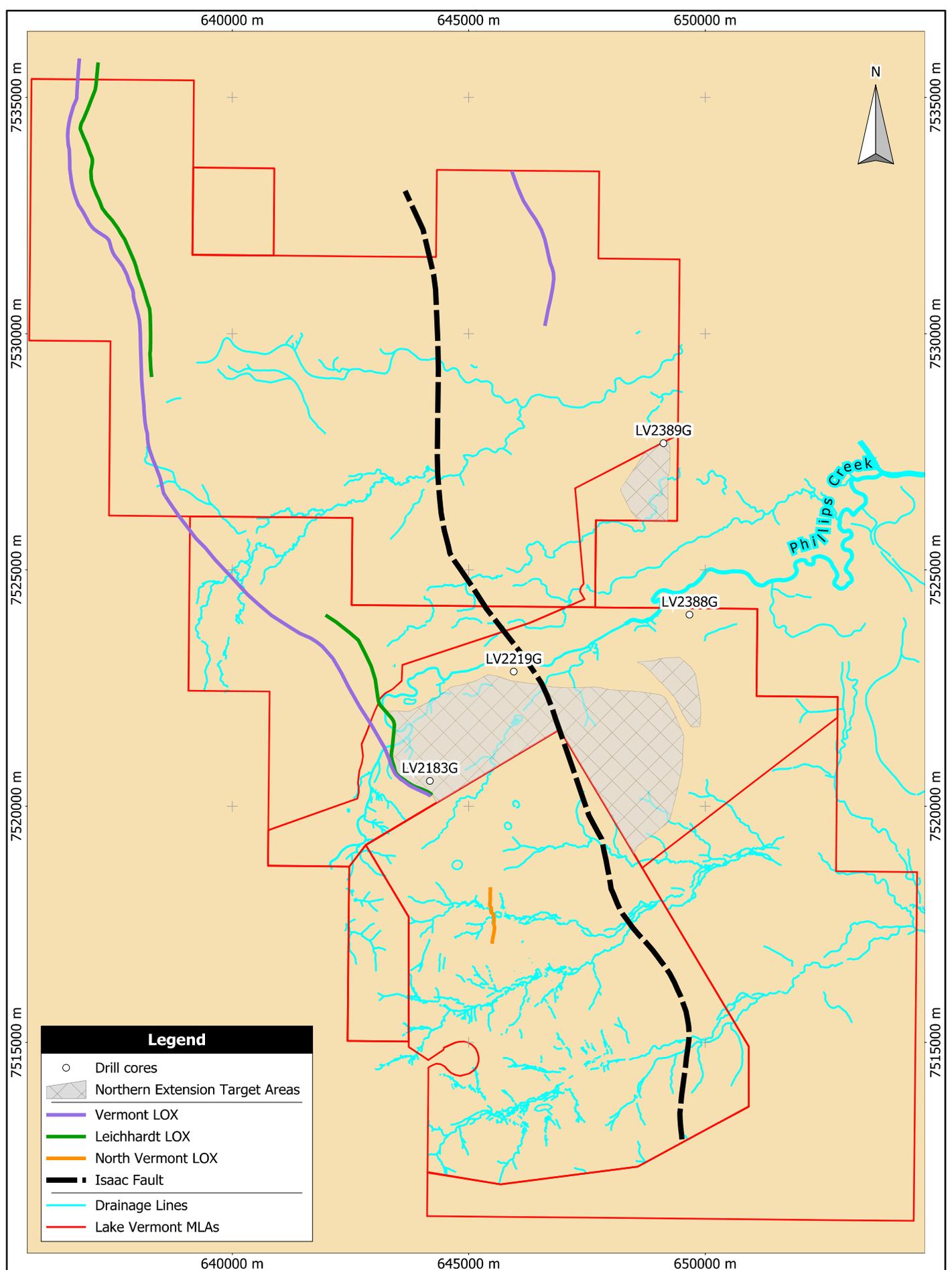
Lake Vermont mine waste (overburden) is dominated by weathered and unweathered Permo-Triassic sediments. The formation contains approximately equal proportions of greyish-green sandstones, siltstones and mudstones (AARC 2012). The depth to the base of weathering/top of fresh rock (TOFR) is an average of 30 m below ground level, but ranges from 12 to 54 m below ground level.

Coal seams to be mined comprise the Leichhardt and Vermont seams within the Rangal Coal Measures. The Isaac Fault has previously marked the eastern edge of mining operations. The present proposal includes extension of operations to the northwest (northern extension target area shown on Figure 2) and to the east of the Isaac Fault, where the Leichhardt and Vermont seams re-surface. The eastern extension area is not shown on Figure 2; however it includes the drill cores LV2388G and LV2389G. The partially delineated limits of oxidation (LOX) where the coal seams extend to are also shown in Figure 2.

The Rangal Coal Measures containing the Leichhardt and Vermont seams that BBC intends to mine can be broken into five distinct units as documented in Table 2.

Table 2: Rangal Coal Measures Stratigraphic Units (Minserve Group 2004)

Unit	Unit Description	Lithology
Unit 1	Interval between the base of the Sagittarius Sandstone and the top of the Leichhardt Seam. Includes the Phillips Seam horizon.	<ul style="list-style-type: none"> • 9 to 14 m thick. • Comprises an upper mudstone bed that coarsens downwards to a siltstone or fine-grained sandstone. • Lower part of the unit is predominantly siltstone and/or fine-grained sandstone. • Mudstone and carbonaceous mudstone adjacent to the top and bottom of the Phillips Seam.
Unit 2	Leichhardt Seam coal.	<ul style="list-style-type: none"> • Average thickness of 3.2 m.
Unit 3	Interval between the Leichhardt and Vermont Seams.	<ul style="list-style-type: none"> • 22 to 45 m thick. • Comprises the mudstone/claystone floor of the Leichhardt Seam. • Coarsens downwards to a medium to coarse-grained sandstone. • Sandstone extends down to and forms the immediate roof of the Vermont Seam over much of the deposit. • Sometimes up to 10 m of siltstone with a thin (<1 m) claystone/mudstone basalt layer below the sandstone, particularly at the northern and eastern edges of the deposit.
Unit 4	Vermont Seam coal and associated splits.	<ul style="list-style-type: none"> • Average thickness of 5.6 m. • Splits into three seams of approximately equal thickness towards the south.
Unit 5	Interval between the Vermont Seam and the Yarrabee Tuff Bed.	<ul style="list-style-type: none"> • 2 to 5 m thick. • Dark brownish-grey mudstone/claystone. • Immediate floor of the Vermont Seam. • Underlain by fine to medium-grained sandstone with occasional siltstone interbeds.



Scale: 1:100000
 Original Size: A4
 Grid: MGA94(55)



AustralAsian
 Resource Consultants
 Lake Vermont
 Waste Characterisation

Figure 2
Drill Core Locations

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2.3 LANDFORM, SOILS AND WATER QUALITY

The Lake Vermont area consists of gently undulating downs country with general relief between 170 to 190 m relative level (mRL). Low, generally southwest to northeast trending ridge lines are present and separate the local watercourses that drain eastwards to the Isaac River. A major north northeast trending ridge is present to the west of the deposit which slopes gently to the north from 220 to 195 mRL. This major ridge marks a watershed and waterflow around the project area is almost entirely surficial with surface water runoff north northeast to Phillips Creek. Phillips Creek is an ephemeral creek with a deeply entrenched channel that flows to the Isaac River. To the east of the major ridge, surface flow drains via several smaller ephemeral creeks that feed into the Isaac River. These creeks are 2 to 4 km apart and are separated by gently sloping ridges that are up to 20 m above the creek beds (Minserve Group 2004).

The dominant soil cover is a 1 to 3 m thick clay-rich soil profile developed over weathered Permo-Triassic sediments. Also present are unconsolidated alluvial deposits of clays, clayey sands and sands, with occasional thin gravel layers across the base that occur sporadically above Permo-Triassic sediments along the floodplains of ephemeral creeks that cross the area (Minserve Group 2004). Subsoil material in particular is known to be saline and sodic (dispersive) in nature and this is considered typical of the Bowen Basin (AARC 2012).

Land use in the area outside coal mining operations is exclusively pastoral (cattle grazing), with stock water collected from surface water runoff.

There is very little shallow aquifer groundwater recorded as being present in the project area, water flows being almost entirely surficial as noted above. Very little groundwater data was thus available at the time of writing for comparison of water quality. A groundwater sample (LV2375W), taken in May 2013 by JBT Consulting, from the perched water table in the near vicinity of the Vermont coal seam was relatively high in salinity (EC 10,600 $\mu\text{S/cm}$), had a high Sodium Absorption Ratio (SAR) (25), but contained low concentrations of nickel (0.012 mg/L) and manganese (0.52 mg/L). Information provided by AARC indicated groundwater encountered across the project area is typically of similar salinity. Surface water monitoring of the 'Environmental Dam' in 2009 showed a pH of 8.6 and EC of 996 $\mu\text{S/cm}$. The 'Co-Disposal Decant pond', sampled at the same time, had a pH of 8.5 and EC of 2,190 $\mu\text{S/cm}$.

2.4 EXISTING MANAGEMENT STRATEGIES (AARC 2012)

At the Lake Vermont Coal Mine, waste (spoil) is initially placed in out-of-pit dumps and then backfilled into the mined out void. Water management is a key element in mitigating any risk of environmental contamination associated with spoil placements. Minimising surface runoff and leachate in saline and sodic spoil reduces the potential for contamination of the surrounding environment.

Runoff from disturbed areas, such as spoil placements yet to be rehabilitated, are directed to water storage dams around the site and reused for industrial purposes such as coal processing or dust suppression. Sedimentation dams are designed to contain a 1 in 10 year ARI 24 hour event plus 20% for sediment storage. The environmental dam and co-disposal dams at the project are designed with an Annual Exceedance Probability (AEP) of 0.05 (AARC).

Progressive rehabilitation is undertaken at the Lake Vermont Coal Mine and includes a topsoil cap over spoil placements and revegetation. Progressive rehabilitation is recommended to limit the exposure of saline and sodic waste to the environment, thus reducing the potential for runoff and infiltration of surface water. The final landform of spoil placements are generally water shedding to further minimise potential for water infiltration, but where it is not, any water that seeps into the ground will flow subterraneously into the mined out area.

3. METHODOLOGY

3.1 ACID FORMING WASTE CLASSIFICATION METHODOLOGY

There is no simple method to define whether mine waste containing small quantities of sulphur will produce sulphuric acid. Sulphide minerals are variable in their behaviour under oxidising conditions and not all forms will produce sulphuric acid (H_2SO_4). Instead, a combination of approaches is often applied to more accurately classify mine waste. These approaches are listed below in order of increasing data requirements (and therefore increased reliability):

- The “Analysis Concept”, which only requires data for total sulphur content. Its adoption is based on long term experience of wastes from Western Australian mine sites in arid and semi-arid conditions. Experience has shown that waste rock containing very low sulphur contents (less than 0.2 to 0.3%) rarely produces significant amounts of acidic seepage. The climatic conditions experienced at Lake Vermont are similar to several mine sites in the northwest of Western Australia; however other forms of sulphur present at Lake Vermont (sulphate sulphur and organic sulphur present in coal) can bias results.
- The “Ratio Concept” which compares the relative proportions of acid neutralising minerals (measured by the Acid Neutralising Capacity (ANC)) to acid generating minerals (measured by the Maximum Potential Acidity (MPA)). Experience has shown that, the risk of generating acidic seepage is generally low when this ratio (the Neutralisation Potential Ratio – NPR) is above a value of two.
- Acid-Base Accounting, in which the calculated value for Net Acid Producing Potential (NAPP) is used to classify the acid generating potential of mine waste. NAPP is equal to MPA minus ANC.
- Procedures recommended by AMIRA (2002), which take into consideration measured values provided by the Net Acid Generation (NAG) test and calculated NAPP values.
- Kinetic leaching column test data, which provides information for the relative rates of acid generation under controlled laboratory conditions, intended to simulate those within a waste rock stockpile or tailings storage facility.

A sound knowledge of geological and geochemical processes must also be employed in the application of the above methods. The methods are described in greater detail in Appendix 1. Non pyrite (FeS_2) sulphides and non-sulphide minerals that contribute to acid drainage are also discussed in Appendix 1.

Classification of wastes undertaken in this report uses procedures recommended by AMIRA (2002) based on NAPP and NAGpH results. However results are also compared to the Analysis Concept (total sulphur) and Ratio Concept models by determination of the following:

- Analysis for total Sulphur (Tot_S).
- Analysis for Sulphate-Sulphur ($\text{SO}_4\text{-S}$), quoted as sulphur, not sulphate.
- Analysis for ANC (quoted in $\text{kg H}_2\text{SO}_4/\text{t}$).
- Calculation of $\text{MPA} = [(\text{Tot_S} - \text{SO}_4\text{-S}) * 30.6] \text{ kg H}_2\text{SO}_4/\text{t}$.
- Calculation of $\text{NAPP} = [\text{MPA} - \text{ANC}] \text{ kg H}_2\text{SO}_4/\text{t}$.
- Analysis for NAG (quoted in $\text{kg H}_2\text{SO}_4/\text{t}$).
- Analysis for NAGpH.
- Calculation of $\text{NPR} = \text{ANC}/\text{MPA}$.

This AMIRA approach is more conservative than either the Analysis Concept or the Ratio Concept alone, but assumes the absence of barium sulphate sulphur. The AMIRA approach of using NAG testing is particularly

useful for PAF-LC materials or where there is very low ANC in the host rock. A combined acid generation classification scheme based on NAPP and NAG determinations is presented in Table 3 (see also Appendix 1).

Table 3: Waste Classification Criteria

Primary Geochemical Waste Type Class	NAPP Value kg H ₂ SO ₄ /t	NAGpH	Sulphide S Content
Potentially Acid Forming (PAF)	≥10	< 4.5	≥ 0.3%
Potentially Acid Forming – Low Capacity (PAF-LC)	0 to 10	< 4.5	0.16 to 0.3%
Uncertain (UC)	0 to 5	> 4.5	Not important
Uncertain (UC)	-10 to 0	< 4.5	Not important
Non Acid Forming (NAF)	-100 to 0	> 4.5	Not important
Acid Consuming Materials (AC)	< -100	>4.5	Not important

Table 3 is based on the Australian Government's Guidelines on Managing Acidic and Metalliferous Drainage (DITR 2007) and is in turn based on an earlier classification system included within the AMIRA ARD Test Handbook (AMIRA 2002), which is advocated by the Global Acid Rock Drainage Guidelines (GARD) published by the International Network for Acid Prevention (INAP 2009). This classification system, based on static acid base accounting procedures and used in conjunction with geological, geochemical and mineralogical analysis can still leave materials classified as 'uncertain' where there is conflicting NAGpH and NAPP results. Uncertain materials demonstrating a NAGpH above 4.5 may be tentatively assigned as potentially NAF and those below pH 4.5 as potentially PAF – however in such cases, further assessment, such as the use of kinetic leaching columns may be required to provide a definitive classification.

3.2 ACID MINE DRAINAGE ASSESSMENT

Sample analysis was performed by a NATA accredited laboratory (ALS Brisbane) as specified by AARC and MBS Environmental so that results could be compared to earlier studies. Preliminary analysis included selected acid base accounting (ABA) parameters. After examination of results of analysis for these parameters, MBS Environmental selected 33 of the original 65 samples to undergo further analysis including elemental composition and water leachate assessment.

Total sulphur, carbon and organic carbon (after acid pre-treatment) were measured by a combustion procedure using a LECO instrument. Total inorganic carbon (TIC) was calculated from the difference between total carbon and total organic carbon.

ANC was measured by a modified Sobek procedure (AMIRA 2002), which involves addition of dilute hydrochloric acid to the sample, followed by gentle simmering (two hours) to complete the reaction. The concentration of acid used for this procedure is first determined by testing the vigour of the reaction of the sample with hydrochloric acid, as assessed by the rate evolution of carbon dioxide gas and any colour change (a 'fizz rating'). ANC was then measured by titrating the amount of excess acid after addition and reaction using standardised sodium hydroxide solution.

The ABA scheme relies on measurement of oxidisable sulphur. The value of this fraction of sulphur in mine waste samples is calculated as the difference between total sulphur and sulphate-sulphur, which is present in a fully oxidised form and therefore not capable of generating additional acidity. Sulphate-sulphur content was determined by a heated hydrochloric acid extraction and Inductively Coupled Plasma – Optical Emission Spectrometry (ICP-OES) finish.

When assessing data for the MPA and NAPP, it must be noted that both parameters are based on the assumption that all sulphur contained in the sample is acid producing (sourced from pyrite (FeS₂) and other iron sulphide

minerals). However, this represents a worst case scenario as not all minerals containing sulphur will result in acid production. Conversely, the NAPP calculation also assumes that the acid neutralising material measured in ANC is rapid-acting. In practice, some neutralising capacity is supplied by silicate and aluminosilicate minerals which can be much slower to react. Further still, iron carbonate minerals such as siderite (FeCO_3) have limited or no capacity to neutralise acidity due to acid producing reactions resulting from oxidation of the dissolved ferrous iron component. Despite these assumptions, NAPP remains a suitable conservative prediction of potential acid generation when used in conjunction with mineralogical data.

Base metals and sulphate-sulphur determinations were made using analytical methods with Inductively Coupled Plasma – Optical Emission Spectrometry (ICP-OES) finish. It is preferable to use a cut-off limit of 0.2% sulphur when using this assay technique instead of the 0.3% limit when total sulphur is analysed using a more accurate technique (such as the LECO technique used for analysis of these samples).

The NAG test involves the addition of hydrogen peroxide, a strong oxidising agent, to a sample of mine waste to oxidise reactive sulphides. An aliquot of 250 mL of 15% hydrogen peroxide is added to a 2.5 g sample weight, allowed to react overnight, heated and then finally boiled the following day. After cooling the sample pH was measured (NAGpH) and any acidity generated was measured by back titrating with sodium hydroxide solution to a pH of 4.5 (NAG to pH 4.5) and pH 7 (NAG to pH 7). NAG is expressed in units of $\text{kg H}_2\text{SO}_4/\text{t}$. A significant NAG result (i.e. final NAGpH less than 4.5) generally indicates that the sample is PAF (Table 3) and the test provides a direct measure of the NAG potential. A NAGpH of 4.5 or more generally indicates that the sample is NAF, but may still be capable of generating metalliferous drainage following oxidation of the sulphide minerals. Results for titrations of aliquots of the NAG solution to endpoint pH values of 4.5 and 7.0 allow estimation by the difference between these results of the relative amounts of non-acid producing base metal (such as copper) and iron sulphides in the sample. This is explained in more detail in Appendix 1.

3.3 ELEMENTAL COMPOSITION

Environmentally significant metals and metalloids were measured following digestion of a finely ground sample with a mixture of nitric and hydrochloric in a ratio of 3:1 (reverse aqua regia) which is a near total determination for the elements measured.

Digest solutions were analysed for a general suite of potential toxicants determinable via ICP-OES or Cold-Vapour AAS (CVAAS) finish (mercury). Samples were analysed for arsenic (As), boron (B), barium (Ba), beryllium (Be), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), lead (Pb), manganese (Mn), mercury (Hg), nickel (Ni), selenium (Se), vanadium (V) and zinc (Zn).

From this data, the global abundance index (GAI) for each element was calculated by comparison to the average earth crustal abundance (Bowen 1979 and AIMM 2001). The main purpose of the GAI is to provide an indication of any elemental enrichment that could be of environmental significance. The GAI (based on a log-2 scale) is expressed in integer increments from zero to six (GARD Guide). A GAI of zero indicates that the content of the element is less than or up to three times the average crustal abundance; a GAI of one corresponds to a three to six fold enrichment; a GAI of two corresponds to a six to 12 fold enrichment and so forth, up to a GAI of six which corresponds to a 96-fold, or greater, enrichment above average crustal abundances. A GAI of more than three is considered significant and may warrant further investigation.

3.4 WATER LEACHATE CHARACTERISATION

Pulverised waste rock and coal samples examined during this investigation were subject to the following two water leaches:

- At a standard soil:water ratio for soil assessments of 1:5 (weight/weight). Leachate from this test was analysed for major cations (sodium, potassium, calcium, magnesium), anions (chloride, sulphate), alkalinity, electrical conductivity (EC) and pH.

- At a soil:water ratio of 1:20 (weight/weight) as per the Australian Standard Leachate Procedure (ASLP) 4439.3 Class 1 specification. Leachate from this test was analysed for trace metals of environmental significance by ICP-OES and Inductively Coupled Plasma Mass Spectrometry (ICP-MS). Analytical finish was via ICP-OES, ICP-MS finish or CVAAS (mercury) as necessary, for silver, arsenic, beryllium, cadmium, cobalt, cadmium, chromium, copper, iron, mercury, manganese, nickel, lead, selenium and zinc.

SAR was calculated from the relative concentrations (in millimole equivalents per Litre) of sodium, calcium and magnesium (ANZECC 2000).

Both of the above tests use naturally oxygenated water at the nominal pH values naturally generated by the samples as the extractant and use a finely ground sample so that the laboratory test mimics weathering conditions that may be expected in a temperate, semi-arid environment over a period of several years. It is not suitable for predicting long term solute release rates, especially in the case of fresh rock samples containing significant amounts of sulphide minerals.

Results for concentrations of major anions, major cations and soluble metals and metalloids are reported as a weight:volume basis (milligrams per litre, mg/L) in the water leachate. Results can be converted to weight:weight (mg/kg) in the original material by multiplying the results by the corresponding extraction ratio (5 or 20). The data can be used to provide an estimate of the corresponding concentrations in waste seepage provided the geochemistry of the associated mineral phases are well understood. For example, concentrations of elements associated with mineral phases that are very soluble in water (halite, NaCl or epsomite, $MgSO_4 \cdot 7H_2O$) can be calculated by dividing the concentration in the dry solids (milligram per kilogram, mg/kg) by a dilution factor corresponding to the volume of fluids in saturated tailings/waste. Typical dilution factors for tailings vary from 0.5 to 1.0, depending on physical properties of the tailings/waste.

Concentrations of some elements are controlled by the solubility of sparingly soluble mineral phases such as calcite ($CaCO_3$), gypsum ($CaSO_4 \cdot 2H_2O$), barite ($BaSO_4$) and fluorite (CaF_2). In such cases, solution concentrations are theoretically independent of the solids to leachate volume when geochemical equilibrium is attained. Seepage concentrations of such elements in milligrams per litre can be estimated by dividing the concentration in dry solids (mg/kg) by a dilution factor of five.

Finally, solution concentrations of other elements are controlled by other factors including rates of desorption from surfaces of clay minerals, diffusion from microscopic pores within the sample matrix and physical weathering of associated minerals. In such cases, appropriate dilution factors for converting dry solid concentrations to tailings seepage concentration vary. Experience has shown that dilution factors between 10 and 20 are appropriate for weathered waste rock and tailings (hence the use of the 1:20 ratio ASLP extraction for environmental metals).

4. SAMPLE DESCRIPTIONS AND SELECTION

Four fresh drill cores (LV2183G, LV2219G, LV2388G and LV2389G) were provided for assessment. These drill cores were distributed spatially across the proposed mining area on either side of the Isaac Fault and represented profiles to the maximum depth of excavation (102 m) (Figure 2).

A total of 65 samples were selected from drill core samples for further assessment, based on the following methodology:

- Zone of weathering, stratigraphic unit and lithology along the sections of drill core were logged by a suitably qualified and experienced geologist in the field prior, to sample selection. Sample selection aimed to capture material from each stratigraphic unit and lithology.
- Samples were selected from across the waste profile to the maximum depth of excavation of 102 m.
- Samples were selected to incorporate all waste rock lithologies and stratigraphic units including the coal seam material, minor amounts of which will report to waste.
- Sample selection avoided overlapping positional/stratigraphic boundaries.
- Samples of waste rock (samples other than coal seam) were prepared only from samples within a drill core which represented the same stratigraphic unit and lithology over a maximum interval of 4.2 m and with a median interval of 1.4 m. Coal was sampled as a single sample per intercept for each seam.

Table A2-1 of Appendix 2 describes the sample depth, weathering zone (subsoil, weathered, fresh or coal), position/stratigraphic rock unit and lithology for each of the 65 composite samples. A summary of this detail is given in Table 4. The list of stratigraphic units in Table 4 represents the vertical breakdown across the depth of excavation and is a slight extension of the five stratigraphic units described by Minserve Group and presented in Table 2.

Each sample was prepared and analysed for ABA parameters as given in Section 3.2. Following ABA analysis, a subset of 33 samples was selected for further assessment including elemental composition and water leachable parameters. The subset was selected based on ABA results for the original 65 samples and representation across stratigraphic units and lithologies.

It should be noted that the limit of excavation will be to the base of the Vermont seam. 'Vermont seam floor' and 'Basement' samples represent samples beneath the level of proposed excavation and these materials are likely to be exposed only briefly, prior to refilling of the void.

Table 4: Sample Selection Summary

Position	Lithology	No. of Samples	Min. Depth	Max. Depth
Subsoil	Sandy Clay to Clay	4	0.6	3
Tertiary	Sandy Clay to Clay, interspersed with Laterite	7	6.5	36
Permian overburden	Mostly Siltstone and Mudstone/Carbonaceous Mudstone	8	26	57
Leichhardt seam roof	Mostly Carbonaceous Mudstone, some Coal, some Sandstone	5	49	83
Leichhardt seam	Coal	2	59	63
Leichhardt seam floor	Siltstone and Mudstone	4	58	84
Interburden	Sandstone and Siltstone	18	62	108
Vermont seam roof	Siltstone and Carbonaceous Mudstone	4	79	109
Vermont seam	Coal	4	80	115
Vermont seam floor	Siltstone, Mudstone with Carbonaceous Bands	5	87	118
Basement	Predominantly Sandstone	4	90	120

5. RESULTS AND DISCUSSION

5.1 ACID BASE ACCOUNTING

Laboratory results for EC, pH, total sulphur, SO₄_S, Total C, TIC, ANC, MPA, NAGpH, NAPP, NAG (pH 4.5 and pH 7), NPR and AMD classification are presented in Tables A2-2 and A2-3 of Appendix 2. The original ALS laboratory reports are included in Appendix 3. Data for ABA determinations has been sorted by stratigraphic unit (position) in order from upper to lower across the depth of excavation to aid the observation of trends discussed below.

5.1.1 Sulphur Forms and Distribution

Comparison of results for total sulphur to the 0.3% total sulphur criteria of the "Analysis Concept" (Appendix 1) indicate uniformly low sulphur content for all samples, other than coal seam samples or those immediately adjacent to the coal seams (roof/floor material). A summary of total sulphur analysis by stratigraphic unit is presented in Table 5.

Table 5: Total Sulphur by Position/Stratigraphic Unit

Position	Weathering Zone	No. of Samples	Minimum (%)	Maximum (%)	Mean (%)
Subsoil	Subsoil	4	0.01	0.05	0.035
Tertiary	Weathered	7	0.03	0.04	0.036
Permian overburden	Weathered/Fresh	8	0.03	0.05	0.041
Leichhardt seam roof	Fresh	5	0.08	0.26	0.164
Leichhardt seam	Coal	2	0.42	0.67	0.545
Leichhardt seam floor	Fresh	4	0.07	0.22	0.113
Interburden	Fresh	18	0.03	0.13	0.033
Vermont seam roof	Fresh	4	0.04	0.45	0.148
Vermont seam	Coal	4	0.32	0.56	0.423
Vermont seam floor	Fresh	5	0.05	0.36	0.214
Basement	Fresh	4	0.04	0.17	0.088

Examination of data in Table 5 and Table A2-2 (Appendix 2) indicates the following:

- Coal and carboniferous Vermont seam roof/floor waste are the only samples showing total sulphur content above the 0.3% threshold given by the Analysis Concept. The average of Vermont roof/floor waste samples was below 0.3%, but results were variable (one of four Vermont roof and two of five Vermont floor samples were above 0.3%).
- SO₄_S values were generally very low (maximum SO₄_S 0.024%). The proportion of sulphur in the sulphate form was highest in the weathered subsoil samples (e.g. LV2389/1 70%) as would be expected, based on previous oxidation of the sulfidic material.
- The potential presence of other sulphur forms, namely organic sulphur in coal and carbon-rich materials which do not contribute to sulphuric acid formation, is expected to overestimate MPA (refer Appendix 1).

A histogram of total sulphur content for Lake Vermont samples is given in Chart 1. All Leichhardt and Vermont coal seam samples have been excluded to provide a clearer view of typical waste materials. Only three samples

(LV2389G/13, LV2389G/15 and LV2183/17, all Vermont seam roof or floor samples) had a sulphur content above 0.3%. The remaining 95% of samples had a sulphur content of less than 0.3% and 90% had a sulphur content of less than 0.2%. This sulphur distribution is consistent with previous studies (AARC 2012, AARC 2009 and Emmerton 2004) which indicated total sulphur concentrations were elevated in coal seams and roof and floor material. However, total sulphur results of this assessment are possibly higher. Maximum total sulphur concentrations in the 2009 and 2012 assessments of roof and floor material were 0.07% and 0.17%, respectively. The maximum total sulphur concentration in this assessment was 0.45%, in a Vermont seam roof sample. A single sample from three taken of Vermont seam roof in 2004 recorded a sulphur content of 1.18%. Others at the time were significantly lower. A breakdown of data by stratigraphic unit to enable a statistical comparison was only provided in the 2004 data report. The average sulphur content of Leichardt roof and floor samples and Vermont roof samples during the 2004 study (0.20% for 9 samples) was slightly higher than this study (0.14% for 14 samples). However the 2004 data is significantly influenced by the single very high Vermont seam roof result of 1.18%.

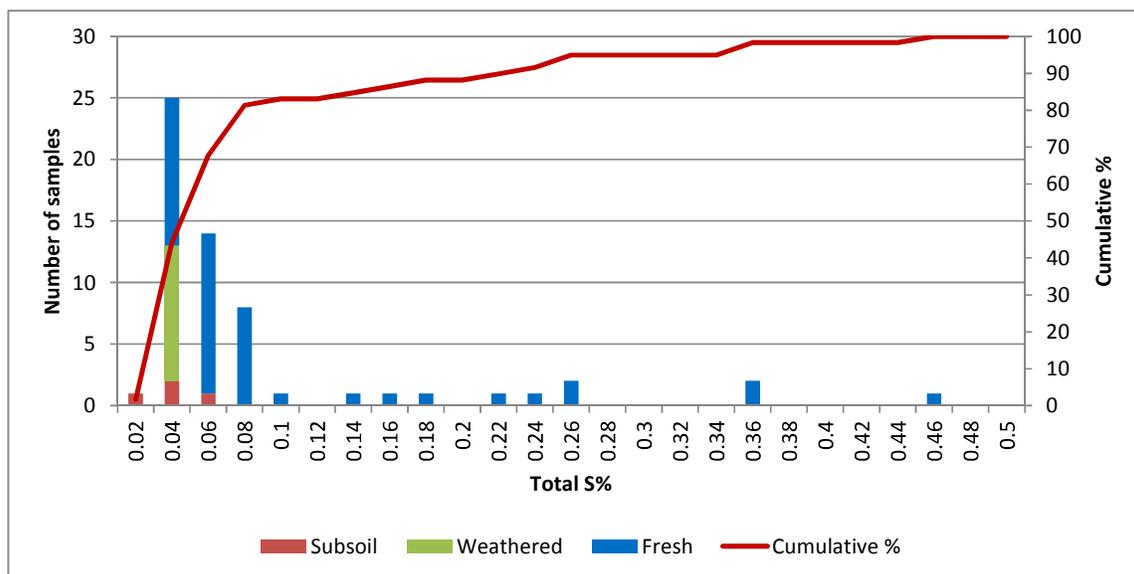


Chart 1: Frequency Plot of Total Sulphur Concentrations

5.1.2 Acid Neutralisation Capacity

ANC values of Lake Vermont samples were variable, ranging from 4.4 to 151 kg H₂SO₄/t (Table A2-2, Appendix 2). A summary of ANC analysis by stratigraphic unit is presented in Table 6. Generally low to moderate ANC values were found in the Leichardt and Vermont coal seam material, moderate ANC values were found in the overburden and the highest ANC values were found in the interburden and basement samples (often associated with sandstone lithology).

Table 6: ANC (kg H₂SO₄/t) by Position/Stratigraphic Unit

Position	Weathering Zone	No. of Samples	Minimum	Maximum	Mean
Subsoil	Subsoil	4	7.6	31.6	17.8
Tertiary	Weathered	7	4.4	58.7	29.1
Permian overburden	Weathered/Fresh	8	7.6	48.2	18.3
Leichardt seam roof	Fresh	5	7.6	22.1	13.2
Leichardt seam	Coal	2	8.4	10.5	9.5
Leichardt seam floor	Fresh	4	7.3	16.1	10.9

Position	Weathering Zone	No. of Samples	Minimum	Maximum	Mean
Interburden	Fresh	18	12.4	151	27.1
Vermont seam roof	Fresh	4	6.5	143	44.9
Vermont seam	Coal	4	5	8.2	6.6
Vermont seam floor	Fresh	5	7.2	16.4	10.4
Basement	Fresh	4	16.9	140	70.3

Samples were also analysed for total carbon (TC) and total organic carbon (TOC), with total inorganic carbon (TIC) calculated as the difference between these parameters. TIC is a measurement of the carbonate content due to carbonate minerals such as calcite (calcium carbonate) or dolomite (calcium/magnesium carbonate). These are the primary acid neutralising minerals in most waste rock materials (refer Appendix 1).

A plot of ANC versus TIC content for the present Lake Vermont samples (excluding coal) is given in Chart 2. The reference line represents the expected ANC result if all TIC was present as calcite or dolomite and readily available for acid neutralisation. Chart 2 indicates that ANC for Lake Vermont samples is carbonate-based, with a good correlation of ANC to TIC, especially for subsoil and weathered samples. The correlation is weaker for fresh rock samples, with increasing TIC not corresponding to proportionate increases in the ANC. This is considered to be due to presence of siderite (iron(II) carbonate – FeCO₃), a carbonate mineral which contributes to TIC, but has no net contribution towards ANC (refer Appendix 1). Siderite was field noted in four samples (LV2183G/7, 13, 15 and LV 2219G/11 samples, Table A2-1 of Appendix 2). Chart 2 indicates that siderite was present mostly in the interburden samples. However, it was also found in the Permian overburden (LV2389G/4) and Leichhardt seam roof (LV2183G/9).

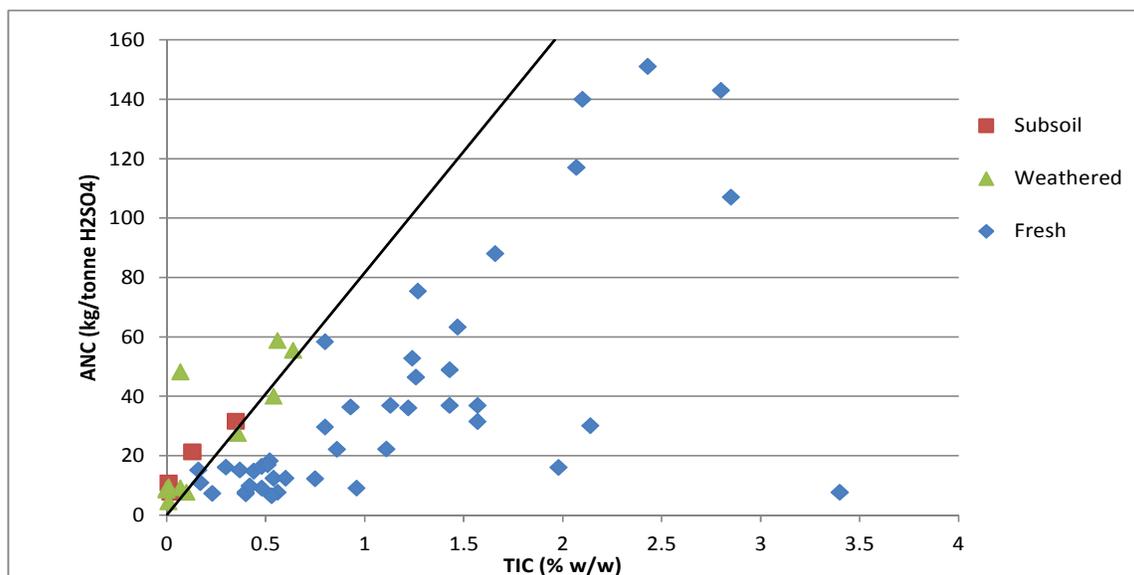


Chart 2: Plot of ANC Versus Total Inorganic Carbon (TIC)

ANC values calculated in this assessment are similar (ranging from 4.4 to 151 kg/t H₂SO₄) to previous work in 2012 (range 3 to 199 kg H₂SO₄/t), 2009 (range 1.6 to 220 kg H₂SO₄/t) and 2004 (range 0.7 to 187 kg H₂SO₄/t). ANC distribution is also similar by stratigraphic position to previous work with the highest values being found in the interburden material and the lowest values in the Leichhardt seam floor and roof material. The high ANC basement material has not been previously characterised. Overall these results demonstrate a moderate to high ANC buffering capacity for any acid production upon exposure to oxygen and are consistent with reports from previous years.

5.1.3 Acid Production Potential

NAPP is calculated as the difference between MPA and ANC. A summary of the range and mean NAPP values for samples, based on stratigraphic position is presented in Table 7.

Table 7: NAPP by Stratigraphic Position

Position	Weathering Zone	No. of Samples	Minimum (kg H ₂ SO ₄ /t)	Maximum (kg H ₂ SO ₄ /t)	Mean (kg H ₂ SO ₄ /t)
Subsoil	Subsoil	4	-31	-7.5	-17
Tertiary	Weathered	7	-57	-3.6	-28
Permian overburden	Weathered/Fresh	8	-47	-6.7	-17
Leichhardt seam roof	Fresh	5	-15	-0.6	-8.6
Leichhardt seam	Coal	2	4.0	10	7
Leichhardt seam floor	Fresh	4	-14	-1.3	-7.8
Interburden	Fresh	18	-150	-8.6	-53
Vermont seam roof	Fresh	4	-142	7	-41
Vermont seam	Coal	4	4.6	8.9	6.1
Vermont seam floor	Fresh	5	-15	2.2	-4.3
Basement	Fresh	4	-135	-15	-68

With the exceptions of the coal seam material (six samples), one Vermont seam floor sample and one Vermont seam roof sample, all samples had a negative NAPP, indicating an excess of ANC. NAPP values for overburden, interburden and basement material from the Leichhardt seam were significantly lower (more negative), indicating low sulphur concentrations and an excess of carbonates capable of neutralising any potential acidity. Chart 3 plots the average NAPP values by position. Only the coal sample average NAPP values were positive.

NAPP values calculated in this assessment are marginally higher (ranging from -150 to 10 kg H₂SO₄/t) than previous work in 2012 (range -199 to -2.8 kg H₂SO₄/t) and 2009 (range -219 to -1.3 kg H₂SO₄/t). NAPP values from 2004 data (15 samples) focussed on the coal seam roof and floor materials and ranged from -88 to 24 kg H₂SO₄/t. The single positive NAPP value of 24 kg H₂SO₄/t recorded in 2004 was for a Vermont seam roof sample, as discussed previously.

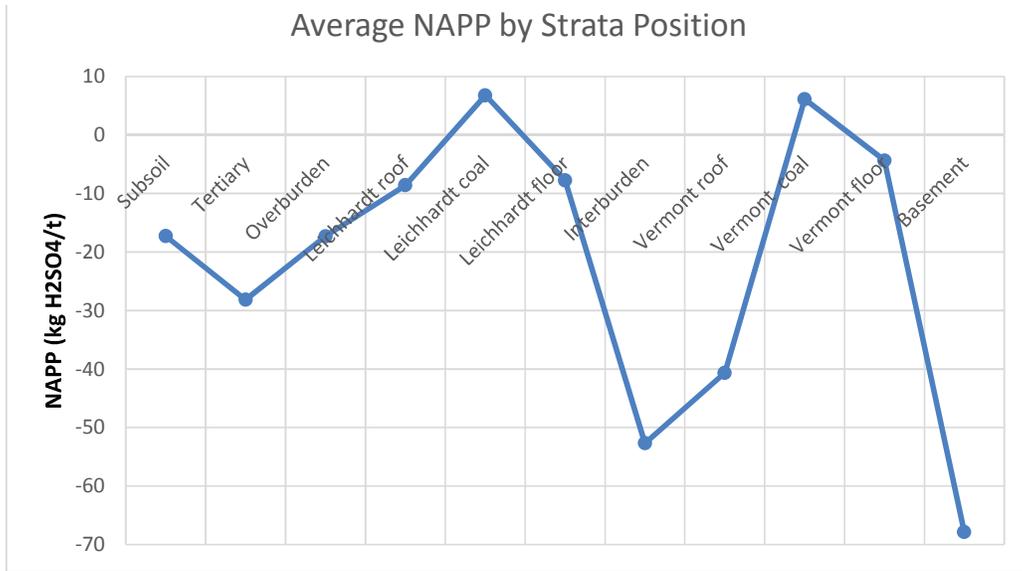


Chart 3: Plot of NAPP Versus Stratigraphic Position

NAG testing was performed on all 65 samples by addition of peroxide to oxidise sulphides to sulphuric acid. A NAGpH below 4.5 from this test indicates acid formation sufficient for classification (in conjunction with NAPP) of material as PAF. Five samples returned NAGpH values below 4.5: LV2389G/4 (Leichhardt seam roof), LV2389G/13 (Vermont seam roof), LV2183G/17 (Vermont seam floor), LV2389G/15 (Vermont seam floor) and LV2389G/16 (Vermont seam floor). Classification of these samples is discussed in Section 5.1.4. There was a good correlation between measured total sulphur and NAGpH for fresh rock samples in particular, as shown in Chart 4, where the blue vertical line indicates a NAGpH of 4.5. Total sulphur is therefore a good indicator of acid formation in fresh rock (particularly roof/floor material) for Lake Vermont samples.

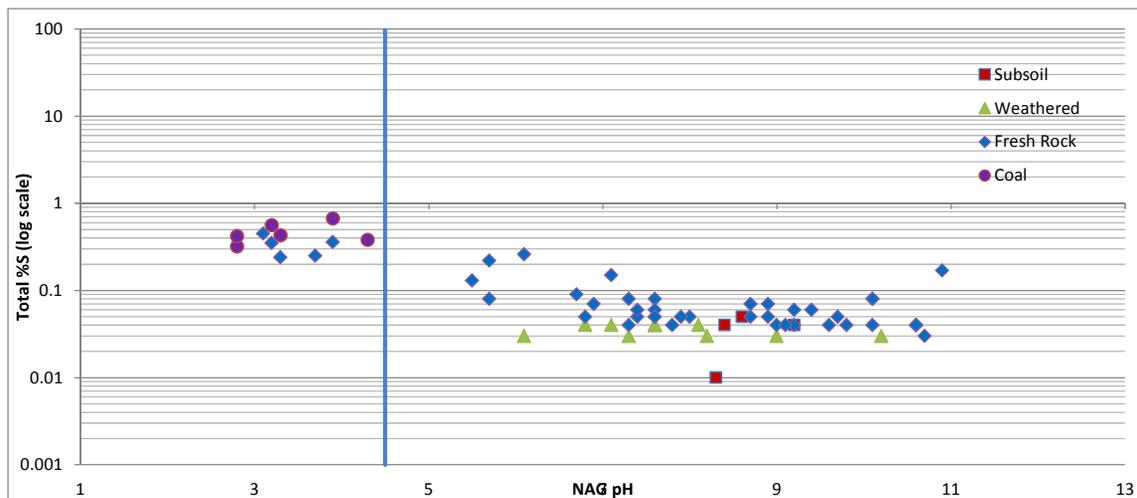


Chart 4: Plot of Total S% (Logarithmic Scale) Versus NAGpH

Results for titrations of aliquots of the NAG solution to endpoint pH values of 4.5 and 7.0 allow estimation, by the difference between these results, of the relative amounts of non-acid producing base metal (such as copper) and iron sulphides in the sample. This is explained in more detail in Appendix 1. In contrast to 2012 testing where all but one sample recorded no detectable result to NAG pH 7.0, the present analysis returned 20 samples (out of 65) with a detectable NAG pH 7.0 result. This was attributed to a combination of generally higher sulphur content in

the present samples, as discussed in Section 5.1.1, and also an effect of interference in the NAG determinations by samples high in organic carbon.

Standard single addition peroxide was used in the analysis of NAG parameters and it is known that for single addition peroxide NAG determinations, samples with greater than 5% TOC consume the available peroxide by formation of organic acids which will contribute to the titration reading to pH 7.0 for NAG (AMIRA 2002). Of the 20 samples recording positive NAG pH 7.0 results, 11 had equal to or greater than 5% TOC with a further four of the remaining lower carbon samples classified as PAF-LC or UC materials due to sulphur content (Section 5.1.4). The five remaining samples were LV2388G/2 Tertiary, LV2389G/3 Permian overburden, LV2389G/6 Leichardt seam floor, LV2183G/17 Vermont seam floor and LV2389G/16 Vermont seam floor. These samples showed NAG pH 7.0 results of between 0.2 and 3.3 kg H₂SO₄/t and some of these results may have been influenced by formation of organic acids below the 5% TOC guide suggested by AMIRA. The result of 3.3 kg/t H₂SO₄ in sample LV2388G/2 is considered an anomalous result with low sulphur (0.03%) and no obvious cause in increased metals content (copper, nickel in particular) of this sample.

NAGpH results can still provide a valid guide for waste classification for all samples, regardless of organic carbon content, if the pH falls below 4.5. This is because sulphide is more reactive than organic carbon material and will still preferentially react. Oxidation of organic material (coal) to produce weak acids is not something normally observed in the field, but does occur under the conditions used for NAG testing with hydrogen peroxide. Future analysis of NAG can account for TOC levels by increasing the peroxide addition volume accordingly.

5.1.4 Waste Classification

As presented in Table 3, waste classification is based on relative NAPP and NAGpH values. Results for this assessment are plotted in Chart 5. Coal samples should not report to waste and have been excluded from this plot for clarity. All coal samples were classified as PAF-LC.

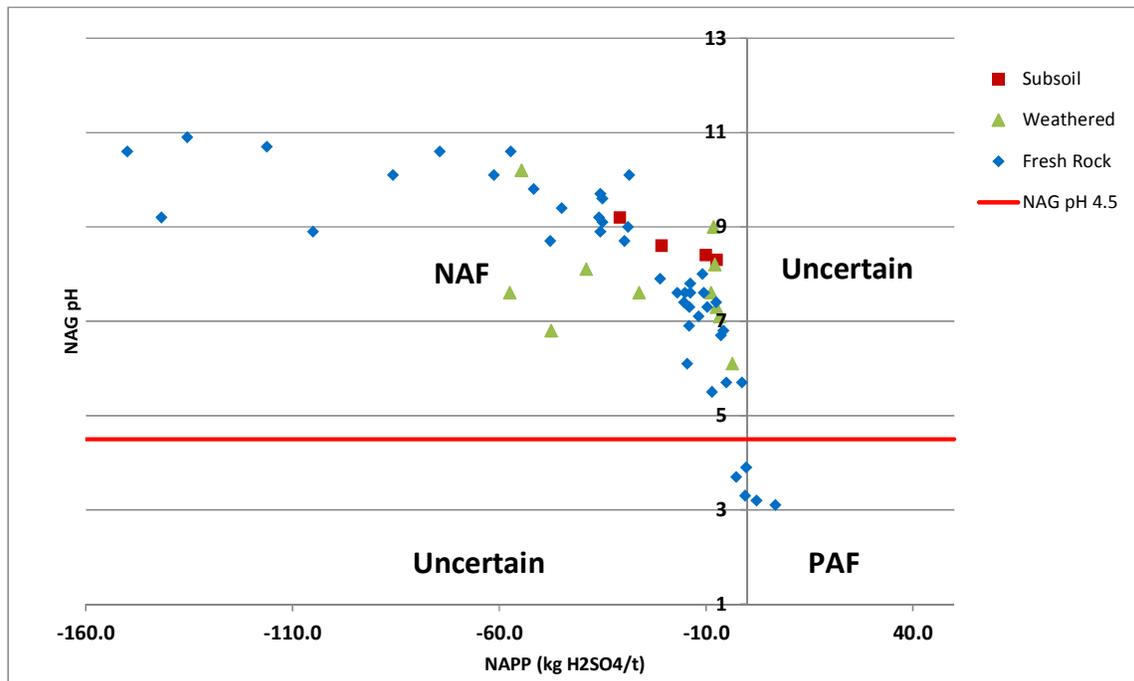


Chart 5: Plot of NAPP Versus NAGpH (Waste Classification)

From Chart 5, it can be seen that five of the 59 non-coal samples fall into either a PAF or UC class. These samples comprise LV2389G/4 (Leichardt seam roof), LV2389G/13 (Vermont seam roof), LV2183G/17 (Vermont

seam floor), LV2389G/15 (Vermont seam floor) and LV2389G/16 (Vermont seam floor). Vermont seam floor material lies below the depth of intended mining (the base of the Vermont seam). As such, only two samples in the present work are within the intended zone of excavation down to the top of the Vermont seam floor. Previous waste characterisation studies at Lake Vermont have often (e.g. 2004) not included Vermont seam floor or basement samples on this basis.

A summary of all classifications by stratigraphic position is presented in Table 8. According to criteria presented in Table 3, five of the 54 samples classified as NAF in Chart 5 are actually acid consuming (AC), with NAPP values below $-100 \text{ kg H}_2\text{SO}_4/\text{t}$.

The UC classifications for LV2389G/4, LV2183G/17 and LV2389G/16 result from zero or marginally negative NAPP values (-1 , 0 and $-3 \text{ kg H}_2\text{SO}_4/\text{t}$, respectively) and a NAGpH of less than 4.5. Conservatively, these materials should be considered as PAF-LC based on the NAGpH and the likely presence of siderite, which may have resulted in overestimation of ANC (Section 5.1.2).

Excluding the coal seams, the two PAF or UC samples of Leichhardt seam roof and Vermont seam roof material represent 4% (2 of 50) of waste samples taken in the zone of excavation. Calculated on the basis of the strata intervals recorded in the cores taken (Table A2-1 Appendix 2), these two samples represent approximately 1.7% of total waste rock volume in the zone of excavation. Much of the remaining waste volume has moderate to high ANC, in particular, the interburden material. This is demonstrated by four samples in the zone of excavation (predominantly interburden) being acid consuming (NAPP below $-100 \text{ kg H}_2\text{SO}_4/\text{t}$), which represents 9.8% of waste rock volume based on core intervals. Vermont seam floor samples (three out of five of which were PAF-LC or UC) represent the level immediately below the maximum depth of excavation and minimal amounts of this material would likely be included with the spoil. This Vermont seam floor is also immediately above the high ANC basement material.

Table 8: Summary of Waste Classification by Stratigraphic Position

Position	Weathering Zone	No. of Samples	NAF	PAF-LC	UC
Subsoil	Subsoil	4	4	0	0
Tertiary	Weathered	7	7	0	0
Permian overburden	Weathered/Fresh	8	8	0	0
Leichhardt seam roof	Fresh	5	4	0	1
Leichhardt seam	Coal	2	0	2	0
Leichhardt seam floor	Fresh	4	4	0	0
Interburden	Fresh	18	18 (3 AC)	0	0
Vermont seam roof	Fresh	4	3 (1 AC)	1	0
Vermont seam	Coal	4	0	4	0
Vermont seam floor	Fresh	5	2	1	2
Basement	Fresh	4	4 (1 AC)	0	0

Results of ABA analysis can also be compared on a plot using the 'Ratio Concept', which compares the proportion of acid neutralising minerals (measured ANC) to acid generating minerals (calculated MPA), as shown in Chart 6. In this plot, results below the red line (NPR of one and hence MPA greater than ANC), indicate acid forming material and an NPR of 2 (blue line) or less is considered potentially at risk of acid formation (AMIRA 2002). All five non-coal samples classified as PAF or UC in Table 8 were found to have an NPR of less than two. In keeping with primary classification based on NAPP and NAGpH above, PAF materials were found exclusively in the coal seams (six samples, NPR values all <1) or the immediately adjacent roof and floor materials (six fresh rock samples below the blue line in Chart 6). The additional fresh rock sample identified in Chart 6 with an NPR of less than 2 was sample LV2219G/7 (Leichhardt seam floor). Despite a low NPR value, this sample had a NAGpH of

5.7 and NAPP of -1.3 kg H₂SO₄/t so was not classified as PAF according to the primary criteria presented in Table 3.

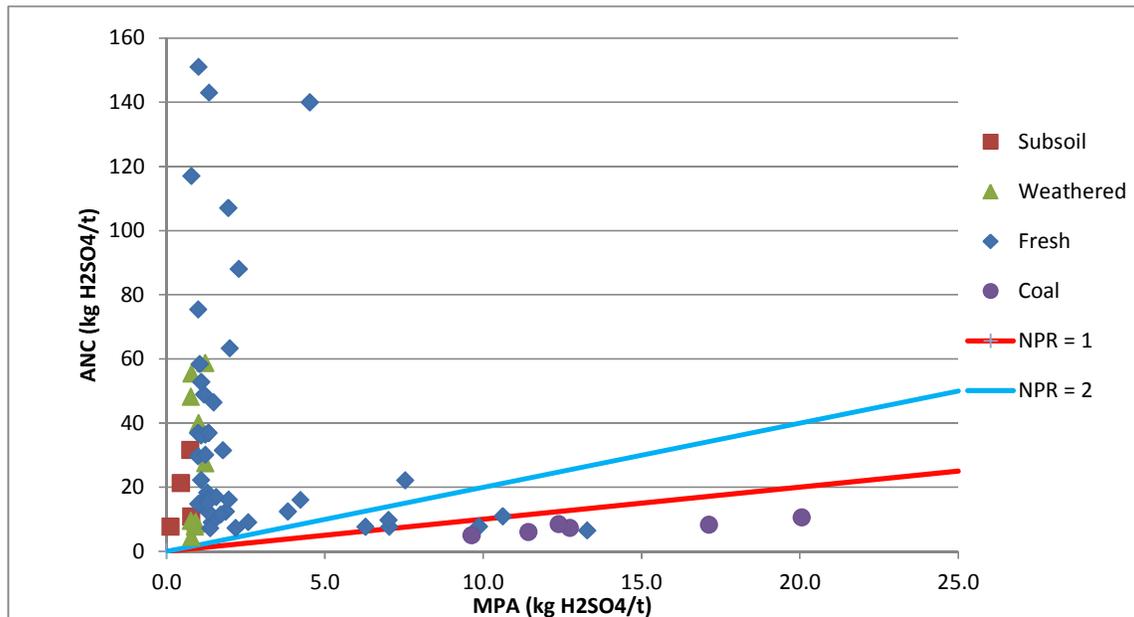


Chart 6: Acid Base Accounting Plot of Lake Vermont Samples

Higher sulphur concentrations within the coal seams and the immediately adjacent roof and floor materials are consistent with findings from all previous waste characterisation work to date. However, sulphur concentrations measured as part of this assessment were higher than most samples in previous studies.

5.2 ELEMENTAL COMPOSITION

Table A2-4 of Appendix 2 presents acid extractable metal and metalloid compositions for the 33 samples selected for further testwork and average earth crustal abundance values for comparison (Bowen 1979).

Table A2-5 of Appendix 2 presents calculated GAIs for these samples, as outlined in Section 3.3.

Concentrations of metals and metalloids in the samples tested were low. The only element with a GAI of three or more was arsenic, in three samples. These three samples were LV2183G/8 (Permian Overburden), LV2219G/10 (Interburden) and LV2389G/17 (Basement) with concentrations of 18, 79 and 18 mg/kg, respectively. Of these results however, only the 79 mg/kg in LV2219GG/10 represents a value above the NEPM 2013 Ecological Investigation Level (EIL) for arsenic of 40 mg/kg. This value remains below the public open space EIL of 100 mg/kg. No EIL exists for pastoral use.

5.3 WATER LEACHATE CHARACTERISATION

The use of a tumbled water extract of a finely ground sample allows the laboratory water extraction test to mimic weathering conditions that may be expected in a temperate, semi-arid environment over a period of several years. A 1:5 ratio extraction was used in the present work for determination of pH, alkalinity and major cations and anions while a 1:20 deionised water ASLP was used to determine extractable trace metals and metalloids.

Observed concentrations of minerals and metalloids in the extract may not represent maximum potential concentrations. This test method can be limited by the rates of dissolution, desorption and solubility (especially for

sparingly soluble minerals such as gypsum (CaSO₄.2H₂O), barite (BaSO₄) and fluorite (CaF₂). Hence an understanding of mineral phases present is important.

5.3.1 pH and Alkalinity

Results for pH, EC and alkalinity in the 1:5 extract are given in Table A2-6 of Appendix 2. Leachates from samples across the subsoil, weathered, and fresh rock zones were moderate to highly alkaline with pH values ranging from 7.6 to 9.9 and alkalinities ranging from 66 mg CaCO₃/L (Vermont seam floor) to 624 mg CaCO₃/L (subsoil). The interburden material had the highest average alkalinity of 456 mg CaCO₃/L. This alkalinity was present as both carbonate and bicarbonate and therefore will be available as buffering for any acid formation.

A plot of pH distribution for all 59 initial waste rock samples excluding coal is given in Chart 7. The highest pH material was generally found at depth in the fresh rock (in particular the interburden and basement material), which is consistent with ANC results (Section 5.1.2).

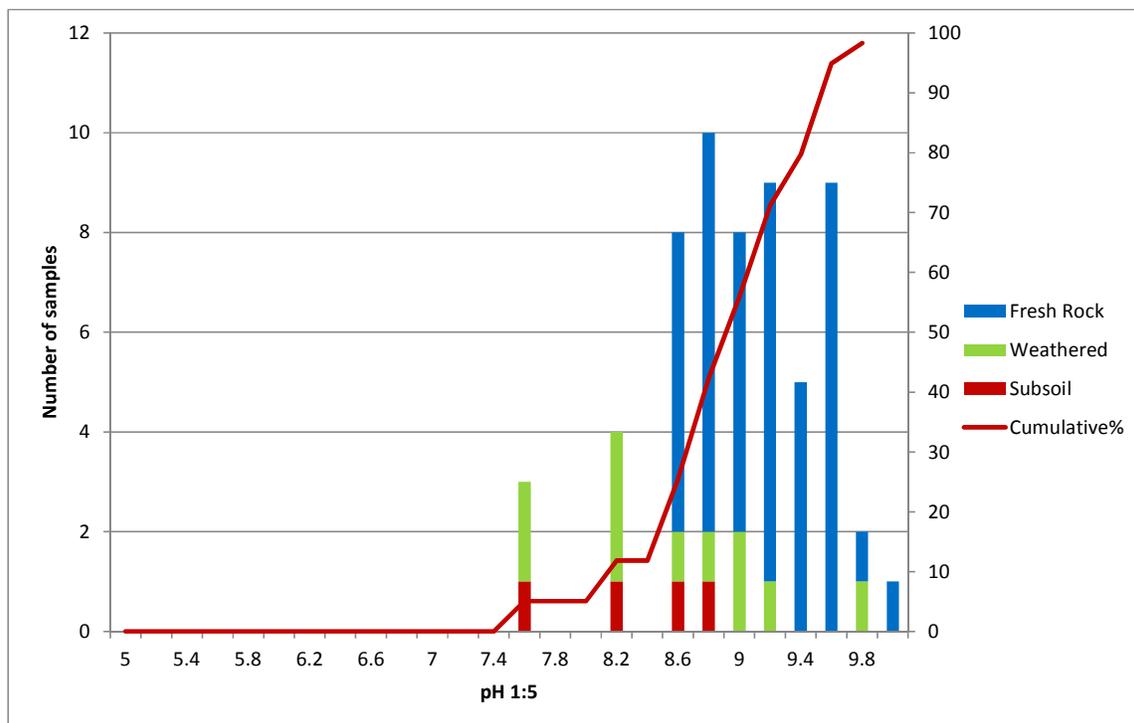


Chart 7: pH Distribution Excluding Coal

5.3.2 Soluble Salts and Sodicity

Results of analysis for major ions on a 1:5 extract are presented in Table A2-7 of Appendix 2. EC results are presented in Table A2-2 of Appendix 2.

EC values of all 65 initial Lake Vermont samples ranged from 72 to 1,760 μS/cm. Results were scattered but there was a generally increasing trend towards the subsoil and tertiary samples in the weathered zone as shown in a plot of the average EC values in Chart 8. Overall, results were marginally higher than those assessed in 2012, but very similar to 2009. According to the Mine Planning Guidelines for Assessment and Management of Saline and Sodic Waste (EHP 1995), the majority of samples (91%) fall into the medium, low or very low categories for salinity based on EC. The example local groundwater data provided indicated an EC in the order of 10-11,000 μS/cm which is well above levels seen in the 1:5 extracts analysed. Surface waters in the area were of a similar range to present results (AARC 2009, Section 2.3).

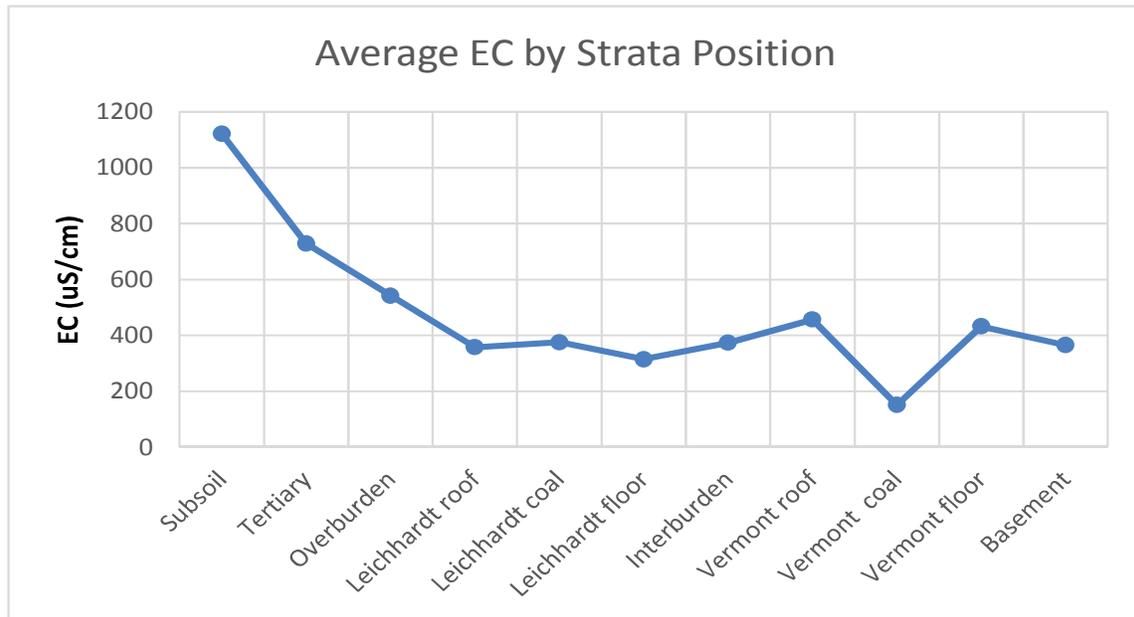


Chart 8: Average EC by Strata Position

Chloride concentrations of the subset of 33 representative samples tested for major anions and cations ranged from 30 to 1,660 mg/L (ppm) in a roughly similar fashion to EC with higher concentrations towards the subsoil and tertiary samples in the weathered zone. On the basis of classifications outlined in Mine Planning Guidelines for Assessment and Management of Saline and Sodic Waste (EHP 1995), 58% of samples fell in the very low to low categories (0 to 300 mg/L) for salinity/sodicity assessment and 88% within the range up to medium potential (0 to 600 mg/L) for sodicity classification. The remaining 12% of samples were classified as high sodicity (600 to 2,000 mg/L chloride). These results were consistent with previous reports where average chloride overburden concentrations in 2009, 2012 and present were 887 mg/L, 129 mg/L and 432 mg/L respectively. Thus, subsoil material in particular, is saline in nature, but within the ranges found previously during mine operations.

Calculated SAR values are given in Table A2-7, Appendix 2. SAR is a measure of the tendency for calcium and magnesium ions attached to soil clay minerals to be replaced with sodium ions in the presence of water. Sodium (sodic) clays have poor structure (are subject to dispersion) and develop permeability problems. SAR calculation provides an indication of waste rock sodicity for wastes containing significant amounts of clay-sized particles.

Chart 9 compares leachate SAR values to EC. The orange and red lines signify approximate boundaries between flocculated (good), potentially dispersive and dispersive soil/rock types (CSIRO 1999). All samples examined were classed as dispersive or potentially dispersive soil types (CSIRO 1999). The risk of potentially dispersive material is greatest (due to a greater proportion of clay fraction material), in subsoil and weathered waste material. With the exception of LV2183G/4 weathered Tertiary sample, the highest SAR values were generally found associated with the Vermont seam roof and floor samples, which is consistent with previous work. No other trends by lithology/stratigraphic position were evident.

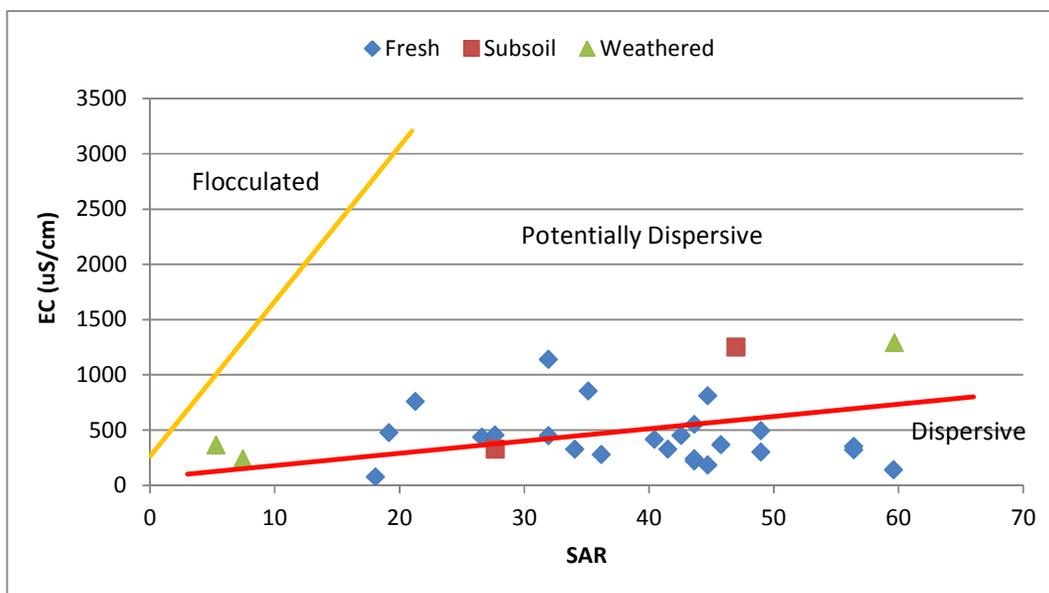


Chart 9: Calculated SAR Values Versus EC

Issues of sodicity are exacerbated by the presence of moderate to high alkalinity in Lake Vermont samples which decreases the availability of calcium and magnesium to displace/balance the sodium. The calcium to magnesium ratio can be used, to a lesser extent than SAR, as an indication of dispersive soils – with ratios of less than one indicating dispersive material (EHP 1995). Soluble calcium and magnesium levels in the soil:water extracts were very low and less than the limits of reporting for most samples due to the alkaline nature of the material. Calcium to magnesium concentrations for two samples LV2183G/1 (Subsoil) and LV2183G/4 (Weathered Tertiary overburden) which were above the limits of reporting indicated a calcium to magnesium ratio of less than one and hence are likely to be dispersive.

In summary, weathered overburden material from Lake Vermont is likely to be saline (especially the subsoil), sodic and dispersive in nature. Deeper material is less saline in nature and by virtue of being less weathered (larger particle sizes), less likely to be dispersive. This is consistent with previous work where the siltstone, mudstone and sandstone material of the weathered overburden was found to be more saline and sodic than deeper material (AARC 2012). A continuation of mine waste management practices outlined in Section 2.4, where surface water runoff is minimised and contained as much as possible is therefore recommended. This will minimise the potential environmental impacts associated with saline and sodic spoil. Placement of the most dispersive overburden material into the innermost (non-exposed) portions of waste dumps or into pits as backfill is another possible management tool.

5.3.3 Metals and Metalloids

Results for water soluble metals and metalloids in the extract are given in Table A2-8 of Appendix 2. ANZECC livestock drinking water guidelines (ANZECC 2000), ANZECC freshwater guidelines (ANZECC 2000/NEPC 2013), and Human Drinking Water Guidelines (NHMRC 2011) are provided for comparison. As discussed in Section 2.3, the only identified water use in the vicinity of the project is for livestock sourced from available surface water runoff.

Concentrations of all metals and metalloids were low and generally less than reportable. The three samples with an arsenic GAL of three (Section 5.2) showed very low concentrations of leachable arsenic (maximum 0.017 µg/L), all well below the Livestock Drinking Water Guideline value of 0.5 mg/L (ANZECC 2000). Available data for groundwater at the time of writing (LV2375W collected May 2013), showed no detectable dissolved arsenic.

These results suggest that water soluble concentrations of metals and metalloids from waste material are unlikely to pose any significant risk to the surrounding environment or water usage.

6. CONCLUSIONS

In summary, geochemical assessment of material from Lake Vermont proposed extension areas provided by AARC indicates that:

- 92% of samples (other than the target coal) were classified as NAF with generally very low sulphur (83% of samples less than 0.1% sulphur and 95% of samples less than 0.3% sulphur) and moderate to high ANC. ANC values were particularly high (up to 151 kg H₂SO₄/t) in the interburden, located between the Leichhardt and Vermont seams.
- Three samples were classified as uncertain (UC) based on conflicting NAGpH and NAPP results. In such cases, NAGpH is often considered the better indicator of acid formation and therefore, in this case, UC samples should be regarded as likely PAF-LC.
- All coal seam material and five non-coal samples were identified as PAF-LC or UC (likely PAF-LC). The five non-coal samples originated from the Leichhardt seam roof (one sample), Vermont seam roof (one sample) and Vermont seam floor (three samples). The presence of higher-sulphur and lower ANC material in the coal seams and adjacent roof/floor is consistent with previous studies (Emmertson 2004, AARC 2009 and AARC 2012). The amount of sulphur present in these samples is somewhat higher than those recorded in 2012 and 2009, but within the upper range of one sample of Vermont seam roof from the 2004 study.
- The PAF-LC and UC material found in some of the Leichhardt seam roof and Vermont seam roof samples (and hence likely to be disturbed during mining) represented 4% of all samples analysed within the zone of excavation (96% were NAF). Calculated on the basis of the strata depths recorded in the cores taken, these two samples represent approximately 1.7% of total waste rock volume in the zone of excavation. In addition to this low proportion of PAF-LC material in the waste rock, a much higher proportion of high ANC (including 9.8% by calculated volume acid consuming) material was found to be present in the overburden and interburden strata. Prediction of acid formation in materials also assumes the material is finely divided and exposed to air for prolonged periods as a conservative approach. Implementation of strategies outlined in the existing mine management plan (Section 2.4) and in particular progressive backfilling and rehabilitation should avoid such long term exposure.
- When mining of the Vermont seam is complete, the Vermont seam floor will be exposed. Three of the five Vermont seam floor samples were classified as PAF-LC or UC (likely PAF-LC). Timely progressive rehab of the exposed area according to existing practices (Section 2.4), after mining has ceased is recommended in order to limit potential for localised acid formation from this material within the base of the open cut. It is noted however, that the risk for AMD seepage into groundwater from any such localised acid formation is reduced by the presence of the high ANC basement material underlying the Vermont seam floor and the lack of significant quantities of groundwater in the area.
- Analysis of samples for total and leachable metals identified no metal or metalloid concentrations of environmental significance. Seepage/surface runoff from any waste is predicted to be below Human and ANZECC 2000 Livestock Drinking Water Guidelines. Based on the low concentrations of metals in samples examined, kinetic leach tests (column tests) are not deemed necessary.
- Waste materials assessed in this study were found to be sodic, with a strong potential to be dispersive. Generally, salinity of the subsoil and weathered Tertiary overburden was higher than for wastes located deeper in the profile, which is consistent with previous studies (Emmertson 2004, AARC 2009 and AARC 2012). SAR values however, did not show any discernible pattern of distribution with strata position. Salinity values found in the present work were within the range experienced during mining operations to date. Salinity levels in water extracts examined were significantly less than the typical local groundwater. As wastes are likely to be sodic and dispersive in nature, it will remain important to continue to reduce and capture runoff from spoil piles using practices described in Section 2.4.

Overall, present testwork from within the proposed extension area is largely consistent with previous assessments and information provided on practical experiences at the operating mine. The existing waste material

management strategies at Lake Vermont site (Section 2.4), should continue, thus minimising the potential for impacts associated with saline and sodic/dispersible waste and the coal seam roof and floor material being excavated.

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APPENDICES

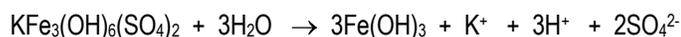
APPENDIX 1: ACID FORMING WASTE CLASSIFICATION METHODOLOGY

ACID FORMING WASTE CLASSIFICATION METHODOLOGY

1. OXIDATION OF SULPHIDES

There is no simple method of defining whether mine waste containing small quantities of sulphur will produce sulphuric acid. Sulphide minerals containing ferrous iron such as pyrite (FeS₂), marcasite (FeS₂) and pyrrhotite (~FeS) normally oxidise to produce sulphuric acid and ferric oxy-hydroxide. Whilst sulphur in pyrite will always form sulphuric acid, a portion of the sulphur in marcasite and pyrrhotite forms highly soluble sulphite, thiosulphate, more complex polythionate ions and elemental sulphur, some or all of which may never form acid. Similarly, sulphur in chalcopyrite and arsenopyrite rarely forms sulphuric acid due to simultaneous oxidation of copper and/or arsenic resulting in formation of non-acid forming copper sulphides and soluble sulphates. Sulphur in galena (PbS), sphalerite (ZnS), molybdenite (MoS₂), stibnite (Sb₂S₃) and other iron-free sulphides is non-acid producing. Sulphur present as sulphate in minerals such as barite (BaSO₄), anhydrite (CaSO₄), gypsum (CaSO₄·2H₂O), epsomite (MgSO₄·7H₂O) and alkali sulphates is also non-acid producing.

There is a group of iron and aluminium sulphate minerals that fall into a special category. An example is the mineral jarosite (KFe₃(OH)₆(SO₄)₂), an oxidation product of pyrite formed under certain environmental conditions. Substitution of aluminium for iron results in the common aluminium sulphate mineral, alunite (KAl₃(OH)₆(SO₄)₂). Although sulphur in jarosite (and alunite) is fully oxidised and therefore cannot produce further acidity under oxidising conditions, it can release acidity by hydrolysis as indicated by the chemical equation:



This form of acidity is commonly referred to as “stored acidity” or “residual acidity”. This aspect of acidity is discussed further in Section 5 of this Appendix.

Potential for acid production relies on determination of total sulphur content (Tot_S), and non-sulphide sulphur content (commonly described as sulphate sulphur (SO₄_S)). Where necessary, determination of sulphur in the acid insoluble minerals barite (barium sulphate) and celestite (strontium sulphate) commonly described as barite sulphur, may be undertaken.

2. ACID NEUTRALISATION

Acid Neutralising Capacity (ANC) is a measure of the natural ability of the sample to neutralise acid. It is normally determined in the laboratory by measuring the amount of residual acidity following reaction of a finely ground sample of mine waste with an excess of dilute hydrochloric acid. This method captures all minerals, including carbonates, oxides, hydroxides, phosphates and some silicate minerals that are capable of neutralising hydrochloric acid.

The ANC results are based on the assumption that all acid-neutralising materials are rapid-acting. In practice, some neutralising capacity is supplied by silicate and aluminosilicate minerals which can have slow to very slow reaction kinetics. The most common and reactive group of acid-consuming minerals are calcite (CaCO₃) and dolomite (CaMg(CO₃)₂). Measurement of total inorganic carbon content provides a rapid and usually accurate method of estimating the contribution of these carbonate minerals to the ANC. Presence of siderite (FeCO₃) in some samples, can complicate estimation from total inorganic carbon because it is not net acid consuming due to the presence of iron(II) in the mineral released upon reaction with acid which oxidises to Fe(III) and releases an equal amount of acid.

3. WASTE CLASSIFICATION

Calculations are undertaken of Maximum Potential Acidity (MPA) and Net Acid Producing Potential (NAPP). MPA is based on the incorrect assumption that all sulphur present in the sample is acid producing (sourced from pyrite FeS_2). NAPP is a calculation based on the MPA, $\text{SO}_4\text{-S}$ and ANC and therefore relies on the same incorrect assumption. As discussed in Section 2 of this appendix, NAPP calculations may also over value the ANC. Generally, NAPP tends to over-estimate potential acidity. However, with care and a good knowledge of the minerals present, it is suitable for conservative prediction of potential acid generation.

Due to the lack of reliability of the MPA calculation, geological and geochemical experience is required to classify the wastes. Two concepts have been developed to alleviate the degree of difficulty associated with evaluating MPA results:

1. **The analysis concept** refers to situations where Tot_S is less than 0.30% sulphur; Acid Rock Drainage (ARD) is unlikely to occur. This sulphur value corresponds to a maximum of 9.2 kg $\text{H}_2\text{SO}_4/\text{t}$. With weathered rocks in arid areas where there may be a substantial percentage of $\text{SO}_4\text{-S}$ and the presence of some carbonate minerals, the analysis concept is often correct. It is, however, commonly inaccurate in humid climates where some sulphur may be present in organic forms and unsuitable for acid sulphate soils investigations.
2. **The ratio concept** compares the direct calculation of MPA from Tot_S and the ANC analytical measurement, then classifies samples as either Non Acid Forming (NAF), where the ratio of ANC/MPA is greater than or equal to two, or Potentially Acid Forming (PAF) where the same ratio is less than or equal to two.

The methodology of the ratio concept is unsatisfactory as it does not allow for $\text{SO}_4\text{-S}$, or sulphur associated with barium sulphate or organic materials. It therefore tends to overestimate the MPA, resulting in a lower ratio value. For oxide to fresh rock, transitional, supergene enriched sulphide samples, many iron ores, most manganese ores and most zinc-copper stratiform sulphide horizons in felsic volcanics, this methodology fails. Ratio concept classification can be incorrect due to $\text{SO}_4\text{-S}$ and barium sulphate content, particularly in manganese ores and most zinc-copper stratiform sulphide horizons where barite is often a substantial rock forming mineral. The ratio concept often gives incorrect results when used with acid sulphate soils and in conditions of very high salinity. It will also give incorrect results if applied to waste dumps that have not been rehabilitated and where the dominant residual sulphides in the wastes are base metal sulphides. This includes the iron-bearing sulphides chalcopyrite, bornite and arsenopyrite which all have high sulphur content but generate very little or no acid.

In arid areas where rainfall comes in short heavy showers, followed by long periods of low humidity, climatic conditions minimise sulphide alteration. Oxidation products are flushed with each rainfall period resulting in dispersal over large areas with little or no acidic build-up. This is the basis behind the Analysis Concept which gives sound results in areas with seasonal rainfall and an arid climate.

The "analysis concept" methodology is suitable to characterise mine waste during the early stages of feasibility drilling to ensure potentially acid forming materials are not missed utilising inexpensive mixed acid analytical methods with ICP-OES finish for base metals and sulphur determination. It is preferable to reduce the total sulphur cut off to 0.20%. This mixed acid methodology does not include barium sulphate sulphur in the final result. The sulphur values obtained approximate sulphide sulphur plus sulphate sulphur required for calculation of NAPP.

Basic classification of wastes undertaken in this report utilises the following methodology:

- Analysis for total sulphur (Tot_S).
- Analysis for non-sulphide sulphur ($\text{SO}_4\text{-S}$), quoted as sulphur, not sulphate.
- Analysis for ANC (quoted in kg $\text{H}_2\text{SO}_4/\text{t}$).

- Calculation of MPA = [(Tot_S - SO₄_S) multiplied by 30.6 kg] H₂SO₄/t.
- Calculation of NAPP = [(Tot_S - SO₄_S) multiplied by 30.6] - ANC] kg H₂SO₄/t.

The waste classifications are based directly on the difference between total and non-sulphide sulphur (Tot_S - SO₄_S) and the NAPP value. The classifications are substantially more conservative than the Analysis Concept and the Ratio Concept but assume the absence of barium sulphate sulphur. The PAF-LC and "Uncertain" Classes will record as NAF using either of the Analysis or the Ratio concepts. These classes are defined in Table A1-1.

Table A1-1: NAPP Classification of Acid Rock Drainage

Primary Geochemical Waste Type Class	Sulphide - Sulphur Content *	NAPP Value kg H ₂ SO ₄ /t *
Potentially Acid Forming (PAF)	≥ 0.33%	≥ 10
Potentially Acid Forming - Low Capacity (PAF-LC)	≥ 0.16 ≤ 0.33%	5 to 10
Uncertain, probably NAF	≥ 0.00 ≤ 0.16%	0 to 5
Non Acid Forming (NAF)	Not important	- 100 to 0
Acid Consuming Materials	Not important	< -100

* The NAPP value, not the sulphur value, is used to define the Class.

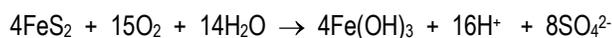
"Uncertain samples" can be reclassified by undertaking a NAG determination (oxidation of a subsample in the laboratory with hydrogen peroxide to oxidise all the sulphide minerals to sulphuric acid where possible followed by an acidity and pH determination). NAG testing is particularly useful for PAF-LC materials or where there is a very low ANC in the host rock. A combined acid generation classification scheme based on NAPP and NAG determinations is presented in Table A1-1.

Table A1-2: Combined NAPP and NAG Classification of Acid Rock Drainage

Primary Geochemical Waste Type Class	NAPP Value kg H ₂ SO ₄ /t	NAG pH	Sulphide S Content
Potentially Acid Forming (PAF)	≥ 10	< 4.5	≥ 0.3%
Potentially Acid Forming – Low Capacity (PAF-LC)	0 to 10	< 4.5	0.16 to 0.3%
Uncertain possibly NAF	0 to 5	> 4.5	Not important
Uncertain possibly PAF	-10 to 0	< 4.5	Not important
Non Acid Forming (NAF)	-100 to 0	> 4.5	Not important
Acid Consuming Materials (AC)	< -100	> 4.5	Not important

4. ACID GENERATION FROM OTHER SULPHIDE MINERALS

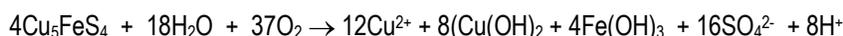
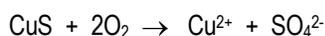
The principle of Acid Base Accounting procedures described above is based on the acid generating properties of the iron sulphide mineral pyrite (FeS₂). Pyrite reacts with oxygen and water to produce acidity (H⁺) according to the chemical equation:



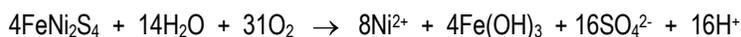
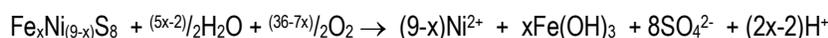
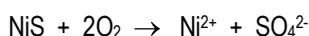
The stoichiometry of this reaction indicates that oxidation of one mole of pyrite will produce two moles of sulphuric acid or alternatively, 30.6 kg of sulphuric acid will be produced by oxidation of 1 t of mine waste containing 1% by weight of sulphur.

Other iron sulphides, such as pyrrhotite ($\text{Fe}_{(1-x)}\text{S}$), marcasite (FeS_2) and mackinawite ($\text{Fe}_{(1+x)}\text{S}$) react by different mechanisms, but all result in production of one mole of sulphuric acid per mole of sulphur (30.6 kg of sulphuric acid will be produced by oxidation of 1 t of mine waste containing 1% by weight of sulphur).

Copper sulphide minerals also react with oxygen, but the amount of acid produced depends on the composition of the mineral, and in particular the iron content. Chemical equations for the oxidation of copper sulphide minerals such as chalcocite (Cu_2S), covellite (CuS), chalcopyrite (CuFeS_2) and bornite (Cu_5FeS_4) are presented below:



Other base metal sulphides containing metals including cobalt, nickel, lead and zinc indicate similar behaviour to those of copper sulphides. Chemical equations for the oxidation of common nickel sulphide minerals such as millerite (NiS), pentlandite ($\text{Fe}_x\text{Ni}_{(9-x)}\text{S}_8$), and violarite (FeNi_2S_4) are presented below:



The predicted maximum amounts of sulphuric acid that can be produced by complete oxidation of various iron, copper and nickel sulphide minerals are listed in Table A1-3. These values indicate that acid generation is only possible if the sulphide mineral contains iron. Chalcopyrite, a common iron-copper sulphide mineral, has potential to generate acidity upon complete oxidation, but the maximum amount of potential acidity per percentage unit of sulphur in the mine waste is only half that of pyrite (or marcasite or pyrrhotite).

Table A1-3: Predicted Sulphur Acid Generation Potential from Oxidation of Iron, Copper and Nickel Sulphide Minerals

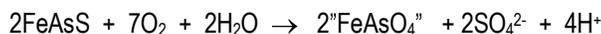
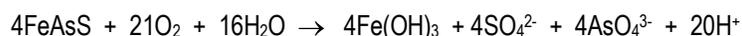
Mineral Name	Formula	Acid Generation Potential (kg H_2SO_4 per t)	
		Per t of Mineral	Per 1% Sulphur
Pyrite	FeS_2	1,633	30.6
Marcasite	FeS_2	1,633	30.6
Pyrrhotite	$\text{Fe}_{(1-x)}\text{S}$	1,115	30.6
Chalcocite	Cu_2S	Nil	Nil
Covellite	CuS	Nil	Nil
Chalcopyrite	CuFeS_2	267	15.3
Bornite	Cu_5FeS_4	49	7.6
Millerite	NiS	Nil	Nil
Pentlandite	$\text{Fe}_x\text{Ni}_{(9-x)}\text{S}_8$	Variable, depending on the value of x.	
Violarite	FeNi_2S_4	650	15.3

It should also be noted that oxidation of copper and nickel sulphide minerals can form soluble copper (Cu^{2+}) and nickel (Ni^{2+}) ions. Both metals form slightly soluble hydroxides ($\text{Cu}(\text{OH})_2$ and $\text{Ni}(\text{OH})_2$), which significantly reduces the concentration of free metal ions in solution if the pH remains above 6.5. However, oxidation of copper and nickel sulphide minerals containing iron (e.g. chalcopyrite and violarite) can result in very low pH values, typically below 4.5 if there are insufficient carbonate minerals present to consume the generated acidity. For this reason, it is recommended that NAG measurements for mine waste containing copper and/or nickel sulphides be conducted to endpoint pH values of 4.5 and 7.0:

- NAG acidity to pH 4.5 includes hydrogen (H^+), ferric (Fe^{3+}), manganese (Mn^{2+}) and aluminium (Al^{3+}) ion acidity, but not copper ions (Cu^{2+}) or nickel (Ni^{2+}) ions.
- NAG acidity to pH 7.0 also includes the amount of alkalinity required to precipitate all of the soluble copper ions as $\text{Cu}(\text{OH})_2$ and nickel ions as $\text{Ni}(\text{OH})_2$. The difference between NAG acidity to pH 4.5 and NAG acidity to pH 7.0 is a measure of the amount of oxidisable copper and nickel sulphides in the sample.

The potential for mixed element iron sulphides to generate variable amounts of acidity is further complicated by the presence of arsenic. Arsenopyrite (FeAsS) is a common sulphide mineral often associated with gold mineralisation in the Western Australian goldfields.

Oxidation of arsenopyrite may be described by the following equations:



" FeAsO_4 " may vary from crystalline ferric arsenate minerals such as scorodite ($\text{FeAsO}_4 \cdot 2\text{H}_2\text{O}$) to arsenate anions adsorbed onto hydrous iron oxide surfaces. Regardless of the actual form of " FeAsO_4 ", oxidation of arsenopyrite results in formation of 30.6 kg of sulphuric acid from 1 t of mine waste containing 1% by weight of sulphur, as for pyrite, marcasite and pyrrhotite (Table A1-3). If, however, the iron end product is $\text{Fe}(\text{OH})_3$, then the resulting amount of acid (in the form of both sulphuric acid, H_2SO_4 , and arsenic acid, H_3AsO_4) will be 2.5 times higher. Alternatively, oxidation of arsenopyrite by this reaction results in formation of 76.5 kg of sulphuric acid equivalents from 1 t of mine waste containing 1% by weight of sulphur.

In conclusion, using a factor of 30.6 to calculate the amount of acidity as kg H_2SO_4 /t is only valid if all of the sulphur is present as iron sulphide minerals. If mixed copper, nickel and other base metals are present, use of the 30.6 conversion factor will over-estimate the amount of acidity produced. If arsenopyrite is present, use of the 30.6 conversion factor may under-estimate the amount of acidity produced.

5. RESIDUAL ACIDITY

It is important to note that material classified as NAF by acid-base accounting methodology described above may not have circum-neutral or alkaline pH values. For reasons outlined in this Section, it is possible for NAF waste to be moderately to highly acidic as a result of existing "residual" or "natural" acidity. Conversely, it is common for PAF waste to be slightly to moderately alkaline.

Laterite waste rock is an example of material that usually classifies as NAF by acid-base accounting procedures described above, but often records moderate to highly acidic pH values. A NAF classification results from very low total sulphur contents, most of which is present in oxidised form, combined with moderate ANC values. However, most of this ANC is associated with silicate minerals that require highly acidic conditions (pH 1.5 to 4.5) to consume acidity in the ANC test procedure.

As discussed in Section 1 of this Appendix, most of the "residual" or "natural" acidity of these materials may be explained by the presence of iron and aluminium sulphate minerals including jarosite and alunite. Additional acidity may be associated with cation exchange properties of highly weathered clay minerals. In circum-neutral or

alkaline wastes, basic cations (calcium, magnesium, sodium and potassium) account for most or all of the Cation Exchange Capacity (CEC). In acidic materials, the sum of concentrations of basic cations (expressed in units of centimoles of positive charge per kilogram) is less than CEC expressed with the same units. In these situations, charge neutrality is maintained by the presence of "acidic" cations including H^+ , Al^{3+} and Mn^{2+} . The sum of the concentrations of these cations (expressed in units of centimoles of positive charge per kilogram) is referred to as "exchangeable acidity". The contribution of "exchangeable acidity" in acidic, clay-rich lateritic waste rock may be as high as 5 kg H_2SO_4/t (depending on clay mineralogy). It is important to note that leachate from materials containing only "exchangeable acidity" usually contain low levels of soluble acidity, which presents a low risk to the receiving environment. However, elevated levels of "exchangeable acidity" are toxic to plants, meaning that such materials are unsuitable as a growth medium or as a subsoil water storage for plants.

pH values of freshly mined waste rock, regardless of a NAF or PAF classification, is determined by the presence of various acid-consuming minerals. A summary of typical pH conditions associated with different waste types is presented in Table A1-4.

Table A1-4: pH Values of Various Waste Rock Types as Controlled by Significant Minerals

Typical pH Values	Significant Minerals	Typical Waste Rock Types
Greater than 9.0	Sodium and potassium carbonate, reactive silicates such as forsterite (Mg_2SiO_4), wollastonite ($CaSiO_3$) and cordierite ($(Mg,Fe)_2Al_3(Si_5AlO_{18})$).	Mafic and ultramafic volcanics.
8.0 to 9.0	Calcium and magnesium carbonates such as calcite ($CaCO_3$), magnesite ($MgCO_3$), dolomite ($CaMg(CO_3)_2$) and ankerite ($Ca(Fe,Mg,Mn)(CO_3)_2$).	Mafic and ultramafic volcanics, calcareous sedimentary rocks.
5.0 to 9.0	Many common silicate and aluminosilicate minerals such as feldspars, micas and pyroxenes.	Many igneous, non-calcareous sedimentary and metamorphic rock types.
4.0 to 5.0	Highly weathered clay minerals including kaolinite ($Al_2Si_2O_5(OH)_4$), goethite ($FeOOH$) and gibbsite ($Al(OH)_3$).	Laterite and saprock developed over acidic igneous rock types.
Less than 4.0	Alunite, jarosite and related minerals.	Gossans, acid sulphate soils, oxidised sulphidic wastes.

APPENDIX 2: COLLATED RESULTS

LIST OF APPENDIX TABLES

- Table A2-1: Sample Descriptions by Drill Core
- Table A2-2: ABA Analysis Part A (Sorted by Stratigraphic Position)
- Table A2-3: ABA Analysis Part B (Sorted by Stratigraphic Position)
- Table A2-4: Elemental Analysis
- Table A2-5: Global Abundance Index Classification
- Table A2-6: pH, EC and Alkalinity
- Table A2-7: Major Ions (1:5 DI Extract)
- Table A2-8: Water Soluble Metals and Metalloids (1:20 DI ASLP)

Table A2-1: Sample Descriptions by Drill Core

Sample ID	From	To	Weathering Zone	Position	Lithology
LV2183G/1	0.60	2.98	Subsoil	Subsoil	Sandy clay
LV2183G/2	7.30	9.00	Weathered	Tertiary	Clay
LV2183G/3	12.53	13.14	Weathered	Tertiary	Shaly coal (Phillips seam)
LV2183G/4	21.22	25.42	Weathered	Tertiary	Laterite + clay
LV2183G/5	25.96	27.61	Weathered	Permian overburden	Claystone + siltstone
LV2183G/6	28.23	29.95	Weathered	Permian overburden	Sandstone + siltstone
LV2183G/7	37.60	39.00	Fresh	Permian overburden	Mudstone + siltstone
LV2183G/8	46.47	47.05	Fresh	Permian overburden	Carbonaceous mudstone
LV2183G/9	58.63	59.42	Fresh	Leichhardt seam roof	Carbonaceous mudstone
LV2183G/10	59.42	62.52	Coal	Leichhardt seam	Coal
LV2183G/11	62.52	63.45	Fresh	Leichhardt seam floor	Mudstone + siltstone + sandstone
LV2183G/12	66.00	68.00	Fresh	Interburden	Carbonaceous sediments
LV2183G/13	70.53	73.34	Fresh	Interburden	Siltstone with siderite
LV2183G/14	77.34	79.07	Fresh	Interburden	Carbonaceous siltstone + mudstone
LV2183G/15	79.07	80.14	Fresh	Vermont seam roof	Carbonaceous mudstone
LV2183G/16	80.14	86.50	Coal	Vermont seam	Coal
LV2183G/17	86.50	87.32	Fresh	Vermont seam floor	Carbonaceous siltstone + mudstone
LV2183G/18	89.97	92.24	Fresh	Basement	Sandstone
LV2219G/1	1.00	2.98	Subsoil	Subsoil	Clay
LV2219G/2	12.00	12.96	Weathered	Tertiary	Clayey sand
LV2219G/3	33.93	35.84	Weathered	Tertiary	Sandstone
LV2219G/4	41.30	41.78	Fresh	Permian overburden	Carbonaceous mudstone
LV2219G/5	48.71	49.58	Fresh	Leichhardt seam roof	Carbonaceous mudstone
LV2219G/6	52.15	53.18	Fresh	Internal waste	Carbonaceous mudstone
LV2219G/7	58.36	59.13	Fresh	Leichhardt seam floor	Carbonaceous mudstone
LV2219G/8	62.00	63.61	Fresh	Interburden	Sandstone + siltstone
LV2219G/9	69.44	70.45	Fresh	Interburden	Siltstone
LV2219G/10	70.76	72.24	Fresh	Interburden	Carbonaceous mudstone
LV2219G/11	88.27	89.52	Fresh	Interburden	Siltstone with siderite
LV2219G/12	94.52	95.70	Fresh	Vermont seam roof	Siltstone
LV2219G/13	95.70	100.57	Coal	Vermont seam	Coal
LV2219G/14	101.18	102.10	Fresh	Vermont seam floor	Siltstone + mudstone
LV2219G/15	104.55	105.66	Fresh	Basement	Sandstone
LV2388G/1	1.74	3.00	Subsoil	Subsoil	Sandy clay

Sample ID	From	To	Weathering Zone	Position	Lithology
LV2388G/2	23.84	26.49	Weathered	Tertiary	Sandy clay with laterite
LV2388G/3	50.52	52.50	Weathered	Permian Overburden	Carbonaceous mudstone
LV2388G/4	55.94	57.33	Fresh	Permian Overburden	Carbonaceous mudstone
LV2388G/5	82.00	82.85	Fresh	Leichhardt seam roof	Sandstone
LV2388G/6	83.65	84.21	Fresh	Leichhardt seam floor	Carbonaceous mudstone + siltstone
LV2388G/7	87.89	88.72	Fresh	Interburden	Siltstone
LV2388G/8	94.70	96.10	Fresh	Interburden	Sandstone
LV2388G/9	99.28	100.68	Fresh	Interburden	Siltstone
LV2388G/10	103.20	104.51	Fresh	Interburden	Siltstone
LV2388G/11	106.41	108.05	Fresh	Interburden	Sandstone
LV2388G/12	108.05	109.16	Fresh	Vermont seam roof	Siltstone
LV2388G/13	109.16	115.13	Coal	Vermont seam	Coal
LV2388G/14	117.34	117.95	Fresh	Vermont seam floor	Siltstone
LV2388G/15	118.27	119.92	Fresh	Basement	Siltstone
LV2389G/1	1.00	2.04	Subsoil	Subsoil	Clayey sand
LV2389G/2	6.50	9.00	Weathered	Tertiary	Sandy clay
LV2389G/3	39.72	40.38	Weathered	Permian overburden	Carbonaceous mudstone
LV2389G/4	58.34	58.75	Fresh	Leichhardt seam roof	Carbonaceous mudstone
LV2389G/5	58.75	60.53	Coal	Leichhardt seam	Coal
LV2389G/6	60.53	60.80	Fresh	Leichhardt seam floor	Carbonaceous mudstone
LV2389G/7	62.36	63.47	Fresh	Interburden	Sandstone
LV2389G/8	67.75	71.00	Fresh	Interburden	Sandstone with calcite
LV2389G/9	75.26	76.92	Fresh	Interburden	Sandstone + siltstone
LV2389G/10	80.95	84.00	Fresh	Interburden	Sandstone
LV2389G/11	87.98	90.00	Fresh	Interburden	Sandstone
LV2389G/12	96.00	96.67	Fresh	Interburden	Siltstone
LV2389G/13	100.08	100.91	Fresh	Vermont seam roof	Carbonaceous mudstone
LV2389G/14	100.91	104.22	Coal	Vermont seam	Coal
LV2389G/15	104.22	104.62	Fresh	Vermont seam floor	Carbonaceous mudstone
LV2389G/16	105.00	105.88	Fresh	Vermont seam floor	Mudstone
LV2389G/17	106.43	109.35	Fresh	Basement	Sandstone

Table A2-2: ABA Analysis Part A (Sorted by Stratigraphic Position)

Sample Number	Weathering Zone	Position	EC (1:5)	Total S	SO ₄ _S	Total C	Total IC	ANC	MPA	Classification
			uS/cm	%	%	%	%	kg H ₂ SO ₄ /t		
LV2183G/1	Subsoil	Subsoil	1250	0.04	0.015	0.14	0.01	11	0.8	NAF
LV2219G/1	Subsoil	Subsoil	1140	0.04	0.015	0.65	0.35	32	0.8	NAF
LV2388G/1	Subsoil	Subsoil	336	0.01	0.006	0.12	0.02	8	0.1	NAF
LV2389G/1	Subsoil	Subsoil	1760	0.05	0.035	0.44	0.13	21	0.5	NAF
LV2183G/2	Weathered	Tertiary	1290	0.04	<0.003	0.6	0.56	59	1.2	NAF
LV2183G/3	Weathered	Tertiary	810	0.04	<0.003	0.4	0.36	27	1.2	NAF
LV2183G/4	Weathered	Tertiary	854	0.04	0.007	0.58	0.54	40	1.0	NAF
LV2219G/2	Weathered	Tertiary	759	0.03	0.004	0.7	0.64	55	0.8	NAF
LV2219G/3	Weathered	Tertiary	77	0.03	<0.003	0.08	<0.01	8	0.9	NAF
LV2388G/2	Weathered	Tertiary	72	0.03	0.004	0.07	0.01	4	0.8	NAF
LV2389G/2	Weathered	Tertiary	1240	0.04	0.015	0.09	0.01	10	0.8	NAF
LV2183G/5	Weathered	Permian overburden	752	0.03	<0.003	0.06	<0.01	9	0.9	NAF
LV2183G/6	Weathered	Permian overburden	551	0.03	<0.003	0.13	0.07	9	0.9	NAF
LV2183G/7	Fresh	Permian overburden	326	0.05	0.003	2.88	0.48	9	1.4	NAF
LV2183G/8	Fresh	Permian overburden	367	0.05	0.007	3.13	0.75	12	1.3	NAF
LV2219G/4	Fresh	Permian overburden	449	0.04	0.008	1.94	0.8	30	1.0	NAF
LV2388G/3	Weathered	Permian overburden	201	0.04	0.011	0.87	0.1	8	0.9	NAF
LV2388G/4	Fresh	Permian overburden	348	0.05	0.014	1.93	1.11	22	1.1	NAF
LV2389G/3	Weathered	Permian overburden	1340	0.04	0.015	0.64	0.07	48	0.8	NAF
LV2183G/9	Fresh	Leichhardt seam roof	220	0.15	0.012	11.3	1.98	16	4.2	NAF
LV2219G/5	Fresh	Leichhardt seam roof	327	0.26	0.014	7.96	0.86	22	7.5	NAF

Sample Number	Weathering Zone	Position	EC (1:5)	Total S	SO4_S	Total C	Total IC	ANC	MPA	Classification
			uS/cm	%	%	%	%	kg H ₂ SO ₄ /t		
LV2219G/6	Fresh	Leichhardt seam roof	475	0.09	0.006	7.54	0.96	9	2.6	NAF
LV2388G/5	Fresh	Leichhardt seam roof	239	0.08	0.024	0.2	<0.01	11	1.7	NAF
LV2389G/4	Fresh	Leichhardt seam roof	526	0.24	0.010	20.2	3.4	8	7.0	UC
LV2183G/10	Coal	Leichhardt seam	237	0.67	0.014	N/A	N/A	11	20.1	PAF-LC
LV2389G/5	Coal	Leichhardt seam	514	0.42	0.015	N/A	N/A	8	12.4	PAF-LC
LV2183G/11	Fresh	Leichhardt seam floor	240	0.08	0.019	1.69	0.54	12	1.9	NAF
LV2219G/7	Fresh	Leichhardt seam floor	301	0.22	0.015	9.85	0.56	8	6.3	NAF
LV2388G/6	Fresh	Leichhardt seam floor	195	0.07	0.006	2.13	0.3	16	2.0	NAF
LV2389G/6	Fresh	Leichhardt seam floor	520	0.08	0.009	3.61	0.23	7	2.2	NAF
LV2183G/12	Fresh	Interburden	436	0.07	0.012	2.74	1.6	32	1.8	NAF
LV2183G/13	Fresh	Interburden	417	0.05	0.007	2.56	1.6	37	1.3	NAF
LV2183G/14	Fresh	Interburden	347	0.06	0.011	2.39	1.3	46	1.5	NAF
LV2219G/8	Fresh	Interburden	456	0.07	0.006	3.95	2.9	107	1.9	AC
LV2219G/9	Fresh	Interburden	493	0.08	0.015	2.16	1.5	63	2.0	NAF
LV2219G/10	Fresh	Interburden	277	0.13	0.005	5.52	0.6	12	3.8	NAF
LV2219G/11	Fresh	Interburden	350	0.04	<0.003	3.3	2.1	30	1.2	NAF
LV2388G/7	Fresh	Interburden	308	0.05	0.008	1.41	0.52	18	1.3	NAF
LV2388G/8	Fresh	Interburden	304	0.04	0.004	2.04	1.2	53	1.1	NAF
LV2388G/9	Fresh	Interburden	319	0.04	0.008	2.27	1.4	37	1.0	NAF
LV2388G/10	Fresh	Interburden	324	0.04	0.007	3.13	2.4	151	1.0	AC
LV2388G/11	Fresh	Interburden	345	0.05	0.011	2.28	1.4	49	1.2	NAF
LV2389G/7	Fresh	Interburden	410	0.05	0.008	0.91	0.16	15	1.3	NAF
LV2389G/8	Fresh	Interburden	370	0.04	0.007	1.69	1.3	75	1.0	NAF

Sample Number	Weathering Zone	Position	EC (1:5)	Total S	SO4_S	Total C	Total IC	ANC	MPA	Classification
			uS/cm	%	%	%	%	kg H ₂ SO ₄ /t		
LV2389G/9	Fresh	Interburden	353	0.04	0.004	1.8	1.2	36	1.1	NAF
LV2389G/10	Fresh	Interburden	378	0.03	0.004	2.22	2.1	117	0.8	AC
LV2389G/11	Fresh	Interburden	382	0.04	0.006	0.94	0.8	58	1.1	NAF
LV2389G/12	Fresh	Interburden	460	0.05	0.007	1.94	1.1	37	1.3	NAF
LV2183G/15	Fresh	Vermont seam roof	455	0.06	0.016	4.9	2.8	143	1.3	AC
LV2219G/12	Fresh	Vermont seam roof	461	0.04	0.005	1.4	0.37	15	1.1	NAF
LV2388G/12	Fresh	Vermont seam roof	329	0.04	0.007	1.32	0.44	15	1.0	NAF
LV2389G/13	Fresh	Vermont seam roof	582	0.45	0.016	1.94	0.53	7	13.3	PAF-LC
LV2183G/16	Coal	Vermont seam	185	0.43	0.014	N/A	N/A	7	12.7	PAF-LC
LV2388G/13	Coal	Vermont seam	114	0.38	0.006	N/A	N/A	6	11.4	PAF-LC
LV2389G/14	Coal	Vermont seam	165	0.56	<0.003	N/A	N/A	8	17.1	PAF-LC
LV2219G/13	Coal	Vermont seam	140	0.32	0.005	N/A	N/A	5	9.6	PAF-LC
LV2183G/17	Fresh	Vermont seam floor	328	0.36	0.013	2.35	0.17	11	10.6	UC
LV2219G/14	Fresh	Vermont seam floor	322	0.05	0.005	1.68	0.4	7	1.4	NAF
LV2388G/14	Fresh	Vermont seam floor	315	0.06	0.017	1.49	0.48	16	1.3	NAF
LV2389G/15	Fresh	Vermont seam floor	616	0.35	0.027	4.46	0.4	8	9.9	PAF-LC
LV2389G/16	Fresh	Vermont seam floor	581	0.25	0.021	1.8	0.42	10	7.0	UC
LV2183G/18	Fresh	Basement	365	0.08	0.005	1.97	1.7	88	2.3	NAF
LV2219G/15	Fresh	Basement	452	0.04	0.000	1.52	0.93	36	1.2	NAF
LV2388G/15	Fresh	Basement	214	0.06	0.009	1.91	0.51	17	1.6	NAF
LV2389G/17	Fresh	Basement	428	0.17	0.022	2.26	2.1	140	4.5	AC

Table A2-3: ABA Analysis Part B (Sorted by Stratigraphic Position)

Sample Number	Weathering Zone	Position	pH	NAG pH	NAPP	NAG (pH 4.5)	NAG (pH7)	NPR	Classification
			pH units		kg H ₂ SO ₄ /t		Ratio		
LV2183G/1	Subsoil	Subsoil	7.6	8.4	-10	<0.1	<0.1	14	NAF
LV2219G/1	Subsoil	Subsoil	8.6	9.2	-31	<0.1	<0.1	42	NAF
LV2388G/1	Subsoil	Subsoil	8.7	8.3	-7	<0.1	<0.1	62	NAF
LV2389G/1	Subsoil	Subsoil	8.2	8.6	-21	<0.1	<0.1	46	NAF
LV2183G/2	Weathered	Tertiary	8.1	7.6	-57	<0.1	<0.1	48	NAF
LV2183G/3	Weathered	Tertiary	8.7	7.6	-26	<0.1	<0.1	22	NAF
LV2183G/4	Weathered	Tertiary	9	8.1	-39	<0.1	<0.1	40	NAF
LV2219G/2	Weathered	Tertiary	9.8	10.2	-55	<0.1	<0.1	71	NAF
LV2219G/3	Weathered	Tertiary	9	7.3	-7	<0.1	<0.1	9.2	NAF
LV2388G/2	Weathered	Tertiary	8.2	6.1	-4	<0.1	3.3	5.6	NAF
LV2389G/2	Weathered	Tertiary	7.5	7.6	-9	<0.1	<0.1	12	NAF
LV2183G/5	Weathered	Permian overburden	8.6	8.2	-8	<0.1	<0.1	9.6	NAF
LV2183G/6	Weathered	Permian overburden	9.2	9	-8	<0.1	<0.1	9.9	NAF
LV2183G/7	Fresh	Permian overburden	8.6	7.4	-8	<0.1	<0.1	6.3	NAF
LV2183G/8	Fresh	Permian overburden	9	8	-11	<0.1	<0.1	9.2	NAF
LV2219G/4	Fresh	Permian overburden	9.4	10.1	-29	<0.1	<0.1	30	NAF
LV2388G/3	Weathered	Permian overburden	8.2	7.1	-7	<0.1	<0.1	8.5	NAF
LV2388G/4	Fresh	Permian overburden	8.7	7.9	-21	<0.1	<0.1	20	NAF
LV2389G/3	Weathered	Permian overburden	7.6	6.8	-47	<0.1	1.3	63	NAF
LV2183G/9	Fresh	Leichhardt seam roof	8.6	7.1	-12	<0.1	<0.1	3.8	NAF
LV2219G/5	Fresh	Leichhardt seam roof	8.6	6.1	-15	<0.1	0.6	2.9	NAF

Sample Number	Weathering Zone	Position	pH	NAG pH	NAPP	NAG (pH 4.5)	NAG (pH7)	NPR	Classification
			pH units		kg H ₂ SO ₄ /t		Ratio		
LV2219G/6	Fresh	Leichhardt seam roof	8.8	6.7	-6	<0.1	0.2	3.5	NAF
LV2388G/5	Fresh	Leichhardt seam roof	8.8	7.3	-10	<0.1	<0.1	6.7	NAF
LV2389G/4	Fresh	Leichhardt seam roof	8.7	3.3	-1	17.7	36.1	1.1	UC
LV2183G/10	Coal	Leichhardt seam	7.6	3.9	10	5.5	28.1	0.5	PAF-LC
LV2389G/5	Coal	Leichhardt seam	8.6	2.8	4	40	71.3	0.7	PAF-LC
LV2183G/11	Fresh	Leichhardt seam floor	8.8	7.6	-11	<0.1	<0.1	6.6	NAF
LV2219G/7	Fresh	Leichhardt seam floor	8.8	5.7	-1.3	<0.1	0.8	1.2	NAF
LV2388G/6	Fresh	Leichhardt seam floor	8.9	6.9	-14	<0.1	0.2	8.2	NAF
LV2389G/6	Fresh	Leichhardt seam floor	8.7	5.7	-5	<0.1	2.1	3.3	NAF
LV2183G/12	Fresh	Interburden	9.2	8.7	-30	<0.1	<0.1	18	NAF
LV2183G/13	Fresh	Interburden	9.4	8.9	-36	<0.1	<0.1	28	NAF
LV2183G/14	Fresh	Interburden	9.2	9.4	-45	<0.1	<0.1	31	NAF
LV2219G/8	Fresh	Interburden	9.6	8.9	-105	<0.1	<0.1	55	AC
LV2219G/9	Fresh	Interburden	9.6	10.1	-61	<0.1	<0.1	32	NAF
LV2219G/10	Fresh	Interburden	9.4	5.5	-9	<0.1	1.3	3.2	NAF
LV2219G/11	Fresh	Interburden	9.6	9	-29	<0.1	<0.1	25	NAF
LV2388G/7	Fresh	Interburden	9.2	7.6	-17	<0.1	<0.1	14	NAF
LV2388G/8	Fresh	Interburden	9.1	9.8	-52	<0.1	<0.1	48	NAF
LV2388G/9	Fresh	Interburden	9	9.2	-36	<0.1	<0.1	37	NAF
LV2388G/10	Fresh	Interburden	9.2	10.6	-150	<0.1	<0.1	150	AC
LV2388G/11	Fresh	Interburden	9.1	8.7	-48	<0.1	<0.1	41	NAF
LV2389G/7	Fresh	Interburden	8.6	7.6	-14	<0.1	<0.1	12	NAF

Sample Number	Weathering Zone	Position	pH	NAG pH	NAPP	NAG (pH 4.5)	NAG (pH7)	NPR	Classification
			pH units		kg H ₂ SO ₄ /t		Ratio		
LV2389G/8	Fresh	Interburden	9.5	10.6	-74	<0.1	<0.1	75	NAF
LV2389G/9	Fresh	Interburden	9.5	9.1	-35	<0.1	<0.1	33	NAF
LV2389G/10	Fresh	Interburden	9.5	10.7	-116	<0.1	<0.1	149	AC
LV2389G/11	Fresh	Interburden	9.6	10.6	-57	<0.1	<0.1	56	NAF
LV2389G/12	Fresh	Interburden	9.5	9.7	-36	<0.1	<0.1	28	NAF
LV2183G/15	Fresh	Vermont seam roof	9.4	9.2	-142	<0.1	<0.1	106	AC
LV2219G/12	Fresh	Vermont seam roof	9.1	7.3	-14	<0.1	<0.1	14	NAF
LV2388G/12	Fresh	Vermont seam roof	8.9	7.8	-14	<0.1	<0.1	15	NAF
LV2389G/13	Fresh	Vermont seam roof	8.6	3.1	7	4.1	7.5	0.5	PAF-LC
LV2183G/16	Coal	Vermont seam	7.7	3.3	5	7.4	22.5	0.6	PAF-LC
LV2388G/13	Coal	Vermont seam	7.1	4.3	5	1.6	16.2	0.5	PAF-LC
LV2389G/14	Coal	Vermont seam	6.6	3.2	9	7.3	21.3	0.5	PAF-LC
LV2219G/13	Coal	Vermont seam	7.7	2.8	5	78.2	143	0.5	PAF-LC
LV2183G/17	Fresh	Vermont seam floor	9	3.9	0	0.9	2	1.0	UC
LV2219G/14	Fresh	Vermont seam floor	9.3	6.8	-6	<0.1	1	5.2	NAF
LV2388G/14	Fresh	Vermont seam floor	8.9	7.6	-15	<0.1	<0.1	13	NAF
LV2389G/15	Fresh	Vermont seam floor	8.7	3.2	2	3	7.3	0.8	PAF-LC
LV2389G/16	Fresh	Vermont seam floor	8.5	3.7	-3	0.8	3.5	1.4	UC
LV2183G/18	Fresh	Basement	9.6	10.1	-86	<0.1	<0.1	39	NAF
LV2219G/15	Fresh	Basement	9.9	9.6	-35	<0.1	<0.1	30	NAF
LV2388G/15	Fresh	Basement	9.2	7.4	-15	<0.1	<0.1	11	NAF
LV2389G/17	Fresh	Basement	9.7	10.9	-135	<0.1	<0.1	31	AC

Table A2-4: Elemental Analysis

Sample Number	As	B	Ba	Be	Cd	Co	Cr	Cu	Hg	Mn	Ni	Pb	Se	V	Zn
LV2183G/1	<5	<50	180	<1	<1	17	85	9	<0.1	500	28	<5	<5	56	18
LV2183G/4	<5	<50	160	5	<1	13	19	37	<0.1	154	39	<5	<5	48	92
LV2183G/8	18	<50	50	1	<1	21	10	49	<0.1	768	33	18	<5	26	81
LV2183G/9	12	<50	30	1	<1	29	10	68	<0.1	2140	31	23	<5	31	107
LV2183G/10	<5	<50	20	<1	<1	3	5	27	<0.1	199	4	6	<5	8	18
LV2183G/11	10	<50	660	1	<1	9	10	65	<0.1	305	21	23	<5	21	72
LV2183G/13	<5	<50	50	1	<1	16	11	55	<0.1	850	24	18	<5	40	78
LV2183G/15	<5	<50	530	1	<1	14	8	47	<0.1	840	18	15	<5	25	68
LV2183G/17	6	<50	90	2	<1	9	8	78	0.1	79	24	21	<5	15	100
LV2219G/3	12	<50	80	<1	<1	10	28	13	<0.1	299	17	14	<5	44	68
LV2219G/6	<5	<50	110	1	<1	6	12	52	<0.1	346	17	17	<5	20	128
LV2219G/10	79	<50	180	1	<1	14	14	54	<0.1	140	30	19	<5	27	79
LV2219G/12	8	<50	210	1	<1	9	14	58	0.1	173	23	20	<5	22	99
LV2219G/13	<5	<50	20	<1	<1	<2	3	12	<0.1	19	<2	<5	<5	<5	7
LV2219G/14	<5	<50	250	1	<1	8	10	81	0.1	47	18	24	<5	16	95
LV2219G/15	7	<50	200	<1	<1	10	21	44	<0.1	520	27	13	<5	24	84
LV2388G/1	<5	<50	300	<1	<1	12	85	9	<0.1	165	32	<5	<5	50	11
LV2388G/2	6	<50	50	<1	<1	<2	44	<5	<0.1	<5	<2	<5	<5	141	<5
LV2388G/4	5	<50	170	1	<1	36	17	56	<0.1	3630	32	17	<5	43	68
LV2388G/5	12	<50	1840	<1	<1	12	35	24	<0.1	131	22	12	<5	30	74
LV2388G/6	11	<50	20	1	<1	17	17	63	<0.1	574	31	18	<5	39	74
LV2388G/9	11	<50	230	1	<1	16	19	62	<0.1	893	31	20	<5	47	93
LV2388G/11	11	<50	190	1	<1	14	14	58	0.1	1150	27	18	<5	39	95

Sample Number	As	B	Ba	Be	Cd	Co	Cr	Cu	Hg	Mn	Ni	Pb	Se	V	Zn
LV2388G/15	12	<50	80	1	<1	13	17	65	<0.1	310	29	17	<5	33	99
LV2389G/4	<5	<50	20	<1	<1	6	5	59	<0.1	20	10	17	<5	11	37
LV2389G/5	<5	<50	250	<1	<1	8	4	47	<0.1	10	14	13	<5	12	45
LV2389G/6	<5	<50	20	1	<1	5	4	62	<0.1	15	16	20	<5	7	74
LV2389G/9	7	<50	30	1	<1	22	28	39	<0.1	870	44	12	<5	48	71
LV2389G/13	10	<50	280	1	<1	22	16	79	0.1	160	34	30	<5	32	143
LV2389G/14	<5	<50	120	<1	<1	<2	2	11	<0.1	23	<2	<5	<5	<5	<5
LV2389G/15	9	<50	550	1	<1	14	6	82	<0.1	66	22	23	<5	12	99
LV2389G/16	<5	<50	300	1	<1	20	10	69	0.1	101	30	21	<5	22	114
LV2389G/17	18	<50	710	<1	<1	12	31	18	0.3	837	21	10	<5	17	68
Soil/Av. Crustal	1.5	10	500	6	0.2	20	100	50	0.08	950	80	14	0.05	160	75

All elements are in mg/kg

Table A2-5: Global Abundance Index Classification

Sample	As	B	Ba	Be	Cd	Co	Cr	Cu	Hg	Mn	Ni	Pb	Se	V	Zn
LV2183G/1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV2183G/4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV2183G/8	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV2183G/9	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0
LV2183G/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV2183G/11	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV2183G/13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV2183G/15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV2183G/17	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV2219G/3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV2219G/6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV2219G/10	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV2219G/12	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV2219G/13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV2219G/14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV2219G/15	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV2388G/1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV2388G/2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV2388G/4	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
LV2388G/5	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0
LV2388G/6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV2388G/9	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV2388G/11	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Sample	As	B	Ba	Be	Cd	Co	Cr	Cu	Hg	Mn	Ni	Pb	Se	V	Zn
LV2388G/15	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV2389G/4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV2389G/5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV2389G/6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV2389G/9	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV2389G/13	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0
LV2389G/14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV2389G/15	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV2389G/16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LV2389G/17	3	0	0	0	0	0	0	0	1	0	0	0	0	0	0

Table A2-6: pH, EC and Alkalinity

Sample Number	Weathering Zone	Position	pH	EC	Alkalinity		
					HCO ₃	CO ₃	Total
			pH units	µS/cm	mg CaCO ₃ /L		
LV2183G/1	Subsoil	Subsoil	7.6	1250	443	<1	443
LV2183G/4	Weathered	Tertiary	8.1	1290	377	66	443
LV2183G/8	Fresh	Permian overburden	8.7	810	196	66	262
LV2183G/9	Fresh	Leichhardt seam roof	9	854	99	<1	99
LV2183G/10	Coal	Leichhardt seam	8.6	752	82	<1	82
LV2183G/11	Fresh	Leichhardt seam floor	9.2	551	124	16	140
LV2183G/13	Fresh	Interburden	8.6	326	312	164	476
LV2183G/15	Fresh	Vermont seam roof	9	367	345	164	509
LV2183G/17	Fresh	Vermont seam floor	8.6	220	217	144	361
LV2219G/3	Weathered	Tertiary	7.6	237	148	16	164
LV2219G/6	Fresh	Leichhardt seam roof	8.8	240	132	16	148
LV2219G/10	Fresh	Interburden	9.2	436	279	66	345
LV2219G/12	Fresh	Vermont seam roof	9.4	417	222	49	271
LV2219G/13	Coal	Vermont seam	9.2	347	115	<1	115
LV2219G/14	Fresh	Vermont seam floor	9.4	455	262	66	328
LV2219G/15	Fresh	Basement	7.7	185	361	197	558
LV2388G/1	Subsoil	Subsoil	9	328	558	66	624
LV2388G/2	Weathered	Tertiary	9.6	365	115	<1	115
LV2388G/4	Fresh	Permian overburden	8.6	1140	181	16	197
LV2388G/5	Fresh	Leichhardt seam roof	9.8	759	99	16	115
LV2388G/6	Fresh	Leichhardt seam floor	9	77	99	16	115
LV2388G/9	Fresh	Interburden	9.4	449	337	164	501
LV2388G/11	Fresh	Interburden	8.6	327	263	131	394
LV2388G/15	Fresh	Basement	8.8	475	115	49	164
LV2389G/4	Fresh	Leichhardt seam roof	8.8	301	132	16	148
LV2389G/5	Coal	Leichhardt seam	9.6	456	164	<1	164
LV2389G/6	Fresh	Leichhardt seam floor	9.6	493	83	16	99
LV2389G/9	Fresh	Interburden	9.4	277	287	279	566
LV2389G/13	Fresh	Vermont seam roof	9.6	350	123	<1	123
LV2389G/14	Coal	Vermont seam	9.1	461	57	<1	57
LV2389G/15	Fresh	Vermont seam floor	7.7	140	131	<1	131
LV2389G/16	Fresh	Vermont seam floor	9.3	322	66	<1	66
LV2389G/17	Fresh	Basement	9.9	452	328	296	624

Table A2-7: Major Ions (1:5 DI Extract)

Sample Number	Weathering Zone	Position	Na mg/L	K mg/L	Ca mg/L	Mg mg/L	Cl mg/L	SO ₄ mg/L	SAR*
LV2183G/1	Subsoil	Subsoil	1010	<10	20	30	1580	270	47
LV2183G/4	Weathered	Tertiary	1010	<10	10	20	1660	70	60
LV2183G/8	Fresh	Permian overburden	420	<10	<10	<10	500	150	45
LV2183G/9	Fresh	Leichhardt seam roof	330	<10	<10	<10	270	280	35
LV2183G/10	Coal	Leichhardt seam	190	<10	<10	10	90	260	16
LV2183G/11	Fresh	Leichhardt seam floor	410	10	<10	<10	510	220	44
LV2183G/13	Fresh	Interburden	390	10	<10	<10	240	160	42
LV2183G/15	Fresh	Vermont seam roof	430	10	<10	<10	220	180	46
LV2183G/17	Fresh	Vermont seam floor	410	10	<10	<10	350	260	44
LV2219G/3	Weathered	Tertiary	70	<10	<10	<10	30	<10	7
LV2219G/6	Fresh	Leichhardt seam roof	410	10	<10	<10	580	140	44
LV2219G/10	Fresh	Interburden	250	<10	<10	<10	140	110	27
LV2219G/12	Fresh	Vermont seam roof	380	<10	<10	<10	560	120	40
LV2219G/13	Coal	Vermont seam	150	<10	<10	<10	80	110	16
LV2219G/14	Fresh	Vermont seam floor	260	<10	<10	<10	250	130	28
LV2219G/15	Fresh	Basement	420	10	<10	<10	80	110	45
LV2388G/1	Subsoil	Subsoil	260	<10	<10	<10	200	40	28
LV2388G/2	Weathered	Tertiary	50	<10	<10	<10	400	20	5
LV2388G/4	Fresh	Permian overburden	300	20	<10	<10	160	280	32
LV2388G/5	Fresh	Leichhardt seam roof	200	10	<10	<10	120	200	21
LV2388G/6	Fresh	Leichhardt seam floor	170	<10	<10	<10	90	150	18
LV2388G/9	Fresh	Interburden	300	20	<10	<10	70	110	32

Sample Number	Weathering Zone	Position	Na mg/L	K mg/L	Ca mg/L	Mg mg/L	Cl mg/L	SO ₄ mg/L	SAR*
LV2388G/11	Fresh	Interburden	320	20	<10	<10	170	120	34
LV2388G/15	Fresh	Basement	180	<10	<10	<10	100	140	19
LV2389G/4	Fresh	Leichhardt seam roof	460	20	<10	<10	560	240	49
LV2389G/5	Coal	Leichhardt seam	440	10	<10	<10	540	240	47
LV2389G/6	Fresh	Leichhardt seam floor	460	10	<10	<10	640	210	49
LV2389G/9	Fresh	Interburden	340	10	<10	<10	140	80	36
LV2389G/13	Fresh	Vermont seam roof	530	20	<10	<10	650	350	56
LV2389G/14	Coal	Vermont seam	160	<10	<10	<10	80	210	17
LV2389G/15	Fresh	Vermont seam floor	560	20	<10	<10	560	480	60
LV2389G/16	Fresh	Vermont seam floor	530	10	<10	<10	590	430	56
LV2389G/17	Fresh	Basement	400	20	<10	<10	80	260	43

*To enable estimation of SAR for most samples, values of Ca and Mg less than the limit of reporting have been entered as half the limit of reporting in the calculation.

Table A2-8: Water Soluble Metals and Metalloids (1:20 DI ASLP)

Sample Number	Weathering Zone	Ag	As	Be	Cd	Co	Cr	Cu	Hg	Mn	Ni	Pb	Se	Zn
LV2183G/1	Subsoil	<0.001	<0.001	<0.001	<0.0001	0.007	0.032	0.006	<0.0001	0.170	0.016	0.003	<0.01	0.042
LV2183G/4	Weathered	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.01	0.016
LV2183G/8	Fresh	<0.001	0.011	<0.001	<0.0001	0.002	0.001	0.001	<0.0001	0.011	0.003	0.002	<0.01	0.021
LV2183G/9	Fresh	<0.001	0.003	<0.001	<0.0001	0.003	0.001	0.002	<0.0001	0.006	0.003	0.001	<0.01	0.020
LV2183G/10	Coal	<0.001	0.002	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.0001	0.030	0.001	<0.001	<0.01	0.008
LV2183G/11	Fresh	<0.001	0.006	<0.001	<0.0001	<0.001	0.002	0.006	<0.0001	0.008	0.002	0.004	<0.01	0.034
LV2183G/13	Fresh	<0.001	0.002	<0.001	<0.0001	0.002	0.002	0.007	<0.0001	0.015	0.003	0.004	<0.01	0.036
LV2183G/15	Fresh	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.001	0.001	<0.0001	0.008	<0.001	<0.001	<0.01	0.013
LV2183G/17	Fresh	<0.001	0.002	<0.001	<0.0001	<0.001	0.001	0.002	<0.0001	0.003	0.001	0.002	<0.01	0.022
LV2219G/3	Weathered	<0.001	<0.001	<0.001	<0.0001	<0.001	0.003	0.001	<0.0001	0.065	0.002	0.001	<0.01	0.027
LV2219G/6	Fresh	<0.001	0.001	<0.001	<0.0001	<0.001	<0.001	0.002	<0.0001	0.004	<0.001	<0.001	<0.01	0.019
LV2219G/10	Fresh	<0.001	0.010	<0.001	<0.0001	0.001	0.002	0.001	<0.0001	0.006	0.002	0.002	<0.01	0.025
LV2219G/12	Fresh	<0.001	0.010	<0.001	<0.0001	0.001	0.003	0.008	<0.0001	0.012	0.004	0.006	<0.01	0.052
LV2219G/13	Coal	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.01	0.008
LV2219G/14	Fresh	<0.001	<0.001	<0.001	<0.0001	0.001	0.002	0.008	<0.0001	0.004	0.002	0.005	<0.01	0.040
LV2219G/15	Fresh	<0.001	0.004	<0.001	<0.0001	<0.001	0.002	0.002	<0.0001	0.011	0.002	0.003	<0.01	0.021
LV2388G/1	Subsoil	<0.001	<0.001	<0.001	<0.0001	0.004	0.028	0.005	<0.0001	0.048	0.022	0.004	<0.01	0.048
LV2388G/2	Weathered	<0.001	<0.001	<0.001	<0.0001	<0.001	0.001	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.01	0.025
LV2388G/4	Fresh	<0.001	<0.001	<0.001	<0.0001	0.002	<0.001	0.002	<0.0001	0.018	0.001	<0.001	<0.01	0.012
LV2388G/5	Fresh	<0.001	0.015	<0.001	<0.0001	<0.001	0.001	0.001	<0.0001	0.004	0.001	0.001	<0.01	0.023
LV2388G/6	Fresh	<0.001	0.006	<0.001	<0.0001	<0.001	0.003	<0.001	<0.0001	0.005	0.001	0.001	<0.01	0.017
LV2388G/9	Fresh	<0.001	0.006	<0.001	<0.0001	<0.001	0.001	0.001	<0.0001	0.008	0.001	0.002	<0.01	0.020

Sample Number	Weathering Zone	Ag	As	Be	Cd	Co	Cr	Cu	Hg	Mn	Ni	Pb	Se	Zn
LV2388G/11	Fresh	<0.001	0.004	<0.001	<0.0001	<0.001	0.001	0.001	<0.0001	0.008	<0.001	0.001	<0.01	0.020
LV2388G/15	Fresh	<0.001	0.011	<0.001	<0.0001	0.001	0.002	0.002	<0.0001	0.006	0.002	0.003	<0.01	0.028
LV2389G/4	Fresh	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.001	0.003	<0.0001	0.001	<0.001	<0.001	<0.01	0.015
LV2389G/5	Coal	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.001	0.003	<0.0001	0.001	<0.001	0.001	<0.01	0.019
LV2389G/6	Fresh	<0.001	<0.001	<0.001	<0.0001	<0.001	0.001	0.014	<0.0001	0.002	0.001	0.005	<0.01	0.041
LV2389G/9	Fresh	<0.001	0.004	<0.001	<0.0001	<0.001	0.001	0.001	<0.0001	0.017	0.002	0.001	<0.01	0.018
LV2389G/13	Fresh	<0.001	0.011	<0.001	<0.0001	0.003	0.002	0.004	<0.0001	0.010	0.004	0.005	<0.01	0.038
LV2389G/14	Coal	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.01	0.008
LV2389G/15	Fresh	<0.001	0.002	<0.001	<0.0001	0.001	0.001	0.008	<0.0001	0.004	0.002	0.003	<0.01	0.035
LV2389G/16	Fresh	<0.001	<0.001	<0.001	<0.0001	0.004	0.002	0.013	<0.0001	0.008	0.006	0.006	<0.01	0.042
LV2389G/17	Fresh	<0.001	0.017	<0.001	<0.0001	<0.001	0.002	0.001	<0.0001	0.007	<0.001	<0.001	<0.01	0.017
Freshwater		0.00005	0.013/ 0.024	N/G	0.0002	N/G	N/G	0.0014	0.00006	1.9	0.011	0.0034	0.005	0.008
Livestock Drinking Water		N/A	0.5	0.06	0.002	N/G	0.05 (Cr(VI))	2*	0.001	0.5	0.02	0.01	0.01	3
Human Drinking Water		0.1	0.01	N/G	0.01	1	1	1	0.002	N/G	1	0.1	0.02	20

*Beef cattle value used for copper guideline comparison.

All elements are mg/L

APPENDIX 3: LABORATORY ANALYSIS REPORTS



Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: EB1320587	Page	: 1 of 15
Client	: AUSTRALASIAN RESOURCE CONSULTANTS	Laboratory	: Environmental Division Brisbane
Contact	: MR GARETH BRAMSTON	Contact	: Customer Services
Address	: SUITE 5B 1 SWANN ROAD TARINGA QLD, AUSTRALIA 4068	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: gbramston@aacrc.net.au	E-mail	: Brisbane.Enviro.Services@alsglobal.com
Telephone	: +61 07 32178772	Telephone	: +61 7 3243 7222
Facsimile	: +61 07 32178775	Facsimile	: +61 7 3243 7218
Project	: Lake Vermont	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----	Date Samples Received	: 26-AUG-2013
C-O-C number	: ----	Issue Date	: 10-SEP-2013
Sampler	: John Irvine	No. of samples received	: 75
Site	: ----	No. of samples analysed	: 65
Quote number	: BN/274/12		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results



NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils
Stephen Hislop	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils
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Page : 2 of 15
Work Order : EB1320587
Client : AUSTRALASIAN RESOURCE CONSULTANTS
Project : Lake Vermont



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

- ASS: EA013 (ANC) Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)

Client sample ID

Compound	CAS Number	LOR	Unit	LV2183G/1	LV2183G/2	LV2183G/3	LV2183G/4	LV2183G/5
				20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00
				EB1320587-001	EB1320587-002	EB1320587-003	EB1320587-004	EB1320587-005
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	7.6	8.1	8.7	9.0	8.6
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	1250	1290	810	854	752
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	8.4	7.6	7.6	8.1	8.2
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	10.8	58.7	27.4	40.0	8.8
ANC as CaCO3	----	0.1	% CaCO3	1.1	6.0	2.8	4.1	0.9
Fizz Rating	----	0	Fizz Unit	0	2	1	2	0
ED040: Sulfur as SO4 2-								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	440	<100	<100	210	<100
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.04	0.04	0.04	0.04	0.03
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.13	0.04	0.04	0.04	0.06
EP003TC: Total Carbon (TC) in Soil								
Total Carbon	----	0.02	%	0.14	0.60	0.40	0.58	0.06

Page : 4 of 15
 Work Order : EB1320587
 Client : AUSTRALASIAN RESOURCE CONSULTANTS
 Project : Lake Vermont



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID				
				LV2183G/6	LV2183G/7	LV2183G/8	LV2183G/9	LV2183G/10
Client sampling date / time				20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00
Compound	CAS Number	LOR	Unit	EB1320587-006	EB1320587-007	EB1320587-008	EB1320587-009	EB1320587-010
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	9.2	8.6	9.0	8.6	7.6
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	551	326	367	220	237
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	9.0	7.4	8.0	7.1	3.9
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	5.5
NAG (pH 7.0)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	28.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	9.1	9.0	12.2	16.0	10.5
ANC as CaCO3	----	0.1	% CaCO3	0.9	0.9	1.2	1.6	1.1
Fizz Rating	----	0	Fizz Unit	1	1	1	1	1
ED040: Sulfur as SO4 2-								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	<100	100	200	350	430
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.03	0.05	0.05	0.15	0.67
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.06	2.40	2.38	9.32	----
EP003TC: Total Carbon (TC) in Soil								
Total Carbon	----	0.02	%	0.13	2.88	3.13	11.3	----



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID				
				LV2183G/11	LV2183G/12	LV2183G/13	LV2183G/14	LV2183G/15
Client sampling date / time				20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00
Compound	CAS Number	LOR	Unit	EB1320587-011	EB1320587-012	EB1320587-013	EB1320587-014	EB1320587-015
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	8.8	9.2	9.4	9.2	9.4
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	240	436	417	347	455
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	7.6	8.7	8.9	9.4	9.2
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	12.4	31.5	36.9	46.4	143
ANC as CaCO3	----	0.1	% CaCO3	1.3	3.2	3.8	4.7	14.6
Fizz Rating	----	0	Fizz Unit	1	2	2	2	3
ED040: Sulfur as SO4 2-								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	560	350	200	340	480
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.08	0.07	0.05	0.06	0.06
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	1.15	1.17	0.99	1.13	2.10
EP003TC: Total Carbon (TC) in Soil								
Total Carbon	----	0.02	%	1.69	2.74	2.56	2.39	4.90

Page : 6 of 15
 Work Order : EB1320587
 Client : AUSTRALASIAN RESOURCE CONSULTANTS
 Project : Lake Vermont



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID				
				LV2183G/16	LV2183G/17	LV2183G/18	LV2219G/1	LV2219G/2
Client sampling date / time				20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00
Compound	CAS Number	LOR	Unit	EB1320587-016	EB1320587-017	EB1320587-018	EB1320587-019	EB1320587-020
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	7.7	9.0	9.6	8.6	9.8
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	185	328	365	1140	759
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	3.3	3.9	10.1	9.2	10.2
NAG (pH 4.5)	----	0.1	kg H2SO4/t	7.4	0.9	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	22.5	2.0	<0.1	<0.1	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	7.3	10.9	88.0	31.6	55.4
ANC as CaCO3	----	0.1	% CaCO3	0.7	1.1	9.0	3.2	5.6
Fizz Rating	----	0	Fizz Unit	0	1	2	2	2
ED040: Sulfur as SO4 2-								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	410	380	160	460	130
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.43	0.36	0.08	0.04	0.03
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	----	2.18	0.31	0.30	0.06
EP003TC: Total Carbon (TC) in Soil								
Total Carbon	----	0.02	%	----	2.35	1.97	0.65	0.70



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID				
				LV2219G/3	LV2219G/4	LV2219G/5	LV2219G/6	LV2219G/7
Client sampling date / time				20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00
Compound	CAS Number	LOR	Unit	EB1320587-021	EB1320587-022	EB1320587-023	EB1320587-024	EB1320587-025
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	9.0	9.4	8.6	8.8	8.8
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	77	449	327	475	301
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	7.3	10.1	6.1	6.7	5.7
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	<0.1	<0.1	0.6	0.2	0.8
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	8.4	29.6	22.1	9.0	7.6
ANC as CaCO3	----	0.1	% CaCO3	0.8	3.0	2.2	0.9	0.8
Fizz Rating	----	0	Fizz Unit	0	1	1	1	1
ED040: Sulfur as SO4 2-								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	<100	230	410	170	440
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.03	0.04	0.26	0.09	0.22
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.08	1.14	7.10	6.58	9.29
EP003TC: Total Carbon (TC) in Soil								
Total Carbon	----	0.02	%	0.08	1.94	7.96	7.54	9.85



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID				
				LV2219G/8	LV2219G/9	LV2219G/10	LV2219G/11	LV2219G/12
Client sampling date / time				20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00
Compound	CAS Number	LOR	Unit	EB1320587-026	EB1320587-027	EB1320587-028	EB1320587-029	EB1320587-030
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	9.6	9.6	9.4	9.6	9.1
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	456	493	277	350	461
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	8.9	10.1	5.5	9.0	7.3
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	<0.1	<0.1	1.3	<0.1	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	107	63.3	12.4	30.1	15.1
ANC as CaCO3	----	0.1	% CaCO3	10.9	6.4	1.3	3.1	1.5
Fizz Rating	----	0	Fizz Unit	3	2	1	2	1
ED040: Sulfur as SO4 2-								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	190	440	140	<100	150
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.07	0.08	0.13	0.04	0.04
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	1.10	0.69	4.92	1.16	1.03
EP003TC: Total Carbon (TC) in Soil								
Total Carbon	----	0.02	%	3.95	2.16	5.52	3.30	1.40



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID				
				LV2219G/13	LV2219G/14	LV2219G/15	LV2388G/1	LV2388G/2
Client sampling date / time				20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00
Compound	CAS Number	LOR	Unit	EB1320587-031	EB1320587-032	EB1320587-033	EB1320587-034	EB1320587-035
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	7.7	9.3	9.9	8.7	8.2
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	140	322	452	336	72
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	2.8	6.8	9.6	8.3	6.1
NAG (pH 4.5)	----	0.1	kg H2SO4/t	78.2	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	143	1.0	<0.1	<0.1	3.3
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	5.0	7.2	36.3	7.6	4.4
ANC as CaCO3	----	0.1	% CaCO3	0.5	0.7	3.7	0.8	0.4
Fizz Rating	----	0	Fizz Unit	0	1	1	0	0
ED040: Sulfur as SO4 2-								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	150	150	<100	180	130
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.32	0.05	0.04	0.01	0.03
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	----	1.28	0.59	0.10	0.06
EP003TC: Total Carbon (TC) in Soil								
Total Carbon	----	0.02	%	----	1.68	1.52	0.12	0.07

Page : 10 of 15
 Work Order : EB1320587
 Client : AUSTRALASIAN RESOURCE CONSULTANTS
 Project : Lake Vermont



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID				
				LV2388G/3	LV2388G/4	LV2388G/5	LV2388G/6	LV2388G/7
Client sampling date / time				20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00
Compound	CAS Number	LOR	Unit	EB1320587-036	EB1320587-037	EB1320587-038	EB1320587-039	EB1320587-040
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	8.2	8.7	8.8	8.9	9.2
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	201	348	239	195	308
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	7.1	7.9	7.3	6.9	7.6
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	0.2	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	7.6	22.2	11.4	16.1	18.2
ANC as CaCO3	----	0.1	% CaCO3	0.8	2.3	1.2	1.6	1.8
Fizz Rating	----	0	Fizz Unit	1	1	1	1	1
ED040: Sulfur as SO4 2-								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	320	430	720	180	240
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.04	0.05	0.08	0.07	0.05
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.77	0.82	0.22	1.83	0.89
EP003TC: Total Carbon (TC) in Soil								
Total Carbon	----	0.02	%	0.87	1.93	0.20	2.13	1.41

Page : 11 of 15
 Work Order : EB1320587
 Client : AUSTRALASIAN RESOURCE CONSULTANTS
 Project : Lake Vermont



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID				
				LV2388G/8	LV2388G/9	LV2388G/10	LV2388G/11	LV2388G/12
Client sampling date / time				20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00
Compound	CAS Number	LOR	Unit	EB1320587-041	EB1320587-042	EB1320587-043	EB1320587-044	EB1320587-045
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	9.1	9.0	9.2	9.1	8.9
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	304	319	324	345	329
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	9.8	9.2	10.6	8.7	7.8
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	52.8	36.9	151	48.9	14.8
ANC as CaCO3	----	0.1	% CaCO3	5.4	3.8	15.4	5.0	1.5
Fizz Rating	----	0	Fizz Unit	2	2	3	2	1
ED040: Sulfur as SO4 2-								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	120	230	210	330	220
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.04	0.04	0.04	0.05	0.04
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.80	0.84	0.70	0.85	0.88
EP003TC: Total Carbon (TC) in Soil								
Total Carbon	----	0.02	%	2.04	2.27	3.13	2.28	1.32

Page : 12 of 15
 Work Order : EB1320587
 Client : AUSTRALASIAN RESOURCE CONSULTANTS
 Project : Lake Vermont



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID				
				LV2388G/13	LV2388G/14	LV2388G/15	LV2389G/1	LV2389G/2
Client sampling date / time				20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00
Compound	CAS Number	LOR	Unit	EB1320587-046	EB1320587-047	EB1320587-048	EB1320587-049	EB1320587-050
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	7.1	8.9	9.2	8.2	7.5
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	114	315	214	1760	1240
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	4.3	7.6	7.4	8.6	7.6
NAG (pH 4.5)	----	0.1	kg H2SO4/t	1.6	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	16.2	<0.1	<0.1	<0.1	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	6.0	16.4	16.9	21.2	9.5
ANC as CaCO3	----	0.1	% CaCO3	0.6	1.7	1.7	2.2	1.0
Fizz Rating	----	0	Fizz Unit	0	1	1	1	0
ED040: Sulfur as SO4 2-								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	190	520	260	1050	450
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.38	0.06	0.06	0.05	0.04
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	----	1.01	1.40	0.31	0.08
EP003TC: Total Carbon (TC) in Soil								
Total Carbon	----	0.02	%	----	1.49	1.91	0.44	0.09

Page : 13 of 15
 Work Order : EB1320587
 Client : AUSTRALASIAN RESOURCE CONSULTANTS
 Project : Lake Vermont



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)

Client sample ID

Client sampling date / time

Compound	CAS Number	LOR	Unit	LV2389G/3	LV2389G/4	LV2389G/5	LV2389G/6	LV2389G/7
				20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00
				EB1320587-051	EB1320587-052	EB1320587-053	EB1320587-054	EB1320587-055
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	7.6	8.7	8.6	8.7	8.6
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	1340	526	514	520	410
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	6.8	3.3	2.8	5.7	7.6
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	17.7	40.0	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	1.3	36.1	71.3	2.1	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	48.2	7.6	8.4	7.3	15.1
ANC as CaCO3	----	0.1	% CaCO3	4.9	0.8	0.8	0.7	1.5
Fizz Rating	----	0	Fizz Unit	2	0	0	1	1
ED040: Sulfur as SO4 2-								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	450	300	450	260	240
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.04	0.24	0.42	0.08	0.05
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.57	16.8	----	3.38	0.75
EP003TC: Total Carbon (TC) in Soil								
Total Carbon	----	0.02	%	0.64	20.2	----	3.61	0.91

Page : 14 of 15
 Work Order : EB1320587
 Client : AUSTRALASIAN RESOURCE CONSULTANTS
 Project : Lake Vermont



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID				
				LV2389G/8	LV2389G/9	LV2389G/10	LV2389G/11	LV2389G/12
Client sampling date / time				20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00
Compound	CAS Number	LOR	Unit	EB1320587-056	EB1320587-057	EB1320587-058	EB1320587-059	EB1320587-060
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	9.5	9.5	9.5	9.6	9.5
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	370	353	378	382	460
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	10.6	9.1	10.7	10.6	9.7
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	75.4	36.1	117	58.3	36.9
ANC as CaCO3	----	0.1	% CaCO3	7.7	3.7	11.9	6.0	3.8
Fizz Rating	----	0	Fizz Unit	2	1	3	2	2
ED040: Sulfur as SO4 2-								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	220	130	130	170	200
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.04	0.04	0.03	0.04	0.05
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.42	0.58	0.15	0.14	0.81
EP003TC: Total Carbon (TC) in Soil								
Total Carbon	----	0.02	%	1.69	1.80	2.22	0.94	1.94

Page : 15 of 15
 Work Order : EB1320587
 Client : AUSTRALASIAN RESOURCE CONSULTANTS
 Project : Lake Vermont



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)

Client sample ID

Client sampling date / time

Compound	CAS Number	LOR	Unit	LV2389G/13	LV2389G/14	LV2389G/15	LV2389G/16	LV2389G/17
				20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00
				EB1320587-061	EB1320587-062	EB1320587-063	EB1320587-064	EB1320587-065
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	8.6	6.6	8.7	8.5	9.7
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	582	165	616	581	428
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	3.1	3.2	3.2	3.7	10.9
NAG (pH 4.5)	----	0.1	kg H2SO4/t	4.1	7.3	3.0	0.8	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	7.5	21.3	7.3	3.5	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	6.5	8.2	7.7	9.7	140
ANC as CaCO3	----	0.1	% CaCO3	0.7	0.8	0.8	1.0	14.3
Fizz Rating	----	0	Fizz Unit	1	1	0	1	3
ED040: Sulfur as SO4 2-								
Sulfate as SO4 2-	14808-79-8	100	mg/kg	470	<100	820	630	660
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.45	0.56	0.35	0.25	0.17
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	1.41	----	4.06	1.38	0.16
EP003TC: Total Carbon (TC) in Soil								
Total Carbon	----	0.02	%	1.94	----	4.46	1.80	2.26



Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: EB1322341	Page	: 1 of 16
Client	: AUSTRALASIAN RESOURCE CONSULTANTS	Laboratory	: Environmental Division Brisbane
Contact	: MR GARETH BRAMSTON	Contact	: Customer Services
Address	: SUITE 5B 1 SWANN ROAD TARINGA QLD, AUSTRALIA 4068	Address	: 2 Byth Street Stafford QLD Australia 4053
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Telephone	: +61 07 32178772	Telephone	: +61 7 3243 7222
Facsimile	: +61 07 32178775	Facsimile	: +61 7 3243 7218
Project	: Lake Vermont	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----	Date Samples Received	: 12-SEP-2013
C-O-C number	: ----	Issue Date	: 19-SEP-2013
Sampler	: ----	No. of samples received	: 33
Site	: ----	No. of samples analysed	: 33
Quote number	: BN/274/12		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results



NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Stephen Hislop	Senior Inorganic Chemist	Brisbane Inorganics
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Page : 2 of 16
Work Order : EB1322341
Client : AUSTRALASIAN RESOURCE CONSULTANTS
Project : Lake Vermont



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting



Analytical Results

Sub-Matrix: DI WATER LEACHATE (Matrix: WATER)				Client sample ID				
				LV2183G/1	LV2183G/4	LV2183G/8	LV2183G/9	LV2183G/10
Client sampling date / time				18-SEP-2013 14:00	18-SEP-2013 14:00	18-SEP-2013 14:00	18-SEP-2013 14:00	18-SEP-2013 14:00
Compound	CAS Number	LOR	Unit	EB1322341-001	EB1322341-002	EB1322341-003	EB1322341-004	EB1322341-005
EG020W: Water Leachable Metals by ICP-MS								
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	0.011	0.003	0.002
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	0.032	<0.001	0.001	0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	0.007	<0.001	0.002	0.003	<0.001
Copper	7440-50-8	0.001	mg/L	0.006	<0.001	0.001	0.002	<0.001
Lead	7439-92-1	0.001	mg/L	0.003	<0.001	0.002	0.001	<0.001
Manganese	7439-96-5	0.001	mg/L	0.170	<0.001	0.011	0.006	0.030
Nickel	7440-02-0	0.001	mg/L	0.016	<0.001	0.003	0.003	0.001
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	0.042	0.016	0.021	0.020	0.008
EG035W: Water Leachable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001



Analytical Results

Sub-Matrix: DI WATER LEACHATE (Matrix: WATER)

Client sample ID

				LV2183G/11	LV2183G/13	LV2183G/15	LV2183G/17	LV2219G/3
Client sampling date / time				18-SEP-2013 14:00	18-SEP-2013 14:00	18-SEP-2013 14:00	18-SEP-2013 14:00	18-SEP-2013 14:00
Compound	CAS Number	LOR	Unit	EB1322341-006	EB1322341-007	EB1322341-008	EB1322341-009	EB1322341-010
EG020W: Water Leachable Metals by ICP-MS								
Arsenic	7440-38-2	0.001	mg/L	0.006	0.002	<0.001	0.002	<0.001
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	0.002	0.002	<0.001	0.001	0.003
Cobalt	7440-48-4	0.001	mg/L	<0.001	0.002	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	0.006	0.007	0.001	0.002	0.001
Lead	7439-92-1	0.001	mg/L	0.004	0.004	<0.001	0.002	0.001
Manganese	7439-96-5	0.001	mg/L	0.008	0.015	0.008	0.003	0.065
Nickel	7440-02-0	0.001	mg/L	0.002	0.003	<0.001	0.001	0.002
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	0.034	0.036	0.013	0.022	0.027
EG035W: Water Leachable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001



Analytical Results

Sub-Matrix: DI WATER LEACHATE (Matrix: WATER)				Client sample ID				
				LV2219G/6	LV2219G/10	LV2219G/12	LV2219G/13	LV2219G/14
Client sampling date / time				18-SEP-2013 14:00	18-SEP-2013 14:00	18-SEP-2013 14:00	18-SEP-2013 14:00	18-SEP-2013 14:00
Compound	CAS Number	LOR	Unit	EB1322341-011	EB1322341-012	EB1322341-013	EB1322341-014	EB1322341-015
EG020W: Water Leachable Metals by ICP-MS								
Arsenic	7440-38-2	0.001	mg/L	0.001	0.010	0.010	<0.001	<0.001
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	0.002	0.003	<0.001	0.002
Cobalt	7440-48-4	0.001	mg/L	<0.001	0.001	0.001	<0.001	0.001
Copper	7440-50-8	0.001	mg/L	0.002	0.001	0.008	<0.001	0.008
Lead	7439-92-1	0.001	mg/L	<0.001	0.002	0.006	<0.001	0.005
Manganese	7439-96-5	0.001	mg/L	0.004	0.006	0.012	<0.001	0.004
Nickel	7440-02-0	0.001	mg/L	<0.001	0.002	0.004	<0.001	0.002
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	0.019	0.025	0.052	0.008	0.040
EG035W: Water Leachable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001



Analytical Results

Sub-Matrix: DI WATER LEACHATE (Matrix: WATER)				Client sample ID				
				LV2388G/6	LV2388G/9	LV2388G/11	LV2388G/15	LV2389G/4
Client sampling date / time				18-SEP-2013 14:00	18-SEP-2013 14:00	18-SEP-2013 14:00	18-SEP-2013 14:00	18-SEP-2013 14:00
Compound	CAS Number	LOR	Unit	EB1322341-021	EB1322341-022	EB1322341-023	EB1322341-024	EB1322341-025
EG020W: Water Leachable Metals by ICP-MS								
Arsenic	7440-38-2	0.001	mg/L	0.006	0.006	0.004	0.011	<0.001
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	0.003	0.001	0.001	0.002	<0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	0.001	<0.001
Copper	7440-50-8	0.001	mg/L	<0.001	0.001	0.001	0.002	0.003
Lead	7439-92-1	0.001	mg/L	0.001	0.002	0.001	0.003	<0.001
Manganese	7439-96-5	0.001	mg/L	0.005	0.008	0.008	0.006	0.001
Nickel	7440-02-0	0.001	mg/L	0.001	0.001	<0.001	0.002	<0.001
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	0.017	0.020	0.020	0.028	0.015
EG035W: Water Leachable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001



Analytical Results

Sub-Matrix: DI WATER LEACHATE (Matrix: WATER)				Client sample ID				
				LV2389G/5	LV2389G/6	LV2389G/9	LV2389G/13	LV2389G/14
Client sampling date / time				18-SEP-2013 14:00	18-SEP-2013 14:00	18-SEP-2013 14:00	18-SEP-2013 14:00	18-SEP-2013 14:00
Compound	CAS Number	LOR	Unit	EB1322341-026	EB1322341-027	EB1322341-028	EB1322341-029	EB1322341-030
EG020W: Water Leachable Metals by ICP-MS								
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	0.004	0.011	<0.001
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	0.001	0.001	0.002	<0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	0.003	<0.001
Copper	7440-50-8	0.001	mg/L	0.003	0.014	0.001	0.004	<0.001
Lead	7439-92-1	0.001	mg/L	0.001	0.005	0.001	0.005	<0.001
Manganese	7439-96-5	0.001	mg/L	0.001	0.002	0.017	0.010	<0.001
Nickel	7440-02-0	0.001	mg/L	<0.001	0.001	0.002	0.004	<0.001
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	0.019	0.041	0.018	0.038	0.008
EG035W: Water Leachable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Page : 9 of 16
 Work Order : EB1322341
 Client : AUSTRALASIAN RESOURCE CONSULTANTS
 Project : Lake Vermont



Analytical Results

Sub-Matrix: DI WATER LEACHATE (Matrix: WATER)				Client sample ID	LV2389G/15	LV2389G/16	LV2389G/17	---	---
Client sampling date / time					18-SEP-2013 14:00	18-SEP-2013 14:00	18-SEP-2013 14:00	---	---
Compound	CAS Number	LOR	Unit	EB1322341-031	EB1322341-032	EB1322341-033	---	---	
EG020W: Water Leachable Metals by ICP-MS									
Arsenic	7440-38-2	0.001	mg/L	0.002	<0.001	0.017	---	---	
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	---	---	
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	---	---	
Chromium	7440-47-3	0.001	mg/L	0.001	0.002	0.002	---	---	
Cobalt	7440-48-4	0.001	mg/L	0.001	0.004	<0.001	---	---	
Copper	7440-50-8	0.001	mg/L	0.008	0.013	0.001	---	---	
Lead	7439-92-1	0.001	mg/L	0.003	0.006	<0.001	---	---	
Manganese	7439-96-5	0.001	mg/L	0.004	0.008	0.007	---	---	
Nickel	7440-02-0	0.001	mg/L	0.002	0.006	<0.001	---	---	
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	---	---	
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	---	---	
Zinc	7440-66-6	0.005	mg/L	0.035	0.042	0.017	---	---	
EG035W: Water Leachable Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	---	---	

Page : 10 of 16
 Work Order : EB1322341
 Client : AUSTRALASIAN RESOURCE CONSULTANTS
 Project : Lake Vermont



Analytical Results

Sub-Matrix: PULP (Matrix: SOIL)

Client sample ID

Client sampling date / time

				LV2183G/1	LV2183G/4	LV2183G/8	LV2183G/9	LV2183G/10
				20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00
Compound	CAS Number	LOR	Unit	EB1322341-001	EB1322341-002	EB1322341-003	EB1322341-004	EB1322341-005
ED037: Alkalinity								
Total Alkalinity as CaCO3	----	1	mg/kg	443	443	262	99	82
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	443	377	196	99	82
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg	<1	66	66	<1	<1
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	270	70	150	280	260
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	10	mg/kg	1580	1660	500	270	90
ED093S: Soluble Major Cations								
Calcium	7440-70-2	10	mg/kg	20	10	<10	<10	<10
Magnesium	7439-95-4	10	mg/kg	30	20	<10	<10	10
Sodium	7440-23-5	10	mg/kg	1010	1010	420	330	190
Potassium	7440-09-7	10	mg/kg	<10	<10	<10	<10	<10
EG005T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	<5	<5	18	12	<5
Barium	7440-39-3	10	mg/kg	180	160	50	30	20
Beryllium	7440-41-7	1	mg/kg	<1	5	1	1	<1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	85	19	10	10	5
Cobalt	7440-48-4	2	mg/kg	17	13	21	29	3
Copper	7440-50-8	5	mg/kg	9	37	49	68	27
Lead	7439-92-1	5	mg/kg	<5	<5	18	23	6
Manganese	7439-96-5	5	mg/kg	500	154	768	2140	199
Nickel	7440-02-0	2	mg/kg	28	39	33	31	4
Selenium	7782-49-2	5	mg/kg	<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg	56	48	26	31	8
Zinc	7440-66-6	5	mg/kg	18	92	81	107	18
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
EN60: ASLP Leaching Procedure								
Final pH	----	0.1	pH Unit	8.2	7.6	7.5	7.8	7.2

Page : 11 of 16
 Work Order : EB1322341
 Client : AUSTRALASIAN RESOURCE CONSULTANTS
 Project : Lake Vermont



Analytical Results

Sub-Matrix: PULP (Matrix: SOIL)

Client sample ID

Client sampling date / time

				LV2183G/11	LV2183G/13	LV2183G/15	LV2183G/17	LV2219G/3
				20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00
Compound	CAS Number	LOR	Unit	EB1322341-006	EB1322341-007	EB1322341-008	EB1322341-009	EB1322341-010
ED037: Alkalinity								
Total Alkalinity as CaCO3	----	1	mg/kg	140	476	509	361	164
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	124	312	345	217	148
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg	16	164	164	144	16
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	220	160	180	260	<10
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	10	mg/kg	510	240	220	350	30
ED093S: Soluble Major Cations								
Calcium	7440-70-2	10	mg/kg	<10	<10	<10	<10	<10
Magnesium	7439-95-4	10	mg/kg	<10	<10	<10	<10	<10
Sodium	7440-23-5	10	mg/kg	410	390	430	410	70
Potassium	7440-09-7	10	mg/kg	10	10	10	10	<10
EG005T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	10	<5	<5	6	12
Barium	7440-39-3	10	mg/kg	660	50	530	90	80
Beryllium	7440-41-7	1	mg/kg	1	1	1	2	<1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	10	11	8	8	28
Cobalt	7440-48-4	2	mg/kg	9	16	14	9	10
Copper	7440-50-8	5	mg/kg	65	55	47	78	13
Lead	7439-92-1	5	mg/kg	23	18	15	21	14
Manganese	7439-96-5	5	mg/kg	305	850	840	79	299
Nickel	7440-02-0	2	mg/kg	21	24	18	24	17
Selenium	7782-49-2	5	mg/kg	<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg	21	40	25	15	44
Zinc	7440-66-6	5	mg/kg	72	78	68	100	68
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	0.1	<0.1
EN60: ASLP Leaching Procedure								
Final pH	----	0.1	pH Unit	8.4	9.1	7.7	7.4	8.5



Analytical Results

Sub-Matrix: PULP (Matrix: SOIL)

Client sample ID

				LV2219G/6	LV2219G/10	LV2219G/12	LV2219G/13	LV2219G/14
Client sampling date / time				20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00
Compound	CAS Number	LOR	Unit	EB1322341-011	EB1322341-012	EB1322341-013	EB1322341-014	EB1322341-015
ED037: Alkalinity								
Total Alkalinity as CaCO3	----	1	mg/kg	148	345	271	115	328
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	132	279	222	115	262
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg	16	66	49	<1	66
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	140	110	120	110	130
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	10	mg/kg	580	140	560	80	250
ED093S: Soluble Major Cations								
Calcium	7440-70-2	10	mg/kg	<10	<10	<10	<10	<10
Magnesium	7439-95-4	10	mg/kg	<10	<10	<10	<10	<10
Sodium	7440-23-5	10	mg/kg	410	250	380	150	260
Potassium	7440-09-7	10	mg/kg	10	<10	<10	<10	<10
EG005T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	<5	79	8	<5	<5
Barium	7440-39-3	10	mg/kg	110	180	210	20	250
Beryllium	7440-41-7	1	mg/kg	1	1	1	<1	1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	12	14	14	3	10
Cobalt	7440-48-4	2	mg/kg	6	14	9	<2	8
Copper	7440-50-8	5	mg/kg	52	54	58	12	81
Lead	7439-92-1	5	mg/kg	17	19	20	<5	24
Manganese	7439-96-5	5	mg/kg	346	140	173	19	47
Nickel	7440-02-0	2	mg/kg	17	30	23	<2	18
Selenium	7782-49-2	5	mg/kg	<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg	20	27	22	<5	16
Zinc	7440-66-6	5	mg/kg	128	79	99	7	95
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	0.1	<0.1	0.1
EN60: ASLP Leaching Procedure								
Final pH	----	0.1	pH Unit	7.8	8.7	6.8	6.6	7.4

Page : 13 of 16
 Work Order : EB1322341
 Client : AUSTRALASIAN RESOURCE CONSULTANTS
 Project : Lake Vermont



Analytical Results

Sub-Matrix: PULP (Matrix: SOIL)

Client sample ID

				LV2219G/15	LV2388G/1	LV2388G/2	LV2388G/4	LV2388G/5
Client sampling date / time				20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00
Compound	CAS Number	LOR	Unit	EB1322341-016	EB1322341-017	EB1322341-018	EB1322341-019	EB1322341-020
ED037: Alkalinity								
Total Alkalinity as CaCO3	----	1	mg/kg	558	624	115	197	115
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	361	558	115	181	99
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg	197	66	<1	16	16
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	110	40	20	280	200
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	10	mg/kg	80	200	40	160	120
ED093S: Soluble Major Cations								
Calcium	7440-70-2	10	mg/kg	<10	<10	<10	<10	<10
Magnesium	7439-95-4	10	mg/kg	<10	<10	<10	<10	<10
Sodium	7440-23-5	10	mg/kg	420	260	50	300	200
Potassium	7440-09-7	10	mg/kg	10	<10	<10	20	10
EG005T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	7	<5	6	5	12
Barium	7440-39-3	10	mg/kg	200	300	50	170	1840
Beryllium	7440-41-7	1	mg/kg	<1	<1	<1	1	<1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	21	85	44	17	35
Cobalt	7440-48-4	2	mg/kg	10	12	<2	36	12
Copper	7440-50-8	5	mg/kg	44	9	<5	56	24
Lead	7439-92-1	5	mg/kg	13	<5	<5	17	12
Manganese	7439-96-5	5	mg/kg	520	165	<5	3630	131
Nickel	7440-02-0	2	mg/kg	27	32	<2	32	22
Selenium	7782-49-2	5	mg/kg	<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg	24	50	141	43	30
Zinc	7440-66-6	5	mg/kg	84	11	<5	68	74
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
EN60: ASLP Leaching Procedure								
Final pH	----	0.1	pH Unit	8.7	8.8	8.5	7.2	8.6



Analytical Results

Sub-Matrix: PULP (Matrix: SOIL)

Client sample ID

Compound	CAS Number	LOR	Unit	LV2388G/6	LV2388G/9	LV2388G/11	LV2388G/15	LV2389G/4
				20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00
				EB1322341-021	EB1322341-022	EB1322341-023	EB1322341-024	EB1322341-025
ED037: Alkalinity								
Total Alkalinity as CaCO3	----	1	mg/kg	115	501	394	164	148
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	99	337	263	115	132
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg	16	164	131	49	16
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	150	110	120	140	240
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	10	mg/kg	90	70	170	100	560
ED093S: Soluble Major Cations								
Calcium	7440-70-2	10	mg/kg	<10	<10	<10	<10	<10
Magnesium	7439-95-4	10	mg/kg	<10	<10	<10	<10	<10
Sodium	7440-23-5	10	mg/kg	170	300	320	180	460
Potassium	7440-09-7	10	mg/kg	<10	20	20	<10	20
EG005T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	11	11	11	12	<5
Barium	7440-39-3	10	mg/kg	20	230	190	80	20
Beryllium	7440-41-7	1	mg/kg	1	1	1	1	<1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	17	19	14	17	5
Cobalt	7440-48-4	2	mg/kg	17	16	14	13	6
Copper	7440-50-8	5	mg/kg	63	62	58	65	59
Lead	7439-92-1	5	mg/kg	18	20	18	17	17
Manganese	7439-96-5	5	mg/kg	574	893	1150	310	20
Nickel	7440-02-0	2	mg/kg	31	31	27	29	10
Selenium	7782-49-2	5	mg/kg	<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg	39	47	39	33	11
Zinc	7440-66-6	5	mg/kg	74	93	95	99	37
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	0.1	<0.1	<0.1
EN60: ASLP Leaching Procedure								
Final pH	----	0.1	pH Unit	7.7	8.8	8.4	8.7	6.9



Analytical Results

Sub-Matrix: PULP (Matrix: SOIL)

Client sample ID

				LV2389G/5	LV2389G/6	LV2389G/9	LV2389G/13	LV2389G/14
Client sampling date / time				20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00
Compound	CAS Number	LOR	Unit	EB1322341-026	EB1322341-027	EB1322341-028	EB1322341-029	EB1322341-030
ED037: Alkalinity								
Total Alkalinity as CaCO3	----	1	mg/kg	164	99	566	123	57
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	164	83	287	123	57
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg	<1	16	279	<1	<1
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	240	210	80	350	210
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	10	mg/kg	540	640	140	650	80
ED093S: Soluble Major Cations								
Calcium	7440-70-2	10	mg/kg	<10	<10	<10	<10	<10
Magnesium	7439-95-4	10	mg/kg	<10	<10	<10	<10	<10
Sodium	7440-23-5	10	mg/kg	440	460	340	530	160
Potassium	7440-09-7	10	mg/kg	10	10	10	20	<10
EG005T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	<5	<5	7	10	<5
Barium	7440-39-3	10	mg/kg	250	20	30	280	120
Beryllium	7440-41-7	1	mg/kg	<1	1	1	1	<1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	4	4	28	16	2
Cobalt	7440-48-4	2	mg/kg	8	5	22	22	<2
Copper	7440-50-8	5	mg/kg	47	62	39	79	11
Lead	7439-92-1	5	mg/kg	13	20	12	30	<5
Manganese	7439-96-5	5	mg/kg	10	15	870	160	23
Nickel	7440-02-0	2	mg/kg	14	16	44	34	<2
Selenium	7782-49-2	5	mg/kg	<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg	12	7	48	32	<5
Zinc	7440-66-6	5	mg/kg	45	74	71	143	<5
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	0.1	<0.1
EN60: ASLP Leaching Procedure								
Final pH	----	0.1	pH Unit	6.8	7.0	7.5	7.2	6.6

Page : 16 of 16
 Work Order : EB1322341
 Client : AUSTRALASIAN RESOURCE CONSULTANTS
 Project : Lake Vermont



Analytical Results

Sub-Matrix: PULP (Matrix: SOIL)				Client sample ID			LV2389G/15	LV2389G/16	LV2389G/17	---	---
Client sampling date / time				20-AUG-2013 15:00	20-AUG-2013 15:00	20-AUG-2013 15:00	---	---	---	---	
Compound	CAS Number	LOR	Unit	EB1322341-031	EB1322341-032	EB1322341-033	---	---	---	---	
ED037: Alkalinity											
Total Alkalinity as CaCO3	---	1	mg/kg	131	66	624	---	---	---	---	
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	131	66	328	---	---	---	---	
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg	<1	<1	296	---	---	---	---	
ED040S : Soluble Sulfate by ICPAES											
Sulfate as SO4 2-	14808-79-8	10	mg/kg	480	430	260	---	---	---	---	
ED045G: Chloride Discrete analyser											
Chloride	16887-00-6	10	mg/kg	560	590	80	---	---	---	---	
ED093S: Soluble Major Cations											
Calcium	7440-70-2	10	mg/kg	<10	<10	<10	---	---	---	---	
Magnesium	7439-95-4	10	mg/kg	<10	<10	<10	---	---	---	---	
Sodium	7440-23-5	10	mg/kg	560	530	400	---	---	---	---	
Potassium	7440-09-7	10	mg/kg	20	10	20	---	---	---	---	
EG005T: Total Metals by ICP-AES											
Arsenic	7440-38-2	5	mg/kg	9	<5	18	---	---	---	---	
Barium	7440-39-3	10	mg/kg	550	300	710	---	---	---	---	
Beryllium	7440-41-7	1	mg/kg	1	1	<1	---	---	---	---	
Boron	7440-42-8	50	mg/kg	<50	<50	<50	---	---	---	---	
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	---	---	---	---	
Chromium	7440-47-3	2	mg/kg	6	10	31	---	---	---	---	
Cobalt	7440-48-4	2	mg/kg	14	20	12	---	---	---	---	
Copper	7440-50-8	5	mg/kg	82	69	18	---	---	---	---	
Lead	7439-92-1	5	mg/kg	23	21	10	---	---	---	---	
Manganese	7439-96-5	5	mg/kg	66	101	837	---	---	---	---	
Nickel	7440-02-0	2	mg/kg	22	30	21	---	---	---	---	
Selenium	7782-49-2	5	mg/kg	<5	<5	<5	---	---	---	---	
Vanadium	7440-62-2	5	mg/kg	12	22	17	---	---	---	---	
Zinc	7440-66-6	5	mg/kg	99	114	68	---	---	---	---	
EG035T: Total Recoverable Mercury by FIMS											
Mercury	7439-97-6	0.1	mg/kg	<0.1	0.1	0.3	---	---	---	---	
EN60: ASLP Leaching Procedure											
Final pH	---	0.1	pH Unit	6.6	6.7	9.4	---	---	---	---	

Appendix E Response to DoEE Information Request

LAKE VERMONT NORTHERN EXPANSION
EPBC REFERRAL – RESPONSE TO INFORMATION REQUEST

PREPARED FOR
BOWEN BASIN COAL PTY LTD

NOVEMBER 2016



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Name of Client:	Bowen Basin Coal Pty Ltd
Name of Project:	Response to EPBC Information Request
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1.0	INTRODUCTION	1
1.1	BACKGROUND.....	1
1.2	SCOPE OF DOCUMENT.....	1
2.0	RESPONSE TO INFORMATION REQUEST	2
2.1	SURFACE WATER.....	2
2.1.1	Issue	2
2.1.2	Information Request	2
2.1.3	Response.....	2
2.1.4	Information Request	5
2.1.5	Response.....	5
2.1.6	Information Request	6
2.1.7	Response.....	6
2.1.8	Information Request	11
2.1.9	Response.....	11
2.2	INTERACTION BETWEEN SURFACE WATER AND GROUNDWATER	11
2.2.1	Issue	11
2.2.2	Information Request	12
2.2.3	Response.....	12
2.2.4	Information Request	13
2.2.5	Response.....	13
2.2.6	Information Request	13
2.2.7	Response.....	14
2.2.8	Information Request	14
2.2.9	Response.....	14
2.3	WATER QUALITY OF A WATER RESOURCE.....	15
2.3.1	Issue	15
2.3.2	Information Request	15
2.3.3	Response.....	15
2.3.4	Information Request	16
2.3.5	Response.....	16
2.3.6	Information Request	17

2.3.7 Response..... 17

LIST OF FIGURES

Figure 1 Lake Vermont aerial photo captured when empty in November 20033
 Figure 2 Lake Vermont aerial photo captured in June 2013.....4
 Figure 3 Simulated Final Void Storage Water Level.....17

LIST OF TABLES

Table 1 Catchment Area Loss6
 Table 2 Existing Projects Considered in the Cumulative Impact Assessment6
 Table 3 New or Developing Projects Considered in the Cumulative Impact Assessment9
 Table 4 Lake Vermont Rainfall Data.....13
 Table 5 Predicted Void Water Levels17

LIST OF APPENDICES

Appendix A Surface Water Balance Modelling Report A

LIST OF ABBREVIATIONS

AARC	AustralAsian Resource Consultants Pty Ltd
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
BOM	Bureau of Meteorology
DoEE	Department of the Environment and Energy
EPBC	Environmental Protection and Biodiversity Conservation Act
HCC	Hard Coking Coal
MBGL	Metres Below Ground Level
MNES	Matters of National Environmental Significance
PCI	Pulverised Coal Injection
SWMS	Surface Water Management System
VWP	Vibrating Wire Piezometer

1.0 INTRODUCTION

AustralAsian Resource Consultants Pty Ltd (AARC) was commissioned by Bowen Basin Coal Pty Ltd (BBC) to prepare this Response to Information Request document. This document supports the Matters of National Environmental Significance Assessment Report submitted as part of the *Environmental Protection and Biodiversity Conservation (EPBC) Act* referral for the Lake Vermont Northern Extension (May 2016).

This report provides the additional supporting information in response to an information request issued by the Department of the Environment and Energy (DoEE) on August 22, 2016.

1.1 BACKGROUND

The Lake Vermont Coal Mine is a medium size open-cut coal mine producing hard coking coal (HCC) and pulverised coal injection (PCI) coal for the export market to be used in steel production. Mining operations at the Project site commenced in September 2008 with first coal production in January 2009.

The purpose of the proposed Project is to extend current mining activities at the Lake Vermont Mine into new resource areas located directly to the north within ML 70528, covering an area of approximately 3,700 hectares (ha). No change in the approved mining or production rate is proposed. An application to amend the Mine's Environmental Authority (EA) (EPML00659513), pertaining to a new ML application by BBC over the subject land, was submitted to the Queensland Department of Environment and Heritage Protection (EHP) for assessment and approval in October 2014. An Information Request was received in January 2015 and a subsequent Information Response was submitted to EHP in May 2015. EHP approved the EA amendment application on 28th September 2015.

The EPBC Referral, to which this document relates, proposes an extension of the existing Lake Vermont Coal Mine into new resource areas located to the north. No change in the approved mining or production rate has been proposed as part of the application. The Northern Extension Project site is located immediately north of the existing mine within ML 70528, covering an area of approximately 3,700 hectares (ha).

As the proposed Project had potential to impact on Matters of National Environmental Significance (MNES), nationally threatened species and ecological communities, migratory species, and water resources in relation to a large coal mining development, it was determined by the proponent that the Project would be referred to the Commonwealth Department of the Environment to determine whether they constituted controlled actions. A pre-referral meeting was held with the Commonwealth Department of the Environment on 26th June 2014. Assessment of potential impacts on MNES determined that a significant impact on water resources was likely to be triggered by the Project. In response, a referral, accompanied by an MNES Assessment Report was submitted to the DoEE on 6th May, 2016.

In June 2016, DoEE confirmed that the Project does constitute a controlled action, specifically due to the potential for impacts on a water resource in relation to a large coal mining development. In August 2016, DoEE issued a Request for Further Information, focussed on issues including surface water hydrology, interaction between surface water and groundwater, and surface water quality impacts.

1.2 SCOPE OF DOCUMENT

The purpose of this Response to Information Request document is to give DoEE all the information requested in the Request for Further Information letter of August 22, 2016.

To achieve this each issue and information request raised by DoEE is summarised and a response to each individual request provided. Responses refer to the section of the MNES Assessment Report where the issue has been addressed, with additional information necessary to address the department's questions included where required.

2.0 RESPONSE TO INFORMATION REQUEST

2.1 SURFACE WATER

2.1.1 Issue

“The proposed action is likely to reduce surface water inputs to Lake Vermont and two creeks because of the reduction of catchment areas and water drawdown. This will have impacts on the lake (water volume or levels) and the creeks (flow regimes, such as volume and timing). It may also interact with other coal mining activities in the project area (i.e. the existing Lake Vermont Coal Mine, Saraji Coal Mine and the closed Norwich Park Coal Mine) and contribute cumulative impacts on the lake and the creeks. These impacts may further affect relevant ecosystems around the lake and along the banks of Phillips Creek (additional to the direct clearing for its diversion).”

2.1.2 Information Request

“Information about current situation of the lake (e.g. average water volume or water levels) and creeks (e.g. average annual flow volume and seasonal change);”

2.1.3 Response

Lake Vermont wetland is an ephemeral waterbody experiencing long periods of dry conditions between periods of rainfall. The wetland is relatively shallow, and is less than 2% full about half of the time and around or above 50% full only 5% of the time.

In response to this information request, WRM Water & Environment were engaged to undertake additional investigations and modelling of surface water balance in the Project area. This modelling is reported in Appendix A, and summarised in relevant sections below.

Interpretations of LiDAR data obtained in July 2014 show that the Lake Vermont wetland is relatively shallow – approximately 1.9 m deep at its deepest point when full, with a surface area of 72.4 ha and total storage capacity of approximately 690 ML.

Although long-term water level monitoring in Lake Vermont has not been undertaken, aerial photographs (Figure 1 and Figure 2), show the variability of water levels in the wetland. Figure 1 shows the wetland empty in November 2003, and Figure 2 shows water at surface elevations of approximately 161m AHD in June 2013.

Geoscience Australia's Water Observations from Space tool indicates the number of times that water is noted in a given water body based on a total number of observations. From this tool, observations indicate that over the period between 1987 and 2014 (which was a wetter than average period of time), water was observed in the centre of the wetland to an elevation of approximately 160.4 m AHD (0.15 m deep - and about 2% of full capacity) about 50% of the time. Elevations of 161.43 m AHD (about 50% full), were exceeded about 5% of the time.

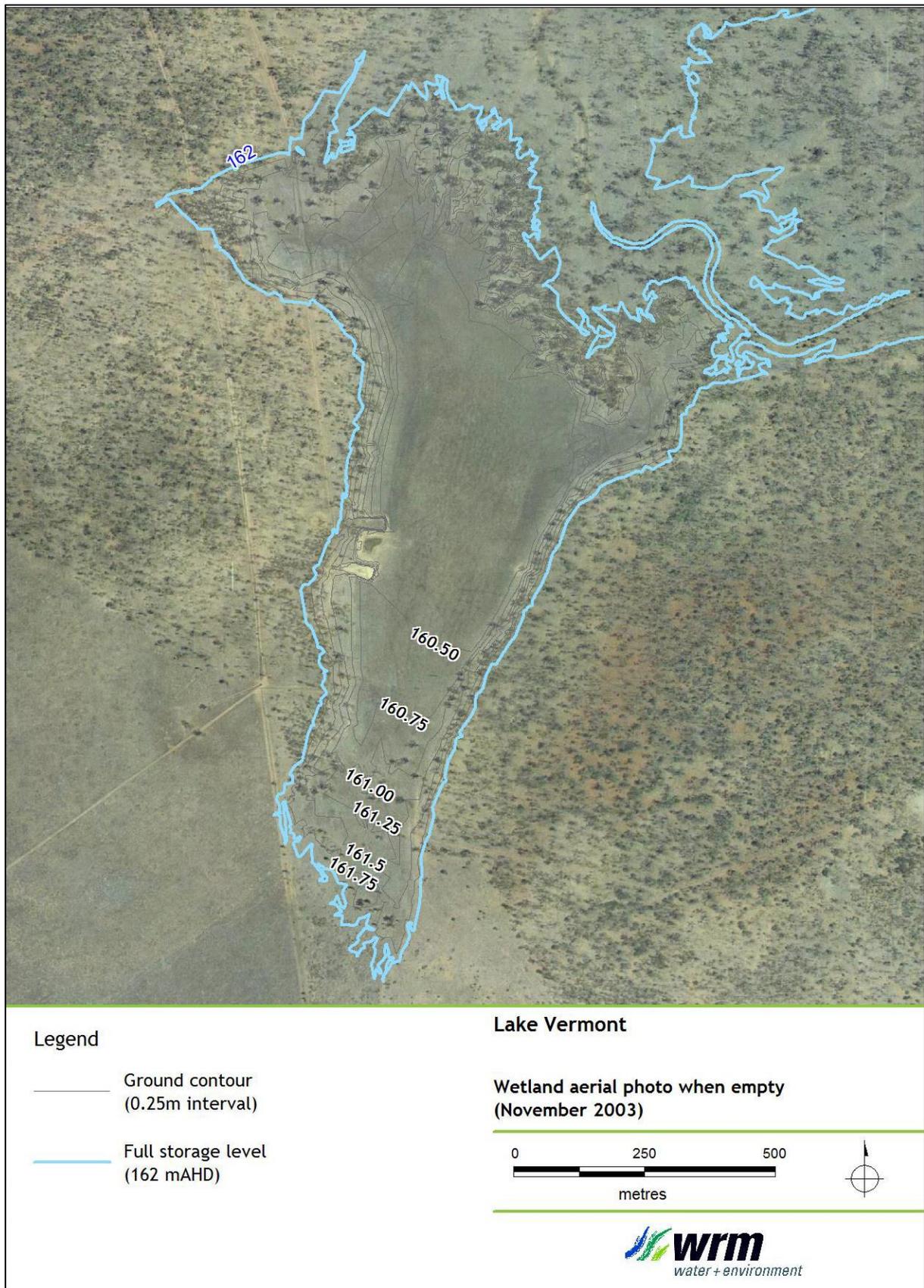


Figure 1 Lake Vermont aerial photo captured when empty in November 2003

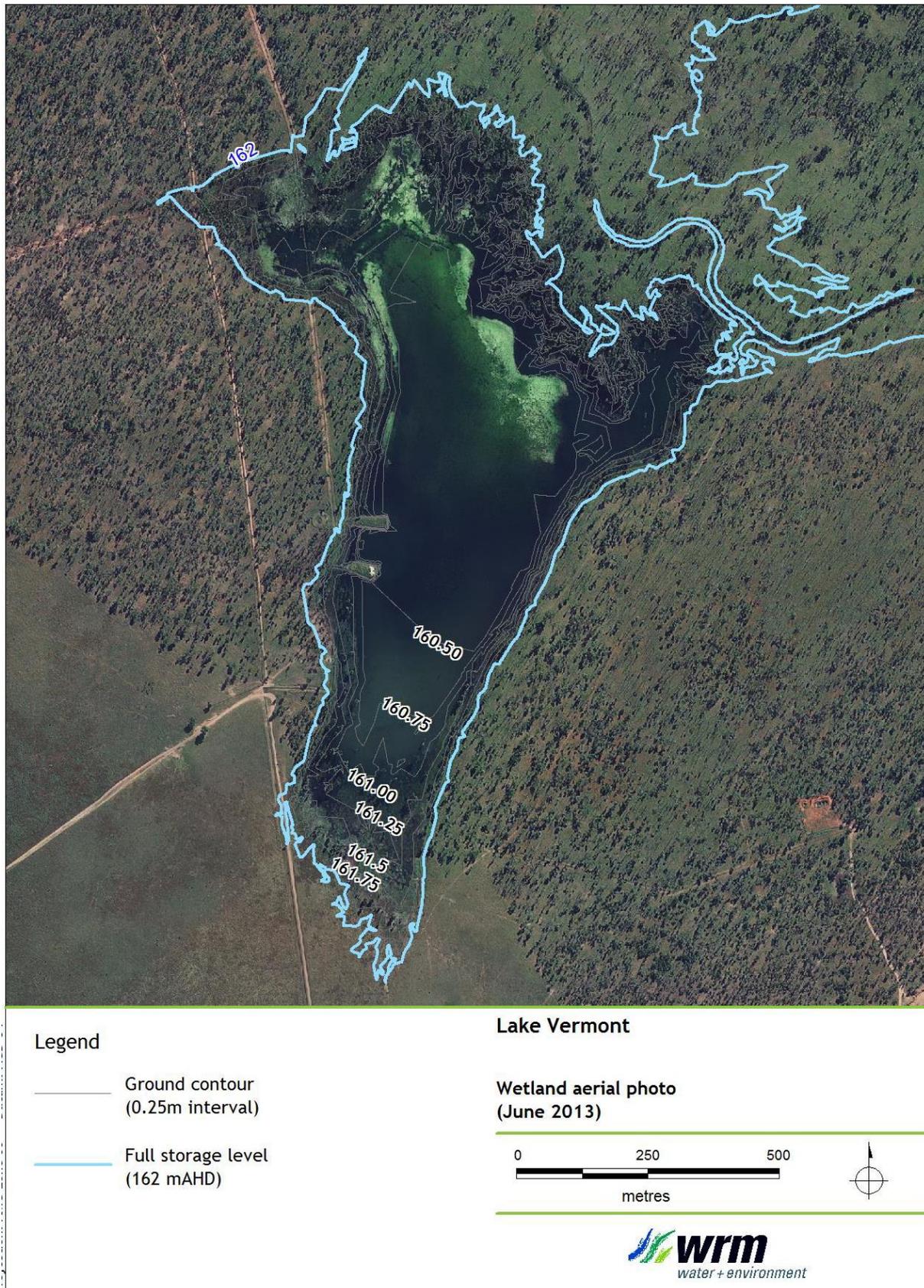


Figure 2 Lake Vermont aerial photo captured in June 2013

Based on the results of flood modelling undertaken for the Project, flood water could be expected to enter the wetland when the Phillips Creek flow rate exceeds approximately 250 m³/s, which is less than the 1 in 5 Annual Exceedance Probability peak flood flow. This implies the wetland could be expected to be filled by Phillips Creek floodwater every 2 to 5 years.

Additionally, modelling results suggest the wetland would be expected to hold water to a depth exceeding 0.5 m (i.e. at about 3.2% of the total storage capacity) about 50% of the time. Stored water volumes would be at less than 25% capacity 80% of the time.

2.1.4 Information Request

“Relevant data or prediction of the proposed action effects from sufficient modelling about the potential impacts on the lake and creeks;”

2.1.5 Response

The Project has the potential to impact on surface water flows in Phillips Creek and into the Lake Vermont wetland, due to the loss of catchment area both during the operation and after closure of the mine. However, modelling of the catchment characteristics, surface water flows and flooding, combined with investigations into the existing flow regimes in the catchment and the wetland, show that these impacts will not be significant.

Section 3.11.3.2 of the MNES Assessment Report describes changes in the nature of water availability and catchment inputs as a result of the Project. The Surface Water Management System (SWMS) report assessed the cumulative impact of the Northern Extension with the existing Lake Vermont Mine.

At the peak of mining disturbance, the maximum captured catchment area during mining operations consists of approximately:

- 49% of the Lake Vermont wetland catchment area, attributable to the Northern Extension Project;
- 4% of the Phillips Creek catchment to the confluence of the Isaac River (half of which is due to the Northern Extension);
- 37% of the Lumpy Gully catchment to the confluence of Downs Creek (10% of which is due to Northern Extension Project); and
- 1% of the Downs Creek catchment to the confluence of the unnamed tributary (due to approved operations).

The impact of the change in Lake Vermont’s catchment area on the frequency of filling the lake is shown in Section 4.1 of WRM’s Surface Water Balance Modelling Report (Appendix A to this report). In summary, the likelihood at the peak of mining disturbance of stored water levels exceeding 160.4 m AHD (approximately 0.15 m deep – i.e. at about 2% of full capacity) would temporarily decrease from approximately 60% to 42%. The likelihood of exceeding an elevation of 161.4 m AHD (1.15 m depth - i.e. at about 47% of the total storage capacity) would reduce from approximately 12% to 8%.

Post-mining, the permanently changed topography as a result of the final landform will have the following impacts on catchment areas:

- A reduction of 5.9 km² in the catchment area draining to Phillips Creek compared to pre-mining conditions. This represents a decrease of less than 1.2%;

- A reduction of 2.6 km² in the catchment area draining to Lumpy Gully compared to pre-mining conditions. This represents a reduction of approximately 2%; and
- A reduction of 1.3 km² in the catchment area draining to the Lake Vermont wetland compared to pre-mining conditions, representing a decrease in catchment area of approximately 12%.

Table 1 Catchment Area Loss

Receiving Watercourse	Pre-Mining Catchment Area (km ²)	Post-Mining Catchment Area (km ²)	Post-Mining Captured Catchment Area (km ²)
Phillips Creek	506.1	500.2	5.9
Unnamed Tributary	128.8	126.2	2.6
Lake Vermont	10.8	9.5	1.3

As outlined in Section 4.1 of WRM's Surface Water Balance Modelling Report (Appendix A to this report), post-mining, the likelihood of stored water levels exceeding 160.4 m AHD (approximately 0.15 m deep – i.e. at about 2 % of the total storage capacity) would decrease from approximately 60% to 55%. The likelihood of exceeding an elevation of 161.4 m AHD (1.15 m deep – i.e. at about 47% of the total storage capacity) would reduce from approximately 12% to 11%.

From the information provided in both the initial Surface Water Impact Assessment and the subsequent Surface Water Balance Modelling Report, it can be concluded that the impact of the Project on the flow regimes within the wetland and its catchment is insignificant, with only slight decreases in the likelihood and frequency of water entering the lake as a result of lost catchment area.

2.1.6 Information Request

“Potential contribution to cumulative impacts in the project area”

2.1.7 Response

Cumulative surface water impacts associated with the proposed Project could include impacts on water quality, flooding and surface water flows, and were assessed taking into consideration both existing and new or proposed projects in the region. The nineteen relevant existing projects considered in the cumulative impact analysis for surface water are listed in Table 2, and seven new or proposed projects are shown in Table 3.

Table 2 Existing Projects Considered in the Cumulative Impact Assessment

Project - Proponent	Description	Operational Status	Relationship to the Project Mining Lease	
			Timing	Location
Burton Mine – Peabody Energy Australia	Open cut coal mine with a yield of 2.1 Mtpa	Operating	May have overlapping operational phases with the construction and operations of the project.	90 km to the north-northwest of the project area. Located within Isaac River catchment.

Project - Proponent	Description	Operational Status	Relationship to the Project Mining Lease	
			Timing	Location
Coppabella Mine – Peabody Energy Australia	Open cut coal mine with a yield of 3.1 Mtpa	Operating	May have overlapping operational phases with the construction and operations of the project.	60 km to the north of the project area. Located within Isaac River catchment.
Moorvale Mine – Peabody Energy Australia	Open cut coal mine with a yield of 2.1 Mtpa	Operating	May have overlapping operational phases with the construction and operations of the project.	45 km to the north of the project area. Located within Isaac River catchment.
Eaglefield Mine – Peabody Energy Australia	Open cut coal mine with a yield of 0.9 Mtpa	Operating	May have overlapping operational phases with the construction and operations of the project.	95 km to the north-northwest of the project area. Located within Isaac River catchment.
North Goonyella Mine – Peabody Energy Australia	Open cut coal mine with a yield of 1.7 Mtpa	Operating	May have overlapping operational phases with the construction and operations of the project.	95 km to the north-northwest of the project area. Located within Isaac River catchment.
Millennium Mine – Peabody Energy Australia	Open cut coal mine with a yield of 5.5 Mtpa	Operating	May have overlapping operational phases with the construction and operations of the project.	45 km to the north-northwest of the project area. Located within Isaac River catchment.
Goonyella Riverside Mine – BMA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	80 km to the northwest of the project area. Located within Isaac River catchment.
Moranbah North Mine – Anglo Coal	Underground coal mine with a yield of 4.5 Mtpa	Operating	May have overlapping operational phases with the construction and operations of the project.	75 km to the northwest of the project area. Located within Isaac River catchment.

Project - Proponent	Description	Operational Status	Relationship to the Project Mining Lease	
			Timing	Location
Carborough Downs Mine – Vale Australia	Underground coal mine with a yield of 2.4 Mtpa	Operating	May have overlapping operational phases with the construction and operations of the project.	55 km to the north-northwest of the project area. Located within Isaac River catchment.
Poitrel Mine – BMC	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	45 km to the north-northwest of the project area. Located within Isaac River catchment.
Peak Downs Mine – BMA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	30 km to the northwest of the project area. Located within Isaac River catchment.
Saraji Mine – BMA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	15 km to the west of the project area. Located within Isaac River catchment.
Norwich Park Mine - BMA	Open cut coal mine	Ceased production indefinitely	May have overlapping operational phases with the construction and operations of the project.	15 km to the southwest of the project area. Located within Isaac River catchment.
Daunia Coal Mine Project - BMA	Open cut coal mine with a yield of 4Mtpa	Operating	May have overlapping operational phases with the construction and operations of the project.	40 km to the north-northwest of the project area. Located within Isaac River catchment.
Eaglefield Expansion Project –Peabody Energy Australian Coal Pty Ltd	Underground coal mine expansion with a yield of 10.2 Mtpa	Expansion in construction phase	May have overlapping operational phases with the construction and operations of the project.	95 km to the northwest of the project area. Located within Isaac River catchment.

Project - Proponent	Description	Operational Status	Relationship to the Project Mining Lease	
			Timing	Location
Grosvenor Coal Mine Project – Anglo Coal	Underground coal mine with a yield of 5 Mtpa	In construction phase	May have overlapping operational phases with the construction and operations of the project.	60 km to the northwest of the project area. Located within Isaac River catchment.
Integrated Isaac Plains Project –IP Coal Pty Ltd and Vale Australia	Expansion to existing open cut coal mine, with a yield of 4 Mtpa.	Existing mine operating, expansion in construction phase	May have overlapping operational phases with the construction and operations of the project.	60 km to the northwest of the project area. Located within Isaac River catchment.
Caval Ridge Mine Project - BMA	Open cut mine with a yield of 5.5 Mtpa and associated infrastructure.	Operating	May have overlapping operational phases with the construction and operations of the project.	45 km to the northwest of the project area. Located within Isaac River catchment.
Eagle Downs Coal Project – Bowen Central Coal Joint Venture Parties	Underground coal mine with a yield of 7 Mtpa and associated infrastructure.	In construction phase	May have overlapping operational phases with the construction and operations of the project.	35 km to the northwest of the project area. Located within Isaac River catchment.

Table 3 New or Developing Projects Considered in the Cumulative Impact Assessment

Project - Proponent	Description	Operational Status	Relationship to the Project Mining Lease	
			Timing	Location
Red Hill Mining Lease Project - BMA	Underground coking coal mine with a yield of 14 Mtpa and expansion of two existing coking coal mines (Broadmeadow and Goonyella Riverside)	EIS active	May have overlapping operational phases with the construction and operations of the project.	85 km to the north-northwest of the project area. Located within Isaac River catchment.
Grosvenor West Project – Carabella Resources	Open cut or underground mine with a yield of 3.5 Mtpa and associated infrastructure.	Final ToR issued – EIS in preparation	May have overlapping operational phases with the construction and operations of the project.	75 km to the northwest of the project area. Located within Isaac River catchment.

Project - Proponent	Description	Operational Status	Relationship to the Project Mining Lease	
			Timing	Location
Moranbah South Project – Anglo Coal and Exxaro Australia Pty Ltd	Underground coking coal mine with a yield of 18 Mtpa and associated infrastructure.	EIS lodged, public notice period completed	May have overlapping operational phases with the construction and operations of the project.	55 km to the northwest of the project area. Located within Isaac River catchment.
New Lenton Coal Project – New Hope Corporation Ltd	Open cut mine with a yield of 5 Mtpa and associated infrastructure.	Final ToR issued – EIS in preparation	May have overlapping operational phases with the construction and operations of the project.	100 km to the north- northwest of the project area. Located within Isaac River catchment.
Carborough Downs Mine Expansion Project - CDJV	Expansion to existing underground coal mine, with a yield of 5 Mtpa.	EIS completed.	May have overlapping operational phases with the construction and operations of the project.	55 km to the north-northwest of the project area. Located within Isaac River catchment.
Codrilla Coal Mine Project – Coppabella and Moorvale Joint Venture	Open cut coal mine with associated infrastructure.	EIS completed.	May have overlapping operational phases with the construction and operations of the project.	35 km to the north-northeast of the project area. Located within Isaac River catchment.
Ellensfield Coal Mine Project – Ellensfields Coal Management Pty Ltd	Open cut coal mine with associated infrastructure.	EIS completed.	May have overlapping operational phases with the construction and operations of the project.	75 km to the north-northwest of the project area. Located within Isaac River catchment.

Cumulative impacts on Surface Water are discussed in the MNES Assessment Report section 3.11.3.2 – Potential Impacts on Surface Water, which includes descriptions of cumulative impacts on Water Quality, Flooding and Surface Water Flows.

For Water Quality, given that the Northern Extension is simply an extension of existing mining activities, and that mine water releases will be managed within an overarching strategic framework for management of cumulative impacts of mining activities, the proposed management approach for mine water from the Project is expected to have negligible cumulative impact on surface water quality and associated environmental values.

For flooding, none of the known projects in the planning or development phase in the vicinity of the Project are expected to result in additional structures on the floodplain. Therefore, cumulative impacts on flooding are not expected to lead to any adverse impacts on human populations, property or other environmental or social values.

For surface water flows, the Project does not require any additional raw water allocations and therefore does not contribute to cumulative impacts in relation to extraction of surface water resources

from other catchments. The Project will locally impact flows in the minor tributaries of Downs Creek and the Isaac River due to water being captured within the SWMS. The impacts of these changes are expected to be minimal. No other projects have been identified which would further increase these impacts.

2.1.8 Information Request

“Prediction of effects of these impacts on ecosystems around the lake and along the banks of Phillips Creek.”

2.1.9 Response

The potential water related impacts to ecosystems associated with Lake Vermont and Phillips Creeks include drawdown, altered surface water catchment, altered flow characteristics and the potential release of contaminants. The likely impact of these changes has been assessed in the following sections of the MNES Assessment report and associated appendices.

As demonstrated by the Surface Water Impact Assessment Report, and the subsequent Surface Water Balance Modelling Report (Appendix A), Phillips Creek and the Lake Vermont wetland are surface water fed and ephemeral, subject to long periods of dry conditions. Phillips Creek only flows to the wetland when the flow rate exceeds approximately 250 m³/s, which is less than the 1 in 5 Annual Exceedance Probability peak flood flow. This implies the wetland is only filled by Phillips Creek floodwater every 2 to 5 years. As such, the terrestrial ecosystems in the wetland and along Phillips Creek are tolerant of extended dry periods, with little or no inflow. Due to the insignificant impact from the Project on storage volumes and fill-empty cycles in the Lake Vermont wetland, changes in Phillips Creek flooding are unlikely to have impact on aquatic / ecological values of the wetland.

Section 3.11.3.2 of the MNES Assessment Report outlines the loss of catchment area as a result of mining and onsite water management and the resulting impacts on water levels, which will be insignificant. Post-mining, for the Lake Vermont wetland, the likelihood of stored water levels reaching about 2% of the total storage capacity would only decrease from approximately 60% to 55%. The likelihood of the wetland filling to about 47% of the total storage capacity would only reduce from approximately 12% to 11%. With these minor changes in flow regimes, and the existing vegetation's tolerance of dry conditions, the impact on ecosystems is expected to be minor.

Additionally, Section 3.11.3.2 describes potential hydraulic impacts, which may result in an elevated erosion risk while banks of the diversion are unvegetated following construction. These impacts will be managed through revegetation, although the relatively cohesive nature of local soils provides some natural mitigation.

The Aquatic Ecology and Stream Morphology Assessment Report discusses potential for drawdown, but, with reference to the Groundwater Impact Assessment, concludes that the risk to groundwater dependent ecosystems will be low due to the depth of the regional groundwater table from the surface and the limited extent of drawdown impacts from mining.

2.2 INTERACTION BETWEEN SURFACE WATER AND GROUNDWATER

2.2.1 Issue

“Water drawdown and the reduction of catchment area may have some impacts on the interaction between surface water and groundwater in the project area, such as recharge rates to groundwater, groundwater table and potentiometric surface levels. This may also interact with other coal mining

activities and contribute cumulative impacts on the interaction between surface water and groundwater.

The dry condition found in the relevant geological and hydrogeological units (i.e. quaternary alluvium and tertiary sediments) within the project area when drilled could be potentially due to the recharge fluctuation from available surface water (rainfall or flooding). If these data had been used in groundwater modelling, it would be unlikely to estimate the groundwater contours correctly.”

2.2.2 Information Request

“Data or information to support the assumption that Lake Vermont is not connected to groundwater”

2.2.3 Response

Groundwater data obtained for the MNES Assessment report included data from:

- Groundwater monitoring bores constructed within the proposed extension area specifically for the assessment;
- Observations from the existing Lake Vermont pit, from a site inspection undertaken in June 2013;
- Geological sections obtained from the site geological model;
- Data available from site exploration drilling (lithology, stratigraphy, groundwater observations from drilling); and
- Publicly available data from registered groundwater bores and nearby projects and operations.

JBT Consulting produced a Groundwater Summary Report (MNES Assessment Report – Appendix E), which concludes that the Lake Vermont wetland is a topographic depression that is maintained by surface water runoff under certain climatic conditions and is not groundwater fed.

The closest groundwater monitoring bore to Lake Vermont is bore 1235C-VWP, which is a vibrating wire piezometer (VWP) installation containing 4 VWP's. The uppermost VWP measures groundwater levels in Permian sandstone, which is the shallowest groundwater unit at that location. Review of monitoring data from November 2015 indicates that the shallow groundwater unit records a depth to water of approximately 36 m below ground level (mbgl), which equates to a relative water level of approximately 130 mAHD. Monitoring data also confirms that the Tertiary sediments are dry at this location, as the depth to base of Tertiary is 20 m (i.e. the groundwater level is approximately 16 m below base of Tertiary).

The ground elevation at Lake Vermont is approximately 160 m AHD at the lake margins, therefore by extension of data from 1235C-VWP the groundwater level could be expected to be approximately 30 to 35 m below the level of the lake. This would place the groundwater level below the base of the Tertiary sediments (which are approximately 18 m thick at the location of Lake Vermont, based on drilling data from exploration bore LV1232, which is located approximately 60 m from the western edge of the lake). This is consistent with observations from the exploration drilling program that the Tertiary sediments are generally dry throughout the Lake Vermont area.

It is therefore concluded that the Lake Vermont wetland could not be maintained by groundwater baseflow.

2.2.4 Information Request

“Long term annual rainfall data and the sampling time for the relevant geological and hydrogeological units within the project area”

2.2.5 Response

Long-term average annual rainfall, measured at the nearby Clermont Post Office Bureau of Meteorology (BOM) station since 1871, is 667.3 mm/year. Daily rainfall data is also collected from the existing mine site, and is summarised for the 2010 – 2015 period in Table 4.

Table 4 Lake Vermont Rainfall Data

Month	2010	2011	2012	2013	2014	2015
Jan	177.0	192.1	179.5	219.1	186.5	266.2
Feb	255.0	67.5	93.8	84.7	64.2	22.0
Mar	60.5	150.6	251.5	62.2	17.7	2.6
Apr	85.0	38.6	26.3	78.8	60.7	6.0
Jun	6.5	50.2	52.6	109.8	8.3	1.5
Jul	3.0	37.4	43.5	2.3	10.3	3.5
Aug	13.0	10.5	97.2	1.1	1.5	0.4
Sep	58.0	48.8	0.4	0.0	46.4	6.0
Oct	136.0	0.0	5.0	0.0	62.5	6.5
Nov	40.8	17.1	11.3	2.0	9.0	1.1
Dec	273.1	20.8	47.1	193.6	43.9	98.4
Total	1439.5	738.9	822.8	769.5	730.6	424.8

Construction and monitoring of groundwater bores for the assessment project was undertaken in late 2013. At this time, alluvium sediments in all holes were observed to be dry. Of the three bores drilled into tertiary sediments, only one (closest to Phillips Creek) has water for any period of time. As the rainfall data above shows, each year leading up to this time was significantly wetter than the long-term average.

Additional monitoring undertaken at bore 1235C-VWP in November 2015 also confirms that the Tertiary sediments are dry at this location, as the depth to base of Tertiary is 20 mbgl and depth to water is approximately 36 mbgl (i.e. the groundwater level is approximately 16 m below the base of Tertiary sediments). As can be seen in Table 4, 2015 was a relatively dry year, with annual rainfall of 424.8mm.

Since groundwater monitoring and geological assessments have consistently found dry conditions in the quaternary alluvium and tertiary sediments following long periods of wetter than average years, and in a drier than average year, it is clear that these dry groundwater conditions are consistent, and not due to fluctuations in rainfall at the time that drilling and monitoring was undertaken.

2.2.6 Information Request

“Additional information about current situation of the interaction (e.g. recharge rates to ground water and groundwater table) and prediction on the change of this interaction as a result of the construction of the mining pits, e.g. the pit immediately south of Phillips Creek and the Satellite Pit on the other side”

2.2.7 Response

In the areas of the proposed Project, the most relevant hydrogeological units in terms of recharge are the Triassic Sediments of the Rewan Group and the Permian Strata of the Fair Hill Group. Current groundwater occurrence and recharge for these hydrogeological units is described in Section 5.3 of the Groundwater Impact Assessment Report (MNES Assessment Report – Appendix D).

Both the Rewan and Fair Hill formations are of low permeability and therefore receive little direct recharge (these sediments tend to be dry when drilled, irrespective of the season, and it tends to be only the coal seams of the Rangal Coal Measures that contain water, albeit at low yields).

The Lake Vermont northern extension is not located within a defined groundwater recharge area (e.g. GAB intake beds or similar). Due to the conditions described above, and because the area where the Project will occur is not regarded as a significant groundwater recharge zone, any reduction in groundwater level due to mining could be expected to have limited impact on recharge rates.

2.2.8 Information Request

“Potential contribution to cumulative impacts in the project area.”

2.2.9 Response

To assess cumulative groundwater impacts, JBT Consulting used the following sources to identify existing projects that may combine with the proposed Project to impact groundwater resources:

- The Queensland Coordinated Projects Map (DSDIP 2014);
- Queensland's Mineral, Petroleum and Energy Operations and Resources map (State of Queensland 2012); and,
- Publicly available documentation (e.g. EIS documents that exist within the public domain).

Based on review of this documentation it was concluded that the projects with the potential to contribute to cumulative groundwater impacts include:

- The existing Lake Vermont operation, of which the proposed Lake Vermont Northern Extension Project will be an extension; and
- The existing Saraji Coal Mine, which is located approximately 6 km to the west of Lake Vermont

Cumulative impacts on Groundwater are discussed in the MNES Assessment Report section 3.11.3.3 – Potential Impacts on Groundwater.

At the end of mining, the 5 m drawdown extent was modelled to be approximately 2 km west of the Lake Vermont and Northern Extension pits. Based on the presence of similar geology, it is assumed that the 5 m drawdown extent resulting from the nearby Saraji Coal Mine extends over a similar distance. Consequently, given that the Saraji Mine is situated approximately 6 km from the closest extent of mining at the Project, coalescence of the two 5 m drawdown cones is not expected to occur at the end of mining.

At 100 years post mining, however, the 5 m drawdown contour is predicted to extend to approximately 4 km west of the pits. Assuming a similar drawdown extent for the Saraji Mine, there is potential for cones of groundwater drawdown to coalesce following the cessation of mining in the area between the

Saraji and Lake Vermont Mines. However, groundwater levels in the region are approximately 20 mbgl (i.e. 20 m below the level that would provide baseflow to existing alluvium or to the root zone of plants). Additional groundwater drawdown from the Project, occurring predominantly within the Permian coal strata, is therefore not considered likely to impact surface ecosystems.

In addition, groundwater bores in the region (of which there is a limited number) are predominately located in areas potentially impacted by either the existing Lake Vermont or Saraji Coal Mines. Consequently, groundwater drawdown caused by the Project is considered unlikely to contribute further impacts to groundwater users in the region.

2.3 WATER QUALITY OF A WATER RESOURCE

2.3.1 Issue

“In the referral, it was concluded that the proposed action is not expected to significantly affect quality of surface water or groundwater in the area. However, overflow of water from sediment dams may occur during inflows exceeding the sediment dam capacity (such as during or after significant rainfall events). The overflow will potentially have impacts to environmental values of the Isaac River if it occurs.

It was anticipated in the referral that aquifers surrounding the Project site are unlikely to be contaminated since the proposed action, with the existing Lake Vermont Coal Mine, will generate a cone of depression generating flow towards the mining pits. The long-term water levels in the voids would be below the regional groundwater levels and void water salinity will increase over time. However, water levels in the voids will fluctuate due to water input from groundwater inflow, rainfall and flooding. Some extreme weather events (e.g. heavy rain and flooding) may significantly increase the water levels in the voids. Therefore, the groundwater contamination could not be excluded because of the potential water exchange between the void and aquifers surrounding the Project site.”

2.3.2 Information Request

“Further information about potential impact to environmental values of the Isaac River if overflow occurs from sediment dams”

2.3.3 Response

The design of both the on-site Surface Water Management System, to ensure mine-affected water is not discharged through the stormwater system, and the sizing of the proposed and existing sediment dams ensures that the downstream impacts from these structures will not be significant.

As outlined in Section 4.10.6 of the Surface Water Impact Assessment (MNES Assessment Report – Appendix C) the proposed sediment dams will be designed and sized for a 1 in 10 year AEP, 24-hour duration design storm runoff volume and an additional 25% capacity for sediment storage. This design is in line with the Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland (Technical Guidelines) prepared by the former Department of Minerals and Energy (DME) in 1995 (the DME Guidelines) for the discharge of low toxicity waste. These design guidelines generally exceed the volumetric requirements for sediment basins sized in accordance with the International Erosion Control Association’s (IECA) Best Practice Erosion and Sediment Control Guidelines. The sediment dams have been sized for their maximum catchment area over mine life, for catchments that include disturbance.

As a result of this design, which aims to allow sediment to settle and reduce downstream loads, the only release from sediment dams would be during significant rainfall events. Given their relatively large capacity, the sediment dam overflows are likely to occur when there is widespread Isaac River rainfall. The Isaac River has a catchment area of 6195 km² immediately downstream of the Downs Creek confluence. The total catchment area of all sediment dams in the extended Project is 30 km², or less than 0.5% of the Isaac River catchment area – so significant dilution is likely.

Additionally, sediment dams have been located to only receive runoff from overburden dumps and undisturbed catchments. Water coming into contact with coal and rejects will be separated as detailed in the proposed SWMS. As outlined in Section 2.5.2 of the Surface Water Impact Assessment, non-mine-affected water in the existing sediment dams on the Lake Vermont site is generally of good quality:

- Stormwater dams' water quality is typically slightly to moderately alkaline, ranging from 7 to 9 pH units.
- Salinity levels are fresh and typically range between 200 and 500 µS/cm.
- Turbidity is typically excellent to fair (<30 NTU), with only occasional poor readings recorded.
- Sulphate levels are very low (<10 mg/L) in all Stormwater dams, with the exception of a high sulphate reading of 91 mg/L recorded in Sediment Dam 1.

2.3.4 Information Request

“Further data or information to support the assumption of water levels in the voids always below the regional groundwater levels”

2.3.5 Response

Section 6.3.1 of the Surface Water Impact Assessment (MNES Assessment Report – Appendix C) describes the long-term water level behaviour in the voids. In summary, due to the limited catchment area around each void, the input of surface water into the voids will essentially be limited to direct rainfall, and the voids will not fill to a level above surrounding groundwater.

As shown in Figure 3, modelling of water levels, based on groundwater inflows and surface water inputs (which will be minimal as the voids do not have a significant catchment beyond their own boundaries), indicates that long term water levels in the Central, North, B and East Pits would be expected to stabilise between 82m AHD and 101m AHD after approximately 120 years. For the Satellite Pit void, the level stabilises at a higher level – around 121m AHD after approximately 60 years.

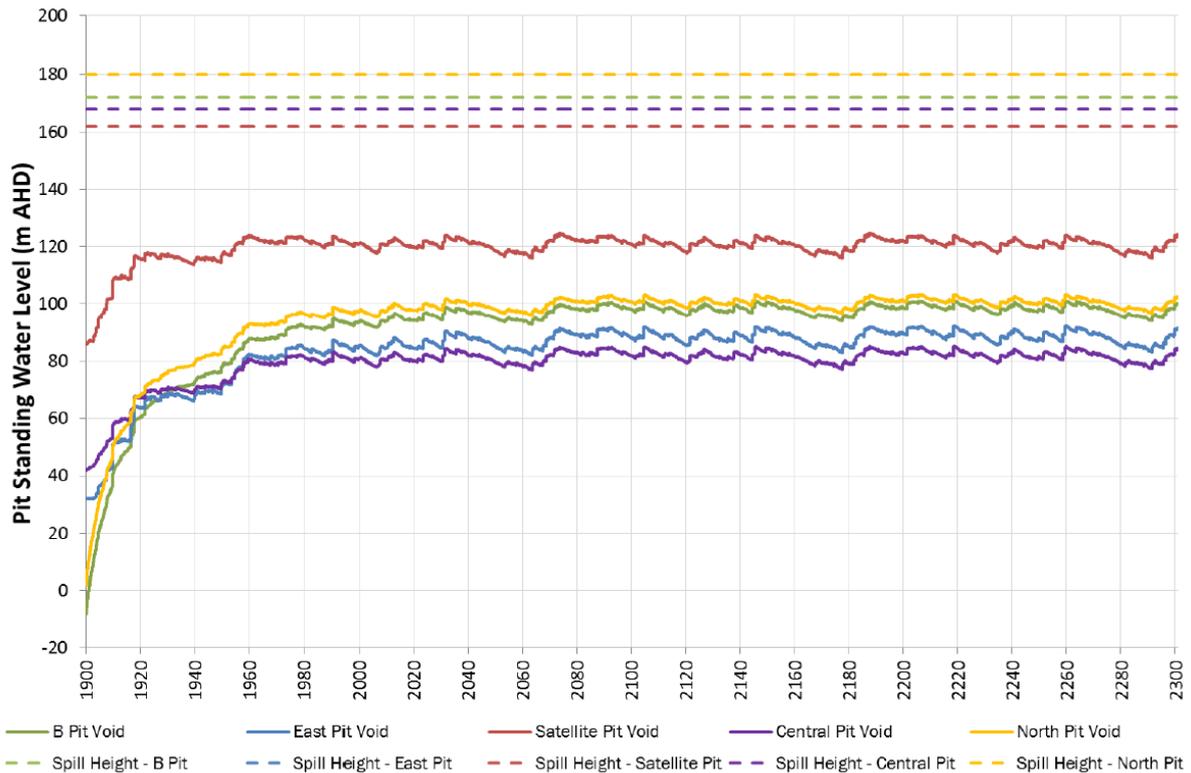


Figure 3 Simulated Final Void Storage Water Level

When compared to regional groundwater levels, it can be concluded that void water levels will remain below groundwater levels, leaving the pits to act as a sink. These comparisons are shown in Table 5 below:

Table 5 Predicted Void Water Levels

Final Void	Regional Groundwater Level (m AHD)	Modelled Long-Term Water Level (m AHD)
Central Pit	130	82
North Pit	138	101
B Pit	143	98
East Pit	140	88
Satellite Pit	146	121

2.3.6 Information Request

“Prediction of impacts on groundwater quality if water levels in the voids equal to or higher than the regional groundwater levels under some extreme weather events (e.g. heavy rain and flooding).”

2.3.7 Response

As demonstrated by the modelling described above, which used data including the extreme rainfall events of 2010-2011, void water levels are expected to remain below groundwater levels, even during extreme rainfall events.

Appendix A Surface Water Balance Modelling Report

Lake Vermont Mine Northern Extension Project

Surface water balance modelling for Lake Vermont wetland

Lake Vermont Resources

0622-19-A2, 9 November 2016

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NOTE: This report has been prepared on the assumption that all information, data and reports provided to us by our client, on behalf of our client, or by third parties (e.g. government agencies) is complete and accurate and on the basis that such other assumptions we have identified (whether or not those assumptions have been identified in this advice) are correct. You must inform us if any of the assumptions are not complete or accurate. We retain ownership of all copyright in this report. Except where you obtain our prior written consent, this report may only be used by our client for the purpose for which it has been provided by us.

Contents

1	Introduction	3
2	Lake Vermont wetland water storage behaviour	3
2.1	Observed water level behaviour	3
2.2	Aerial photographs and LiDAR data	3
2.3	Landsat satellite imagery	6
3	Water balance modelling	8
3.1	Methodology	8
3.2	Existing wetland behaviour	10
4	Impact assessment	12
4.1	Peak temporary impact at maximum mining extent	12
4.2	Permanent impact at completion of mining	14
5	Conclusions	17

List of Figures

Figure 2.1	- Lake Vermont wetland - aerial photo captured when empty in November 2003	4
Figure 2.2	- Lake Vermont wetland - aerial photo captured in June 2013	5
Figure 2.3	- Storage curves - Lake Vermont wetland	6
Figure 2.4	- Water Observations from Space data (source: Geoscience Australia)	7
Figure 3.1	- Lake Vermont wetland catchment	9
Figure 3.2	- Phillips Creek flood inundation at point of overtopping into Lake Vermont during flood of 250 m ³ /s.	10
Figure 3.3	- Modelled behaviour of wetland under existing conditions 2001-2016	11
Figure 3.4	- Modelled inundation frequency compared to WOfS analysis - 1987-2014	11
Figure 4.1	- Temporary loss of catchment area at maximum extent of mining disturbance	13
Figure 4.2	- Impact of temporary loss of catchment on frequency of inundation at Lake Vermont wetland	14
Figure 4.3	- Permanent loss of catchment area at completion of mining	15
Figure 4.4	- Impact of permanent loss of catchment on frequency of inundation at Lake Vermont wetland	16

1 Introduction

The Lake Vermont Mine Northern Extension Project (LVNEP) Surface Water Impact Assessment identified that during operations, runoff from parts of the catchments draining to the downstream environment will be intercepted in the expanded water management system.

As a result, there will be some additional short-term changes to downstream flows to the Lake Vermont wetland, an ephemeral lake located adjacent to Phillips Creek.

The maximum captured catchment areas during mining operations (all of which is due to the LVNEP) make up approximately 49 % of the Lake Vermont wetland catchment area.

The changed topography as a result of the project final landform will reduce the catchment draining to Lake Vermont wetland by 1.3 km² (compared to pre-mining conditions). This represents a reduction in catchment area of about 12 %.

This report has been prepared in response to a request from the Independent Expert Scientific Committee (IESC) for further information on the potential impacts of the LVNEP on the hydrology of the wetland.

The impacts of the LVNEP on the frequency of inundation of the Lake Vermont wetland were assessed using a water balance model of the surface water characteristics of the wetland.

2 Lake Vermont wetland water storage behaviour

2.1 OBSERVED WATER LEVEL BEHAVIOUR

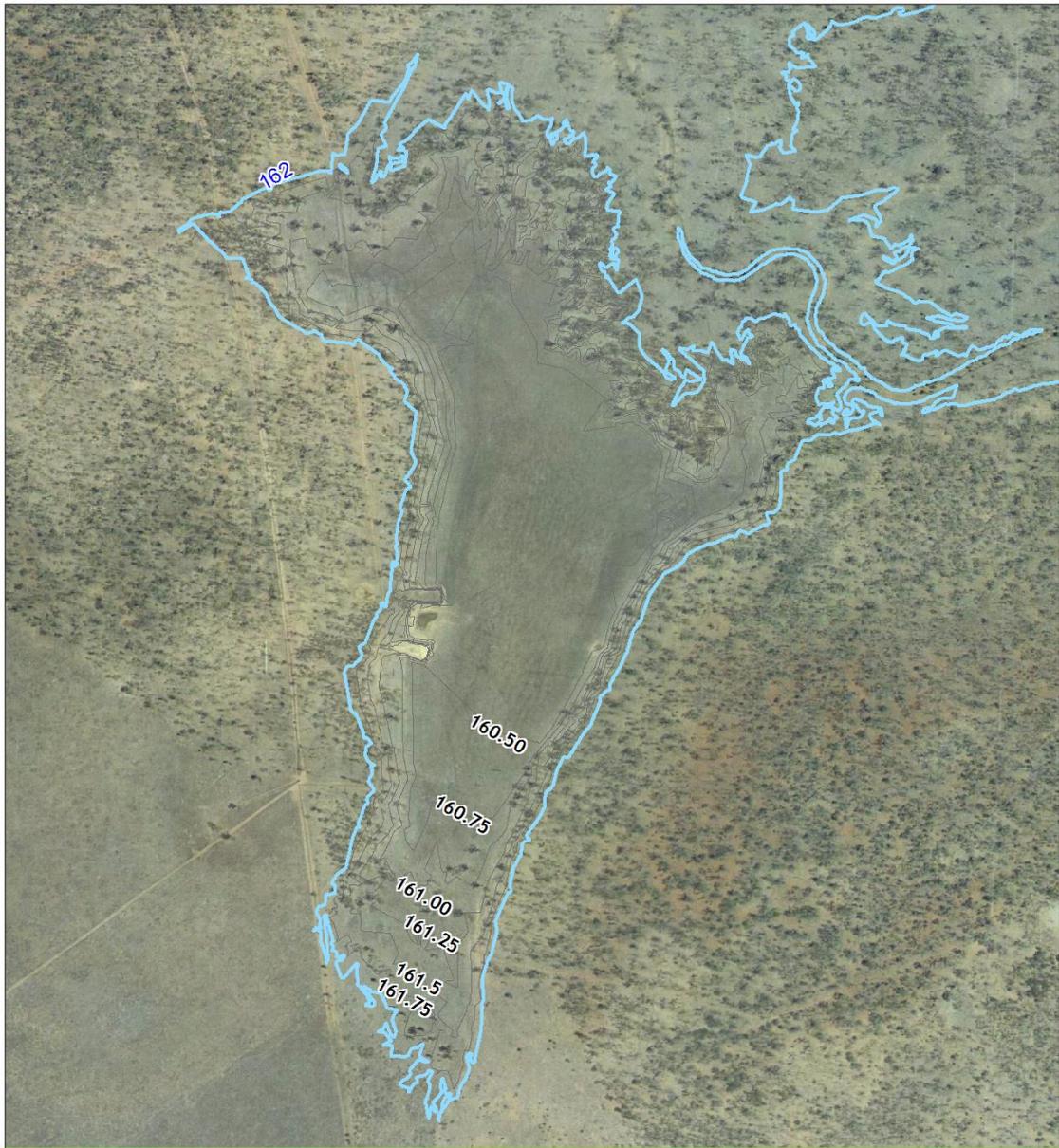
Anecdotally, the Lake Vermont wetland is reported to be highly ephemeral, rarely holding significant quantities of water.

As it was not anticipated that the Lake Vermont wetland would be affected by the originally proposed activities at the Lake Vermont Mine, water levels in the wetland have not been monitored as part of the Lake Vermont Mine surface water monitoring program.

In the absence of such data, aerial photographs and satellite imagery were used to infer the existing surface water behaviour in the Lake Vermont wetland.

2.2 AERIAL PHOTOGRAPHS AND LIDAR DATA

The aerial photographs in Figure 2.1 and Figure 2.2 show the wetland empty in November 2003, and with water a surface elevation at approximately 161 mAHD (maximum depth of approximately 0.9 m) in June 2013.



Projection: AMG Zone 55 Datum: AGD 84

Legend

-  Ground contour (0.25m interval)
-  Full storage level (162 mAHD)

Lake Vermont

Wetland aerial photo when empty (November 2003)

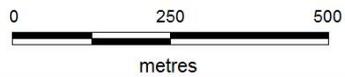
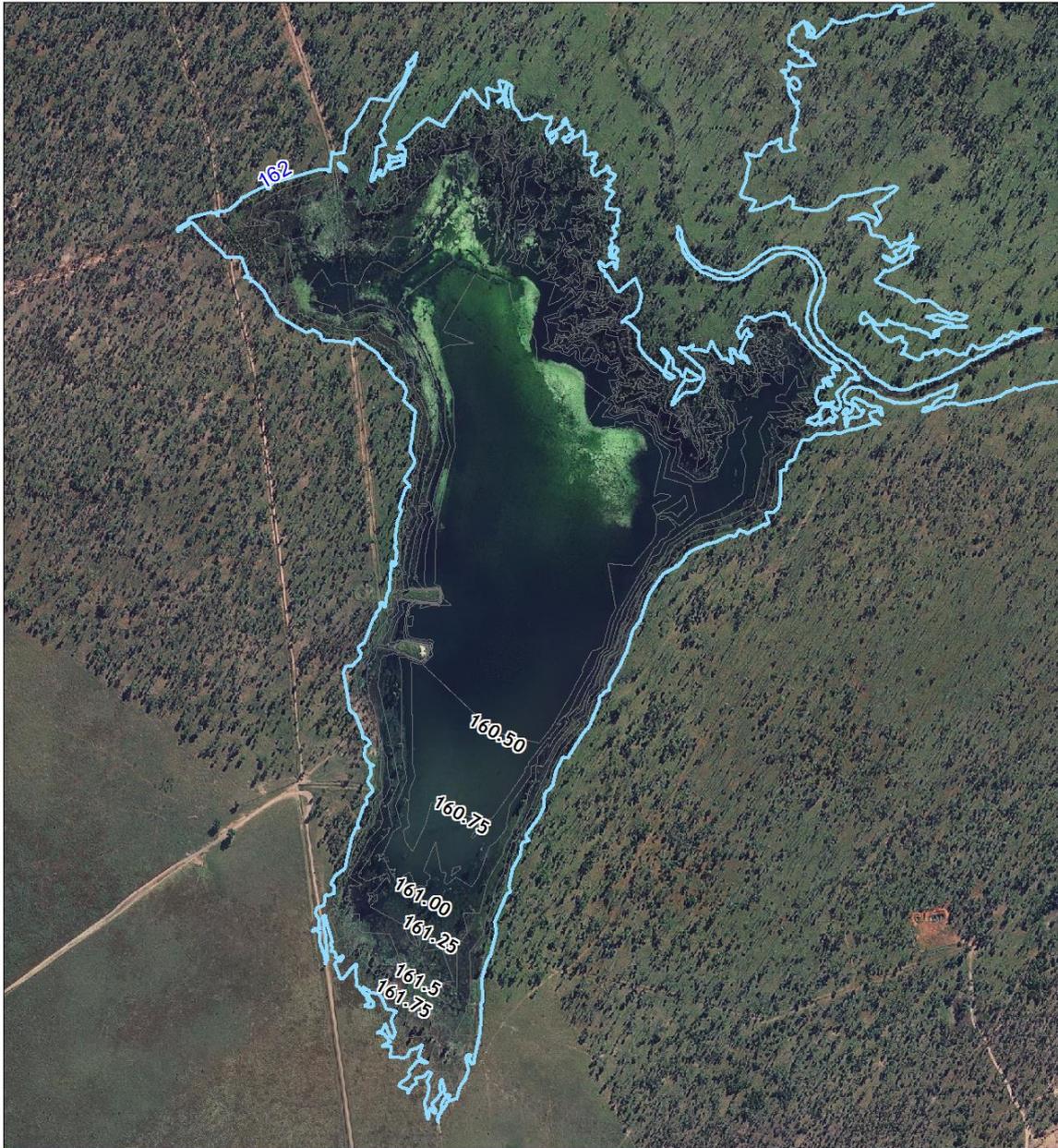


Figure 2.1 - Lake Vermont wetland - aerial photo captured when empty in November 2003



Projection: AMG Zone 55 Datum: AGD 84

- Legend**
- Ground contour (0.25m interval)
 - Full storage level (162 m AHD)

Lake Vermont

Wetland aerial photo (June 2013)

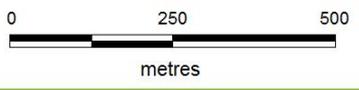


Figure 2.2 - Lake Vermont wetland - aerial photo captured in June 2013

The storage curve of the wetland (elevation vs area and stored volume) shown in Figure 2.3 was derived from LiDAR data obtained in July 2014, when the wetland was empty. The lake is relatively shallow. When full (water level at 162 m AHD), it is approximately 1.9 m deep at its deepest point, and has a surface area of 72.4 ha. The total storage capacity is approximately 690 ML.

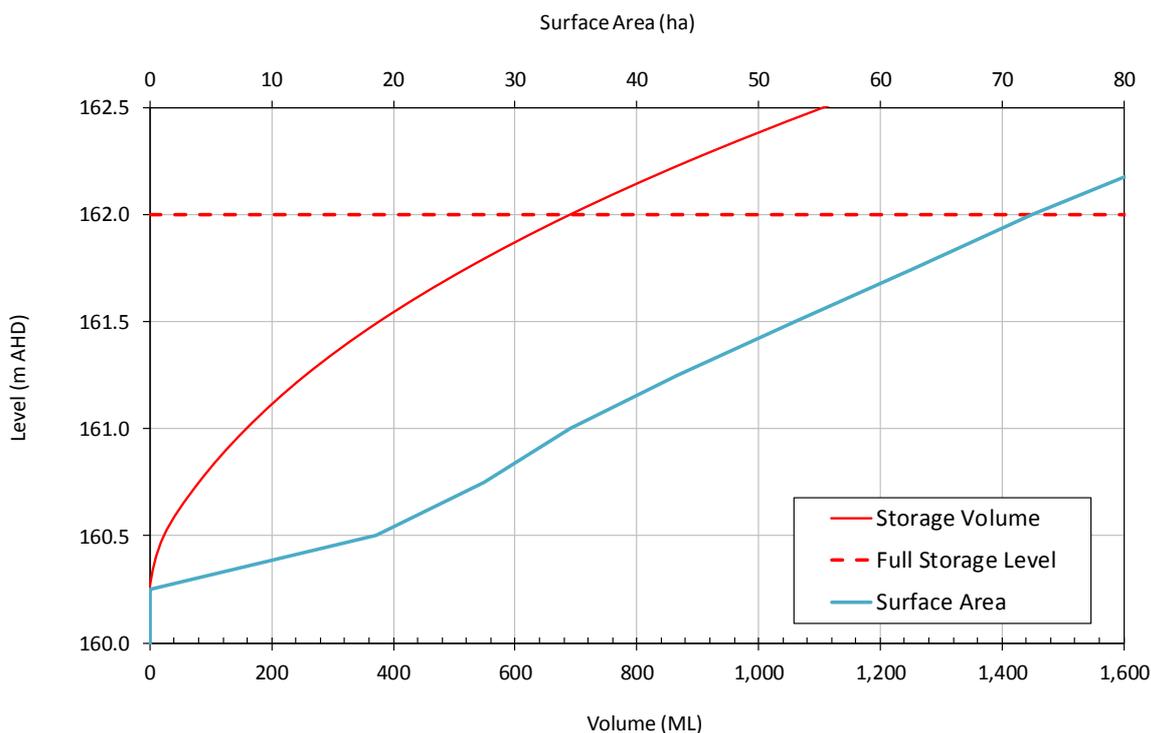


Figure 2.3 - Storage curves - Lake Vermont wetland

2.3 LANDSAT SATELLITE IMAGERY

Geoscience Australia’s Water Observations from Space (WOfS) service provides some information regarding the frequency of inundation at the wetland. The data is derived from Landsat-5 and Landsat-7 satellite imagery acquired over Australia between 1987 and 2014. The detection process is based on spectral analysis of each pixel in each Landsat scene. The water detection for a pixel through time is combined to produce a total number of water observations for each pixel. This is compared to a total number of clear observations for the same pixel. The ratio is expressed as a percentage water recurrence. Figure 2.4 shows the “Water Summary Filtered” output from the service for Lake Vermont wetland.

A height vs frequency curve was approximated from the data, by overlaying the available LiDAR data. The results indicate that over the period between 1987 and 2014 (which was a wetter than average period of time), water was observed in the centre of the wetland to an elevation of approximately 160.4 m AHD (0.15 m deep - and about 2% of full capacity) about 50% of the time. Elevations of 161.43 m AHD (about 50% full), were exceeded about 5% of the time.

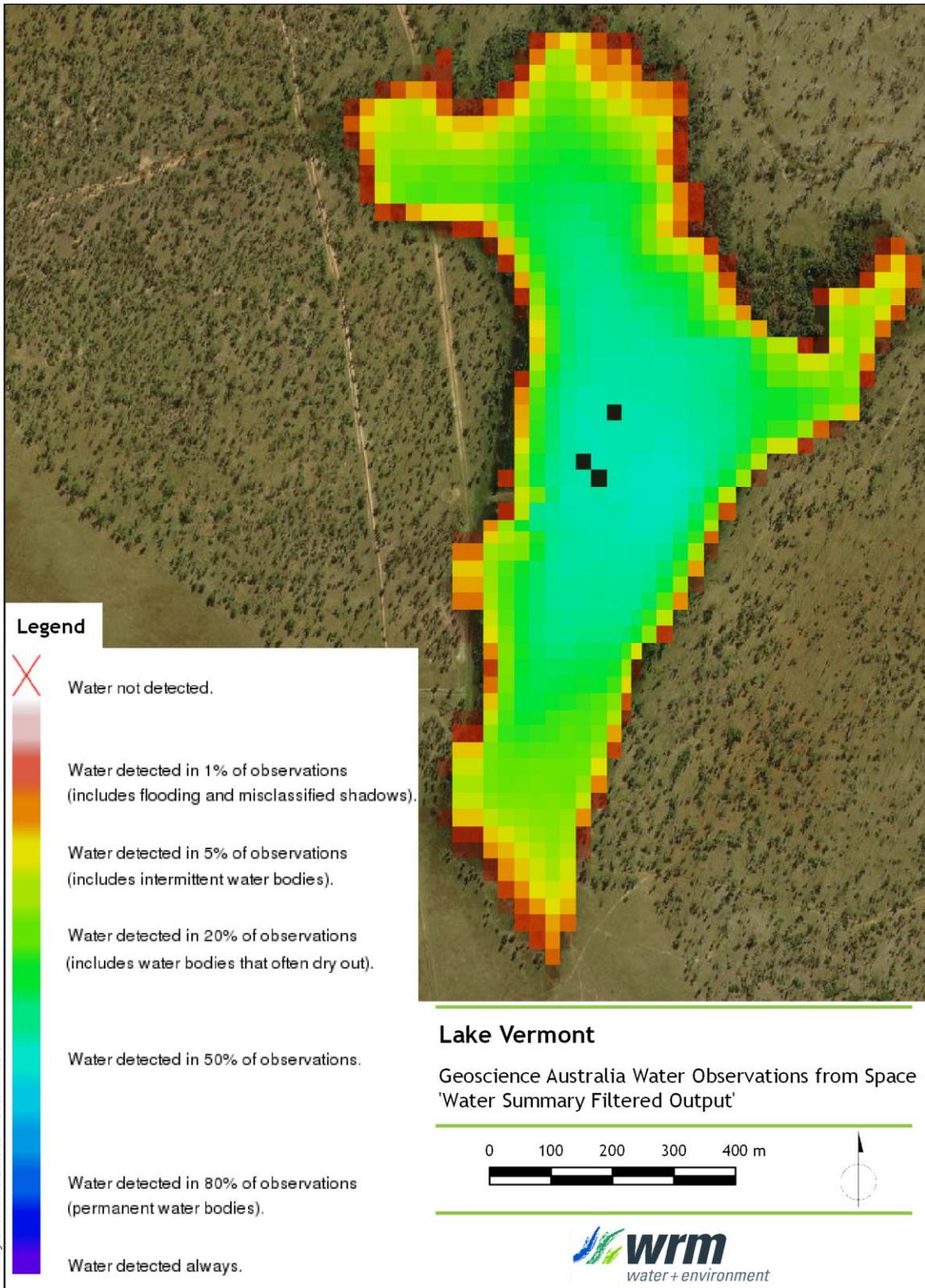


Figure 2.4 - Water Observations from Space data (source: Geoscience Australia)

3 Water balance modelling

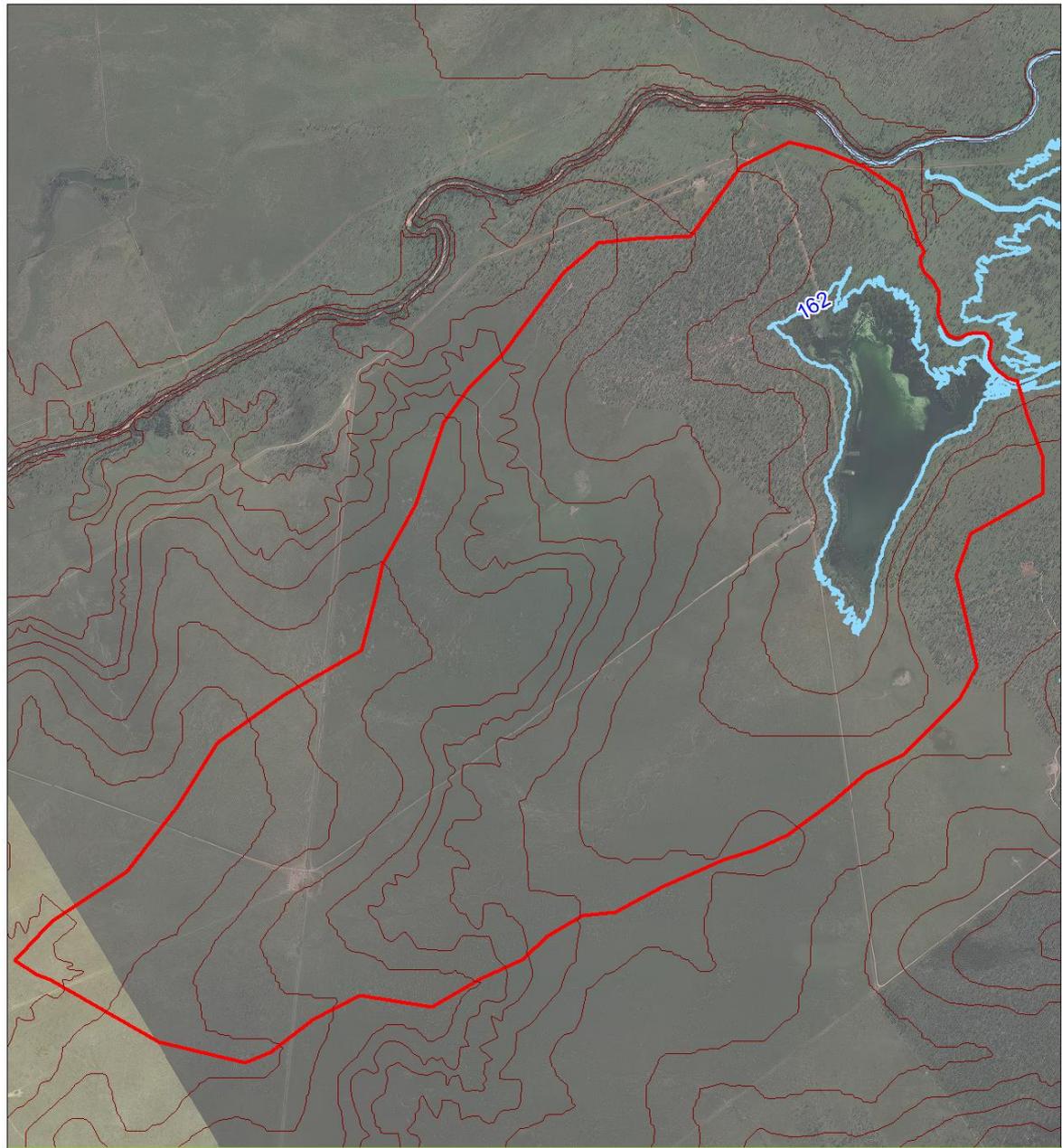
3.1 METHODOLOGY

A surface water balance model was prepared for the wetland and its catchment using the GoldSim software. The model comprises a single water storage, with the following processes simulated on a daily timestep using climate data from the Data Drill over the period 1889 to 2016:

- Surface runoff from the upstream catchment using the AWBM rainfall-runoff model. The AWBM model parameters were adopted from the site water balance model calibration;
- Evaporation from and direct rainfall to the water surface;
- Overflows from the wetland when its capacity is exceeded;
- Losses due to seepage and or water rural water use;
- Inflows due to flooding in Phillips Creek.

Groundwater inflows were assumed to be nil.

The surface water catchment to the Lake Vermont wetland is shown in Figure 3.1. The total existing catchment area to the wetland is 1,070 ha.



Projection: AMG Zone 55 Datum: AGD 84

- Legend**
- Ground contour (2m interval)
 - Full storage level (162 mAHd)
 - Existing catchment

Lake Vermont

Existing catchment to wetland

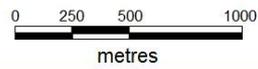


Figure 3.1 - Lake Vermont wetland catchment

Based on the results of the flood modelling for the project (shown in Figure 3.2) flood water could be expected to enter the wetland when the Phillips Creek flow rate exceeds approximately 250 m³/s, which is less than the 1 in 5 Annual Exceedance Probability peak flood flow. This implies the wetland could be expected to filled by Phillips Creek floodwater every 2 to 5 years.

The influence of flooding was modelled by directing an additional inflow sufficient to fill the storage every time the 3-day rainfall total exceed 180 mm. This resulted in modelled flood inflows occurring approximately 30 times over the 128 years of simulation (once every 4 years).

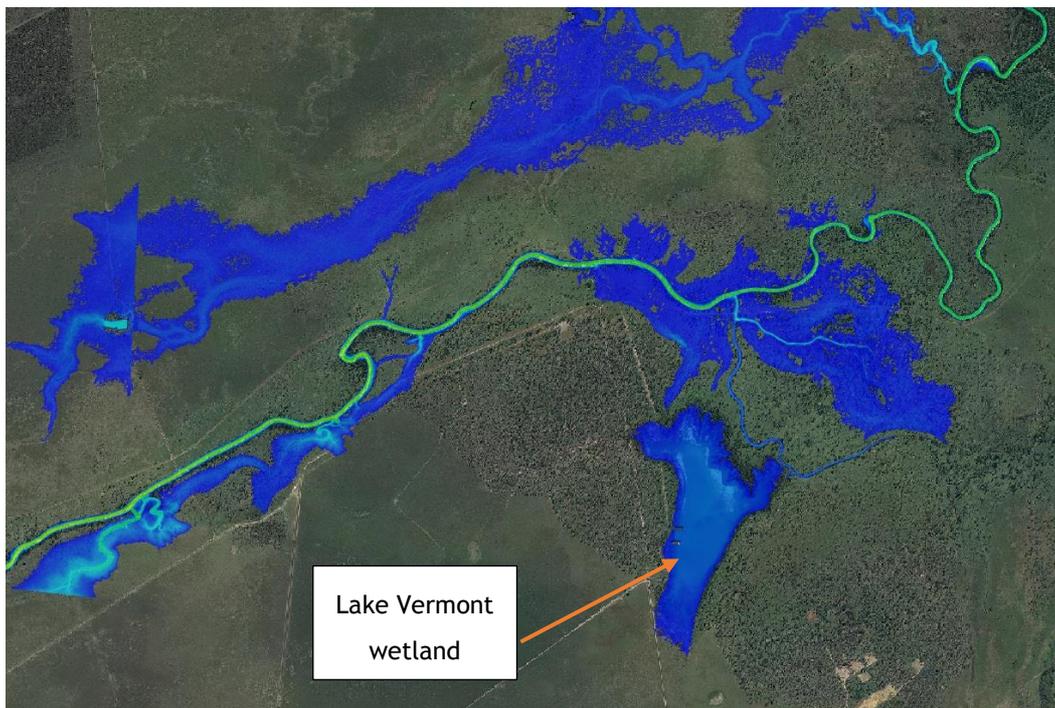


Figure 3.2 - Phillips Creek flood inundation at point of overtopping into Lake Vermont during flood of 250 m³/s.

3.2 EXISTING WETLAND BEHAVIOUR

The modelled behaviour of the existing wetland is illustrated in the following depth time series from the model. The results show occasional filling of the wetland, followed by a gradual reduction in water levels due to evaporation over dry periods. Figure 3.3 shows the model reproduces the recorded empty conditions in November 2003 and July 2014, and provides a good representation of the stored volume in June 2013. In the absence of rainfall, losses would typically empty the lake from full over a period of approximately seven months.

The results of the modelling for the period 1987 to 2014 are also presented in the frequency curve shown in Figure 3.4. Modelled loss rates were chosen to achieve a reasonable comparison with the frequency curve approximated from the WOfS data also shown in Figure 3.4. To achieve this, the storage pan factor was increased to 1.2, and a loss rate of 1.4 ML/d was applied when stored water volumes exceeded 150 ML.

The results suggest the wetland would be expected to hold water to a depth exceeding 0.5 m (i.e. at about 3.2% of the total storage capacity) about 50% of the time. Stored water volumes would be at less than 25% capacity 80% of the time. The figure also illustrates the influence of including estimated flood inflows on the frequency of inundation.

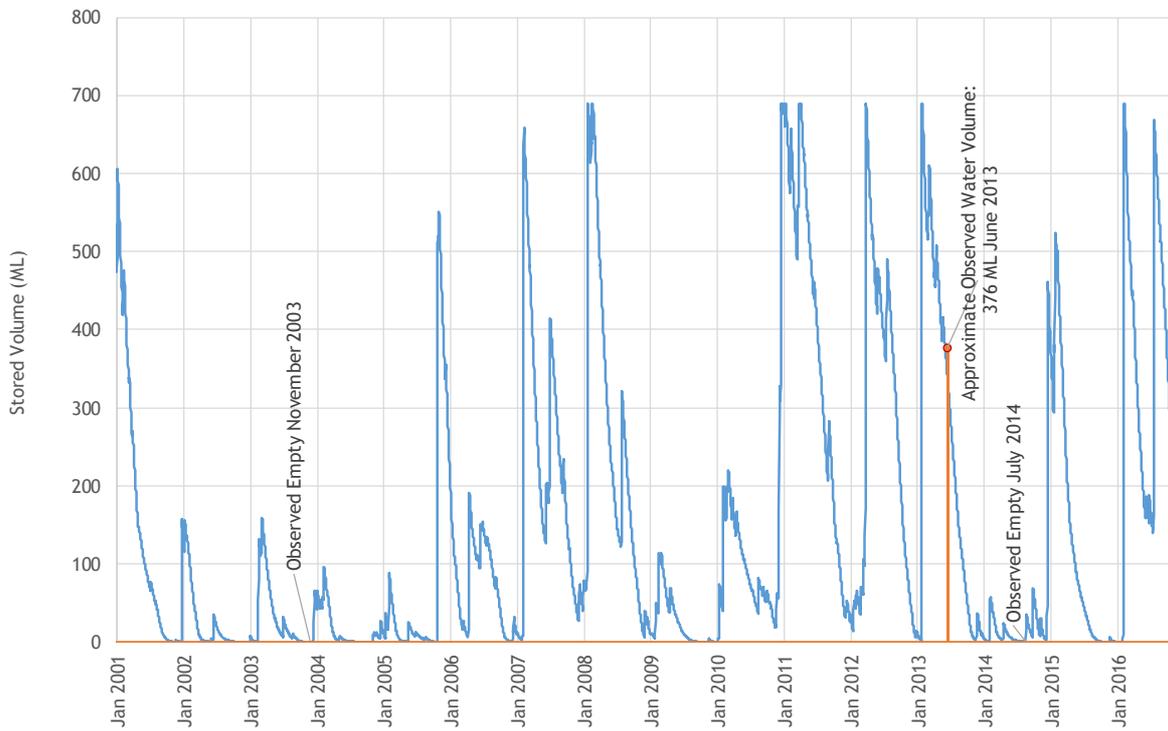


Figure 3.3 - Modelled behaviour of wetland under existing conditions 2001-2016

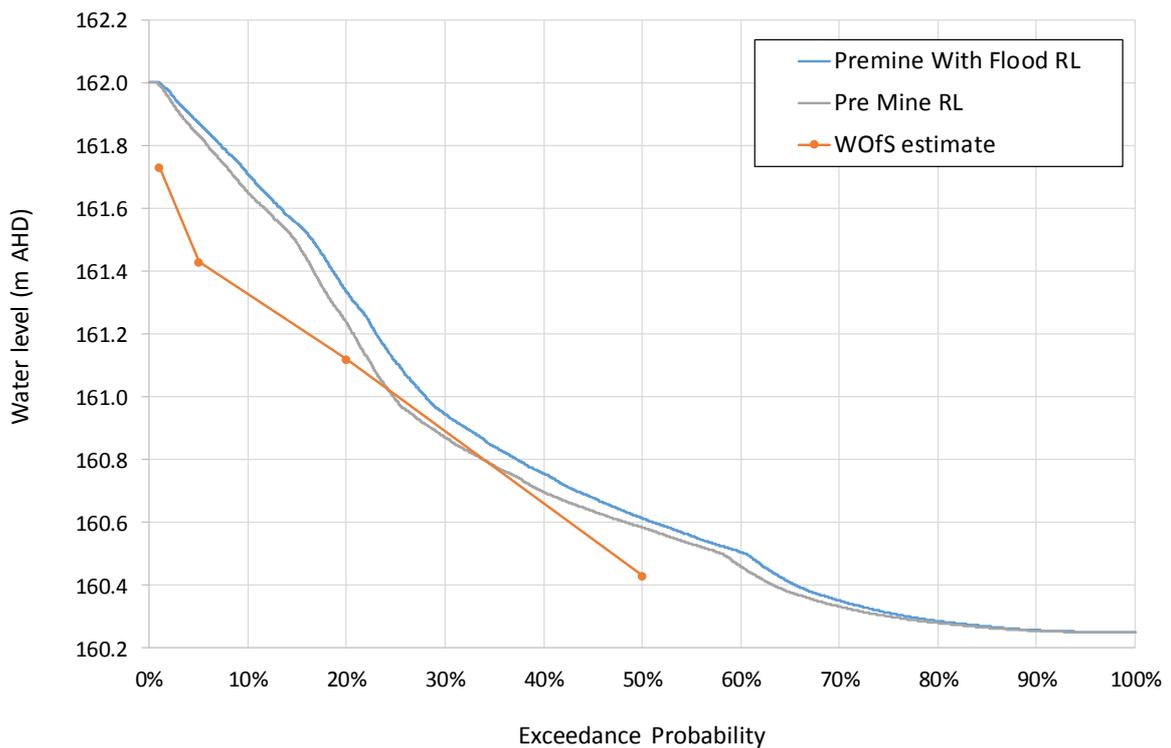


Figure 3.4 - Modelled inundation frequency compared to WOfS analysis - 1987-2014

4 Impact assessment

The LVNEP will result in the capture of runoff from areas that currently flow to Lake Vermont wetland. There will be a temporary impact due to disturbed area runoff being captured in the site water management system, and a smaller permanent impact at the end of mining due to water being captured in the final void.

The model was used to assess the impact of both these changes on the expected frequency of inundation in the wetland by reducing the catchment in the Lake Vermont wetland water balance model.

4.1 PEAK TEMPORARY IMPACT AT MAXIMUM MINING EXTENT

At the peak extent of mining, the catchment area to the wetland will be temporarily reduced by approximately 5.2 km² or 49%. This is illustrated in Figure 4.1.

The impact of this change on the frequency of filling the Lake Vermont wetland is illustrated in Figure 4.2 which shows that the likelihood of stored water levels exceeding 160.4 mAHD (approximately 0.15 m deep - i.e. at about 2 % of the total storage capacity) would temporarily decrease from approximately 60% to 42%. The likelihood of exceeding an elevation of 161.4 mAHD (1.15 m deep - i.e. at about 47 % of the total storage capacity) would reduce from approximately 12% to 8%.

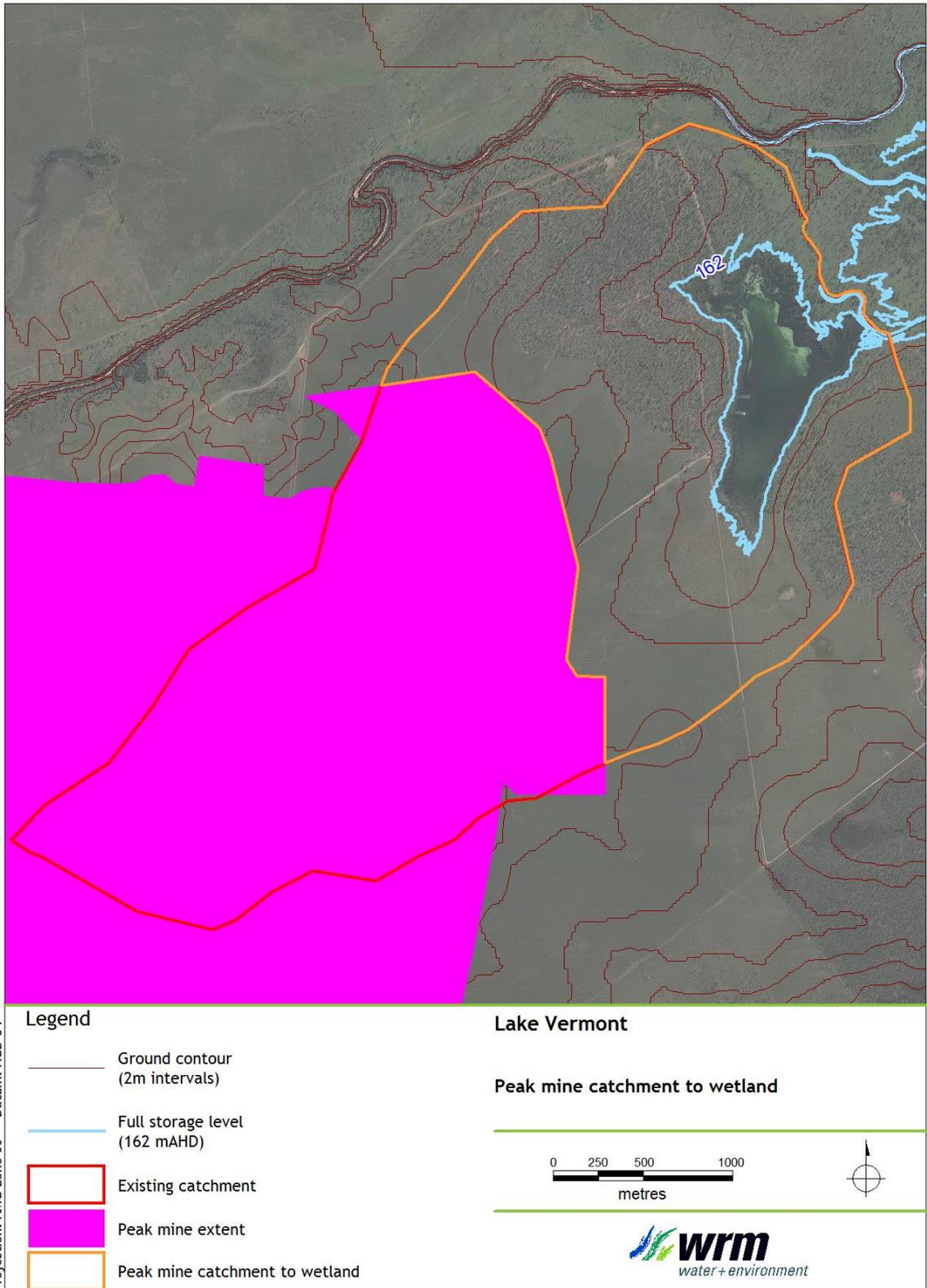


Figure 4.1 - Temporary loss of catchment area at maximum extent of mining disturbance

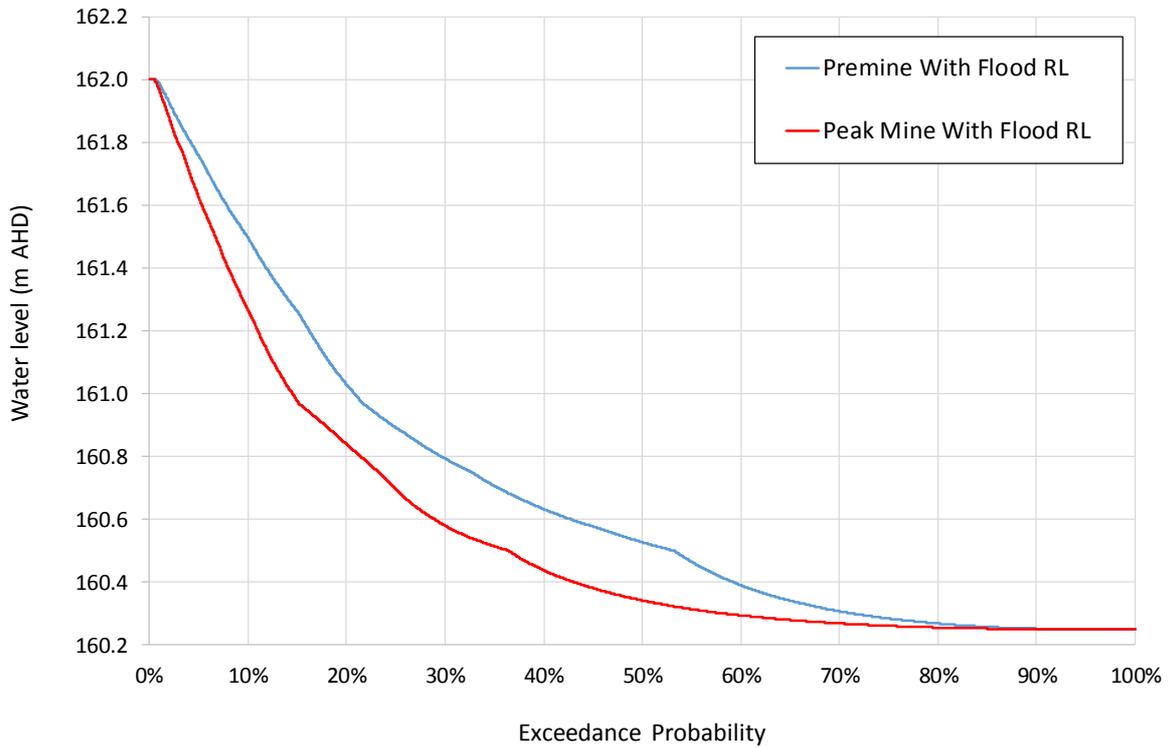
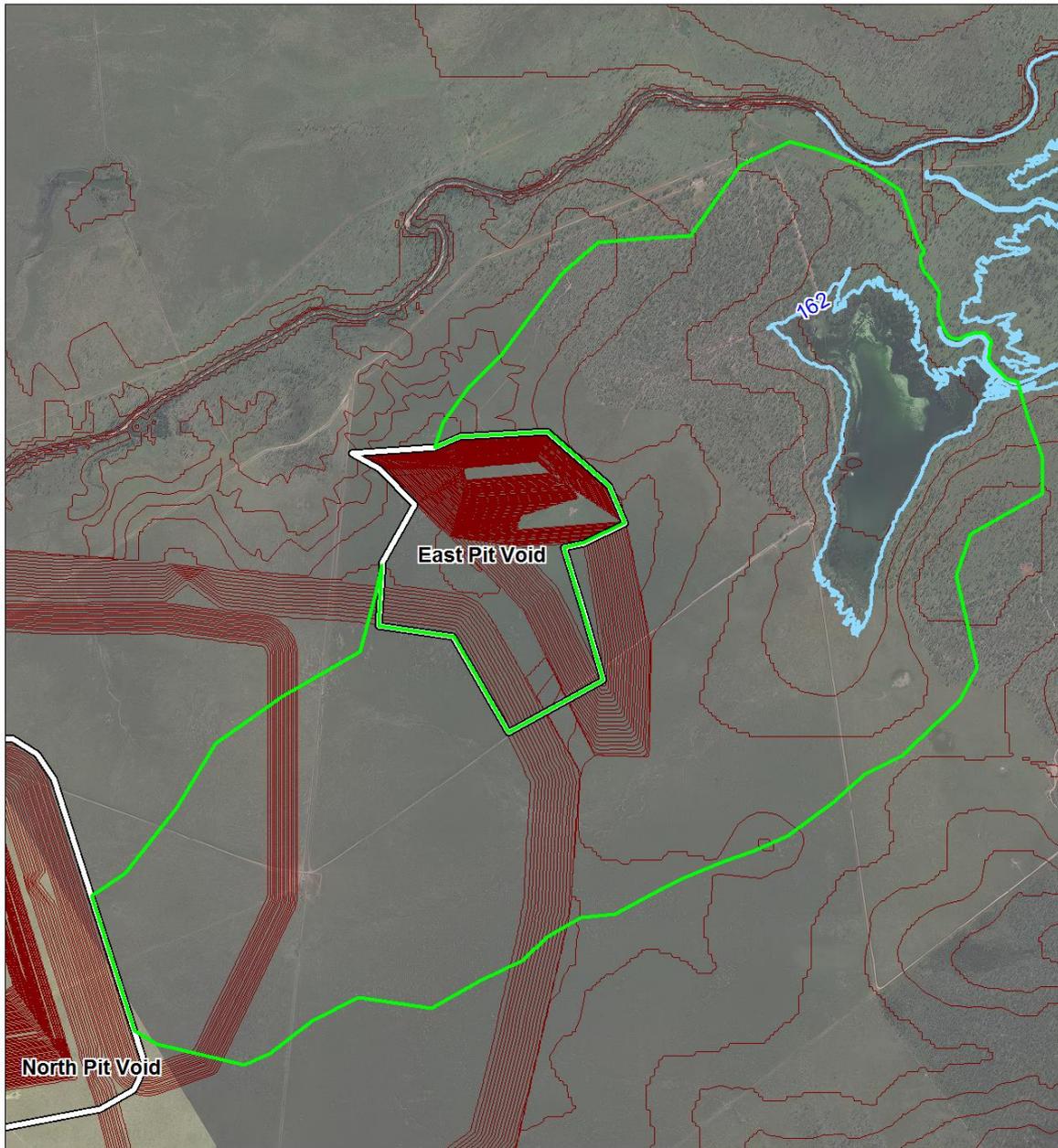


Figure 4.2 - Impact of temporary loss of catchment on frequency of inundation at Lake Vermont wetland

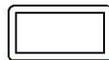
4.2 PERMANENT IMPACT AT COMPLETION OF MINING

At the completion of mining, surface runoff from rehabilitated overburden emplacement areas will be released from the site. It has been assumed that permanent drainage of overburden emplacement areas will be installed to minimise capture of surface runoff in the final void. An area of approximately 3.3 km² will continue to drain to the final voids. The catchment draining to Lake Vermont wetland will reduce by 1.3 km² (compared to pre-mining conditions) or about 12 %. This is illustrated in Figure 4.3.



Projection: AMG Zone 55 Datum: AGD 84

Legend

-  Ground contour (2m interval)
-  Full storage level (162 mAHd)
-  Mine final void catchment
-  Post mine catchment

Lake Vermont

Post mine catchment to wetland

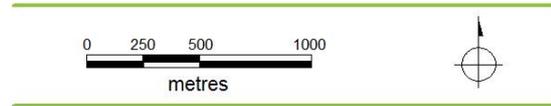


Figure 4.3 - Permanent loss of catchment area at completion of mining

The long-term impact of this change on the frequency of filling the Lake Vermont wetland is illustrated in Figure 4.4, which shows that the likelihood of stored water levels exceeding 160.4 mAHD (approximately 0.15 m deep - i.e. at about 2 % of the total storage capacity) would decrease from approximately 60 % to 55 %. The likelihood of exceeding an elevation of 161.4 mAHD (1.15 m deep - i.e. at about 47 % of the total storage capacity) would reduce from approximately 12 % to 11 %.

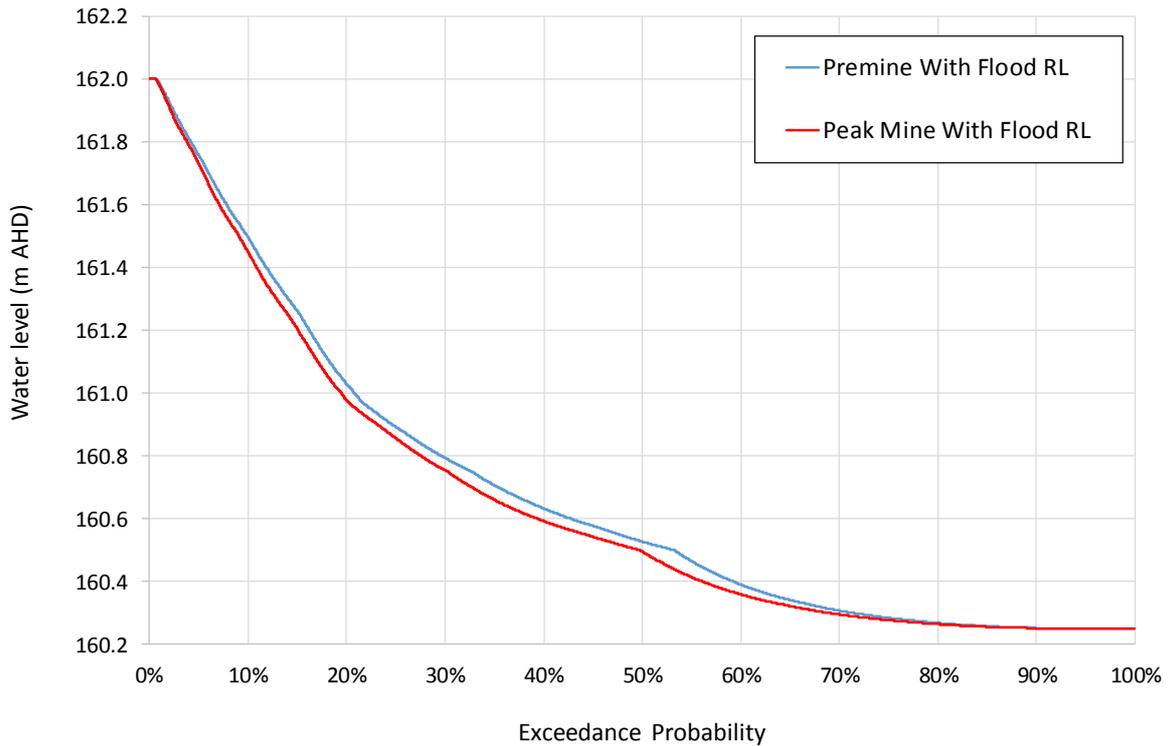


Figure 4.4 - Impact of permanent loss of catchment on frequency of inundation at Lake Vermont wetland

5 Conclusions

The Lake Vermont Mine Northern Extension Project Surface Water Impact Assessment identified that during operations, runoff from parts of the catchment draining to the downstream environment will be intercepted in the expanded water management system.

As a result, there will be some additional short-term changes to downstream flows to the Lake Vermont wetland. The maximum captured catchment area during mining operations make up approximately 49 % of the Lake Vermont wetland catchment area.

The changed topography as a result of the project final landform will reduce the catchment draining to Lake Vermont wetland by 1.3 km² (compared to pre-mining conditions). This represents a reduction in catchment area of about 12 %.

The impacts of these proposed changes on the frequency of inundation of the Lake Vermont wetland were assessed using a water balance model of the surface water characteristics of the wetland.

In the absence of water monitoring data for the wetland, the modelling parameters derived for undisturbed catchments within the site operational water balance model were adopted for the analysis. Additional losses were applied so that the results were consistent with observations of inundation based on satellite monitoring and aerial photographs, which show that the wetland is ephemeral, and generally contains only small volumes of water. The modelling suggests the wetland would be expected to hold water to a depth exceeding 0.5 m (i.e. at about 3.2% of the total storage capacity) about 50% of the time. For about 80% of the time, stored water volumes would be at less than 25% capacity.

Flood inflows from Phillips Creek were assumed to fill the storage following prolonged heavy rainfall at a frequency of about once every 4 years, which is consistent with the results of previous flood modelling of Phillips Creek. This has the effect of mitigating the impacts of the loss of local surface water catchment. The results of the impact assessment summarised in Table 5.1 show that:

- During the period of maximum disturbance, the likelihood of wetland water levels exceeding 160.4 mAHD (approximately 0.15 m deep - i.e. at about 2 % of the total storage capacity) would temporarily decrease from approximately 60 % to 42 %. The likelihood of exceeding an elevation of 161.4 mAHD (1.15 m deep- i.e. at about 47 % of the total storage capacity) would reduce from approximately 12 % to 8 %.
- The long-term impact on the frequency of filling the Lake Vermont wetland is relatively small. The likelihood of stored water levels exceeding 160.4 mAHD (approximately 0.15 m deep - i.e. at about 2 % of the total storage capacity) would decrease from approximately 60 % to 55 %. The likelihood of exceeding an elevation of 161.4 mAHD (1.15 m deep - i.e. at about 47 % of the total storage capacity) would reduce from approximately 12 % to 11 %.

Table 5.1 - Water balance model results - frequency of filling Lake Vermont wetland

Development stage	Catchment Area km ²	Frequency of exceeding water level (% of days)	
		160.4 mAHD 2% full	161.4 mAHD 47% full
Existing	10.7	60	12
Peak mining disturbance (temporary)	5.5	42	8
Post mining (permanent)	9.4	55	11