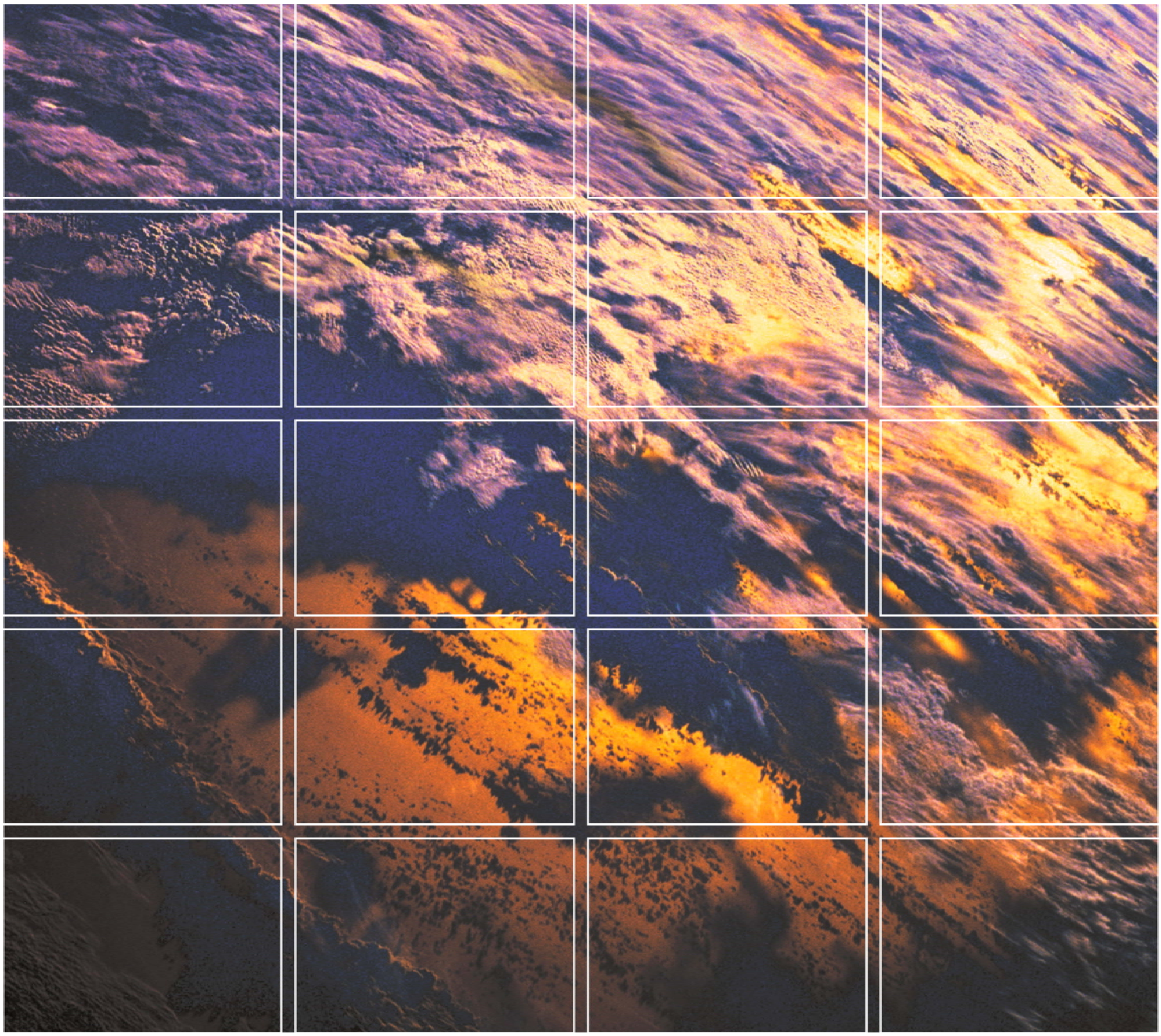

Volume 2
NRE No. 1 Colliery Preliminary Works

Annexures

Gujarat NRE Coking Coal Limited

October 2010

0079383RP01 Preliminary Works EA Final

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ERM

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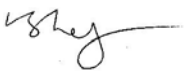
Signed:	
Date:	*1 October, 2010*

Environmental Resources Management Australia Pty Ltd Quality System

This report was prepared in accordance with the scope of services set out in the contract between Environmental Resources Management Australia Pty Ltd ABN 12 002 773 248 (ERM) and the Client. To the best of our knowledge, the proposal presented herein accurately reflects the Client's intentions when the report was printed. However, the application of conditions of approval or impacts of unanticipated future events could modify the outcomes described in this document. In preparing the report, ERM used data, surveys, analyses, designs, plans and other information provided by the individuals and organisations referenced herein. While checks were undertaken to ensure that such materials were the correct and current versions of the materials provided, except as otherwise stated, ERM did not independently verify the accuracy or completeness of these information sources

Annex A

Water Management Report
No.1 Colliery, Russell Vale

Report

Water Management Report
No. 1 Colliery, Russell Vale

Prepared for Gujarat NRE Coking Coal Limited (NRE) (Client)

By Beca Pty Ltd (Beca)
ABN: 85 004 974 341

13 September 2010

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This report has been prepared by Beca on the specific instructions of our Client. It is solely for our Client's use for the purpose for which it is intended in accordance with the agreed scope of work. Any use or reliance by any person contrary to the above, to which Beca has not given its prior written consent, is at that person's own risk.

Revision History

Revision Nº	Prepared By	Description	Date
A	Dianne Thomas	For use in 3 A approval submission	7th May 2010
B	Dianne Thomas	Incorporating ERM requested changes	22nd May 2010
C	Dianne Thomas	Address DoP comments	12th September 2010

Document Acceptance

Action	Name	Signed	Date
Prepared by	Dianne Thomas & Paul Irwin		09.09.10
Reviewed by	Dianne Thomas		12.09.10
Approved by	NRE		13.09.10
on behalf of	Beca Pty Ltd		

In preparing this report, Beca has relied upon and presumed accurate information relative to the Russell Vale site, Shaft # 4 site and surrounding areas provided by Gujarat NRE and others identified herein. Except as otherwise stated in the report, Beca has not attempted to verify the accuracy or completeness of any such information.

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1 Purpose

The purpose of this report is to provide water management information for the operation of the Gujarat NRE Coking Coal Limited (NRE), No1 Colliery at Russell Vale for inclusion in and submission of the Environmental Assessment report under Part 3A of the EP&A Act over the next 3 years. The water supply, water management on site and discharge will not change from the current operation under this part 3A application. The water management after coal production is increased will be described in a separate Part 3A application.

This report outlines and assesses the following:

- Water management at the Russell Vale and No. 4 Shaft sites now and for the next 3 years under current coal production of up to 1 Mtpa. The current water management that exists on site under the existing EPL will not change.
- Water balance for the Russell Vale site:- There will be no significant changes in water volumes expected, therefore, no changes to the current operation under the existing EPL. .
- Collection and treatment of mine water:- This will not change from the existing operation. Water quality produced under the current coal production rates is expected to continue to meet current EPL requirements.
- Collection and treatment of dirty storm water:- Collection of storm water will continue as it currently does and there's expected to be no significant change to dirty storm water catchment areas.
- Clean storm water management:- There are significant beneficial changes proposed to manage clean stormwater by 1) reducing the probability of pipe blockages in the clean storm water system; 2) maximising the capture/flow of clean storm water; 3) reducing greatly the inflow of dirty storm water to the clean storm water collection.
- Quantity and quality of water discharged to Bellambi Gully is not expected to change from current operations and EPL requirements under this Part 3A application.
- Assesses the impact of the water discharged to Bellambi Gully considering receiving water quality
- Potential management measures to reduce environmental impact
- Conclusions

2 Current NRE Operations

2.1 Operating Environment

The Russell Vale mine is approximately 8 km north of Wollongong CBD and 70 km south of Sydney, within the local government areas (LGAs) of Wollongong and Wollondilly in the Illawarra region of NSW.

The site includes the Illawarra Escarpment. The escarpment reaches up to 400m elevation and slopes steeply down to the foothills at approximately 30m. The steep slopes of the escarpment are heavily vegetated.

The Russell Vale site is located on the lower slopes and foothills of the escarpment at approximately 140m elevation. The Russell Vale site is bounded by the Princes Highway to the

east, with residential areas of Russell Vale and Corrimal to the north and south respectively and the Woronora Plateau to the west. The Russell Vale golf course also bounds the site to the north.

The underground lease area lies under the Woronora Plateau west of the escarpment. The surface land of the plateau is covered by native bush land and Cataract Dam, with perennial creeks, ephemeral tributary streams and upland headwater swamps.

In addition to the Russell Vale site, NRE has surface leases at one access shaft (No.4 Shaft) and four ventilation shaft sites (No. 1, 2, 3 and 5 Shafts) across the mine operations.

(Note: this section was extracted and edited from ERM report.)

2.2 Water Management at Russell Vale

The current water management system implemented at No. 1 Colliery site at Russell Vale consists of the following components which are described in more detail:

- Potable water supply and use
- Process water supply
- Process water use
- Stormwater
- Licensed discharge

2.2.1 Potable Water Supply and Use

Potable water supply for surface infrastructure is supplied by Sydney Water and is generally not used for mining operations. Although not frequently used, there is provision to supply emergency make-up quantities from the potable water tank (Brick Tank) to the mine water supply system (into the plastic tank). Black and grey water is discharged to the Sydney Water sewerage system. See **Figure 1** below for details.

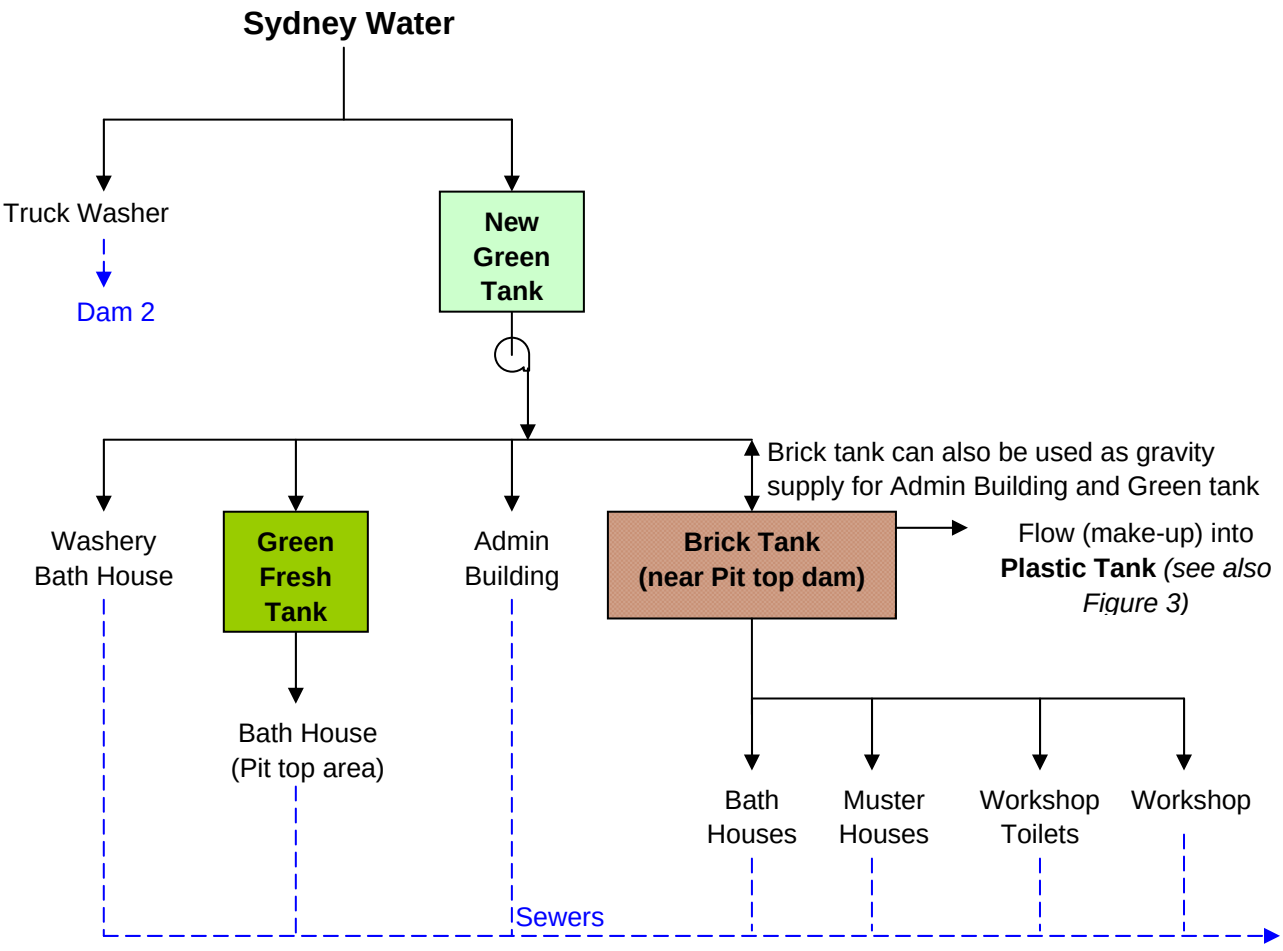


Figure 1 - Schematic of the current potable water supply for NRE No. 1 Colliery
(blue dotted lines indicate discharge.

The potable water supply and potable water use on the site will not change significantly from the current operation.

2.2.2 Process Water Supply

Process water is a combination of:

- Clean raw water from Corrimal Springs,
- Potable water from the Brick Tank (generally not used),
- Treated mine water from the Thickener Tank overflow, and
- Mine dewatering water from No. 4 shaft

A natural spring outflows to the surface on NRE's site which is controlled by directing this water flow to the concrete tank for use on site. The flow is approximately 0.1ML/day. This particular arrangement is believed to have been in place in excess of 50 years.

Figure 2 shows the supply sources for process water.

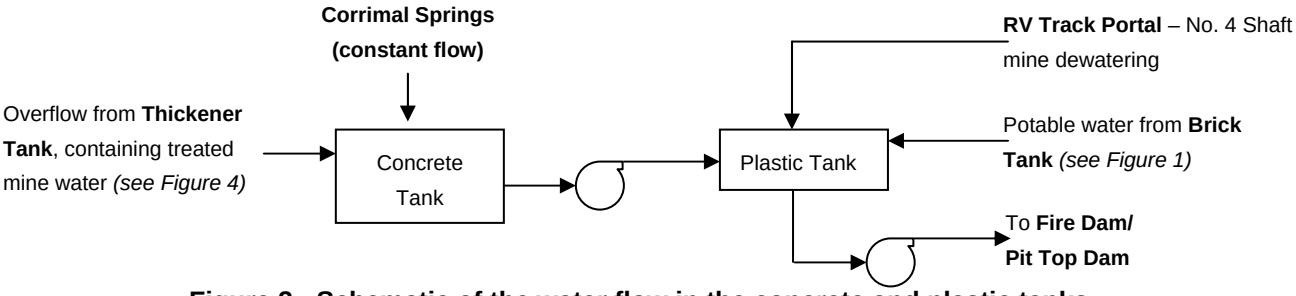


Figure 2 - Schematic of the water flow in the concrete and plastic tanks
(Mine water from the RV Track Portal is transferred when the storage dams at the No. 4 shaft have reached full capacity).

2.2.3 Process Water use

Process water is used to supply underground mine workings, fire water, truck filling points for site dust suppression, wash-down and on the stock piles. **Figure 3** shows the use of process water on site.

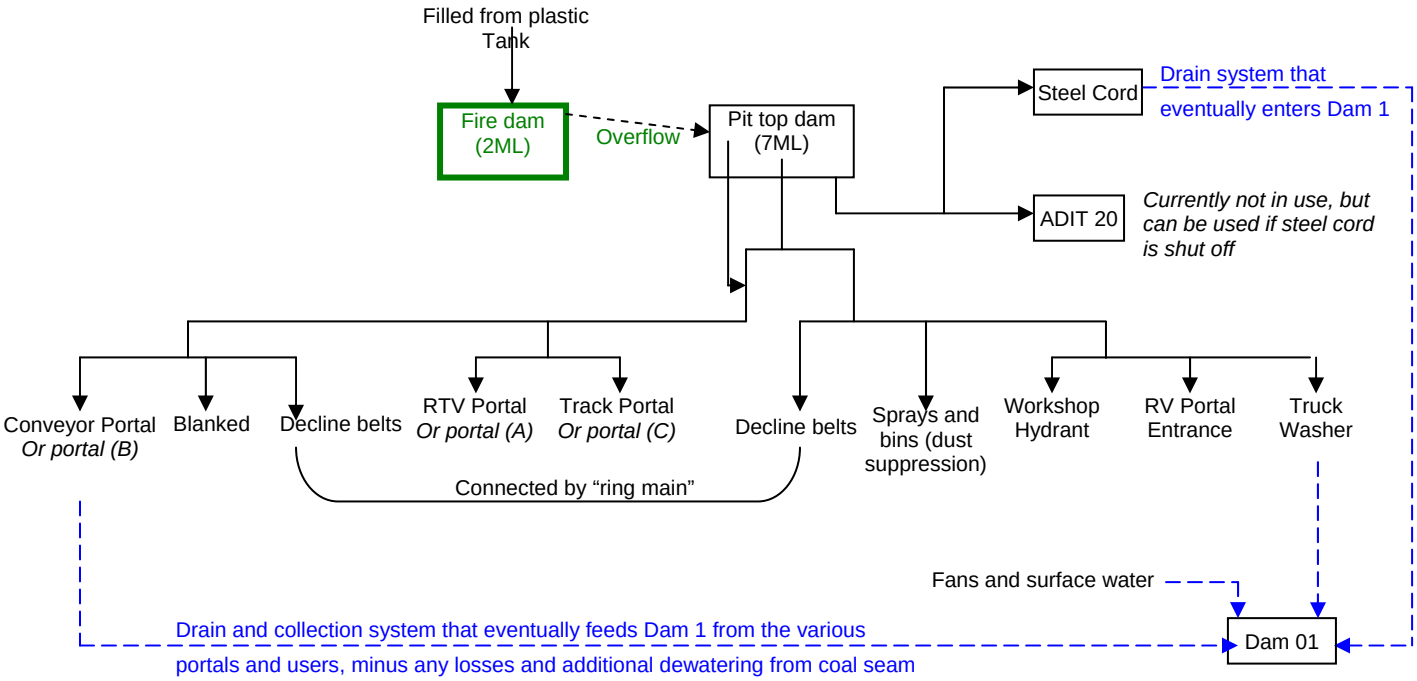


Figure 3 - Schematic of the current process water supply for NRE No. 1 Colliery *(The black dotted lines denote overflow, and the blue dotted lines denotes 'un-processed' water, which can include used process water and water from the coal seams). Portals refer to mine entrances.*

The truck washer uses a combination of potable and process water to wash the trucks.

Collected water from mining operations (dewatering at the Russell Vale site) together with water collected from drains in the processing areas flows to Dams 1 and 2 and then to the Storm Water Control Dam (SWCD), see **Figure 4**. From the SWCD water is treated and reused where possible. Any surplus water is then discharged via the licensed discharge points LDP2 and LDP3 (Environmental Protection Licence -EPL 12040) according to licence terms.

The current process water supply and use will not change under current coal production covered under this Part 3A application.

2.2.4 Dirty Stormwater

The SWCD has a capacity of 62ML and contains dirty water from the following sources:

- Runoff from unsealed surfaces
- Roadside water runoff from the Highway dam
- Mine dewatering water and dirty storm water from Dams 1 and 2, and
- First flush system (is the system that manages any sediment from the hardstand area immediately in front of the portals).

Figure 4 shows stormwater management on site.

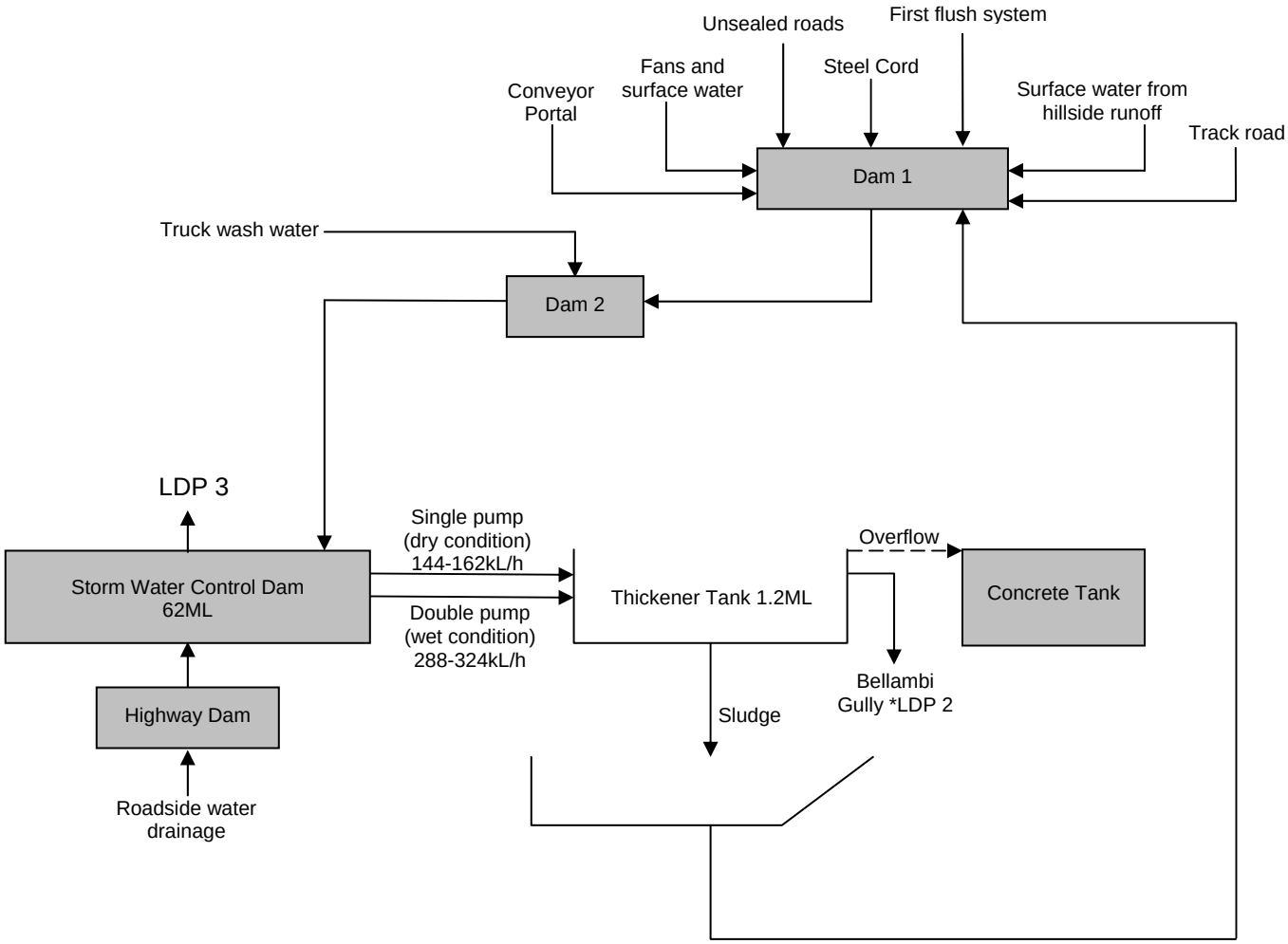


Figure 4 - Schematic of the current water flow of the various dams and treatment processes for NRE No. 1 Colliery

Overflow from the thickener tank is reused as process water, with any excess discharged to Bellambi Gully.

**Maximum discharge limit under dry weather conditions is up to 2.5ML/d; discharge limit exceeding 2.5ML/d is only applicable for the next 72 hours under wet weather conditions.*

Water from the Storm Water Control Dam is pumped to the Thickener Tank from where it flows either to:

- The concrete tank to be pumped via the plastic tank to the Fire and Pit Top Dams for use as fire and process water
- It is discharged to the licensed discharge point (LDP2) into Bellambi Gully (2.5ML/day EPL discharge limit).

Note: the final discharge via LDP2 is a combination of mine dewatering, process water and treated dirty stormwater.

The flow rate through the dam wall is monitored by NRE, although not as a licence requirement. The results of this monitoring are shown in figure 5. The average instantaneous flow through the dam wall is 0.42L/s.

Dirty stormwater management will not change under existing coal production rate as outlined within this Part 3A application.

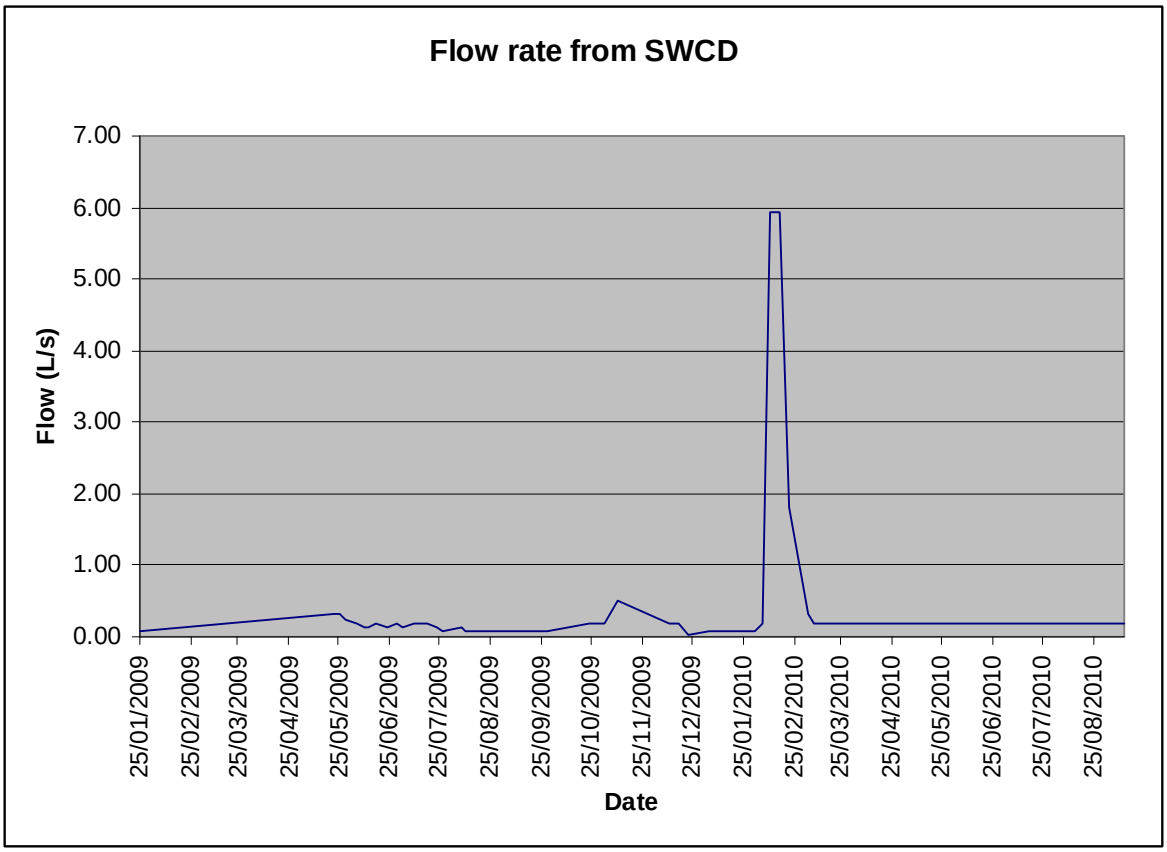


Figure 5 – Flow rate of water through SWCD wall to Bellambi Gully (Data provided by NRE)

2.2.5 Clean Stormwater

The clean stormwater on the site is defined as the stormwater that does not flow across disturbed surfaces on site. The catchment is natural escarpment that is made up of heavily vegetated slopes. The stormwater flows across the site through the natural water course of Bellambi Gully, which in places has been replaced by pipes and man made channels.

The clean stormwater system is described in the "Gujarat NRE Stormwater Hydrology Review" revised by Beca 9th September 2010 and included in appendix C of this report.

Proposed upgrades to the stormwater system are described in section 4 of this report and **Appendix C.**

2.2.6 Licensed discharge to Bellambi Gully

NRE currently holds an Environmental Protection Licence (EPL 12040) that allows discharge of 2.5ML/d to Bellambi Gully under dry weather conditions, from a single licensed discharge point (LDP) located near the Thickener Tank (LDP 2). Bellambi Gully flows from LDP2, under the Princes Highway, past several industrial premises, under the northern distributer, through residential streets, under the railway line, through Holy Spirit High School grounds, and then flows out into the ocean. The gully length is approximately 3km from LDP2 to Bellambi Beach. The Gully comprises either culverts under main transport structures and roads, or disturbed creek bed, through urban areas. According to the WBM Oceanics Australia report completed for Wollongong City Council in June 2005, the Bellambi Gully catchment is 427Ha and the total creek length is 4.3km.

Figure 6 shows the path of Bellambi Gully (Creek).

Figure 6 - Flow path of Bellambi Gully

Photos in **Figures 7-9** show images of Bellambi Gully.

Figure 7 - Bellambi Gully at Gladstone Street looking towards Holy Spirit

Figure 8 - Bellambi Gully looking west from Pioneer Rd

Figure 9 - Bellambi Gully in Holy Spirit, near Bellambi Beach

Twelve water samples have been taken by NRE in Bellambi Gully. Water quality was tested and found to be as shown in **Table 1**. Detailed results of the testing are provided in **Appendix B**.

Table 1 - Water Quality in Bellambi Gully as measured by NRE

Analyte	Bellambi Gully
pH	8.1-9.2
Oil & Grease mg/L	<0.1
Conductivity mg/L	1220-1900
TKN mg/L	0.4-0.9
TP mg/L	0.08-0.13
TSS mg/L	1-52

A literature search was completed and water quality data was found for Bellambi Gully and other similar creeks in the area from 2005. This second data sample for water quality provides a larger sample base, giving comfort that representative samples have been taken.

Table 2 describes water quality in the project area.

Table 2 - Water Quality in the Region (from "Wollongong Northern Coastal Creeks and Lagoons by WBM 2005)

Pollutant	Flanagan's Creek	Collins Creek	Bellambi Gully	ANZECC* guideline
pH	6.6-8.4	7.5-8.6	7-9	6.5-8
Total Dissolved Solids (TDS)	400-288	1000	1000-7000	125-2200
TKN mg/L	0.1 – 0.55	0.2 – 1.6	0.2-0.9	0.5
TP mg/L	0-0.11	0.1-1.5	0.02-0.3	0.05

***Australian New Zealand Environment Conservation Council 2000 marine and freshwater guidelines for lowland rivers**

Table 2 demonstrates that background water quality levels for creeks in the project area have nutrient, pH and EC levels that exceed ANZECC guidelines. This is probably because of the urban nature of the catchment and having a level of tidal influence. The area around the creek downstream of the EPL has been cleared with a small section near Bellambi beach being returned to a more natural state.

The EPL controls treated water discharge within the limits presented in **Table 3**.

Table 3 - Discharge Water Concentration Limits according to the EPL (No. 12040) LDP2

Pollutant	Units	100 percentile concentration limit
Oil and grease	mg/L	10
pH	pH units	6.5 – 9.2
TSS	mg/L	50

Sampling results are provided in **Appendix A** providing more detail of EPL discharge water quality. These show that licence conditions are met.

During wet weather conditions (ie. >10mm/24hrs), water can be discharged under the licence conditions in excess of 2.5ML/day from LDP 2 for the next 72 hours to ensure a safe water level is maintained in the Storm Water Control Dam.

Discharging to the gully is considered a last resort to avoid having to make-up water from other sources (i.e. potable). Reuse within the mining operation is the preferred and primary destination. **Figure 10** summarises the quantity of water that was discharged to the gully from July 2008 to June 2009. Averaging this annual volume to a continuous hourly rate suggests that on average approximately 20kL/h of water is currently discharged to the gully. It should however, be noted that the data also shows there is little to no discharge of treated water for January and February. During April, May and June 2009 there were instances when the EPL dry weather limit (2.5ML/day) was exceeded due to wet weather conditions.

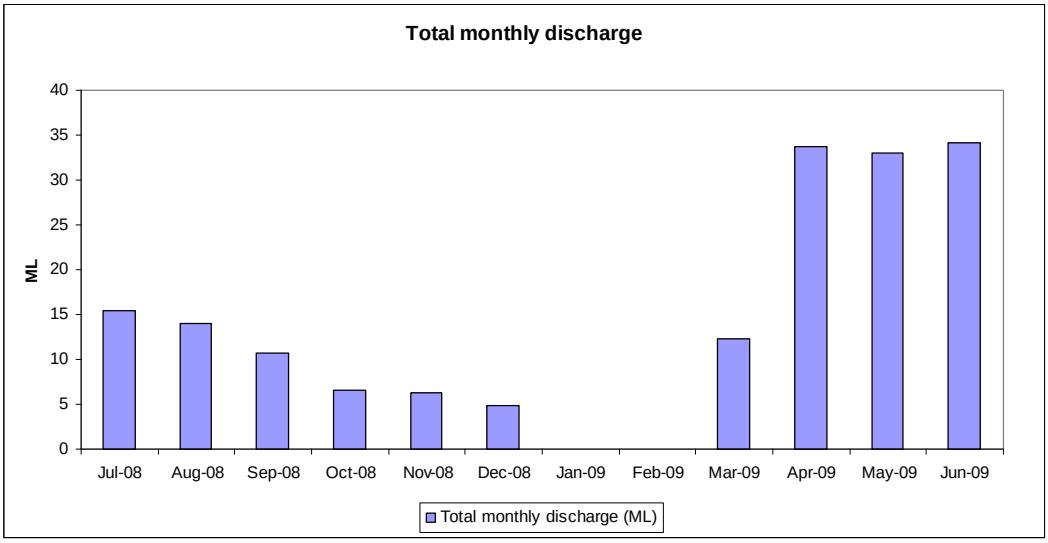


Figure 10 - The total monthly discharge of water into Bellambi Gully from July 2008 to June 2009

Discharge (max. 2.5ML/d, dry weather condition) is required to maintain the storm water control dam level less than 40% to provide storage for flood attenuation

The wall of the storm water control dam is designed to be permeable and slowly filter and discharge water. This dam is registered with the dam safety committee. Any changes to the dam would need to be approved by the dam safety committee to ensure safety of downstream dwellings. The dam wall provides filtering and some pH adjustment as the water flows through. This is identified as Licence Discharge Point 3 (LDP3) in the NRE EPL 12040.

Note: Under the current proposal covered by this part 3A application, it is not proposed to alter any of the current licensed discharge points.

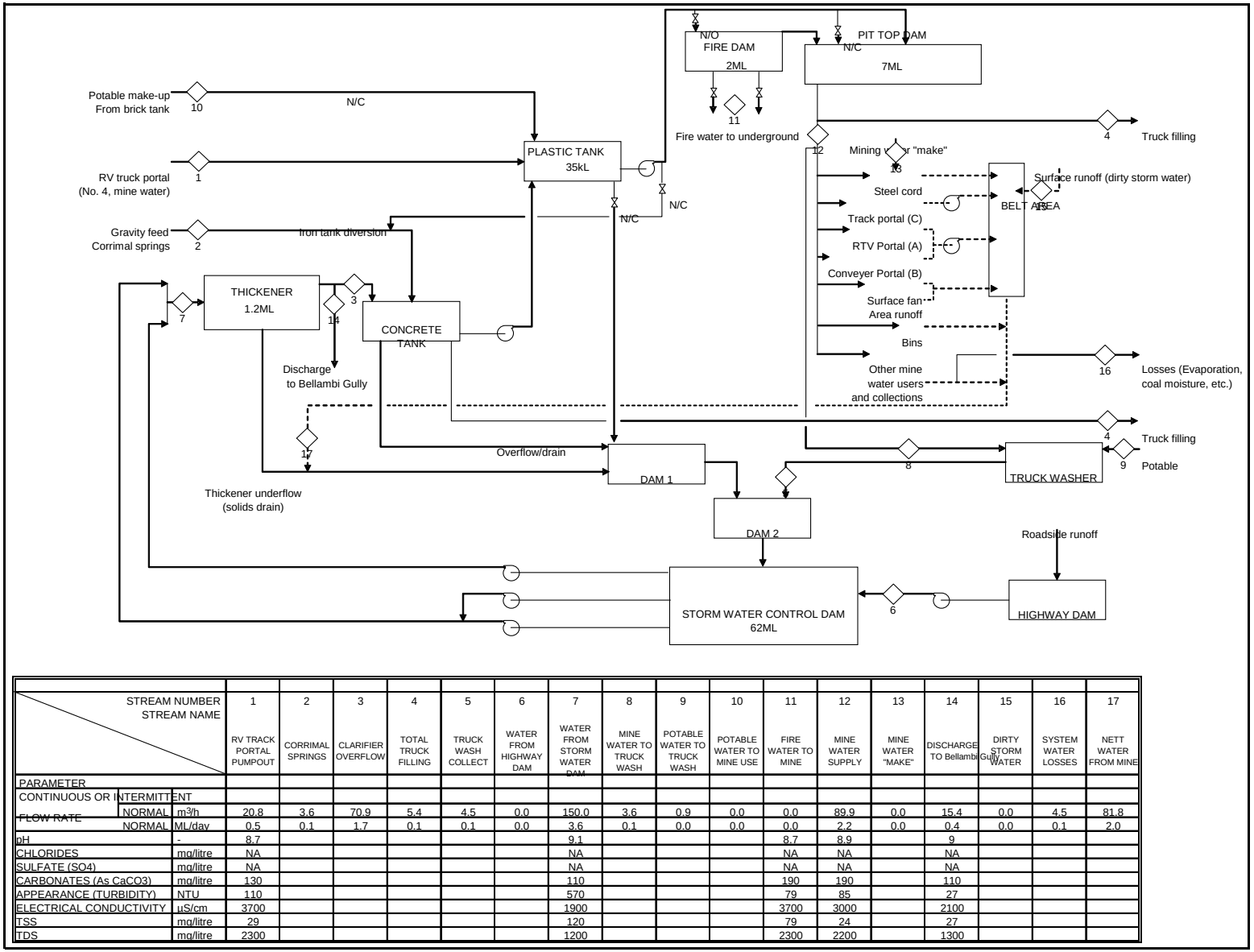
2.2.7 Summary of water use on site

A summary of water use on site is shown below in **Figure 11**. This figure combines the various aspects of water on site into an overall block/process flow diagram and flow balance. It should be noted that limited flow information was available at the time of preparing this balance and that information presented is a combination of provided information and flow estimates together with a few assumptions. The balance presented is for the average case only. The following information and assumptions were used and/or made to arrive at the balance presented in **Figure 11**:

- Supply and recovery of water to and from the mine is not a simple distribution and was therefore simplified to show only the total combined supply (labelled stream 12) and return (stream 17) of water to and from the mine. To account for any future balances, provision was made to allow for additional mine water make-up (stream 13 that could result from mining a wetter seam) as well as any storm water or other surface water drains (stream 15) that might enter the system.
- The balance assumes flows for dry weather conditions ie, normally no flow from the Highway Dam (stream 6) and dirty storm water (stream 15).
- The balance assumes normally no flow from potable water make-up (stream 10) and no nett “mine water make” or pump out (stream 13) from the mining of roadways in the Wongawilli seam (known as ‘Wonga Mains’). This is consistent with flow meter results communicated that indicate <0.1ML/day.

- The overall balance assumes continuous average normal flows for a 24 hour working day (except for the flows shown for stream 7 that is based on 0, 1 or 2 pumps running to meet the other "continuous stream" flows).
- The balance assumes non-continuous flows are successfully buffered by intermediate holding volumes in dams and tanks.
- The RV track portal pump out provided as a range of 0.5 to 1ML/day (0.5ML/day assumed normal and 1ML/day assumed as maximum for stream 1).
- Corrimal springs make-up (stream 2) rate assumed as 1L/s.
- Thickener Tank overflow (stream 3) estimated from hydraulic difference between Thickener Tank and Concrete Tank with existing piping connection and valve fully open.
- Truck filling (stream 4) estimated from 13kL trucks at 10 trucks per day
- Stock pile (truck filling) and truck wash daily consumption was quoted as 9kL/h. The difference between this and truck filling is assumed to be truck wash (stream 8).
- Potable water to truck wash (stream 9) is assumed to be 25% of the mine water that is supplied to the truck wash.
- Water loss (stream 16) through evaporation, coal moisture, etc. from the system was assumed to be 5% of the water supply to the mine (stream 12).
- The balance of water was assumed to be discharged to the creek (stream 14).

The water balance shows that currently during dry weather conditions approximately 15kL/h of water could be discharged to the creek. This compares favourably with the 20kL/h hour average calculated from actual discharge data for the period July 2008 to June 2009. It is believed that the difference is probably made up of a small amount each for stream 13 (Mine water make) and 15 (dirty storm water) respectively that was assumed to be zero for the purposes of this balance.



STREAM NUMBER / STREAM NAME			1 RV TRACK PORTAL PUMPOUT	2 CORRIMAL SPRINGS	3 CLARIFIER OVERFLOW	4 TOTAL TRUCK FILLING	5 TRUCK WASH COLLECT	6 WATER FROM HIGHWAY DAM	7 WATER FROM STORM WATER DAM	8 MINE WATER TO TRUCK WASH	9 POTABLE WATER TO TRUCK WASH	10 POTABLE WATER TO MINE USE	11 FIRE WATER TO MINE	12 MINE WATER SUPPLY	13 MINE WATER "MAKE"	14 DISCHARGE TO Bellambi Gully	15 DIRTY STORM WATER	16 SYSTEM WATER LOSSES	17 NETT WATER FROM MINE
PARAMETER																			
CONTINUOUS OR INTERMITTENT																			
FLOW RATE	NORMAL	m^3/h	20.8	3.6	70.9	5.4	4.5	0.0	150.0	3.6	0.9	0.0	0.0	89.9	0.0	15.4	0.0	4.5	81.8
	NORMAL	ML/day	0.5	0.1	1.7	0.1	0.1	0.0	3.6	0.1	0.0	0.0	0.0	2.2	0.0	0.4	0.0	0.1	2.0
pH		-	8.7						9.1				8.7	8.9		9			
CHLORIDES		mg/litre	NA						NA				NA	NA		NA			
SULFATE (SO4)		mg/litre	NA						NA				NA	NA		NA			
CARBONATES (As CaCO3)		mg/litre	130						110				190	190		110			
APPEARANCE (TURBIDITY)		NTU	110						570				79	85		27			
ELECTRICAL CONDUCTIVITY		uS/cm	3700						1900				3700	3000		2100			
TSS		mg/litre	29						120				79	24		27			
TDS		mg/litre	2300						1200				2300	2200		1300			

Figure 11- Current Russell Vale block/process flow diagram and balance summary

2.3 Water Management at Shaft No. 4

The current water management system implemented at Shaft No. 4 consists of the following strategy:

- Potable water is supplied to surface infrastructure by tanker
- Process (hydrant) water supply for underground and emergency response is provided from the main collector dam
- Underground workings dewatering is pumped to the main collector dam or flows to Russell Vale via U/G pipes and pumps
- Grey and black water effluent is treated on site
- Treated black water is disposed of via spray irrigation on site in accordance with the then Department of Environment and Conservation Environmental Guidelines for the Use of Effluent by Irrigation 2004.
- Treated grey water is stored in the main collector dam for underground use
- Clean storm water flows into a collection chamber prior to discharge into the catchment area
- Oily waste from the workshop enters the oil arrestor pit where grease and oil is trapped, and the underflow then goes to the main collector dam.

A schematic of the current water flow management at Shaft No. 4 is provided in **Figure 12**.

During the review of the effluent reuse on site against the DEC guidelines, the following aspects were indentified:

Monitoring

The DEC guidelines recommend that '*the water content (or moisture) requirements of the soil is regularly monitored to ensure that the irrigation site is not overloaded. Soil moisture indicators can be used to determine the maximum amount of effluent that can be applied on the surface without causing water-logging or runoff. DEC advises that a 5-10mm soil water deficit will be sufficient to act as a buffer capacity in the soil should rainfall occur soon after an irrigation event'.*

Gujarat NRE should implement a control system with monitoring to control the irrigation pumps to automatically start and stop based on soil moisture content and timers. Where this is initially not implemented, manual monitoring should be undertaken.

Gujarat NRE has identified a natural low area in the irrigation area and would be the most appropriate position to install the soil moisture content sensor or complete a manual assessment. A manual assessment approach may be to visually inspect for the presence of ponding of water on the surface of the lawn. Physically pressing down on freshly irrigated lawn should not cause water to seep out of the soil.

Gujarat NRE has also implemented trenching along the perimeter of the irrigation area to assist in managing any excess surface water runoff entering the catchment by draining to the stormwater collection dam.

Protection from Pathogens

Spray irrigation will continue to be used to assist with managing the treated black water. Gujarat NRE will restrict personnel access to this area during irrigation events, to minimise the spread of pathogens arising from aerosols.

Treated grey water is added to the stormwater collection dam for reuse underground. It is expected that NRE will implement a tertiary treatment system to reduce pathogens resulting in a 1mg\L chlorine residual after 30 minutes as is required under the DEC reuse guidelines. Ongoing monitoring of the disinfection system will be undertaken daily.

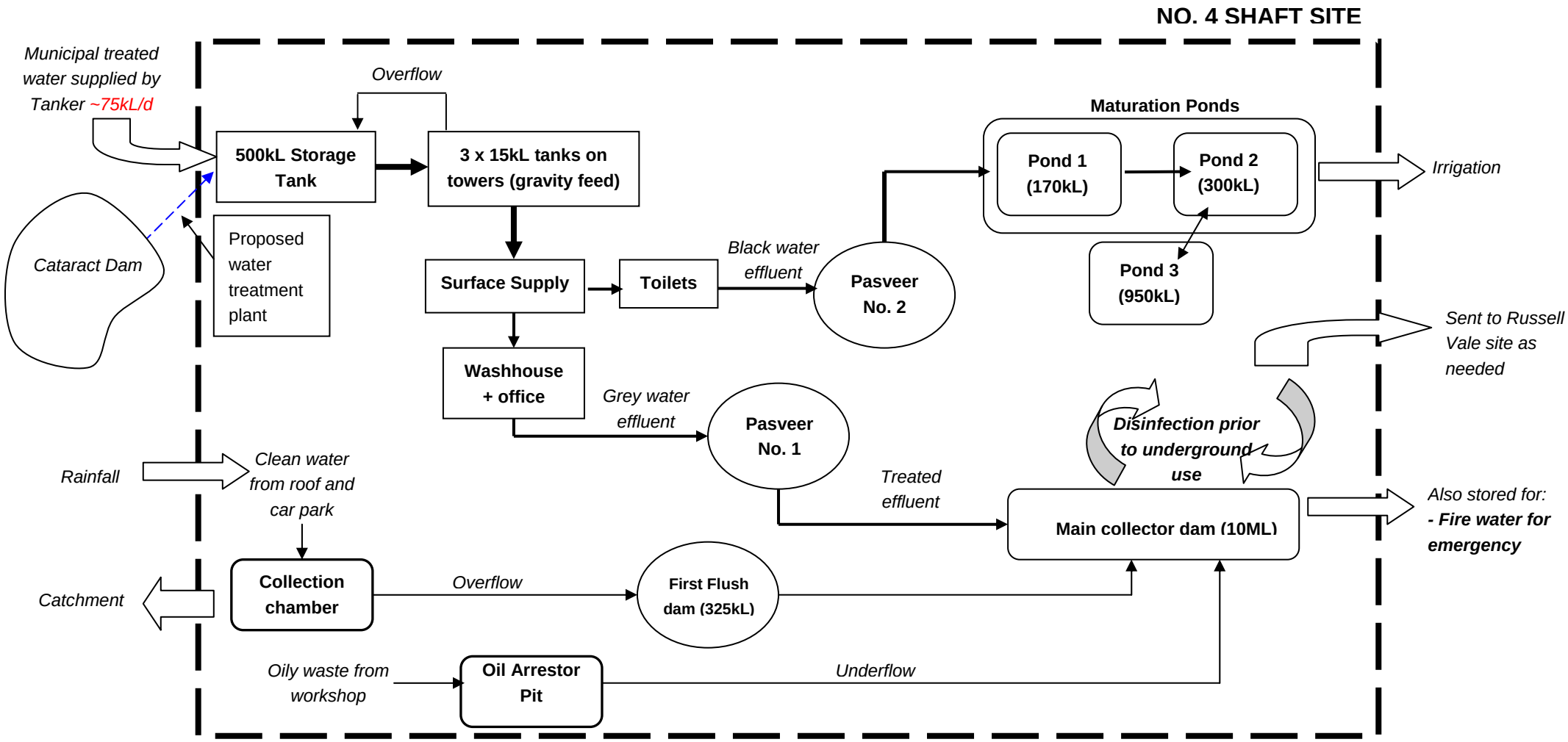


Figure 12- Schematic of the current water flow and management system at Shaft No. 4

the blue dotted line from Cataract Dam indicates an existing pipeline for raw water to supply the site. Note: this schematic does not show any valves or pipe sizes

3 Water Impact assessment

This section describes the impacts of the water management in the mine over the next three years under current production rates (up to 1 Mtpa) on the quantity and quality of surface water in the project area, specifically considering the discharge of mine water and surface water runoff into Bellambi Gully. The discharges to the environment from the site will not change from the current situation under this Part 3A application.

3.1 Water Quality

The water quality in Bellambi Gully is variable. The gully is a disturbed urban creek. Water sample results taken by NRE are shown in **Appendix B**. Water quality from Wollongong Council samples for Bellambi Gully and other local creeks are provided in **Table 2**.

Table 4 provides a comparison between water quality in Bellambi Gully, Russell Vale discharge water quality, ANZECC Guidelines and NRE EPL.

Table 4 - Water Quality Comparison

Analyte	Bellambi Gully*	Russell Vale Discharge LDP2***	ANZECC** Guidelines	Licence***
pH	8.1-9.2	7.1-9	6.5-8(9)	6.5-9.2
Oil & Grease mg/L	<0.1	<0.1	-	10
Total Dissolved Solids mg/L	1220-1900	1100-1900	125-2200	-
TKN mg/L	0.4-0.9	0.4-1.1	0.5	-
TP mg/L	0.08-0.3	0.03-0.12	0.05	-
TSS mg/L	1-52	13-27	-	50

*from Wollongong Northern Coastal Creeks and Lagoons report by WBM January 2006 and NRE testing

** Australian and New Zealand Environment Conservation Council's Guidelines for Fresh and Marine Water Quality, lowland rivers (ANZECC)

*** for more details see appendices A & B

Tables 2 and 4 show that while Russell Vale LDP2 water quality sometimes exceeds ANZECC freshwater guidelines for lowland rivers, it has a similar water quality to the background water quality in the creek and other creeks in the area.

Nutrient levels are already an issue in the creek presumably due to urban runoff. Current discharge concentrations for TP are less than background levels in the creek. Algae growth or other biological growth is more pronounced in stagnant water. Discharging some water through the creek reduces this stagnation and the associated algal growth.

This part 3A application does not facilitate the need to alter the existing EPL for the site.

3.1.1 Potential Impacts

The water quality from the NRE EPL could have impacts on the gully associated with

- suspended solids settling in the gully
- nutrients increasing above background levels
- Flow adding to flooding
- Potential discharge from water treatment plant malfunction

3.1.2 Management measures

Prior to discharge water is treated in the thickener (clarifier) on site. TSS is reduced to less than 50mg/L under the operating licence.

The storm water dam is kept at a level that allows 30ML of stormwater to be captured on site. This dam stores water on site, reducing the flow and flood potential downstream.

NRE propose modifications to the clean stormwater system on site to better control and reduce the chance of blockage in the clean stormwater system and the uncontrolled flow of water across the site associated with such a blockage.

Chemicals are properly stored and bunded. Dosing of flocculent is metered and monitored on site using a computer controlled dosing system. Trigger points are built in to the system to ensure that 'over-dose' or 'under-dose' of flocculent is managed. Chemical use is kept to a minimum.

3.2 Water Quantity

The natural flow through Bellambi Gully is highly variable. The low lying area east of the Princes Highway is cleared of natural vegetation. The catchment is small and the gully reacts quickly to rainfall events rising rapidly and falling to a trickle for extended periods.

3.2.1 Potential Impacts

Discharge of water could cause erosion of Bellambi Gully. The gully is highly urbanised and vegetated. The discharges of water from the mine are predicted to be smaller in flow than the flow experienced during high rainfall events. Erosion associated with mine water discharge would be insignificant compared with the flows experienced during heavy rainfall events.

There are no changes proposed under this Part 3A application to the volumes of water discharged from the site. Therefore, no additional flooding potential downstream of the site is expected. .

3.2.2 Management measures

Stormwater from hard surfaces is diverted into the SWCD via a number of earthen channels and concrete pipes. The water is stored in the SWCD prior to treatment that is then discharged via controlled valve at LDP2. This reduces solids, but also holds the water in the dam, reducing flow rates through Bellambi Gully during storm events.

The SWCD is kept at a level that allows flow attenuation prior to discharge to environment. This reduces erosion potential by reducing the peak flow during these storm events.

Changes will be made to stormwater management on site to divert water from steep Bellambi Gully areas of the site that have experienced significant erosion. These are on the mine site above the

discharge point. The drawings in **Appendix C** describe the proposed changes. They provide a realignment of the stormwater on the site. This work will reduce the velocity of water flowing down the gully. The longer channel runs and storage in the dam prior to discharge significantly reduces potential energy and hence erosion potential.

The replacement of pipe drainage with channel drainage as described in **Appendix C** reduces the risk of uncontrolled flows across the site that is associated with blocked pipes. NRE will take appropriate actions to ensure drains are effective with regular maintenance of the channels.

4 Operational Improvements - Clean Stormwater channel realignment of Bellambi Gully at Russell Vale

Although there is no increase in impervious area or flow intensities, NRE has identified an opportunity to improve stormwater management and control, through the installation/re-alignment of the clean storm water channel, being Bellambi Gully. The stormwater concept presented in appendix C proposes a number of measures which will minimise the likelihood of a failure, such as the 1998 floods occurring in the future through both the maintenance and upgrade of existing diversions and flowpaths (such as those in the upper sub-catchments) and the proposed implementation of open channels and diversions around NRE's proposed stockpile area.

In addition to this, for the existing Dirty Water system, it is proposed to implement both a dry and wet basin arrangement with better access for maintenance to minimise sediment transportation to the stormwater dam which must maintain a minimum of 30ML spare capacity (or 35ML if only one pump is to operate) at all times to minimise the chance of a major storm surcharging to Bellambi Gully.

The existing and proposed diversion channels and drains will be lined as shown in the "Gujarat NRE Stormwater Hydrology Review" prepared by Beca 8th September 2010 and as required after taking geotechnical advice. The channels will be maintained regularly to minimise scouring during major flow events. All reno mattress areas will be regularly inspected and repaired where necessary, and all shotcrete areas are to be inspected for undermining and eddies, which could lead to erosion if left unaddressed.

The stormwater diversion work is described in **Figure 13** following. A larger copy is provided in **Appendix C**.

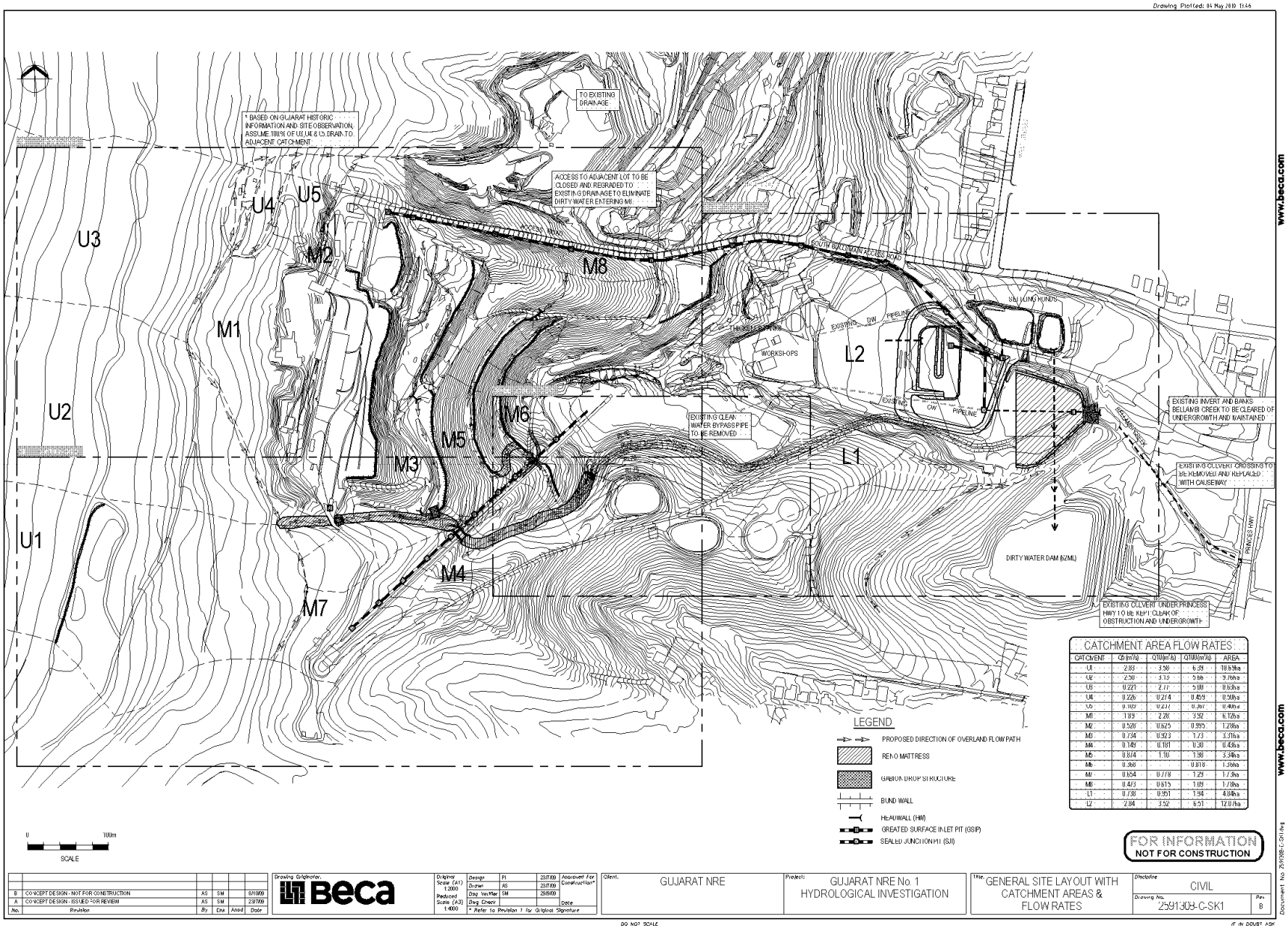


Figure 13 – Proposed stormwater diversions for Russell Vale

NRE are undertaking a tender process to allow for a more detailed design of this channel realignment. The detailed design will address, but not be limited to, the following:

- Geotechnical
- Long term stability
- Environmental aspects.

A conceptual construction environmental management plan (CEMP) has been created for the work and will be updated to address requirements if necessary once tender is accepted.

5 Conclusion

In conclusion, this Part 3A application does not change the water management at the Russell Vale site. The existing operation has been assessed considering potential impacts on the water quality and quantity in Bellambi Gully. After a comparison of water quality in Bellambi Gully and similar creeks in the area, the discharge from the site is not expected to significantly impact the water quality or quantity in the Gully over the next 3 years under current production rates (up to 1 Mtpa).

NRE propose to implement the construction of a clean stormwater realignment on the site, changing flow from an 'in pipe' system to a 'open channel' system. This will assist to reduce the risk of blockages in the stormwater system and by the introduction of a dissipation pond, will reduce the energy of the clean stormwater flowing across the site.

NRE will investigate further water treatment and reuse on site, including the potential to separate process water and dirty storm water.

NRE also anticipates undertaking further investigations for improving the management of solids from the water treatment plant on site.

Appendix A

NRE Russell Vale Water Quality Samples

Appendix 1

Table A1 – Water quality samples of the discharge into Bellambi Creek (from Post-thickener line); note- oil and grease is not monitored

Parameters	Units	Sample (23/01/09)	Sample (18/02/09)	Sample (04/03/09)	Sample (01/04/09)	ANZECC Guidelines, unless specified	Comments
Alkalinity	Mg $CaCO_3$/L	790	650	700	950	**NA**	
Ammonia	mg/L	<0.02	<0.02	<0.02	<0.02	**0.9**	95% protection level
Bicarbonate	Mg $CaCO_3$/L	700	540			**NA**	
BOD5	mg O_2/L		5	<2	<2	**<15**	Lowland River discharge
Carbonate as $CaCO_3$	mg/L	91	110			**NA**	See *Alkalinity* comments
COD	mg/L		28	32	24	**<40**	Lowland River discharge
Conductivity	µS/cm	1600	1600	1600	2100	**125-2000**	Lowland River discharge
Enterococcus	cfu/100mL		130	2000	60	**NA**	
pH	pH units	8.8	9	9	9	**6.5-9.2**	**EPL licence requirement**
Thermo tolerant coliforms	cfu/100mL		300	2800	80	**<0.02** **100**	Lowland river discharge Low effect on livestock drinking water
Total coliforms	cfu/100mL		10000	2500	400	**NA**	Microbial growth evident
Total dissolved solids	mg/L	750	890	870	1300		
Total organic carbon	mg/L	6	6	6	11	**NA**	
Total phosphorus	mg/L	0.03	0.03	0.03	0.05	**0.025**	Lowland river discharge
Total suspended solids	mg/L	13	20	22	27	**<50**	**EPL licence requirement**
Turbidity	NTU		26	33	27	**1-20**	Assumed for lakes and reservoirs category
Hardness	mg/L			40	42	**20-100**	Fouling potential >350mg $CaCO_3$/L
UV Transmissivity @ 254nm					51		

Appendix B

Bellambi Gully
Water Quality Samples

V Notch Weir @ SWCD

Analyte	Units	22/1/2010	2/10/2010
pH	***pH***	7.1	7.74
Conductivity	**µS/cm @ 25˚C**	1700	1200
Oil and Grease	**mg/L**	-	-
TSS	**mg/L**	2	164
Turbidity	**NTU**	-	1010
TKN	**mg N/L**	0.4	-
TP	**mg/L**	0.07	-

Bellambi Creek Water Quality Data from Year 2007 -2009

Year - 2007

Analyte	Units	1/08/2007	2/09/2007	3/06/2007	4/03/2007	18/5/2007	21/6/2007	23/7/2007	17/8/2007	9/05/2007	10/02/2007	11/08/2007	#########	Min	Mean	Max
pH (Limit Between 6.5-9.2)	***pH***	9.2	8.3	9	8.9	8.85	8.5	8.8	9.1	9.1	8.2	8.8	8.8	8.2	8.68	9.2
[H+]		6.31E-10	5.012E-09	1E-09	1.259E-09	1.413E-09	3.162E-09	1.585E-09	7.943E-10	7.943E-10	6.31E-09	1.5849E-09	1.585E-09	6.310E-10	2.094E-09	6.31E-09
Oil and Grease (Limit 10)	**mg/L**	<0.1	<0.1	<0.1	<0.1	1.3	2	0.5	0.1	<2	<0.1	0.1	<0.1	0.1	0.8	2
TSS (Limit 50)	**mg/L**	5	8	15	6	35	52	17	13	20	12	17	15	5	17.92	52
Turbidity	**NTU**	45	13	19	15	33	50	19	30.7	11	10.6	19	28	10.6	24.44	50

Year - 2008

Analyte	Units	1/11/2008	19/2/2008	14/3/2008	4/03/2008	5/09/2008	20/6/2008	7/09/2008	20/8/2008	9/03/2008	17/10/2008	20/11/2008	#########	Min	Mean	Max
pH (Limit Between 6.5-9.2)	***pH***	8.9	8.5	8.7	8.5	8.5	8.5	8.7	8.6	8.8	9	9	9	8.5	8.68	9
[H+]		1.26E-09	3.162E-09	1.995E-09	3.162E-09	3.162E-09	3.162E-09	1.995E-09	2.512E-09	1.585E-09	1E-09	1E-09	1E-09	1E-09	2.083E-09	3.162E-09
Oil and Grease (Limit 10)	**mg/L**	<0.1	0.4	<0.1	7.4	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	0.5	0.1	2.1	7.4
TSS (Limit 50)	**mg/L**	10	11	5	24	11	17	25	22	15	11	16	11	5	14.83	25
Turbidity	**NTU**	16	12	10	38	22	17	24	39	10	9	22	8	8	18.92	39

Year - 2009

Analyte	Units	1/09/2009	2/06/2009	3/10/2009	4/09/2009	22/5/2009	6/09/2009	15/7/2009	14/8/2009	9/01/2009	10/08/2009	11/10/2009	#########	Min	Mean	Max
pH (Limit Between 6.5-9.2)	***pH***	8.3	9	9	9.1	9	8.9	8.8	8.9	9	9.1	9.1	9.1	8.3	8.87	9.1
[H+]		5.01E-09	1E-09	1E-09	7.943E-10	1E-09	1.259E-09	1.585E-09	1.259E-09	1E-09	7.943E-10	7.9433E-10	7.943E-10	7.943E-10	1.358E-09	5.012E-09
Oil and Grease (Limit 10)	**mg/L**	0.5	0.4	0.5	<0.1	<0.1	0.3	<0.1	<0.1	0.2	<0.1	0.2	0.1	0.1	0.314	0.5
TSS (Limit 50)	**mg/L**	1	4	11	12	22	19	7	14	4	13	18	21	1	12.17	22
Turbidity	**NTU**	12	3.5	8	0.3	25	28	11	20	12	25	21	61	0.3	18.9	61

Year 2007-2009

Analyte	Units	Min	Mean	Max
pH (Limit Between 6.5-9.2)	***pH***	8.2	8.73	9.2
[H+]		6.31E-10	1.845E-09	6.31E-09
Oil and Grease (Limit 10)	**mg/L**	0.1	1.07	7.4
TSS (Limit 50)	**mg/L**	1	14.97	52
Turbidity	**NTU**	0.3	20.75	61

Appendix C

Gujarat NRE Stormwater Hydrology Review and Stormwater Diversion Drawings

Report

Gujarat NRE Stormwater Hydrology Review

Edited for Part 3A submission

Prepared for Gujarat NRE (Client)

By Beca Pty Ltd (Beca)
ABN: 85 004 974 341

13th September 2010

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Revision History

Revision Nº	Prepared By	Description	Date
A	Paul Irwin	Preliminary Draft – For Information	30/09/2009
B	Paul Irwin	Preliminary Draft 2 – For Information	02/10/2009
C	Paul Irwin	Issued for Information	15/10/2009
D	Paul Irwin	Final Issue	25/11/2009
E	Dianne Thomas	Edited for Part 3 Approval for use by ERM.	26/05/2010
F	Paul Irwin	Update Methodology	08/09/2010

Document Acceptance

Action	Name	Signed	Date
Prepared by	Paul Irwin		8.9.10
Reviewed by	Dianne Thomas		12.09.10
Approved by	Gujarat NRE		13.09.10
on behalf of	Beca Pty Ltd		

Introduction

During 1998 the Illawarra experienced a major storm event which caused considerable flooding throughout the region. Review of the rainfall data for this event taken from the Russel Vale catchment confirms that this storm was a statistical 100 year average recurrence interval (ARI) event when compared to BoM statistical models.

Although the mine operators at the time had in place a number of diversion drains, settlement and piped stormwater systems, these proved inadequate due mostly to maintenance, inadequate design, and lack of redundancy factors of safety. This resulted in large quantities of escarpment runoff water diverting through the existing coal stockpile.

As this coal stockpile drained to the dirty water treatment and collection system, this system was overwhelmed and resulted in black water and coal washing down the Bellambi Creek and through a number of private properties causing considerable damage.

This study will attempt to review and address these existing inadequacies as well as propose new measures to minimise the likelihood of future failures.

Stormwater Methodology

As the mine upgrade is primarily to underground activities and to a limited extent the surface areas, it's expected that the proposed mine upgrade will not result in a significant change in impervious areas when compared to the existing site. This study therefore is intended to calculate the flowrates and flowpaths of the existing catchments to Bellambi Creek with the aim of producing a stormwater management concept to form the basis of future detailed design.

As stated above, the primary cause of the failure of the stormwater management system in the past (i.e. the 1998 storms) was due to blockages and diversion of the primary clean water through the dirty water and coal stockpile areas. This was primarily a result of inadequate sizing of diversion drains, poor maintenance, and insufficient erosion protection. The intention of this study is therefore to provide a concept for the management of this stormwater coming from the upper catchments reducing the risk of this situation reoccurring into the future.

The guide for the collection, storage, and treatment of dirty water within the site is primarily through the application of recommendations outlined in both Managing Urban Stormwater: soils and construction volume 1 (Landcom 2004) and Managing Urban Stormwater: soils and construction volume 2E mines and quarries (Dept. Of Environment and Change 2008). As per these outlines the primary focus of the concept is that clean upper catchment flows should be diverted around the operational area "dirty water" flows to minimise the required dirty water treatment volume. Further consideration was also given to flooding studies and additional literature where relevant and as appropriate.

It should be noted that the intention of the concept is to provide a solution which will significantly reduce the possibility of blockage and diversion of the clean water flow through the dirty water areas and propose minimum basin and treatment area for the dirty water collected from operational areas on site. This concept will therefore maintain the existing flowrates generated by the subject site to Bellambi Creek via the existing RTA culvert under the Princes Highway. The concept will propose options for the reduction in potential blockages due to debris on the Russell Vale site, which would have contributed heavily to the

downstream flooding. However, it will not reduce the flowrate or propose options for any upgrades and/or maintenance that may be required downstream of the site not owned by or in the control of Gujarat NRE.

Each of the catchments has been modelled using an ILSAX hydrological model within the DRAINS application using the latest Bureau of Meteorology IFD data for the subject site.

The ILSAX storage parameters used were 1mm of storage for both paved and supplementary areas, and 5mm of storage for pervious areas. A soil type 3 was selected as clays are present in the upper escarpment. This will be conservative for the middle and lower catchments which are freer draining fill.

Rainfall data used as per the BoM IFD information was:

- 2yr1hr 47.22
- 2yr12hr 11.43
- 2yr72hr 4.51
- 50yr1hr 107.86
- 50yr12hr 28.25
- 50yr72hr 9.58
- G 0.00
- F2 4.28
- F50 15.81

Storms modelled for the purposes of the preliminary design of channels and pipes were the 5, 10, and 100 year frequency events (Q5, Q10, Q100 respectively).

Storm durations modelled within each Annual Recurrence Interval (ARI) were 5min, 10min, 20min, 30min, 45min, 1hr, 1.5hr, 2hr, 3hr, 4.5hr, and 6hr with the Dirty Water storage basin being assessed up to a 72 hour duration 10yr ARI event.

Based on these flows, site observations, and survey information Hec-Ras channel models and DRAINS piped flow models have been produced for the preliminary design of the proposed stormwater treatments.

Catchments

Catchment Zones

The subject site consists of three major catchment zones depending on their location and broadly their land use and grade. These three catchment zones are defined as:

Upper Catchments – This zone is characterized by predominantly natural escarpment and steep heavily vegetated slopes with thick undergrowth. The Upper Catchments include a number of small dams for use within the mines and also a number of unsealed access roads and fire trails.

This catchment zone is considered to be 100% clean water with no coal stockpiling or conveyor activities within any of its subcatchments.

Middle Catchments – This zone includes the workshop, offices, a number of existing and proposed portals, and a network of access roads between the stockpile and the Upper

Catchments. It is characterized by steep batters of both natural slopes and mine tailing material and with the exception of Subcatchment M7 will not be exposed to coal stockpiling, conveyor operations, or hauling in the proposed mine upgrade.

The catchment M1 is also used to store plant and materials and has both a sealed and gravel surface which although not used for the storage or transportation of coal has the potential for light contamination during initial runoff.

Lower Catchments – This zone is dominated by the coal stockpile and haul areas, truck loading facility and settlement basins. It is also the location of the clean water discharge point to Bellambi Creek.

Sub-Catchments

Each of the above zones has then been broken down into sub-catchments based on their location within the overall catchment plan and their dirty water or clean water characteristics.

As stated above, each of these sub-catchments have been reviewed, modelled, and recommendations made based on preliminary plans and information provided in meetings with the client.

Note: All flow rates and areas are for individual subcatchments and not a cumulative total and are subject to change upon final design and detail following Part 3A approval.

Subcatchment U1

10.69ha

100% pervious

Clean Water (CW) catchment.

Q5: 2.83m^3/s

Q10: 3.58m^3/s

Q100: 6.39m^3/s

This sub-catchment is a natural escarpment catchment which is dominated by heavy trees and undergrowth with a number of unsealed access roads and fire trails. The sub-catchment also includes two open dams which are used for underground water supply, these dams do not collect or store water from the natural catchment and are instead fed by pump from the lower catchments. As the dams do not intercept a larger catchment than their own surface area they are not at risk of overtopping during a major event provided adequate freeboard is maintained.

The current catchment drains by sheet flow in a general easterly direction and in minor events will be contained within the unsealed access road swale drains. Which eventually discharge into the existing southern stormwater channel. However the capacity of these roads to contain major events is limited and will result in overtopping of these flows down the catchment grade and through M7 (which is a Dirty Water catchment).

In order to ensure that all major storm events reach the stormwater channel a diversion drain is required to be constructed along grade. The grade of this channel should be kept to a

minimum to limit scouring and generally following the contour of the catchment from south to north.

A Hec-Ras channel flow model was constructed assuming a trapezoidal channel and the flow rates up to and including the Q100 flow indicated above. In order to limit the impact of minor land slips, local settlement, obstructions and poor maintenance a freeboard of at least 500mm should be allowed for in the sizing of this channel.

The length of the channel will be approximately 170m and a longitudinal grade of 2% has been assumed to limit velocities and scour.

Based on the above parameters a trapezoidal channel of base width 2.0m (minimum) and minimum depth 1.5m with 1:2 side slopes is required. It is not advisable to reduce this width or depth along the length of the channel as it is possible (though unlikely) that a majority of the flow rate will enter the channel at its southern extent in the event that a roadside drain fails towards the southern extent of the catchment.

This approximate channel location and details have been shown in the sketch plans provided.

Subcatchment U2

9.76ha

100% pervious

Clean Water (CW) catchment.

Q5: 2.50m3/s

Q10: 3.13m3/s

Q100: 5.66m3/s

As with U1, this subcatchment is a natural escarpment catchment which is dominated by heavy trees and undergrowth with a number of unsealed access roads and fire trails.

The current catchment drains by sheet flow in a general easterly direction until intercepted by the access road which then discharges to an existing diversion drain. In the event that the roadside swales are breached and water continues east, this diversion drain is intended to direct flows to the southern stormwater channel.

The capacity of this existing diversion drain upon inspection was reduced due to very dense undergrowth which had choked up the channel. Upon clearing of this channel it was also apparent that local settlement and land slip had reduced the cross section of this drain in several locations.

The channel was then surveyed and a Hec-Ras model of the existing drain was produced. The Hec-Ras model makes the assumption that in future events the channel will remain clear of undergrowth and lantana through regular maintenance.

The Hec-Ras analysis of the existing diversion drain has concluded that in its current maintained form there is insufficient capacity between chainages 140 and 304 to contain a 100yr ARI event which would result in overtopping of this drain to M1 and subsequently lead to erosion of the drain and an increase of flows to M1.

The cause of this section of channels insufficient capacity was due to a combination of insufficient cross section due to slump and design and a very flat longitudinal grade.

This section of the diversion drain therefore requires upgrading to achieve a consistent grade from Ch140 to Ch304 which matches in with existing at each extent. Due to the change in elevation along this length of 164m a longitudinal grade of 2.75% is required to minimise upstream and downstream alterations.

An alternative Hec-Ras model of the diversion drain, including the upgraded trapezoidal section was then created. Based on the above parameters a trapezoidal channel of base width 2.0m (minimum) and minimum depth 1.25m with 1:2 side slopes is required at a minimum slope of 2.75%.

This channel location and preliminary details have been included in the sketch plans provided.

Subcatchment U3

8.63ha

100% pervious

Clean Water (CW) catchment.

Q5: 2.21m3/s

Q10: 2.77m3/s

Q100: 5.00m3/s

As with U1 and U2, this subcatchment is a natural escarpment catchment which is dominated by heavy trees and undergrowth with a number of unsealed access roads and fire trails.

The southern section of the catchment drains by sheet flow in a general easterly direction until intercepted by the access road, this is then channelled in the roadside drainage to the north and into an existing diversion drain. This diversion drain has been maintained by the mine operator and in the event of failure drains to subcatchment U4.

The capacity of this existing diversion drain on the steep grades is adequate for major events and historically discharges to the northern valley/channel system on the adjacent lot.

As this catchment historically discharges into the adjacent northern valley it does not form part of the stormwater model for the Russel Vale site. This channel should be regularly maintained and free from obstructions, weeds, lantana, and undergrowth to ensure its continued capacity. Emphasis should also be placed on the maintenance of the existing access road in the southern portion of this site to ensure that the swales and cross fall are even and free from obstructions.

Subcatchment U4

0.50ha

100% pervious

Clean Water (CW) catchment.

Q5: 0.226m3/s

Q10: 0.274m3/s

Q100: 0.459m3/s

This subcatchment is located east of the U3 catchment and is the site of the original electrical power station of the mine. The power station is no longer in use and there are no significant structures or impervious areas within the catchment to increase runoff intensity. The natural soil in this location is comprised of a high percentage of ash and fine silty materials and is therefore highly prone to erosion.

As with subcatchment U3 this subcatchment historically drains to the north via an existing diversion drain which has recently been maintained by the mine operator. This diversion drain has been oversized to allow for redundancy of the U3 diversion drain in the event of failure. The capacity of this existing diversion drain on the steep grades would be adequate for major events.

As this catchment historically discharges into the adjacent northern valley it does not form part of the stormwater model for the Russel Vale site. This channel should be regularly maintained and free from obstructions, weeds, lantana, and undergrowth to ensure its continued capacity. As with U3 emphasis should also be placed on the maintenance of the existing access road in the southern portion of this site to ensure that the swales and cross fall are even and free from obstructions.

Subcatchment U5

0.4ha

100% pervious

Clean Water (CW) catchment.

Q5: 0.189m3/s

Q10: 0.237m3/s

Q100: 0.367m3/s

As with U3, this subcatchment is a natural escarpment catchment which is dominated by heavy trees and undergrowth with a section of unsealed access roads and fire trails. This is adjacent to the M2 subcatchment which comprises of the mine office building, carpark and substation.

As with subcatchment U3 this subcatchment historically drains to the north via an existing diversion drain which is required to be upgraded and maintained by the mine operator. This diversion drain is the last line of diversions to the northern catchment before the substation

and so a concrete diversion channel is proposed to ensure that major storm events will not cause damage to the mines power supply.

A Hec-Ras model of the proposed channel upgrade has been prepared assuming a rectangular section using concrete culverts. A conservative catchment area of 1ha was assumed to allow for redundancy of the U4 catchment diversion drain. This has resulted in a design section of 1m wide by 0.5m depth with a factor of safety of 2 on the existing grade.

As this catchment historically discharges into the adjacent northern valley it does not form part of the stormwater model for the Russel Vale site. This channel should be regularly maintained and free from obstructions to ensure its continued capacity. Emphasis should also be placed on the maintenance of the existing access road in the southern portion of this site to ensure that the swales and cross fall are even and free from obstructions.

Subcatchment M1

1.89ha

55% Pervious

45% Paved

First Flush (FF) catchment.

Q5:	1.89m3/s
Q10:	2.28m3/s
Q100:	3.92m3/s
DW:	0.02m3/s maximum flow

Subcatchment M1 is characterised by both a section of natural escarpment slopes located below the U2 and U3 catchment and also the workshop and mine portal area. Although the workshop and mine portal area (and surrounding roads) are not proposed for the stockpiling or haul of coal, due to the presence of plant and machinery for service (or entry/exit to the pit) on the hardstand areas there is potential for minor contaminants to be on the surface within this area.

Due to the potential for contaminants the existing M1 catchment drains to a piped stormwater pit system with restricted first flush outflow. The existing first flush system includes at the pit invert a 100mm diameter pipe and 200mm high weir. The first flush of stormwater which falls on the paved component of the M1 catchment is diverted down this line to the Dirty Water drainage system. As the flow rate within this catchment increases during a major event the water level increases until it spills over the 200mm high weir and enters the 225mm diameter Clean Water pipe which discharges east to the southern stormwater channel. In a major storm event, with 1m of head the maximum flow rate of the Dirty Water first flush pipe is 0.02m3/s.

In a major event this 225mm diameter pipes capacity is exceeded and water is then directed overland to the primary stormwater channel at the base of the U1/U2 catchment where it then drains to the M3 subcatchment.

It is also important to construct a crest perpendicular to the access road to subcatchment M3 which will prevent overland flows from spilling down this road. Additional flows down this road would increase the flow rate in the southern channel of M3 which although it has the capacity would generate potential erosion to the M3 access road due to steep grades. The location of this crest has been shown on sketch SK5.

The U1 and U2 catchments drain to the M1 subcatchment via the southern stormwater channel. The eastern extent of this channel (to the west of the culvert crossing location) is heavily eroded due to steep grades and the high erodability of the coal seam in this location. In order to minimise future erosion a number of options have been considered:

Sprayed Concrete ('shotcrete') Lining – This method provides a relatively smooth and high capacity channel lining which is not prone to blockage. However, the subgrade in this location consists of a highly erodible natural soil which, through the action of eddies in cracked sections has a tendency to become undermined in high velocity flow areas. It is therefore not an ideal long term solution in a high velocity/flow location.

Gabion Basket – The construction of a stepped gabion basket channel is a good solution hydraulically as it has considerable energy dissipation characteristics and low maintenance. Disadvantages to gabion basket construction are the considerable earthworks required to install a stepped basket structure with benching, batters, and footing systems requiring substantial remodelling of the hillside.

Reno Mattress – The installation of a reno mattress (underlain with geofabric) is an alternative to gabion baskets. Instead of a stepped basket structure on a solid foundation the channel can instead be smoothed out and lined with a geofabric which is then covered in a layer of large crushed rock under a heavy duty galvanised steel mattress (size of rocks to be dependant on flow velocity and to be determined at detailed design stage). Reno mattresses have the added advantage of the ability to conform to the shape of the channel more naturally. Disadvantages of reno mattresses are that they are not as tolerant to the action of vertical cascading water (such as that on a waterfall or vertical drop) and still require regular maintenance.

For the lining of this section of channel it is recommended that a reno mattress be installed to the entire length of the eroded channel section. In addition to this the existing trash rack structure is to be maintained and cleaned out regularly.

Subcatchment M2

1.28ha

34% Pervious

66% Paved

Clean Water (CW) catchment.

Q5:	0.528m3/s
Q10:	0.625m3/s
Q100:	0.995m3/s

This subcatchment consists of the office building, and carparking facilities as well as a small section of natural catchment to the west. Sheet flows and concentrated flows from the small section of natural catchment are captured above ground and directed via piped stormwater to the M8 Catchment.

There is no mine operations in this section of the subject site and so it is assumed that all surface runoff will be considered as clean water. There is potential for some sediment load to come from the carpark area, this water will bypass the energy dissipater at the base of the stormwater channel, but in all low flows will pass through the lower existing weirs and ponds n Bellambi Creek before exiting the site which will allow for any light sediments to be removed, however it is therefore recommended that consideration be given to providing a bitumen sprayed seal to the carpark.

The M2 catchment drains overland in all events to its north eastern corner due to bunding along its eastern carpark edge. A number of options were considered, including regrading of the north eastern extent of this catchment to drain to the M3 catchment and then through to the southern channel. This option was rejected as it unnecessarily increased the flow through the M3 catchment with no net benefit. An alternative option of extending the proposed piped stormwater from M8 to the eastern extent of M2 would provide a safe and efficient passage of runoff and provide a failsafe overland flowpath (in the unlikely event of blockage) down the access road kerb and gutter.

Subcatchment M3

3.31ha

100% Pervious

Clean Water (CW) catchment.

Q5: 0.734m3/s

Q10: 0.923m3/s

Q100: 1.73m3/s

This subcatchment consists of an existing steep man made batter and set down area for materials, items of plant, and deliveries as well as an access road which links this area to the workshop area. The set down area and batters are free from coal and the mine operators have confirmed that there will be no dirty plant left in this area (dirty plant will be confined to the M1 catchment which has a first flush system).

Surface runoff from the northern extent of M3 collects along its access road which runs generally at a minimum longitudinal grade of 1.75%. Based on a basic check of capacity (manning's flow model) this longitudinal grade and an assumed crossfall of a minimum 3% and a 1m wide 250mm deep swale the roadway has capacity to contain a Q100 event (half of total catchment flow was assumed for northern half of catchment). Despite this, it is recommended that a minimum 0.5m bund be maintained along the length of this access road to ensure that obstructions within the flowpath (such as a poorly located piece of plant) do not result in water cascading to M5.

Beyond the roadway stormwater then enters a piped culvert which discharges to a broad channel. The capacity of this pipe is critical and its blocking would result in an increase of flows into M5. Based on a manning's calculations this pipe should be a minimum of 650mm

diameter and at a grade of not less than 2% to withstand the Q100 flow however due to the unpredictable nature of the materials being set down in this area there is potential for blockage of this pipe from floating debris (such as packaging or wooden pallets).

It is therefore advisable regardless of pipe capacity to maintain the existing piped culvert, but also provide a failsafe overland flowpath between the roadway and the broad channel. This can be achieved by constructing a higher crest in the access road to M5.

The southern portion of the M3 subcatchment then drains to a broad channel which is approximately 9m wide at its narrowest point. This channel is bunded to the east to prevent flows from entering the M5 catchment. The substantial cross section of this channel has more than adequate capacity for the Q100 event. In addition to its capacity the broad base of this channel provides a low flow filtration of sediments and runoff from this catchment and set down area.

The M3 catchment then drains to the southern stormwater channel which contains flows from the U1, U2, and M1 catchments. This section of the southern stormwater channel is highly eroded due to steep grades and the previous relocation of this channel along a ridgeline. As with the western portion of the southern stormwater channel in M1, it is recommended that a reno mattress be employed in this location to the entire length of this channel between the M1 and M5 catchments.

The junction with the M3 channel flows currently requires a vertical drop of 3-4m which is causing considerable additional erosion at this node. For reasons discussed in M1 above, it is recommended that a gabion drop structure be constructed at this node to ensure that no further erosion occurs. The sizing and detail of this drop structure will be determined at detailed design stage.

Beyond the spillway to the southern stormwater channel subcatchment then passes under the proposed conveyor crossing. This crossing was the site of a key failure in the 1998 storms in which debris caused blockage in the piped crossing and diverted the majority of the upper catchment flows. In order to minimise the risk of future major events overtopping this crossing it is recommended that an open channel or culvert structure be employed.

The option of an open gabion lined channel and concrete box culvert was assessed, however as this crossing will include a road overpass as well as the dirty water pipeline passing underneath minimising cross section whilst maximising flow is a priority. For this reason a box culvert was employed. The combined catchment flow rate through this section of the southern stormwater channel are below, and a minimum longitudinal grade of 10% has been assumed:

Q5: 7.69m3/s

Q10: 9.66m3/s

Q100: 17.3m3/s

In order to convey the above flow rates with a 0.5m freeboard in the Q100 event a minimum cross section of approximately 2.5m wide by 1.75m deep is recommended as per the sketches, this will allow for approximately 0.5m of freeboard above the Q100 water level. In addition to this it is recommended that the adjacent downstream ridgeline be extended to the roadside and the road and adjacent area to the south be graded towards the south. This regrading and extension of the ridgeline will provide a redundancy in the event of blockage of the culvert where water will re-enter the southern stormwater channel rather than continue down the belt decline towards the dirty water channel.

Subcatchment M4

0.30ha

100% Pervious

Clean Water (CW) catchment.

Q5: 0.149m3/s

Q10: 0.181m3/s

Q100: 0.300m3/s

This is a small component of heavily vegetated natural slope adjacent to the M7 conveyor portal catchment.

This catchment will be experiencing reduced flows with the collection of the M7 Dirty Water and drains to the M5 catchment. There are no works proposed for this catchment.

Subcatchment M5

1.98ha

100% Pervious

Clean Water (CW) catchment.

Q5: 0.874m3/s

Q10: 1.10m3/s

Q100: 1.98m3/s

This subcatchment consists entirely of steep man made batters and access roads. As with M3 the access roads are not proposed to be used for the haul of coal and all slopes are vegetated with grass. All stormwater on M5 is collected and channelled along its eastern extent. This channel is directly adjacent to the steep batter of the M6 subcatchment and so it is important that this stormwater is contained during a major event.

The M5 stormwater channel is very flat at its northern extent and increases gradually to a grade of approximately 6%. In order to effectively transport stormwater this area should be regraded to a minimum of 1% and a trapezoidal cross section of approximately 0.5m depth, 1m base, and 1:4 batters be provided. In addition to this a bund should be constructed and maintained along the eastern edge of this subcatchment adjacent to the batter slope of M6 to minimise the possibility of overland flow down this batter which could lead to erosion.

The entry to the proposed diversion drain is located adjacent to the steep batter of the M6 subcatchment. This batter is of concern due to geotechnical considerations and therefore it is important that flows are efficiently transported away. For this reason it is recommended that the proposed M5 channel be shotcreted to minimise infiltration of flows to the batter.

In addition to shotcreting of the channel, stabilisation and seeding of the steep batter slope should be undertaken to minimise the likelihood of any surface erosion in future rainfall events.

Subcatchment M6

1.36ha

100% Pervious

Clean Water (CW) catchment.

Q5: 0.368m3/s

Q10: 0.470m3/s

Q100: 0.818m3/s

This subcatchment, as with M5 is characterised by steep man made batters and an access road. M6 is also directly adjacent to the coal stockpile catchment L2 and is the final Clean Water catchment on the southern stormwater channel before the entry to the diversion drain. M6 carries overland flow via a channel along its eastern extent adjacent to the batter to L2. The average longitudinal grade of the M6 channel is to be regraded to a minimum of 1% and in order to contain the Q100 flow a swale of approximately 0.5m depth with 1:4 batters is recommended. As with M5 it is also recommended that a bund be constructed and maintained adjacent to the eastern extent of this subcatchment in order to minimise the possibility of diversion of flows down the steep batter.

At its southern extent the flows from the M6 subcatchment join with those of the M5 catchment and then pass under the conveyor to the southern stormwater channel. This combined flow of 2.798m3/s in the Q100 event is to be constructed at a minimum grade of 5%. A Hec-Ras model of the proposed channel has resulted in a rectangular box culvert channel of approximate base width 1.5m wide by 1.0m deep which will provide a 0.5m depth of freeboard above the Q100 limit (i.e. factor of safety of 2).

As with subcatchment M3, the road adjacent to the culvert crossing is recommended to be regraded towards the southern stormwater channel to provide a redundancy overland flowpath to the southern stormwater channel in the event of blockage of the box culvert.

As with M5, this diversion drain is located adjacent to the steep batter of the L2 subcatchment. This batter is of concern due to geotechnical considerations and therefore it is important that flows are efficiently transported away. For this reason it is recommended that the channel be shotcreted to minimise infiltration of flows to the batter. In addition to shotcreeting of the channel, stabilisation and seeding of the steep batter slope should be undertaken to minimise the likelihood of any surface erosion in future rainfall events.

Subcatchment M7

1.73ha

100% Pervious

Dirty Water (DW) catchment.

Q5: 0.654m3/s

Q10: 0.778m3/s

Q100: 1.290m3/s

The M7 subcatchment is located at the southern extent of the subject site and is the location of the conveyor portal outlet from underground operations. Although conveyor design is placing emphasis on the clean transportation of coal from the portal to the stockpile, as a precaution this area has been assumed as Dirty Water to minimise the impact of localised coal spills and dust from the conveyor systems and maintenance.

Dirty Water runoff from this catchment is to be graded towards and along the access road (which is to be sealed) and directed to a piped stormwater system which will carry the Dirty Water down to the stockpile area and sediment basins. By piping this water we can ensure that it will remain separate from the clean water system.

Subcatchment M8

1.78ha

95% Pervious

5% Paved

Clean Water (CW) catchment.

Q5: 0.473m3/s

Q10: 0.615m3/s

Q100: 1.09m3/s

The M8 subcatchment runs along the northern extent of the subject site adjacent to the access road. The subcatchment is characterised by a long narrow natural ridge and a sealed roadway. The roadway is not proposed to be used for the haul of coal and is primarily an access for the office and U3 catchment. The existing stormwater which runs off the road and the ridge enters a road side swale which is heavily eroded and in need of maintenance or replacement.

As all water entering this catchment is free from coal it is to be considered Clean Water and is proposed to be collected via a piped stormwater system which will transport the water through

the L2 subcatchment into an existing section of the Clean Water diversion pipeline which is to remain (east of stockpile).

As the natural soil in this location is that of a ridgeline and also passes through a naturally exposed coal seam it is highly erodible and showing considerable scour in many locations. This scouring is also resulting in degradation of the pavement edge adjacent to this drain. As discussed with the mine operators, it is advised that this section of drainage be piped underground and the road regraded towards a kerb and gutter system with kerb inlet pits at a maximum of 50m spacing.

The alternative of kerb and gutter is an open swale with grated surface inlet pits, however to address the issue of scouring the swale would require shotcrete treatment and regular maintenance to inspect for undercutting and erosion of the shotcrete.

Kerb and gutter adjacent to the pavement also provides a solid edge for pavement which will minimise erosion and degradation of this edge from the action of vehicles and prolong the life of the pavement.

Subcatchment L1

4.84ha

100% Pervious

Clean Water (CW) catchment.

Q5: 0.738m3/s

Q10: 0.951m3/s

Q100: 1.940m3/s

This catchment consists of the ridge and slope immediately adjacent to the clean water diversion channel which runs past the proposed stockpile area.

A number of options have been considered for the diversion of stormwater around the stockpile site, with emphasis being placed on the requirement for the channel to remain at a higher level than the adjacent stockpile area. The reason for this was to ensure that even in the event of heavy rainfall occurring during a full stockpile (i.e. during a rare shipping delay) the slumped stockpile would not be able to spill into the clean water diversion drain.

In addition to the elevation requirement an existing dam on the ridge adjacent to this drain is strongly recommended by the geotechnical engineer to be removed and the slope regraded to ensure that slope stability in major rainfall events (minimising the chance of land slip obstructing channel). Three channel alignment options were proposed to the mine operators including expected regraded contours of slope which are presented in sketch SK6. The option of a channel commencing at elevation RL65 has been selected as a conservative option in the absence of a final design for the stockpiles however it is recommended that the slope stability of this area be of particular attention to the detailed design of this channel on the hillside.

Design requirements of the client for this section of channel are that it needs to be wide enough to drive up and maintain (min 2.5m wide) be resistant to erosion, and be able to convey the 1:100 year storm event with a safety margin of 0.5m freeboard.

Options investigated included a gabion lined trapezoidal channel, grass lined channel, concrete box culvert, and earth channel with shotcrete coating. Grades considered ranged from 1% minimum to a 5% maximum.

Due to the requirement to maintain a level above the stockpile (which at the time of writing has not been finalised) and also to minimise velocities in the channel, a maximum grade of 1% was decided upon adjacent to the stockpile and the option of a concrete box culvert for minor storm flow was chosen. The proposed design will incorporate a concrete box culvert section of approximate dimensions 2.5m wide by 1.2m high which has capacity to deal with a 10year ARI event, this box culvert then opens to a trapezoidal channel of 1m depth which provides capacity for a 100year ARI storm with a freeboard of 0.5m. This structure is recommended to be constructed into the newly regraded slope which will minimise the likelihood of failure (rather than a cut/fill balanced bund arrangement. A detail of this preliminary cross section option can be seen on sketch SK4.

As the length of this channel is approximately 530m and the elevation change between its extents is approximately 25m in the conservative option chosen (in the absence of stockpile elevations) a 1% grade is not appropriate for the entire length of the site. For this reason it is suggested that the channel be steepened to a maximum of 5% grade beyond the stockpile and if compatible with the stockpile the main channel grade increased to 2%. This will reduce the required section of the channel but will substantially increase flow velocities. If it is assumed that 180m of channel is to be constructed at 5% grade, with the remaining 350m at 1% there will need to be a total of 12.5m in vertical drop structures along the length of the channel, or alternatively at 2% for the length of the stockpile a vertical drop of 9m.

Subcatchment L2

12.07ha

90% Pervious

10% Paved

Dirty Water (DW) catchment.

Q5: 2.84m3/s

Q10: 3.52m3/s

Q100: 6.51m3/s

This catchment consists primarily of the coal stockpile, truck loading bay, and surrounding dirty areas. It is the primary generator of dirty water within the site and the final catchment before entry of dirty water to the sediment basins.

Stormwater collected from this catchment as well as stormwater collected from the M7 and M1 (first flush) catchments is directed via a piped stormwater system to the proposed

sediment basins. The sizing and location of this piped system will be detailed in construction issue drawings and is dependent heavily on the location, elevation, and size of proposed stockpiles and infrastructure on site.

The proposed sediment collection system will allow for settlement of fine and coarse sediments through two basins of combined surface area of up to 8500m2 at a minimum depth of 0.5m (i.e. providing a minimum of 4250m3). This preliminary design is based on the requirement of approximately 300m3/ha of storage and using the Soils and Construction Handbook (Blue Book). Basins should be constructed such that easy draining and access is available to the mine operators.

The existing 62ML dam is to continue to be used for storage of dirty water for treatment prior to discharge to the creek or reuse on site. Sizing and assessment of this basin has been based on hydrographs for the base of this catchment and the requirement to contain all storms up to and including a 10yr ARI event. The facility has the ability to pump out of this dam at between 150-300kl/hr via two pumps which are fed to clarifiers which treat the dirty water prior to reuse or discharge to the creek during storm events.

The total capacity of this basin is highly dependent on its level of silts and fines which were not fully captured in basins 1 & 2 (due to the nature of the low density of coal fines suspending in water for extended periods).

In order for the mine to ensure that all storms up to a 10year event can be contained/treated within the site, a minimum of 30ML of capacity should be maintained within the basin at all times. This is assuming a pump rate of 300kL/hr and an increase to 35ML capacity is required if pumping at 150kl/hr is only available. It is important that pumping be available in the dam at all times as spare capacity in a dry spell can easily be used up in the weeks leading to a major storm.

Channel Treatments

The southern drainage channel is characterised by a steep grade and in a number of areas appears to contain highly erodible soils and coal seams. This appears to have been a major contributor to a number of the blockages experienced during the 1998 event where large rocks, plants, and debris were washed downstream until they lodged in pipes or culverts.

Due purely to the grade and velocities within the varying soil conditions it is recommended that further detailed geotechnical assessment be undertaken following the Part 3A approval and prior to detailed civil design along the length of the southern stormwater channel. The purpose of this investigation will be to determine which areas of the channel are stable (and possibly on bedrock) and only require maintenance and which areas require reno mattress reinforcement.

Based on investigations following our own site inspection it is recommended that a reno mattress or gabion be placed in at least the following areas:

- Subcatchment M1 – (Reno mattress) Directly west of culvert crossing extending beyond coal seams and highly eroded steep channel section.

- Subcatchment M1 – (Gabion basket drop structure) Directly east of culvert crossing where channel drops into M3 subcatchment.

- Subcatchment M3 – (Gabion basket drop structure) Southern extent of M3 channel at junction of southern stormwater channel.
- Subcatchment M3 – (Reno mattress) Approximately 50m adjacent to culvert crossing of conveyor road.
- Subcatchment M5 – (Gabion basket drop structure) Directly downstream of conveyor road culvert crossing.
- Subcatchment M5 – (Reno mattress) M5 to M6 connection swale.
- Subcatchment M6 – (Reno mattress) Approximately 50m adjacent to headwall inlet to stockpile diversion channel.
- Subcatchment M6 – (gabion basket drop structure) Southern extent of M6 channel at junction of southern stormwater channel.

It should be reinforced that if we are to ensure that in the event of a major storm the only way to minimise any potential blockage of the channel is to ensure that the entire southern channel be stabilised. If areas other than those above are considered geotechnically stable it is still advised that these areas be cleared of large rocks and vegetation, trimmed, compacted and stabilised with either shotcrete or preferably a reno mattress.

Maintenance

The above recommended treatments should be regularly inspected (at least annually) to ensure that all gabions, reno mattresses, shotcrete, and banks are free from slumps and damage. This should include inspection of any damage to the basket of rock mattresses and gabions and if required repair of damaged sections. Shotcrete in particular should be checked for holes or damage in the flowpath of the creek as their presence can often lead to the undermining of the channel through the action of piping and eddies which will eventually lead to the failure of the channel, for this reason reno mattress (underlain with geofabric) is preferred as it will conform to slips and settlement more dynamically than rigid shotcrete.

In addition to the above treated sections of channel, all open grass lined channels and batters should be kept free from trees, heavy weeds (such as lantana) and any blockages (branches, rocks, etc.).

Bellambi Creek and Princes Hwy Culvert Crossing

Following diversion of clean water around the stockpile and dirty areas this water then enters Bellambi Creek at the eastern extent of the site where it continues east combined with additional lower catchment flows before passing under the Princes Highway via an existing concrete Culvert of dimensions 2.4m wide by 1.5m high. It is important to note that the proposed stormwater concept will not alter the flowrate of stormwater to this lower catchment, however due to the treatment of the flowpath around the site the likelihood of blockages in this catchment will be significantly reduced.

A preliminary study of this catchment has confirmed that the existing culvert is inadequate for even a Q10 event during which backwaters would accumulate until they spill over the Princes Highway. From site observations, it is not clear whether the low point of this road crossing is located at the culvert crossing and visibly appears to be further north. This would result in

flood waters potentially flowing through the adjacent workshop and business before re-entering Bellambi Creek due to a man made bund adjacent to the creek (possibly as a reaction to flooding in the 1998 event).

In order to reduce this risk the RTA should consider the upgrading of the existing culvert crossing, as well as regrading to ensure that waters quickly divert back to the creek. The existing Bellambi Creek east of the Princes Highway culvert crossing should be maintained by the relevant authority to be free from heavy undergrowth and weeds to ensure that this does not contribute to blockage of the culvert (resulting in overtopping of the Princes Highway).

In addition to this, it is recommended that the mine operators clear all obstructions from the Bellambi creek west of the Princes Highway culvert such as undergrowth, trees in invert and banks, weeds and crossings to minimise the chance of blockage to the existing culvert. The flowpath of the existing Bellambi Creek west of the Princes Highway is also currently inhibited by an existing small piped culvert crossing which serves as an access for the mine operators to the south eastern portion of the site. It is recommended that this crossing be removed and a low level causeway crossing be erected instead. This would have the dual benefit of slowing velocities in minor flow events, whilst not causing a major obstruction in a major event. Although flooding of this area will not affect mine operations, this areas maintenance should minimise future flooding possibilities from minor storms.

Conclusion

Although there is no increase in impervious area or flow intensities across the site, this is an opportunity to improve stormwater performance in a major event. In accordance with the recommendations of *Managing Urban Stormwater: soils and construction volumes 1 and 2E*; the stormwater concept proposes a number of measures which will minimise the likelihood of a failure such as 1998 occurring in the future, through both the maintenance and upgrade of existing diversions and flowpaths (such as those in the upper subcatchments) and the recommendation of open channels and diversions around the stockpile area with settlement basins, scour protection, and clearing of undergrowth.

It should also be noted that downstream of the site there are issues that may result in substantial impacts on the community due to flooding. These are the road culvert under the Princes Highway giving rise to a potential choke point and also the state of the Bellambi Creek East of the Princes Highway that has been significantly altered, with the potential to restrict the flow of water along its length.

It is recommended that the existing and proposed diversion channels and drains be lined as recommended above in consultation with geotechnical advice and maintained regularly to minimise scouring during major flow events. All reno mattress areas should be regularly inspected and repaired where necessary, and all shotcrete areas are to be inspected for undermining and eddies which could lead to erosion if left unaddressed.

Appendix 1) – Hydrology Review Sketches

Drawing Plotted: 04 May 2010 13:50

0 25m

SCALE

FOR INFORMATION
NOT FOR CONSTRUCTION

No.	Revision	By	Chk	Appd	Date
B	CONCEPT DESIGN - NOT FOR CONSTRUCTION	AS	SM		8/10/09
A	CONCEPT DESIGN - ISSUED FOR REVIEW	SK	SM		23/7/09

Drawing Originator: Beca

Original Scale (A1) 1:500	Design	PI	23/7/09
	Drawn	SK	23/7/09
Reduced Scale (A3) 1:1000	Dsg Verifier	SM	29/9/09
	Dwg Check		Date

Approved For Construction*

* Refer to Revision 1 for Original Signature

Client: GUJARAT NRE

Project: GUJARAT NRE No. 1 HYDROLOGICAL INVESTIGATION

Title: PROPOSED DAM WALL REGRADE AND CHANNEL OPTIONS

Discipline: CIVIL

Drawing No.: 2591308-C-SK6

Rev.: B

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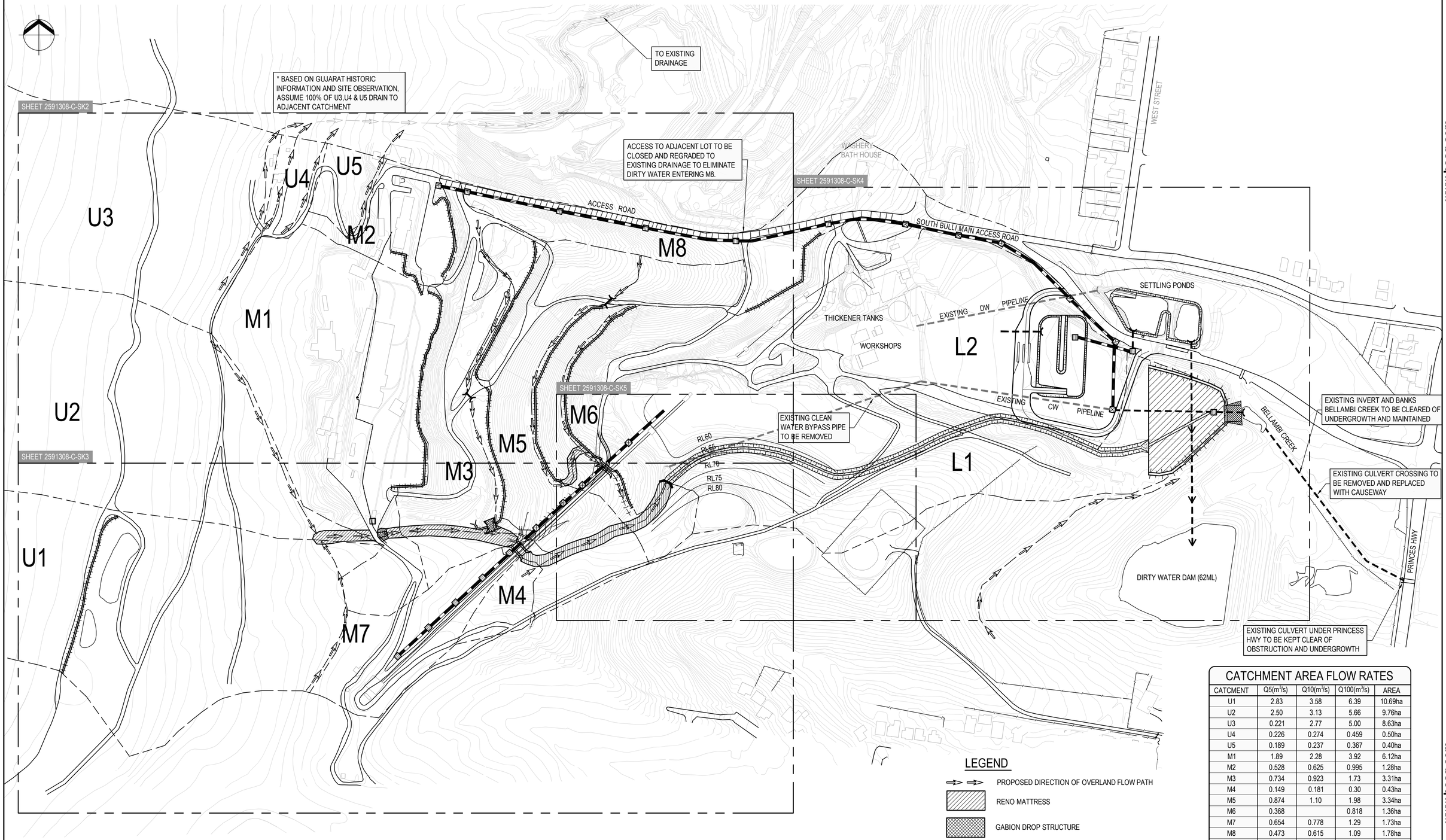


CATCHMENT AREA FLOW RATES

CATCMENT	Q5(m^3/s)	Q10(m^3/s)	Q100(m^3/s)	AREA
U1	2.83	3.58	6.39	10.69ha
U2	2.50	3.13	5.66	9.76ha
U3	0.221	2.77	5.00	8.63ha
U4	0.226	0.274	0.459	0.50ha
U5	0.189	0.237	0.367	0.40ha
M1	1.89	2.28	3.92	6.12ha
M2	0.528	0.625	0.995	1.28ha
M3	0.734	0.923	1.73	3.31ha
M4	0.149	0.181	0.30	0.43ha
M5	0.874	1.10	1.98	3.34ha
M6	0.368		0.818	1.36ha
M7	0.654	0.778	1.29	1.73ha
M8	0.473	0.615	1.09	1.78ha
L1	0.738	0.951	1.94	4.84ha
L2	2.84	3.52	6.51	12.07ha

LEGEND

- PROPOSED DIRECTION OF OVERLAND FLOW PATH
- RENO MATTRESS
- GABION DROP STRUCTURE
- BUND WALL
- HEADWALL (HW)
- GREATED SURFACE INLET PIT (GSIP)
- SEALED JUNCTION PIT (SJI)

0 100m

SCALE

FOR INFORMATION
NOT FOR CONSTRUCTION

No.	Revision	By	Chk	Appd	Date
B	CONCEPT DESIGN - NOT FOR CONSTRUCTION	AS	SM		8/10/09
A	CONCEPT DESIGN - ISSUED FOR REVIEW	AS	SM		23/7/09

Drawing Originator: Beca

Original Scale (A1) 1:2000	Design	PI	23/7/09
	Drawn	AS	23/7/09
Reduced Scale (A3) 1:4000	Dsg Verifier	SM	29/9/09
	Dwg Check		Date

Approved For Construction*

* Refer to Revision 1 for Original Signature

Client: GUJARAT NRE

Project: GUJARAT NRE No. 1 HYDROLOGICAL INVESTIGATION

Title: GENERAL SITE LAYOUT WITH CATCHMENT AREAS & FLOW RATES

Discipline: CIVIL

Drawing No.: 2591308-C-SK1

Rev.: B

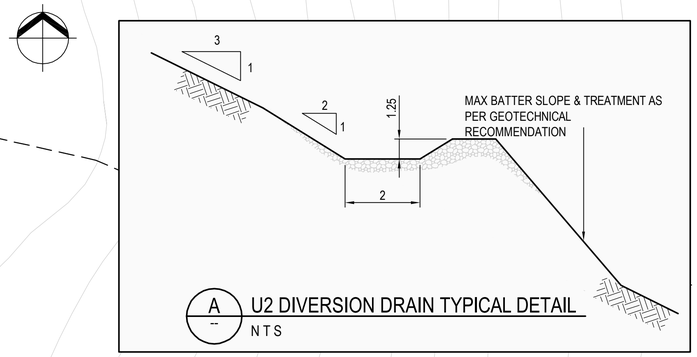
DO NOT SCALE

IF IN DOUBT ASK.

www.beca.com

Document No. 2591308-C-SK1.dwg

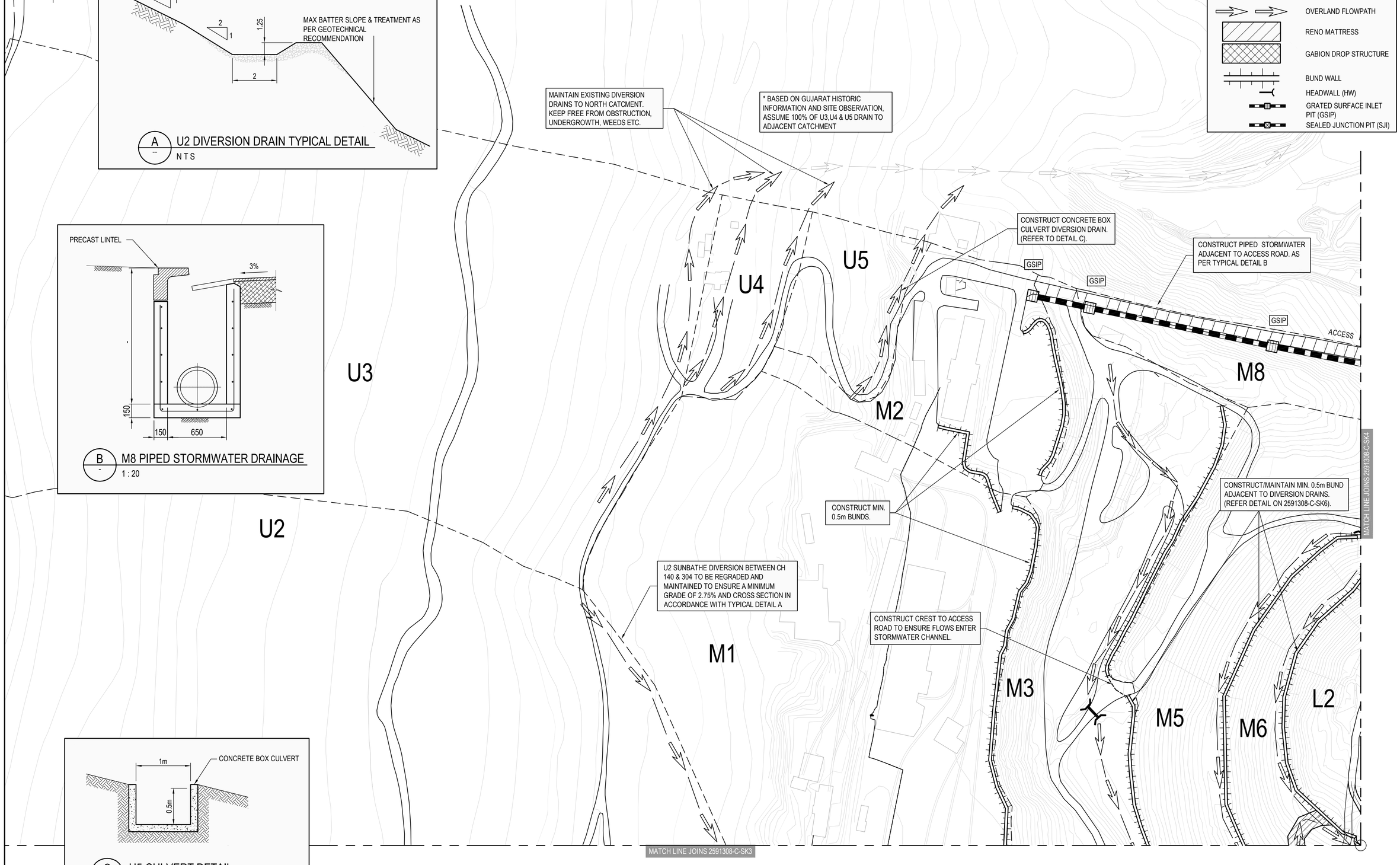
Drawing Plotted: 04 May 2010 13:48



A — U2 DIVERSION DRAIN TYPICAL DETAIL
NTS

B — M8 PIPED STORMWATER DRAINAGE
1 : 20

C — U5 CULVERT DETAIL
1 : 50



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SCALE

FOR INFORMATION
NOT FOR CONSTRUCTION

No.	Revision	By	Chk	Appd	Date
B	CONCEPT DESIGN - NOT FOR CONSTRUCTION	AS	SM		8/10/09
A	CONCEPT DESIGN - ISSUED FOR REVIEW	SK	SM		23/7/09

Drawing Originator: Beca

Original Scale (A1) 1:1000	Design	PI	23/7/09
	Drawn	SK	23/7/09
Reduced Scale (A3) 1:2000	Dsg Verifier	SM	29/9/09
	Dwg Check		Date

Approved For Construction*
* Refer to Revision 1 for Original Signature

Client: GUJARAT NRE

Project: GUJARAT NRE No. 1 HYDROLOGICAL INVESTIGATION

Title: SITE LAYOUT DETAIL 1 OF 4 - NORTH WEST

Discipline: CIVIL

Drawing No.: 2591308-C-SK2

Rev.: B

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www.beca.com

Document No. 2591308-C-SK2.dwg

MATCH LINE JOINS 2591308-C-SK2

U2

U1

M1

M3

M4

M5

M7

MAINTAIN EXISTING BUND ADJACENT TO DAMS TON ENSURE DIVERSION OF UPPER CATCHMENT FLOWS,

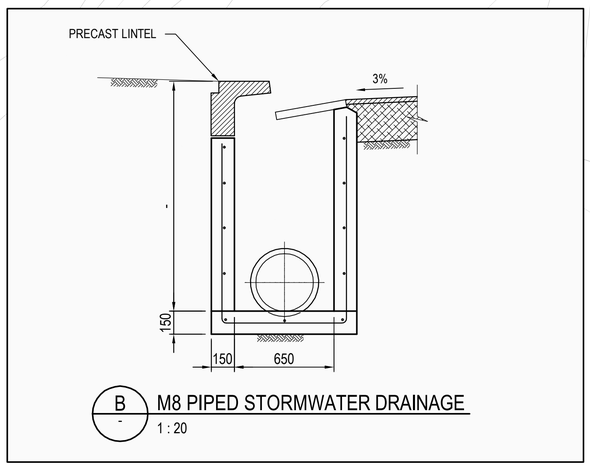
STORAGE DAMS FOR MINE USE

U1 SUBCATCHMENT DIVERSION DRAIN TO BE CONSTRUCTED AND MAINTAINED TO ENSURE MINIMUM GRADE OF 2% AND CROSS SECTION IN ACCORDANCE WITH TYPICAL DETAIL A.

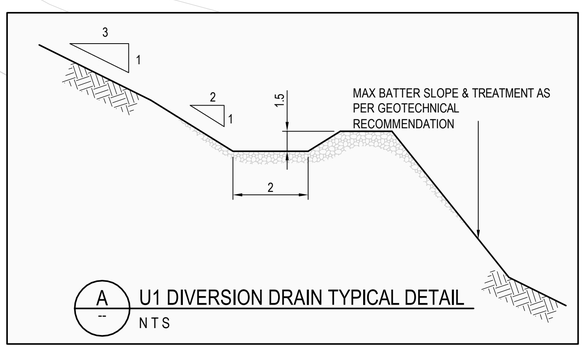
EXISTING FIRST FLUSH SYSTEM TO BE MAINTAINED.

CONSTRUCT DIRTY WATER PIPE PIT COLLECTION SYSTEM. (SEE TYPICAL DETAIL B).

MATCH LINE JOINS 2591308-C-SK4



B
-
M8 PIPED STORMWATER DRAINAGE
1 : 20



A
--
U1 DIVERSION DRAIN TYPICAL DETAIL
NTS

LEGEND:

- OVERLAND FLOWPATH
- RENO MATTRESS
- GABION DROP STRUCTURE
- BUND WALL
- HEADWALL (HW)
- GRATED SURFACE INLET PIT (GSIP)
- SEALED JUNCTION PIT (SJI)

0 50m

SCALE

FOR INFORMATION
NOT FOR CONSTRUCTION

No.	Revision	By	Chk	Appd	Date
B	CONCEPT DESIGN - NOT FOR CONSTRUCTION	AS	SM		8/10/09
A	CONCEPT DESIGN - ISSUED FOR REVIEW	SK	SM		23/7/09

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Original Scale (A1) 1:1000	Design	PI	23/7/09
	Drawn	SK	23/7/09
Reduced Scale (A3) 1:2000	Dsg Verifier	SM	29/9/09
	Dwg Check		Date

Approved For Construction*

* Refer to Revision 1 for Original Signature

Client: GUJARAT NRE

Project: GUJARAT NRE No. 1 HYDROLOGICAL INVESTIGATION

Title: SITE LAYOUT DETAIL 2 OF 4 - SOUTH WEST

Discipline: CIVIL

Drawing No.: 2591308-C-SK3

Rev.: B

DO NOT SCALE

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www.beca.com

Document No. 2591308-C-SK3.dwg

ACCESS ROAD

GSIP

GSIP

GSIP

ACCESS TO ADJACENT LOT TO BE CLOSED AND REGRADED TO EXISTING DRAINAGE TO ELIMINATE DIRTY WATER ENTERING M8.

SJP

SJP

SJP

SOUTH BULLI MAIN ACCESS ROAD

M8

MATCH LINE JOINS 2591308-C-SK2

BUND

NOTE: DIRTY WATER TO BE DIRECTED THROUGH A PRIMARY (DRY) AND SECONDARY SETTLEMENT BASIN IN ORDER TO REMOVE COARSE AND FINE SEDIMENTS. TOTAL SURFACE AREA OF BASINS APPROX 8500m^2 DIRTY WATER THEN STORED IN 62ML DIRTY WATER DAM FOR TREATMENT AND DISCHARGE TO BELLAMBI CREEK. 62ML DIRTY WATER DAM TO HAVE A MINIMUM SPARE CAPACITY OF 30ML TO ACCOMMODATE A 10 YEAR ARI EVENT.

ACCESS RAMPS FOR MAINTENANCE

DRY SEDIMENT BASIN AS PER TYPICAL DETAIL. (REFER TO DWG 2591308-C-SK4)

SJP

SETTLING PONDS

EXISTING SETTLEMENT POND WALL TO BE DEMOLISHED AND BASIN REGRADED

EXISTING DW PIPELINE

THICKENER TANKS

L2

NO STOCKPILE INFORMATION AVAILABLE, TO BE UPDATED

DIRTY WATER INFLOW

BASIN 2 (WET)

WORKSHOPS

EXISTING AND PROPOSED DIRTY WATER FLOW TO BE DIRECTED TO NEW SETTLEMENT BASIN. (TO BE FINALISED UPON STOCKPILE DETAIL).

STORMWATER ENERGY DISSIPATER AND SETTLEMENT AREA WITH LOW FLOW PIT. (REFER DETAIL DWG 2591308-C-SK6)

BASIN 1 (DRY)

GABION BASKET SPILLWAY TO DISCHARGE TO BELLAMBI CREEK IN MAJOR STORM EVENTS

NO STOCKPILE INFORMATION AVAILABLE, TO BE UPDATED

SJP

EXISTING CW PIPELINE

ACCESS RAMPS FOR MAINTENANCE

EXISTING HEADWALL AND STORMWATER PIPE TO BE REMOVED

CONSTRUCT CLEAN WATER DIVERSION DRAIN AS PER TYPICAL DETAIL A.

BELLAMBI CREEK

SLOPE 1%

GRATED SURFACE INLET PIT WITH RESTRICTED INLET CAPACITY TO ALLOW LOW FLOWS TO ENTER BELLAMBI CREEK.

RL60

RL65

RL70

RL75

RL80

L1

MAINTAIN EXISTING DIVERSION DRAIN

LOW FLOW CONCRETE LINED INVERT FOR DRY WEATHER AND MINOR STORM FLOWS.

L1

M6

EXISTING DW PIPELINE

LEGEND:

OVERLAND FLOWPATH

RENO MATTRESS

GABION DROP STRUCTURE

BUND WALL

HEADWALL (HW)

GRATED SURFACE INLET PIT (GSIP)

SEALED JUNCTION PIT (SJI)

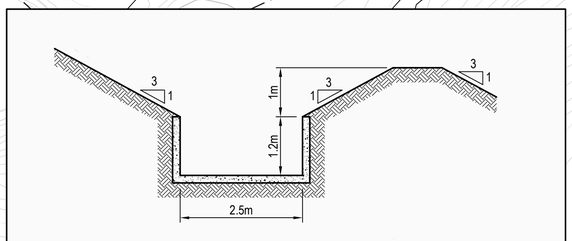
EXISTING DAM TO BE REMOVED AND NORTHERN SLOPE TO BE REGRADED.

M5

MATCH LINE JOINS 2591308-C-SK3

DIRTY WATER DAM (62ML)

NOTE: DIRTY WATER DAM TO BE MAINTAINED WITH A MIN. 30ML CAPACITY AT ALL TIMES TO MINIMISE RISK OF OVERTOPPING IN A 10 YEAR EVENT



A - CLEAN WATER DIVERSION DRAIN
1 : 50

0 50m
SCALE

FOR INFORMATION
NOT FOR CONSTRUCTION

No.	Revision	By	Chk	Appd	Date
B	CONCEPT DESIGN - NOT FOR CONSTRUCTION	AS	SM		8/10/09
A	CONCEPT DESIGN - ISSUED FOR REVIEW	SK	SM		23/7/09

Drawing Originator: Beca

Original Scale (A1) 1:1000	Design	PI	23/7/09
	Drawn	SK	23/7/09
Reduced Scale (A3) 1:2000	Dsg Verifier	SM	29/9/09
	Dwg Check		Date

Approved For Construction*

* Refer to Revision 1 for Original Signature

Client: GUJARAT NRE

Project: GUJARAT NRE No. 1 HYDROLOGICAL INVESTIGATION

Title: SITE LAYOUT DETAIL 3 OF 4 - EAST

Discipline: CIVIL

Drawing No.: 2591308-C-SK4

Rev.: B

www.beca.com

Document No. 2591308-C-SK4.dwg

DO NOT SCALE

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NOTE: EXISTING GRASSED OVERLAND FLOW AREA AVAILABLE AS PRIMARY SETTLEMENT AREA FOR FINE SEDIMENTS AND POLLUTANTS FROM SET DOWN AREA

ROAD TO BE REALIGNED AROUND CROSSING

EXISTING PIPED CLEAN WATER DIVERSION DRAIN AND HEADWALL TO BE REMOVED

M6 CONVEYER UNDERPASS CHANNEL AS PER TYPICAL DETAIL B.

CONSTRUCT CONCRETE HEADWALL TO DIRECT FLOWS INTO CLEAN WATER DIVERSION CHANNEL

CONSTRUCT CREST TO ACCESS ROAD TO ENSURE FLOWS ENTER STORMWATER CHANNEL

MAINTAIN EXISTING BUND WALL.

CONSTRUCT CLEAN WATER DIVERSION CHANNEL AS PER DETAIL. (REFER TO DWG 2591308-C-SK4).

CONSTRUCT GABION DROP STRUCTURE TO CULVERT CROSSING

GABION BASKET SPILLWAY.

EXTEND RIDGELINE ADJACENT TO ROAD

REGRADE PAVEMENT AND ADJACENT AREA TO PROVIDE FAIL SAFE OVERLAND FLOW IN EVENT OF CULVERT BLOCKING

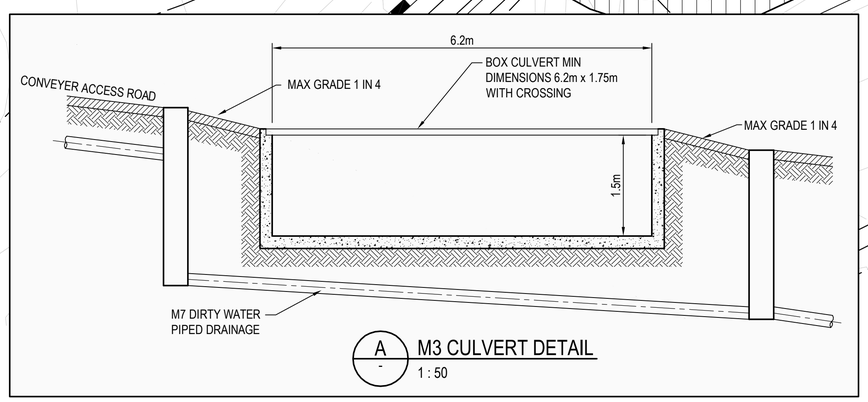
M3 CONVEYER UNDERPASS CHANNEL AS PER TYPICAL DETAIL A.

EXISTING CHANNEL TO BE CLEARED AND STABILISED. ALL AREAS NOT ON BEDROCK TO BE LINED WITH RENO MATTRESS. ALL LARGE BOULDERS AND OBSTRUCTIONS TO BE CLEARED FROM CHANNEL TO MINIMISE POTENTIAL BLOCKAGE DOWN STREAM.

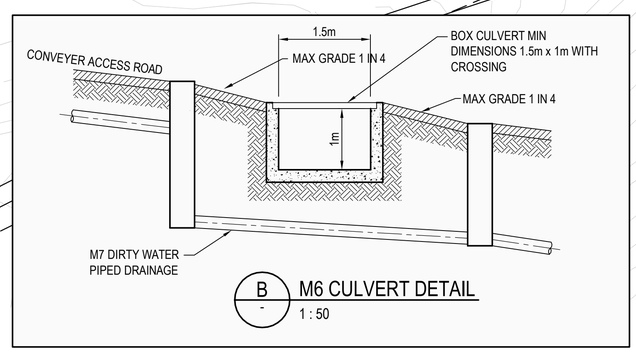
EXISTING CHANNEL TO BE CLEARED AND STABILISED. ALL AREAS NOT ON BEDROCK TO BE LINED WITH RENO MATTRESS. ALL LARGE BOULDERS AND OBSTRUCTIONS TO BE CLEARED FROM CHANNEL TO MINIMISE POTENTIAL BLOCKAGE DOWN STREAM.

0 25m

SCALE



A - M3 CULVERT DETAIL
1 : 50



B - M6 CULVERT DETAIL
1 : 50

LEGEND:

- OVERLAND FLOWPATH
- RENO MATTRESS
- GABION DROP STRUCTURE
- BUND WALL
- HEADWALL (HW)
- GRATED SURFACE INLET PIT (GSIP)
- SEALED JUNCTION PIT (SJI)

FOR INFORMATION
NOT FOR CONSTRUCTION

No.	Revision	By	Chk	Appd	Date
B	CONCEPT DESIGN - NOT FOR CONSTRUCTION	AS	SM		8/10/09
A	CONCEPT DESIGN - ISSUED FOR REVIEW	SK	SM		23/7/09

Drawing Originator: Beca

Original Scale (A1) 1:500	Design	PI	23/7/09
Reduced Scale (A3) 1:1000	Drawn	SK	23/7/09
	Dsg Verifier	SM	29/9/09
	Dwg Check		Date

Approved For Construction*

* Refer to Revision 1 for Original Signature

Client: GUJARAT NRE

Project: GUJARAT NRE No. 1 HYDROLOGICAL INVESTIGATION

Title: SITE LAYOUT DETAIL 4 OF 4 - CLEAN WATER CHANNEL

Discipline: CIVIL

Drawing No.: 2591308-C-SK5

Rev.: B

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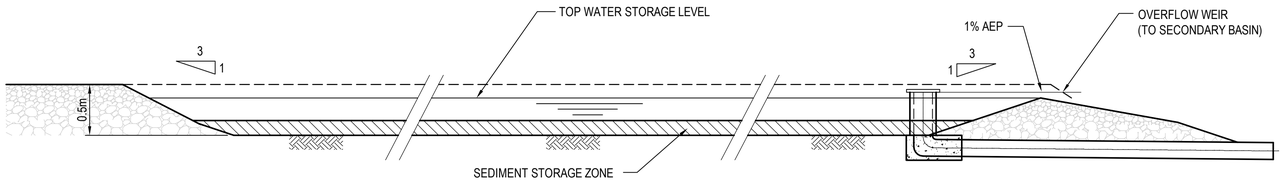
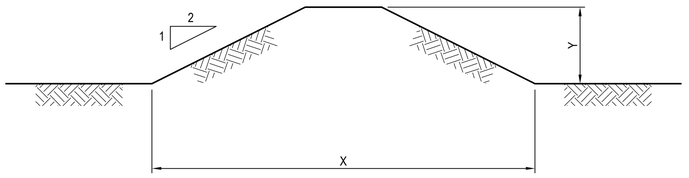
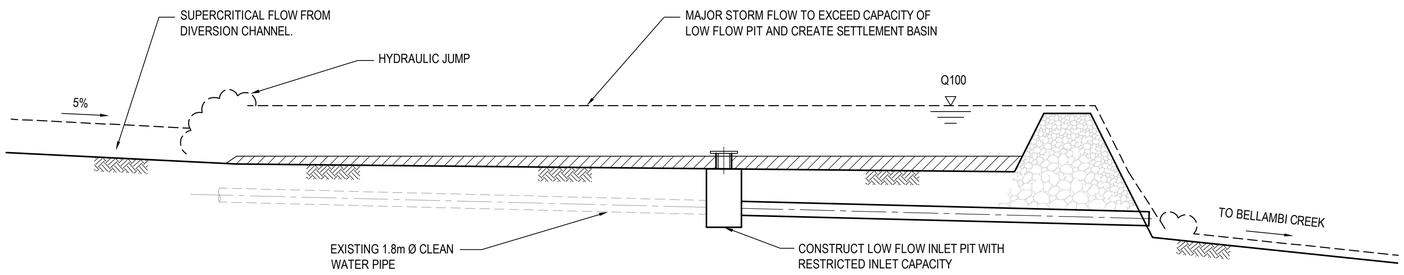
Document No. 2591308-C-SK5.dwg



1 - TYPICAL SECTION DETAIL - DRY SEDIMENT POND
NTS



3 - DETAIL - TYPICAL EARTH BUND
1 : 20



2 - CLEAN WATER SETTLEMENT BASIN
NTS

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NOT FOR CONSTRUCTION

No.	Revision	By	Chk	Appd	Date
B	CONCEPT DESIGN - NOT FOR CONSTRUCTION	AS	SM		8/10/09
A	CONCEPT DESIGN - ISSUED FOR REVIEW	SK	SM		23/7/09

Drawing Originator: Beca

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	Drawn	SK	23/7/09
Reduced Scale (A3) 1:40	Dsg Verifier	SM	29/9/09
	Dwg Check		Date

Approved For Construction*
* Refer to Revision 1 for Original Signature

Client: GUJARAT NRE

Project: GUJARAT NRE No. 1
HYDROLOGICAL INVESTIGATION

Title: DETAILS SHEET

Discipline: CIVIL

Drawing No.: 2591308-C-SK8

Rev.: B

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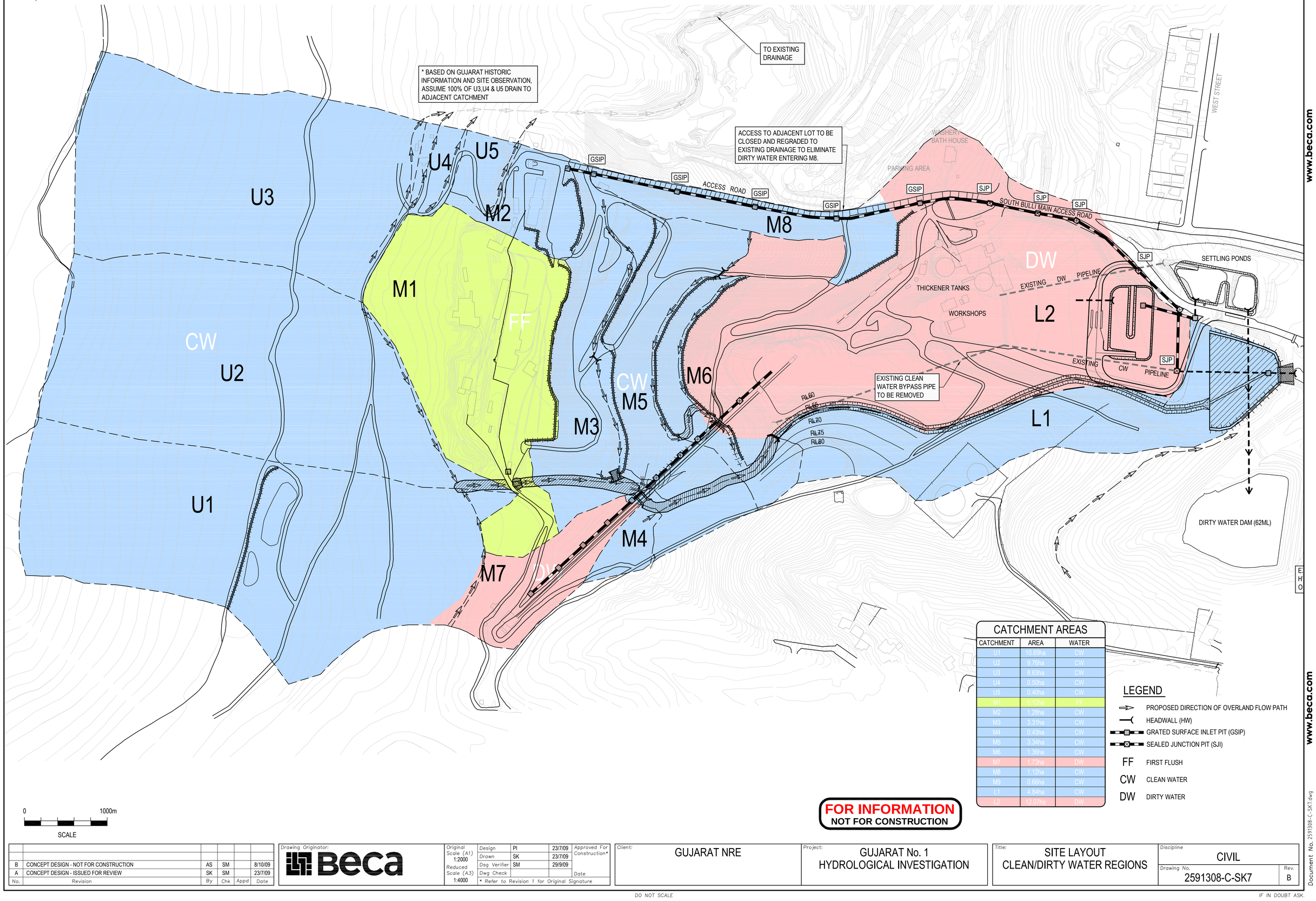
Drawing Plotted: 04 May 2010 13:51



CATCHMENT AREAS		
CATCHMENT	AREA	WATER
U1	10.69ha	CW
U2	9.76ha	CW
U3	8.63ha	CW
U4	0.50ha	CW
U5	0.40ha	CW
M1	6.12ha	FF
M2	1.28ha	CW
M3	3.31ha	CW
M4	0.43ha	CW
M5	3.34ha	CW
M6	1.36ha	CW
M7	1.73ha	DW
M8	1.12ha	CW
M9	0.66ha	CW
L1	4.84ha	CW
L2	12.07ha	DW

LEGEND

- PROPOSED DIRECTION OF OVERLAND FLOW PATH
- HEADWALL (HW)
- GRATED SURFACE INLET PIT (GSIP)
- SEALED JUNCTION PIT (SJI)
- FF FIRST FLUSH
- CW CLEAN WATER
- DW DIRTY WATER

0 1000m

SCALE

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NOT FOR CONSTRUCTION

No.	Revision	By	Chk	Appd	Date
B	CONCEPT DESIGN - NOT FOR CONSTRUCTION	AS	SM		8/10/09
A	CONCEPT DESIGN - ISSUED FOR REVIEW	SK	SM		23/7/09

Drawing Originator: Beca

Original Scale (A1) 1:2000
Reduced Scale (A3) 1:4000

Design	PI	23/7/09	Approved For Construction*
Drawn	SK	23/7/09	
Dsg Verifier	SM	29/9/09	
Dwg Check			Date

* Refer to Revision 1 for Original Signature

Client: GUJARAT NRE

Project: GUJARAT No. 1 HYDROLOGICAL INVESTIGATION

Title: SITE LAYOUT CLEAN/DIRTY WATER REGIONS

Discipline: CIVIL

Drawing No.: 2591308-C-SK7

Rev.: B

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www.beca.com

Document No. 2591308-C-SK7.dwg

Annex B

JBK Plans

REFERENCE DRAWINGS	DRG. No.
LONG SECTION OF BELT LINE	282804

NOTES:
1. WONGA COAL FED TO C5 BELT VIA FEEDER IN TUNNEL.
2. BULLI COAL FED TO C5 BELT VIA EXCAVATOR/ SIZER AND FEEDER SIMILAR TO CURRENT BALGOWNIE BIN OPERATION

MGA

MAIN SUB STN
ADMIN BUILDING
CAR PARK
BATH HOUSE
MINE PORTAL
MAIN WORKSHOP
RAIL PORTAL
MECHANICAL SPARES
ELECTRICAL SPARES
COMPRESSOR HOUSE & ELECTRICAL SWITCH ROOM
VENTILATION FAN
SRTV PORTAL
CONVEYOR PORTAL
WONGA MAINS CONVEYOR PORTAL
MASONRY BATH ROOMS
PARKING AREA
COLLIERY MAIN ACCESS ROAD
WEST STREET
EXISTING 600T BIN
EXISTING BREAKER BUILDING
EXISTING BELT
WONGA STOCKPILE. FROM TRIPPER FITTED WITH DUST SUPPRESSION SPRAYS. TOE OF STOCKPILE APPROX 10m FROM C5 TUNNEL OPENING. SEE NOTE 1.
THICKENER TANK
WORKSHOP
EXISTING TRUCK LOADING FACILITY
PART SEALED STOCKPILE ROAD. SECTION OF SEALED ROAD TO BE USED IN NEW TRUCK LOADING ROAD IN FUTURE.
SETTLING PONDS
TRUCK WASH STN
WEIGHBRIDGE
RE GRADE SIZING PLANT ACCESS ROAD TO ACCOMMODATE 100 TONNE CRANE. (GEOTECH REQ'D)
DEMOLISH EXISTING BALGOWNIE BIN
EXISTING BULLI BIN
BULLI BIN STOCKPILES. SEE NOTE 2.
PROPOSED SIZING PLANT
PROPOSED WONGA. 1 BELT
EXISTING BELTS
PART UNSEALED STOCKPILE ROAD
CREEK FLOW DISSIPATION POND APPROX CAPACITY 4125ML
TEMP BUNDED WALL
CREEK FLOW DIVERSION
EXISTING DAM TO BE REMOVED AND NORTHERN SLOPE TO BE REGRADED.
WATER TANKS
DAM
SPILLWAY
DAM Floor R.L. of Dam 25.0
REEDY CREEK
PRINCES HIGHWAY

REV	DATE	REVISIONS	DRN	APP	REV	DATE	REVISIONS	DRN	APP
E	10/5/10	NEW ROM STOCKPILE LOADING ROUTE ADDED	JAH	DC					
D	6/5/10	SECTION C ADDED. NEW LEADERS AND NOTES ADDED	JAH	-					
C	14/4/10	TEXT BOX REMOVED, TEMP STOCKPILE RE WORDED	JAH	DC					
B	8/4/10	DETAIL WORKS AND TRUCK MOVEMENTS ADDED.	JAH	-					
A	6/4/10	PRELIMINARY	MJD	-	-	-	-	-	-

AS 1100
ALL DIMENSIONS IN MILLIMETRES UNLESS STATED OTHERWISE

	NAME	DATE
DESIGN	GKL	APRIL '10
DRAWN	GKL	APRIL '10
CHECKED	XXX	XXX
APPROVED	XXX	XXX
SCALE	1 : 1000	

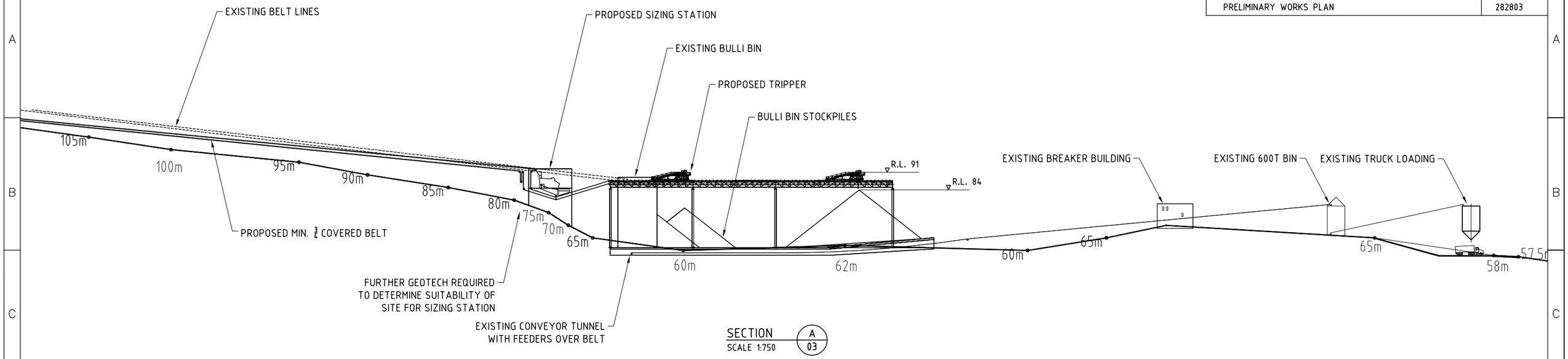
JBK Engineering & Mining
Ph. 02 4271 6424 Fax. 02 4272 6424
Workshop: 6 Investigator Drive UNANDERRA
P.O. Box 1184 UNANDERRA DELIVERY CENTRE UNANDERRA NSW 2526

GUJARAT NRE COKING COAL Ltd

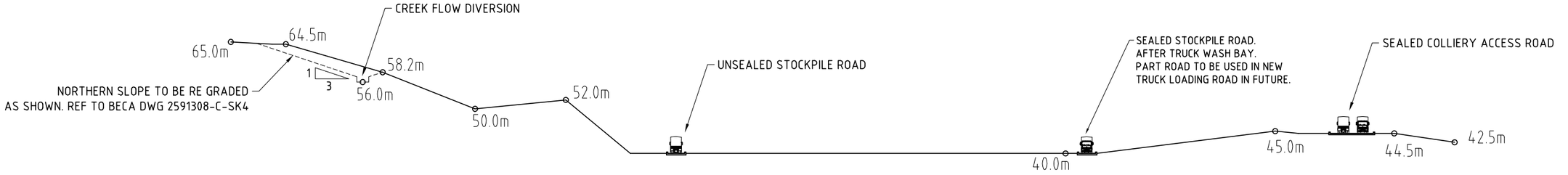
No. 1 COLLIERY RUSSELL VALE
PRELIMINARY WORKS PLAN
–

ISSUE	DWG. SIZE
PRELIMINARY	A1
JBK DWG No. 282803	REVISION E

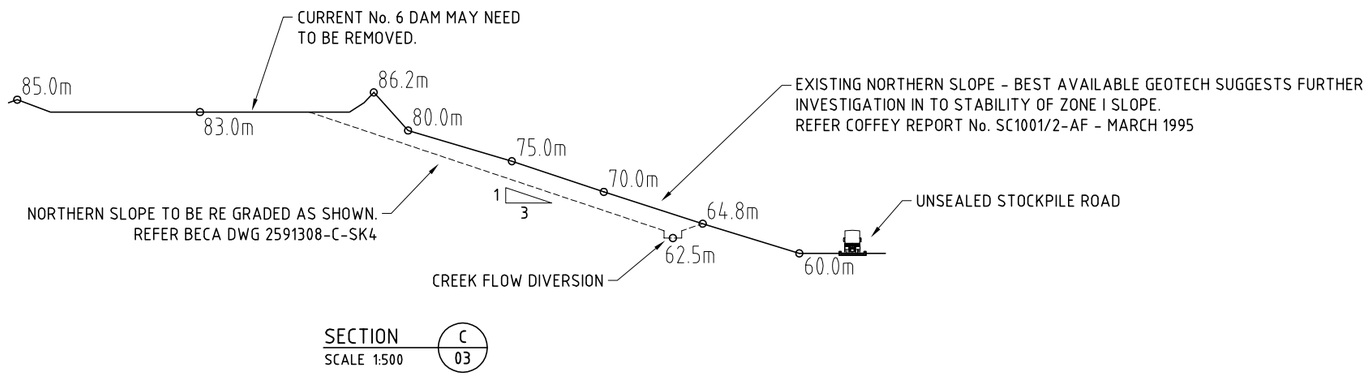
REFERENCE DRAWINGS	DRG. No.
PRELIMINARY WORKS PLAN	282803



SECTION A
SCALE 1:750 03



SECTION B
SCALE 1:500 03



SECTION C
SCALE 1:500 03

REV	DATE	REVISIONS	DRN	APP
D	10/5/10	NEW ROM STOCKPILE LOADING ROUTE ADDED	JAH	-
C	6/5/10	SECTION C ADDED	JAH	-
B	8/4/10	SECTION B ADDED	JAH	-
A	6/4/10	PRELIMINARY	MJD	-

AS 1100
ALL DIMENSIONS IN MILLIMETRES UNLESS STATED OTHERWISE

	NAME	DATE
DESIGN	GKL	APRIL '10
DRAWN	GKL	APRIL '10
CHECKED	XXX	XXX
APPROVED	XXX	XXX
SCALE	1 : 750	

JBK Engineering & Mining
Ph. 02 4271 6424 Fax. 02 4272 6424
Workshop: 6 Investigator Drive UNANDERRA
P.O. Box 1184 UNANDERRA DELIVERY CENTRE
UNANDERRA NSW 2526

GUJARAT NRE COKING COAL Ltd

No. 1 COLLIERY RUSSELL VALE

PRELIMINARY WORKS LONG SECTION

–

ISSUE	DWG. SIZE
PRELIMINARY	A1
JBK DWG No. 282804	REVISION D

Annex C

NRE No 1 Colliery Russell Vale Site Surface Facilities And On-Site Traffic Preliminary Works Part 3A

Olsen Environmental Consulting Pty Limited

FINAL

NRE No 1 Colliery
Russell Vale Site

Surface Facilities and On-site Traffic
Preliminary Works Part 3A

26th May 2010

Olsen Environmental Consulting Pty Limited
26 Paltarra Place CORDEAUX HEIGHTS NSW 2526
PO Box 101 FIGTREE 2525
NEW SOUTH WALES

Telephone: (02) 4272 7340
Mobile: 0417 219 293
Email: davidolsen@ocg.net.au

OEC File Reference: P84/2308

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1. INTRODUCTION

Gujarat NRE Coking Coal Limited (NRE) own and operate the NRE No 1 Colliery at Russell Vale and propose to upgrade the colliery. The colliery upgrade includes a reorganisation of the surface infrastructure, services and facilities at Russell Vale.

The upgrading will occur in a staged process with a Preliminary Stage providing a transition to the Final Upgraded Stage. This report describes the surface facilities and on-site traffic arrangements for the Preliminary Stage.

An additional report is being prepared to describe the surface facilities and on-site traffic arrangements for the Final Upgraded Stage of the project (Final Upgraded Surface Facilities and On-site Traffic Report, June 2010, Olsen Environmental Consulting Pty Limited).

NRE are required to obtain a valid development approval for the colliery in accordance with the Environmental Planning and Assessment Act 1979 (EP&A Act). This requires the preparation of an Environmental Assessment under the provisions of Part 3A of the EP&A Act. NRE have commissioned Environmental Resources Management (ERM) to prepare this Environmental Assessment.

In April 2009 NRE commissioned Olsen Consulting Group Pty Ltd (OCG) to provide the following services:

- Provide specific input into some components of the No 1 Mine Colliery Upgrade. These components include developing a storm water control and management system and developing a site traffic arrangement that addressed heavy, mining and light vehicle routes.

- Undertake a detailed survey of the existing facility at Russell Vale.

- Provide assistance to the Project Manager (Don Jephcott) to co-ordinate assessments relating to geotechnical, hydrological and water treatment systems for the Russell Vale site. These studies would provide the information necessary to determine general design and to locate components of the surface upgrade project. The design would be undertaken to a stage that ensures the proposed facilities can be built as described and where located. The general design does not include detailed construction design.

- To develop site plans incorporating the outcomes of the various component projects and studies. These plans will eventually be used in describing the proposed project within the Part 3A Environmental Assessment being prepared by ERM.

Other consultant groups have been involved in determining the layout of the upgraded surface facilities at NRE No 1 Colliery. These include;

- ERM have been commissioned to prepare the Part 3A Environmental Assessment. They have also been commissioned to conduct the noise, dust and visual assessments for the Part 3A Environmental Assessment.

- The engineering consultancy Beca was commissioned to provide expert hydrological advice for the design of the surface layout.

- Ellton Conveyors (Ellton) was engaged to design a conceptual conveyor/stockpile system. This was the central component of the overall layout design. The Ellton proposal became an option for the project.

- JBK Engineering and Mining were subsequently commissioned to provide an alternative conveyor/stockpile system. Their design became the adopted design for the project.

- Coffey Geosciences Pty Ltd (Coffeys) was commissioned to undertake geotechnical studies for the project.

- Cardno Eppell Olsen was engaged for an off-site Traffic Study.

In April 2010 NRE commissioned Olsen Environmental Consulting (OEC) to prepare reports on the surface facilities and on-site traffic proposals for the Preliminary and Final Upgraded Stages of the developments proposed for the No 1 Colliery at Russell Vale. This is the first of those two reports.

2. EXISTING SITE ARRANGEMENTS

2.1. OPERATIONS HISTORY

Gujarat NRE Coking Coal Limited (GNCCL) is the holder of Consolidated Coal Lease No 745 (CCL 745), which includes the surface at No.1 Colliery Russell Vale and ML 1575. CCL 745 covers approximately 6,001 ha and ML 1575 covers approximately 544 ha. The total area held under lease is therefore approximately 6545 ha of which 750 ha is freehold land. The balance is Crown Land located within the Cataract Dam catchment and is under the control of the Sydney Catchment Authority (SCA).

The mine includes 5 surface sites near Wollongong on the escarpment and in the catchment near to the dam. This report focuses on the original site at Russell Vale, which has been operating continuously since 1887. In the mid 1970's a vertical shaft (No. 4 Shaft) was established for men and materials access to the workings about 15 km west of the escarpment and the facilities at Russell Vale. This area comprises offices, workshop, bathhouse, store and winder. There are four other shafts, including the No.1, No.3 and No.5 which are all ventilation shafts and the No.2 Shaft which has been decommissioned.

2.2. MINE OWNERSHIP

Gujarat NRE Australia Pty Ltd (GNAL) purchased the colliery in December 2004. GNAL was a private company with its major shareholder an Indian public company and India's largest independent metallurgical coke producer, Gujarat NRE Coke Limited (GNCL). GNAL has subsequently gained its own listing on the stock exchange and changed its name to Gujarat NRE Coking Coal limited.

2.3. PROPOSED AND FUTURE OPERATIONS

Since taking over operation of the Mine, GNCCL has been sequentially implementing a Mine Plan that includes the following three broad stages:

Stage 1 (2007 – 2008)

- Continued mining in remnant Bulli blocks.
- Developed three new entries into Wongawilli Seam at Russell Vale.
- Conducted pre-feasibility study for longwall mining in Wongawilli Seam.

- Conducted pre-feasibility study for longwall mining in Bulli Seam.

Stage 2 (2008 – 2010)

- Develop new main access headings in Wongawilli Seam towards No.5 Shaft.
- Connect Wongawilli roadways to No.1 Shaft.
- Form stone drifts from Bulli to Wongawilli Seam.
- Conduct feasibility study for longwall mining in Wongawilli Seam.
- Recover coal from some existing roadways and commence development of new roadways heading towards the Western reserves of CCL 745.

Stage 3 (2010 and beyond)

- Develop longwall gateroad in Wongawilli Seam underneath extracted Bulli longwalls.
- Commence Wongawilli longwall operations.
- Form Wongawilli partial extraction panels between No.1 and No.5 Shafts.
- Undertake Bulli Pillar extraction in V Mains.
- Main heading development V Mains and Western longwall blocks.
- Commence longwall operations Western Bulli reserves.

The implementation of all stages of the proposed Mine Plan has been and will continue to be subject to feasibility studies on commercial viability and necessary stakeholder approvals and stakeholder endorsements.

2.4. EXISTING SURFACE INFRASTRUCTURE

The existing Russell Vale Site arrangement is shown on **Figure** 1. The mining leases area can be split into landuse areas that are identified as follows:

- Russell Vale Site.
- Russell Vale Emplacement Area.
- SCA Catchment.

This report focuses on the Russell Vale Site which is the only area under assessment, however brief descriptions of the other two areas are included to provide project context.

2.4.1. Russell Vale Site

This site supports the following infrastructure:

- The pit top which provides storage for most of the mining materials.
- The main administration building.
- Two older portals. One, identified as the Mine Portal on **Figure 1**, operates as a track road which gives men and materials access to the mine. The other, identified as the Conveyor Portal is where a belt road conveys coal to the surface.
- The 3 new main access headings (Wonga Mains) in Wongawilli Seam, which have recently been constructed. They are identified as the Rail Portal, RTV Portal and the Wonga Mains Conveyor Portal on **Figure 1**.
- After reaching the surface on the belt road conveyor via the belt portal, the coal passes through a vibrating feeder and is delivered onto a belt decline.
- The belt decline that leads from the belt portal to the ROM Stockpile area.
- A ROM stockpile and reclaim tunnel.
- The breaker building and conveyor that delivers coal to the road truck loading bins.

- A truck access road that runs to the public road system at the intersection of Bellambi Road with the Princes Highway. Trucks using the access road pass through a truck wash station and over a weighbridge before leaving the site.
- A water management facility that consists of thickener tanks which are remnants of the washery removed following a cessation of operations in 2003.

2.4.2. Russell Vale Emplacement Area

The emplacement area is located to the north of the pit top and administration access road, which forms the approximate boundary of the studies described in this report. The site washery ceased operations in 2003 and since then limited material has been deposited in the emplacement area.

2.4.3. SCA Catchment

CCL 745 extends for approximately 20 km to the west of the Russell Vale Site beneath and in some places on the surface of SCA Catchment land. There are five shaft sites identified as No.1 Shaft to No.5 Shaft located west of the Illawarra Escarpment.

2.5. WATER MANAGEMENT

The Beca Report, "Water Management Report No. 1 Colliery Russell Vale" (**Beca 2010**) contains a detailed description of current water management arrangements at Russell Vale (Refer to Section 3 of their report).

2.5.1. Russell Vale Site

Fresh water for the Russell Vale Site is supplied from the Sydney Water reticulated supply. Up to 500 kL per day of mine discharge water can be recycled into the surface water reticulation system. The recycled water is used for a wide range of purposes including dust suppression, make up water to the washery, truck washing and road cleaning.

Site toilet and bathroom wastes are disposed of via the normal domestic sewage disposal system operated by Sydney Water.

The Storm Water Control Dam (SWCD) is identified as the Dam on **Figure 1** and is the main facility for controlling 'dirty' surface runoff water on the site. Excess water is discharged to Bellambi Gully in accordance with EPA license quality and quantity criteria and general conditions. The water collected in the SWCD is primarily 'dirty' storm water run-off that comes from disturbed areas such as the stockpile areas and unsealed roads around the coal handling facilities including the belt decline system. This water undergoes primary settling in both concrete and earthen dams prior to entering the SWCD.

Water is drawn from the SWCD via a floating suction and pumped into the water treatment facility adjacent to the truck loading bins. Coagulant is added to the water as it enters the water treatment facility. This coagulant dosing is controlled and occurs just prior to the water entering a mixing chamber, which thoroughly mixes the coagulant and water. The mix is then delivered into a large thickener where settling of sediment occurs.

After settling in the thickener, clarified water overflows into a launder and then to a pipe that discharges to Bellambi Gully. The inflow and outflow water quality is monitored using turbidity meters. Dosing of the coagulant is automatically controlled in response to the monitoring results.

In principle, wherever possible, dirty water is collected and directed into the SWCD. All water is collected from areas such as the coal handling facilities at the portals, ROM stockpile, reclaim tunnel, breaker building, former clean coal stockpile area and truck loading and tarping sections. In addition, perimeter roads both sealed and unsealed are drained such that contaminated rain water and wash down water is collected.

2.5.2. Mine Water

Mine water is pumped to the surface from the mine at both Russell Vale and No.4 Shaft sites. At Russell Vale up to 1,000 kL per day is added to the water storages for re-use or, if not required, is discharged directly under license into Bellambi Gully.

3. FACTORS AFFECTING SURFACE FACILITY LAYOUT

3.1. INTRODUCTION

This section discusses those factors that have been considered during the design of the various components of the Russell Vale No. 1 Colliery surface layout arrangement. These factors will be discussed in more detail in the Part 3A Environmental Assessment however they are included here to provide context and understanding on the selection of the components of the proposed surface layout.

The factors can be conveniently divided into the following sectors and are discussed in Sections 3.2, 3.3 and 3.4 respectively:

- Coal Mining and Transport Requirements.
- Land Ownership and Availability.
- Environmental.

An iterative planning approach was used in order to ensure that the broad range of relevant environmental, safety, practical operational requirements, technology availability matters and financial objectives were incorporated into the final proposals. This approach is discussed in Section 3.5.

3.2. COAL MINING AND TRANSPORT REQUIREMENTS

The surface facilities at Russell Vale form integral components of the coal handling system that NRE is developing in order to plan, construct and operate a modern efficient coal mining operation within the current mining leases.

Coal will be mined from various areas within these leases. It will then be conveyed to the surface and stockpiled in readiness for transport to the Port Kembla Coal Terminal (PKCT) by truck. Coal is exported overseas from PKCT.

The coal stockpiles provide surge storage for coal and enable loading of coal shipments with specific quality parameters and in the quantities required. Surge storage is required to maintain relatively constant rates of truck loading. The interruptive effects of mining delays can be avoided or minimised by utilising the surge capacity provided by the stockpiles. Similarly, trucking, port and shipping delays can be minimised or avoided by the surge capacity in the stockpiles.

3.3. LAND OWNERSHIP AND AVAILABILITY

The mining lease covering the land on which construction is proposed, is held by GNCCL. The Russell Vale surface is located east of, and within, the foothills of the Illawarra Escarpment. It is not intended to construct any of the surface facilities at elevations higher than those currently supporting existing elements.

The land to the east, northeast and south of the site supports urban development and is not available for coal handling infrastructure.

3.4. ENVIRONMENTAL

3.4.1. Topography and Land Use

The Russell Vale site is located in the foothills of the Illawarra Escarpment, which is located immediately to the west.

The Escarpment provides scenic and conservation values. The pit top (highest point) is located at approximately 150 m AHD and the entry to the site from Bellambi Road (lowest point) is located at approximately 25 m AHD.

Planning for adequate drainage across this topographic range is a critical part of the proposal to upgrade and improve the Russell Vale site.

The Russell Vale site has been used for coal production for over 120 years and its appearance reflects this long term land use.

Urban development occurs along the north eastern, eastern and southern boundaries of the Russell Vale site.

The Princes Highway is located along the eastern boundary of the site. Land adjacent to the Highway is used for a range of small industrial and commercial purposes typical of ribbon development along a main road within an urban area.

The vehicle entry point for the site is off the Princes Highway at a point where it intersects with Bellambi Lane. Bellambi Lane is located alongside an old railway line reserve that originally served the colliery providing direct loading of coal onto the State Government rail system.

3.4.2. Drainage

The site is drained by a number of streams that are primarily sub-catchments of Bellambi Gully and flow to the southern end of Bellambi Beach. All items of infrastructure located within the Russell Vale site are located in the Bellambi Gully catchment. The total catchment area of the Russell Vale site within Bellambi Gully is approximately 57 ha.

The proposed construction works to upgrade the site infrastructure all fall within the Bellambi Gully catchment. It is noted that small sections of the total mine area lie outside this immediate catchment area, however works are not proposed at these locations.

Beca have prepared a detailed Hydrology Report for the development proposal (**Beca 2009D**). Their report includes a detailed description of the various catchments on site. **Figure 2** shows these areas with individual catchments within the Upper Middle and Lower Zones identified U, M and L respectively.

Beca describe three broad catchment zones as follows:

Upper Catchment Zone (U). This zone is predominantly natural escarpment area above the Russell Vale Site and considered to generate clean runoff water.

Middle Catchment Zone (M). This zone supports the workshop, offices, portals and a number of roads. It is characterised by steep batters of both natural and mine washery reject material.

Lower Catchment Zone (L). The coal stockpile and truck haulage area facilities are located in this zone. It is where clean water, which has been directed around disturbed areas on site, discharges into Bellambi Gully.

3.4.3. Rainfall

As discussed in Section 3.4.1, the site is located in the foothills of the Illawarra Escarpment. This geographical location is conducive to generation of high intensity/high rainfall storm events. Local rainfall data has been used by Beca when assessing and designing hydrological aspects of the proposals.

3.4.4. Air Quality

Consideration of the various components of the surface facilities took potential air quality impacts into consideration. A range of responses were implemented to minimise air quality impacts including:

- Constructing the coal stockpiles close to geographical features to minimise exposure to wind.
- Enclosure of elevated conveyors (where appropriate).
- Provision for dust sprays at coal transfer points.
- Truck washing on site before departure.
- Clean up arrangements will be developed and implemented during operations to manage fugitive dust sources. ERM has undertaken a detailed air quality assessment.

3.4.5. Visual

Potential visual impact was an important consideration in selecting the finally proposed surface layout arrangement.

A range of responses were implemented to minimise visual impact including:

- Consideration of the most effective orientation of individual components of the surface infrastructure.
- Constructing the coal stockpiles close to existing physical features.
- Placing the coal stockpile as far to the west, while taking into account geotechnical stability characteristics of the embankment, maximising the visual attenuation provided by two naturally occurring ridge lines.
- Consideration of the colour treatment of components.

- Artificial bunds and landscaping.
- Utilising already disturbed areas for the location of replacement components eg downslope conveyor and stockpiles.

ERM have undertaken a more detailed assessment of the potential visual impact and its management.

3.4.6. Heritage and Archaeology

The Russell Vale site has supported coal mining activities for over 120 years. It is unlikely that any Aboriginal heritage items remain where new infrastructure is proposed.

Some of the early mine buildings and entries remain and they have heritage value. Those items with heritage value have been identified and their presence has been considered during the planning of the proposed surface infrastructure.

ERM have undertaken a detailed assessment to verify the actual site heritage and archaeological features. Their findings will be included in the Part 3A Environmental Assessment for the proposals.

3.4.7. Geotechnical and Land Stability

Land stability issues were incorporated into the design of the proposed surface infrastructure. Adequate geotechnical assessment was been undertaken by Coffey Geosciences Pty Ltd (Coffeys) to determine that the proposals are able to be constructed as indicated. Further geotechnical assessment will be required during the construction design phase.

3.4.8. Flora and Fauna

Wherever possible, proposed infrastructure has been located in areas where vegetation has been removed or disturbed. Where vegetation has to be disturbed, appropriate fauna and flora investigations have been undertaken to assess impact and develop amelioration and management actions as required.

ERM have undertaken a detailed ecological assessment of the site and the details of that investigation will be included in the Part 3A Environmental Assessment for the proposals.

3.4.9. Traffic

This report only identifies onsite traffic arrangements. All traffic will access the site via the existing entry location where Bellambi Lane intersects the Princes Highway immediately east of the site.

Matters taken into consideration for onsite traffic movements included:

- Separation of light and heavy vehicles.
- Avoiding at grade cross-over movements of coal trucks.
- Provision of adequate on-site parking for heavy vehicles during short term interruptions to coal loading.
- Provision of suitable access for delivery and dispatch of materials from the workshop area.

An offsite traffic study was undertaken by Cardno Keppell Olsen.

3.4.10. Acoustic

The potential acoustic impacts were considered during the planning of the location of the various components of the surface layout. Matters taken into consideration during planning included:

- Location of components with respect to neighbours.
- "Line-of-site" considerations.
- Availability of noise attenuated items.
- Ability to incorporate noise attenuation in final structures.
- Location of acoustic and visual bunding.

A detailed noise assessment was undertaken by ERM to determine the potential impact and management that will be required to ameliorate noise impacts. Additional acoustic input will be provided during the construction design phase. Operational monitoring will be an integral part of ongoing management of the acoustic environment.

3.5. ITERATIVE PLANNING APPROACH

Development of the proposed surface layout at Russell Vale utilised an iterative approach to ensure that the broad range of relevant environmental, safety, practical operational requirements, technology availability matters and financial objectives were considered.

Early planning deliberations defined the range of issues that required consideration during the planning phase. These issues were then constantly considered during the iterative development of the final proposals.

The size and location of coal stockpile was identified as being the critical issue in designing a suitable surface layout at Russell Vale. There is only one general location for the coal stockpile, however, it was possible to incorporate small adjustments in response to the range of matters and objectives relevant to the proposal.

The size and location of the coal stockpile was determined taking into account such issues as noise, visual, air quality, drainage, geotechnical stability, practical operational considerations and financial objectives.

The construction of a by-pass channel in Bellambi Gully is required to facilitate the positioning of the stockpile footprint. This by-pass channel will replace a section of the existing Bellambi Gully that is currently conveyed in a concrete pipe beneath the existing coal stockpile area.

Site surface water treatment has been developed using the established general principle of separating clean and dirty water, while minimising the volume of potential dirty water needing treatment. The water treatments proposed do not affect the runoff flow characteristics downstream of the site. Details are included in the Beca Report (**Beca 2009D**).

Consequently, the proposed surface layout has been developed with consideration of the potential environmental impacts. The environmental impact of the final proposed layout has been assessed in detail in the Part 3A Project Environmental Assessment prepared by ERM.

4. SURFACE INFRASTRUCTURE COMPONENTS LAYOUT AND FUNCTION

This section describes the surface components proposed for the Russell Vale site during the Preliminary Stage of the development, which will enable the Colliery to logically progress to the Final Upgraded Stage. It also identifies the alternatives considered during the preliminary planning of the site.

4.1. STOCKPILE AND CONVEYOR

4.1.1. Proposal

Figure 3 (JBK Drawing 282803) shows plan perspectives of the mine site facilities proposed for the Preliminary Stage of the development. **Figure 4** (JBK Drawing 282804) shows a number of cross sections of the coal stockpiles and associated conveyors. The location of the cross sections is shown on **Figure 3**.

The installation and operation of the Preliminary Stage will allow the orderly development of the No 1 Colliery in a logical, sequential manner and enables coal supply to be maintained continually during modification of the stockpile arrangements.

Actual timing of each stage is indicated as follows, but will be dependent on coal markets existing at the time:

Stage 1.

Preliminary works. (to be completed by DECEMBER 2011 in readiness for LW4 start):

- Completely enclosed decline conveyor belt;
- Sizing/screening tower;
- Stack-out conveyor;
- Entire Tripper install;
- Integration of the above facilities into the existing coal clearance system, including the removal of the 'Balgownie Bin' and stockpiling for approximately 60,000 t;
- Re-alignment of 'Bellambi Gully/Creek' via an open channel, to include removal or other of the existing pipeline;
- Drainage associated with the Stockpile from 'up the hill' to the culvert at the highway, including stabilisation works and removal of '#6 Dam'(**Beca 2009D**).

Stage 2.

Transition works. (DECEMBER 2011 - DECEMBER 2012):

- New reclaim belt;
- New coal load out facility;
- New truck management facility, including new roads, truck parking, Traffic Management Plan, truck washing, etc;
- New 'dirty water' treatment facility and/or settling pond/s; and
- New stockpile area 2 to allow for stockpiling of approximately 140,000 t.

Stage 3.

Final Stockpile for 3Mtpa. (from DECEMBER 2012):

- New stockpile area 3 to allow for stockpiling of approximately 140,000 t.

Note: Stages 2 & 3 will be the subject of further applications and as such do not form part of this current proposal.

Bulli Seam coal reaches the surface via conveyor at the Conveyor Portal (**Figure 3**). The existing decline conveyor will be retained to deliver Bulli Seam coal from the Portal to the stockpile area. This coal will pass through a new sizing station that will be constructed as part of the Preliminary Stage of development. The Sizing Station will be located just before the existing Bulli Bin and Bulli Bin Stockpiles (**Figures 3 and 4**).

The sized coal will then be delivered by conveyor and tripper onto the Bulli Bin Stockpiles.

Wongawilli Seam coal reaches the surface via conveyor at the newly established Wonga Mains Conveyor Portal (**Figure 3**).

A new decline conveyor will be constructed during the Preliminary Stage to deliver this coal from the Portal to the stockpile area. This new conveyor will be located in the existing decline conveyor easement and will be fully enclosed. The conveyor will deliver the coal to the Sizing Station, from where it will be delivered to the Wonga Stockpile.

Coal will be transferred from the Sizing Station to both the Bulli Bin Stockpile and the Wonga Stockpile via a conveyor and tripper arrangement as shown in **Figure 4**.

The Bulli Bin will be retained however the existing Balgownie Bin will be removed to accommodate the proposed Wonga Stockpile.

This stockpile arrangement will include the capability to push out coal from the stockpile to enable additional storage. A temporary bund wall will be constructed in the location shown on **Figure 3**. This wall will limit the extent of the stockpile and provide a barrier in order to prevent wet weather coal slumps from travelling into the surface drainage system.

The trippers and the stockpile areas will be serviced by water spray systems to provide dust control capability.

The existing unsealed heavy vehicle access road will continue to provide access to the Bulli Bin Stockpile and the Wonga Stockpile from the mine access road. Part of this road will be sealed and this sealed section could be used as part of a future upgraded truck loading arrangement. The unsealed section will have water sprays to moisten the surface and reduce dust generation.

The existing coal retrieval system will be retained during the Preliminary Stage (**Figures 3 and 4 Section A**). Coal will be reclaimed from the base of both stockpiles and feed onto an existing conveyor located within a tunnel beneath the stockpile area. The coal from this stockpile passes through an existing 'Breaker' Building and into a 600 t capacity surge bin. The breaker will not be operational during the Preliminary Stage.

Coal passes from the 600 t bin into the truck loading bins from where it is loaded for road transport to the PKCT. Apart from regular maintenance this existing coal retrieval system will not be modified during the Preliminary Stage.

During the Preliminary Stage there will be a temporary emplacement of clean fill established immediately south of the unsealed access road.

With this arrangement there are two operational scenarios for the Preliminary Stage of the development. These scenarios will operate typically independently and not concurrently and are as follows:

1. Normal operations from the existing coal loading bin (7am to 6pm Monday to Friday, and 8am to 6pm Saturday).

2. Extended trucking operations from existing coal loading facility (7am-6pm) then truck loading directly from the stockpile (6pm-10pm).

Normal operating conditions give an average of 20,000 t per week to achieve 1 Mtpa based on 50 weeks per year.

Extended operational conditions give an average of 28,000 t per week to achieve a particular shipping deadline.

Trucking in the evenings Monday to Friday and trucking on Sunday will only be used for the extended conditions in order to achieve shipping deadlines. When trucking is occurring for the extended hours identified as 7 am to 10 pm Monday to Friday and 8 am to 6 pm Saturday and Sunday, NRE plan to move 80% of the product during daylight hours with the remaining 20% to go in the evenings and Sunday.

Table 4.1 lists the equipment, hours of operation, percentage of time operating and additional comments that provide an understanding of the operational activities typical of the range of operating conditions during the Preliminary Stage of the development.

Table 4.1. Typical Operational Activity Involving Existing Coal Loading Arrangements and Loading Directly From Stockpile.

Equipment	Hours of Operation	% of time Operating	Comment
1x Dozer size as appropriate	7 am to 6 pm Monday to Friday. 8 am to 6 pm Saturday	60% of operational hours.	To push sized coal into reclaim points in stockpile.
1x Excavator 345	7 am to 10 pm Monday to Friday.	60% of operational hours.	Will be used to load trucks directly from stockpile.
Existing Conveyors	24x7	100%	Covered.
Proposed Conveyor	24x7	100%	Enclosed.
New sizer	27x7	100%	Enclosed.
Existing Trucking facilities	7 am to 6 pm Monday to Friday. 8 am to 6 pm Saturday	100% of daytime hours.	
Evening operation loading trucks directly from stockpiles.	6 pm to 10 pm Monday to Friday.	100% of evening hours.	
Sunday Operations (only when required)	8 am to 6 pm	100% of daytime hours.	
ROM stockpile	24x7	100%	Dust suppression spray system.

4.2. BYPASS STORMWATER CHANNEL

4.2.1. Proposal

The existing drainage of the Russell Vale site includes a clean water bypass pipe which conducts clean water flowing in Bellambi Gully underneath and past the current stockpiling and coal loading arrangements.

It is proposed to remove this pipe and replace it with a suitably designed and engineered open bypass stormwater channel constructed on the southern side of the planned coal stockpile area.

Detailed discussions of the Bypass Stormwater Channel are included in the Beca Report (**Beca 2009D**). The location of the Bypass Stormwater Channel is shown on **Figure 3**.

The channel commences at elevation RL65. At this point a reinforced concrete headwall structure will be built to direct stormwater flows out of the existing Bellambi Gully alignment and into the channel.

An existing dam on the ridge adjacent to the proposed channel will be removed and the slope regraded to ensure slope stability in major rainfall events. This will minimise the chance of landslip obstructing the channel.

The Bypass Stormwater Channel follows an alignment along the southern side of the coal stockpile and is positioned at a relative level generally above the stockpile coal stacking operations. A temporary bunded wall will prevent coal slumping into the channel from the Bulli Bin Stockpile and the Wonga Stockpile (**Figure 3**).

The channel is required to be wide enough (2.5 m) to permit vehicle access for inspection, maintenance and repair, more importantly it needs to be resistant to erosion and able to convey the 1:100 year storm event with a safety margin of 0.5 m freeboard.

The channel alignment is planned to generally follow the natural contour of the ridge on the southern side of the stockpile facility to:

- Minimise the cut necessary to construct the channel.
- Restrict the channel grade/maximum flow rate so a suitable cross section for the channel can be selected.

The channel grade from where it commences will be between 2 and 5%. Where the ridge terrain falls sharply on the eastern side of the stockpile a cascade drop structure consisting of gabion baskets or other suitable materials will be employed to control the stormwater flows.

Parts of the channel will be constructed in bedrock and will be stable. To ensure stability, all other sections will require installation of reno mattresses or shotcreting. Detailed geotechnical investigations during final design will define those areas requiring stabilisation and the appropriate treatments.

The proposed design incorporates a concrete box culvert section of approximate dimensions 2.5 m wide and 1.25 m high. This cross section has the capacity to deal with a 10 year ARI event. The box culvert then opens to a trapezoidal channel of 1 m depth which provides capacity for a 100 year ARI storm with a freeboard of 0.5 m.

The Bypass Stormwater Channel cascades into a pond (identified as Creek Flow Dissipation Pond on **Figure 3**) that will dissipate the flow rate of stormwater prior to discharge back into Bellambi Gully. During 1:100 year events water would discharge from the pond via a reno mattress lined spillway. In lesser events, stormwater would discharge from the base of the pond via a purpose built outlet pipe structure. This would consist of a grated surface inlet pit with restricted inlet capacity to allow low flows to enter Bellambi Gully. Details are included in Drawing 2591308-C-SK8 in the Beca Report (**Beca 2009D**). The inlet pit would be connected to the last section of the existing underground clean water pipeline. The remaining sections of the clean water pipeline upstream of this connection would be removed.

Downstream of the gabion basket spillway from the pond, the existing invert and banks of Bellambi Gully would be cleared of undergrowth and maintained to ensure potential flood debris is controlled.

There is an existing culvert crossing of Bellambi Gully between the proposed Creek Flow Dissipation Pond spillway and the existing culvert under the Princes Highway. The culvert crossing of Bellambi Gully will be removed and replaced with a causeway, which is less likely to be problematic during storm events.

Undergrowth and obstructions would be removed from around the existing culvert under the Princes Highway, and the area subject to ongoing maintenance to ensure that flood flow obstructions are not generated.

The Bypass Stormwater Channel would be inspected regularly (at least annually) to ensure all treatments are functioning and the system is free of slumps and damage.

4.2.2. Alternatives Considered

The majority of stormwater runoff emanating from the steeper areas of the mine site is currently collected and diverted through various pipes and channels and across benches to a watercourse that descends to the south western corner of the coal stockpile area. The watercourse channels into a large diameter sub-surface pipeline that runs under the stockpile pad to Bellambi Gully.

The existing pipeline is in poor condition and would need to be replaced if the existing stormwater drain connection into Bellambi Gully were to be retained. This option was investigated and eliminated due to the risk of blockages in the pipe caused by debris being carried down the watercourse during storm events. Should pipe blockage occur, overflow would pass through the coal stockpiling and handling area and could result in silt-containing water discharging directly into Bellambi Gully.

The preferred option is to employ an open channel located to by-pass the coal stockpiling and handling facilities and into Bellambi Gully.

4.3. CONVEYOR DECLINE CREEK CROSSING

4.3.1. Proposal

The new Downhill Conveyor from the Wonga Mains Portal (**Figure 3**) will be built in the corridor of the existing decline conveyor. The Bellambi Gully currently crosses beneath the conveyor corridor in a piped crossing.

The crossing was the site of a key failure in the 1998 storms. Storm debris caused blockage in the piped crossing and diverted the majority of stormwater flow from uphill catchment out of the alignment of Bellambi Gully and through the coal stockpile area.

In order to minimise the risk of future major storm events overtopping this crossing, a concrete box culvert will be installed at the location shown on **Figure 3**. The Beca Report (**Beca 2009D** under discussion of Catchment M3) provides typical details of this proposed crossing. In order to convey predicted flow rates with a 0.5 m freeboard in the 1:100 year storm event, a minimum cross section of approximately 2.5 m wide and 1.75 m deep is required for the box culvert.

In addition, the adjacent downstream ridgelines will be extended to the roadside and the road and adjacent area to the south will be graded toward the south. This regrading and ridgeline extension will provide a mechanism that, in the event of blockage of the culvert, stormwater flows will re-enter Bellambi Gully rather than continue down the belt decline towards the dirty water channel/catchment. This will maintain separation of clean and dirty water.

4.3.2. Alternatives Considered

Due to the potential for blockage resulting from storm debris, it was not considered appropriate to re-install a piped crossing.

An open gabion lined channel was also considered in combination with the box culvert. However, minimising cross section while maximising flow rate is the higher priority and a box culvert alone was selected.

4.4. ESCARPMENT DRAINAGE AND CREEKS STABILISATION

4.4.1. Proposals

The Russell Vale site is located at the foothills of the Illawarra Escarpment and runoff from the Escarpment traverses the site. Drainage considerations are an important component of surface infrastructure planning and design.

OCG developed concept plans for site drainage and creek stabilisation. Beca investigated the hydrological parameters of the concept designs and recommended various alternative treatments. A detailed description of their findings are included in their report, “Gujarat NRE Stormwater Hydrology – Summary of Investigations.” (**Beca 2009D**).

The main considerations in designing a suitable drainage system included the following:

- Separate clean water and dirty water catchments.
- Determine catchment area characteristics and design appropriate drainage structures.
- Ensure flow channels are stabilised.
- Provide facilities for treating dirty water prior to reuse or discharge.

Drainage proposals are shown on **Figure 2**, which is Drawing 2591308-C-SK7 from the Beca Report (**Beca 2009D**). There are a number of catchments in the north western sector of the site that flow toward the north of the site. These are identified as catchments U3, U4 and U5 on **Figure 2**. They do not create flow that has to be handled on site. However, drainage channels and access tracks that currently direct the flow to the north will be maintained to ensure that these catchments do not contribute storm flows to the site. In addition, a box culvert drain will be installed at the base of U5 to isolate runoff water from the lower catchments within the site.

There are another two catchments (U1 and U2 on **Figure 2**) on the escarpment slopes above and to the west of the site. Water flowing from these catchments will be directed by earthen channels into the upper reaches of Bellambi Gully that flows immediately south of the current workshop and stores area. This section of Bellambi Gully was constructed early in the mine operating life. It is heavily eroded and requires stabilisation for continued use.

The entire length of this flow channel will be stabilised with reno mattresses and gabion drop structures where required. An existing debris and trash collection device will be retained. The existing channel will be cleared and stabilised. All areas that are not on bedrock will be lined with reno mattress. In addition, all large boulders and obstructions will be cleared from the channel in order to minimise the potential for downstream blockages.

In addition to the runoff water from the catchments on the Escarpment, Bellambi Gully will also receive clean runoff water from the other catchments located around the mine office, workshop and stores areas. These are identified as catchments M1, M3, M4, M5, and M6 on **Figure 2**. Earthen bunds approximately 0.5 m high will be constructed where required to define these catchments. These bunds will ensure that storm water does not flow between catchments during intense storm events leading to exceedances of structure design capacities and/or the mixing of clean and dirty water.

Prior to entering Bellambi Gully, runoff water from M1 passes through a first flush system which will be retained and maintained as part of the proposed site drainage system.

Clean water runoff from catchment M3 flows into Bellambi Gully at a location with high erosion potential. A Gabion Basket spillway will be installed here to enable water to safely pass from catchment M3 into Bellambi Gully.

Catchment M4 directs clean runoff water into Bellambi Gully. No works are proposed in this catchment.

Catchments M5 and M6 will have diversion drains and bunds constructed to direct runoff water to Bellambi Gully without causing erosion and sediment generation. Runoff water from these catchments will pass under the new Downhill Conveyor (DC01) via a box culvert approximately 1.5 m wide and 1.0 m deep.

Catchments M2 and M8, while having the potential to generate clean water, are for operational reasons directed along with M7 to the dirty water treatment system, which is discussed in section 4.5.

Details of typical diversion drains, piped stormwater drainage and box culvert diversions are included in the Beca Report (**Beca 2009D**).

There are two catchments on the relative flatter eastern section of the site. These are identified as catchments L1 and L2 on **Figure 2**. Catchment L1 generates clean water which will flow into the Bypass Stormwater Channel. No works are proposed for this catchment. Catchment L2 generates dirty water and as discussed in Section 4.5, existing dirty water treatment systems will be retained.

As discussed in Section 4.2, the Bypass Stormwater Channel cascades into a pond that, by dissipating energy, will enable stormwater to discharge safely back into Bellambi Gully.

4.4.2. Alternatives Considered

Erosion control design requirements dictated the location of drains, channels, culverts and other treatment structures.

Alternative materials were considered for stabilising flow channels. These included shotcrete lining of channels with sprayed concrete, reno mattressing and gabion basket treatments. The final selection was based on the degree of stabilisation required.

4.5. DIRTY WATER HANDLING AND TREATMENT

4.5.1. Proposals

There are no proposed changes to the existing dirty water handling treatment system (Refer Section 2.5.1).

4.5.2. Alternatives Considered

Due to the decision to not change existing dirty water handling treatment system, consideration of alternatives was not necessary.

4.6. SITE ROADWORKS AND TRAFFIC ARRANGEMENTS

4.6.1. Proposals.

The mine site road system substantially remains unaltered during the preliminary Stage of the development at No 1 Site Russell Vale.

The general site layout, including the site roads and traffic arrangements is shown in **Figure 1**.

4.6.2. Alternatives Considered

Due to the decision to not substantially change existing traffic system, consideration of alternatives was not necessary.

4.6.3. Operational Traffic Arrangements

The following sections describe the historic, current and future on-site traffic levels associated with the proposed Preliminary Stage. Traffic will be associated with construction activities during the proposed upgrade and with operational activities following construction.

Off-site traffic impacts have been addressed in another report prepared by Cardno Eppell Olsen and titled, “Gujarat NRE No 1 Mine Traffic Study, 2010”.

During normal operating times, there will be a mix of vehicle types accessing the site including coal trucks, assorted heavy vehicles delivering stores and supplies, courier vans, with regular sedans and some motorbikes providing employee, contractor and visitor access.

In addition, there will be a number of heavy vehicles permanently located on site to handle delivery and dispatch of stores and to load and deliver stores and materials underground. They are also used for general maintenance activities around the site as required.

During construction, there will be a range of vehicle types accessing the site and permanently located on site for the duration of construction activities.

Figure 3 details the proposed Preliminary Stage site layout including the site roadworks and traffic arrangements.

Coal trucks will use the existing Truck Loading Facility under normal conditions and new loading facilities are not proposed for the Preliminary Stage.

All mine traffic will enter the site from the Princes Highway/ Bellambi Lane intersection and follow the existing access road. NRE operate a CCTV (closed circuit television) to monitor mine vehicles entering and leaving the site through this intersection. This facility provides a real time direct record of all mine vehicle movements adjacent to the intersection.

Empty coal trucks travelling towards the Truck Loading Facility will leave the site access road and diverge to the left onto the existing one-way dedicated coal dispatch road which passes beneath the coal loading bins.

After loading, the coal trucks will leave the coal dispatch road and re-enter the access road via an at grade intersection. Existing traffic controls and management procedures will continue.

When coal is directly loaded from the stockpiles, trucks will use the stockpile road (**Figure 3**) to access the stockpile area.

The practice of washing trucks prior to departure and use of the existing weighbridge will be retained.

After entering the site from the Princes Highway/Bellambi Lane intersection, all mine traffic other than coal trucks, will avoid entering the coal dispatch road and continue along the existing mine access road to the pit top site further up the escarpment. The mine traffic will continue to follow existing access roads to the employee, stores and workshop facilities on the pit top further up the escarpment.

When leaving the site, mine traffic will merge with the loaded coal trucks and proceed to the Princes Highway/ Bellambi Lane intersection to exit the mine site. There is a general 40kph site maximum speed limit.

The existing employee's car park is located adjacent to the mine administration building (**Figure 1**). The current car park can readily accommodate 90 vehicles. Additional car parking spaces (30) are located on the western side of the administration building and also generally throughout the pit top area (20). Consequently, there are 140 existing car parking spaces on site around the administration office. These parking spaces will be retained in their current condition. Safe walking access to the bathhouse buildings from the car parking spaces will be provided.

Heavy vehicles permanently located on site normally operate around the stores area, administration building and mine entries. From time to time, as required, they may operate in other distant areas.

Vehicles accessing the store area will travel past the employee, contractor and visitor car parking areas and will traverse a section of pavement between the administration building and the escarpment.

No changes are proposed to the current access and facilities at the No 4 Shaft site. Vehicular access is along a bitumen-sealed mine access road that branches off the Picton to Mount Keira Road.

4.6.4. Construction Traffic Arrangements

Construction will be limited to the No 1 Colliery Site at Russell Vale. The majority of construction activity will be associated with the stockpile area and immediate environs to:

- Install the enclosed decline conveyor,
- Install the sizing station,

- Install the stackout conveyor and associated trippers,
- Remove the Balgownie Bin and general civil works associated with integrating the new construction into existing facilities, and,
- Improve general site drainage to control water flow across the entire site from the escarpment to the Princes Highway. The Storm Bypass Channel will be installed as part of the Preliminary Stage.

A temporary contractor's site and lay down area will be established south of the existing truck loading facility. The site will be levelled and paved with a layer of road base for all-weather use, with a perimeter security fence.

Construction workforce vehicle access will be via the current access road. Employees will park their vehicles on the temporary contractor's site.

4.6.5. Current and Historic On-site Traffic

Both the Russell Vale Site and the No 4 Shaft Site are currently operating. The Russell Vale Site has operated continuously since 1887 and the No 4 Shaft Site since the 1970s. Most of the vehicles entering the sites transport employees and contractors. In addition, consultants, visitors and sales representatives make regular visits to both sites.

Parking facilities are established that have accommodated an historically large number of vehicles associated with the workforce and other groups of people accessing the site.

Heavy vehicles access the sites to deliver equipment and bulk stores such as fuel. Heavy vehicles are also utilised as required to dispatch heavy mine equipment offsite for maintenance and repairs as required.

Courier vehicles, which include pantechnicons of varying sizes, also access both sites, generally during daytime from Monday to Friday.

Coal is dispatched in trucks from the No 1 Colliery Site for delivery to PKCT with subsequent export to world markets.

A coal preparation plant has previously operated at the No 1 Mine Site. This required truck haulage of waste material to an on-site refuse emplacement area and a fleet of heavy vehicles associated with the emplacement, compaction and rehabilitation of the emplaced refuse. NRE do not currently operate an on-site preparation plant.

4.6.6. Historic and Current Employee Vehicle Access

The size of the workforce accessing both sites has varied over time, both in size and the proportion of the workforce attending each site accessed. The workforce has at various times included both company employees and contractors.

The size of the workforce has varied in response to market conditions and the objectives of various owners over time. Since the establishment of the No 4 Shaft Site in the 1970s, there has always been workforce attendance at both sites. The workforce has been distributed at varying ratios between the Russell Vale Site and the No 4 Shaft Site depending on the location of mining activity underground.

During the late 1970s and early 1980s, there were up to 1,200 people employed at the sites. These employees reported for duty at both locations and car parking spaces were sufficient to accommodate this large workforce. Typically, up to 800 employees would report for duty at the No 4 Shaft Site and up to 400 at the Russell Vale Site.

The current workforce totals approximately 337 individuals with an approximate 40/60 split between Russell Vale and the No 4 Shaft.

The mine operates on a three shift basis during the week and a two shift basis at weekends covering 24 hours per day, 7 days per week. On weekdays the shift times are day shift (6.30am to 2.30pm), afternoon shift (2.30pm to 10.30pm) and night shift (10.30pm to 6.30am). On weekends shift times are day shift 10.30am to 10.30pm and night shift 10.30pm to 10.30am Friday and Saturday.

There is a concentration of vehicles accessing and leaving the site around the shift change times. This concentration tends to be spread over the two hour period around the actual shift change time as not every employee will access and leave the site precisely at shift change time.

There are more employees on site during the day shift than on the other two shifts. In addition, there are more employees on site during the afternoon shift than there are during the night shift.

The actual numbers on each shift will vary in response to work requirements and attendance aspects. **Table 4.2** provides a typical breakdown of the number of employees currently on site during each shift.

Table 4.2. Typical Spread of Employees and Contractors on Site at the Russell Vale Site and the No 4 Shaft Site. February 2010.

SHIFT	Russell Vale	No 4 Shaft
Day Shift (6.30am to 2.30pm)	51	102
Afternoon Shift (2.30pm to 10.30pm)	46	59
Night Shift (10.30pm to 6.30am)	36	43

These numbers provide a basis for determining the number of vehicles accessing and leaving the sites during the two hour period surrounding the shift change times. General site observations indicate a vehicle occupancy rate of 2 people per vehicle.

Table 4.3 includes the most likely number vehicles required to transport the workforce assuming an occupancy rate of 2 employees per vehicle and the spread of these vehicles over the two hour period surrounding shift change times. This spread is based on the assumption that all the previous shift leaves the site in the hour following the shift change and all the following shift arrive at site during the hour prior to commencement of that shift. In reality, these numbers are likely to vary from this due to absentees and work arrangements including overtime and delayed departures. Despite this likely variation, the data in **Table 4.3** provides a sound basis for impact assessment.

Table 4.3. Typical Employee On-site Vehicle Movements at Russell Vale and No 4 Shaft Site. February 2010.

Site	Shift	Total Shift Vehicles	Time	Vehicles Accessing and Leaving site
No 1 Mine Site Russell Vale	Day (6.30am to 2.30pm)	26	5.30am to 6.30am	26 arriving
			6.30am to 7.300am	13 leaving
	Afternoon (2.30pm to 10.30pm)	23	1.30pm to 2.30pm	23 arriving
			2.30pm to 3.30pm	26 leaving
	Night (10.300pm to 6.30am)	13	9.30pm to 10.30pm	13 arriving
			10.30pm to 11.30pm	23 leaving
No 4 Shaft Site	Day (6.30am to 2.30pm)	51	5.30am to 6.30am	51 arriving
			6.30am to 7.300am	22 leaving
	Afternoon (3.00pm to 11.00pm)	25	1.30pm to 2.30pm	25 arriving
			2.30pm to 3.30pm	51 leaving
	Night (11.00pm to 7.00am)	22	9.30pm to 10.30pm	22 arriving
			10.30pm to 11.30pm	25 leaving

4.6.7. Historic and Current Visitor and Other Vehicles

In addition to employee and contractor vehicles, site access to both sites is required for visitors, sales representatives, stores deliveries and equipment dispatch for maintenance and repairs. These access visits normally occur Monday to Friday and during daylight hours. There may be special requirements for vehicle access outside these times, but they would be relatively infrequent and insignificant in relation to impact assessment.

During a typical day at both the Russell Vale Site and the No 4 Shaft Site, approximately 40 vehicles would access the site transporting visitors, consultants and sales representatives. At Russell Vale, these visits would be spread fairly evenly over the time 6.30am to 6.30pm with a bias towards morning and mid day visits. At the No 4 Shaft Site these vehicles access the site between 6.00am and 3.00pm.

During a typical day at both sites approximately 15 courier vehicles (pantechnicons of various sizes) would access the sites. This number is likely to peak at 25 vehicles per day.

The number of heavy vehicles accessing both sites is between 6 and 8 per day.

Visitor and consultant vehicles typically park in the main car parks at both sites adjacent to the administration buildings. Sales representatives, courier vehicles and heavy vehicles park adjacent to, or within, the stores areas at both sites.

4.6.8. Historic and Current Coal Truck Vehicles

Coal trucks access the Russell Vale Site only. During the 1980s and 1990s, the Mine was producing up to 3 Mtpa of Run-of-Mine coal. Washed coal was transported from site by 25 t capacity coal trucks regularly transporting between 8,000 and 12,000 tpd on a typical day and peaking at 18,000 tpd. This was achieved at a coal truck access rate of typically 35 per hour, ranging up to 55 per hour. During these times an average of approximately 250 truck loads per day (to and from the site) were required to achieve the transport task.

The report by Cardno Eppell Olsen and titled, “Gujarat NRE No 1 Mine Traffic Study, 2010”, details the current coal truck numbers accessing the Russell Vale site.

In summary, coal vehicles generally access and leave the site between 7.00am to 6.00pm Monday to Friday and between 8.00am to 6.00pm on Saturdays. When shipping schedules require, the mine has approval for trucks to operate from 6am-10pm Monday to Friday and 8am-6pm Saturday, Sunday and Public Holidays.

There is a fleet of between 8 and 10 coal trucks with an average 34 t capacity that service the Russell Vale Site. Approximately 120 truck visits per day (and subsequent dispatches) are required to achieve the current coal transport task for the NRE No 1 Mine.

The rate of truck movement at the site typically is biased towards greater numbers in the morning with a gradual decline over the day. During a typical day an average 10 trucks per hour would access the site (and then depart the site). Typically, during the first 2 to 3 hours an average 14 trucks per hour would access the site. Then the rate declines to between 8 and 9 trucks per hour thereafter until, during the last two hours of truck operations, the transport task is achieved at a rate varying between 1 and 4 trucks per hour.

Table 4.4 incorporates the above comments with employee and contractor vehicle data from **Table 4.3** and presents an overview of vehicle movements for both sites on a typical day. The data is focussed on the change of shift times when the traffic levels would be at their highest.

Table 4.4. Typical Current Levels of Vehicle Access to Russell Vale and No 4 Shaft Sites at Peak Traffic Times Associated with Shift Changes.

Site	Time	Employee and Contractor Vehicles Accessing and Leaving site	Coal Trucks	Visitors and Sales representatives	Couriers	Heavy Vehicles
No 1 Mine Site Russell Vale	5.30am to 6.30am	26 arriving	Nil	5	3	1
	6.30am to 7.30am	13 leaving	14 arriving and 14 leaving	10	4	2
	1.30pm to 2.30pm	23 arriving	9 arriving and 9 leaving	5	2	1
	2.30pm to 3.30pm	26 leaving	Nil	5	2	1
	9.30pm to 10.30pm	13 arriving	Nil	Nil	Nil	Nil
	10.30pm to 11.30pm	23 leaving	Nil	Nil	Nil	Nil
No 4 Shaft Site	5.30am to 6.30am	51 arriving	Nil	5	3	1
	6.30am to 7.30am	22 leaving	Nil	10	4	2
	1.30pm to 2.30pm	25 arriving	Nil	5	4	2
	2.30pm to 3.30pm	51 leaving	Nil	5	Nil	Nil
	9.30pm to 10.30pm	22 arriving	Nil	Nil	Nil	Nil
	10.30pm to 11.30pm	25 leaving	Nil	Nil	Nil	Nil

4.6.9. Proposed On-site Traffic

NRE propose to instigate the Preliminary Stage works to upgrade the NRE No 1 Colliery Site to enable stockpile and dispatch of approximately 1 mtpa. Coal transport from site by trucks will continue. Various improvements to the site layout and underground mining facilities will be installed to underpin the upgrade.

During the Preliminary Stage construction will be undertaken on the Russell Vale Site only.

NRE do not plan to increase the current workforce during the Preliminary Stage.

Construction

All construction workforce will be located on the Russell Vale Site. Construction will be undertaken in two stages over a nine month period and a peak construction workforce is predicted to be up to 32.

Construction work will be undertaken during daylight hours, generally 7.00am to 6.00pm Monday to Friday and from 8.00am to noon on Saturdays.

It is most likely that construction workers will arrive on site in their own vehicles. Assuming an occupancy rate of 2 people per vehicle, there will be approximately 16 vehicles arriving around the start time of 7.00am and leaving around the finishing time of 7.00pm Monday to Friday. Similar numbers would arrive and leave on Saturdays.

These vehicles would be parked within the contractors' construction and laydown area.

During construction there will be a range of vehicle types delivering supplies and equipment. At peak construction it is likely that up to 10 concrete agitators per day will access the site. Typically, 2 to 3 semi trailers will deliver materials to site. There may be peaks above these levels, but only during special construction activities.

Heavy vehicles associated with construction will be located permanently on site. These vehicles would typically be a Grader Cat 24H or equivalent, a Dozer Cat D6R or equivalent, an Excavator Cat 345B or equivalent, a dump truck and a mobile crane.

Operational Employees and Contractors.

In the early years of operation during the Preliminary Stage of development, mining activity will be located in an area known as Wongawilli East. While mining operations are focussed in Wongawilli East, the bulk of the proposed operational workforce would report for duty at Russell Vale. It is anticipated that the current workforce would be unaltered. The current workforce numbers and location are shown in **Table 4.2**. During this time approximately 133 employees and contractors will report for duty at the Russell Vale Site and the remaining 204 employees and contractors will report to the No 4 Shaft Site.

Shift times will remain the same as current arrangements. The mine operates on a three shift basis during the week and a two shift basis at weekends covering 24 hours per day, 7 days per week. On weekdays the shift times are day shift (6.30am to 2.30pm), afternoon shift (2.30pm to 10.30pm) and night shift (10.30pm to 6.30am). On weekends shift times are day shift 10.30am to 10.30pm and night shift 10.30pm to 10.30am Friday and Saturday.

It can be assumed that these employees and contractors will drive to work in vehicles having an average occupancy rate of 2 people per vehicle. The arrival times will be concentrated in the two hour period around shift change times.

Operational Visitors and Other Vehicles

It is predicted that the number of visitor and other vehicles that access the sites will remain at existing levels as described in Section 4.6.7.

Consequently, it is predicted that during a typical day at both the Russell Vale Site and the No 4 Shaft Site, approximately 40 vehicles would access the site transporting visitors, consultants and sales representatives. At Russell Vale, these visits would be spread fairly evenly over the time 6.30am to 6.30 pm with a bias towards morning and mid day visits. At the No 4 Shaft Site these vehicles access the site between 6.00am and 3.00pm.

During a typical day at both sites approximately 15 courier vehicles (pantechnicons of various sizes) would access the site. This number is likely to peak at 25 vehicles per day.

The number of heavy vehicles accessing both sites is between 6 and 8 per day.

Visitor and consultant vehicles typically park in the main car parks at both sites adjacent to the administration buildings. Sales representatives, courier vehicles and heavy vehicles park adjacent to, or within, the stores areas at both sites.

Coal Trucks

Trucks will access the site to transport coal from the mine to PKCT. Detailed trucking arrangements are discussed in the Traffic Study **(Cardno Eppell Olsen 2010).**

4.6.10. Employee and Contractor Facilities

The existing employee's car park is located adjacent to the mine administration building (**Figure 1**). The parking area will be retained. Safe walking access will be provided for employees to the bathhouse buildings.

5. REFERENCES

Ellton Conveyors. 2009. Proposed Concept Plan. Russell Vale Surface Works. Stockpile Facility Project.

Beca 2009D. Gujarat NRE. Stormwater Hydrology Review. November 2009.

Beca 2010. Water Management Report No. 1 Colliery Russell Vale. May 2010.

Cardno Eppell Olsen 2010. Gujarat No. 1 Mine Traffic Study April 2010.

Figure 1.

Drawing DP 3673. Existing Mine Site Facilities.

MGA

N

ILLAWARRA ESCARPMENT

MAIN SUB STN

ADMIN BUILDING

CAR PARK

BATH HOUSE

TANKS

MINE PORTAL

1887 PORTAL

MAIN WORKSHOP

MECHANICAL SPARES

ELECTRICAL SPARES

RAIL PORTAL

COMPRESSOR HOUSE & ELECTRICAL SWITCH ROOM

VENTILATION FAN

RTV PORTAL

DAM

DAM

WONGA MAINS CONVEYOR PORTAL

CONVEYOR PORTAL

FIRST FLUSH PIPELINE

DECLINE COAL CONVEYORS

COAL STOCKPILE AREA

BIN

BIN

BIN

THICKENER TANK

THICKENER TANK

WORKSHOP

TRUCK LOADING STATION

COLLIERY MAIN ACCESS ROAD

WEST STREET

DIRTY WATER DRAIN 1000ø

STORMWATER BYPASS PIPELINE 1800ø

SETTLING PONDS

TRUCK WASH BAY

WEIGHBRIDGE

SPILLWAY

BELLAMBI CREEK

PRINCES HIGHWAY

DAM

WATER TANKS

DAM

Floor R.L. of Dam 25.0

MINE SITE FREEHOLD PROPERTY BOUNDARY

20 0 20 40 60 80 100

METRES

No.	DESCRIPTION	DRN	CHKD	DATE
	REVISIONS			

Olsen Consulting Group Pty Ltd
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WOLLONGONG
NSW 2500
PH: 42 283144

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DESIGN:	
DATE:	
DRAWN:	K.E.
DATE:	10.12.09
CAD – B1	

OLSEN CONSULTING GROUP

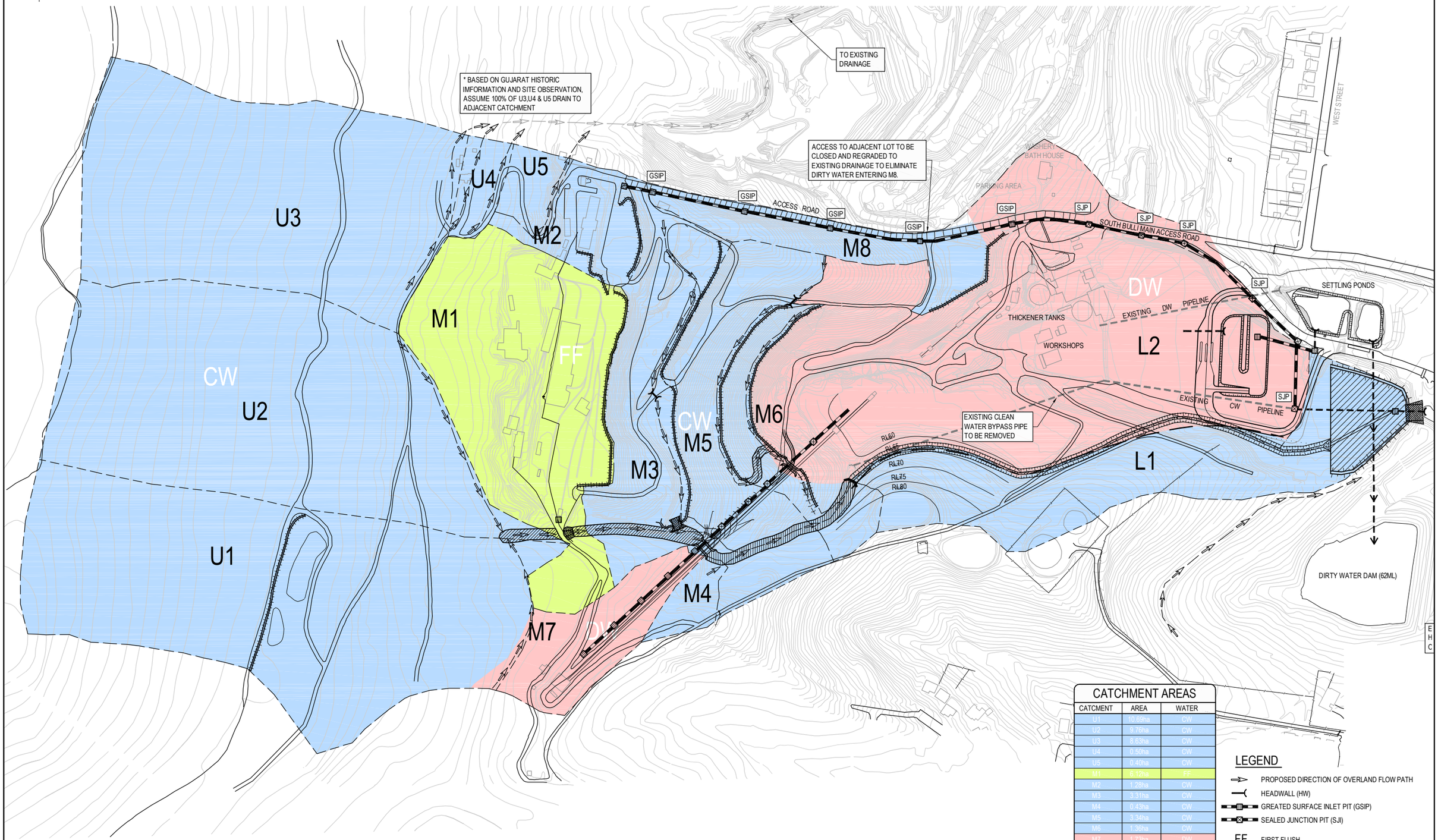
GUJARAT NRE No.1 COLLIERY RUSSELL VALE

EXISTING MINE SITE FACILITIES

DATUM: AHD | SCALE: 1:1750 | DRAWING No: DP-3673 | REV:

Figure 2.

Drawing No 2591308-C-SK7. Site layout Clean/Dirty Water Regions.



CATCHMENT AREAS

CATCMENT	AREA	WATER
U1	10.69ha	CW
U2	9.76ha	CW
U3	8.83ha	CW
U4	0.50ha	CW
U5	0.40ha	CW
M1	6.12ha	FF
M2	1.28ha	CW
M3	3.31ha	CW
M4	0.43ha	CW
M5	3.34ha	CW
M6	1.36ha	CW
M7	1.73ha	DW
M8	1.12ha	CW
M9	0.66ha	CW
L1	4.84ha	CW
L2	12.07ha	DW

LEGEND

- PROPOSED DIRECTION OF OVERLAND FLOW PATH
- HEADWALL (HW)
- GREATED SURFACE INLET PIT (GSIP)
- SEALED JUNCTION PIT (SJI)
- FF FIRST FLUSH
- CW CLEAN WATER
- DW DIRTY WATER

FOR INFORMATION
NOT FOR CONSTRUCTION

0 1000m
SCALE

No.	Revision	By	Chk	Appd	Date
B	CONCEPT DESIGN - NOT FOR CONSTRUCTION	AS	SM		8/10/09
A	CONCEPT DESIGN - ISSUED FOR REVIEW	SK	SM		23/7/09

Drawing Originator: Beca

Original Scale (A1) 1:2000
Reduced Scale (A3) 1:4000

Design	PI	23/7/09	Approved For Construction*
Drawn	SK	23/7/09	
Dsg Verifier	SM	29/9/09	
Dwg Check			Date

* Refer to Revision 1 for Original Signature

Client: GUJURAT NRE

Project: GUJURAT No. 1 HYDROLICAL INVESTIGATION

Title: SITE LAYOUT CLEAN/DIRTY WATER REGIONS

Discipline: CIVIL

Drawing No.: 2591308-C-SK7

Rev.: B

DO NOT SCALE

Figure 3.

JBK Drawing 282803. No. 1 Colliery Russell Vale.
Preliminary Works Plan.

REFERENCE DRAWINGS	DRG. No.
LONG SECTION OF BELT LINE	282804

NOTES:
1. WONGA COAL FED TO C5 BELT VIA FEEDER IN TUNNEL.
2. BULLI COAL FED TO C5 BELT VIA EXCAVATOR/ SIZER AND FEEDER SIMILAR TO CURRENT BALGOWNIE BIN OPERATION

MGA

MAIN SUB STN
ADMIN BUILDING
CAR PARK
BATH HOUSE
MINE PORTAL
MAIN WORKSHOP
RAIL PORTAL
MECHANICAL SPARES
ELECTRICAL SPARES
COMPRESSOR HOUSE & ELECTRICAL SWITCH ROOM
VENTILATION FAN
SRTV PORTAL
CONVEYOR PORTAL
WONGA MAINS CONVEYOR PORTAL
MASONRY BATH ROOMS
PARKING AREA
COLLIERY MAIN ACCESS ROAD
WEST STREET
EXISTING 600T BIN
EXISTING BREAKER BUILDING
EXISTING BELT
WONGA STOCKPILE. FROM TRIPPER FITTED WITH DUST SUPPRESSION SPRAYS. TOE OF STOCKPILE APPROX 10m FROM C5 TUNNEL OPENING. SEE NOTE 1.
THICKENER TANK
WORKSHOP
EXISTING TRUCK LOADING FACILITY
PART SEALED STOCKPILE ROAD. SECTION OF SEALED ROAD TO BE USED IN NEW TRUCK LOADING ROAD IN FUTURE.
SETTLING PONDS
TRUCK WASH STN
WEIGHBRIDGE
RE GRADE SIZING PLANT ACCESS ROAD TO ACCOMMODATE 100 TONNE CRANE. (GEOTECH REQ'D)
DEMOLISH EXISTING BALGOWNIE BIN
EXISTING BULLI BIN
BULLI BIN STOCKPILES. SEE NOTE 2.
PROPOSED SIZING PLANT
PROPOSED WONGA. 1 BELT
EXISTING BELTS
PART UNSEALED STOCKPILE ROAD
CREEK FLOW DISSIPATION POND APPROX CAPACITY 4125ML
TEMP BUNDED WALL
CREEK FLOW DIVERSION
EXISTING DAM TO BE REMOVED AND NORTHERN SLOPE TO BE REGRADED.
WATER TANKS
DAM
SPILLWAY
DAM Floor R.L. of Dam 25.0
REEDY CREEK
PRINCES HIGHWAY

REV	DATE	REVISIONS	DRN	APP	REV	DATE	REVISIONS	DRN	APP
E	10/5/10	NEW ROM STOCKPILE LOADING ROUTE ADDED	JAH	DC					
D	6/5/10	SECTION C ADDED. NEW LEADERS AND NOTES ADDED	JAH	-					
C	14/4/10	TEXT BOX REMOVED, TEMP STOCKPILE RE WORDED	JAH	DC					
B	8/4/10	DETAIL WORKS AND TRUCK MOVEMENTS ADDED.	JAH	-					
A	6/4/10	PRELIMINARY	MJD	-	-	-	-	-	-

AS 1100
ALL DIMENSIONS IN MILLIMETRES UNLESS STATED OTHERWISE

	NAME	DATE
DESIGN	GKL	APRIL '10
DRAWN	GKL	APRIL '10
CHECKED	XXX	XXX
APPROVED	XXX	XXX
SCALE	1 : 1000	

JBK Engineering & Mining
Ph. 02 4271 6424 Fax. 02 4272 6424
Workshop: 6 Investigator Drive UNANDERRA
P.O. Box 1184 UNANDERRA DELIVERY CENTRE UNANDERRA NSW 2526

GUJARAT NRE COKING COAL Ltd

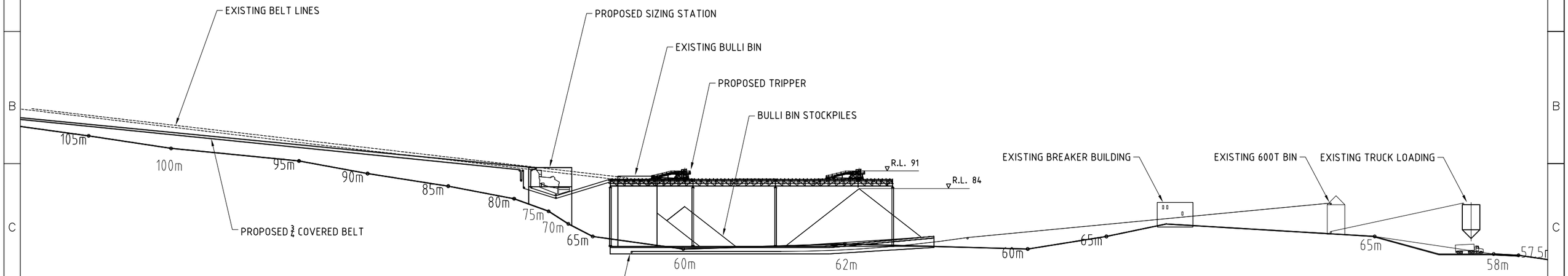
No. 1 COLLIERY RUSSELL VALE
PRELIMINARY WORKS PLAN
–

ISSUE	DWG. SIZE
PRELIMINARY	A1
JBK DWG No. 282803	REVISION E

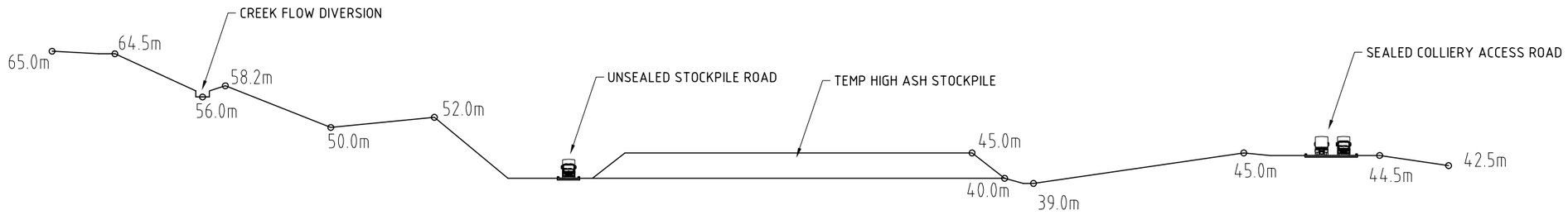
Figure 4.

JBK Drawing 282804. No. 1 Colliery Russell Vale.
Preliminary Works Long Section.

REFERENCE DRAWINGS	DRG. No.
PRELIMINARY WORKS PLAN	282803



SECTION A
SCALE 1:750 03



SECTION B
SCALE 1:500 03

REV	DATE	REVISIONS	DRN	APP
B	8/4/10	SECTION B ADDED	JAH	-
A	6/4/10	PRELIMINARY	MJD	-

AS 1100
ALL DIMENSIONS IN MILLIMETRES UNLESS STATED OTHERWISE

	NAME	DATE
DESIGN	GKL	APRIL '10
DRAWN	GKL	APRIL '10
CHECKED	XXX	XXX
APPROVED	XXX	XXX
SCALE	1 : 750	

JBK Engineering & Mining
Ph. 02 4271 6424 Fax. 02 4272 6424
Workshop: 6 Investigator Drive UNANDERRA
P.O. Box 1184 UNANDERRA DELIVERY CENTRE
UNANDERRA NSW 2526

GUJARAT NRE FGCL

#1 COLLIERY RUSSELL VALE
PRELIMINARY WORKS LONG SECTION
–

ISSUE	DWG. SIZE
PRELIMINARY	A1
JBK DWG No. 282804	REVISION B

Annex D

Existing Permits And Approvals

I. Development consent - D2004/32

II. EPL 12040

WOLLONGONG
City of Innovation

41 Burelli Street Wollongong Locked Bag 8821 South Coast Mail Centre NSW 2521
DX: 27811 Wollongong Court Ph: (02) 4227 7111 Fax: (02) 4227 7277
Email: council@wollongong.nsw.gov.au Web: www.wollongong.nsw.gov.au
ABN 63 139 525 939 - GST Registered

TCW Consulting Pty Ltd
29 Beach Street
WOLLONGONG NSW 2500

Our Ref	D.WT/KI
File	DA-2004/32
Date	14 December 2004

Dear Sir/Madam

NOTICE OF DETERMINATION OF DEVELOPMENT APPLICATION NO D2004/32

Pursuant to section 81 of the Environmental Planning and Assessment Act, 1979, notice is hereby given of the determination of Development Application No D2004/32 relating to -

Lot 31 DP 1006012 Princes Highway, Russell Vale

and being development described as -

Decommissioning and Removal of Coal Washery Plant – Bellpac No 1 Colliery (formerly South Bulli Colliery)

The Development Application has been determined by **granting of consent subject to the following conditions:**

GENERAL MATTERS

1 **Approved Plans and Supporting Documentation**

The development is to be carried out in compliance with the following plans and documentation listed below and endorsed with Council's stamp, except where amended by other conditions of this consent:

Drawing N°/Documentation	Dated
Statement of Environmental Effects for South Bulli Colliery prepared by TCW Consulting Pty Ltd	January 2004
Statement of Heritage Impact for Bellpac No 1 prepared by Godden Mackay Logan	10 February 2004

Heritage

2 An Archival Record of the site of the Coal Washery Plant demolition works and the different elements to be demolished shall be taken by a Heritage Consultant before, during and after undertaking the works. This work must be undertaken in accordance with the Heritage Office guidelines, *How to Prepare Archival Records of Heritage Items (1998) and Guidelines for Photographic Recording of Heritage Sites, Buildings and Structures (2001).* A copy of all records must be retained as part of the Bellpac/South Bulli archive to be collated as part of the Conservation Management Plan. Copies must be lodged with the Local Studies Section of Wollongong City Council Library and the Heritage Council of NSW.

3 The nominated heritage consultant shall submit a final report providing written and graphic information of the works and certifying that they have been carried out in conformity to the above Statement of Heritage Impact within three (3) months of the demolition works being completed.

4 The applicant must ensure that no damage is caused to any other significant elements within the South Bulli Colliery site during the demolition process.

5 The applicant must ensure that the elements associated with the Coal Washery Plant to be demolished and the event related to their demolition is incorporated in any future interpretation of the South Bulli Colliery site and that information on their history and heritage significance is adequately presented to the greater community.

6 Should any historical relics be unexpectedly discovered during demolition works, then all work is to stop immediately and the Heritage Council of NSW is to be informed in accordance with Section 146 of the Heritage Act, 1977.

7 Should any Aboriginal objects be uncovered, excavation or disturbed, work is to stop immediately and the National Parks and Wildlife Division of Department of Environment and Conservation is to be informed in accordance with Section 91 of the National Parks and Wildlife Act, 1974.

8 An archaeological assessment of the Coal Washery Plant site must be undertaken as part of the Conservation Management Plan for the South Bulli Colliery Site prepared by Godden Mackay Logan.

9 No further applications will be considered for the South Bulli Colliery Site unless they are to address urgent health and safety matters or they are for works of low or nil significance at the site as identified in the South Bulli Colliery Stage 1 Conservation Management Plan (2004) by Godden Mackay Logan.

10 The Coal Washery Plant is an aspect of the history of the mine site and must be included in the long term interpretation of the site. An Interpretation Plan for the whole site must be included in the final Conservation Management Plan and the planning process for the ongoing use of the mine and in any alternate uses of the site.

Risk Assessments

11 Risk assessments (including health risk assessment) shall comply with AS2601-2001 "Demolition of Structures" and Workcover requirements.

Prior to the Commencement of Works

12 **Demolition Works**

The demolition of the existing nominated structures shall be carried out in accordance with Australian Standard AS 2601-2001: Demolition of Structures or any other subsequent relevant Australian Standard and the requirements of the NSW WorkCover Authority.

No demolition materials shall be burnt on-site. The person responsible for the demolition works shall ensure that all vehicles leaving the site carrying demolition materials have their loads

covered and do not track soil or waste materials onto the road. Any unforeseen hazardous and/or intractable wastes shall be disposed of to the satisfaction of Council.

13 **Consultation with NSW WorkCover Authority**
Prior to any work commencing on the site it is the responsibility of the owner to contact NSW WorkCover Authority in writing in respect to any demolition or use of any crane, hoist, plant or scaffolding.

14 **Notification to Surrounding Property Owners/Occupants Prior to Commencement of Demolition Works**
At least five (5) days notice must be given in writing to any residence or business within 100 metres of the premises to which this consent pertains of the impending demolition works. The written notice must include at least the following information:

14.1 a summary of the work plan and method for the demolition and a timetable for completion of works, including hours of operation, transport routes etc;
14.2 details of the primary contractor and/or company conducting the demolition works;
14.3 the name and telephone number for a person supervising the works to which residents can direct questions, comments and/or concerns about the works for the duration of the works.

15 **Hazardous Materials Survey**
At least one week prior to demolition, the applicant must prepare a hazardous materials survey of the structures to be demolished and submit to Council a report of the results of the survey. **Hazardous materials** include, but are not limited to, asbestos materials, synthetic mineral fibre, PCB materials and lead based paint. The report must include at least the following information:

15.1 the location of the hazardous materials throughout the structures to be demolished;
15.2 descriptions of the hazardous materials;
15.3 the forms in which the hazardous materials are found, eg AC sheeting, transformers, contaminated soil;
15.4 an estimation (where possible) of the quantity of each particular hazardous material by volume, number, surface area or weight;
15.5 a brief description of the method for removal, handling, on-site storage and transportation of the hazardous materials, and where appropriate, reference to relevant legislation, standards and guidelines;
15.6 identification of the disposal sites to which the hazardous materials will be taken.

16 **Waste Management**
Adequate receptacle(s) with lockable lid(s) to store all waste generated by the development pending disposal must be provided within the property boundaries. The receptacle(s) must be regularly emptied and waste must not be allowed to lie or accumulate on the property other than in the receptacle(s). Consideration should be given to the source separation of recyclable and reusable materials.

17 **Erosion and Sediment Controls**
Erosion and sediment controls are to be installed prior to the commencement of any demolition works upon the site. These devices are to be maintained throughout the entire demolition phase and until the site has become stabilised.

18 **Sediment Control Measures**
Sediment-laden runoff from the site must be controlled at all times subsequent to the commencement of demolition works. Sediment control measures must be maintained at all times and checked for adequacy at the conclusion of each day's work and after any rain event of 10mm or more.

During Demolition, Excavation or Construction

19 **Waste Inventory Report**
A Waste Inventory report must be maintained on-site during the demolition works. The waste inventory is a register of all materials and waste removed from the site during the demolition works. The register must record each load or movement of materials and waste from the site and must include at a minimum the following information:

a) a description of the materials (including identified hazardous materials);
b) an estimate of the quantity by volume or weight;
c) the name of the transporter and registration details of the relevant vehicle(s);
d) the intended destination(s) of the materials.

A copy of the Waste Inventory and copies relevant receipts of disposal must be forwarded to Council's Planning Division within fourteen (14) days of the completion date of demolition works.

20 **Restricted Hours of Work**
The applicant must not carry out any demolition work other than emergency procedures to control dust or sediment laden runoff outside the following hours, namely, 7.00 am to 6.00 pm, Monday to Friday and 8.00 am to 1.00 pm Saturday, without the prior written consent of Council. No work is permitted on Sundays or Public Holidays.

Any request to vary these hours shall be submitted to Council in writing detailing:

20.1 the variation in hours required;
20.2 the reason for that variation;
20.3 the type of work and machinery to be used.

21 **Noise Control During Demolition**
To minimise the impact on the surrounding environment the equivalent continuous noise level (L_{Aeq}) measured over a period of 15 minutes when the demolition site is in operation, shall not exceed the background noise level (L_{A90}) by more than 10dB(A) when measured at the most affected point on the boundary of the most affected residential premises.

22 Work must be carried out at all times in a manner which will not cause a nuisance, by the generation of unreasonable noise, dust or other activity, to the owners and/or occupiers of adjoining and adjacent land.

23 Any materials accidentally or otherwise spilled, tracked or placed on the road or footpath area during demolition works without the prior approval of Council's Works Division shall be immediately swept up or immediately removed by "dry" methods. Collected material must be disposed of in a way that prevents its mobilisation. Evidence that any approval to place material on the road or road reserve shall be available for inspection by Council officers on-site at any time.

24 Drains, gutters, access ways and roadways must be maintained free of sediment and any other material.

25 **Dust Suppression Measures**
Activities occurring during demolition works must be carried out in a manner that will minimise the generation of dust.

26 **Dust Control During Demolition Works – Weather Conditions**
Demolition works must not be undertaken in weather conditions where dust is likely to be blown off site.

27 **Trucks**
Trucks which are entering and leaving the premises and carrying loads must be sealed or covered at all times, except during loading and unloading.

28 **Asbestos – Removal, Handling and Disposal Measures/Requirements Asbestos Removal by a Licensed Contractor**
The removal of any asbestos material must be carried out by a licensed contractor if over 200 square metres in area of bonded asbestos or if any type of friable asbestos in strict accordance with the NSW WorkCover Authority's requirements.

29 **Sign – Asbestos Removal Work in Progress**
A sign shall be erected in a prominent location stating that asbestos removal work is in progress and advising of the project manager and company undertaking the work and relevant contact details.

30 **Asbestos Waste Collection**
The asbestos waste must be collected and stored on-site in impermeable bags inside an adequate waste receptacle pending transportation. The receptacle must be lined and covered in accordance with the bin provider's requirements and s29 of the Protection of the Environment Operations (Waste) Regulation 1996.

31 Asbestos waste must be prepared in accordance with WorkCover requirements and disposed of to an EPA licensed landfill site.

32 **Asbestos Transportation Requirements**
Transportation of asbestos from the site must comply with the Protection of the Environment Operations (Waste) Regulation 1996.

33 Asbestos waste must only be disposed of at a land-fill site lawfully approved to receive this type of waste. A receipt must be retained and submitted to Council's Development Assessment and Compliance Division within fourteen (14) days after the completion of demolition works.

34 Any demolition works involving asbestos shall be carried out in accordance with the NSW WorkCover Authority's *Your Guide to Working with Asbestos – Safety guidelines and requirements for work involving asbestos."* Transportation and disposal of asbestos materials shall be in accordance with the NSW Department of Environment and Conservation's requirements.

35 In order to prevent the spread of hazardous material, the applicant shall ensure that:

35.1 power tools are not used on any asbestos material;

35.2 work is undertaken in weather conditions where asbestos dust is unlikely to be blown off site;

35.3 the work area is dampened to prevent any potential for dust generation;

35.4 all asbestos waste is dampened prior to being wrapped or otherwise contained in heavy duty plastic material for storage on site within a waste receptacle and later transportation off site;

35.5 the area affected, or likely to have been affected, by scattering of asbestos pieces, particles or fibres during demolition or cutting into the building is to be cleaned by vacuuming by a contractor approved by WorkCover.

36 The wastewater generated from the washdown of residual coal dust during demolition shall be captured, treated and discharged in accordance with the requirements of the NSW Environment Protection Authority.

37 The contents of the concrete tanks to be demolished shall be emptied and disposed of in a manner acceptable to the NSW Environment Protection Authority.

38 **Demolition Materials - Disposal**
All demolition materials must be disposed of only at reuse, recycling or waste management facilities that may lawfully receive those wastes.

39 **Concrete Crusher**
The concrete crusher shall be located as far away from residences as possible.

40 The equivalent continuous noise level (L_{Aeq}) of the operation of the concrete crusher when measured over a period of 15 minutes, shall not exceed the background noise level (L_{A90}) by

more than 5dB(A) when measured at the most affected point on the boundary of the most affected residential premises.

41 A certificate from a NATA accredited hygienist shall be submitted to Council's Development Assessment and Compliance Division within fourteen (14) days of the completion of demolition works verifying that the site is free from asbestos contamination, if asbestos was detected during demolition.

42 **Waste Inventory**
A copy of the Waste Inventory which was maintained on-site during the demolition works and copies of relevant receipts of waste materials being deposited at waste recycling or disposal facilities shall be forwarded to Council's Development Assessment and Compliance Division within fourteen (14) days of the completion of demolition works.

43 The premises must be kept free of rubbish at all times. All refuse capable of being wind blown must be kept in a suitable waste container.

The reasons for the imposition of the conditions are -

1 To minimise any likely adverse environmental impact of the proposed development.

2 To ensure the protection of the amenity and character of land adjoining and in the locality.

3 To ensure the proposed development complies with the provisions of Environmental Planning Instruments and Council's Codes and Policies.

4 To ensure the development does not conflict with the public interest.

ENDORSEMENT OF DATE OF CONSENT

.....

NOTES:

1 This consent becomes effective and operates from the date shown as **"Endorsement of date of consent"** on this notice.

2 This consent will lapse unless development is commenced within two years (three years with the prior written approval of Council) from the date shown as **"Endorsement of date of consent"** on this notice.

3 Section 97 of the Environmental Planning and Assessment Act confers on an applicant who is dissatisfied with the determination of a consent authority a right of appeal to the Land and Environment Court exercisable within twelve months from the date of receipt of this notice.

4 A **Tree Management Order** has been proclaimed in the City of Wollongong. Under this order, no tree on the land the subject of this approval may be ringbarked, cut down, topped, lopped or wilfully destroyed except with the prior consent of Council which may be given subject to such conditions as Council considers appropriate. However, unless specified otherwise in this consent, those trees which are specifically designated to be removed on the plans approved under this consent or are within 3 metres of an approved building footprint may be removed, provided that a Construction Certificate has been issued for the development the subject of this consent and a Principal Certifying Authority appointed and the required Bank Guarantees have been lodged with Council.

5 In this consent the developer means the applicant for development consent and any person or corporation who carries out the development pursuant to that consent.

6 Section 82A of the Environmental Planning and Assessment Act confers on an applicant who is dissatisfied with the determination of a consent authority a right to request the consent authority to review the determination.

The request for review must be made within 12 months after the date on which the applicant received the notice of determination and must be accompanied by the fee set by the Regulations.

The request for review does not apply to an application in respect of Designated Development or Integrated Development.

Yours faithfully

Wendy Todd
Senior Development Control Officer
Wollongong City Council
Direct Line (02) 4227 7314

Section 55 Protection of the Environment Operations Act 1997

Environment Protection Licence

Licence - 12040

Department of
Environment, Climate Change and Water NSW

Licence Details	
Number:	12040
Anniversary Date:	19-May
Review Due Date:	19-May-2012

Licensee

GUJARAT NRE MINERALS LIMITED
PO BOX 281
FAIRY MEADOW NSW 2519

Licence Type

Premises

Premises

NRE NO 1 COLLIERY
Broker Street
RUSSELL VALE NSW 2517

Scheduled Activity

Mining for coal
Coal works

Fee Based Activity	**Scale**
Mining for coal	> 500000 - 2000000 T produced
Coal works	0 - 2000000 T loaded

Region

Metropolitan
Level 3, NSW Govt Offices, 84 Crown Street
WOLLONGONG NSW 2500
Phone: 02 4224 4100
Fax: 02 4224 4110

PO Box 513 WOLLONGONG EAST
NSW 2520

Archived: 02-Oct-2009

Environment Protection Licence

Licence - 12040

Department of
Environment, Climate Change and Water NSW

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Licence review 4
Fees and annual return to be sent to the EPA 4
Transfer of licence 5
Public register and access to monitoring data 5
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Archived: 02-Oct-2009

Environment Protection Licence

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Information about this licence

Dictionary

A definition of terms used in the licence can be found in the dictionary at the end of this licence.

Responsibilities of licensee

Separate to the requirements of this licence, general obligations of licensees are set out in the Protection of the Environment Operations Act 1997 ("the Act") and the Regulations made under the Act. These include obligations to:

- ensure persons associated with you comply with this licence, as set out in section 64 of the Act;
- control the pollution of waters and the pollution of air (see for example sections 120 - 132 of the Act); and
- report incidents causing or threatening material environmental harm to the environment, as set out in Part 5.7 of the Act.

Variation of licence conditions

The licence holder can apply to vary the conditions of this licence. An application form for this purpose is available from the EPA.

The EPA may also vary the conditions of the licence at any time by written notice without an application being made.

Where a licence has been granted in relation to development which was assessed under the Environmental Planning and Assessment Act 1979 in accordance with the procedures applying to integrated development, the EPA may not impose conditions which are inconsistent with the development consent conditions until the licence is first reviewed under Part 3.6 of the Act.

Duration of licence

This licence will remain in force until the licence is surrendered by the licence holder or until it is suspended or revoked by the EPA or the Minister. A licence may only be surrendered with the written approval of the EPA.

Licence review

The Act requires that the EPA review your licence at least every 5 years after the issue of the licence, as set out in Part 3.6 and Schedule 5 of the Act. You will receive advance notice of the licence review.

Fees and annual return to be sent to the EPA

For each licence fee period you must pay:

- an administrative fee; and
- a load-based fee (if applicable).

The EPA publication "A Guide to Licensing" contains information about how to calculate your licence fees.

The licence requires that an Annual Return, comprising a Statement of Compliance and a summary of any monitoring required by the licence (including the recording of complaints), be submitted to the EPA. The Annual Return must be submitted within 60 days after the end of each reporting period. See condition R1 regarding the Annual Return reporting requirements.

Usually the licence fee period is the same as the reporting period.

Transfer of licence

The licence holder can apply to transfer the licence to another person. An application form for this purpose is available from the EPA.

Public register and access to monitoring data

Part 9.5 of the Act requires the EPA to keep a public register of details and decisions of the EPA in relation to, for example:

- licence applications;
- licence conditions and variations;
- statements of compliance;
- load based licensing information; and
- load reduction agreements.

Under s320 of the Act application can be made to the EPA for access to monitoring data which has been submitted to the EPA by licensees.

This licence is issued to:

GUJARAT NRE MINERALS LIMITED
PO BOX 281
FAIRY MEADOW NSW 2519

subject to the conditions which follow.

1 Administrative conditions

A1 What the licence authorises and regulates

A1.1 Not applicable.

A1.2 This licence authorises the carrying out of the scheduled activities listed below at the premises specified in A2. The activities are listed according to their scheduled activity classification, fee-based activity classification and the scale of the operation.

Unless otherwise further restricted by a condition of this licence, the scale at which the activity is carried out must not exceed the maximum scale specified in this condition.

Scheduled Activity
Mining for coal
Coal works

Fee Based Activity	Scale
Mining for coal	> 500000 - 2000000 T produced
Coal works	0 - 2000000 T loaded

A1.3 Not applicable.

A2 Premises to which this licence applies

A2.1 The licence applies to the following premises:

Premises Details
NRE NO 1 COLLIERY
Broker Street
RUSSELL VALE
NSW
2517
PORTIONS OF CONSOLIDATED COAL LEASE 745
Shaded area nominated on Map titled "Bellpac No. 1 Colliery - Areas to be covered by EPA Licence" dated 19 /4/04

A3 Other activities

A3.1 Not applicable.

A4 Information supplied to the EPA

A4.1 Works and activities must be carried out in accordance with the proposal contained in the licence application, except as expressly provided by a condition of this licence.

In this condition the reference to "the licence application" includes a reference to:
(a) the applications for any licences (including former pollution control approvals) which this licence replaces under the Protection of the Environment Operations (Savings and Transitional) Regulation 1998; and
(b) the licence information form provided by the licensee to the EPA to assist the EPA in connection with the issuing of this licence.

2 Discharges to air and water and applications to land

P1 Location of monitoring/discharge points and areas

P1.1 The following points referred to in the table below are identified in this licence for the purposes of monitoring and/or the setting of limits for the emission of pollutants to the air from the point.

Air

EPA Identification no.	Type of Monitoring Point	Type of Discharge Point	Description of Location
4	Dust Monitoring		Dust Gauge located at 2 Broker Street and labelled as "Point 4" on map titled "Bellpac No 1 Colliery Position of EPA Monitoring Points Russell Vale" submitted to the EPA on 29 January 2004.
5	Dust Monitoring		Dust Gauge located at the Water Board Compound labelled as "Point 5" on map titled "Bellpac No 1 Colliery Position of EPA Monitoring Points Russell Vale" submitted to the EPA on 29 January 2004.
6	Dust Monitoring		Dust Gauge located at 30 West Street labelled as "Point 6" on map titled "Bellpac No 1 Colliery Position of EPA Monitoring Points Russell Vale" submitted to the EPA on 29 January 2004.
7	Dust Monitoring		Dust Gauge located at 22 West Street labelled as "Point 7" on the map titled "Bellpac No 1 Colliery Position of EPA Monitoring Points Russell Vale" submitted to the EPA on 29 January 2004.
8	Dust Monitoring		Dust Gauge located at on the property boundary at Midgely Street and labelled as "Point 8" on map titled "Bellpac No 1 Colliery Position of EPA Monitoring Points Russell Vale" submitted to the EPA on 29 Januray 2004.

P1.2 The following points referred to in the table are identified in this licence for the purposes of the monitoring and/or the setting of limits for discharges of pollutants to water from the point.

P1.3 The following utilisation areas referred to in the table below are identified in this licence for the purposes of the monitoring and/or the setting of limits for any application of solids or liquids to the utilisation area.

Water and land

EPA identification no.	Type of monitoring point	Type of discharge point	Description of location
1		Underground drainage from coal stockpile and forested area.	Concrete weir on energy dissipater in Rath's Gully labelled as "Point 1" on map titled "Bellpac No 1 Colliery Position of EPA Monitoring Points Russell Vale" submitted to the EPA on 29 January 2004.
2	Discharge of treated stormwater runoff and minewater.	Discharge of treated stormwater runoff and minewater.	Outlet of the 200m steel pipe located in the square concrete sump labelled as "Point 2" on map titled "Bellpac No 1 Colliery Position of EPA Monitoring Points Russell Vale" submitted to the EPA on 29 January 2004.
3		Discharge from dam wall (dam wall is designed to drain and has been approved by the dam safety committee).	Waste water that seeps through the dam wall immediately downstream of the stormwater dam labelled as "Point 3" on map titled "Bellpac No 1 Colliery Position of EPA Monitoring Points Russell Vale" submitted to the EPA on 29 January 2004.

3 Limit conditions

L1 Pollution of waters

L1.1 Except as may be expressly provided in any other condition of this licence, the licensee must comply with section 120 of the Protection of the Environment Operations Act 1997.

L2 Load limits

L2.1 Not applicable.

L2.2 Not applicable.

L3 Concentration limits

L3.1 For each monitoring/discharge point or utilisation area specified in the table\s below (by a point

number), the concentration of a pollutant discharged at that point, or applied to that area, must not exceed the concentration limits specified for that pollutant in the table.

L3.2 Where a pH quality limit is specified in the table, the specified percentage of samples must be within the specified ranges.

L3.3 To avoid any doubt, this condition does not authorise the pollution of waters by any pollutant other than those specified in the table\s.

Water and Land

POINT 2

Pollutant	Units of Measure	50 percentile concentration limit	90 percentile concentration limit	3DGM concentration limit	100 percentile Concentration Limit
Oil and Grease	milligrams per litre				10
pH	pH				6.5-9.2
Total suspended solids	milligrams per litre				50

L4 Volume and mass limits

L4.1 For each discharge point or utilisation area specified below (by a point number), the volume/mass of:

(a) liquids discharged to water; or;

(b) solids or liquids applied to the area;

must not exceed the volume/mass limit specified for that discharge point or area.

Point	Unit of measure	Volume/Mass Limit
2	kilolitres per day	2500

L4.2 The volume of wastes discharged from Point 2 on any day must not exceed 2500kL under dry weather conditions, but may exceed this volume under wet weather conditions provided all practical measures are taken to minimise additional pollution caused by the wet weather.

Note 1: For compliance with the above condition, 'Dry Weather Conditions' means less than ten millimetres of rain falling within a 24 hour period and is measured at a point on the premises; and 'Wet Weather Conditions' means anything other than Dry Weather Conditions.

Note 2: For 72 hours following wet weather conditions, water may be discharged in excess of 2500kL/day from Point 2, in order to allow the dam level to be quickly reduced to a safe level,

provided all practical measures are taken to minimise additional pollution caused by the wet weather.

L5 Waste

L5.1 Not applicable.

L6 Noise Limits

L6.1 Not applicable.

4 Operating conditions

O1 Activities must be carried out in a competent manner

O1.1 Licensed activities must be carried out in a competent manner.

This includes:
(a) the processing, handling, movement and storage of materials and substances used to carry out the activity; and
(b) the treatment, storage, processing, reprocessing, transport and disposal of waste generated by the activity.

O2 Maintenance of plant and equipment

O2.1 All plant and equipment installed at the premises or used in connection with the licensed activity:
(a) must be maintained in a proper and efficient condition; and
(b) must be operated in a proper and efficient manner.

O3 Dust Control

O3.1 All operations and activities occurring at the premises must be carried out in a manner that will minimise the emission of dust from the premises.

5 Monitoring and recording conditions

M1 Monitoring records

M1.1 The results of any monitoring required to be conducted by this licence or a load calculation protocol

must be recorded and retained as set out in this condition.

M1.2 All records required to be kept by this licence must be:
(a) in a legible form, or in a form that can readily be reduced to a legible form;
(b) kept for at least 4 years after the monitoring or event to which they relate took place; and
(c) produced in a legible form to any authorised officer of the EPA who asks to see them.

M1.3 The following records must be kept in respect of any samples required to be collected for the purposes of this licence:
(a) the date(s) on which the sample was taken;
(b) the time(s) at which the sample was collected;
(c) the point at which the sample was taken; and
(d) the name of the person who collected the sample.

M2 Requirement to monitor concentration of pollutants discharged

M2.1 For each monitoring/discharge point or utilisation area specified below (by a point number), the licensee must monitor (by sampling and obtaining results by analysis) the concentration of each pollutant specified in Column 1. The licensee must use the sampling method, units of measure, and sample at the frequency, specified opposite in the other columns:

POINT 2

Pollutant	Units of measure	Frequency	Sampling Method
Oil and Grease	milligrams per litre	Monthly during discharge	Grab sample
Total suspended solids	milligrams per litre	Monthly during discharge	Grab sample
pH	pH	Monthly during discharge	In situ

POINTS 4,5,6,7,8

Pollutant	Units of measure	Frequency	Sampling Method
Ash	grams per square metre per month	Monthly	Australian Standard 3580.10.1-2003
Combustible solids	grams per square metre per month	Monthly	Australian Standard 3580.10.1-2003
Particulates - Deposited Matter	grams per square metre per month	Monthly	Australian Standard 3580.10.1-2003

M3 Testing methods - concentration limits

M3.1 Monitoring for the concentration of a pollutant emitted to the air required to be conducted by this licence must be done in accordance with:

(a) any methodology which is required by or under the Act to be used for the testing of the concentration of the pollutant; or

(b) if no such requirement is imposed by or under the Act, any methodology which a condition of this licence requires to be used for that testing; or

(c) if no such requirement is imposed by or under the Act or by a condition of this licence, any methodology approved in writing by the EPA for the purposes of that testing prior to the testing

taking place.

Note: The Protection of the Environment Operations (Clean Air) Regulation 2002 requires testing for certain purposes to be conducted in accordance with test methods contained in the publication "Approved Methods for the Sampling and Analysis of Air Pollutants in NSW".

M3.2 Subject to any express provision to the contrary in this licence, monitoring for the concentration of a pollutant discharged to waters or applied to a utilisation area must be done in accordance with the Approved Methods Publication unless another method has been approved by the EPA in writing before any tests are conducted.

M4 Recording of pollution complaints

M4.1 The licensee must keep a legible record of all complaints made to the licensee or any employee or agent of the licensee in relation to pollution arising from any activity to which this licence applies.

M4.2 The record must include details of the following:
(a) the date and time of the complaint;
(b) the method by which the complaint was made;
(c) any personal details of the complainant which were provided by the complainant or, if no such details were provided, a note to that effect;
(d) the nature of the complaint;
(e) the action taken by the licensee in relation to the complaint, including any follow-up contact with the complainant; and
(f) if no action was taken by the licensee, the reasons why no action was taken.

M4.3 The record of a complaint must be kept for at least 4 years after the complaint was made.

M4.4 The record must be produced to any authorised officer of the EPA who asks to see them.

M5 Telephone complaints line

M5.1 The licensee must operate during its operating hours a telephone complaints line for the purpose of receiving any complaints from members of the public in relation to activities conducted at the premises or by the vehicle or mobile plant, unless otherwise specified in the licence.

M5.2 The licensee must notify the public of the complaints line telephone number and the fact that it is a complaints line so that the impacted community knows how to make a complaint.

M5.3 Conditions M5.1 and M5.2 do not apply until 3 months after:
(a) the date of the issue of this licence or
(b) if this licence is a replacement licence within the meaning of the Protection of the Environment Operations (Savings and Transitional) Regulation 1998, the date on which a copy of the licence was served on the licensee under clause 10 of that regulation.

M6 Requirement to monitor volume or mass

M6.1 For each discharge point or utilisation area specified below, the licensee must monitor:

(a) the volume of liquids discharged to water or applied to the area;
(b) the mass of solids applied to the area;
(c) the mass of pollutants emitted to the air;

at the frequency and using the method and units of measure, specified below.

POINT 2

Frequency	Unit Of Measure	Sampling Method
Continuous	kilolitres per day	Flow meter and continuous logger

6 Reporting conditions

R1 Annual return documents

What documents must an Annual Return contain?

R1.1 The licensee must complete and supply to the EPA an Annual Return in the approved form comprising:
(a) a Statement of Compliance; and
(b) a Monitoring and Complaints Summary.
A copy of the form in which the Annual Return must be supplied to the EPA accompanies this licence. Before the end of each reporting period, the EPA will provide to the licensee a copy of the form that must be completed and returned to the EPA.

Period covered by Annual Return

R1.2 An Annual Return must be prepared in respect of each reporting period, except as provided below.

Note: The term "reporting period" is defined in the dictionary at the end of this licence. Do not complete the Annual Return until after the end of the reporting period.

R1.3 Where this licence is transferred from the licensee to a new licensee:
(a) the transferring licensee must prepare an Annual Return for the period commencing on the first day of the reporting period and ending on the date the application for the transfer of the licence to the new licensee is granted; and
(b) the new licensee must prepare an Annual Return for the period commencing on the date the application for the transfer of the licence is granted and ending on the last day of the reporting period.

Note: An application to transfer a licence must be made in the approved form for this purpose.

R1.4 Where this licence is surrendered by the licensee or revoked by the EPA or Minister, the licensee must prepare an Annual Return in respect of the period commencing on the first day of the reporting period and ending on:
(a) in relation to the surrender of a licence - the date when notice in writing of approval of the surrender is given; or
(b) in relation to the revocation of the licence - the date from which notice revoking the licence operates.

Deadline for Annual Return

R1.5 The Annual Return for the reporting period must be supplied to the EPA by registered post not later than 60 days after the end of each reporting period or in the case of a transferring licence not later than 60 days after the date the transfer was granted (the 'due date').

Notification where actual load can not be calculated

R1.6 Not applicable.

Licensee must retain copy of Annual Return

R1.7 The licensee must retain a copy of the Annual Return supplied to the EPA for a period of at least 4 years after the Annual Return was due to be supplied to the EPA.

Certifying of Statement of Compliance and signing of Monitoring and Complaints Summary

R1.8 Within the Annual Return, the Statement of Compliance must be certified and the Monitoring and Complaints Summary must be signed by:
(a) the licence holder; or
(b) by a person approved in writing by the EPA to sign on behalf of the licence holder.

R1.9 A person who has been given written approval to certify a certificate of compliance under a licence issued under the Pollution Control Act 1970 is taken to be approved for the purpose of this condition until the date of first review of this licence.

R2 Notification of environmental harm

Note: The licensee or its employees must notify the EPA of incidents causing or threatening material harm to the environment as soon as practicable after the person becomes aware of the incident in accordance with the requirements of Part 5.7 of the Act.

R2.1 Notifications must be made by telephoning the Environment Line service on 131 555.

R2.2 The licensee must provide written details of the notification to the EPA within 7 days of the date on which the incident occurred.

R3 Written report

R3.1 Where an authorised officer of the EPA suspects on reasonable grounds that:
(a) where this licence applies to premises, an event has occurred at the premises; or
(b) where this licence applies to vehicles or mobile plant, an event has occurred in connection with the carrying out of the activities authorised by this licence,
and the event has caused, is causing or is likely to cause material harm to the environment (whether the harm occurs on or off premises to which the licence applies), the authorised officer may request a written report of the event.

R3.2 The licensee must make all reasonable inquiries in relation to the event and supply the report to the EPA within such time as may be specified in the request.

R3.3 The request may require a report which includes any or all of the following information:
(a) the cause, time and duration of the event;
(b) the type, volume and concentration of every pollutant discharged as a result of the event;
(c) the name, address and business hours telephone number of employees or agents of the licensee, or a specified class of them, who witnessed the event;
(d) the name, address and business hours telephone number of every other person (of whom the licensee is aware) who witnessed the event, unless the licensee has been unable to obtain that information after making reasonable effort;
(e) action taken by the licensee in relation to the event, including any follow-up contact with any complainants;
(f) details of any measure taken or proposed to be taken to prevent or mitigate against a recurrence of such an event; and
(g) any other relevant matters.

R3.4 The EPA may make a written request for further details in relation to any of the above matters if it is not satisfied with the report provided by the licensee. The licensee must provide such further details to the EPA within the time specified in the request.

R4 Quarterly Report

R4.1 Every calender quarter, the licensee must prepare and submit to the EPA a Quarterly Report comprising:
- Monitoring data, reported graphically where applicable;
- Statement of compliance; and
- Complaints summary.

The Quarterly Report should reach the EPA no later than six weeks after the end of the period being reported.

General conditions

G1 Copy of licence kept at the premises

G1.1 A copy of this licence must be kept at the premises to which the licence applies.

G1.2 The licence must be produced to any authorised officer of the EPA who asks to see it.

G1.3 The licence must be available for inspection by any employee or agent of the licensee working at the premises.

Pollution studies and reduction programs

U1 Pollution Reduction Programs (PRPs) – Completed

PRP No	PRP	Description	Completed Date
1	Progressive Rehabilitation	Progressive rehabilitation of areas of the site no longer in use, eg, dredging of stormwater ponds.	31 January 2005
2	Investigation of Dust Sources in Gauges	Determine the source(s) of particles collected in dust gauges at the Gujarat NRE Russell Vale Colliery	2008
3	Noise Investigation and Mitigation Program	Investigate noise levels and identify reasonable and feasible noise controls and management measures	12 December 2008

Pollution Reduction Program 4 – Noise Mitigation Program

Pollution Reduction Program 3 required the development of a program of noise reduction measures to meet project specific noise goals for the premises. The licensee submitted a letter dated 12 December 2008 containing an acoustic study and a program of proposed noise reduction measures. The aim of this Pollution Reduction Program is the implementation of those measures.

The licensee must implement the noise mitigation measures listed in the revised table titled "Russell Vale Site – Noise Reduction Schedule V7" contained in the licensee's letter to the EPA dated 9 March 2009 (DECC File No. LIC06/434-03).

The Licensee must submit a report to the EPA notifying it of the completion of the noise mitigation measures that are scheduled to be installed by June 2009. The report must also contain the results of site and ambient noise monitoring that will indicate the level of noise reduction achieved by the mitigation measures. The report must be submitted to the EPA by the due date.

DUE DATE

31 August 2009

Special conditions

Dictionary

General Dictionary

In this licence, unless the contrary is indicated, the terms below have the following meanings:

3DGM [in relation to a concentration limit]	Means the three day geometric mean, which is calculated by multiplying the results of the analysis of three samples collected on consecutive days and then taking the cubed root of that amount. Where one or more of the samples is zero or below the detection limit for the analysis, then 1 or the detection limit respectively should be used in place of those samples
Act	Means the Protection of the Environment Operations Act 1997
activity	Means a scheduled or non-scheduled activity within the meaning of the Protection of the Environment Operations Act 1997
actual load	Has the same meaning as in the Protection of the Environment Operations (General) Regulation 1998
AM	Together with a number, means an ambient air monitoring method of that number prescribed by the *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales*.
AMG	Australian Map Grid
anniversary date	The anniversary date is the anniversary each year of the date of issue of the licence. In the case of a licence continued in force by the Protection of the Environment Operations Act 1997, the date of issue of the licence is the first anniversary of the date of issue or last renewal of the licence following the commencement of the Act.
annual return	Is defined in R1.1
Approved Methods Publication	Has the same meaning as in the Protection of the Environment Operations (General) Regulation 1998
assessable pollutants	Has the same meaning as in the Protection of the Environment Operations (General) Regulation 1998
BOD	Means biochemical oxygen demand
CEM	Together with a number, means a continuous emission monitoring method of that number prescribed by the *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales*.
COD	Means chemical oxygen demand
composite sample	Unless otherwise specifically approved in writing by the EPA, a sample consisting of 24 individual samples collected at hourly intervals and each having an equivalent volume.
cond.	Means conductivity
environment	Has the same meaning as in the Protection of the Environment Operations Act 1997
environment protection legislation	Has the same meaning as in the Protection of the Environment Administration Act 1991
EPA	Means Environment Protection Authority of New South Wales.
fee-based activity classification	Means the numbered short descriptions in Schedule 1 of the Protection of the Environment Operations (General) Regulation 1998.
flow weighted	Means a sample whose composites are sized in proportion to the flow at each composites time of

composite sample	collection.
general solid waste (non-putrescible)	Has the same meaning as in Part 3 of Schedule 1 of the Protection of the Environment Operations Act 1997
general solid waste (putrescible)	Has the same meaning as in Part 3 of Schedule 1 of the Protection of the Environment Operations Act 1997
grab sample	Means a single sample taken at a point at a single time
hazardous waste	Has the same meaning as in Part 3 of Schedule 1 of the Protection of the Environment Operations Act 1997
licensee	Means the licence holder described at the front of this licence
load calculation protocol	Has the same meaning as in the Protection of the Environment Operations (General) Regulation 1998
local authority	Has the same meaning as in the Protection of the Environment Operations Act 1997
material harm	Has the same meaning as in section 147 Protection of the Environment Operations Act 1997
MBAS	Means methylene blue active substances
Minister	Means the Minister administering the Protection of the Environment Operations Act 1997
mobile plant	Has the same meaning as in Part 3 of Schedule 1 of the Protection of the Environment Operations Act 1997
motor vehicle	Has the same meaning as in the Protection of the Environment Operations Act 1997
O&G	Means oil and grease
percentile [in relation to a concentration limit of a sample]	Means that percentage [eg.50%] of the number of samples taken that must meet the concentration limit specified in the licence for that pollutant over a specified period of time. In this licence, the specified period of time is the Reporting Period unless otherwise stated in this licence.
plant	Includes all plant within the meaning of the Protection of the Environment Operations Act 1997 as well as motor vehicles.
pollution of waters [or water pollution]	Has the same meaning as in the Protection of the Environment Operations Act 1997
premises	Means the premises described in condition A2.1
public authority	Has the same meaning as in the Protection of the Environment Operations Act 1997
regional office	Means the relevant EPA office referred to in the Contacting the EPA document accompanying this licence
reporting period	For the purposes of this licence, the reporting period means the period of 12 months after the issue of the licence, and each subsequent period of 12 months. In the case of a licence continued in force by the Protection of the Environment Operations Act 1997, the date of issue of the licence is the first anniversary of the date of issue or last renewal of the licence following the commencement of the Act.
restricted solid waste	Has the same meaning as in Part 3 of Schedule 1 of the Protection of the Environment Operations Act 1997
scheduled activity	Means an activity listed in Schedule 1 of the Protection of the Environment Operations Act 1997
special waste	Has the same meaning as in Part 3 of Schedule 1 of the Protection of the Environment Operations Act 1997
TM	Together with a number, means a test method of that number prescribed by the *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales*.

TSP	Means total suspended particles
TSS	Means total suspended solids
Type 1 substance	Means the elements antimony, arsenic, cadmium, lead or mercury or any compound containing one or more of those elements
Type 2 substance	Means the elements beryllium, chromium, cobalt, manganese, nickel, selenium, tin or vanadium or any compound containing one or more of those elements
utilisation area	Means any area shown as a utilisation area on a map submitted with the application for this licence
waste	Has the same meaning as in the Protection of the Environment Operations Act 1997
waste type	Means liquid, restricted solid waste, general solid waste (putrescible), general solid waste (non-putrescible), special waste or hazardous waste

Mr William Dove

Environment Protection Authority

(By Delegation)

Date of this edition - 02-Oct-2009

End Notes

1	Licence varied by notice 1038753, issued on 08-Jul-2004, which came into effect on 02-Aug-2004.
2	Licence varied by notice 1042218, issued on 10-Nov-2004, which came into effect on 05-Dec-2004.
3	Licence transferred through application 143206, approved on 01-Feb-2005, which came into effect on 03-Dec-2004.
4	Licence varied by change to DEC Region allocation , issued on 17-Mar-2006, which came into effect on 17-Mar-2006.
5	Licence varied by notice 1063707, issued on 11-Oct-2006, which came into effect on 11-Oct-2006.
6	Licence varied by notice 1066632, issued on 09-Nov-2006, which came into effect on 09-Nov-2006.
7	Licence varied by notice 1067231, issued on 17-Nov-2006, which came into effect on 17-Nov-2006.

End Notes

8	Licence varied by notice 1068091, issued on 22-Dec-2006, which came into effect on 22-Dec-2006.
9	Licence varied by notice 1089943, issued on 18-Aug-2008, which came into effect on 18-Aug-2008.
10	Condition A1.3 Not applicable varied by notice issued on <issue date> which came into effect on <effective date>
11	Licence varied by notice 1097766, issued on 08-May-2009, which came into effect on 08-May-2009.
12	Licence varied by notice 1104188, issued on 02-Oct-2009, which came into effect on 02-Oct-2009.

Annex E

Subsidence Assessment - Remnant Bulli Areas And Wongawilli First Workings

SEEDSMAN GEOTECHNICS PTY LTD
ACN 082 109 082

285 Cordeaux Road, Mt Kembla NSW 2526
Telephone 0417279556
Facsimile 0242712220

GUJARAT NRE

SUBSIDENCE ASSESSMENT – REMNANT BULLI AREAS AND WONGAWILLI FIRST WORKING

GNE - 121 MAY 2010

SEEDSMAN GEOTECHNICS PTY LTD
ACN 082 109 082

285 Cordeaux Road, Mt Kembla NSW 2526
Telephone 0417279556
Facsimile 0242712220

Monday, 24 May 2010

REF: GNE - 121.doc

Dr C Harvey
Technical Services Superintendent,
Gujarat NRE Coking Coal Ltd
PO Box 281,
Fairy Meadow, NSW, 2519.

Dear Chris

Re: Reduced part 3A subsidence assessment.

We are pleased to submit the following report on the subsidence impacts of the mining proposed in the immediate future at NRE No 1 Colliery.

Please contact the undersigned if you require further information.

Yours sincerely,

Ross Seedsman

EXECUTIVE SUMMARY

This report is a compilation of reports prepared for V Mains and the Part 3A submission for the entire colliery.

309 panel is the last panel in the Bulli seam at the western end of T and W Mains. The maximum vertical subsidence associated with the proposed extraction is forecast to be 200mm. This subsidence will not impact the optic fibre of the fire trail.

V Mains is a block of Bulli Seam coal between earlier longwalls at South Bulli and Cordeaux Collieries. The maximum vertical subsidence associated with this extraction is 1.02m. A management plan will need to be developed with Telstra concerning the fibre optic cable.

H panel is in the Bulli Seam under and adjacent to the stored water of Cataract Reservoir. Wonga Mains and associated longwall gate roads are in the Wongawilli Seam closer to Russell Vale. These are first workings only and any subsidence will be very low and not impact on the surface.

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1 Introduction

In 2010 and 2011, Gujarat NRE No 1 Colliery proposes to use pillar extraction methods to extract Bulli Seam coal from remaining areas in the western area of the lease and to develop new roadways in the Wongawilli Seam in the eastern area.

There are to be 4 main areas of mining (Figure 1):

- 309 panel - the last panel in the Bulli seam at the western end of T and W Mains
- V mains area – a block of Bulli Seam coal between earlier longwalls at South Bulli and Cordeaux Collieries
- H panel in the Bulli Seam under and adjacent to the stored water of Cataract Reservoir
- Wonga Mains and associated longwall gate roads in the Wongawilli Seam closer to Russell Vale.

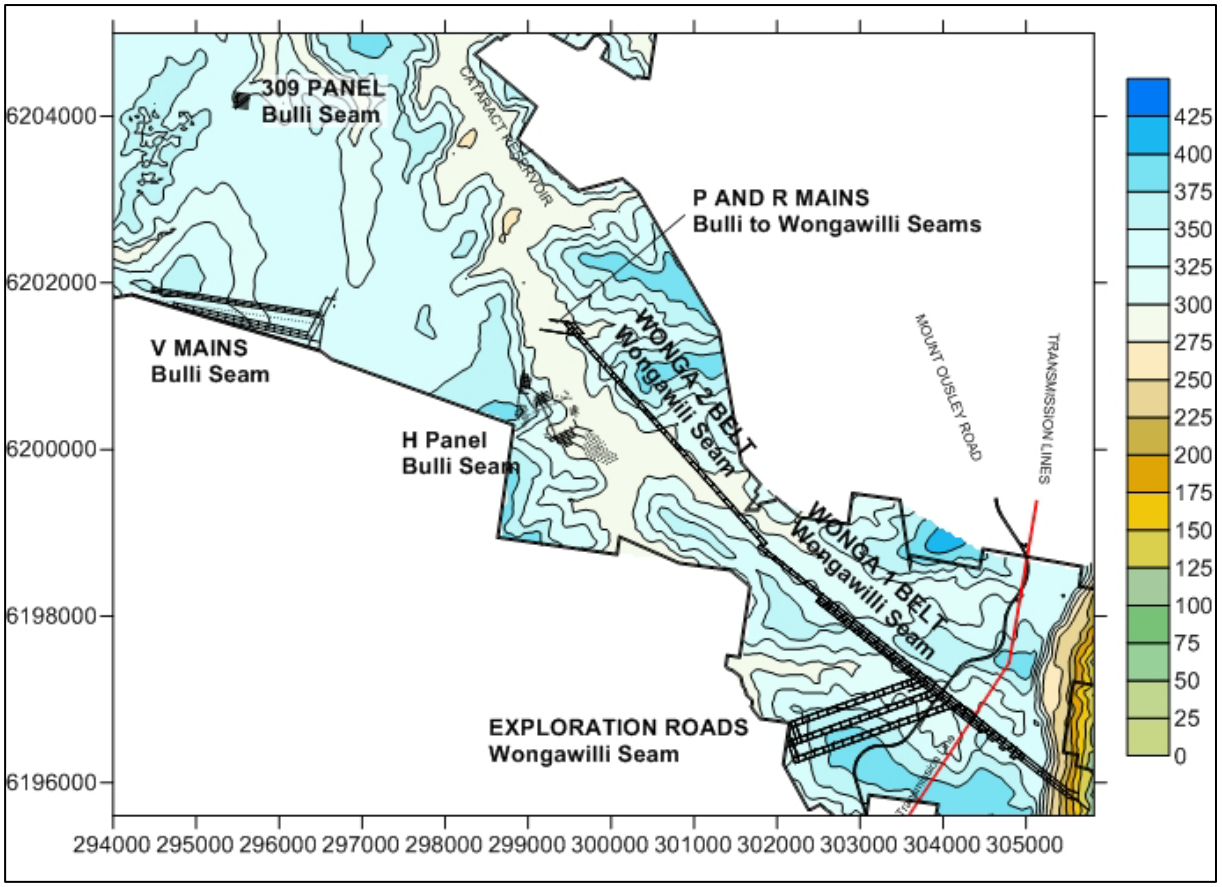

Figure 1 Location of the 3 mining areas together with topography (contour interval in metres)

The general area of the NRE No 1 Colliery lease forms part of a westerly-dipping plateau, which is incised by the deep valleys of the Cataract River and its tributaries. Maximum elevation on the plateau within the study area is slightly above 380m and the maximum local relief is less at 50m.

1.1 309 Panel

A small block of coal is left immediately to the south of the last longwall panel taken in March 1993. Pillar extraction techniques are to be used. The surface topography is relatively flat with no cliffs. The area is designated as a Schedule 1 restricted area (Metropolitan Special Area) and is administered by the SCA. The area is outside the Notification Area of the NSW Dams Safety Committee. A fire trial which is also the location of a fibre optic cable passes near the area. The depth of cover to the Bulli Seam is approximately 450m.

Figure 2 Location of 309 panel and topography (hatched – previous longwalls, outline recent or approved pillar extraction, contour interval in metres).

1.2 V Mains

V Mains is a block of Bulli Seam coal within the previous Cordeaux Mine area to the south walls of the 200 series longwalls (Figure 3). It is located within the previous Cordeaux

Colliery area in a block of coal that is separated from the Cordeaux longwalls by a major dyke. The block of coal is a wedge shape ranging from 75m to 340m wide. Longwall extraction has been conducted on all sides – to the south west and east by Cordeaux Colliery and to the north by what was then known as South Bulli Colliery.

The area overlying the extraction is within the catchment for Sydney Catchment Authority's (SCA) Cataract Reservoir. The surface is mainly natural bushland and includes Wollandoola Creek and associated upland swamps. The area is designated as a Schedule 1 restricted area (Metropolitan Special Area) and is administered by the SCA. The area is outside the Notification Area of the NSW Dams Safety Committee.

The topography comprises gently undulating rises on a plateau surface with a general elevation of about 350m (Figure 3). Wollandoola Creek does not follow a specific drainage line on the topographic map. Surface improvements include fire access tracks and a fibre optic cable.

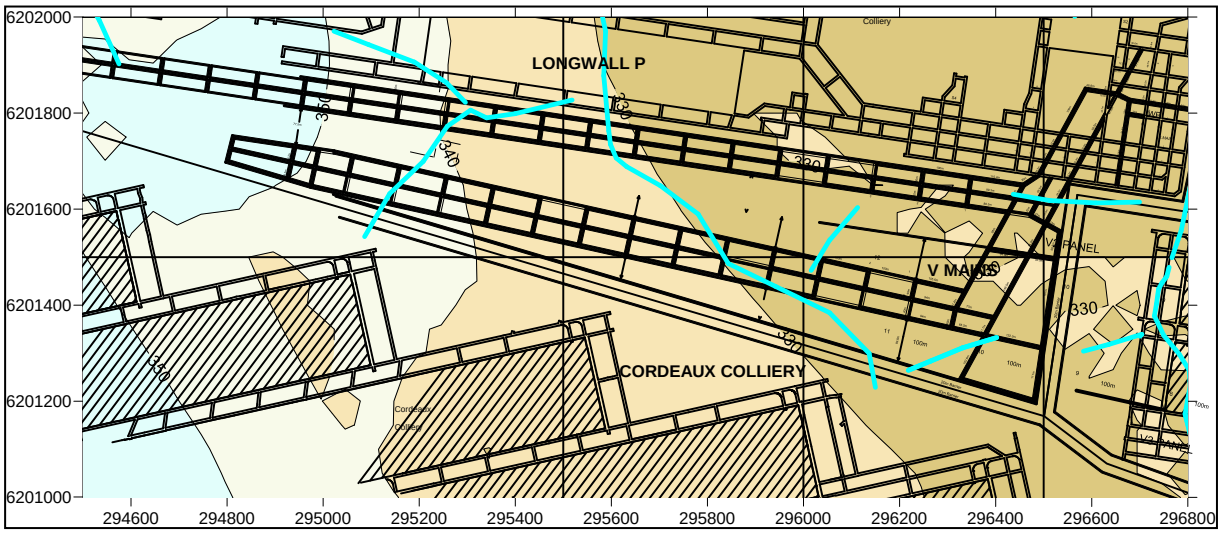

Figure 3 V Mains mine plan and topography (contour interval in metres)

1.3 H panel

H panel includes small blocks of Bulli Seam coal that lie under and immediately adjacent to the stored water of Cataract Reservoir. The mining will be by bord and pillars with no pillar extraction (Figure 4). The depth of cover is between 275m and 350m.

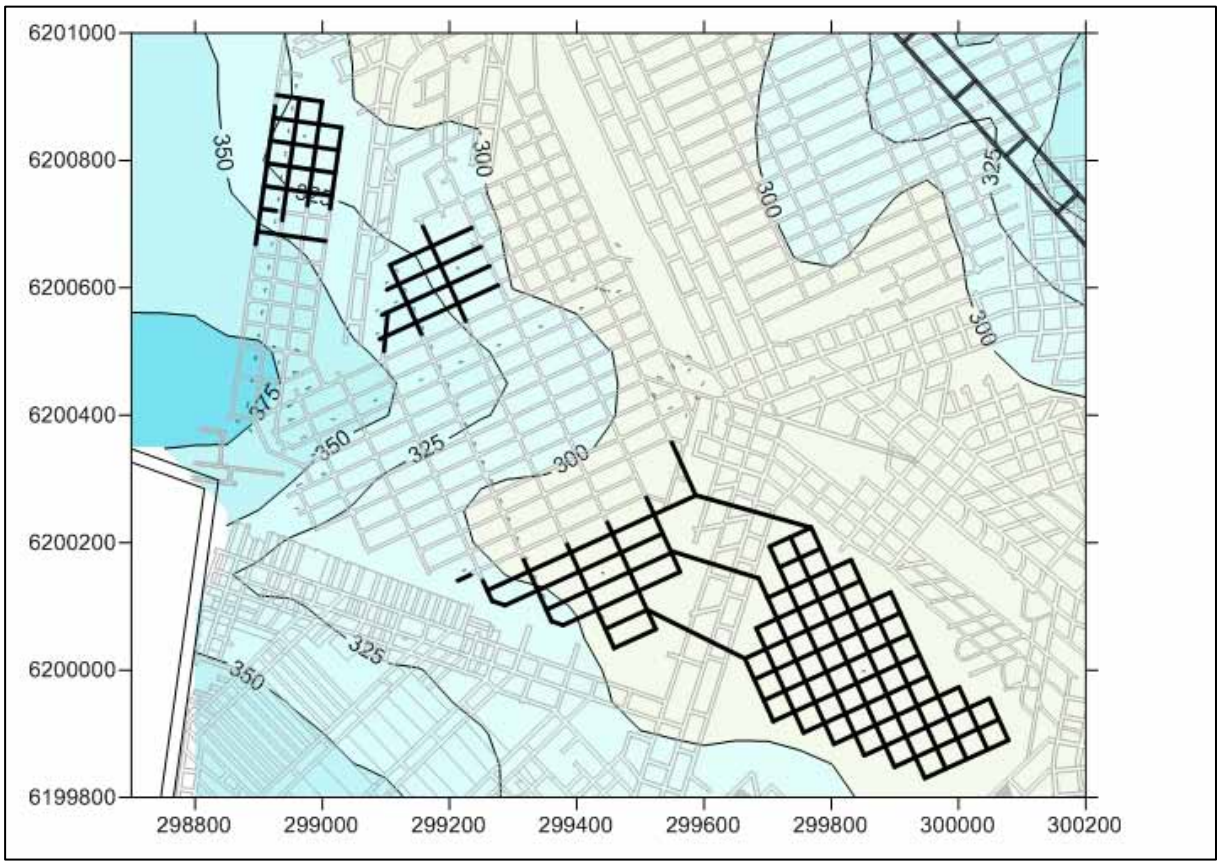

Figure 4 H panel plan with depth of cover contours (contour interval in metres)

1.4 First workings for Wonga Mains and P/R Mains Drifts

New roadways are being driven in the Wongawilli Seam underneath existing workings in the Bulli Seam and in some areas under workings of the Balgownie Seam. Wonga Mains consist of 2 belt roads – Wonga 1 and Wonga 2 (Figure 54). Connection to the Bulli Seam workings is to be made by P and R Mains roadways at the north west end of the Wonga 2 belt. Longwall gateroads are to be driven on the north west side of Mount Ousley Road. Features on the surface include the DSC Notification Area, stored water of Cataract Reservoir, Mount Ousley Road, and transmission lines.

Currently these workings have progressed to about the location of Mount Ousley Road.

As can be seen in Figure 6, the proposed workings are in areas where there are numerous old workings in both the Bulli and Balgownie Seams.

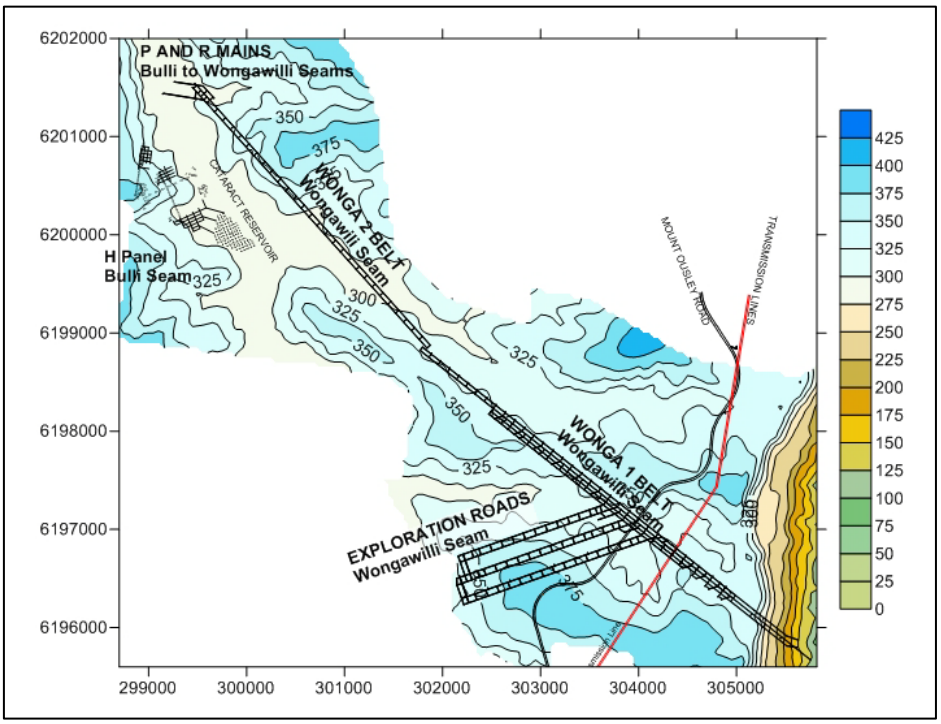

Figure 5 Wonga Mains location (contour interval in metres)

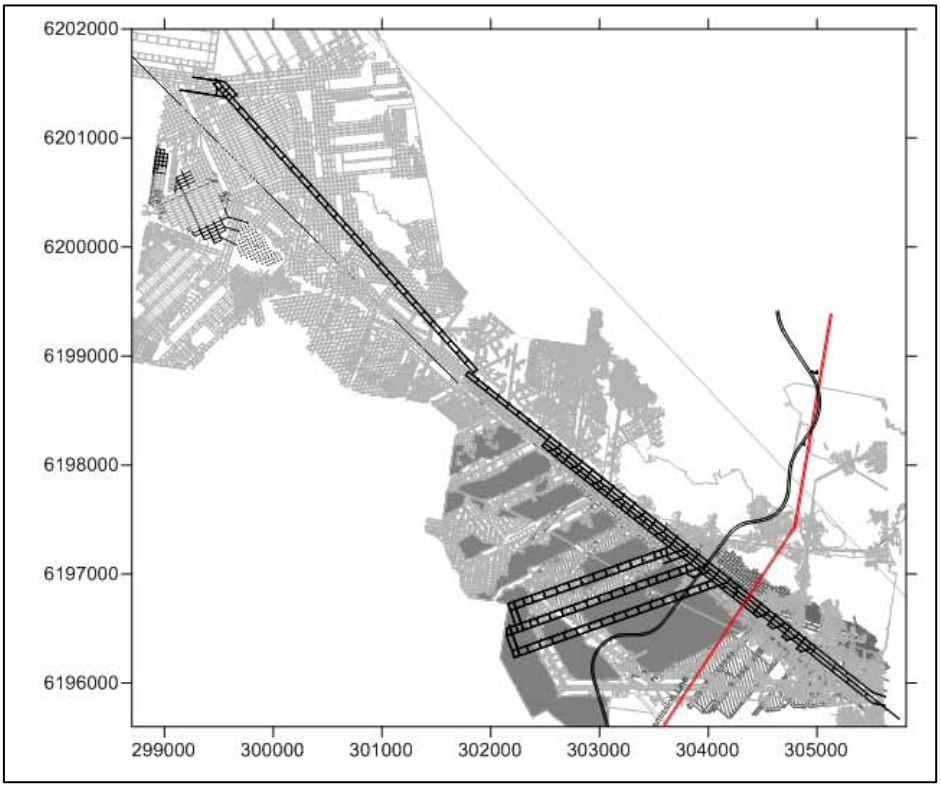

Figure 6 Previous workings in Bulli and Balgownie Seam

2 Mining systems

2.1 Bord and pillar

H Panel includes a number of small areas of Bulli Seam coal where first working pillars will be formed on either 36m by 36m centres or 33m by 72m centres at a maximum depth of 350m depth. The Bulli Seam is 2.5m thick.

2.2 Pillar extraction

Mining in 309 panel and V Mains will utilise pillar extraction techniques. The target seam is the 2.5m thick Bulli Seam with the full seam section to be recovered. There are no overlying seams, and the underlying Balgownie and Wongawilli Seams have not been extracted. The depth of cover in both areas is about 450m.

The 309 panel is 190m by 290m. For V Mains, and sssuming full extraction of the coal, the result will be a goaf that is 2km long and between 75m and 300m wide. This pillar extraction goaf will be 165m from the goaf edge of LWP, and 120m from the Cordeaux longwalls.

2.3 Wonga Mains

Wonga Mains and the gateroads will be driven with 5.5m wide/ 3.0m high roadways located in the base of the Wongawilli Seam. A number of pillars widths will be used (Figure 7):

- 35m, 38m, and 40.9m centres in Wonga 1 belt.
- 45m centres in the Wonga 2 belt.
- 65m centres in the gate roads.

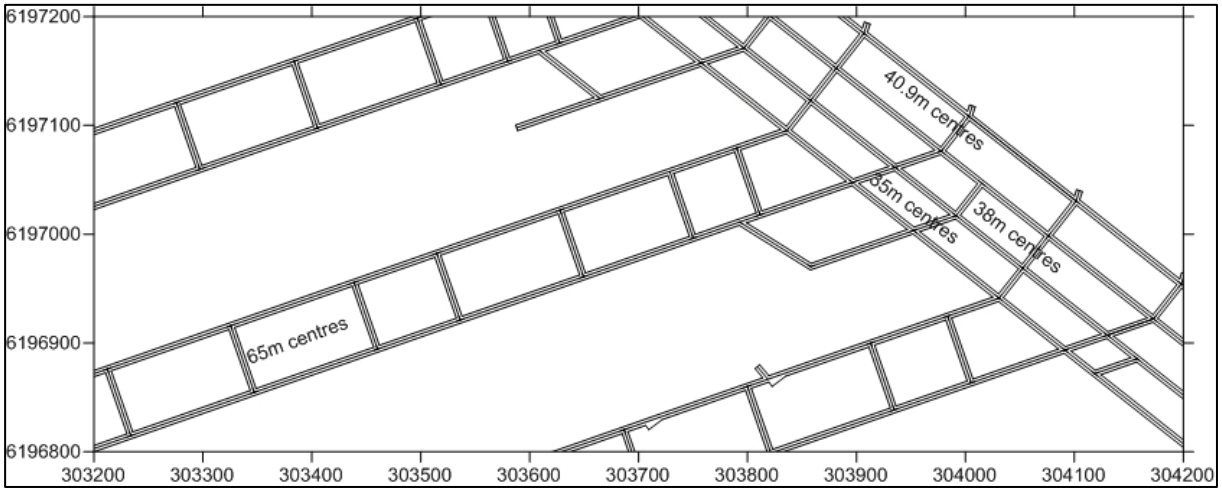

Figure 7 Pillar sizes in Wonga Mains

The depth of cover to the Wongawilli Seam in the area of interest is in the range of 300m to 350m.

3 Site conditions

3.1 Geology

The overburden sequence is typical of the Southern Coalfield and includes the Bulgo and Hawkesbury Sandstones (Figure 8). In the Wongawilli East area, the Hawkesbury Sandstone is about 40m thick, and in the Wongawilli West area this unit will be thicker – in the order of 160m. The Bulgo Sandstone is about 140m thick. The Wongawilli Seam lies approximately 45m below the Bulli Seam and 38m below the Balgownie Seam.

The immediate roof of the Bulli Seam is a massive/cross-bedded medium grained sandstone. In some areas a laminated mudstone roof may be present. The immediate Bulli Seam floor consists of thinly bedded carbonaceous shales, shale, and mudstone. Based on the lack of floor heave in the area, there are no soft puggy clays in the immediate floor.

Whilst the Wongawilli Seam is often referred to as being in the order of 10m thick, in NRE No 1 Colliery the upper portion of the seam is mostly stone (Figure 9). From a mining perspective, the Wongawilli Seam in the Western area is better considered to be a 3m thick economic seam with coal horizons in the immediate roof. The Wongawilli Sandstone Band is well developed in both areas – it is noted that this is a local term only as the band is in fact a tuffaceous unit.

The dominant structural trends (faults and dykes) at the Bulli Seam level are 050^{o} and 120^{o}. In Cordeaux Colliery, the major dyke is some 5m thick and mainly hard with coked coal some 4m either side. Strong jointing was noted to have developed parallel to the dyke underground. This dyke has poor outcrop exposure. In the older workings of NRE No 1 Colliery, the dykes in the 050^{o} direction have given a range of mining conditions from being readily mined to being a major obstacle to gateroad development and extraction.

4 Previous subsidence

4.1 South Bulli Colliery

To the immediate north of V Mains, the 200 series longwalls of the then South Bulli Colliery used 35m chain pillars with 190m wide longwall panels (Figure 10). Subsidence was measured along a cross line between 1978 and 1989 and the maximum subsidence was in the order of 1.3m with most of the subsidence being between 1.05m and 1.20m..

A very similar layout further to the north (300 series) resulted in maximum vertical subsidence of about 0.9m. Figure 11presents one of the survey lines from the 300 series longwalls together with a plan showing interpreted contours of vertical subsidence over the northern end of the 300 series panels. In Figure 12, the interpretation is extended to visualise the likely subsidence that was present at the end of longwall mining in the general 309 panel area.

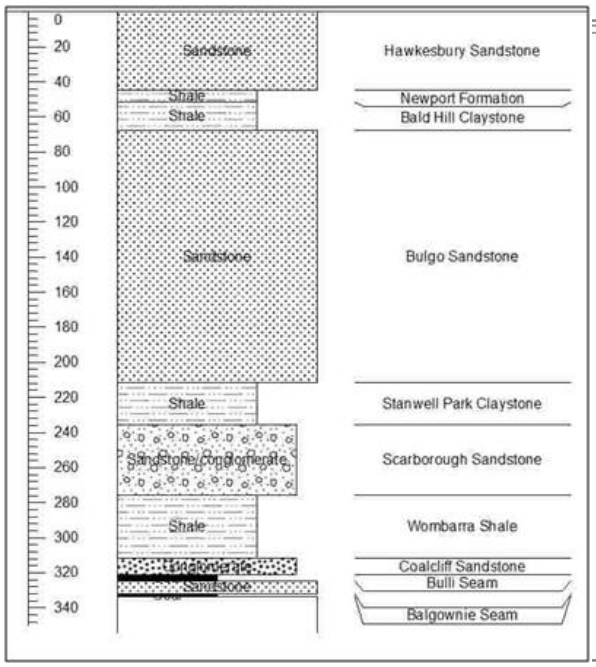

Figure 8 Overburden stratigraphy

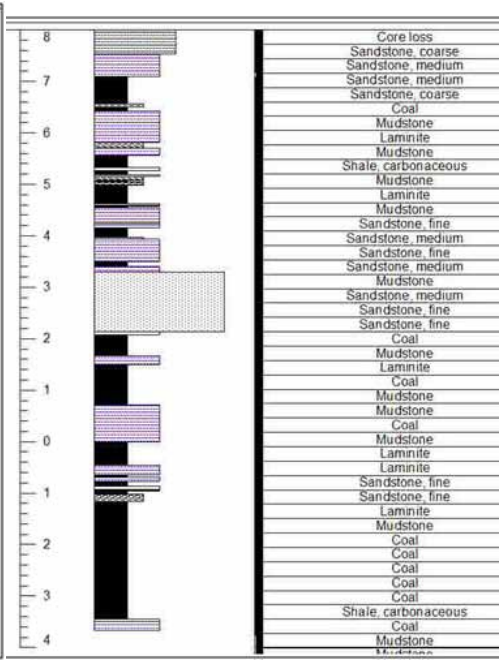

Figure 9 Detail of the Wongawilli Seam

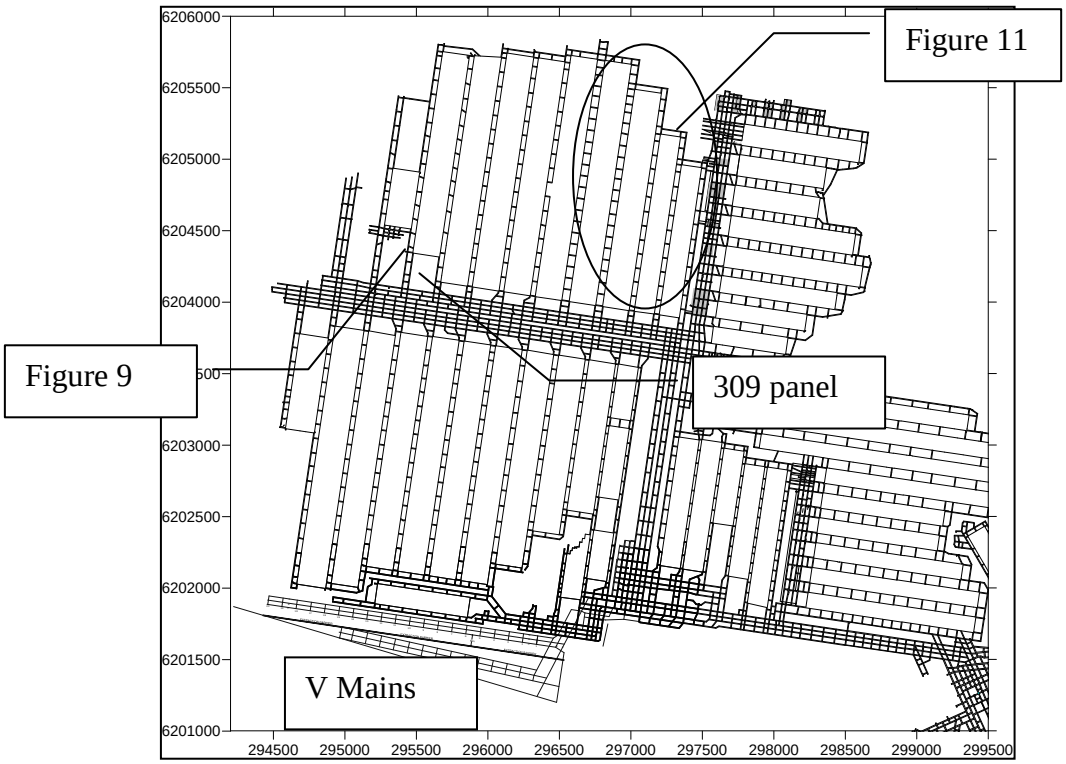

Figure 10 Other Bulli Seam mining in the area of V Mains and 309 panel

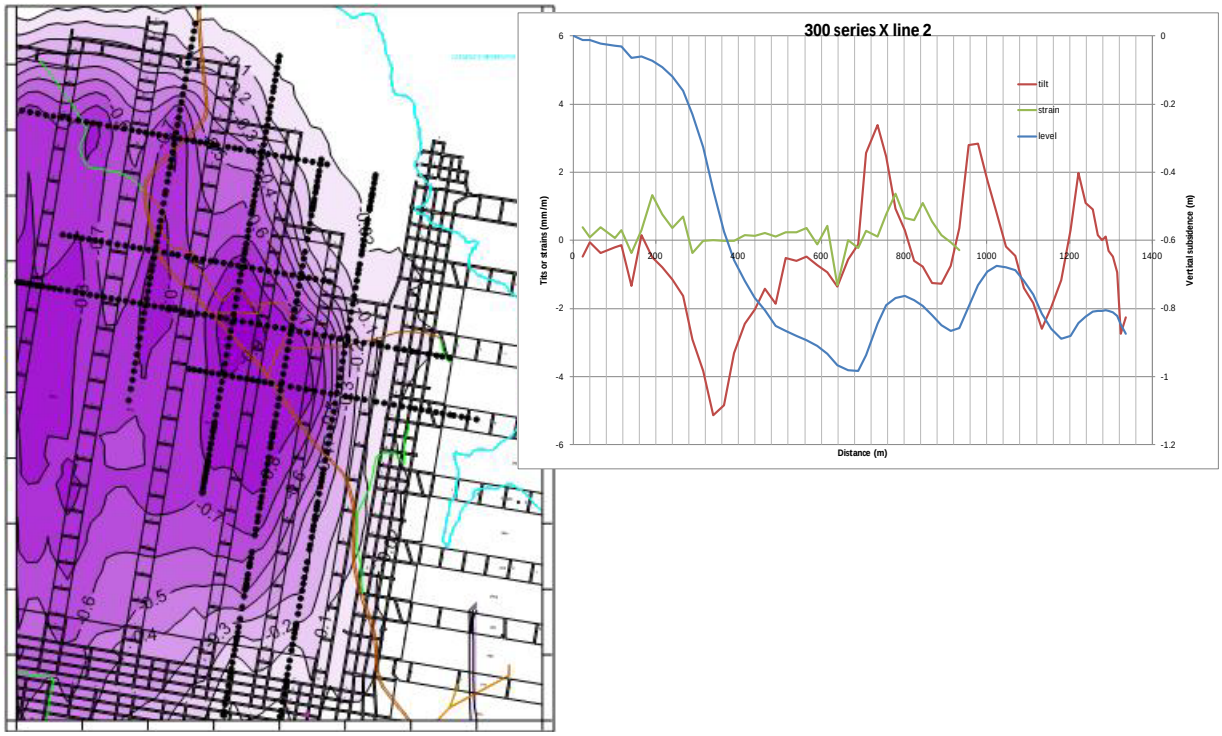

Figure 11 Subsidence during earlier Bulli longwall

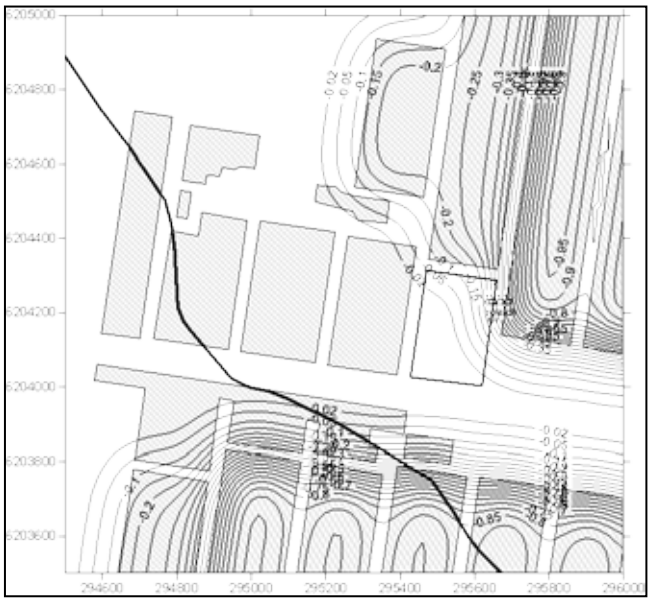

Figure 12 Visualisation of likely subsidence at the end of longwall mining in the 1990's decade (contour intervals in metres)

4.2 NRE No 1 Colliery

A subsidence survey line has been monitored during the recent pillar extraction in the area immediately to the west of 309 panel (Figure 13). The data in Figure 14 indicates a maximum subsidence of about 150mm has been recorded to date.

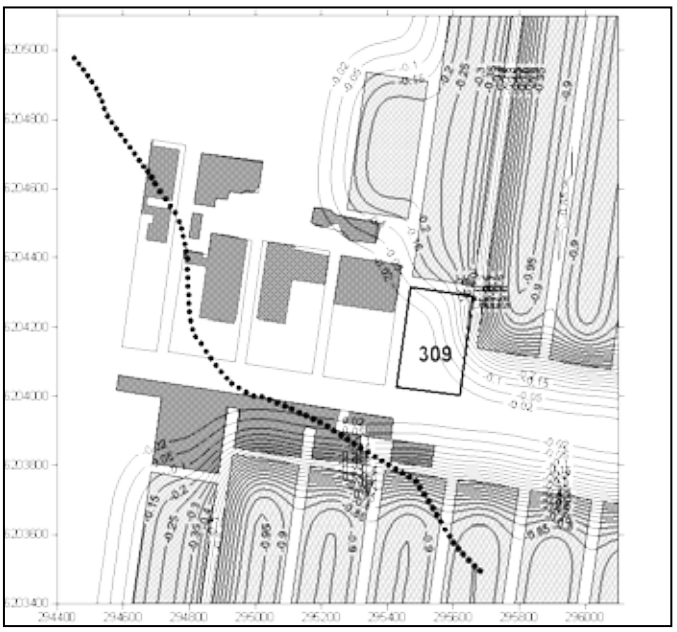

Figure 13 Location of subsidence monitoring line and extent of recent pillar extraction (contour intervals in metres, shaded areas indicate recent extraction)

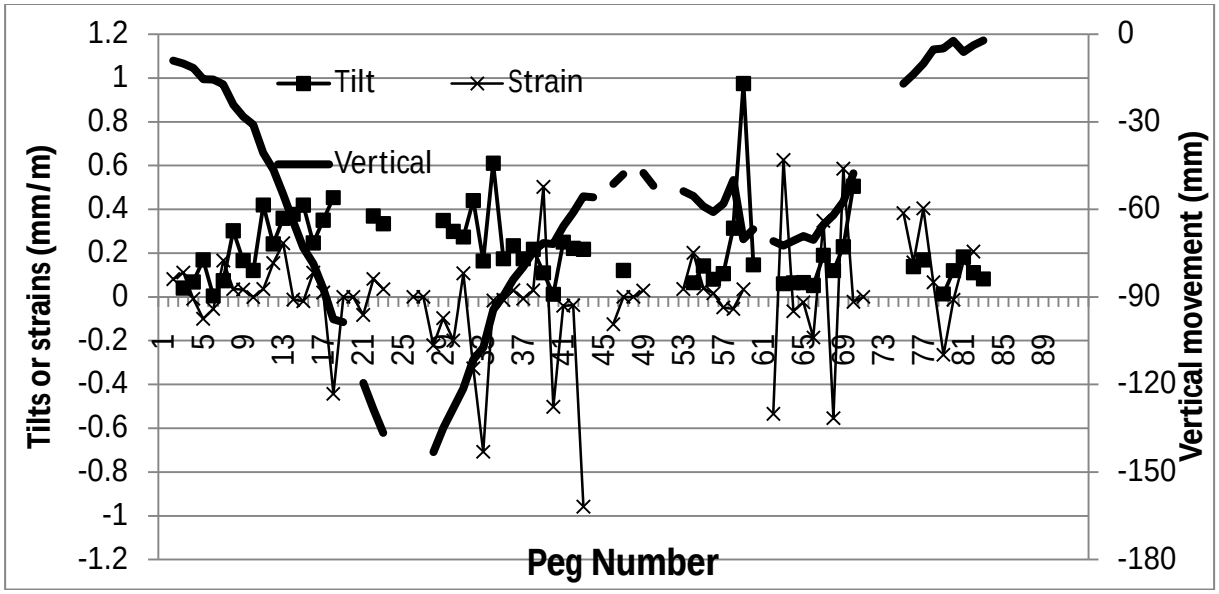

Figure 14 Recent in-line subsidence results (line runs south east to north west)

The data in Figure 14 has been used in the SDPS program for subsidence visualisation to establish a new set of prediction parameters (Class B prediction – Lambe, 1973). Figure 15 gives the results of the calibration with the important difference that the strains are maximum values anticipated and not the in-line values. It can be seen that the in-line tilts are in reasonable agreement. These calibrated parameters (Table 1) are then used to visualise the likely subsidence that has been induced by the pillar extraction in the last few years (Figure 16).

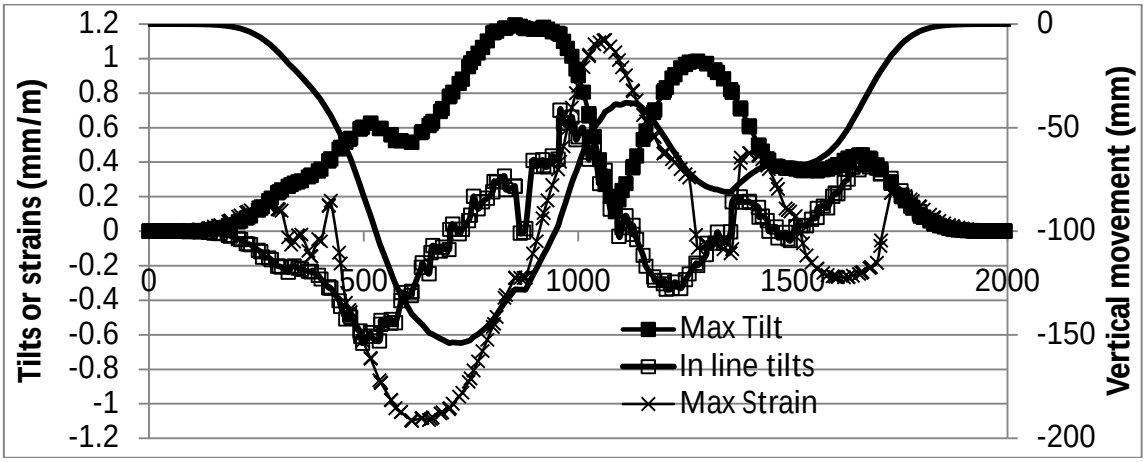

Figure 15 Vertical subsidence and maximum tilts and strains along a slice

Table 1 SDPS calibration

Panel offset	Influence angle	Strain coefficient	Smax	
			Leading panel	Goaf both sides
0.0m	66.6^{o}	0.35	144mm	288mm

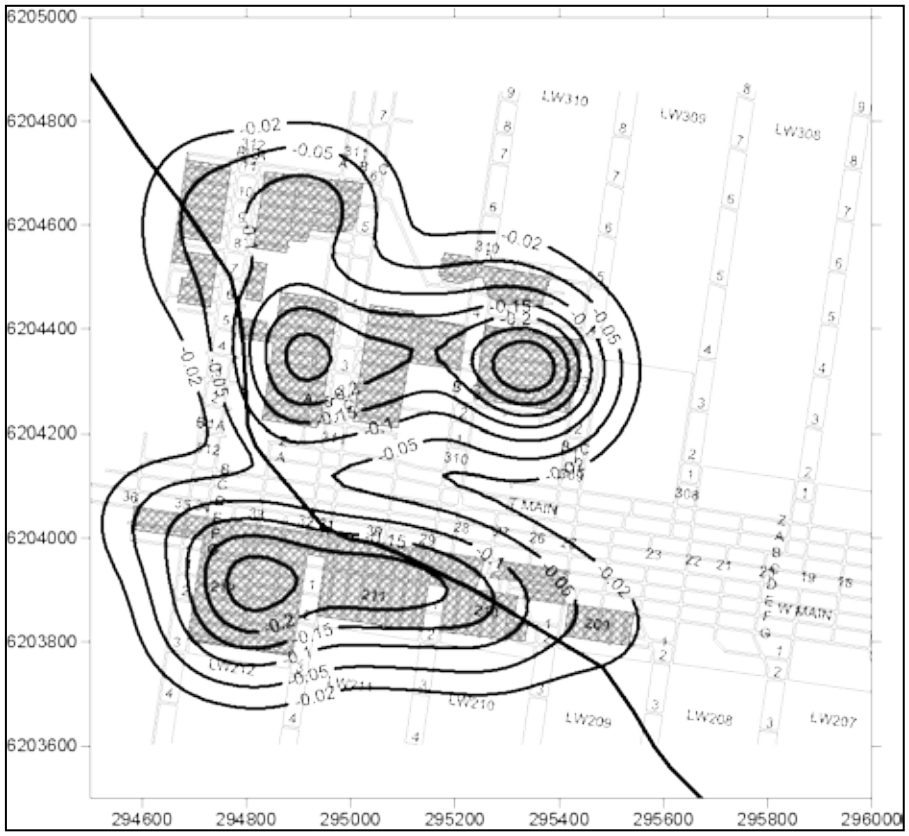

Figure 16 Visualisation of likely subsidence induced above the recent pillar extraction (contour intervals in metres)

4.3 Cordeaux Colliery

Subsidence data from the longwalls to the east of V Mains indicate a maximum vertical subsidence of 1.1 m. This subsidence was developed above 155m wide extraction voids and 30m wide pillars.

The vertical subsidence above the 205m wide panels and 30m pillars to the south west is estimated to have been in the order of 1.2m to 1.3m.

5 Stability of underground workings

5.1 H panel

The pillars in H Panel have very high levels of stability as required by the NSW Dams Safety committee.

Using the University of NSW squat pillar formulation for rectangular pillars and tributary area stress assumptions, the factors of safety are in excess of 3.0. A value of 2.11 is conventionally taken as indicating long terms stability.

Table 2 Pillar strength and loading estimates for H panel

Pillar	**Strength (MPa)**	**Stress at 350m (MPa)**	**Factor of safety**
36m by 36m	40.13	11.95	3.36
33m by 72m	40.15	11.14	3.60

5.2 309 panel

Observations of the roadway conditions in the vicinity of 309 panel indicate that the surround pillars are adequately stable to provide long term stable layouts.

5.3 V Mains

In V Main, the goaf edge will be 120m from the bleeder/tailgate of Longwall P, and hence 170m to the goaf edge. Within this 120m, there will be 3 roadways. On the southern side there will be a distance of 130m - 150m to the goaf edge of Cordeaux longwalls. These blocks of coal will have high levels of stability and the stress changes will be such that the deformations of the coal pillar/roof/floor system will be negligible.

5.4 Wongawilli pillars

The various pillars being used in Wonga Mains and the gateroads have adequately high factors of safety (Table 3). These values are based on the minimum width strength equation in the UniNSW pillar design approach. Given that most pillars will be rectangular, the actual factors of safety will be higher. The nominal frame of reference for long term stability of an individual pillar is 2.11, and it is assessed that the mine design being considered will produce an overall stable mine layout.

Table 3 Factors of safety for first working 3.3m high pillars at 350m depth

Pillar width – solids (m)	Factor of safety
30	1.97
33	2.28
35.9	2.62
40	3.05
60	6.9

6 Subsidence prediction

6.1 Methods

For 309 panel, the best approach is extrapolating from the adjacent extraction panels.

Subsidence prediction for V Mains can be extrapolated from the results of extensive monitoring of subsidence in the immediate adjacent areas of NRE No1 Colliery. It is our view that the reliability of the following estimates is very high given the extensive monitoring of subsidence that has been conducted at Bellambi West and Cordeaux on which the predictions are based.

For first workings, the conventional wisdom is that any surface deformations will be undetectable with standard survey techniques. This is conveniently taken to imply less than 20mm of vertical subsidence.

6.2 309 panel

Using the calibrated parameters discussed above, Figure 17 shows the likely evolution of vertical subsidence above 309 panel. The mining will induce up to 200mm of vertical movement and when added to the subsidence induced in 1992, the total vertical movement is forecast to be between 0.15m to 0.4m. The associated tilts and strains are anticipated to be similar to those recorded already along the subsidence survey line (+/- 1mm/m).

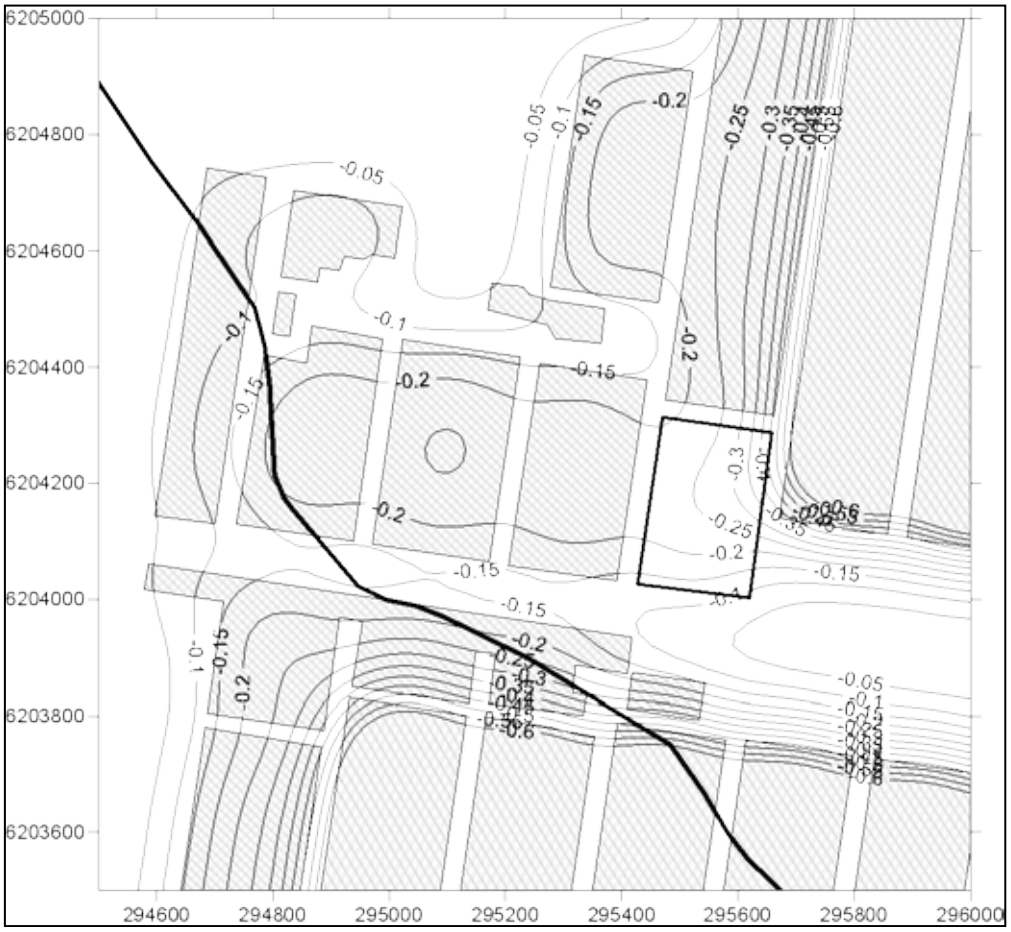

Figure 17 Subsidence above 309 panel - before 309, 309 itself, and likely total subsidence after 309 (contour intervals in metres).

6.3 V Mains

6.3.1 Holla and Barclay

The charts in Holla and Barclay (2000) provide the basis for the prediction for the isolated panel such as V Mains. The method utilises a data base of subsidence in the Southern Coalfield, with longwall panels of up to 207m width and also pillar extraction and Wongawilli panels of widths of 260m to 920m

For V Mains, the depth of cover is taken to be 460m and the seam thickness is 2.5m. Table 4 presents the derivation of the vertical subsidence and other parameters for a range of panel widths.

6.3.2 SDPS visualisation

The evidence from subsidence surveys in the area indicate that sag associated with extraction panels is not "measureable" with panels of less than 120m wide. For wider panels the sag becomes measureable and it is for these panels that the subsidence bowl can visualised using influence function methods (SDPS, www.carslonsw.com).

SDPS requires 3 inputs: inflexion point relative to goaf edge, maximum subsidence expressed as a percentage of seam thickness, and the influence angle (angle subtended to the horizontal by the point of zero subsidence). In this case a subsidence ratio of 0.3, no subsidence at panel less than 100m wide, and offset of 0 for 120m wide and 36m for 300m wide panels has been used. Based on our experience with the method, a value of 66.6^{o} for the influence angle has been used. A strain factor of 0.35 has been used.

Table 4 Analysis of isolated panels using Holla and Barclay

Panel width (m)	**W**	**75**	**120**	**175**	**220**	**260**	**300**
Width/depth ratio at 460m depth	W/H	0.16	0.26	0.38	0.48	0.57	0.65
Subsidence ratio	Smax/T	0	0.05	0.2	0.25	0.3	0.45
Maximum vertical subsidence (mm)	Smax	0	125	500	625	750	1125
Location of inflexion point (m)	D/H			-0.05	0.0	0.1	0.10
	In from goaf edge (m)			-23	0.0	46	46
Tensile strain parameter	K1	0.5	1	1.3	1.35	1.3	0.65
Compressive strain parameter	K2	1	2.5	2.9	3	1.7	1.1
Tilt parameter	K3	1.3	4	4.8	4.9	4.5	3.5
Max tensile strain	mm/m	0	0.3	1.4	1.8	2.1	1.7
Max compressive strain	mm/m	0	0.7	3.2	4.1	2.8	2.8
Maximum tilt	mm/m	0	1.1	5.2	6.7	7.3	8.9

Table 5 presents the maximum values of the various subsidence parameters as visualised in SDPS. The values compare well with predictions using Holla and Barclay (Table 3). The distribution of the various subsidence parameters are shown in Figures 18 to 21, and these show how the subsidence parameters are distributed across the area.

Table 5 Maximum values of subsidence parameters for V Mains derived in the SDPS analysis

Subsidence parameter	Maximum values
Vertical movement	1.02m
Horizontal movement	0.43 m
Tilt	6.1 mm/m
Curvature	-0.05km^{-1} to 0.09 km^{-1}
Horizontal strain	-6.5mm/m to 3.3 mm/m

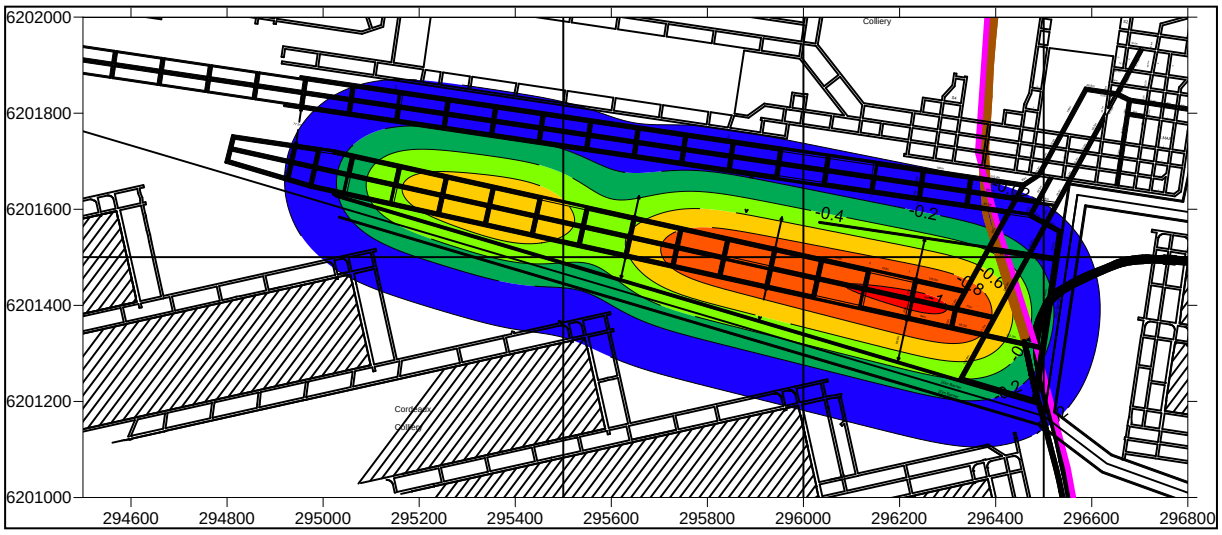

Figure 18 Vertical movements above V Main (m)

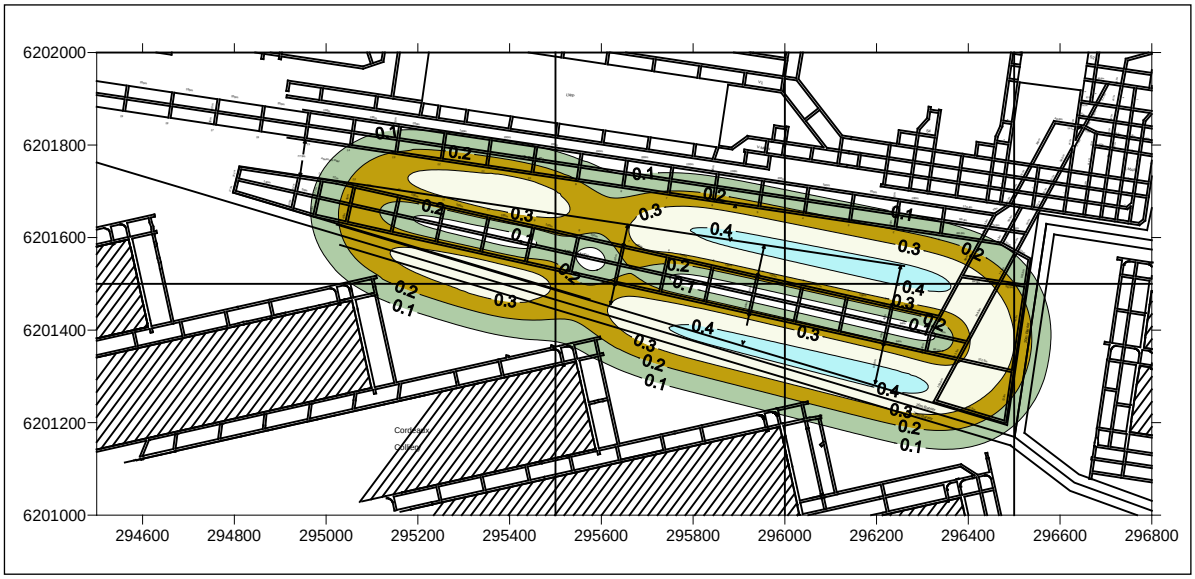

Figure 19 Horizontal movements above V Main (m)

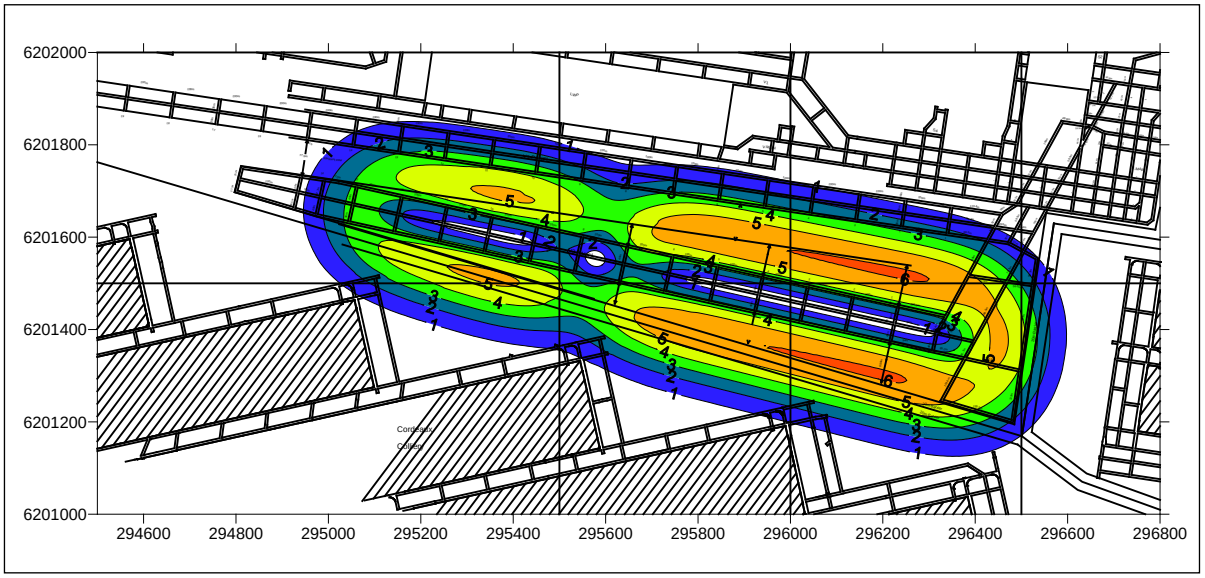

Figure 20 Tilts above V Main (mm/m)

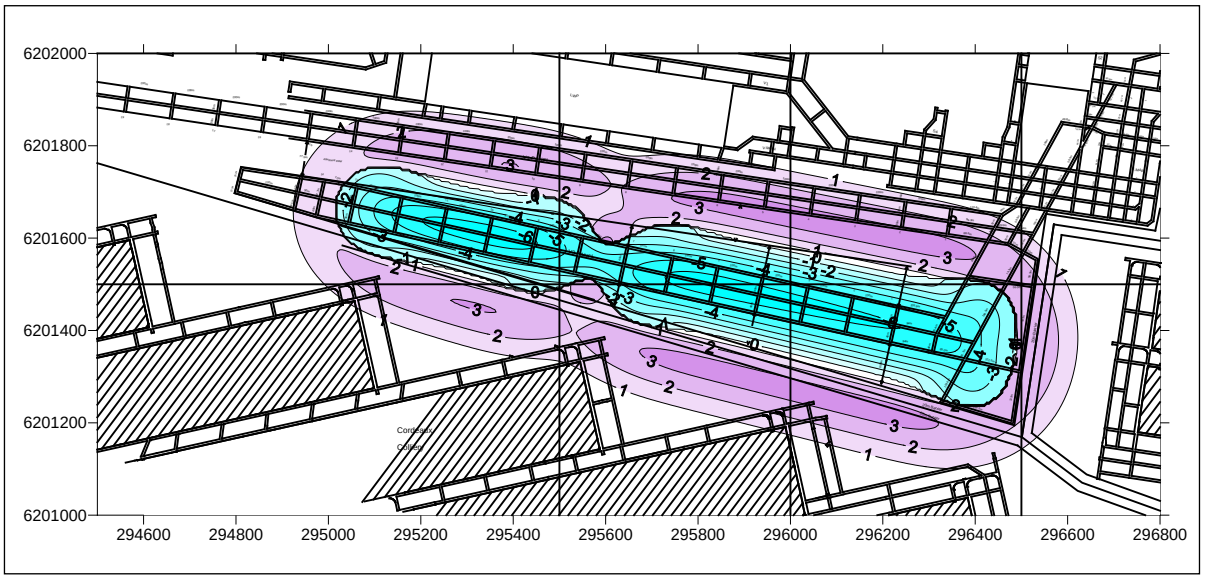

Figure 21 Maximum strains above V Main (mm/m)

6.4 Wongawilli first workings

There is a justifiable presumption that stable first workings result in less than 20mm of vertical subsidence. SGPL is aware of only one case where measurements have been made and this presumption certainly has been demonstrated to be valid. The issue is somewhat trivial as the overwhelming evidence is the lack of reports of adverse surface deformation (except for the case of pot hole subsidence at less than say 30m of cover depth).

It is valid to assess subsidence above first workings in terms of compression of the roof/coal/floor system at the mined seam level in response to changes in the vertical stress

acting on the pillars. The stress assumption can be the same as for pillar design (tributary area). The pillars can be assumed to be rigid footing. There are significant uncertainties in allocating deformation values to the various rock types. Based on our use of this approach at other mines, the deformation of the roof/coal/floor system for the range of pillar widths at 350m is predicted to be in the order of 18-19mm. When previously used for first workings, this approach has been found to over-estimate the measured vertical subsidence at the surface.

Table 6 Estimation of vertical subsidence for first working pillars in the Wongawilli Seam.

DEPTH	**m**	**350**	**350**	**350**	**350**
ROCK DENSITY	t/m3	2.4	2.4	2.4	2.4
TOTAL COAL THICKNESS	M	5	5	5	5
PILLAR WIDTH	m	30	33	35.9	60
PILLAR LENGTH	m	120	120	120	120
ROADWAY WIDTH	m	5	5	5	5
ROADWAY HEIGHT	m	3.3	3.3	3.3	3.3
INITIAL STRESS	MPa	8.2	8.2	8.2	8.2
TRIB. AREA STRESS	MPa	10.0	9.9	9.8	9.3
% EXTRACTION	%	0.2	0.2	0.2	0.1
STRESS CHANGE	MPa	1.8	1.6	1.5	1.1
MATERIAL PROPERTIES					
Coal modulus	MPa	4000	4000	4000	4000
Roof modulus	MPa	18000	18000	18000	18000
Floor modulus	MPa	18000	18000	18000	18000
Coal Poisson Ratio		0.35	0.35	0.35	0.35
Geological Strength Index		50	50	50	50
SHORT TERM SUBSIDENCE					
Constrained modulus factor		1.6	1.6	1.6	1.6
GSI reduction		0.3	0.3	0.3	0.3
Coal compression	mm	4.5	4.2	3.9	2.7
Roof compression	mm	6.7	6.9	7.0	8.0
Floor compression	mm	6.7	6.9	7.0	8.0
Total compression	mm	18.0	17.9	17.9	18.7

6.5 Prediction uncertainty

6.5.1 Prediction

Morgenstern[1] said:

"It is rare for the geotechnical engineer to rely on quantitative prediction to meet his objectives. In practice reliance on quantitative prediction is only worth contemplating under the most idealised circumstances. The practice of the geotechnical engineer is more modest. Risk must be managed to overcome the limitations of site characterisation, knowledge of material properties, other unknowns and the vagaries of construction practice. In order to

[1] Morgenstern, N. Performance in geotechnical practice. The Inaugural Lumb lecture, May 10, 2000, Hong Kong.

mange this risk effectively, it is essential that the geotechnical engineer maintain an on-going awareness of factors that contribute to unsuccessful performance and introduce this awareness into comprehensive risk management tools.'

Morgenstern went on to say: *"The assurance of geotechnical performance would be enhanced if geotechnical engineering shifted from the promise of certainty to the analysis of uncertainty.*

Lambe[2] classified predictions into 3 basic types:

A. Before the event
B. During the event
    1. results no known at the time of the prediction
    2. result known at the time of the prediction
C. After the event
    1. results no known at the time of the prediction
    2. result known at the time of the prediction

Reliability of the predictions increases as monitoring results are obtained. Whilst Type A predictions are the holy grail, the quest is somewhat futile. Instead the geotechnical profession focuses on B1 predictions through the use of the observational method. Type C2 predictions are autopsies, and one must be very suspicious when a Type C2 prediction is claimed to have been "accurate" in retrospect.

Prediction methods can include precedent practice, empirical methods, or the application of geotechnical engineering analysis.

6.5.2 309 panel

There is no empirical data on the vertical subsidence that develops during the extraction of small pillar panels in the Southern Coalfield. The predictions for 309 panel have a high degree of uncertainty attached to them and should not be relied on. The presence of un-extracted coal to the south and east is of advantage but it is not known what the deformations associated with the floor of the seam will be.

The fibre optic cable is not exposed to the uncertainty of the predictions.

6.5.3 V Mains

Treating V Mains as an isolated panel is considered valid and it is noted that the effective seam thickness has not been reduced to account for coal left in the goaf as compared to longwall mining. It is assessed that the predictions of the systematic deformations can be relied on.

[2] Lambe T.W. Predictions in soil engineering. Geotechnique, 23,2,149-202.

It is noted that the dyke at seam level may result in localised higher tilts and strains. The surface location of the dyke, if it does outcrop, is not known. Importantly, if the dyke can be considered as a vertical planar feature, it will intersect the fire trail/optic fibre cable near the edge of the subsidence bowl (Figure 18).

6.5.4 H panel

H panel involves first workings in an area where the geology is well known. The stability levels are high. It is assessed that a high level of reliance can be placed on the predictions of stability.

We have not sought to predict subsidence deformations. There is a robust precedent that the deformations will be less than 20mm. It is noted that the surface prevents any monitoring to confirm this prediction.

More importantly in terms of risk management, precedent at this site is that this mining can be conducted without any adverse impact to the surface or to the integrity of the stored water.

6.5.5 Wonga Mains

For the first workings in the Wongawilli Seam, there is a high level of confidence in the predictions of stability.

Once again there is a robust precedent that the deformations will be less than 20mm. The analyses based on foundation engineering are exposed to a high level of uncertainty related to the selection of deformation parameters. There is a possibility that the actual deformation, if they could be measured, would be found to be out by anywhere up to 50% to 100% - i.e. 10 to 20mm.

More importantly in terms of risk management, precedent that first workings can be formed at these depths without any adverse impact to the surface..

7 Physical Impacts to the surface

This section discusses only the physical impacts at the surface and only for 309 panel and V Mains. It is understood that other specialists will assess other impacts. There is no precedent for the development of physical impacts above the stable first workings discussed in this report.

For 309 panel and V Mains, it is noted that the predicted subsidence is similar in magnitude to that which has already developed in the immediately adjacent areas. On this basis, it is assessed that the impacts will be similar. We are not aware of any reports of adverse impacts from the Cordeaux or South Bulli operations in this area.

7.1 Surface deformations

The subsidence deformations induced by the mining will be applied to relatively flat terrain with very few rock outcrops. This should mean that systematic impacts will dominate and there will few dis-ordered movements. Similarly, because there is no defined valley, there will be no identifiable valley closure or upsidence deformations.

For V Mains, the predicted strains are in the range of +3 mm/m tensile to 6 mm/m compression. Based on our experience, these strain levels are not sufficient to cause tensile cracking in solid rock. The tensile strains may cause existing joints to open slightly but only to relatively shallow depth. No interconnected cracking to the workings is predicted. Without interconnected cracking, there is no potential for loss of surface water. As noted above, monitoring of piezometric levels in the Hawkesbury and Bulgo Sandstone indicate no adverse impacts associated with the earlier mining at Bellambi West and Cordeaux.

7.2 Surface Improvements

7.2.1 Optic fibre

The optic fibre follows the fire trail. By reference to the various figures presented above, the optic fibre crosses V Main where the subsidence predicted to be the greatest. In particular, some compressive strains are predicted. Figure 22 presents the strains that may develop along the cable in the direction of the cable – the maximum tensile strains may be in the order of 2 mm/m and the maximum compressive strains in the order of 4 mm/m. These levels of strain will require a management plan with Telstra and that plan will need to recognise the risk of localised strains associated with the dyke scenario discussed previously. The mining of 309 panel will have no impact on the optic fibre.

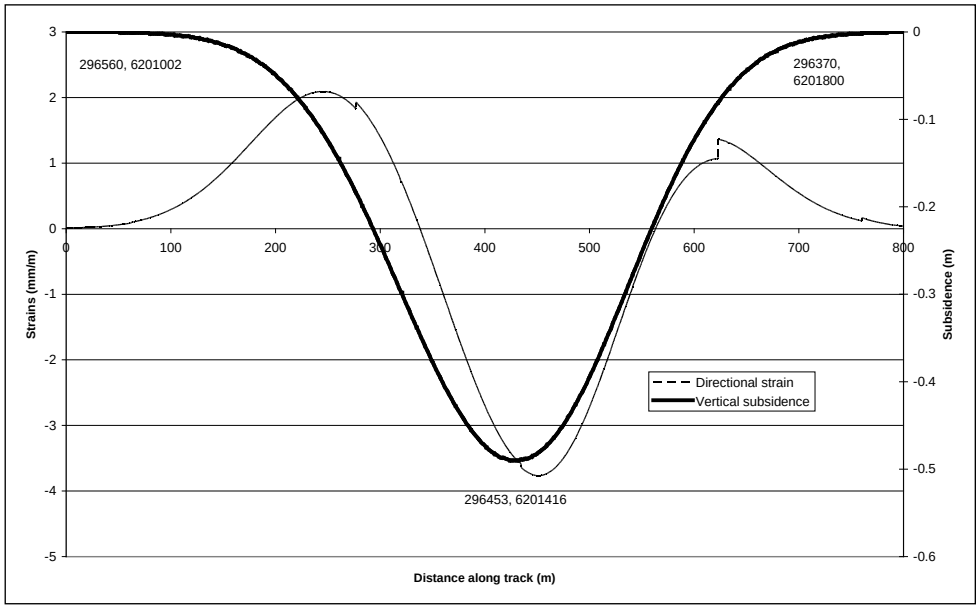

Figure 22 Directional strain along optic fibre line

7.2.2 Access tracks

With the predicted levels of strain, there may be minor cracking and bump formation on the vehicle trail associated with V Mains. These can be readily remediated. Compression bumps may present a hazard to vehicles travelling at excessive speed. A management plan that incorporates signs, daily inspections, and a pre-approved treatment strategy as the coal is extracted in the immediate area should be considered. The mining of 309 panel will have no impact on the optic fibre.

Annex F

V Mains Surface And Groundwater Assessment

GeoTerra

GUJARAT NRE NO. 1 COLLIERY

V MAINS
SURFACE WATER & GROUNDWATER ASSESSMENT

Bellambi, NSW

GUJ3-R1A

12 MAY, 2009

GeoTerra PTY LTD **ABN 82 117 674 941**

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GUJ3-R1A (12 MAY, 2009)

GeoTerra

Gujarat NRE No. 1 Colliery
PO Box 281
Fairy Meadow NSW 2519

Attention: Dr C Harvey

Chris,

RE: V Mains Surface Water and Groundwater Assessment

Please find enclosed a copy of the above mentioned report.

Yours faithfully

GeoTerra Pty Ltd

Andrew Dawkins (AuSIMM CP-Env)

Managing Geoscientist

Distribution: Original GeoTerra Pty Ltd
1 electronic copy Gujarat NRE No. 1 Colliery

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Date	Rev	Comments
06.02.2009		Initial Draft
12.05.2009	A	Incorporate Reviewer Comments

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1. INTRODUCTION

Gujarat NRE Minerals Ltd (Gujarat) propose to extract coal by pillar extraction of the "V Mains" in the Bulli Seam at the NRE No. 1 Colliery.

The proposed V Mains workings are located within the Sydney Catchment Authority managed, restricted access Metropolitan Special Area within which Gujarat have been granted Consolidated Coal Lease 745 (CCL745) and Mining Lease 1575 (ML1575) as shown in **Drawing 1**.

The Project Area is located 13km north of Wollongong and is defined as the area within the predicted 20mm subsidence zone around the proposed V Mains. It contains ephemeral 1st and 2nd order tributary creeks draining into the Schedule 2 streams of Wollandoola and Lizard Creeks along with valley infill upland swamps located along the riparian zone of the creeks

The Project Area does not contain any rivers, gorges or cliff lines and is within an essentially undeveloped bushland region, apart from limited fire access trails and mine surface infrastructure. The land is used as a surface water catchment area that drains into the Cataract River. Water from the Cataract River is regulated by Broughtons Pass Weir, from which the water is diverted through Cataract Tunnel to the Macarthur Water Treatment Plant.

The Project Area contains a Risk Management Zone (RMZ) (NSW Department of Planning, 2008) which laterally extends to either side of Wollandoola Creek for 400m away from the centre line of the creek. This RMZ is wholly enclosed within the Project Area.

A Risk Management Zone has not been defined along Lizard Creek as it is not anticipated the creek or its riparian zone will be affected by subsidence, as outlined in this report.

This study provides a baseline, pre-mining assessment of the potentially affected surface water and groundwater systems within the proposed mining area and has been conducted to satisfy the Subsidence Management Plan (SMP) approvals process as administered by the Department of Primary Industries-Mineral Resources (DPI-MR).

Office, field and laboratory studies have been used to prepare a baseline stream water, stream geomorphology and groundwater assessment as well as an indicative management and monitoring strategy that will be suitable to manage any potential adverse effects on the systems caused by subsidence.

Surface water and groundwater features within the V Mains Project Area include;

- the main channel and tributaries of Wollandoola Creek, which flows to the north and joins the Cataract River approximately 9km due NNW of V Mains, or approximately 12 km along the stream reach,
- the main channel of Lizard Creek, which joins with the Cataract River approximately 7km to the north, or approximately 8km to the north along the stream reach. It should be noted that Lizard Creek will not be directly undermined by V Mains, and is on the eastern periphery of the 20mm subsidence zone
- An valley infill upland swamp area located along the riparian channel periphery of Wallandoola Creek

- Perched, ephemeral basement aquifers located within the upper Hawkesbury Sandstone, and
- a regional aquifer located deeper within the Hawkesbury sandstone.

There are no registered private bores within the Project Area, whilst some monitoring piezometers are located within the Gujarat Lease Area, although they are not directly located within the Project Area.

The main channel of Wallandoola and Lizard Creek are classified as Schedule 2 streams with 3rd order or higher channels (DIPNR, 2005), which have some limited, ephemeral Category 1, 1st to 2nd order tributaries.

No dams are present within the V Mains Project Area.

Baseline stream investigations commenced in Lizard Creek in March 2001 and during September 2001 within Wallandoola Creek by assessing the;

- ephemeral or perennial nature and flow in streams over the panels;
- creek bed and bank erosion and channel bedload;
- stream and upland swamp water quality;
- stream bed and bank vegetation;
- sediment bedload;
- presence and appearance of pools;
- the presence or absence of bedrock , stream bed or bank cracking;
- any observed or inferred groundwater discharge zones, and the;
- presence of hydrocarbon gas.

Baseline groundwater investigations commenced in December 1992 using vibrating wire piezometers targeted in the Bulli Seam and Hawkesbury Sandstone. The piezometer intakes were installed over and adjacent to mined out areas, outside of the V Mains Project Area, adjacent to Cataract Dam.

Shallow upland swamp groundwater level monitoring commenced in July 2004, whilst upland swamp groundwater quality monitoring commenced during July 2006 over the T and W Mains extraction area.

2. SCOPE OF WORK

Geoterra Pty Ltd were commissioned by Gujarat NRE Minerals Ltd to monitor the existing baseline status and to address any potential surface water and groundwater impacts relating to the proposed extraction and associated subsidence of V Mains.

The report will be incorporated into a Subsidence Management Plan (SMP) application to the Department of Primary Industries-Mineral Resources that will be prepared by Gujarat.

3. PREVIOUS RELATED STUDIES

Prior to V Mains specific studies detailed further in this report, the stream flow and stream water quality status of Wallandoola Creek has been assessed in:

- September 2001 (Seedsman Geotechnics Pty Ltd, 2001) at two sites within Wallandoola Creek, approximately 500m downstream of the V Mains Project Area
- November to December 2001 (Geoterra Pty Ltd, 2002) at three sites within the main channel and a tributary of Wallandoola Creek, downstream of V Mains. This was in preparation for a proposed expansion of longwall mining to the west of the existing Bulli Seam workings, which, in the end, did not proceed.
- Between July 2007 and July 2008 (Environmental Resources Management Pty Ltd, 2008) at three locations within Wallandoola Creek upstream and downstream of V Mains, as well as in a generally dry, ephemeral tributary upstream of V Mains

The stream flow and stream water quality status of Lizard Creek has previously been assessed in:

- March 2001 (Australian Water Technologies, 2001) at two sites (LC2 and LC8)
- September 2001 (Seedsman Geotechnics Pty Ltd, 2001) at numerous sites within Lizard Creek and its tributaries downstream of V Mains
- November to December 2001 (Geoterra Pty Ltd, 2002) at numerous sites within the main channel and tributaries of Lizard Creek, adjacent to and downstream of V Mains in preparation for a potential expansion of longwall mining to the west of the existing Bulli Seam workings (which did not proceed),
- Between July 2006 and the present (Ecoengineers Pty Ltd, 2008) in two unnamed ephemeral tributaries of Lizard Creek over the current extraction area at T and W Mains, and;
- Between July 2007 and July 2008 (Environmental Resources Management Pty Ltd, 2008) at three locations upstream, adjacent to and downstream of V Mains

4. GENERAL DESCRIPTION

4.1 Mine Layout

Coal has been extracted in the Bulli Seam at NRE No. 1 Colliery (and its predecessors) to the east, north and west of V Mains, as well as in the BHP Cordeaux Colliery to the south of V Mains as shown in **Drawing 2** by both longwall and pillar extraction methods.

In addition, the Balgownie and Wongawilli Seams have also been extracted from within the Gujarat Lease area, although not within the V Mains Project Area.

The BHP Cordeaux Colliery longwalls are separated from V Mains by a 5m thick dyke.

V Mains is a wedge shaped block of coal ranging from 75m to 340m wide, with approximately 460m depth of cover, with the full 2.5m seam thickness planned to be mined by pillar extraction.

4.2 Land Use

The Project Area is located within the Sydney Catchment Authority restricted access Metropolitan Special Area in which Gujarat have been granted coal mining lease CCL745 and ML1575.

The Project Area is within an essentially undeveloped bushland region, apart from limited fire access trails and mine surface infrastructure.

4.3 Topography

The area comprises three main soil landscapes (Hazelton, 1990). In general, the upper portions of the catchment are within the Maddens Plains landscape, which migrates into the Lucas Heights landscape, whilst the Hawkesbury landscape is located in the lower, downstream incised valleys as described below.

- **Maddens Plains:** moderately to gently undulating rises on plateau surfaces with widespread upland swamps / wetlands. Local relief ranges from 10-40m with valley slope gradients of 1-10%. The dominant landform elements are broad, usually waterlogged drainage depressions with scattered rock outcrop. The Maddens Plains landscape is located over V mains along the channels of Wollandoola and Lizard Creeks.

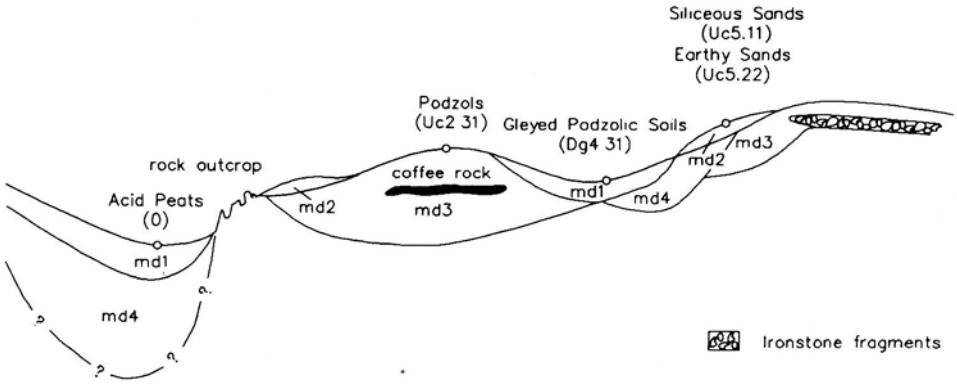


Figure 1 Maddens Plains Soil Landscape

- **Lucas Heights:** gently undulating plateau surfaces and ridges 200-1000m wide, with level to gently inclined slope gradients of <10%. Local relief is <30m and rock outcrops are absent. The Lucas Heights landform is located to the west of the V Mains Project Area. Lateritic podzolic soils can be present within the Lucas Heights profile, which would be a source of dissolved iron into stream waters

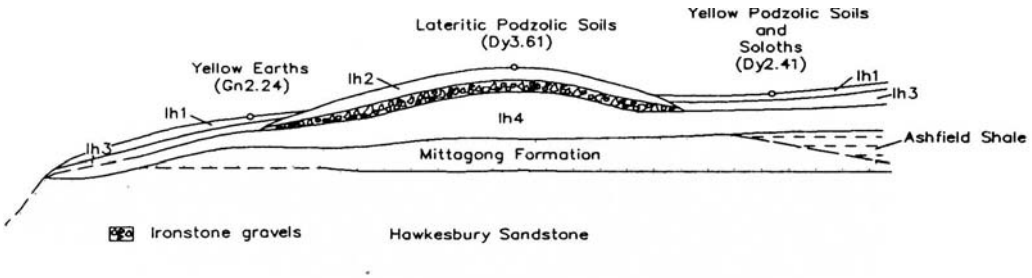


Figure 2 Lucas Heights Soil Landscape

Hawkesbury: Rolling to very steep hills. Local relief of 100-200m with slope gradients of 20-70%. Crests and ridges are convex and narrow and <100m wide. Slopes are moderately inclined to precipitous. Valleys are narrow (20-100m) and incised. Rock outcrop is common and occurs as horizontal benches and broken scarps up to 10m high. Rock outcrops and surface boulders and cobbles up to 50% of the ground surface.

The Hawkesbury landscape is not present within the V Mains Project Area, although is present in the steeper, downstream, incised sections of Lizard and Wallandoola Creeks.

Ironstone fragments are present in the profile, which would be a source of dissolved iron into receiving streams.

No cliffs associated with the Hawkesbury landscape are present within the V Mains Project Area.

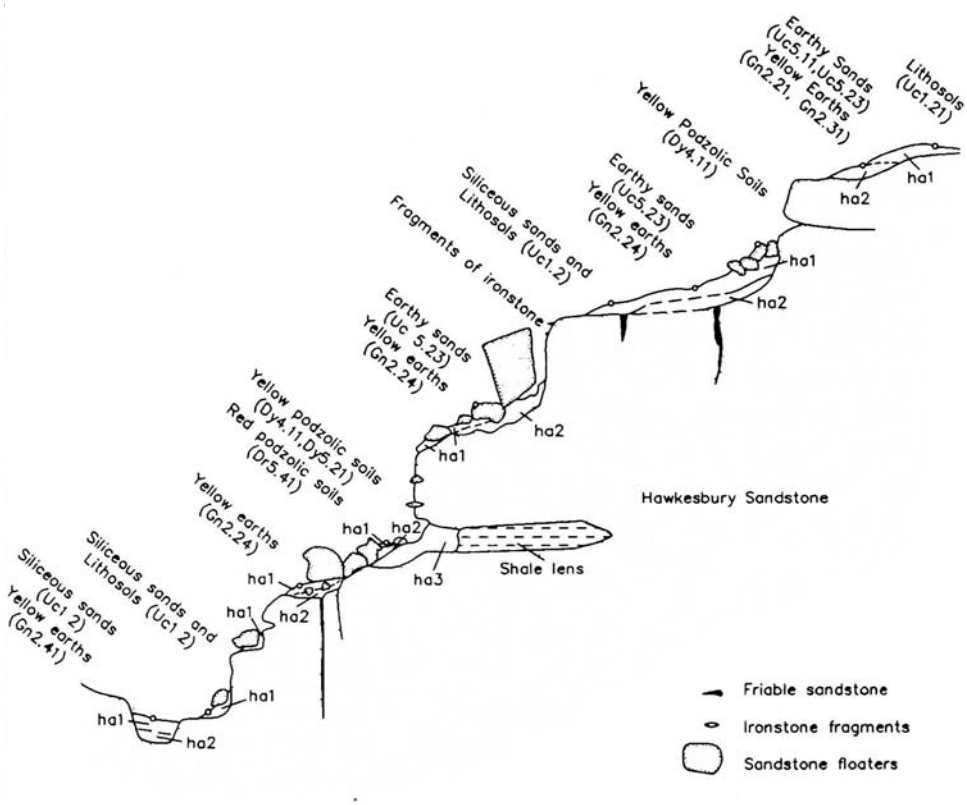


Figure 3 Hawkesbury Soil Landscape

4.4 Upland Swamps

Upland swamps are accumulations of colluvial and alluvial medium to coarse grained sand moving under gravity from ridges and "steps" into the stream network along with sediment formed by insitu bedrock weatehring.

Upland swamps in the Gujarat Lease area have relatively small upstream catchments, with their saturation being a function of storage in the sandy sediments and accumulated organic matter. The storage and water transmission characteristics of the surrounding and underlying Hawkesbury Sandstone is critical in sustaining these environments.

Upland swamps within the NRE No. 1 Mine Lease area occur in either headwater tributary valleys that are characteristically derived from colluvial sand movement from Hawkesbury Sandstone dominated ridgelines, or along the riparian zone of the major creeks.

They are only located within areas underlain by Hawkesbury Sandstone, which provides a low permeability base on which the swamp sediments and organic matter accumulate and do not form on Wianamatta or Narrabeen Group sediments.

Regional groundwater flow within the Hawkesbury Sandstone is largely horizontal, as vertical permeability is low.

Due to their gentle slope, only the larger swamps contain open channels, which are generally short and located at the downstream end, whilst a series of discontinuous elongated pools can be present further upstream in headwater valleys.

Mudstone bands within the strata can provide an impermeable barrier that restricts vertical surface water infiltration through the sandstone, and can limit recharge to groundwater systems beneath the band.

Swamps in the Mine Lease Area are not located close to the edge of signifcant cliff scarps, as is the case for “hanging” swamps in the Blue Mountains, and as such there are no “hanging” swamps in the Project Area.

Upland swamps generally are located within gently-sloping, trough shaped valleys, but can extend onto steep slopes or benches on valley sides. They are more extensive where the plateau is least dissected, and are more confined to headwater tributaries in more dissected catchments.

The central axes of the swamps are generally saturated, though the margins and central section may dry out, particularly after extended dry periods.

The sand and humic material, which increases the swamps water-holding capacity, store and subsequently discharges rainfall infiltration, groundwater seeps and low-flow runoff into the local streams. Rainfall saturates the swamp and drains slowly due to the low slopes on a low permeability base as the average rainfall generally exceeds evaporation.

Sediments below and laterally lensing into the carbonaceous material are variable in nature and can be composed of fine to medium grained sands which are usually well sorted, light grey in colour and contain bands with a higher clay content, and, clayey sands, which are usually mottled red-orange due to insitu weathering.

The sediments accumulate in upstream areas and are transported to the downstream areas, whilst the marginal slopes are generally smoother and flatter than the higher areas, which tend to be steep and distinctly stepped.

Upland swamps can be classified as “in-valley” or “headwater” upland swamps, however, only in-valley swamps are present in the V Mains Project Area as shown in **Drawing 1**.

4.4.1 In Valley Upland Swamps

In-valley, in-stream or valley infill swamps occur along well defined drainage lines and are the predominant form in the Project Area.

They occupy relatively flat sections of streams within the main valleys and can form through sediment deposition behind logs at choke points in a stream, or terminate at ‘steps' in the underlying sandstone substrate.

They are mainly sustained by surface flow along streams, along with direct rainfall

infiltration and ephemeral shallow groundwater seepage from sandstone walls or “steps” at the edge of a swamp. The “steps” are generally located on higher elevation bedding planes in elevated sandstone areas, with their seepage rate dependent on the prevailing rainfall.

The swamps can also be recharged by direct rainfall infiltration when sufficient rain falls.

4.4.2 Headwater Upland Swamps

Headwater swamps are not located within the V Mains Project Area, but are present within the NRE No. 1 Mine Lease Area in upper tributaries along elevated ground with relatively flat to gently slopes.

They are essentially rain-fed where rainfall exceeds evaporation and their water levels fluctuate with climatic conditions, as rain adds and evapotranspiration removes moisture from storage. Excess rainfall can produce a permanent perched shallow water table that is independent of the regional water table in the underlying Hawkesbury Sandstone.

During rain events, some stream flow and runoff along indistinct braided channels can infiltrate through the swamp sediments, whilst the dense vegetation and the low gradient restricts the formation of open channels.

In some headwater swamps, groundwater seepage is usually present along outcropping sandstone at the swamp edge.

4.5 Geology

NRE No. 1 Colliery is situated at the southern end of the Permo-Triassic (225-270 Million years old) Sydney Basin within the Illawarra Coal Measures, which contains the Bulli Seam. The Bulli Seam is underlain by the Balgownie and Wongawilli seams.

Isolated exposures of Hawkesbury Sandstone are present along stream beds and banks as well as in isolated outcrop outside of the sedge / upland swamps within the Project Area.

Isolated outcrop of Wianamatta Shale is present in more elevated country to the north, and downstream of the Project Area.

The surficial geology within the Project Area is shown in **Figure 5**.

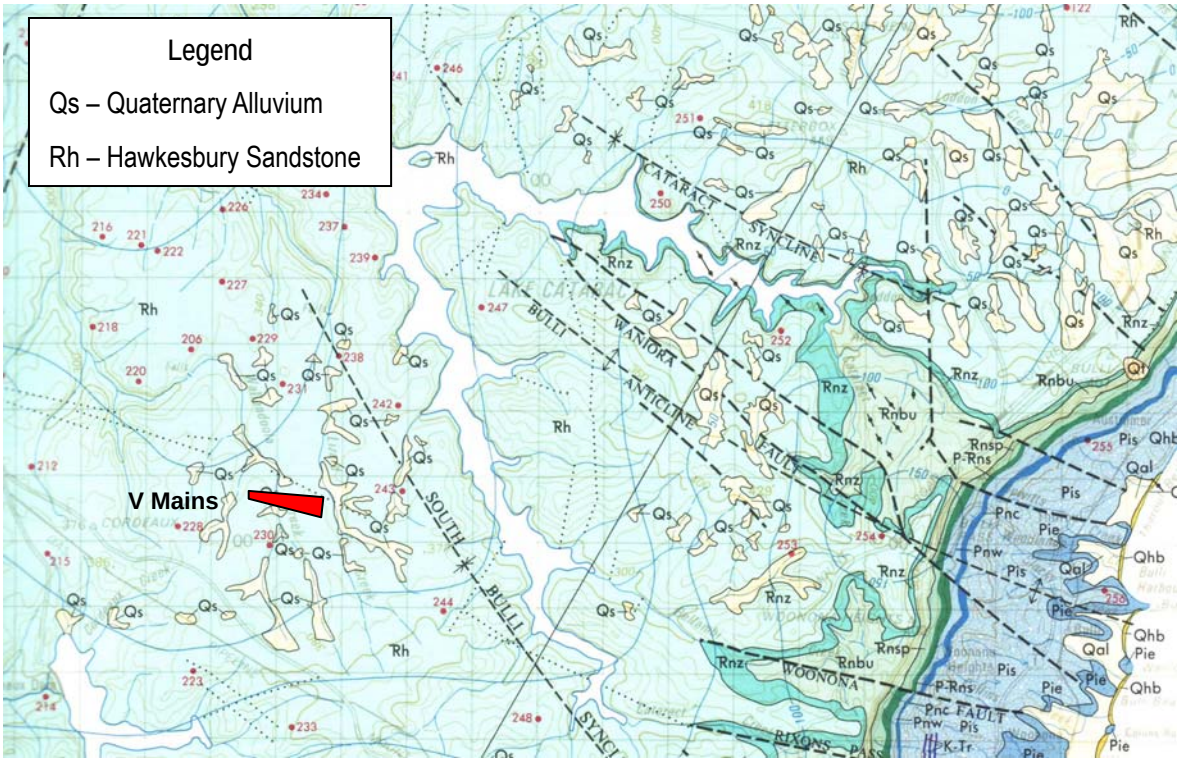


Figure 4 Local Geology

4.5.1 Stratigraphy

The stratigraphic sequence within the Project Area comprises the;

- **Wianamatta Shale** - isolated outliers of the shale located north of the Project Area
- **Hawkesbury Sandstone** - Isolated outcrops consisting of thickly bedded or massive quartzose sandstone with grey shale lenses up to several metres thick. The maximum geological thickness is about 155m to 175m below ground level (bgl). Finer grained siltstone and shale facies along with bedding discontinuities are present that would form vertical flow barriers.
- **Newport and Garie Formations** - present to approximately 160m to 180m bgl within the approximately 230m thick Narrabeen Group. The Newport Formation consists of interbedded grey shales and sandstones whilst the Garie Formation consists of cream to brown, massive, characteristically oolitic claystone.
- **Bald Hill Claystone** - present to approximately 185m to 205m bgl, brownish-red "chocolate shale", which is a physically weak but is relatively “plastic”. It is easily recognised as a marker horizon and has a near constant thickness in the Project Area. The Bald Hill Claystone is a major barrier to vertical groundwater flow and divides the groundwater systems above and below the claystone.
- **Bulgo Sandstone** - present to approximately 350m to 405m bgl, thickly bedded, medium to coarse grained lithic sandstone with occasional beds of conglomerate or shale.
- **Stanwell Park Claystone** - present to approximately 355m bgl with greenish-grey mudstones and sandstones.

- **Scarborough Sandstone** - present to approximately 385m bgl, medium to coarse grained lithic sandstone with occasional beds of conglomerate or shale
- **Wombarra Claystone** - has similar properties to the Stanwell Park Claystone.
- **Coal Cliff Sandstone** - basal shales and mudstones that overly the Bulli Seam.
- **Illawarra Coal Measures** - interbedded shales, mudstones, lithic sandstones and ten named seams. The 3m thick Bulli Seam (approximately 391m to 447m bgl) is the the uppermost mineable seam and has been worked extensively in the northern portion of the Southern Coalfield. The Bulli Coal is the target seam in the Project Area.

4.5.2 Structure

In general, individual structural features located within the Bulli Seam are not identified at surface, whilst regional scale surface features have not been identified in the Bulli Seam.

The Hawkesbury Sandstone is characterised by a system of pre-mining fractures which comprise steeply dipping joints, low angle bedding planes and local unconformities. Although some faulting is recognised at seam level, no surface expression has been mapped.

Cross-bedded sandstones are typically weathered at the surface, are generally weak and exhibit chemical leaching and precipitation of iron mineralisation from the shallow groundwater system and surrounding sediments.

Erosion in the valleys preferentially removes the less competent beds, particularly along systematic joint directions, whilst pools can exhibit significant erosional undercutting and weakening of the downstream rock bars, particularly at the base. Lithological changes from thinly cross-bedded to massive sandstone (unconformities) usually define changes in elevation along the axis of a creek channel, with joint planes and cross-bedding direction modifying this relationship.

Tertiary age igneous dykes post date the sedimentary strata, with the dykes being generally less than 1m which have altered to clay at surface. At seam level, a 5m dyke separates the Cordeaux and proposed V Mains workings, however, it is not exposed at surface. The smaller dykes and faults at seam level have a dominant trend of 050^{o} and 120^{o}, which, also, do not outcrop at surface. No igneous sills or diatremes are known to be present within the Project Area.

4.6 Hydrogeology

No DWE registered bores are within or near the Project Area, however five piezometers have been installed within the NRE No. 1 lease area as shown in **Drawing 1** and **Table 5**.

TABLE 1 Piezometer Details

GW	Drilled	Depth (m)	SWL (m)	Aquifer	YIELD (L/s)	EC (mg/L)	pH
PC2	July 2006	1.8	0.68	Upland swamp	V low	116	4.82
PC4	July 2006	0.77	Generally dry	Upland swamp	V low	66	5.03
VWP501	10/12/1992	325	See Figs 5-7	Bulli Seam / Hawkesbury Sandstone	n/a	n/a	n/a
VWP502	13/8/1993	167	See Figs 5-7	Bulli Seam / Hawkesbury Sandstone	n/a	n/a	n/a
P514	01/11/1998	n/a	See Figs 5-7	Bulli Seam / Hawkesbury Sandstone	n/a	n/a	n/a

4.6.1 Upland Swamps

The upland swamps within the Project Area and interpreted to be perched systems that are hydraulically seperated and independent of the deeper, regional groundwater table in the Hawkesbury Sandstone, although they can be connected to shallower, ephemeral seepage from the upper Hawkesbury Sandstone where bedding discontinuities or low permeabilities enhance horizontal flow into a swamp. Depending on the relative height of the perched and regional water tables, groundwater can supplement swamp moisture or swamp moisture can drain towards the underlying shallow sandstone aquifer.

In turn, the shallow bedrock aquifers are also usually ephemeral, and are not directly hydraulically connected to the deeper, regional aquifers within the Hawkesbury Sandstone.

The water table within the swamps is dependent on surface inflow after rain and is maintained by continuous seepage of near surface groundwater from the Hawkesbury Sandstone. Significant water storage is usually limited within the more clay rich sandy sediments, although they can allow relatively small inflows that can maintain a higher water table in contact with the more organic layers.

Recharge into the Hawkesbury Sandstone shallow aquifer feeding a swamp is buffered by water stored in a swamp that is, in turn, recharged by rainfall. Water accumulates in the swamps through a series of seeps that are usually located at the top and base of topographic steps in more elevated areas.

Periodic episodes of inundation and surface run off within the swamps are associated with storm events whilst storm event drainage is mainly associated with distinct channels and ponds eroded into the swamp.

Groundwater seepage into the swamps is usually transmitted subsurface within sandy accumulations and interacts with surface ponds if the water table intersects a pond. Water accumulation within the swamp is a balance between:

- Surface inflow,
- Horizontal seepage and downstream flow,
- Storage within the swamp,
- Vertical leakage into the lower rock strata, and;
- Evaporative processes.

No upland swamps are used for groundwater supply in the Project Area.

4.6.2 Basement Systems

Apart from coal seam aquifers at depths of greater than 460m, the significant aquifers within the Project Area are in the Hawkesbury Sandstone and the Narrabeen Group sandstones.

The Project Area is located within the Hawkesbury Sandstone - South-East groundwater flow system (GFS) within the Metropolitan Water Supply Catchment Area that includes Cataract Dam. Very little groundwater development has been permitted in the protected area, with only 82 bores registered in the GFS for stock and domestic use with total entitlements of 55ML/year. This contrasts with a sustainable yield estimate of

58,000 ML/year.

There are no high yield bores (>6 L/s) identified within the GFS (Grey and Ross, 2003).

Groundwater flow through bedding discontinuities, fractures and joints predominates over primary rockmass porosity within the alternating sheet and massive facies, where flow is primarily horizontal with minor vertical leakage and porous flow through the matrix of the rock is significantly less in volume and has a significantly slower flow rate. Surface water fed perched water systems that are hydraulically disconnected from the regional aquifer are observed adjacent to cliff faces and within upland swamps.

Individual facies within the Hawkesbury Sandstone represent localised sedimentary processes that may not persist across the Project Area.

The Hawkesbury Sandstone within the Sydney Basin generally provides low yielding aquifers with low hydraulic conductivities. No groundwater supplies have been obtained from sandstone aquifers within the Project Area. However, it is likely that more significant aquifers could be present around 50m below surface, with shallower, low yielding, ephemeral aquifers present near surface as perched ephemeral aquifers.

4.6.3 Hawkesbury Sandstone

The only recognised economic aquifer in the area is the Hawkesbury Sandstone where the water quality is quite good, but deteriorates rapidly towards the northern limits of the Southern Coalfield. In the vicinity of the NRE No. 1 Colliery, the salinity is generally in the range 1000-3000 mg/L .

The Hawkesbury Sandstone has relatively low yield although has higher permeability compared to other units and is capable of higher groundwater yields.

It is currently the subject of investigations by the SCA in the Southern Highlands at Kangaloon-Robertson and at Leonay-Wallacia. High yields of up to 30 L/s have been found in both areas where the sandstone is heavily fractured.

4.6.4 Narrabeen Group

Vertical continuity with the underlying Narrabeen Group is interrupted by the Bald Hill Claystone which is a major aquitard, whose thickness is consistent across the Project Area. This unit retards vertical flow from the Hawkesbury Sandstone and is consistent with SCA's findings in the Upper Nepean (Kangaloon) Borefield Project Environmental Assessment (KBR, 2008).

The base of the Narrabeen Group, at the top of the Bulli Seam, is marked by the Wombarra Claystone which is an aquitard that limits vertical flow into workings. The Coal Cliff Sandstone lies between the two where it is developed.

The Narrabeen Group is a much poorer aquifer than the Hawkesbury Sandstone, with no known use in the Southern Coalfield.

The low permeability of the Narrabeen Group lithologies is substantiated by the common experience of "dry mines" in the Southern Coalfield.

4.6.5 Groundwater Dependent Ecosystems

The Project is located within the Sydney Basin Sedimentary Rock Groundwater System as described in the NSW State Groundwater Dependent Ecosystems Policy (SGDEP) (DLWC, 2002) which has its associated dependent ecosystems. The SGDEP recognises four groundwater dependent ecosystems types in NSW, namely:

- Terrestrial vegetation;
- Base flows in streams;
- Aquifer and cave ecosystems; and
- Wetlands.

Groundwater dependent ecosystems which are present within the Project Area are;

- terrestrial vegetation, in terms of the “in-valley” upland swamps which are susceptible to changes in groundwater seepage inflow rates, the balance between rainfall and evaporation, the effect of bushfies and changes to the erosional regime,
- baseflows in streams, which are affected by changes in groundwater seepage inflow rates to a stream and the balance between rainfall and evaporation.

4.7 Climate

The study area is in a warm temperate region, however it has significant variation in temperature and precipitation due to topographic effects and its proximity to the Illawarra Escarpment and the coast.

Up to 1470mm/year of rainfall has been observed at Helensburgh (Hazelton, P.A., 1990), with the maximum rainfall in Autumn to Winter.

A plot of rainfall recorded at Cordeaux Colliery since January 2002, which is located to the immediate north of the Gujurat NRE No. 1 Colliery lease area, is shown in **Figure 5**.

Winds are predominantly westerly with some severe rain storms originating from the south and southeast.

The plateau generally experiences cooler temperatures than the coast, below the escarpment. Average diurnal temperature ranges from 21.5^{o}C in January to 12.5^{o}C in Winter.

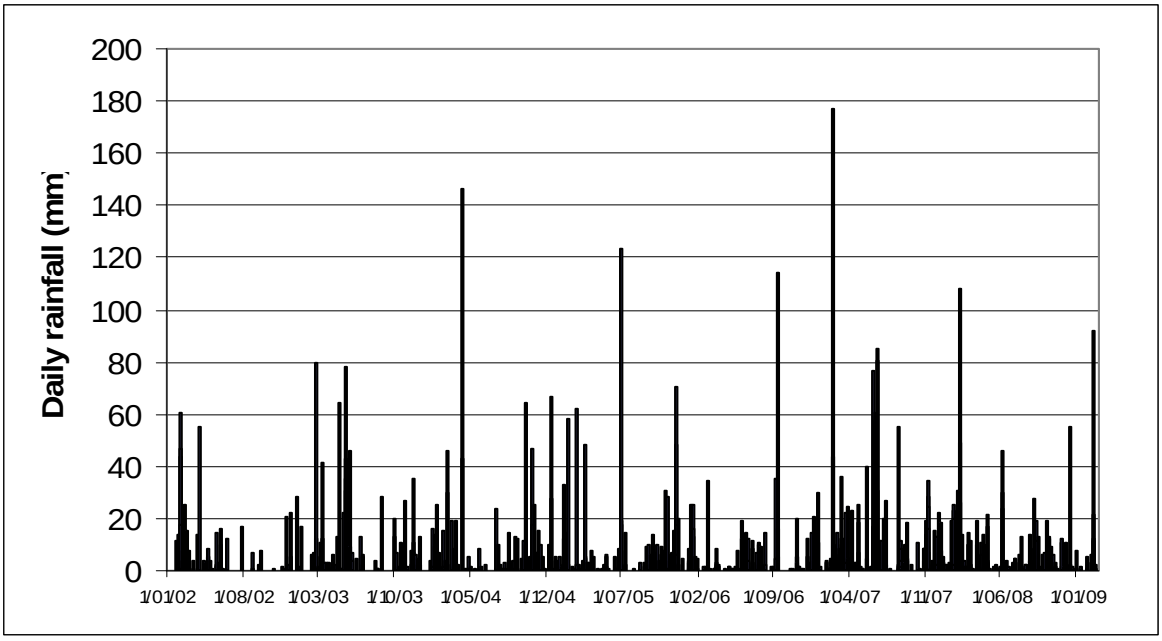


Figure 5 Rainfall

5. PREVIOUS SUBSIDENCE EFFECTS AT NRE NO.1 COLLIERY

To date, the NRE No. 1 Colliery (and its predecessors), as well as the adjoining BHP Billiton Cordeaux Colliery to the immediate south of the NRE Colliery have undermined sections of both Lizard Creek and Wollandoola Creek, with up to 1.3m of subsidence being recorded (Seedsman Geotechnics, 2008).

No specific pre and post mining surveys of the creek flow and water quality are known to be available over the Cordeaux subsidence area.

Limited post subsidence reconnaissance monitoring and geomorphological inspections of both Lizard Creek and Wollandoola Creek were conducted between March and November 2001 (AWT, 2001 / Seedsman Geotechnics, 2001 / Geoterra, 2001). As there was no follow up monitoring subsequent to the initial inspections, and as the monitoring was not conducted at the same locations in the different surveys, no trend analyses are available for the 2001 sites.

The 2001 inspections did note hydrous ferruginous iron precipitates with associated acidic pH within both creeks and associated tributaries at numerous locations over previously subsided areas. No definitive link could be made, however, between the presence of the ferruginous springs and subsidence effects as no pre-subsidence monitoring had been conducted.

Based on monitoring by Gujurat at the NRE No. 1 Colliery (and its predecessors), no adverse effects due to subsidence on flow in Lizard Creek or Wollandoola Creek has been recorded.

5.1 T and W Mains Streams and Upland Swamp Monitoring

Stream monitoring conducted since August 2006 over the T and W Mains area within two ephemeral tributary creeks have not observed any geomorphological or geochemical changes due to the maximum 0.15m of subsidence (Ecoengineers, 2008).

The creek containing site C10 (upstream) and C11 (downstream) can contain dry weather groundwater seepage emerging from a sandstone headwall.

Monitoring in the C10 / C11 creek indicates an average (variable) pH of 5.00 (C10) and a less variable pH averaging 4.37 (C11) along with an average electrical conductivity of 140uS/cm (C10) and 166uS/cm (C11). The difference between C10 and C11 is attributed to the presence of a groundwater seep located just upstream of C10, which on incorporation of dissolved oxygen and precipitation of iron and manganese oxyhydroxides, becomes more acidic and more saline at C11. No significant trends in pH, EC, sulfate or filterable iron, manganese, nickel and zinc were observed over the 26 month monitoring period that would indicate any effects from subsidence.

Monitoring sites PC2 and PC4 are two hand installed shallow piezometers installed within an upland swamp along an unnamed ephemeral tributary creek located north-west of the C10/C11 creek. The piezometers are located directly over the T and W Mains extraction area, north of the longwall Panels 211 and 212.

PC2 was installed at 1.8m below surface, whilst PC4 is 0.77m deep. Both piezometers were dry between July 2006 and August 2007 due to a drought. Once the drought broke, PC2 contained water since September 2006, whilst PC4 was mostly dry, apart from September 2007 and February / March / April and June 2008.

PC2 has a relatively constant pH, averaging 4.82 with an average EC of 116uS/cm, whereas PC4 has a relatively constant, average pH of 5.03 along with a low average EC of 66uS/cm.

Monitoring of pH, EC, sulfate and filterable iron, manganese, nickel and zinc, along with no visual indication of soil cracking indicates that shallow groundwater in the upland swamp at PC2 has no indication of local, shallow fracturing in the Hawkesbury Sandstone, whilst the infrequent data available from PC4 is considered to be similar to rainwater and is not conclusive.

5.2 Groundwater

Regular monitoring of two vibrating wire piezometers near, although outside of the V Mains Project Area, was initiated in December 1992 (P501) and August 1993 (P502), along with an open standpipe piezometer (P514) in November 1998.

The piezometer locations are shown in **Drawing 1**. P501 and P502 are located adjacent to Panel 501 and 502, near the Cataract Dam, whilst P514 is located near Panel 514, also adjacent to Cataract Dam.

Plots of vibrating wire piezometer water levels in the Hawkesbury Sandstone down to the Bulli Seam are shown in **Figures 6** and **7**, whilst the standpipe piezometer water levels in the Hawkesbury Sandstone are shown in **Figure 8**.

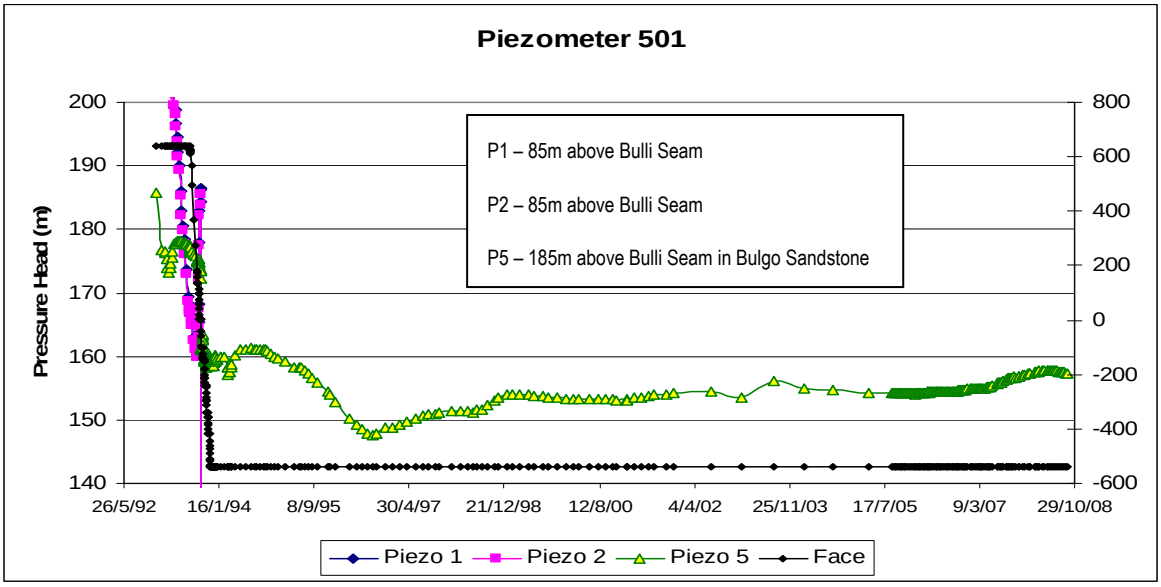


Figure 6 Piezometer 501 Groundwater Levels

Groundwater head pressures in Piezometer 501 (P1 and P2), which were installed 85m above the Bulli Seam at 325m below surface, gradually reduced from 284m of head in December 1992 then went down to approximately 161m in September 1993. Just prior to the piezometer being undermined, the head pressure rose by approximately 26m in both P1 and P2, and then, when the panel undermined the piezometer, intakes P1 and P2 failed and did not record any further data.

The initial rise in pressure before each piezometer is undermined is due to overburden compression that occurs ahead of the advancing longwall. The overburden initially deforms in compression just before subsidence fracturing occurs, which then causes a sudden drop in groundwater pressure heads as the system re-equilibrates to the secondary porosity generated by the fracturing. The effect of rising pressure heads is generally more prevalent at the start of a longwall panel, with the effect reducing as the panel advances.

Intake P5, which is installed at 226m below surface in the Bulgo Sandstone, initially had its head pressure fall as the intake equalised with the hydrostatic and lithostatic pressures in the overburden from around 185m down to approximately 177m. After that, pressures varied from approximately 173m to 177m, and then, as the panel approached the piezometer, the pressure gradually fell to around 174m. When the piezometer was undermined, P5 directly fell by around 15m to around 160m, and settled until continued mining of the panel generated a pressure reduction to approximately 148m in September 1996.

Since September 1996, the pressure has remained relatively static around 153 to 155m to around early to mid 2007, then rose to around 157m in September 2008, presumably in response to rainfall recharge and infiltration into the cracked overburden following the break in the drought.

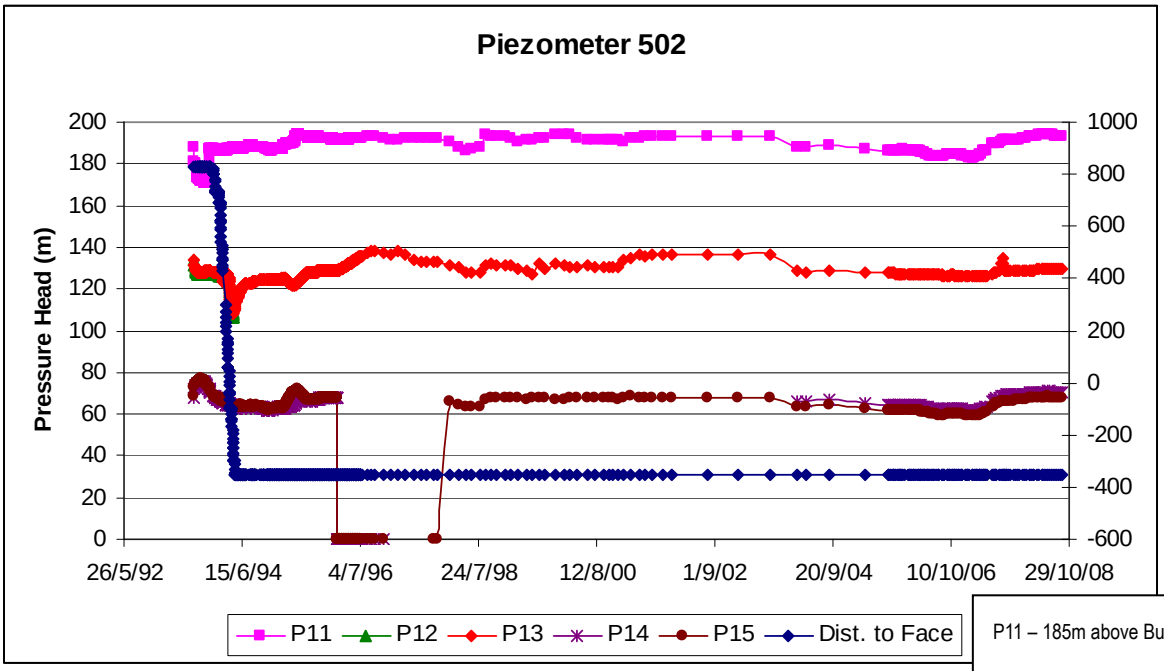


Figure 7 Piezometer 502 Groundwater Levels

Within the piezometer array at P502, groundwater head pressures in intake P11, which was installed within the Hawkesbury Sandstone at 90m below surface, have remained essentially static, ranging between approximately 186m and 194m below surface, with a rise in pressures following the start of the rainy period around April 2007.

Intakes P12 and P13 were installed 240m above the base of the Bulli Seam in the Bulgo Sandstone. When the piezometers were undermined, both piezometers fell by around 18m to 20m around March 1994, to approximately 106m to 108m, then P13 recovered up to around October 1996 to approximately 138m. Piezometer P12 stopped functioning after it was undermined. Since October 1996, P13 wavered around 130m to 135m, until responding to the rainy period around April / May 2007.

Intakes P14 and P15 were installed at 100m below surface in the Hawkesbury Sandstone. When the piezometers were undermined, both piezometers fell by around 10m between October 1993 and April 1994 to approximately 63m, then P15 recovered up until around October 1996 to approximately 71m, whilst P14 recovered to around 67m. Piezometer P14 then stopped functioning between August 1995 and February 2004.

Both P14 and P15 responded with falling pressures during the drought then rising pressures after the rainy period began in April 2007.

Monitoring over the 110m wide Panels 501 to 509, indicated a maximum subsidence of 202mm, with maximum tensile / compressive strain of 0.8mm/m and 0.4mm/m.

Groundwater pressure monitoring indicated that over Panels 501 and 502, vertical interconnected fracturing extended for less than 153m above the Bulli Seam, with a low permeability connection from the lower Bulgo Sandstone to the Bulli Seam goaf. It was interpreted that linked vertical fracturing was unlikely to have extended up into the middle Bulgo Sandstone, however the middle Bulgo Sandstone was potentially affected by horizontal bed separation (Seedsman Geotechnics, 1998).

The open standpipe piezometer P514 was installed in November 1998 within the Hawkesbury Sandstone over the 150m wide, 310-380m deep Panel 514.

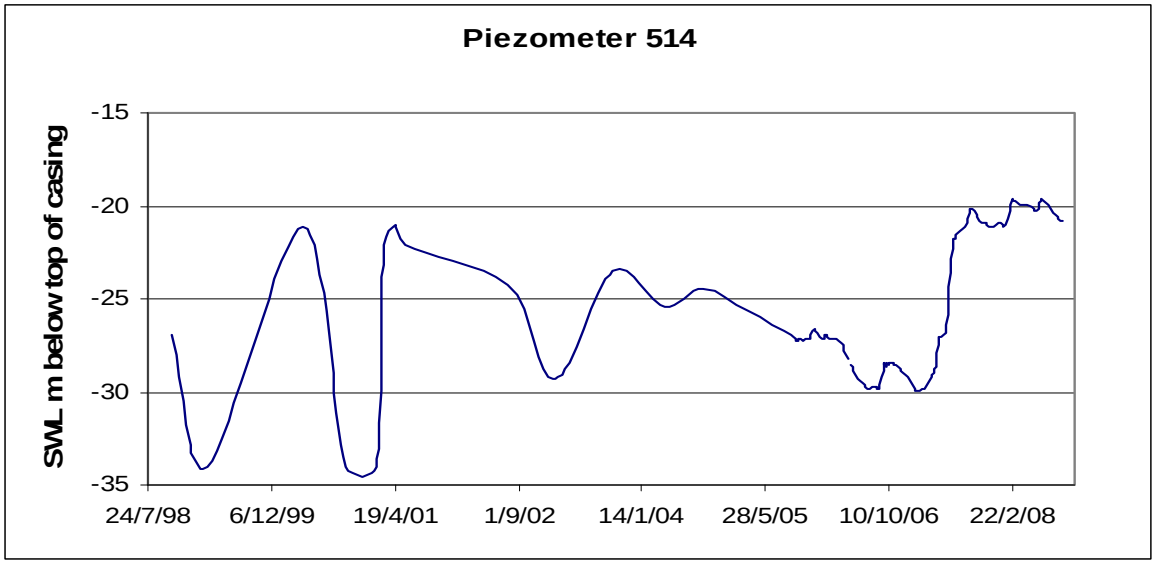


Figure 8 Piezometer 514 Groundwater Levels

Since installation, P514 had a wavering water level between approximately 23m and 34m below surface, then essentially fell from 21 to 30m below surface between April 2001 and March 2007 due to the drought. The standing water level then rose following the start of the rainy period around April 2007 by approximately 10m from 30m to 20m below surface.

6. FIELD INSPECTIONS

6.1 Stream Bed Geomorphology

The major creeks in the V Mains Project Area vary along their reach from “losing streams” where the shallow groundwater system is recharged from water in the stream, to “gaining streams” where seepage from shallow sediment groundwater systems in the upland swamps enters the creeks. The classification between “losing” and “gaining” streams also varies depending on the amount of rainfall recharge and the resultant standing water levels within an upland swamp at any one time.

Within the V Mains Project Area, the two creek catchments are separated by a shallow, approximately 10m high shallow watershed.

Three distinct channel types can be present:

- Narrow indistinct overgrown channels associated with a low sedge/ heath and a relatively thick sandy riparian soil. The streambed consists of weathered bedrock and/or sandy materials.
- Rock platforms of variable width are usually smooth except for minor depressions on joint planes and occasional potholes. These platforms normally grade to a thinly vegetated sandy soil on either side and usually exhibit the effects of chemical deposition of hydrated iron oxide. This deposition ranges from a slight colouration of the surface strata to intense replacement of the rock fabric.
- Channels that are erosive into cross-bedded sandstone and exhibit a rough riffle like surface usually with accumulations of boulders and other sediments. These channels are usually bounded by solid rock outcrop.

A number of distinct pool types can be present:

- Shallow, usually linear, small pools located in depressions formed by joint systems or cross-bedding and sometimes associated with potholes. Accumulated water is usually less saline than that in surrounding pools and probably has little interaction with the local groundwater system.
- Linear pools associated with narrow erosion channels in sandy soil profiles. The soil profile is usually vegetated with heath like species. The downstream end is usually associated with a low rockbar or outcrop.
- Larger pools constrained by a rockbar on the downstream end that can be undercut by erosion and exhibit signs of chemical weathering.
- Larger pools constrained mainly by sediments on the downstream end. The sediments may extend for a considerable distance downstream.

6.1.1 Wollandoola Creek

Wollandoola Creek is located within the Sydney Catchment Authority restricted access Metropolitan Special Area which intersects the middle of the V Main Project Area and essentially drains through it in a SSE - NNW direction.

A second order, ephemeral tributary drains into Wollandoola Creek to the north-east in the middle of the Project Area.

The main channel of Wallandoola Creek is classified as a Schedule 2 stream with 3rd order or higher channels (DIPNR, 2005), along with ephemeral Category 1, 1st to 2nd order tributaries, which is incised into the weathered, massive to cross bedded Hawkesbury Sandstone and erodes stratigraphically lower strata as it drains downstream.

Wollandoola Creek joins the Cataract River approximately 9km (or 12km along the stream reach) NNW of the Project Area, whilst its headwaters are located to the south over the previously longwalled Cordeaux Colliery lease area.

The creek is not regulated by any dams or weirs.

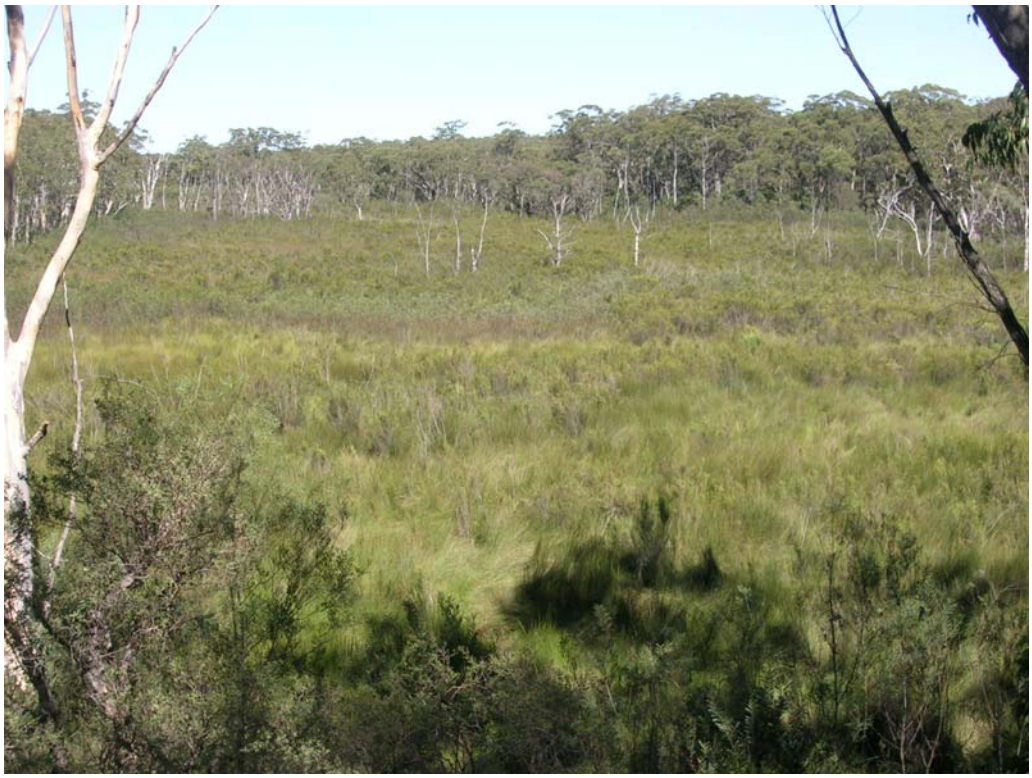
The stream reach falls river falls by approximately 10m over a run of 1250m within the V Mains Area, with an average gradient of 0.8 mm/m.

The Wollandoola stream reach within the Project Area is generally characterised by extended pools backed up behind isolated exposed sandstone ledges, often with less than 0.5m drop from the upstream to downstream pools. The stream banks can be up to 0.5 to 1.0m high within a well defined channel along as shown in **Photograph 1**, with up to approximately 100m of flanking riparian sedge / upland swamp vegetation along each stream bank. The sedge / upland swamp areas grade into Scribbly Gum Woodland away fro the main creek channel.

No significant iron hydroxide flocculant has been observed within the V Mains stretch of Wollandoola Creek.

Wallandoola Creek has been previously undermined by SW-NE oriented longwall panels within the BHP Cordeaux workings to the south of the NRE No. 1 lease, however, no specific studies have been conducted on the subsidence effects on stream flow, stream water quality or upland swamps. As a result, it is not possible to indicate whether, or not, subsidence has had an effect on the surface water system over the BHP panels

The stream bed and banks of the plateau streams are well vegetated, and do not show significant erosion or bank instability.



PHOTOGRAPH 1 Wollandoola Creek over V Mains

6.1.2 Lizard Creek

Lizard Creek is located within the Sydney Catchment Authority restricted access Metropolitan Special Area and is located on the eastern periphery of the predicted 20mm subsidence zone, and does directly overly V Mains. The creek essentially drains in a northerly direction.

The main channel of Lizard Creek is classified as a Schedule 2 stream with 3rd order or higher channels (DIPNR, 2005), along with ephemeral Category 1, 1st to 2nd order tributaries, which is incised into the weathered, massive to cross bedded Hawkesbury Sandstone, and erodes stratigraphically lower strata as it drains downstream.

Lizard Creek joins the Cataract River approximately 7km (or 8km along the stream reach) due NNW of the Project Area, whilst its headwaters are located to the south over the previously longwalled Cordeaux Colliery lease area.

The creek is not regulated by any dams or weirs.

The stream reach falls river falls by approximately 10m over a run of 1400m adjacent to the V Mains Area, with an average gradient of 0.71 mm/m.

The stream reach of Lizard Creek within the Project Area is generally characterised by extended, shallow, reed filled, pools backed up behind isolated exposed sandstone ledges, often with less than 0.5m drop from the upstream to downstream pools. The stream banks are generally less than 0.5m high within a less well defined channel as shown in **Photograph 2**, along with up to approximately 100m of flanking riparian sedge / upland swamp vegetation along each stream bank. The sedge / upland swamp areas grade into Scribbly Gum Woodland away from the main creek channel.

PHOTOGRAPH 2 Lizard Creek adjacent to V Mains

Upstream and downstream of the main culvert, Lizard Creek has characteristic iron hydroxide flocculant present within the reed filled sections of the channel.

Lizard Creek has been previously undermined by both east / west and SW-NE oriented longwall panels within the BHP Cordeaux workings to the south of the NRE No. 1 lease, however, no specific studies have been conducted on the subsidence effects on stream flow, stream water quality or upland swamps. As a result, it is not possible to indicate whether, or not, subsidence has had an effect on the surface water system over the BHP panels

The stream bed and banks of the plateau streams are generally well vegetated, and do not show significant erosion or bank instability.

6.1.3 Stream Flow

Apart from spot visual estimates of flow, no specific stream flow monitoring has been conducted in either Lizard or Wollandoola Creek.

6.2 Stream Water Quality

6.2.1 Wollandoola Creek

Water quality monitoring in Wollandoola Creek initially commenced in September 2001, with regular data collected since July 2007 as shown in **Figure 9**.

The main channel sampling sites within Wollandoola Creek are perennial, whilst WC2 in an ephemeral tributary is generally dry or has small pools of ponded water for the majority of the monitoring period.

Monitoring plotted in **Figure 9** indicates Wollandoola Creek is within the acceptable range for potable water, however it is generally outside the ANZECC 2000 South Eastern Australia Upland Stream criteria for pH and can be above the ANZECC 2000 95% Species Protection Level for Freshwater Aquatic Ecosystem Guidelines as shown in **Figure 9** for the following parameters, depending on the flow conditions at the time of sampling;

- filtered zinc at all sites
- total nitrogen at most sites, and
- total phosphorous, occasionally, and
- filtered aluminium, very occasionally.

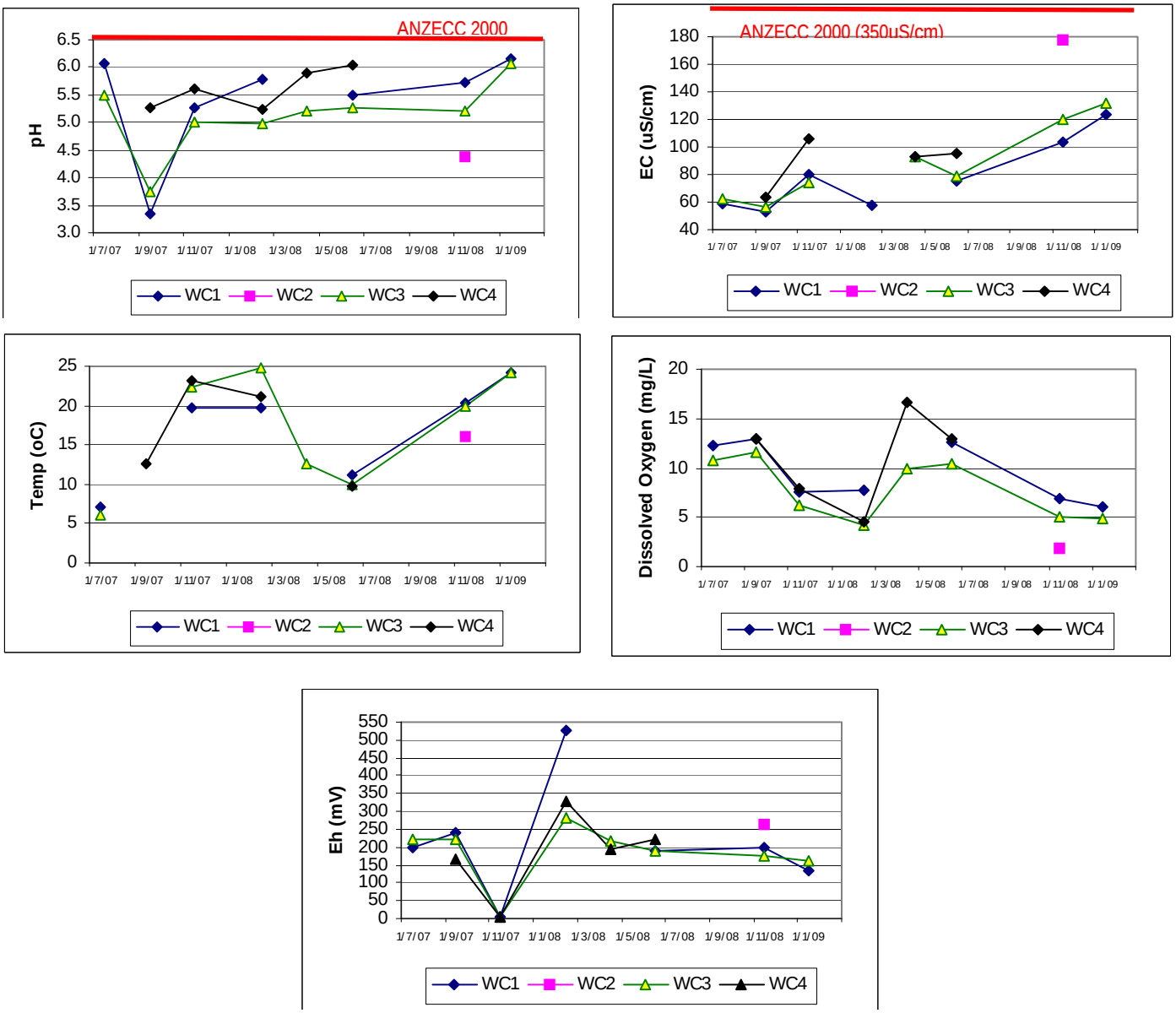


Figure 9 Wollandoola Creek Water Chemistry

6.2.2 Lizard Creek

Water quality monitoring in Lizard Creek initially commenced in September 2001, with regular data collected since July 2007 as shown in **Figure 10**.

The main channel sampling sites within Lizard Creek are perennial, with sampling sites SW5 and LC1 being within or adjacent to the V Mains subsidence area.

Monitoring indicates that Lizard Creek at SW5 and LC2 is within the acceptable range for potable water, however it is generally outside the ANZECC 2000 South Eastern Australia Upland Stream criteria for pH and can be above the ANZECC 2000 95% Species Protection Level for Freshwater Aquatic Ecosystem Guidelines as shown in **Figure 10** for the following parameters, depending on the flow conditions at the time of sampling;

- filtered zinc at all sites
- total nitrogen at most sites, and
- total phosphorous, occasionally, and
- filtered copper and aluminium, very occasionally.

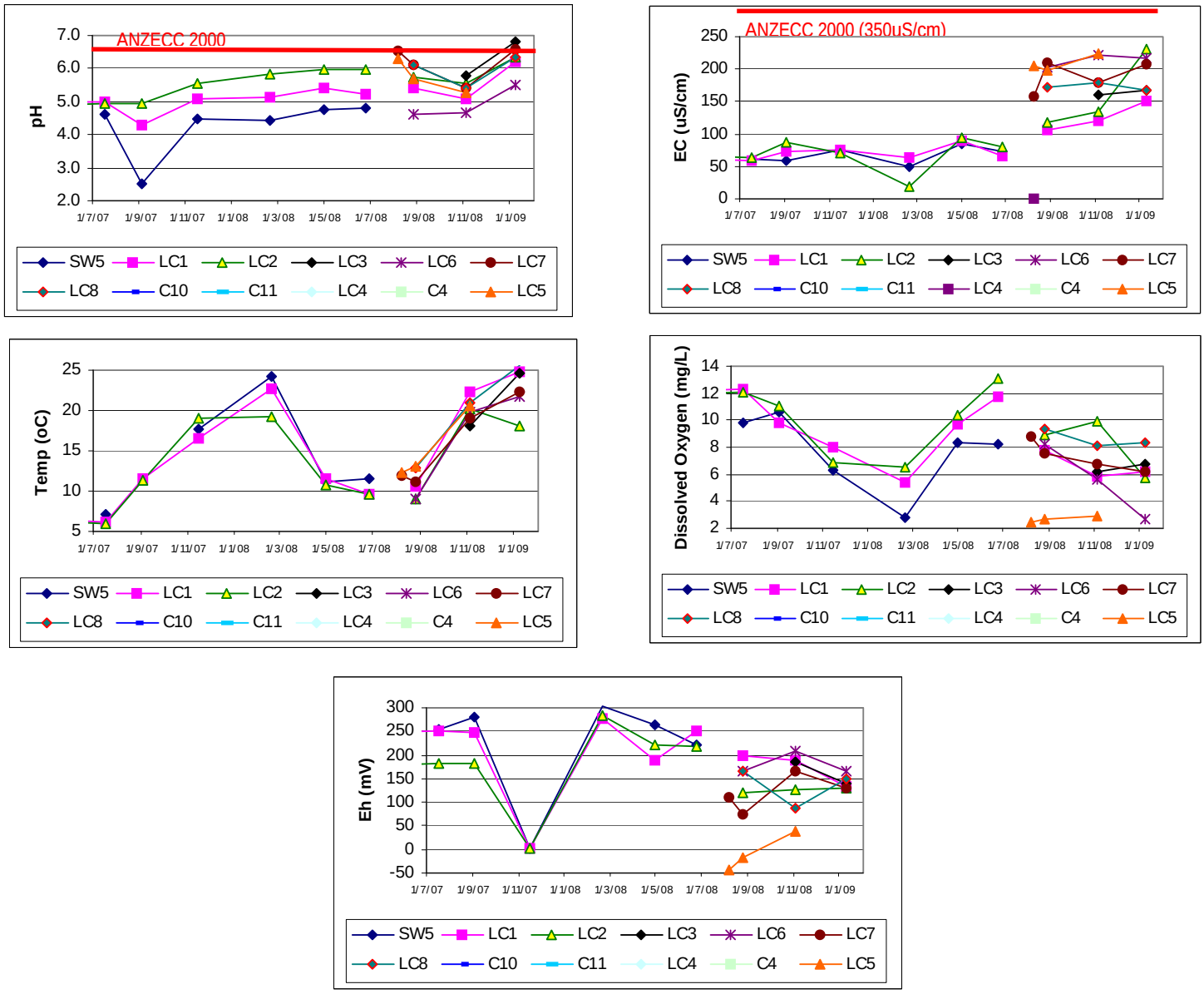


Figure 10 Lizard Creek Water Chemistry

7. PREDICTED SUBSIDENCE AND SUBSIDENCE IMPACTS

7.1 Subsidence Predictions

The maximum subsidence after completion of V Mains, as determined by both the Holla and Barclay as well as the SDPS visualisation methods will be located over the middle to eastern portion of the Project Area (Seedsman Geotechnics Pty Ltd, 2008).

The 20mm subsidence is predicted to extend over the channel of Wallandoola Creek, and very marginally into Lizard Creek as shown in **Table 2** and **Figure 11**.

The goaf is predicted to be approximately 2km long and between 75m to 300m wide and is predicted to be located 165m south of the northern workings and 120m north of the Cordeaux longwalls.

TABLE 2 Maximum Predicted Subsidence

Parameter	V Mains
Vertical subsidence	1.02m
Horizontal Movement	0.43m
Tilt	6.1mm/m
Strain	-6.5 to 3.3mm/m

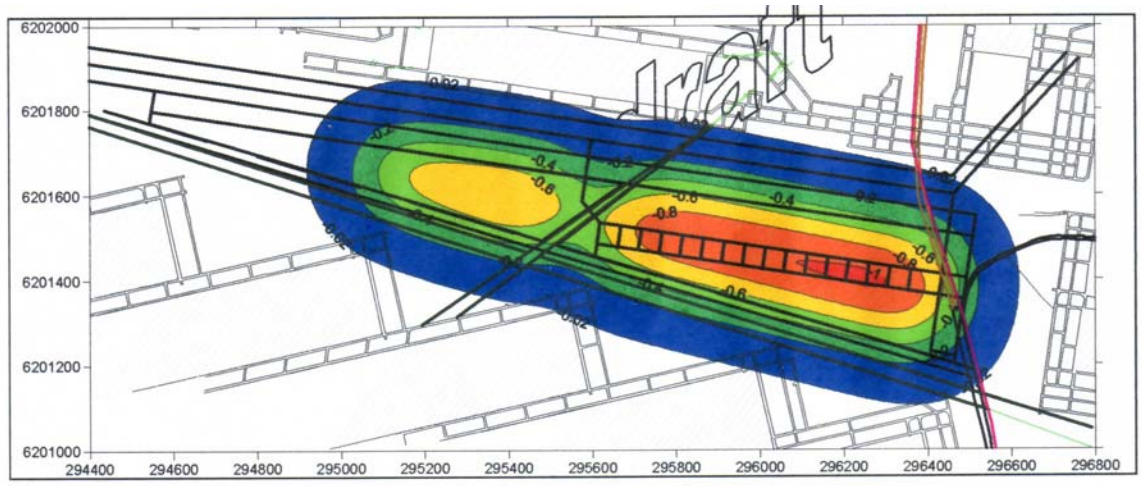


Figure 11 V Main Subsidence (Seedsman Geotechnics Pty Ltd, 2008)

It is predicted that surface subsidence above the narrower western portion of the goaf will not be measureable up to an extraction width of approximately 100m.

In the 200 series longwalls to the north of V Mains, no subsidence was measured with 190m wide panels and 35m wide chain pillars, whilst in the same layout to the north in the 300 series panels, 0.9m of subsidence was recorded. Mining in longwalls to the east of V Mains generated a maximum vertical subsidence of 1.1m for 155m wide longwalls with 30m wide pillars, whilst 205m wide panels in Cordeaux Colliery with 30m wide chain

pillars generated 1.2 to 1.3m of subsidence (Seedsman Geotechnics Pty Ltd, 2008).

Microseismic monitoring at Bellambi West and at Appin indicates that rock fracturing extends approximately 100m above the Bulli Seam, whilst vibrating wire piezometer monitoring between longwalls 501 and 502 indicates that the hydraulic integrity f the Bulli Seam and the Hawkesbury Sandstone was not adversely affected (Seedsman Geotechnics Pty Ltd, 2008).

7.2 Potential Subsidence Impacts

Potential geomechanical effects generated in the surficial Hawkesbury Sandstone due to subsidence can include:

- Bending, delamination or lifting of discrete surface sheets of rock into an inverted V due to compression at right angles to the axis of the V, particularly above and immediately behind the active extraction area,
- Horizontal stress concentration or mobilisation of natural horizontal stress, mainly in areas of localised topographic highs such as rock bars, with surface shearing, usually along bedding planes, or sliding of one sheet above the other with measurable horizontal and relative vertical displacement of the sheets,
- Horizontal and low angle shearing, particularly in cross-bedded sandstone,
- Isolated thin sheet shear and failure,
- Tensile failure of upper beds, mainly perpendicular to the direction of compression,
- Vertical hairline fracturing perpendicular to the axis of horizontal shearing, usually with significant horizontal opening up to several centimetres, but usually with short vertical penetration into the strata. The fracturing can be characterised by iron rich seeps that oxidise on exposure to the air. These seeps are a visible precursor to progressive fracturing in creek areas close to mining activity,
- Isolated fracturing or failure of slabs from underneath overhanging rock shelves where the slabs are located below bedding planes with minimal cohesion or tensile strength across the plane. The rock mass is usually subjected to axial compressive stress which breaks the slab into smaller fragments with insufficient friction to resist gravity.

Based on experience gained during longwall mining in other Southern Coalfield operations, mining under a creek, river valley or gorge can result in horizontal separation of strata in the base of the valley and redistribution of the existing horizontal stresses in the walls and base of the valleys. If the redistributed stress exceeds the bulk shear strength of the strata then relative horizontal shear produces uplift of the valley floor.

Localised weathering patterns may significantly influence the geometry of deformation.

8. POTENTIAL SURFACE WATER IMPACTS

The potential subsidence effects on the surface water environment can include:

- Loss of water from pools due to rockbar fracturing where surface water is temporarily diverted through near surface fractures. The stream water can fully or partially re-emerge further downstream,
- Loss of surface water inflow to pools due to upstream diversion into the near surface groundwater system,
- Reduced water retention in isolated pools, or sequential pools,
- Modification of surface water quality during with geochemical and biochemical reactions on fresh mineral surfaces generated by mining induced fracturing,
- Alteration of water quality by slumping, erosion and modified sediment transport,
- Impacts on ecosystems by changes in surface water flow, pool water retention time and changes in water quality, or;
- Changes to aquatic habitats due to lower water levels in pools, drying of riffle zones, sedimentation etc

Subsidence and valley uplift is usually associated with shallow horizontal fracturing and diversion of surface water to the near surface groundwater system.

Although horizontal stress redistribution can result in localised instability within steep valley slopes, minimal influence on geomorphic features on the plateau or slopes is expected.

8.1 Stream Flow

Cracking may occur in the creek bed which could lead to loss of flow into the underlying dilated strata or drainage of ponds, however it is not anticipated to generate a net loss of water from the creek systems since the subterranean flow, if it occurs, would re-emerge downstream.

After heavy rain, the majority of runoff would flow along the creek bed, with a lesser proportion flowing through the dilated, subsided strata, whilst during low flows, a greater proportion of water would flow in the bedrock.

8.1.1 Wollandoola Creek

It is assessed that, based on the predicted 0.8m of subsidence, the 3.3 - 6.5mm/m of strain and the predominantly highly vegetated and sediment covered nature of the stream bed and banks within the channel of Wollandoola Creek, there will be no observable loss of stream flow.

If stream flow diversion does occur, it could manifest through rock bar leakages in pools or transfer to shallow, ephemeral, groundwater systems within 10m of the stream surface, however no observable surface water flow depletion has been recognised over previous mined areas in similar geomorphological and mining conditions within the NRE Mine Lease area. Any flow loss that may develop may be mitigated due to the high sediment cover in both creeks.

Cracks only form in the base of a stream, and are generally prevalent in more incised cliff or gorge areas along a channel, if the bedrock lifts and “dilates”. Based on observations in similar topography to the V Mains area, where there are no gorges or cliffs, the cracked

zone depth can extend up to 10m into the bedrock. If cracking is located directly beneath the stream, and as the zone is not anticipated to be hydraulically connected to lower stratigraphic bedrock horizons, based on extrapolation of observations in similar environments, streamflow into the cracks, if it occurs, will re emerge back to the stream downstream of the compressional strain zone.

Studies into the depth of dilation of a river bed due to upsidence and closure of Waratah Rivulet at Metropolitan Colliery (Mills and Huuskes 2004) indicate that cracking occurred to 9m within a zone monitored to 27m below surface in a 60m wide valley which subsided by up to 1.3m, with 140mm of vertical dilation of the strata due to uplift.

Due to the sequential and migratory development of uplift as mining progresses, the development of stream bed cracking may also migrate downstream as mining advances. Uplift does not develop instantaneously, but rather as a progressive wave with advance of the panels, and therefore the effect will progress down stream over time.

If cracks develop, water flow to the new voids may occur as subsidence sequentially develops in the stream valley, with the rate of inflow controlled or modified by the;

- time frame of uplift
- location of uplift
- depth and width of cracking in the bedrock, and
- degree of filling in cracks with sediment

Modification of stream flow can affect the function and integrity of ecological systems, whilst enhanced recharge from streams to shallow ephemeral aquifers can raise the groundwater table and potentially dry up restricted portions of a stream. As no observable changes to stream flow are anticipated, there will also be no observable ecological changes, particularly in the ephemeral tributary streams.

No significant, observable uplift is predicted, however, within the channel of Wollandoola Creek.

8.1.2 Lizard Creek

Due to the approximate 20mm or less of predicted subsidence, along with the low strains and low tilts, no observable loss in stream flow is anticipated in Lizard Creek.

8.2 Stream Water Quality

Previous observations in similar geomorphological and hydrological environments within the Southern Coalfields, with a similar depth of cover to the mined seam, have determined that water quality can be adversely affected through;

- increased groundwater discharge to a stream following direct undermining and subsidence,
- lowered dissolved oxygen, lowered pH, elevated dissolved Fe / Ni / Zn / Mn, elevated sulfate and salinity from flow through fresh cracks in cliff and stream bed sandstone following subsidence which manifests as orange-brown, low dissolved oxygen plumes in receiving waters

- increased rainfall recharge through cracked / delaminated Wianamatta Shale and discharge out of the interface between the shale and the underlying Hawkesbury Sandstone which generates elevated salinity and dissolved iron, manganese, nickel and zinc. Waters affected by Wianamatta Shale discharge do not have the elevated sulfate or lowered pH noted in discharges from fresh sandstone. Some acidity can be generated, however, from shale leachates when dissolved iron and manganese form metal hydroxide precipitates on mixing with aerated water
- pool depth reduction and enhanced stagnation and evaporative concentration which enhances low dissolved oxygen and elevated salinity

The main observable change in stream waters results from dissolution of freshly exposed diffuse iron sulfide (marcasite) or siderite (iron carbonate) from cracked sandstone which subsequently precipitates on discharge to a receiving water body as orange-brown iron hydroxide and generates sulfuric acid, iron, manganese, aluminium, nickel and zinc which can exceed the ANZECC 95% protection of aquatic species trigger values.

In addition, enhanced armouring of stream bed substrate with precipitated iron hydroxide has been observed at discharge areas, however this effect has also be observed in natural, non mining affected streams in the NRE Mine Lease area.

Water quality in Wollandoola and Lizard Creeks has historically been highly variable, although is generally outside the ANZECC 2000 (95% protection of aquatic species) trigger level for pH, with Wollandoola Creek ranging from 3.35 to 6.16 and Lizard Creek ranging from 2.50 to 8.5, based on available data.

Filtered zinc generally also exceeds the ANZECC 2000 criteria, ranging from 0.003mg/L to 0.054mg/L in Wollandoola Creek and from <0.001mg/L to 0.065mg/L in Lizard Creek.

To date, filtered nickel has not exceeded the ANZECC 2000 criteria in either stream, whilst filtered aluminium generally does not exceed criteria (based on pH >6.5, which is currently unspecified, although would be significantly lower for pH<6.5), although can reach up to 0.07mg/L in Wollandoola Creek and 0.11mg/L in Lizard Creek.

Total nitrogen and to a lesser degree, total phosphorous can also exceed the ANZECC 2000 criteria due to the large variability of runoff in the catchment.

Dissolution of accessory marcasite (iron sulfide) and siderite (iron carbonate) from freshly fractured pathways within the shallow bedrock groundwater system that drains into, or is connected with a stream, can generate increased concentrations of dissolved sulfate, iron, manganese, aluminium, nickel or zinc and the re-emergence of more acidic and higher salinity water downstream of subsidence affected areas.

The increased concentration of dissolved aluminium may be due to dissolution from kaolinite in the fractured bedrock along the groundwater flow-path or if it is remobilised from precipitated hydrous iron, manganese or aluminium oxides due to dissolution by humic and fulvic acids originating from the organic rich upland swamps.

The diversity and abundance of aquatic species within the Project Area may be restricted by the relatively acidic pH, as well as dissolved aluminium and zinc. Sulfate and dissolved humic and fulvic acids may be insufficient to form complexes with the dissolved aluminium and thus reduce the stream water ecotoxicity.

If additional adverse geochemical seepage to a stream occurs, it could be significantly diluted, with the resultant lowering of dissolved pollutant concentrations in the stream at the point of emergence. This assumes, however that the possible discharge occurs at an

isolated identifiable location in a stream, whereas it is equally possible that the seepage may be disseminated at various points along a stream depending on the subsidence induced flow regime, with the resultant additional enhanced dilution, precipitation and adsorption effects described above.

The generation of the ferruginous orange brown plumes decreases over a time frames of years due to armouring of marcasite with hydrous ferric oxide precipitates (Nicholson et al, 1990).

Studies at Eloura Colliery, in a similar geomorphological and hydrological environment to the Project Area, indicate there are no residual ecotoxic effects from acidic pH along with dissolved aluminium, nickel or zinc, with the chemical effects of undermining requiring less than 10 years to be ameliorated. It has also been observed at Eloura that natural attenuation with downstream from a stream reach affected by acidic pH, aluminium, nickel or zinc can also occur at distances of up to 750m (BHP Billiton, 2004).

The effect of acidity is reduced mainly through dilution with receiving waters as well as buffering from alkaline solutes such as bicarbonate ($HCO3^-$) and, to a lesser degree hydroxide species (OH^-).

The increased acidity and lowered dissolved oxygen in receiving waters is generally only observed close to the discharge point, and depends on the flow rate and volume at the discharge point.

Dilution of the discharge as well as precipitation of iron and manganese hydroxides, adsorption of dissolved Ni and Zn onto the iron hydroxides, as well as binding and adsorption onto dissolved / total organic carbon significantly improves water quality away from the emergence point.

Further downstream of the emergence point, the receiving water can be affected by moderately elevated salinity, however this also quickly diminishes on mixing with the stream water.

The lack of pre and post subsidence monitoring data in both the NRE No. 1 and BHP Cordeaux lease areas, outside of the T and W Mains area, makes definitive assessment of subsidence effects difficult, however there are numerous ferruginous seeps within both streams and their tributaries, particularly in Lizard Creek within and upstream of the V Mains Project Area.

With the lack of observed adverse effects from stream bed cracking due to subsidence on stream flow and upland swamps in the NRE No. 1 and Cordeaux lease areas, it is not anticipated that a significant observable adverse effect on water quality will occur due to coal extraction and subsidence within the V Mains Project Area.

8.3 Water Supply Reservoirs

Potential discharge out of the Project Area of water-borne contaminants, possibly to the the Cataract River and subsequently the SCA offtake at Broughtons Pass Weir, could include fluvial transport of fine sands and clays and/or ferruginous precipitates following mining of V Mains.

Both Lizard Creek and Wollandoola Creek are remote from the Broughtons Pass Weir SCA water supply off-take. Any sediment discharge from the Project Area is likely to be contained within the Wollanddola and Lizard Creek stream reaches and are unlikely to

extend as far as Broughtons Pass Weir.

Substantial monitoring within the Eloura Colliery area (BHPB, 2004) indicates there was no evidence that erosion is significant, and therefore, it is considered highly unlikely there would be an adverse effect on the bulk drinking water supply quality in the SCA offtake at Broughtons Pass Weir due to mining V Mains. It is considered that mining of the Project Area will be compatible with SCA's raw water supply quality standards.

It should also be noted that the passage of the 2001 / 2002 bushfires through SCA lands over previously mined areas in the Southern Coalfields has substantially increased the supply of eroded sediments to streams.

8.4 Stream Bed and Bank Stability

A subsidence trough of up to 1.02m deep may develop between, as opposed to within, the Wollandoola and Lizard Creek channels (Seedsman Geotechnics, 2008).

Remnant relative "highs" will remain over the upstream and downstream section of the V Mains subsidence trough where the ground subsides less than over the centre of the mined area. Development of "trough and ridge" structures can induce erosion of high points and accretion of sediments in troughs in order for the creek to regain its original bed gradient. In steep gradients and / or poorly vegetated streams, this can lead to increased erosion and sediment bedload discharge from a catchment along with possible increased nutrient input to waterways.

Creek bed incision may occur on the upstream (headward) section where the stream gradient steepens into the trough, however due to the anticipated low flow volumes, these headward incisions or "nick" points are not anticipated to be significant over V Mains.

Tensional cracks can form in the soil and bedrock as the workings advance, with transverse "faceline cracks" closing again as the ground subsides behind the progressive face of the longwall. In addition, cracks parallel to the panel sides can form through the ground surface "falling in" to the centre of a panel, whilst "bending" of the ground surface over the chain pillar can cause cracking of soil and bedrock that may enable transfer of stream water through cracks to the local shallow water table.

As strains along the watercourses are predicted to be less than 3.3mm/m tensile, with compressive strains less than 6.5mm/m, the creeks may experience minor ground movements due to subsidence (Seedsman Geotechnics, 2008).

Due to the lack of significant exposed sandstone in the stream beds, and as only minor fracturing of any exposed bedrock and the riparian soil banks in the stream valley may occur, it is not anticipated that any observable adverse effects on the stream bed or bank sedimentation regime will occur.

The lack of adverse changes is due to the low predicted subsidence and strains as well as the high vegetative cover in the bed and banks.

8.5 Stream Pools

Pool water retention capacity has been potentially modified due to subsidence, with the capacity being impacted for up to 500 metres outside the area of Eloura extraction area at the depth of cover, supercritical width, coal thickness extracted, overburden strength and stress conditions for longwalls 6 and 7 (BHPB, 2004). The water level drop at Eloura was associated with a period of extremely dry weather, and was significantly greater than that recorded during the 2001-2002 summer dry period. Some visible compressive fracturing was subsequently identified 50 metres upstream approximately one year after Longwall 7 was adjacent to this position.

The maximum predicted tilt of 6.1mm/m within the V Mains Project Area exceeds the stream bed gradient of 0.8mm/m and therefore it is possible that subsidence may oppose the natural stream gradient and surface water pondage may be reduced in both volume and retention time.

It is possible there may be isolated changes to localised ponding in the streams, however the changes are not anticipated to be significant.

8.6 Upland Swamps

Coal mining and the associated maximum 1.02m of subsidence is not anticipated to directly have an adverse observable effect on the “in-valley” swamps.

Swamps, however, can also be affected by variations in factors such as the geomorphic, hydrological, physical and biological processes in effect at the time of undermining, along with the climatic conditions at the time of, and subsequent to, subsidence.

Low water tables during extended dry periods, erosion in localised areas, the effect of bushfires and changes in sediment transport can all adversely affect upland swamps.

8.7 Gas Emissions at Surface

The dilation in the strata immediately beneath the base of a stream due to valley bulging is restricted to the shallow surface strata, up to 20m below the surface and does not provide a direct conduit for the release of gases from underlying, deeper strata.

Emission of gases at the surface is not, normally, a major issue, as the emissions are short lived events and the consequences are generally minor and readily managed.

9. POTENTIAL GROUNDWATER IMPACTS

In general it is anticipated that subsidence over the 460m deep V Mains workings may affect both shallow (<20m below surface) and regional (>50m) groundwater systems through;

- surface cracking to approximately 20m below surface;
- goaf fracturing to 100-150m above the seam, with partial loss of groundwater if fracturing extends into an overlying aquifer which can cause minor groundwater inflow through the goaf to the workings, and;
- an exponential decrease in overburden permeability with height above the workings.

Groundwater systems experience standing water level (or piezometric head pressure) changes caused by bedrock fracturing due to subsidence, with the new fracture voids filling with water and generating head drops, particularly in confined aquifers. In general, unconfined or unconsolidated aquifers are not significantly affected by mining (Booth, C.J., 2002).

After undermining, water levels may recover due to partial closure of fractures and by recharge flowing back to the affected area, on the basis there is no sustained discharge from the subsided zone out of the system. These outflow paths can develop through, for example, post subsidence springs flowing into valleys or by connection to enhanced permeability goaf zones over mined out panels.

The response to undermining and permeability changes varies both spatially and temporally within a mined area, whilst factors such as topographic relief and stratigraphic variation have a significant effect on the observed response.

Overburden at the advancing front of the subsidence trough undergoes a sequence of horizontal compression and tension of the overburden which manifests as volumetric compression followed by dilation of the strata. The strata movement occurs through fracturing, bedding separation and changes in existing joint apertures which can cause substantial changes in fracture porosity and rock permeability, which in turn lead to changes in piezometric heads, groundwater flow patterns and well yields.

A rapid response and temporary decline in piezometric heads can be primarily related to in situ hydraulic property changes in bedrock aquifers caused by;

- a sudden increase in fracture porosity and drainage of groundwater into the new void space, with confined aquifers altering to an unconfined or threshold unconfined condition, whilst unconfined aquifers have a significantly less sensitive response
- a secondary effect of transmitted drawdown around the potentiometric low which spreads laterally and exponentially from the subsided area. This regional effect generally spreads ahead of undermining and is generally the first observed response in standing water levels, with greater regional responses usually observed in higher transmissivity aquifers. The actual observed drop in head relates to the depth of a bore, its intake lithology and its confined or unconfined nature, a bores distance from the subsidence zone, its overburden thickness or

separation distance from the bottom of the bore to the top of the disturbed goaf as well as the local relief.

- leakage from upper to lower aquifers through fractured aquitards, with discharge to lower aquifers or local surface water systems. Groundwater flow patterns are affected in areas with high topographical relief by a combination of the topography which drives vertical flow and the layered stratigraphy which favours lateral flow, with subsidence changing the balance toward the topographic driven system. Bores below the regional drainage level may rise due to dewatering of perched aquifers and increased recharge through subsidence fractured layers.
- changes in hydraulic gradients caused by increased permeabilities, as permeability is linked to hydraulic gradient and specific discharge according to Darcy's Law

If the permeability is increased due to secondary fracture flow, the hydraulic gradient must decline or the specific discharge must increase to maintain stasis. Heads can decline upgradient and rise downgradient from the affected area and groundwater discharges may increase. The overall effect will be seen as an increase in spring or stream flow and a lowering of groundwater levels and loss of stream flow in upland recharge areas.

Groundwater level recovery is driven by two separate mechanisms, which are compression and recharge of the overburden. Partial re-compression of faceline cracks generally follows the dilational subsidence phase, with tension fractures closing, causing a reduction in secondary void space in the bedrock and a resultant increase in groundwater head pressures. Settlement of beds may also cause some closure of bedding separations and groundwater level recovery.

Water level recovery can also occur as regional recharge water flows back to the temporary potentiometric low over a period of a few months. This recovery is dependent on connection to sources of groundwater recharge, the ability of the aquifer to transmit water back into the affected area and the amount of rainfall recharge. Areas of low transmissivity will require longer to recover than those in higher transmissive formations.

Changes in permeability can permanently affect the groundwater flow system, with the degree of recovery relating to the degree of fracture recompression. A higher permeability residual fracture network generally remains along the rib line tensional edges of the subsidence trough compared to the inner sections of the trough where faceline cracking has a higher post subsidence recompression ratio. Areas directly over the rib line area can have permanent head losses, with lesser changes in the mid or external panel areas. The combination of the two effects can make long term groundwater system recovery assessment hard to predict although valley water levels are more likely to recover than hilltop areas or in lithologies below the regional water table compared to perched aquifers (Booth, C. J., 2002).

An idealised plot of groundwater responses to undermining and subsidence is shown in **Figure 12**.

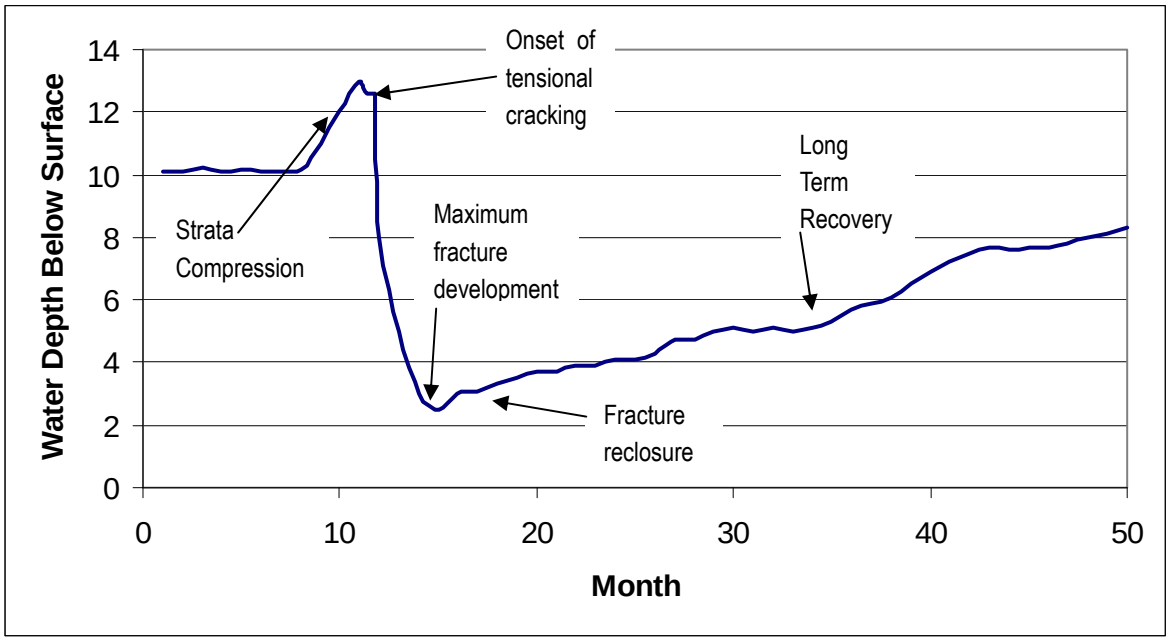


Figure 12 Schematic Groundwater Changes with Subsidence
(modified from Booth, C.J., 2002)

9.1 Aquifer / Aquitard Interconnection

From past experience in NSW coalfields, it has been assessed that hydraulic connection of surface water or alluvial groundwater systems is not likely at mining depths of cover greater than 150m.

Mining induced cracking and vertical subsidence of strata over the extraction area will occur over the workings, and may potentially extend to 20m below surface, with bedding dilation below the tensional zone to around 100-150m below surface.

In the upper 20m, subsidence can alter the dominance of the pre-mining horizontal flow along or above aquitards to generate a combination of vertical and horizontal flow regimes as aquitards are breached and water drains from higher to lower strata.

Vertical flow continues down the strata until the drainage is restricted by intact aquitards, at which the depth flow then resumes its horizontal dominance.

Below the surface cracked zone, an increased horizontal flow component can occur due to dilation and bending of strata, even though the layers are not actually breached by vertical cracking. The increased horizontal permeability extends across the subsided area, gradually diminishing as the subsidence and dilation decreases out to the edge of the subsidence zone.

No adverse interconnection of regional aquifers and aquitards is anticipated within 20m of the plateau surface as there are no recorded aquifers in this interval, however there may be an increased rate of recharge into the shallow overburden following rainfall due to the increased secondary porosity and permeability of the cracked sandstone / shales.

This can either result in higher discharge volumes and duration of temporary rain dependent seeps along cliff lines or higher recharge rates to underlying aquifers. The resultant enhanced seepage or vertical recharge patterns depend on which preferential

flow path, or paths, develops.

9.2 Groundwater Levels

9.2.1 Upland Swamps

Based on observations at Southern Coalfield longwall mines with similar geomorphological, hydrological and mining layout / depth of cover conditions to V Mains indicates that it is not anticipated that any adverse effects will be observed in the shallow ephemeral groundwater systems of the “in-valley” upland swamps following mining the V Mains area.

9.2.2 Regional Groundwater

Temporary lowering of the regional piezometric surface over the subsidence area due to horizontal dilation of strata may occur due to the increase in secondary porosity and permeability. This effect will be more notable directly over the area of greatest subsidence and dilation, and will dissipate laterally out to the edge of the subsidence zone.

Based on similar observations in the Southern Coalfields, regional groundwater levels may reduce by up to 10m, and may stay at that reduced level until maximum subsidence develops at a specific location. The duration of the reduced levels depends on the time required to develop maximum subsidence, the time for subsidence effects to migrate away from a location as mining advances to subsequent panels and the time required to recharge the secondary voids.

The degree of groundwater level decline due to subsidence is significantly affected by rainfall recharge to an aquifer. On the basis that the pre mining circumstances of rainfall recharge remain the same, it is anticipated that groundwater levels will recover over a few months as the secondary void space is recharged by rainfall infiltration.

There is generally no permanent post mining reduction in water level in the plateau unless a new outflow path develops, which can occur in close proximity to cliffs where new or enhanced seeps are generated, with the effect reducing with increased set back from a cliff.

It is anticipated there will be no adverse observable permanent reduction in groundwater levels in the base of the Wollandoola Creek or Lizard creek gorge sections as the subsidence area does not extend into the gorge section of the creeks, which lie to the north and downstream of the V Mains 20mm subsidence area.

No groundwater monitoring has been conducted directly within the V Mains Project Area, whist monitoring at other locations within the NRE No.1 Mine Lease area are discussed earlier in the report.

9.3 Groundwater Quality

The groundwater quality of subsidence affected aquifers is important in assessing the significance of potential issues that may apply to post mining effects on streams, groundwater dependent ecosystems or local bores, if present.

Previous observations across the Southern Coalfields indicate that groundwater quality within the regional groundwater system has not generally been adversely affected, however there may be increased iron hydroxide precipitation and a lowering of pH if the groundwater is exposed to “fresh” surfaces in the strata with dissolution of unweathered iron sulfide (marcasite).

The degree of iron hydroxide and pH change is difficult to predict, and can range from no observable effect to a distinct discolouration of the formation water. The discolouration does not pose a health hazard, however it can cause clogging of pumping equipment and piping in extreme cases where bores are used to extract the water.

It should be noted that many sandstone aquifers in the Southern Coalfield already have significant iron hydroxide levels, and a pre-mining survey of any active bores or piezometers is required to assess the baseline water quality prior to undermining an area.

Acidity (pH) changes of up to 1 order of magnitude can occur, however the change can be reduced if the aquifer has sufficient bicarbonate levels.

Generally, no significant adverse groundwater quality changes have been reported in regional aquifers within subsidence affected areas in the Southern Coalfields, however it is likely that water quality changes have occurred, but not been observed, particularly in regard to increased iron concentrations and precipitation of iron hydroxide through pumping and aeration of groundwater.

Subtle changes may occur with regard to dissolved aluminium, nickel, zinc, iron or manganese levels through oxidation and dissolution of iron sulfide (marcasite) or iron carbonate (siderite) after subsidence induced fracturing within the aquifer. Identification of subsidence related changes in dissolved metals requires the appropriate collection, preservation and laboratory analysis of samples from an aquifer prior to undermining.

9.4 Seeps, Springs and Baseflow From Upland Swamps to Streams

Lowering of intermittent, perched seep levels within the upland swamps may occur after extraction of V Mains through cracking of underlying confining, low permeability layers in the plateau. Cracking can enable the pre-mining perched water to percolate to lower levels in the strata than occurred before subsidence. The current swamp seeps are generally ephemeral, with the volume and duration of flow directly related to the degree of rainfall. The seeps flow after wet periods and stop flowing after prolonged dry periods.

It is unlikely that the swamp seep volume and duration will increase due to enhanced rainfall recharge through the plateau due to subsidence. The low order creeks on the plateau will be subjected to low tensile strains and are not expected to be observably affected by subsidence related surface cracking.

No significant change to groundwater inflow or outflow to or from the tributary streams is anticipated to occur.

A potential change in groundwater seepage and stream baseflow resulting from the effects of subsidence, valley closure and uplift in the base of a valley which increases

permeability and the interconnection between the stream bed and banks is schematically shown in **Figure 13**.

A component of groundwater flow to the local streams can be observed at isolated iron stained seeps along the creek beds, where low volume and variable duration seeps discharge for a few days to weeks after significant rainfall. The seeps are located at the interface between coarser and underlying finer sandstone or shale layers which restrict vertical flow through the bedrock and enhance lateral flow. Most observed seeps in the local streams are anticipated to flow at less than 1L/sec.

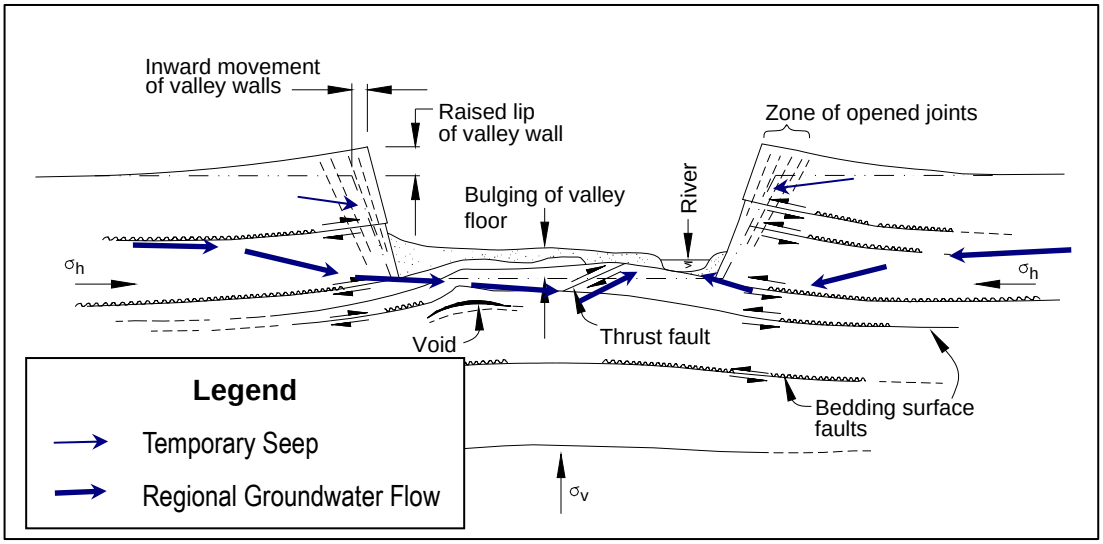


Figure 13 **Schematic Effects on Groundwater Systems** (MSEC, 2006)

9.5 Stream Flow and Groundwater Interaction

The current interaction between surface water and the perched and regional groundwater systems is not well understood, although it is postulated that pre-mining conditions prevail such that in wet periods there is a net contribution of groundwater to the surface system, while in dry conditions there is a net loss of surface water to the groundwater system, with the resulting surface flow depending on the relative balance between inflow and outflow.

This balance is expected to vary along the length of the streambeds.

Upland swamp storage is a component of the shallow, ephemeral groundwater system, whilst an extensive water storage potentially exists within the deeper, regional Hawkesbury Sandstone aquifers.

A number of mechanisms are hypothesised to occur within the shalow groundwater system associated with the streams and swamps:

- Direct flow of surface water into mining induced fracture systems and removal from shallow groundwater systems, and, where the depth of cover allows hydraulic connection, inflow directly to the mine workings,
- Flow of surface water into the shallow groundwater system migrates along the hydraulic gradient to re-emerge further downstream. This mechanism could also cause reversal of flow from groundwater to the surface during periods of high

recharge to the groundwater system.

- Flow of surface water into the shallow groundwater system migrating along the hydraulic gradient to merge further downstream with other groundwater regimes, possibly associated with dam water storage.

The surface water and shallow groundwater system is isolated from the mine workings by the 460m of overburden which contains two potential aquifer systems generated through subsidence fracturing and three units of low vertical permeability, with the main unit being the Bald Hill Claystone.

Direct vertical migration is unlikely from the surface to the workings, and has not been observed in Southern Coalfield mines with a similar depth of cover to V Mains, although inter-aquifer connection may be locally enhanced by mining induced subsidence in the shallow surficial aquifer and within the goaf zone, which are seperated by the intact Bald Hill Claystone.

Surface water drainage from the plateau to the local streams in the Project Area is through ephemeral first and second order gullies. The smaller gullies discharge into the major streams from elevated stream beds after sufficient rain, whilst the majority of rain would infiltrate into the plateau and swamp soils. Recharge to the shallow, and subsequently the deeper regional groundwater system, would occur over an extended delay of months to years after meteoric water has soaked through the plateau's soil and bedrock lithologies, with the majority of water discharging from temporary seeps in the swamps due to the significantly preferential horizontal rather than vertical flow regime in the Hawkesbury Sandstone.

The predominantly horizontal flow regime and restricted vertical recharge is essentially determined by the;

- horizontally bedded strata with preferential flow along bedded zones with coarser grain size,
- claystone/mudstone banding at the base and tops of sedimentary facies which restrict vertical migration and enhance horizontal flow at the base of the more porous unit,
- fracture zones enhancing horizontal flow through the strata, and;
- bedding planes or unconformities located immediately above finer grained sediments or iron rich zones.

Groundwater within the plateau and swamps discharge to the main streams, occurs as a "gaining" system where surface water flows down gradient under gravity to s stream, and then along the stream beds to the Cataract River.

9.6 Potential Inflow to Mine Workings

Loss of stream flow or groundwater to the underlying workings has not been observed in any mines in the Southern Coalfield at similar depths of cover to the proposed V Mains workings.

Vertical hydraulic connection to the workings is restricted by the Bald Hill Claystone aquitard, which is not breached after subsidence as it is from 150m to 200m below the surface and significantly below the depth of surface cracking and overburden bedding dilation.

The horizontal permeability above the claystone may be enhanced after subsidence, however there is no additional vertical connectivity through the claystone, with the groundwater systems above and below the Claystone remaining separate.

Interpretation of field test data for the Reynolds enquiry (Reynolds, 1977) indicated that vertical flow through the stratigraphy could occur, however it would be too small to measure, with flow in the strata over the workings dominantly in the horizontal direction.

A minimum thickness of unfractured overburden is required to maintain hydraulic separation between a mine and saturated aquifers, with the critical value depending on lithology, structure and topography. The minimum separation has been established through observation and research in NSW mines as ranging from less than 90m up to 150m. The separation distance over V Mains is well in excess of 150m, where the depth of cover is around 460m.

Based on the low permeability of the Bald Hill Claystone and Stanwell Park Claystone aquitards both pre and post mining and the lack of observed water inflow changes to other Southern Coalfield mines, it is assessed there would be no discernible flow into the proposed workings, even though movement of rock and fracturing will occur in the overburden through;

- fracturing and localised shear on joints and bedding in cliff lines and valley slopes,
- shear on bedding planes at the valley floor,
- subsidence and uplift of the valley floor,
- localised buckling and uplift of blocky strata in the stream bed through horizontal thrusting, and
- fracturing and yield failure of the strata extending up to 150m above the workings, with strata above this zone remaining intact and subsiding by interlaminar shearing on bedding planes.

The Bald Hill Claystone aquitard is situated around 185m to 205m below the plateau, with the upper groundwater system above the claystone being separated from the underlying hydrogeological system.

The shallow, horizontal flow dominated system can discharge into the valley floor or have localised flow through mining induced shear zones on bedding planes at the base of the valley.

10. WATER MONITORING AND MANAGEMENT

A Water Monitoring and Management Plan incorporating detailed provisions for surface water and groundwater data collection, interpretation and reporting will be incorporated into the V Mains Subsidence Management Plan (SMP).

The proposed monitoring and data interpretation is considered best practice for the detection of surface water and groundwater impacts of subsidence within stream beds and the broader sub-catchments, as well as in the shallow and deeper (regional) groundwater systems.

A key aspect of the Plan will deal with the early detection and assessment of subsidence (or uplift) effects within the subject streams and groundwater systems using properly sampled and analysed geochemical and physical data to provide early indication of any subsidence related surface water or groundwater effects.

10.1 Stream Pools

Daily automated monitoring of selected pool water depths upstream, within and downstream of the V Mains Project Area should be conducted and compared to rainfall in the local area. The monitoring sites would be sited upstream, within and downstream of the proposed 20mm subsidence area, at locations that are permanently wet.

Monitoring should assess the inputs from catchment runoff and any flow variations within the Project Area before, during and after the V Mains extraction period.

The collected data should review any observable changes that develop, and, subsequently develop a plan to manage any adverse issues, if appropriate.

Use of portable / dismountable flow gauging equipment that does not adversely affect the stream ecology may be required to obtain quantitative flow data for hydrologic assessment.

10.2 Stream Water Quality

Monthly water quality monitoring should be conducted in both Wollandoola and Lizard Creeks upstream, within and downstream of the Project Area during the period of extraction, with bi-monthly monitoring in the period before extraction begins.

Water quality related field studies should concentrate initially on regular visits to main channel sites that would be monitored for identifiable inputs from catchment runoff and for all key water quality parameter variation for the duration of mining and for an appropriate period following mining.

Monitoring should be conducted for the following parameters;

- Field pH, electrical conductivity, dissolved oxygen, oxidation / reduction potential and temperature,
- total dissolved solids,
- Na / Ca / Na / K / SO4 /Mg / Cl / F,
- total alkalinity,

- dissolved organic carbon
- total / filterable Fe, Mn, Al,
- filterable Ni, As, Li, Ba, Sr, Cu, Pb, Zn
- total nitrogen and total phosphorous

Stream water level, or spot flow monitoring and sampling should be conducted at all locations on the same day. All samples should be collected in appropriately cleaned and prepared equipment, stored in appropriately cleaned and rinsed sample containers, then transported and analysed according to ANZECC 2000 standards, with 0.45µm filtering and nitric acid preservation to <pH2 for metals samples.

Trigger values for selected pollutants of concern should be set within the context of a Triggers Action Response Plan (TARP) after one year of full data is collected, and where the values are exceeded, the cause and effect of the exceedance should be investigated and a management plan developed if the cause is directly related to mining.

Initial TARPs for the V Mains area would be a pH decline of between 1.5 and 2.0 pH units, an electrical conductivity increase of between 50 µS/cm and 100 µS/cm and an oxidation reduction potential declines from between 150mV and 200 mV.

These would be reviewed following collection of additional baseline data, and additional water quality monitoring sites may need to be established as the monitoring program progresses.

10.3 Stream Bed and Bank Stability

The stream bed and banks are not anticipated to be observably affected, however water depths in the stream monitoring sites should be automatically monitored and photographed during site visits, unless access to the sites is deemed temporarily unsuitable.

Subsidence may induce minor bed or bank erosion over the proposed panels, particularly in the headward and downstream sections of the subsidence trough, as well as over the chain pillars.

As the creeks are well vegetated, no significant change is anticipated and it is not envisaged that stream bed or bank remediation will be required.

Any changes to the current state will be visually monitored after significant stream flow events, and if adverse subsidence / uplift effects occur, a specific management and rehabilitation plan should be developed for the affected areas.

10.3.1 Bedload Movement

If erosion occurs in a stream, it may cause a minor increase in potential bedload movement in and downstream of the subsidence area, which will be visually monitored during and after significant flow events.

Significant bedload movement is not anticipated and therefore stream bed or bank management and rehabilitation is not anticipated to be required.

10.3.2 Stream Gradient

It is not anticipated that significant observable change will occur due to subsidence and that stream gradient rehabilitation measures will not be required.

10.3.3 Riparian Vegetation

Vegetation in the stream and banks will be visually monitored over the V Mains mining area before and after any stream is undermined, particularly after significant flow events.

As no adverse effect on the riparian vegetation is anticipated, no vegetation rehabilitation measures are anticipated.

10.4 Upland Swamp Groundwater

If required, a suite of shallow piezometers may be installed within upland swamp/s to assess the extent and/or vertical thickness of a hillslope aquifer and to gauge any changes standing water levels and quality over the active mining area.

It should be noted that no vehicular access is available within the V main upland swamps, and installation of any piezometers requires entry to the swamps on foot.

Water quality related field studies may focus initially on regular visits to any sand apron or upland piezometers within the swamp areas if they are installed. These could be monitored for identifiable impacts to the groundwater level and for all key water quality parameters on a regular basis for the duration and an appropriate time following mining.

10.4.1 Standing Water Levels

Where piezometers are installed in the swamps, standing water levels will be measured automatically, twice daily by pressure transducers and at least bi-monthly by manual dip meter.

Should the standing water level or groundwater quality be unacceptably affected due to subsidence, the Colliery will investigate methods to ameliorate the situation until the water level or water quality recovers.

10.4.2 Groundwater Quality

Where piezometers are installed, at least one appropriately purged and collected, stored and transported groundwater sample should be collected from each piezometer pre and post undermining to enable ongoing assessment of any subsidence related changes in groundwater quality.

Samples should be analysed for;

- Field pH, electrical conductivity, temperature,
- total dissolved solids,
- Na / Ca / Na / K / SO4 / Mg / Cl / F,
- total alkalinity,
- total / filterable Fe, Mn, Al,
- filterable Ni, As, Li, Ba, Sr, Cu, Pb, Zn
- total nitrogen and total phosphorous

Observations should be made on the quantum of iron hydroxide precipitating from the pumped water before and after undermining.

10.5 Mine Inflows

Mine inflows will be monitored through measurement of all water pumped into and out of the NRE No. 1 workings.

10.6 Rainfall

Rainfall will be monitored daily at the mine's and the nearest Bureau of Meteorology weather station for the duration of mining.

The quantity and variability of streamflow in Wollandoola and Lizard Creeks will be monitored by data loggers to assess the rainfall / runoff relationship, with photography used to monitor flow conditions in both creeks as well as their unnamed tributaries.

10.7 Reporting

An end of extraction report will be prepared for the mined panel, which summarises all monitoring over the period. The report will outline any changes in the surface water or groundwater system over the mined out areas.

If required, a meeting will be convened with the Department of Primary Industries - Mineral Resources and / or the Department of Water and Energy and the Sydney Catchment Authority (SCA) at the mine office to discuss requirements for remediation and ongoing monitoring.

All monitoring and management activities will be reported in the Annual Environmental Management Report (AEMR) in subsequent years.

10.8 Ongoing Monitoring

All results will be reviewed one year after each panel has been completed and an updated ongoing monitoring and remediation program will be developed in association with the Department of Primary Industries - Mineral Resources, Department of Water and Energy and the SCA.

10.9 Quality Assurance and Control

QA/QC will be attained by calibrating all measuring equipment, ensuring that sampling equipment is suitable for the intended purpose, NATA registered laboratories are used for chemical analyses and that site inspections and reporting follow procedures outlined in the ANZECC 2000 Guidelines for Water Quality Monitoring and Reporting.

Field sample collection, storage, despatch, laboratory analysis, interpretation and reporting will be conducted according to ANZECC 2000 requirements.

10.10 Subsidence Impact Management and Contingency Measures

In the event that future water monitoring shows that there has been significant hydrologic or aquatic ecotoxic effects then it is possible that some management and mitigation measures may be required. Management measures may involve alterations to the area of extraction or modifications to the orientation and/or disposition of future mining.

At this time, there are no specific recommendations for stream or groundwater management and rehabilitation over the proposed mining area as the predicted impacts are not anticipated to be significantly adverse.

Ongoing monitoring is required to assess whether any subsidence related physical and / or chemical changes to stream flows, stream water quality and stream integrity occur, as well as to validate predicted impacts on groundwater levels, mine seepage and groundwater water quality.

All relevant rehabilitation actions will be derived in association with the DPI-DMR, DWE and SCA and will be acted upon as appropriate.

At the end of the subject mining, assessment of the field and laboratory data will be completed to determine whether any unanticipated trends are occurring, and a review of measures will be required to address the issue if a subsidence / uplift related trend is apparent.

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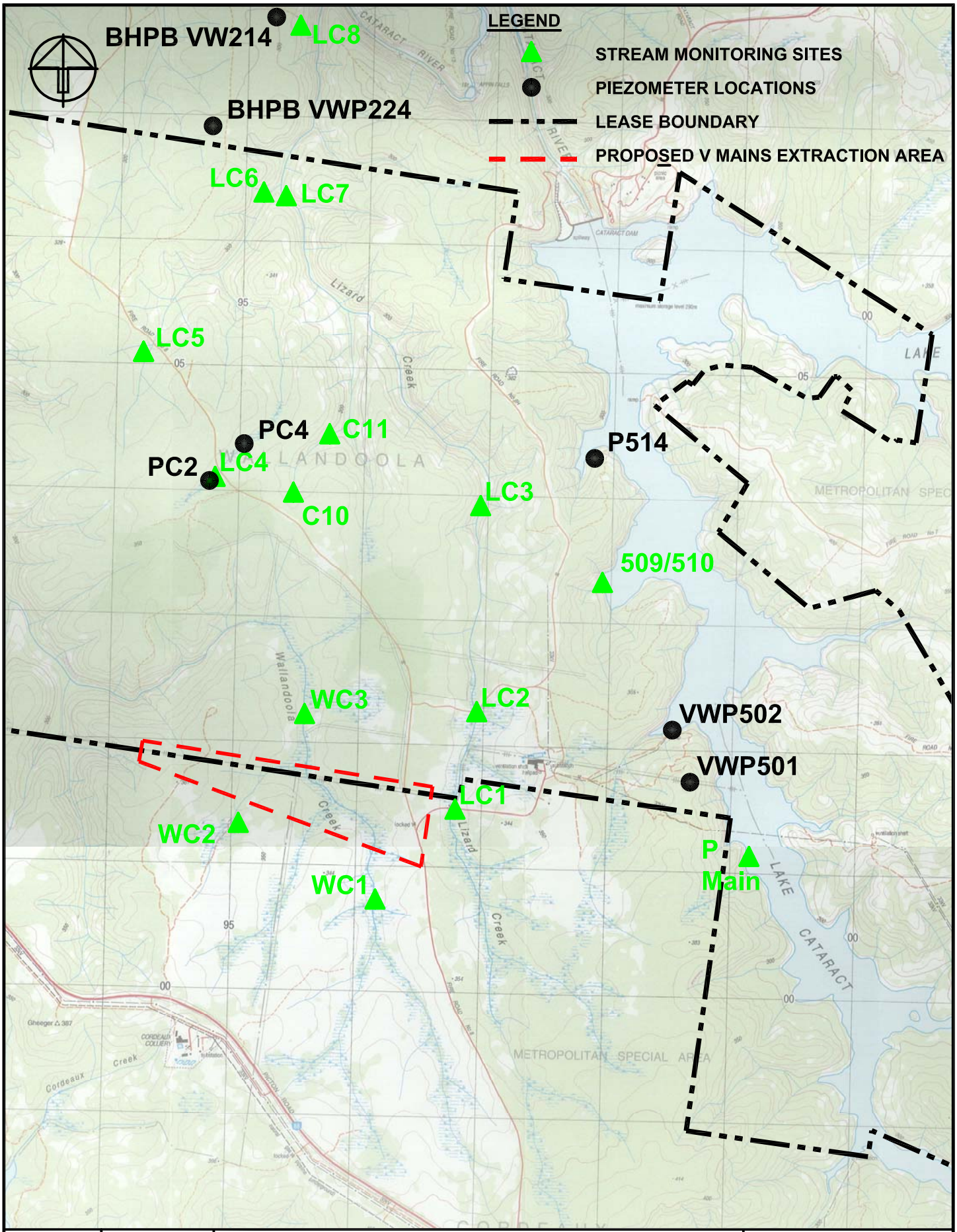
LIMITATIONS

This report was prepared in accordance with the scope of services set out in the contract between Geoterra Pty Ltd (Geoterra) and the client, or where no contract has been finalised, the proposal agreed to by the client. To the best of our knowledge the report presented herein accurately reflects the clients requirements when it was printed. However, the application of conditions of approval or impacts of unanticipated future events could modify the outcomes described in this document.

In preparing this report, Geoterra has relied upon information and documentation provided by the client and / or third parties. Geoterra did not attempt to independently verify the accuracy or completeness of that information. To the extent that the conclusions and recommendations in this report are based in whole or in part on such information, they are contingent on its validity. Geoterra assume the client will make their own enquiries in regard to conclusions and recommendations made in this document. Geoterra accept no responsibility for any consequences arising from any information or condition that was concealed, withheld, misrepresented, or otherwise not fully disclosed or available to Geoterra.

The findings contained in this report are the result of discrete / specific methodologies used in accordance with normal practices and standards. To the best of our knowledge, they represent a reasonable interpretation of the general condition of the site in question. Under no circumstances, however, can it be considered that these findings represent the actual state of the site at all points.

Interpretations and recommendations provided in this report are opinions provided for our Client's sole use in accordance with the specified brief. As such they do not necessarily address all aspects of water, soil or rock conditions on the subject site. The responsibility of Geoterra is solely to its client and it is not intended that this report be relied upon by any third party. This report shall not be reproduced either wholly or in part without the prior written consent of Geoterra.



PROJECT:	GUJ3-R1
DRAWN:	A. DAWKINS
DATE:	13 Feb 2009
SCALE:	AS SHOWN

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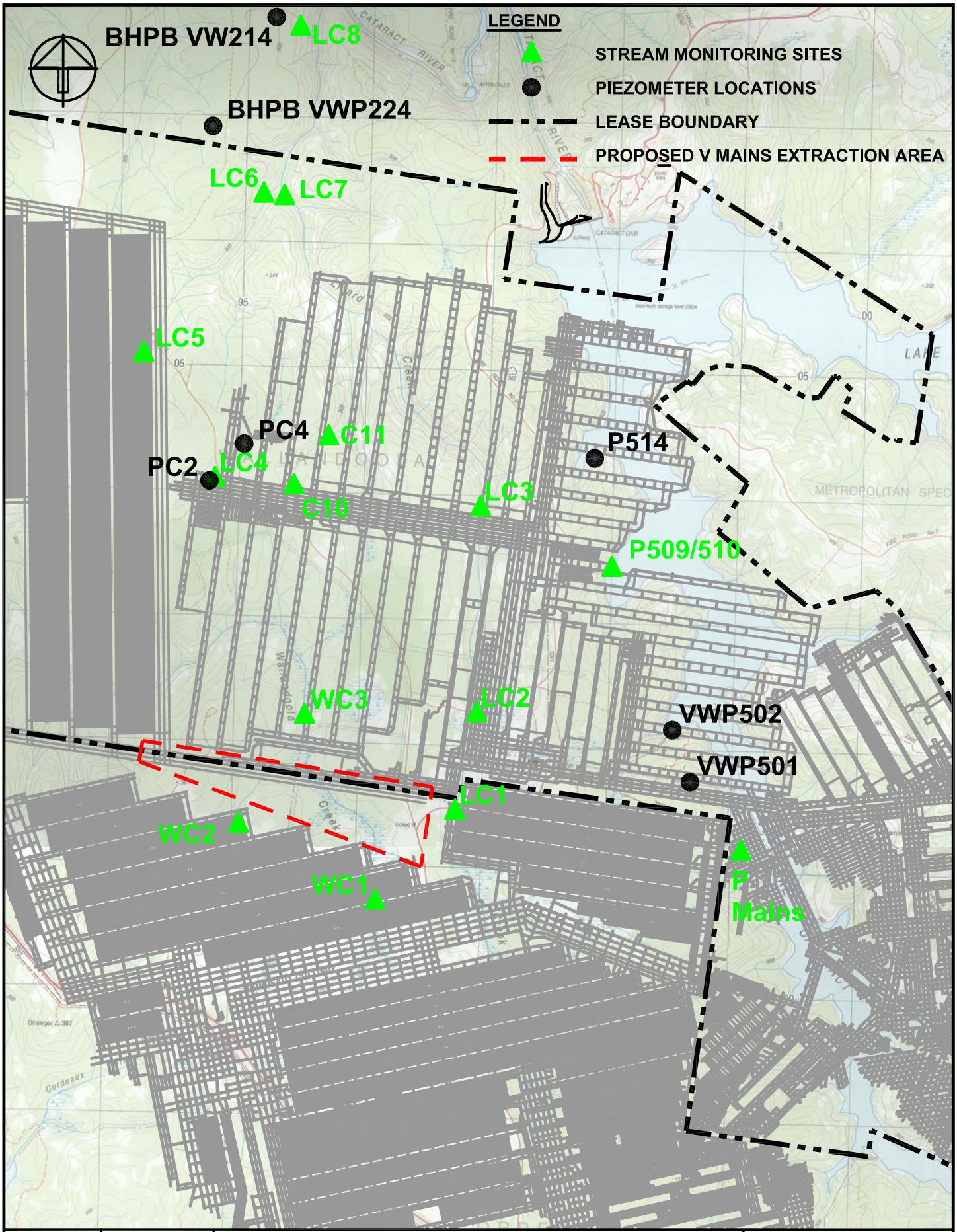
NRE No. 1 COLLIERY
V Mains

Project Area and Monitoring Locations

GeoTerra

DRAWING 1



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DRAWN:	A. DAWKINS
DATE:	6 FEB 2009
SCALE:	AS SHOWN

GUJARAT NRE MINERALS PTY LTD
NRE No. 1 COLLIERY
V Mains

Existing Bulli Seam Workings

GeoTerra

DRAWING 2

APPENDIX A
WATER QUALITY MONITORING

Annex G

Preliminary Works Surface Water and Groundwater Assessment

GeoTerra

GUJARAT NRE COKING COAL LTD

PRELIMINARY WORKS SURFACE WATER & GROUNDWATER ASSESSMENT

Bellambi, NSW

GUJ3-R1C

24 SEPTEMBER, 2010

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GUJ3-R1C (24 SEPTEMBER, 2010)

Gujarat NRE Coking Coal Ltd
PO Box 281
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Attention: Dr C Harvey

Chris,

RE: Preliminary Works Surface Water and Groundwater Assessment

Please find enclosed a copy of the above mentioned report.

Yours faithfully

GeoTerra Pty Ltd

Andrew Dawkins (AuSIMM CP-Env)

Managing Geoscientist

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Date	Rev	Comments
06.02.2009		Initial Draft
12.05.2009	A	Incorporate Reviewer Comments
10.09.2010	B	Update report to include new data
24.09.2010	C	Incorporate Reviewer Comments

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APPENDICES

Appendix A Wallandoola Creek and Lizard Creek 3rd Order Channel Photographic Mapping

EXECUTIVE SUMMARY

The findings of the current assessment for the potential impacts, effects and consequences from the proposed workings are summarised below for the:

- secondary mining of the Bulli Seam via pillar extraction of V Mains and 309 Panel;
- first workings in the Bulli Seam at H Panel; and
- first Workings in the Wongawilli Seam at P & R Drifts, Wonga Mains Driveage and the gate roads for Longwalls 4 & 5.

Potential Surface Water Impacts Summary

UPLAND SWAMPS
No adverse water level, water seepage or water quality effects on valley fill swamp Wcvfs1
STREAM FLOW
Negligible adverse loss or diversion of stream flow in Wallandoola Creek over swamp Wcvfs1 or in the first order tributary of Lizard Creek over Panel 309. *No impact on streams and tributaries overlying H Panel, Wonga Mains, P & R Drifts and Longwalls 4 and 5 gateroads*
STREAM WATER QUALITY
Negligible adverse impacts on stream water quality in Wallandoola Creek over swamp Wcvfs1 or in the first order tributary of Lizard Creek over Panel 309. *No impact on streams and tributaries overlying H Panel, Wonga Mains, P & R Drifts and Longwalls 4 and 5 gateroads*
CATARACT RESERVOIR AND BROUGHTONS PASS WEIR POOL
No impact on Cataract Reservoir or Broughtons Pass Weir pool water levels, water storage or water quality from the proposed workings
STREAM BED AND BANK STABILITY
No impacts on stream bed and bank stability on streams and tributaries overlying the proposed workings
STREAM POOLS
No impacts on the natural drainage behaviour stream pools overlying the proposed workings
GAS EMISSIONS
No gas emissions at surface over the proposed workings

Potential Groundwater Impacts Summary

UPLAND SWAMPS
Negligible adverse water level, water seepage or water quality effects on valley fill swamp Wcvfs1
SHALLOW TO MID HAWKESBURY SANDSTONE
Temporary lowering and subsequent recovery of the phreatic surface by up to 15m, with no observable adverse change to water quality, which will be tempered by the existing depressurisation regime from previous mining
DEEP HAWKESBURY SANDSTONE
Temporary lowering and subsequent recovery of the phreatic surface, with no observable adverse change to water quality, which will be tempered by the existing depressurisation regime from previous mining effects
BALD HILL CLAYSTONE
Due to insufficient deflection of the Bulgo Sandstone, the Bald Hill Claystone is predicted to remain intact and as a result, there will be no predicted hydraulic interconnection, or loss of surface water / Hawkesbury Sandstone groundwater into the mine workings
NARRABEEN GROUP AND ILLAWARRA COAL MEASURES
Hydraulic interconnection and depressurisation of the sedimentary overburden under the Bald Hill Claystone up to the mid Bulgo Sandstone, which will be tempered by the existing depressurisation from previous mining
Potential iron hydroxide precipitation and acidification of the interstitial water due to oxidation in aerated groundwater in the sedimentary overburden
MINE INFLOWS
Negligible change to mine inflows as the Bulli and Wongawilli Seam overburden is already depressurised.

1. INTRODUCTION

As part of their preliminary works program, Gujarat NRE Coking Coal Ltd (Gujarat) propose to extract coal from the following first and secondary extraction workings within the NRE No.1 Colliery;

Pillar Extraction Areas in the Bulli Seam

- V Mains
- T & W Mains Panel 309

First Workings in the Bulli Seam

- H Panel

First Workings in the Wongawilli Seam

- P & R Drifts
- Wonga Mains Driveage, and
- gate roads for Longwalls 4 & 5

The proposed workings are located within the Sydney Catchment Authority (SCA) managed, restricted access Metropolitan Special Area in which Consolidated Coal Lease 745 (CCL745) and Mining Lease 1575 (ML1575) have been granted as shown in **Drawing 1**.

The proposed workings are located approximately 13km north of Wollongong.

The Study Area is defined as the area covered by the Gujarat leases. It contains ephemeral 1st and 2nd order tributary creeks draining into the 3rd order Schedule 2 streams of Wallandoola, Lizard and Cataract Creeks along with valley fill and headwater upland swamps.

It should be noted, however, that only one upland swamp (Wcvfs1, along Wallandoola Creek) is within any predicted 20mm subsidence zone over all of the proposed workings.

The proposed secondary extraction areas do not contain any rivers, gorges or cliff lines and are within an essentially undeveloped bushland region, apart from limited fire access trails, mine access tracks and mine surface infrastructure.

The land is used as a surface water catchment area that drains into the Cataract River from V Mains and 309 Panel, whilst H Panel partially underlies the eastern bank as well as Cataract Reservoir as shown in **Drawing 1**.

Water from the Cataract River is regulated by Broughtons Pass Weir, from which the water is diverted through Cataract Tunnel to Prospect weir, then directed on to the Macarthur Water Treatment Plant.

The Study Area contains a Risk Management Zone (RMZ) (NSW Department of Planning, 2008) which laterally extends to either side of Wallandoola Creek for 400m away from the centre line of the creek, which is wholly enclosed within the V Mains extraction area.

Risk Management Zones have not been defined along Lizard Creek for V Mains as it is not anticipated that the stream reach or its riparian zones will be affected by subsidence, as outlined subsequently in this report.

In addition, no RMZ's have been defined for the other proposed first and second workings extraction areas due to their position under first order channels (Panel 309) or their lack of proposed subsidence.

This study provides a baseline, pre-mining assessment of the potentially affected surface water and groundwater systems within the proposed mining areas and has been conducted to satisfy Environmental Assessment approvals process as administered by the Department of Planning (DoP).

Office, field and laboratory studies have been used to prepare baseline assessments of stream water, stream geomorphology and groundwater, as well as an indicative management and monitoring strategy that will be suitable to manage any potential adverse effects on the systems that may be caused by subsidence.

Surface water features within the Study Area include:

V MAINS

- the main channel and tributaries of Wallandoola Creek, which flows to the north and joins the Cataract River approximately 9km NNW of V Mains, or approximately 12 km along the stream reach;
- the main channel of Lizard Creek, which joins with the Cataract River approximately 7km to the north, or approximately 8km to the north along the stream reach. It should be noted that Lizard Creek will not be directly undermined by V Mains, as it is outside the eastern periphery of the V Mains 20mm subsidence zone; and
- a valley fill upland swamp (Wcvfs1) is located along Wallandoola Creek

T & W MAINS 309 PANEL

- a first order, northerly flowing, ephemeral tributary of Lizard Creek

H PANEL

- the eastern edge of the stored waters in Cataract Reservoir

WONGA MAINS DRIVEAGE

- tributaries of the Cataract River and Cataract Creek, predominantly upstream of the Cataract Reservoir; and
- the stored waters of Cataract Reservoir.

P & R DRIFTS WONGA SEAM

- the stored waters of Cataract Reservoir

LONGWALLS 4 & 5 GATE ROADS

- first and second order tributaries of the Cataract River and the third order channel of Cataract Creek over the Longwall 5 gateroads, upstream of Cataract Reservoir.

The main channel of Wallandoola and Lizard Creeks are classified as Schedule 2 streams with 3rd order channels (DIPNR, 2005) in the vicinity of V Mains, whilst the remaining proposed mining areas are overlain by ephemeral Category 1, 1st to 2nd order tributaries of Lizard Creek, Cataract Creek and Cataract River (upstream of Cataract Reservoir).

Baseline stream investigations commenced in Lizard Creek in March 2001 and during September 2001 within Wallandoola Creek by assessing the:

- ephemeral or perennial nature and flow in streams over the proposed workings;
- creek bed and bank erosion and channel bedload;
- stream and upland swamp water quality;
- stream bed and bank vegetation;
- sediment bedload;
- presence and appearance of pools;
- the presence or absence of bedrock;
- stream bed or bank cracking;
- any observed or inferred groundwater discharge zones; and
- presence of hydrocarbon gas.

Groundwater features overlying the proposed mining areas include:

- a valley fill upland swamp associated with Wallandoola Creek (Wcvfs1), and to a lesser degree, as it is outside of the predicted 20mm subsidence zone, Lcvfs1 along Lizard Creek
- perched, ephemeral basement aquifers located within the upper Hawkesbury Sandstone; and
- a regional aquifer located deeper within the Hawkesbury Sandstone.

There are no registered private bores, whilst a suite of piezometers which are located within the Gujarat Lease, apart from P6, are not directly relevant to the proposed mining areas.

Baseline groundwater investigations commenced in December 1992 using vibrating wire piezometers targeted in the Bulli Seam and its overburden. The piezometer intakes were installed over and adjacent to mined out areas, outside of the proposed V Mains, 309 Panel and H Panel mining areas.

Shallow upland swamp groundwater level and water quality monitoring commenced in September 2007 over the T and W Mains extraction area (Ecoengineers, 2009).

1.1 State Surface Water and Groundwater Policies and Management Plans

1.1.1 Surface Water

A draft water sharing plan for the Greater Metropolitan Region Unregulated Rivers has been developed (NSW Office of Water, 2010) in parallel with a groundwater sharing plan.

As Cataract River upstream of the Cataract Dam is a regulated river, it is not covered by the plan, however Cataract River between the dam wall and Broughtons Pass Weir is covered by the Upper Nepean River (Mid Cataract River) Management Zone.

It should be noted that the proponet does not intend to extract any surface water from Lizard Creek or Wallandolla Creek, which are contained within the mid Cataract River catchment area.

1.1.2 Groundwater

The aquifers in the study area are covered, as appropriate, by the generic State Groundwater Policy (DLWC, 1997), Groundwater Quality Protection Policy (DLWC, 1998).

The study area lies within Groundwater Flow System 5 (GFS5) Hawkesbury Sandstone - South-East (Grey and Ross, 2003) which includes the catchment of Cataract Dam. The study area is within the SCA - controlled Metropolitan Special Area, and as a result, no groundwater development is permitted. GFS5 has a sustainable yield estimate of 58,000 ML/year (Grey and Ross, 2003).

A Draft Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources has been developed (NSW Office of Water, 2010), with the Study Area covered by the Sydney Basin Nepean Porous Rock Groundwater Source Management Area 2.

The draft water sharing plan annual rainfall recharge in the management area is assessed at 224,483ML/year. This volume is subdivided into consumptive pool water and environmental water, with 124,915ML/year of the long term annual average recharge being reserved as environmental water. The remaining water is classified as a sustainable yield or long term average extraction limit of 99,568ML/year. The current extraction limits and groundwater entitlement volumes do not include all water taken through aquifer interference activities such as mine voids

Reservation of environmental water aims to support the long term viability of the aquifers and their dependent ecosystems.

The draft plan also includes rules aimed at protecting Groundwater Dependent Ecosystems consistent with the Groundwater Dependent Ecosystem Policy (DLWC, 2002). The policy includes wetlands, terrestrial vegetation and caves or karst systems. In the proposed plan, terrestrial ecosystems are protected by a 200m stand off for new bores from any sandstone escarpment where hanging swamps or base flow to rivers is supported by groundwater. It should be noted, however, that no extraction bores are proposed and there are no “hanging” swamps, as opposed to “upland” swamps in the Study Area.

Although it does not extend into the Study Area, there is currently an embargo on further applications for sub-surface water licences in the Southern Coalfield (ordered under section 113A of the Water Act, 1912) within the Sydney Basin Nepean Porous Rock Groundwater Source Management Area 1, for areas covering the:

- Nepean Sandstone Water Shortage Zone GWMA 607 (gazetted 8 June 2007); and
- NSW Southern Highlands (gazetted 21 May 2004 and 16 December 2005).

2. SCOPE OF WORK

Geoterra Pty Ltd were commissioned by Gujarat NRE Coking Coal Ltd to monitor the existing baseline status and to address any potential surface water and groundwater impacts relating to the proposed extraction areas and their associated subsidence.

The report will be incorporated into an Environmental Assessment application to be submitted to the DoP being prepared by ERM on behalf of Gujarat NRE.

3. PREVIOUS RELATED STUDIES

Prior to the specific studies detailed further in this report, the stream pondage height and stream water quality status of Wallandoola Creek has been assessed in:

- September 2001 (Seedsman Geotechnics Pty Ltd, 2001) at two sites within Wallandoola Creek, approximately 500m downstream of the V Mains Project Area;
- November to December 2001 (Geoterra Pty Ltd, 2002) at three sites within the main channel and a tributary of Wallandoola Creek, downstream of V Mains. This was in preparation for a proposed expansion of longwall mining to the west of the existing Bulli Seam workings, which, in the end, did not proceed; and
- Between July 2007 and July 2008 (Environmental Resources Management Pty Ltd, 2008) at three locations within Wallandoola Creek upstream and downstream of V Mains, as well as in a generally dry, ephemeral tributary upstream of V Mains.

The stream flow and stream water quality status of Lizard Creek has previously been assessed in:

- March 2001 (Australian Water Technologies, 2001) at two sites (LC2 and LC8);
- September 2001 (Seedsman Geotechnics Pty Ltd, 2001) at numerous sites within Lizard Creek and its tributaries downstream of V Mains;
- November to December 2001 (Geoterra Pty Ltd, 2002) at numerous sites within the main channel and tributaries of Lizard Creek, adjacent to and downstream of V Mains in preparation for a potential expansion of longwall mining to the west of the existing Bulli Seam workings (which did not proceed);
- Between September 2007 and the present (Ecoengineers Pty Ltd, 2009) in two unnamed ephemeral tributaries of Lizard Creek over the current extraction area at T and W Mains; and
- Between July 2007 and July 2008 (Environmental Resources Management Pty Ltd, 2008) at three locations upstream, adjacent to and downstream of V Mains.

4. GENERAL DESCRIPTION

4.1 Previous Workings

Coal has been extracted in the Bulli Seam at NRE No. 1 in or around the proposed mining areas within the Gujarat lease area. Extraction of coal has also occurred in the BHP Billiton (BHPB) Cordeaux Colliery to the south of V Mains and in the Bulli Colliery to the east of the lease area as shown in **Drawing 2** by longwall, first workings and pillar extraction methods.

In addition, longwalls in the Balgownie Seam and limited first workings in the Wongawilli Seam have also been extracted in the vicinity of the proposed gate roads for Longwalls 4 and 5 and the eastern portion of the Wonga Mains Driveage as shown in **Drawing 3**.

4.2 Proposed Workings

V Mains is proposed to be a wedge shaped mining area ranging from 75 - 340m wide, with approximately 460m depth of cover, with a 2.5m seam thickness planned to be mined by pillar extraction.

Panel 309 is a rectangular area approximately 180m wide located between a Longwall Panel to the north and gateroads to the south which is proposed to be mined by pillar extraction.

H Panel is a polygonal shaped area, approximately 500m x 500m that is located within a previously mined area of first workings in the Bulli Seam. Due to its location under the Cataract Reservoir, H Panel will only be mined by first workings methods and designed to not generate significant impacts to surface features (i.e. <20mm subsidence) or the potential for hydraulic connection from the workings to the surface.

4.3 Topography

The area comprises three main soil landscapes (Hazelton, 1990). In general, the upper portions of the catchment are within the Maddens Plains landscape, which migrates into the Lucas Heights landscape, whilst the Hawkesbury landscape is located in the lower, downstream incised valleys as described below and shown in **Figures 1** to **3**.

- **Maddens Plains:** moderately to gently undulating rises on plateau surfaces with widespread upland swamps / wetlands. Local relief ranges from 10-40m with valley slope gradients of 1-10%. The dominant landform elements are broad, usually waterlogged drainage depressions with scattered rock outcrop. The Maddens Plains landscape is located over V mains along the channels of Wallandoola and Lizard Creeks.

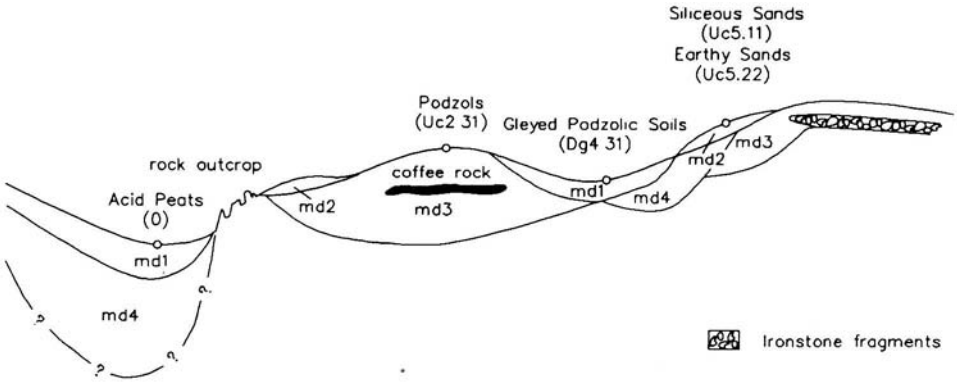


Figure 1 Maddens Plains Soil Landscape

- **Lucas Heights:** gently undulating plateau surfaces and ridges 200-1000m wide, with level to gently inclined slope gradients of <10%. Local relief is <30m and rock outcrops are absent. The Lucas Heights landform is located to the west of the V Mains Project Area. Lateritic podzolic soils can be present within the Lucas Heights profile, which would be a source of dissolved iron into stream waters

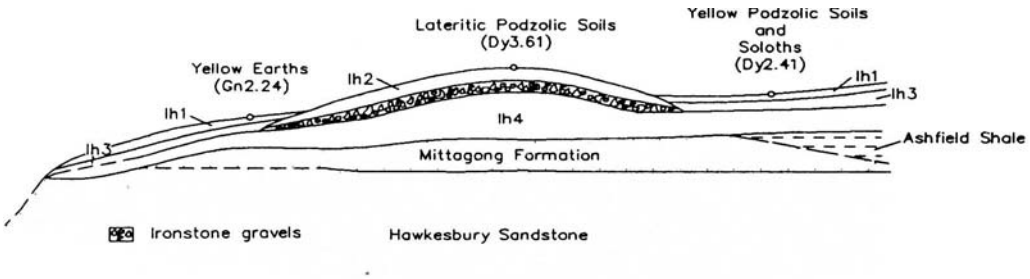


Figure 2 Lucas Heights Soil Landscape

- **Hawkesbury:** Rolling to very steep hills. Local relief of 100-200m with slope gradients of 20-70%. Crests and ridges are convex and narrow and <100m wide. Slopes are moderately inclined to precipitous. Valleys are narrow (20-100m) and incised. Rock outcrop is common and occurs as horizontal benches and broken scarps up to 10m high. Rock outcrops and surface boulders and cobbles up to 50% of the ground surface.

The Hawkesbury landscape is not present within the V Mains Project Area, although is present in the steeper, downstream, incised sections of Lizard and Wallandoola Creeks.

Ironstone fragments are present in the profile, which would be a source of dissolved iron into receiving streams.

No cliffs associated with the Hawkesbury landscape are present within the V Mains Project Area.

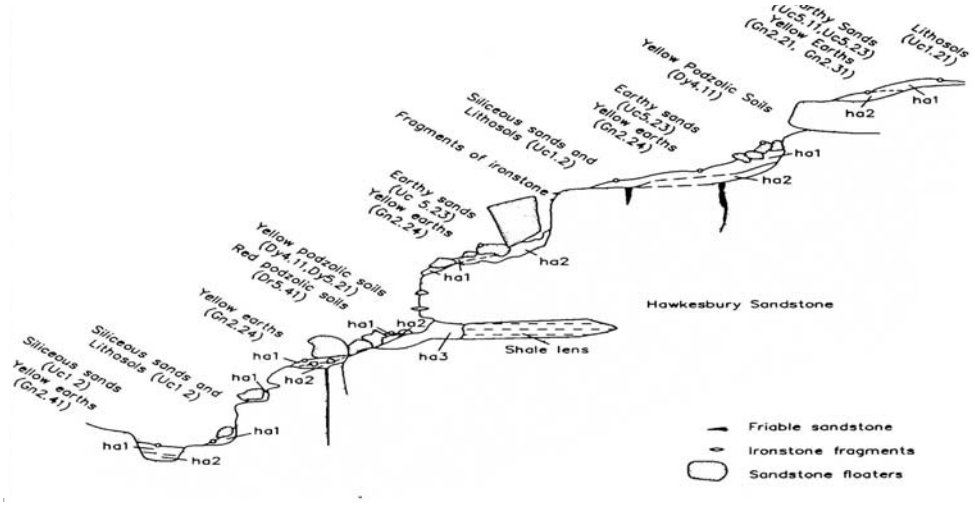


Figure 3 Hawkesbury Soil Landscape

4.1 Climate

The study area is in a warm temperate region with significant variation in temperature an precipitation due to topographic effects and its proximity to the Illawarra Escarpment an the coastline.

Up to 2293mm/year of rainfall has been observed at Cataract Dam, with the maximur rainfall in Autumn to Winter.

A plot of rainfall to the immediate north of the Gujarat lease area, is shown in **Figure 4**.

The plateau generally experiences cooler temperatures than the coast, below the escarpment. Average diurnal temperature ranges from 21.5°C in January to 12.5°C in Winter.

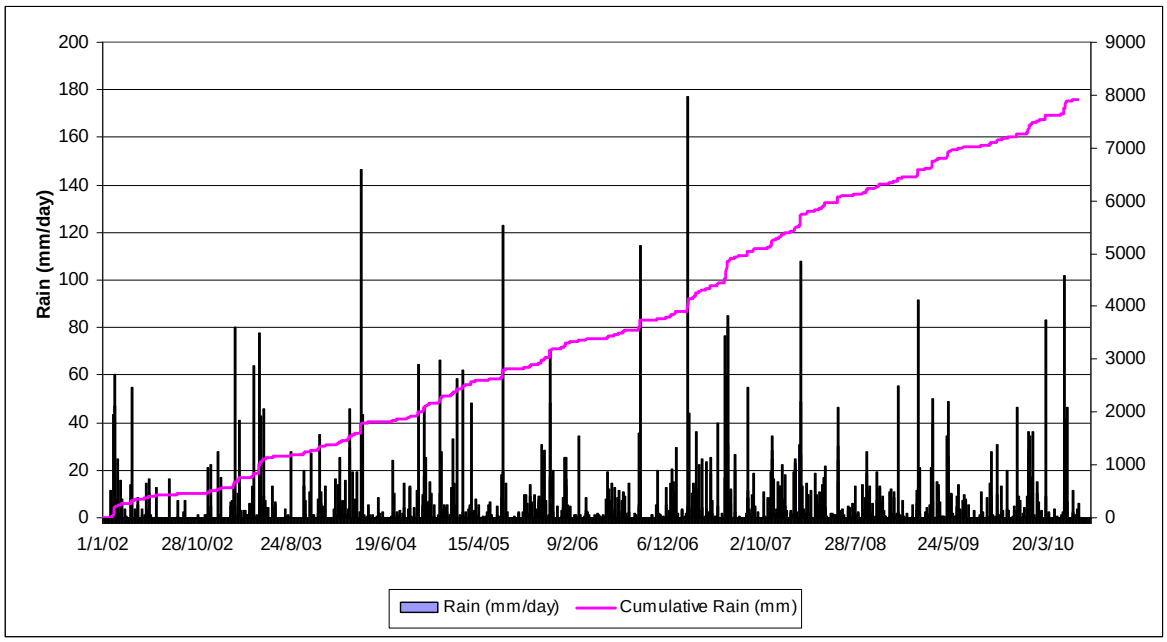


Figure 4 Rainfall

5. STREAM CATCHMENTS

5.1 V Mains, Panel 309 and H Panel

Lizard Creek and Wallandoola Creek vary along their reach from “losing streams” in the southern headwaters, where the shallow groundwater system is recharged due to stream flow seeping vertically down from the base of the creek, to “gaining streams” in the middle and northern portions of the Gujarat lease where the creeks are incised into Hawkesbury Sandstone.

Variable seepage from the Hawkesbury Sandstone enters the creeks and can maintain a low volume stream baseflow, depending on the interaction between rainfall runoff / recharge and groundwater level applying at any one time.

Differentiation between the distribution of “losing” and “gaining” streams also varies depending on the amount of rainfall recharge into the sandstone plateau and the resultant standing water levels within the regional groundwater system.

Upstream of the incised stream sections, the two catchments are separated by a 15 - 25m high watershed, with the watershed height increasing significantly downstream where between 55 – 85m deep valleys are located in the northern lease area.

Three channel types are present over the proposed V Mains, Panel 309 and H Panel workings:

- narrow indistinct overgrown channels associated with a low sedge / heath and a relatively thick sandy riparian soil with a streambed consisting of weathered bedrock and/or sandy material;
- rock platforms of variable width which are usually smooth except for minor depressions on joint planes and occasional potholes. These platforms normally grade into a thinly vegetated sandy soil on either bank and can exhibit deposition of hydrated iron oxide observed as orange to black discolouration of the rock surface; and
- channels incised in sandstone which exhibit rough riffle like surfaces, usually with accumulations of boulders and other sediments. These channels are usually bound by solid rock outcrop.

Four pool types can also be present:

- shallow, linear, small pools located in depressions formed by joint systems or cross-bedding and sometimes associated with potholes. Accumulated water is usually less saline than in surrounding pools and have minor to no interaction with the local groundwater system;
- linear pools associated with narrow erosion channels in sandy soil. The soil is usually vegetated with heath like species, whilst the downstream end is constrained by a rockbar or outcrop;
- larger pools constrained by a downstream rockbar which can be undercut by erosion and exhibit signs of chemical weathering; and
- larger pools constrained downstream by sediments. The sediments may extend for a considerable distance downstream.

5.1.1 Wallandoola Creek

Wallandoola Creek, which flows in a northerly, then westerly direction across the NRE lease area, has previously been undermined by longwalling in the Bulli Seam in both the BHPB Cordeaux and Gujarat NRE No.1 leases.

The creek overlies the proposed V Mains extraction area, although none of the other proposed mining areas underlie the creek as shown in **Drawing 1**.

The main channel of Wallandoola Creek over V Mains is a Schedule 2, 3rd order stream (DIPNR, 2005) with ephemeral 1st and 2nd order tributaries, which becomes increasingly incised into Hawkesbury Sandstone as it drains downstream to the north.

Wallandoola Creek joins the Cataract River approximately 8km (or 11km along the stream reach) NNW of the Study Area, downstream of the Cataract Dam wall, whilst its headwaters are located south of the Gujarat lease over the previously longwalled BHPB Cordeaux Colliery workings.

The creek is not regulated by any dams or weirs.

Wallandoola Creek stream monitoring site location details are shown in **Table 1** and **Drawing 1**.

Table 1 Wallandoola Creek Stream Monitoring Sites

SITE	E (MGA)	N (MGA)	DESCRIPTION
WC1	296155	6200724	Upstream of the proposed V Mains workings and overlying the BHPB Cordeaux workings.
WC2	295854	6201546	Over the pro[posed V Mains workings on southern NRE No.1 lease boundary
WC3	295560	6202488	Located in a long linear pool to the south west of the proposed panel A3 LW2
WC4	294830	6202802	Upstream of waterfall W1 to the south of the proposed panel A3 LW5
WC5	294792	6202671	In a plunge pool downstream of waterfall W1, downstream of V Mains
WCT1	295038	6201404	Generally dry tributary which discharges into Wallandoola Creek between WC2 and WC3

NOTE: WC6, 7 and 8 were irregularly monitored prior to 2007, but are not discussed in detail in this report as they are significantly downstream of the V Mains subsidence area
Co-ordinates supplied from GPS

The stream gradient generally increases with distance downstream as shown in **Table 2** and **Figure 5**.

Table 2 Wallandoola Creek Gradient

Stream Reach	Vertical Fall (m)	Distance (m)	Gradient
WC1 - WC2	7	1115	0.006
WC2 - WC3	5	650	0.008
WC3 - WC4	6	1190	0.005
WC4 - WC5	34	780	0.044

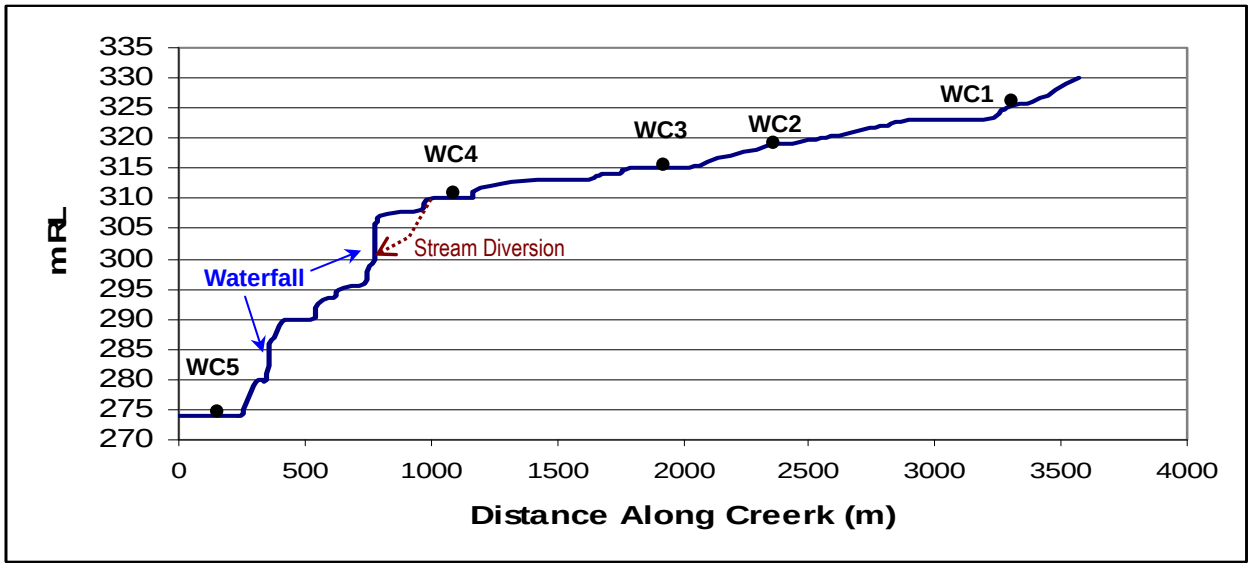


Figure 5 Wallandoola Creek Stream Reach

As shown in **Appendix A**, Wallandoola Creek over and adjacent to V Mains is characterised by the valley fill swamp Wcvfs1 which overlies both the BHPB Cordeaux longwall subsidence area, upstream of the Gujarat lease as well as the proposed V Mains extraction area.

Monitoring site WC1 is located at the downstream end of a long linear pool which is constrained by a sandstone rock bar at WC1, upstream of the predicted V Mains 20mm subsidence area.

Site WC2 is located within the Wcvfs1 valley fill swamp, which has no discernible stream channel in the sedge dominated channel over V Mains at the southern end of the NRE No.1 lease boundary.

WC3 is located within an approximately 1.25km long linear pool, whose water level is maintained by a rock bar at the downstream end.

Downstream of WC3, Wallandoola Creek reverts back to a valley fill swamp which is approximately 110m long, then transposes into a linear pool approximately 300m long, followed by a restricted channel flowing over exposed sandstone, at the downstream end of which is a distinct iron hydroxide orange coloured pool. This pool terminates at a rock bar that includes a less than 3m high shallow “step”, leading into a “clear” pool which is

approximately 1.7km long, situated immediately upstream of the less than 5m drop into a plunge pool at WC4.

No evidence of stream bed cracking or enhanced pool drainage has been observed between Sites WC1 and WC4.

The WC4 pool water level is constrained by a rock bar with evident cracking located approximately 100m upstream of Waterfall W1, where the pool level and extent is affected by enhanced drainage of the pool through the downstream cracked sandstone streambed.

Waterfall W1 has two major "steps" of 11m and 16m, for a total drop of approximately 30m over a 1.1km stream reach. Downstream of the waterfalls, and outside of the 20mm subsidence zone, the stream gradient flattens out to a series of extended pools constrained by rock bars.

The waterfall is also affected by cracking in the sandstone, as the stream has not been observed to flow over the falls during "dry" periods.

The sandstone streambed located approximately 100m upstream of Waterfall W1 is situated over the western edge of the old Bulli Seam workings subsidence area, and it is assessed that the stream bed cracks are due to mine subsidence.

Downstream of the waterfall, the plunge pool containing Site WC5 maintains a consistent pool, with a distinct orange colour.

The valley fill swamp Wcvfs2 dissipates approximately 200m upstream of the WC4 pool, with shrubs, grasses and trees dominating along the creek banks at and downstream of WC4.

The stream bed and banks of the plateau streams are well vegetated, and do not show significant erosion or bank instability.

PLATE 1 Wallandoola Creek Monitoring Sites in the Vicinity of V Mains

5.1.2 Lizard Creek

Lizard Creek flows in a north to north westerly direction and has been undermined by longwalling in the Bulli Seam in both the BHPB Cordeaux and Gujarat NRE No.1 leases.

Lizard Creek does not overlie the proposed V Mains workings, and is outside the V Mains 20mm subsidence envelope.

Panel 309 underlies a first order ephemeral tributary of Lizard Creek as shown in **Drawing 1**.

The main channel of Lizard Creek is a Schedule 2, 3rd order stream (DIPNR, 2005) with ephemeral 1st to 3rd order tributaries, which becomes increasingly incised into the Hawkesbury Sandstone as it drains downstream, to the north of the Gujarat lease area.

Lizard Creek joins the Cataract River approximately 6km (or 7km along the stream reach) to the north of the Study Area, downstream of the Cataract Dam wall, whilst its headwaters are located to the south of the Gujarat lease over the previously mined BHPB Cordeaux Colliery longwall workings.

The creek is not regulated by any dams or weirs.

Lizard Creek stream monitoring site details are shown in **Table 3**.

Table 3 Lizard Creek Stream Monitoring Sites

SITE	E (MGA)	N (MGA)	DESCRIPTION
LC1	296982	6200704	in valley fill swamp Lcvfs1 over Cordeaux workings
LC2	296773	6201510	south of lease boundary, downstream of main road access bridge
LC3	296947	6202290	upstream of Fire Road 8 creek crossing
LC4	296972	6203921	downstream of Waterfall L1
LC5	296918	6204276	downstream of Panel 309
LC6	296174	6205204	downstream of Panel 309
LC7	295293	6206428	upstream of LCT3 tributary
LC8	295408	6206686	at Gujarat lease northern boundary
LC9	295534	6207794	downstream of Gujarat lease, upstream of Lizard Creek Waterfall 2
LCT1	294836	6204153	within Swamp Lchs4 on Fire Road 8
LCT2	294280	6205173	on Fire Road 8
LCT3	295185	6206397	Downstream of LCT1 and LCT2 tributaries and enters Lizard Creek immediately downstream of LC7

NOTE: LC1 was monitored irregularly up to June 2008 and was then discontinued as it was upstream of the Gujarat lease, whilst monitoring at LC9 was discontinued after March 2010 as it is located downstream of the Gujarat lease

Co-ordinates supplied from GPS

The stream gradient varies with distance downstream with extended pools, rock bars, boulder fields and a 26m high waterfall / stepped zone to the west of No. 5 shaft as shown in **Table 4** and **Figure 6**.

Table 4 Lizard Creek Gradient

Stream Reach	Vertical Fall (m)	Distance (m)	Gradient
LC1 - LC2	7	675	0.010
LC2 - LC3	6	795	0.008
LC3 - Falls	18	1350	0.013
Falls - LC4	20	300	0.067
LC4 - LC5	25	375	0.013
LC5 - LC6	5	1270	0.004
LC6 - LC7	15	1580	0.009
LC7 – LC9	32	1475	0.022

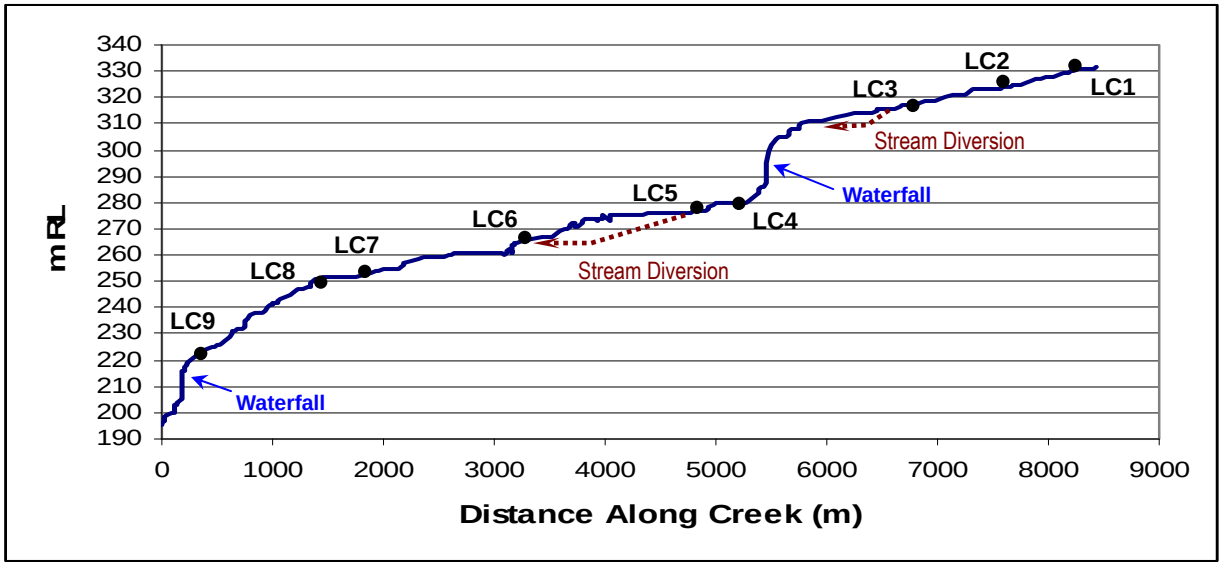


Figure 6 Lizard Creek Stream Reach

Lizard Creek is characterised by a series of valley fill fringing upland swamps (Lcvfs 1 and Lcvfs2) and pools between LC1 and approximately 50m downstream of LC3. The pool levels are supported behind exposed sandstone rock bars, often with less than a 0.5m drop between pools which range up to approximately 500m long.

The pool at Site LC3 is predominantly full and overflowing, however on one occasion for a few weeks, the stream flow temporarily ceased after an extended lack of rainfall / runoff in the catchment

The upland swamp fringed stream banks can be up to 0.5 to 1.0m high within a reasonably well defined channel in the upstream section, which becomes more defined

toward LC3. The creek can have up to approximately 50m of flanking riparian sedge / upland swamp vegetation along each bank, with the sedge / swamp areas grading upslope, out of the channel into either headwater swamps (Lchs1 and Lchs2) or Scribbly Gum Woodland.

The valley fill swamp Lcvfs2 terminates in an area of headward erosion near the junction with headwater swamp Lchs2.

Shrubs, grasses and trees dominate along the creek banks downstream of LC3 where the stream becomes increasingly more incised into sandstone.

PLATE 2 Lizard Creek Monitoring Sites in the Vicinity of V Mains

5.2 Longwalls 4 & 5 Gateroads / Wonga Mains Driveage / P & R Drifts

5.2.1 Cataract Creek

Cataract Creek flows in a westerly direction over the proposed Longwalls 4 and 5 gateroads and Wonga Mains Driveage as a Schedule 2, 3rd order (DIPNR, 2005) channel as shown in **Drawing 1**.

The creek has previously been partially undermined by longwalls in the Balgownie Seam as well as bord and pillar workings in the overlying Bulli Seam.

The main channel of Cataract Creek has eroded sequentially into the Newport and Garie Formations, Bald Hill Claystone and upper Bulgo Sandstone, although it does not have any steep to vertical incised sandstone valley sides due to the absence of the Hawkesbury Sandstone in the upper to middle sections of the creek.

The creek does not flow over, or within, Hawkesbury Sandstone until near the backwaters of Cataract Reservoir.

Cataract Creek flows directly into Cataract Reservoir, whilst its headwaters are located immediately to the west of the Illawarra Escarpment.

It is not regulated by any dams or weirs.

Cataract Creek stream monitoring site details are shown in **Table 5**.

Table 5 Cataract Creek Stream Monitoring Sites

SITE	E (MGA)	N (MGA)	DESCRIPTION
CC1	304893	6196615	Headwater tributary draining east of the escarpment to the east of proposed Panel A1 LW2
CC2	304107	6196418	Headwater tributary draining east of the escarpment over proposed Panel A1 LW3
CC3	303937	6196961	Northern tributary junction east of freeway, between proposed Panels A1 LW3 and A2 LW4
CC4	303964	6196992	Southern tributary junction east of freeway, between proposed Panels A1 LW3 and A2 LW4
CC5	303852	6197005	Start of main Cataract Creek channel west of freeway upstream of proposed panel A2 LW5
CC6	302175	6197415	Upstream of dam high water level over proposed panel A2 LW9
CC7	301740	6197503	Creek site within creek high water level on western edge of proposed panel A2 LW9
CD1	301257	6198280	Cataract Reservoir to north of Cataract Creek, outside of proposed 20mm subsidence zone

NOTE: Co-ordinates supplied from GPS

The creek is relatively steep, particularly in its headwaters, having a reducing gradient with distance downstream and flows through a series of short pools, rock bars and boulder fields as shown in **Table 6** and **Figure 7**.

Table 6 Cataract Creek Gradient

Stream Reach	Vertical Fall (m)	Distance (m)	Gradient
Headwater to CC2	87	865	0.101
CC2 to CC3	8	535	0.015
CC3 to CC5	1	110	0.009
CC5 to CC6	10	1765	0.006
CC6 to CC7	4	435	0.009
CC7 to Cataract Dam	1	375	0.003

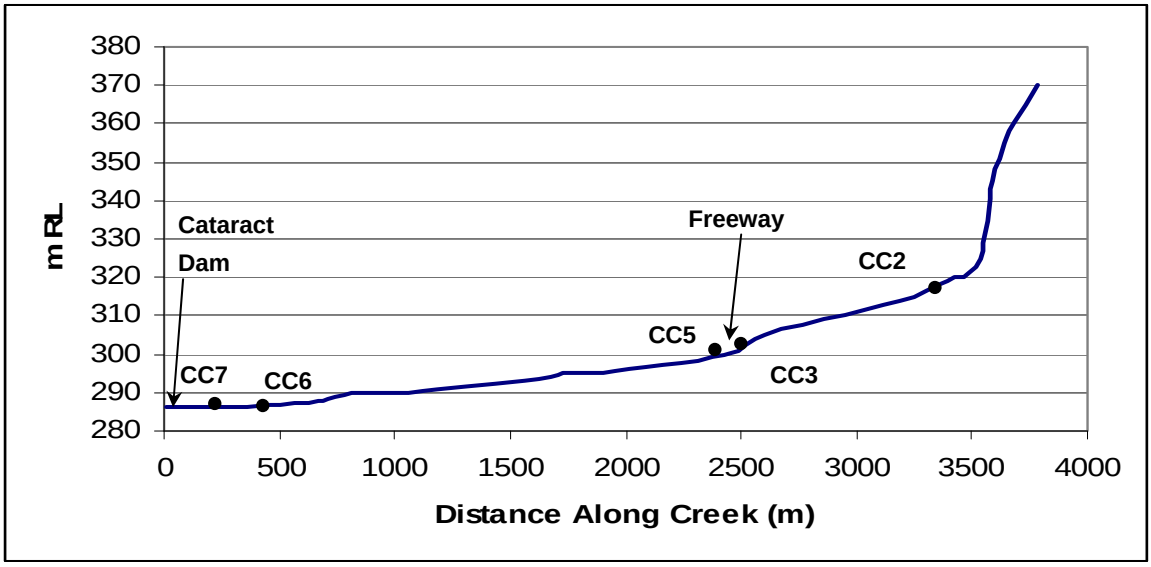


Figure 7 Cataract Creek Stream Reach

Cataract Creek is characterised by two steeply sloping headwater valleys monitored by Sites CC1 and CC2, which flow to Sites CC3 and CC4 before joining as a single stream bed at Site CC5.

The headwater and main valleys have eroded through the base of the Hawkesbury Sandstone and, in the deeper valley areas, the Bald Hill Claystone into the Upper Bulgo Sandstone, although it has not formed distinctively incised channels.

The series of flowing channels, short pools, shallow rock bars and riffle / boulder sections are predominantly developed in a relatively more erosive interspersed shale and sandstone sequence compared to the Hawkesbury Sandstone, and therefore have not developed deep or long pools that are held back by exposed sandstone rock bars as is the case in the lower reaches in the creeks to the west of Cataract Reservoir.

Shrubs, grasses and trees dominate along the creek banks.

No waterfalls or highly stepped zones are present in the creek.

The high water mark of Cataract Reservoir is located between CC6 and CC7, with the reservoir high water mark varying depending on the dam capacity at any one time, with CC6 being above the high water mark and CC7 being occasionally inundated.

The stream bed and banks of the plateau streams are well vegetated, and do not show significant erosion or bank instability. Heavily vegetated rainforest is developed from the edge of the escarpment to downstream of the freeway, which transgresses into more open schlerophyll forest between the freeway and the dam.

PLATE 3 Cataract Creek Monitoring Sites in the Vicinity of Longwalls 4 and 5

6. UPLAND SWAMPS

Upland swamps are accumulations of colluvial and alluvial, medium to coarse grained sand, moving under gravity from ridges and "steps" into the stream network along with sediment formed by insitu bedrock weathering.

Upland swamps in the Gujarat lease area have relatively small upstream catchments, with their saturation being a function of storage in the sandy sediments, accumulated organic matter and rain events. The storage and water transmission characteristics of the surrounding and underlying Hawkesbury Sandstone is critical in sustaining these environments.

The Upland swamps also occur in either headwater tributary valleys that are characteristically derived from colluvial sand movement from Hawkesbury Sandstone dominated ridgelines, or along the riparian zone of the major creeks.

They are only located within areas underlain by Hawkesbury Sandstone, which provides a low permeability base on which the swamp sediments and organic matter accumulate and do not form on Wianamatta or Narrabeen Group sediments.

Regional groundwater flow within the Hawkesbury Sandstone is largely horizontal, as vertical permeability is low.

Due to their gentle slope, only the larger swamps contain open channels, which are generally short and located at the downstream end, whilst a series of discontinuous elongated pools can be present further upstream in headwater valleys.

Mudstone bands within the strata can provide an impermeable barrier that restricts vertical surface water infiltration through the sandstone, and can limit recharge to groundwater systems beneath the band.

The swamps are not located close to the edge of signifcant cliff scarps, as is the case for “hanging” swamps in the Blue Mountains, and as such there are no “hanging” swamps in the Gujarat lease area.

Upland swamps generally are located within gently-sloping, trough shaped valleys, but can extend onto steep slopes or benches on valley sides. They are more extensive where the plateau is least dissected, and are more confined to headwater tributaries in more dissected catchments.

The central axes of the swamps are generally saturated, though the margins and central sections may dry out, particularly after extended dry periods.

The sand and humic material, which increases the swamps water-holding capacity, store and subsequently discharges rainfall infiltration, groundwater seeps and low-flow runoff into the local streams. Rainfall saturates the swamp and drains slowly due to the low slopes on a low permeability base as the average rainfall generally exceeds evaporation.

Sediments below and laterally lensing into the carbonaceous material are variable in nature and can be composed of fine to medium grained sands which are usually well sorted, light grey in colour and contain bands with a higher clay content, and clayey sands, which are usually mottled red-orange due to insitu weathering.

The sediments accumulate in upstream areas and are transported to the downstream areas, whilst the marginal slopes are generally smoother and flatter than the higher areas, tending to be steep and distinctly stepped.

Upland swamps can be classified as “valley fill” or “headwater” upland swamps, however, only one swamp (valley fill swamp Wcvfs1) overlies within the V Mains extraction area, whilst no other swamps overlie any of the other proposed mining areas as shown in **Drawing 1**.

Part 5 piezometer installation licences from NOW for 6 swamp piezometers, along with SCA approval for the piezometer installation were obtained prior to installation as shown in **Table 7** at locations shown in **Drawing 2**.

It should be noted that P6 overlies the proposed V Mains extraction area, and that none of the remaining swamp piezometers overlie any of the proposed workings in this application.

Table 7 Upland Swamp Piezometer Details

Piezometer	License	Swamp	Total Depth (m)	E (MGA)	N (MGA)	Installed	Swamp Depth (m)
C2 (P1)	10BL603272	LCHS4	1.72	294808	6204141	July 06	1.41
C2A (P1A)	10BL603272	LCHS4	2.0	294795	6204130	Oct 09	1.
C4 (P2)	10BL603272	LCHS4	0.77	295806	6204436	July 06	0.77
C4A (P2A)	10BL603272	LCHS4	1.45			Oct 09	0.95
P3	10BL603272	WCHS2	1.69	295961	6202990	July 09	1.25
P4	10BL603272	WCHS1	1.38	296014	6202447	July 09	1.15
P5	10BL603272	LCHS1	1.09	296860	6202187	July 09	0.69
P5U	10BL603272	LCHS1	1.47	296820	6202161	July 09	0.97
P6	10BL603272	WCVFS	1.79	295854	6201546	July 09	1.29

6.1.1 Wallandoola and Lizard Creek Valley Fill Upland Swamps

Valley fill swamps occur along the southern headwater sections of Lizard Creek and Wallandoola Creek in the vicinity of, or over the proposed V Mains extraction area.

They occupy relatively flat sections of streams within the main valleys and can form through sediment deposition behind logs at choke points in a stream, or terminate at ‘steps' in the underlying sandstone substrate.

They are mainly sustained by surface flows along streams, along with direct rainfall infiltration and ephemeral shallow groundwater seepage from sandstone walls or “steps” at the edge of a swamp. The “steps” are generally located on higher elevation bedding planes in elevated sandstone areas, with their seepage rate dependent on the prevailing rainfall.

The swamps can also be recharged by direct rainfall infiltration when sufficient rain falls.

Wallandoola Creek valley fill swamp 1 (Wcvfs1) extends up to approximately 120m wide where the creek channel is present either as an indiscernible channel amongst the swamp in the upper reaches near the southern boundary between the Gujarat and BHPB leases between WC1 and WC3, then migrates into a more distinctive channel with a series of open pools between up and downstream of WC3.

As shown in **Drawing 2**, swamp Wcvfs1 was not undermined by either the BHPB Cordeaux or NRE1 Bulli Seam workings, whilst Wcvfs2 was undermined by the southern end of LW208 in the NRE1 Bulli Seam workings during 1988, with no observable adverse effects on stream or swamp flow, water quality or ecosystem health.

Lizard Creek valley fill swamp 1 (Lcvfs1) extends up to approximately 170m wide where the channel is essentially indiscernible with associated, isolated open water pools in the upper reaches of the creek near the southern boundary between the Gujarat and BHPB leases between LC1 and LC3

The swamp thins out to approximately 45m upstream of LC3, primarily without any discernible channel, then reduces to less than 10m wide at the LC3 fire road crossing where the exposed sandstone channel is distinctive, although the banks are less than 0.5m high.

As shown in **Drawing 2**, swamp Lcvfs1 was undermined by the western edge of LW19 and LW20 in the BHP Cordeaux Bulli Seam workings as well as first workings in the southern Gujarat lease area, with no observable adverse effects on stream or swamp flow, water quality or ecosystem health.

6.1.2 Wallandoola and Lizard Creek Headwater Upland Swamps

No headwater swamps overly the proposed mining areas, however they are present within the lease in upper tributaries of Catarct River, Cataract Creek, Wallandola Creek and Lizard Creek along elevated ground with relatively flat to gentle slopes.

6.1.3 Cataract Creek Upland Swamps

No headwater or valley fill swamps are located within the Cataract Creek catchment.

6.1.4 Cataract River Upland Swamps

Cataract River headwater swamp 1 (Crhs1) is located over the proposed gate road first workings for Longwalls 4 and 5, to the east of Mount Ousley Road and is located in the headwaters of a north easterly draining tributary of Cataract River. The swamp is up to approximately 300m long and 210m wide.

Headwater swamp Crhs1 was undermined by Bulli Seam first workings with no observable adverse effects on stream / swamp flow, water quality or ecosystem health.

7. GEOLOGY

NRE No. 1 colliery is situated at the southern end of the Permo-Triassic (225-270 Million years old) Sydney Basin within the Illawarra Coal Measures, which contains the Bulli Seam. The Bulli Seam is underlain by the Balgownie and Wongawilli seams.

Isolated exposures of Hawkesbury Sandstone are present along stream beds and banks as well as in isolated outcrops outside of the sedge / upland swamps within the Project Area as shown in **Figure 8**.

Isolated outcrops of Wianamatta Shale are present in more elevated country to the north, and downstream of the Project Area.

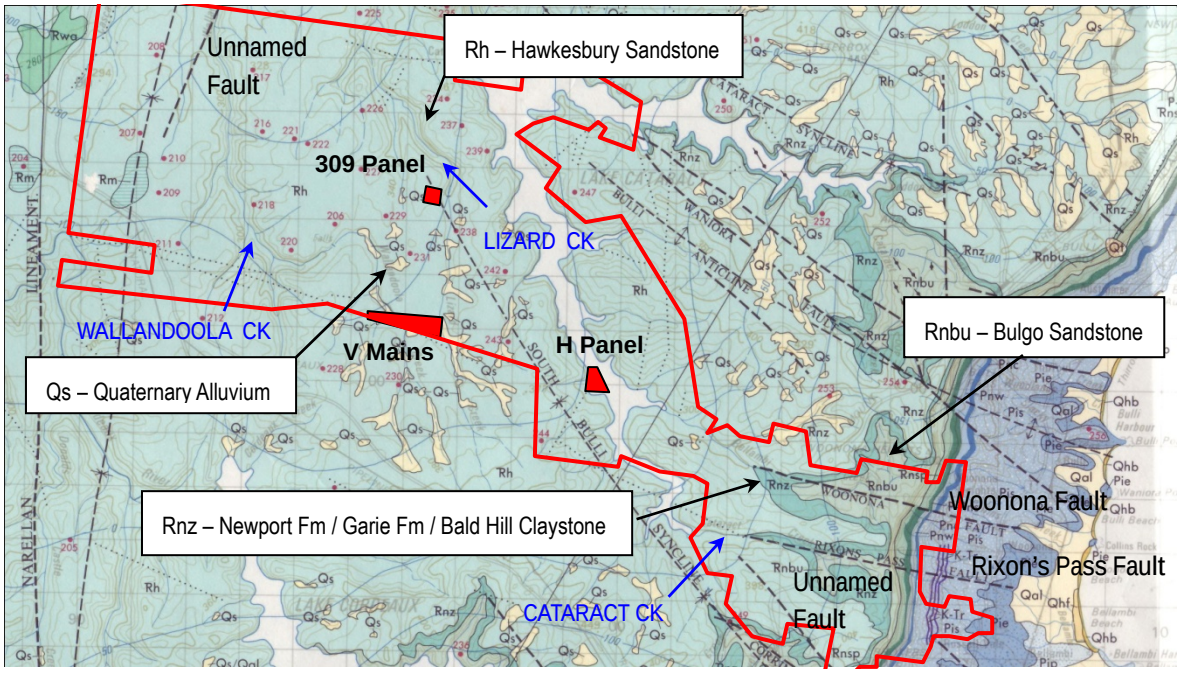


Figure 8 Local Geology

The stratigraphic sequence within the Project Area comprises the following:

- **Wianamatta Shale** - isolated outliers of the shale located north of the Project Area
- **Hawkesbury Sandstone** - Isolated outcrops consisting of thickly bedded or massive quartzose sandstone with grey shale lenses up to several metres thick. The maximum geological thickness is about 155m to 175m below ground level (bgl). Finer grained siltstone and shale facies along with bedding discontinuities are present that would form vertical flow barriers.
- **Newport and Garie Formations** - present to approximately 160m to 180m bgl within the approximately 230m thick Narrabeen Group. The Newport Formation consists of interbedded grey shales and sandstones whilst the Garie Formation consists of cream to brown, massive, characteristically oolitic claystone.
- **Bald Hill Claystone** - present to approximately 185m to 205m bgl, brownish-red "chocolate shale", which is a physically weak but is relatively “plastic”. It is easily recognised as a marker horizon and has a near constant thickness in the Project Area. The Bald Hill Claystone is a major barrier to vertical groundwater flow and divides the groundwater systems above and below the claystone.
- **Bulgo Sandstone** - present to approximately 350m to 405m bgl, thickly bedded, medium to coarse grained lithic sandstone with occasional beds of conglomerate or shale.
- **Stanwell Park Claystone** - present to approximately 355m bgl with greenish-grey mudstones and sandstones.
- **Scarborough Sandstone** - present to approximately 385m bgl, medium to coarse grained lithic sandstone with occasional beds of conglomerate or shale
- **Wombarra Claystone** - has similar properties to the Stanwell Park Claystone.
- **Coal Cliff Sandstone** - basal shales and mudstones that overly the Bulli Seam.
- **Illawarra Coal Measures** - interbedded shales, mudstones, lithic sandstones and ten named seams. The 3m thick Bulli Seam (approximately 391m to 447m bgl) is the the uppermost mineable seam and has been worked extensively in the northern portion of the Southern Coalfield. The Bulli Coal is the target seam in the Project Area.

7.1 Structural Geology

7.1.1 Faults Mapped at Surface

Known major faults or fault systems that outcrop at surface in the Study Area are shown in **Figure 4** and include the following:

- west north west / east south east trending Rixons Pass and Woonona Faults in the area to the east of Cataract Reservoir which control the location and trend of Cataract and Bellambi Creeks respectively;
- north west / south east trending, unnamed splay off the Corrimal Fault to the south of Cataract Creek in the area to the east of Cataract Reservoir; and
- north east south west trending unnamed fault to the west of Wallandoola Creek to the west of the Cataract Reservoir.

7.1.2 Bulli and Balgownie Seam Underground Faults

Structures mapped in the underground Bulli Seam level NRE1 workings, which may or may not extend up to surface with the same dislocation values and directions, indicate a predominantly south south east / north north west and conjugate north east / south west faulting as shown in **Drawing 1**.

A regional faulted zone to the north of the lease area is indicated with a throw from 50m to the north and 30m to the northeast of the workings, with the NRE1 area on the downthrown side.

In addition, a faulted zone between the NRE1 workings and the decommissioned BHPB Cordeaux to the south has a throw of 3 - 5m at seam level, with the NRE1 workings located on the downthrown side.

This means that the Bulli Seam in the Gujarat lease is from 30 - 50m lower than the proposed Appin Area 3 Extended BHPBilliton longwalls and from 3 - 5m lower than the Cordeaux workings.

The fault located to the west of the NRE1 workings is a horizontal strike slip fault with normal movement at Bulli seam level.

The fault movements and throws indicate the NRE1 workings to the west of Cataract Reservoir are in a downthrown block (horst and graben structure) and are at a lower relative elevation to the BHP workings to the north and south, meaning that groundwater flow in the Bulli / Hargraves and Wongawilli Seam would be toward the NRE1 workings.

The workings to the east of the reservoir, however, are on the same side of the fault as the Cordeaux workings.

Outside of the mine workings, the exact location, throw and inclination of the faulted zones are not accurately known, as their position is based on extrapolation of drill hole and workings intersections.

Based on past mining experience, the faults in the Bulli / Balgownie workings are essentially dry, with some localised ponding, and therefore are not anticipated to provide enhanced permeability fluid pathways in the mining area.

7.1.3 Bulli and Balgownie Seam Igneous Intrusions

Variable thickness dykes intruded along the same fault trends have been identified within the lease area.

A north-east south-west trending dyke / sill, up to approximately 130m wide, with a combined sill / cinder zone up to 250m wide is located to the east of the 500 Series longwalls under Cataract Reservoir.

The southern bord and pillar workings in the Bulli Seam to the east of the lease area are bound by an east west trending dyke up to approximately 30m wide.

A south - east north - west trending dyke up to 5m wide on the southern boundary of Mining Lease ML1575 was intersected in the Cordeaux workings, which are from 20 - 40m south of the NRE No.1 workings.

A north east south west trending dyke is also located to the west of the Bulli Seam 300 Series workings.

It should be noted that the dykes identified at the Bulli Seam level have not been mapped at surface.

No water inrush has been reportedly associated with faults or dykes in the Bulli or Balgownie workings.

No diatremes have been identified within the Study Area.

8. BASEMENT HYDROGEOLOGY

Three main aquifer systems are present in the Study Area, namely:

- Unconsolidated, perched ephemeral colluvial aquifers within upland swamps (refer to Section 6);
- perched ephemeral aquifers within the dual porosity shallow Hawkesbury Sandstone; and
- deeper basement Hawkesbury Sandstone and underlying lithologies in a variable sequence of aquicludes and aquitards comprising mainly mudstones and shales and low yielding dual porosity aquifers in sandstones and coal seams.

Due to the steep topography and limited alluvium within the Cataract Reservoir storage, there is no notable groundwater bearing stream based alluvium in the study area.

8.1.1 Hawkesbury Sandstone

Apart from aquifers in the coal seams, the main aquifer in the Study Area is the dual porosity Hawkesbury Sandstone which, although having generally low permeability, can provide relatively higher groundwater yields compared to other lithologies in the area.

The Hawkesbury Sandstone outcrops over the majority of the lease area.

Regional water levels within the sandstone result from interaction between rainfall recharge and topography over a very long period of geological time. Rainfall percolation has elevated the water table while drainage channels have incised the water table and provided leakage pathways that constrain groundwater levels to the elevation of stream beds or deeper.

Groundwater flow within the Hawkesbury Sandstone is primarily horizontal with minor vertical leakage due to the primarily horizontal bedding planes and bedding discontinuities within the sandstone which are interspersed with generally poorly connected vertical joints

Ephemeral perched water tables within the upper 20m of the Hawkesbury Sandstone can occur following extended rainfall recharge periods which are hydraulically disconnected from the underlying regional aquifer.

Vertical hydraulic connectivity between the Hawkesbury Sandstone and the Bargo Sandstone is retarded by the Bald Hill Claystone which is a pervasive regional aquitard that extends across the Study Area.

In rainfall recharge periods, water levels in shallow aquifers respond by rising, whilst in dry periods, levels are lowered through seepage to the local watercourses. At these times, salinity in surface drainages normally rises as seepage from the coal measures sequence potentially increases. Measured standing water levels in the Hawkesbury Sandstone range from 12m to 39m below surface within the Study Area.

High yields of up to 30L/s have been identified outside of the local area by Sydney Catchment Auhority in the Kangaloon and Leonay-Wallacia areas where the sandstone is distinctly affected by deep regional scale fracturing, associated with igneous intrusions or a major regional lineament along the base of the Blue Mountains associated with the Lapstone Monocline (SCA, 2006).

These high yielding sandstones are not in the vicinity of the Study Area.

Water quality in the Hawkesbury Sandstone generally has low salinity (81 - 420µS/cm) with relatively acidic pH (3.22-5.45) and can contain high iron levels up to 12.0mg/L in the Study Area.

8.1.2 Narrabeen Group Lithologies

The Narrabeen Group lithologies have significantly lower yielding aquifers compared to the Hawkesbury Sandstone, with very minor productive supplies obtained in the Southern Coalfields, due to its generally deeper elevation below surface and its very low permeability. The Bulgo Sandstone can contain salinities of up to 1500mg/L (KBR, 2008) whilst the Scarborough Sandstone (Short et al. 2007) can average around 550mg/L.

The base of the Narrabeen Group is marked by the Wombarra Claystone which is an aquitard in its unsibsided state.

The Narrabeen Group is an assemblage of aquifers, aquitards and aquicludes with very low primary hydraulic conductivities where groundwater flow is mostly within coal seams with cleats providing enhanced secondary permeability. The sandstones can provide porous storage with limited fracture flow and have very low transmitting capacity, whilst mudstones, siltstones and shales effectively impede vertical flow. In some localities, groundwater flow may be enhanced by localised, secondary fracturing where faulting and/or jointing associated with bedding flexure or igneous intrusions can increase the hydraulic conductivity.

Hydraulic connection between the lithologies occurs through fractures and joints. Where vertical connectivity is present, more laterally, uniform pressure distributions are exhibited. Some local scale faults and dykes are present in the Study Area as shown in **Figure 4** although they are considered to be large enough to enable loss of surface stream flow into the workings if dislocated by subsidence.

The Narrabeen Group is generally low yielding (<1.0L/sec), with its highest yields obtained from coal seams with low to minimal yield obtained from the mudstone, shale, sandstone and conglomerates compared to the coal seams.

No water level monitoring has been conducted in the Narrabeen Group lithologies by Gujarat or its predecessors.

The Newport and Garie Formations, along with the underlying Bald Hill Claystone and the upper Bulgo Sandstone outcrop within the base of the headwater valleys within the area to the east of Cataract Reservoir, would be directly recharged by stream flow leakage from Cataract Creek and Bellambi Creek.

8.1.3 Illawarra Coal Measures

Water quality varies regionally both within and between coal seams and interburden in the Illawarra Coal Measures due to the complexity of groundwater flow, with the water being mostly brackish to saline.

The Balgownie, Bulli or Wongawilli Seams do not outcrop within the Study Area, although they outcrop along the lower section to the base of the Illawarra Escarpment. They would be recharged by vertical infiltration from overlying lithologies, however there is no direct connection between the seams and the surface creeks.

Since coupled pumping in / out monitoring began in October 2005, groundwater inflows from 0.02 - 0.97ML/day (median 0.59ML/day) have occurred into the NRE No1 workings.

8.1.4 Registered Piezometers

No groundwater extraction is conducted from private bores or wells in the Study Area, with the nearest private registered bore on the Woronora Plateau being a test bore at Appin Colliery, which is located approximately 4.9km to the north of the proposed workings.

At present, one monitoring piezometer P514 (GW102223) is recorded in the NSW Natural Resource Atlas database in the vicinity of the proposed workings.

Part 5 piezometer installation licences from the NSW Office of Water (NOW) for 7 open standpipe piezometers as shown in **Tables 8** and **9**, along with SCA approval for the piezometer installation was obtained prior to installation at locations shown in **Drawing 2**.

Prior to the current investigation, no regional data within the lease area was available on bore yields.

Table 8 NSW Office of Water Registered Open Standpipe Basement Bores

Piezometer	Installed	License	E	N	SWL mAHD	TD mbg	Intake	SWL mbg	EC (uS/cm)	pH
NRE A	21/11/09	10BL603362	303692	6196033	356.61	47.2	24 - 47.2	19.57	232	3.22
NRE C	3/12/09	10BL603272	303233	6198797	349.9	24	18 - 24	12.82	152	4.88
NRE D	6/11/09	10BL603272	301870	6198509	321.62	52	40 - 52	27.21	130	4.02
NRE E	23/10/09	10BL603272	296727	6202286	317.46	29	17 - 29	11.78	420	5.45
NRE G	20/10/09	10BL603272	296949	6205678	329.34	53	36 - 53	29.93	81	5.34
NE3	5/12/09	10BL603272	294803	6201954	320.05	60	48 - 60	39.22	223	5.24
P514	1/11/98	GW102223	297917	6204280	287.24	191	160 - 188	20.99	n/a	n/a

NOTE: n/a - not available mbg - metres below ground SWL - standing water level
mbtoc - metres below top of casing

Table 9 Vibrating Wire Piezometer Bores

Piezometer	E	N	TD mbg	VWP Intakes (mbgl)
NRE A VWP	303680	6196034	153	45(mid HS) 60(low HS) 75(up BS) 140(mid BS)
NRE B	303939	6197567	170	27.5(low HS) 43(up BS) 63(mid BS) 168(SPCS)
NRE D VWP	301875	6198493	176	33(mid HS) 60(low HS) 73(BHCS) 135(mid BS)
NE3	294794	6201945	281	100(mid HS) 130(low HS) 155(NP) 255(low BS)
P501	298771	6201855	335	110(HS) 174(up BS) 226(mid BS) 274(low BS) 325 (SS)
P502	298598	6202049	167	90(low HS) 167(up BS) 218(mid BS)

NOTE: HS - Hawkesbury Sandstone NP - Newport Formation BHCS - Bald Hill Claystone
BS - Bulgo Sandstone SS - Scarborough Sandstone SPCS - Stanwell Park Claystone

8.1.5 Groundwater Dependent Ecosystems

The proposed extraction areas are located within the Sydney Basin Sedimentary Rock Groundwater System as described in the NSW State Groundwater Dependent Ecosystems Policy (SGDEP) (DLWC, 2002) which has its associated dependent ecosystems. The SGDEP recognises four groundwater dependent ecosystems types in NSW, namely:

- terrestrial vegetation;
- base flows in streams;
- aquifer and cave ecosystems; and
- wetlands.

Groundwater dependent ecosystems present within the Study Area are:

- terrestrial vegetation, in terms of the “valley fill” and “headwater” upland swamps which can be susceptible to changes in groundwater seepage inflow rates, the balance between rainfall and evaporation, the effect of bushfies and changes to the erosional regime. Note that only Wcvfs1 overlies any of the proposed mining areas; and
- baseflows in streams, which can be affected by changes in groundwater seepage inflow rates to a stream and the balance between rainfall and evaporation.

9. PREVIOUS SUBSIDENCE EFFECTS IN THE VICINITY OF THE PROPOSED WORKINGS

The previous operators of NRE No.1 Colliery, as well as the decommissioned BHP Billiton Cordeaux Colliery to the south of NRE No.1 have undermined sections of both Lizard and Wallandoola Creeks, whilst Cataract Creek was only undermined by the previous operators to NRE No.1.

Up to 1.3m of subsidence was generated by extraction of the Bulli Seam in the 200, 300 and 500 series longwalls to the west of and beneath Cataract Reservoir (Seedsman Geotechnics, 2010).

Bord and pillar extraction of the Bulli Seam along with longwalls in the Balgownie Seam was conducted to the east of Cataract Reservoir as shown in **Drawing 2**.

In the 200 series longwalls, no subsidence was measured with 190m wide panels and 35m wide chain pillars, whilst the same layout to the north in the 300 series panels, 0.9m of subsidence was recorded. Longwall mining generated a maximum vertical subsidence of 1.1m for 155m wide longwalls with 30m wide pillars, whilst the 205m wide panels in Cordeaux Colliery with 30m wide chain pillars generated up to 1.3m of subsidence (Seedsman Geotechnics Pty Ltd, 2010).

Microseismic monitoring at Bellambi West indicated that rock fracturing extended to approximately 100m above the Bulli Seam, whilst vibrating wire piezometer monitoring between longwalls 501 and 502 indicates that the hydraulic integrity of the Bulli Seam and the Hawkesbury Sandstone was not adversely affected (Seedsman Geotechnics Pty Ltd, 2010).

No publicly available pre and post mining surveys of creek flow, creek water quality, groundwater levels or groundwater quality are known to be available over the BHPB Cordeaux or Bulli mine workings.

The following sections outlined the observed effects of subsidence due to the previous extraction of the Bulli Seam and the underlying Balgownie Seam in the Study Area.

9.1 Wallandoola Creek

As shown in **Drawing 2**, from south to north within the Gujarat lease, Wallandoola Creek sequentially overlies the Bulli Seam east west oriented panel LWP, and subsequently the north south oriented Bulli Seam Longwalls 208 to 211.

Between the southern lease boundary and downstream to site WC4, Wallandoola Creek has been observed to be at least continuously ponded and generally flowing between WC1 and WC4 since 2001.

The creek water is primarily clear up to the major bend in the creek and becomes more ferruginous over and downstream of the old Bulli Seam longwall 209 to Site WC4.

The southern end of the WC4 pool can be dry, or have low water levels following extended low rainfall periods, with the ponded water flowing into a crack in the sandstone creek bed as shown in **Plate 4**.

9.2 Lizard Creek

As shown in **Drawing 2**, from south to north within the Gujarat lease, Lizard Creek overlies the north south oriented access drives to the east of the 200 series longwall 202A and directly overlies the subsidence goaf of longwalls 202B and 202.

Between the southern lease boundary and downstream of stream monitoring site LC3, Lizard Creek has been observed to be continuously ponded and predominantly flowing during all site visits.

At the southern end of the valley fill swamp Lcvfs2, downstream of LC3 where a 2m to 3m deep rock bar constrained pool is present, the creek is continuously ponded and generally flowing, with low levels of ferruginous precipitation.

The downstream end of Lcvfs2 has an area of headward eroded valley fill swamp sediments as well as a rock bar constrained pool as shown in **Plate 4** that can dry out after extended dry periods.

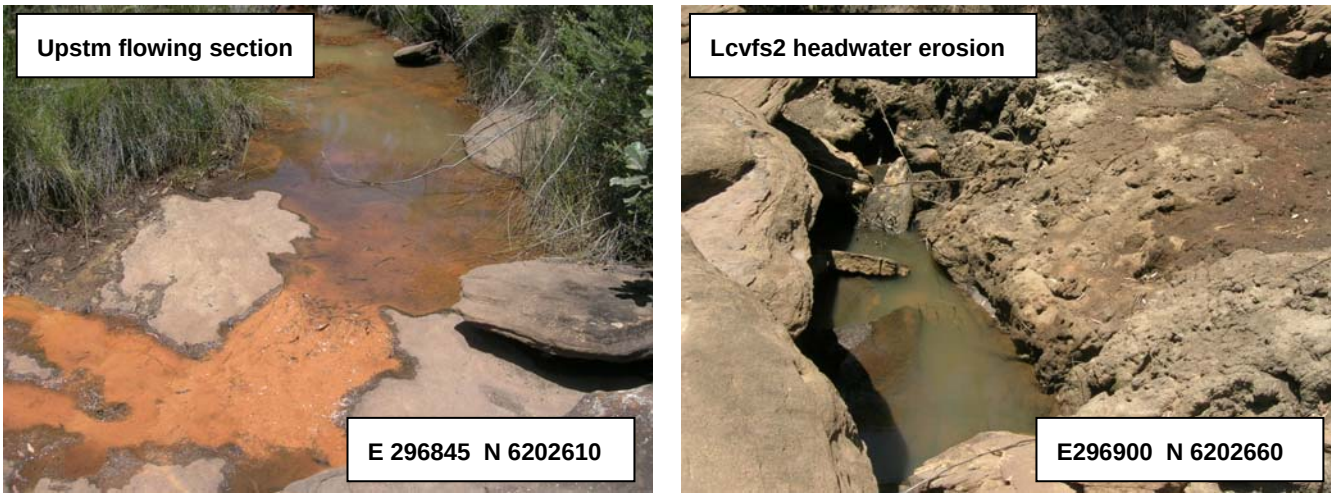


PLATE 4 Downstream End of Valley Fill Swamp Lcvfs2

9.3 Lizard Creek C10 / C11 Tributary

Dedicated stream monitoring conducted since August 2006 over the T and W Mains area located between the western area of the 200 and 300 series Bulli Seam longwalls, which lies within the headwaters of two ephemeral tributaries has not observed any adverse geomorphological, hydrological or water chemistry changes due to subsidence (Ecoengineers, 2009).

The ephemeral C10 - C11 tributary that joins with Lizard Creek downstream of Site LC6 has been observed to have dry weather groundwater baseflow seeping from a sandstone headwall (Ecoengineers, 2009).

Stream monitoring conducted since August 2006 over the T and W Mains area within two ephemeral tributary creeks have not observed any geomorphological or geochemical changes due to the maximum 0.15m of subsidence (Ecoengineers, 2008).

The creek containing site C10 (upstream) and C11 (downstream) can contain dry weather groundwater seepage emerging from a sandstone headwall.

Monitoring in the C10 / C11 creek indicates an average (variable) pH of 5.00 (C10) and a less variable pH averaging 4.37 (C11) along with an average electrical conductivity of 140uS/cm (C10) and 166uS/cm (C11). The difference between C10 and C11 is attributed to the presence of a groundwater seep located just upstream of C10, which on incorporation of dissolved oxygen and precipitation of iron and manganese oxyhydroxides, becomes more acidic and more saline at C11. No significant trends in pH, EC, sulfate or filterable iron, manganese, nickel and zinc were observed over the 26 month monitoring period that would indicate any effects from subsidence.

Swamp piezometers P1 and P2 were installed by hand within upland swamp Lchs4 along an unnamed ephemeral tributary creek located north-west of the C10/C11 creek. The piezometers are located directly over the T and W Mains extraction area, north of longwalls 211 and 212.

P1 was installed at 1.8m below surface, whilst P2 is 0.77m deep. Both piezometers were dry between July 2006 and August 2007 due to a drought. Once the drought broke, P1 has generally contained water since September 2006, whilst P2 is mostly dry, apart from during September 2007 and February / March / April and June 2008.

P1 has a relatively constant pH, averaging 4.82 with an average EC of 116uS/cm, whereas P2 has a relatively constant, average pH of 5.03 along with a low average EC of 66uS/cm.

Monitoring of pH, EC, sulfate and filterable iron, manganese, nickel and zinc, along with no visual indication of soil cracking indicates that shallow groundwater in the upland swamp at P1 has no indication of local, shallow fracturing in the Hawkesbury Sandstone, whilst the infrequent data available from P2 is considered to be similar to rainwater and is not conclusive.

The 3rd order reach downstream of site C11 lies over the western end of the Bulli Seam longwall 308 and 309 has been observed to have unaffected stream flow and water quality to approximately 350m upstream of the Lizard Creek junction.

Downstream of that point over the mid panel section of Bulli Seam longwall 307 as shown in **Drawing 2**, which was mined during 1990, the stream can contains ponded ferruginous water with intermittent flow after extended dry periods (ERM, pers comm.), although without any observable stream bed cracking as shown in **Plate 5.**

In closer proximity to the Lizard Creek junction, also over the mid panel section of Longwall 307, the ponded ferruginous water has an enhanced drying out period, although no distinctive stream bed cracking is evident.

PLATE 5 350m upstream of Lizard Creek in Tributary C11 – Site LC6

9.4 Cataract Creek

As shown in **Drawing 2** Cataract Creek overlies the north west / south east and south west / north east oriented bord and pillar workings in the Bulli Seam as well as the south west / north east oriented longwalls in the underlying Balgownie Seam.

The first and second order tributaries containing Sites CC1 to CC4 have been continuously flowing during all site visits and have not been observed to dry out, although they contain ferruginous precipitates.

The third order stream channel between CC5 and CC7 has also been continuously flowing, although only CC5 shows ferruginous precipitation.

Downstream of CC5 the creek water becomes sequentially clearer with flow downstream.

No evidence of stream bed cracking, flow loss or adverse effects on pool levels has been observed in Cataract Creek in the areas undermined by the Bulli Seam or Balgownie Seam workings.

9.5 Upland Swamps

No adverse effects have been observed on the shallow, ephemeral, perched, colluvial groundwater systems or groundwater seepage to streams within (or from) any upland swamps within the NRE No.1 lease area due to extraction of the Bulli or Balgownie Seam workings.

It is also noteworthy that the Southern Coalfield Inquiry Panel was also not made aware of any significant impacts on headwater swamps caused by mining subsidence.

Most known impacted swamps are valley infill swamps. However, at all sites inspected by the Panel, there had been a range of other environmental factors in play including evidence or pre existing scour pools, previous initiation of erosion, concurrent drought, and subsequent heavy rainfall and / or severe bushfires. The sequence of events was not clear in relation to the swamp impacts (drying, erosion, and scouring, water table drop, burning, vegetation succession etc.). The Panel therefore could not be certain that subsidence either initiated or contributed to the damage at these swamps (NSW

Department of Planning, 2008).

9.1 Stream Bed and Bank Erosion

No enhanced stream bed or bank erosion has been observed within Lizard, Wallandoola or Cataract Creeks.

9.2 Fracturing and Depressurisation over the NRE No.1 500 Series Longwalls

Studies over Longwall 501 and 502 (Singh R. N. and Jakeman, M. 2001) in 1992 and 1993 indicate that for the 115m wide longwalls with 65m wide pillars and 400 – 440m depth of cover, seepage from the walls or overlying goaf was too small to measure. It should be noted that the eastern portion of the panels underly Cataract Reservoir and that the Bellambi West Colliery at the time was essentially a “dry” pit.

A 338m deep multi level vibrating wire piezometer was installed in P501 with intakes in the:

- Hawkesbury Sandstone at 110mbgl;
- Bulgo Sandstone at 174mbgl, 228mbgl and 274mbgl; and
- Scarborough Sandstone at 328mbgl.

In addition, 3 experimental open standpipe piezometers were installed in P502 with multiple intakes in the different bores at 90mbgl in the Hawkesbury Sandstone as well as 167mbgl and 21mbgl in the Bulgo Sandstone.

Just after undermining, the Scarborough Sandstone in P501 indicated a 30m rise in head which was attributed to compression of the strata ahead of the longwall face.

Following passage of the longwall, the P501 piezometers indicated propagation of fractures up to 85m above the seam floor. The middle Bulgo Sandstone water pressure dropped by 11m when undermined, indicating a smaller pressure reduction up to 185m above the seam floor due to horizontal bedding plane separation.

The deeper P502 piezometers did not show any clear link with the mining operations, whereas the upper Bulgo Sandstone piezometer at 240m above the seam floor did not record any measureable pressure changes.

A combined study over Longwall 514 at Bellambi West in 1998 using micro seismic monitoring (CSIRO, 2000) and an open standpipe piezometer indicated that the majority of fracturing was concentrated in the Coalcliff and Scarborough Sandstones, to approximately 100m above the Bulli Seam.

Vibrating wire piezometer monitoring between longwalls 501 and 502 indicates that the hydraulic integrity of the Bulli Seam and the Hawkesbury Sandstone was not adversely affected (Seedsman, R,W. & Kerr, G, 2001).

Regular monitoring of P501 and P502 began in December 1992 and August 1993 respectively, whilst P514 began in November 1998. The piezometer locations are shown in **Drawing 1** and the water levels are plotted in **Figures 9** to **11**. P501 and P502 are located over Panels 501 and 502 respectively, whilst P514 is located over Panel 514. All three piezometers are adjacent to Cataract Reservoir.

Groundwater head pressures in Piezometer 501 (P1 and P2), which were installed 85m above the Bulli Seam at 325m below surface, gradually reduced from 284m of head in December 1992 then went down to approximately 161m in September 1993. Just prior to the piezometer being undermined, the head pressure rose by approximately 26m in both P1 and P2, and then, when the panel undermined the piezometer, intakes P1 and P2 failed and did not record any further data.

The initial rise in pressure before each piezometer is undermined, is due to overburden compression that occurs ahead of the advancing longwall. The overburden initially deforms in compression just before subsidence fracturing occurs, which then causes a sudden drop in groundwater pressure heads as the system re-equilibrates to the secondary porosity generated by the fracturing. The effect of rising pressure heads is generally more prevalent at the start of a longwall panel and reduces as the panel advances.

Intake P5, which is installed at 226m below surface in the Bulgo Sandstone, initially had its head pressure fall as the intake equalised with the hydrostatic and lithostatic pressures in the overburden from around 185m down to approximately 177m. After that, pressures varied from approximately 173m to 177m, and then, as the panel approached the piezometer, the pressure gradually fell to around 174m. When the piezometer was undermined, P5 directly fell by around 15m to around 160m, and settled until continued mining of the panel generated a pressure reduction to approximately 148m in September 1996.

Since September 1996, the pressure has remained relatively static around 153 to 155m to around early to mid 2007, then rose to around 157m in September 2008, presumably in response to rainfall recharge and infiltration into the cracked overburden following the break in the drought.

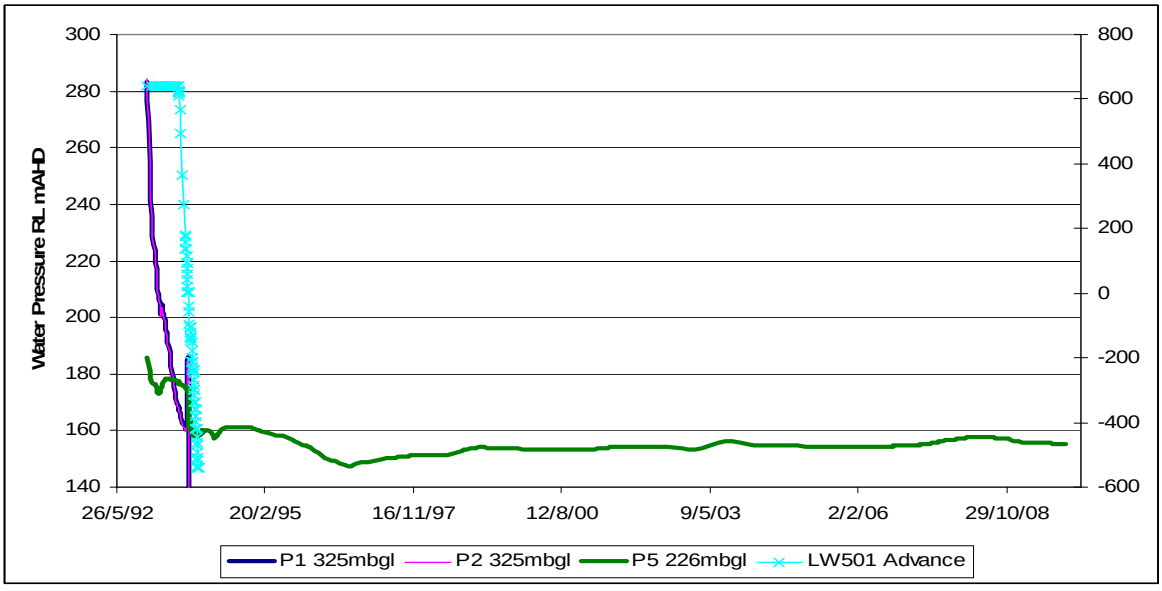


Figure 9 Longwall 501 Water Pressures

Within piezometer P502, head pressures at intake P11, which was installed within the Hawkesbury Sandstone at 90m below surface, have remained essentially static, ranging between approximately 186m and 194m below surface, with a rise in pressures following the start of the rainy period around April 2007.

Intakes P12 and P13 were installed 240m above the base of the Bulli Seam in the Bulgo Sandstone. When the piezometers were undermined, both piezometers fell by around 18m to 20m around March 1994, to approximately 106m to 108m. P13 then recovered up to around October 1996 to approximately 138m. Piezometer P12 stopped functioning after it was undermined.

Since October 1996, P13 wavered around 130m to 135m, until responding to the rainy period around April / May 2007.

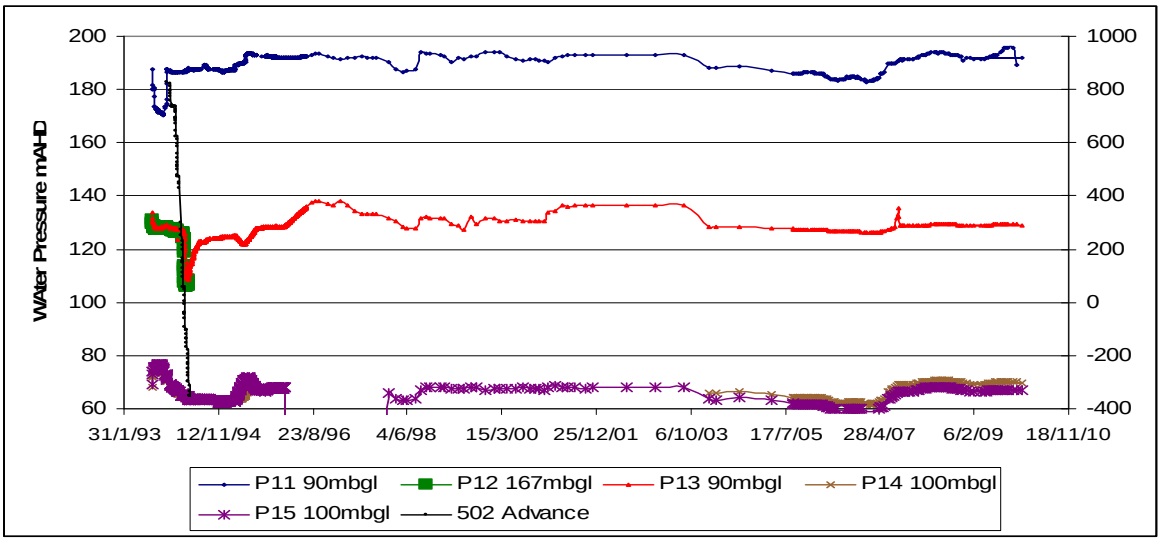


Figure 10 Longwall 502 Water Pressures

Intakes P14 and P15 were installed at 100m below surface in the Hawkesbury Sandstone. When the piezometers were undermined, both piezometers fell by around 10m between October 1993 and April 1994 to approximately 63m, then P15 recovered up until around October 1996 to approximately 71m, whilst P14 recovered to around 67m. Piezometer P14 then stopped functioning between August 1995 and February 2004.

Both P14 and P15 responded with falling pressures during the drought then rising pressures after the rainy period began in April 2007.

Monitoring over the 110m wide Panels 501 to 509, indicated a maximum subsidence of 202mm, with maximum tensile / compressive strain of 0.8mm/m and 0.4mm/m.

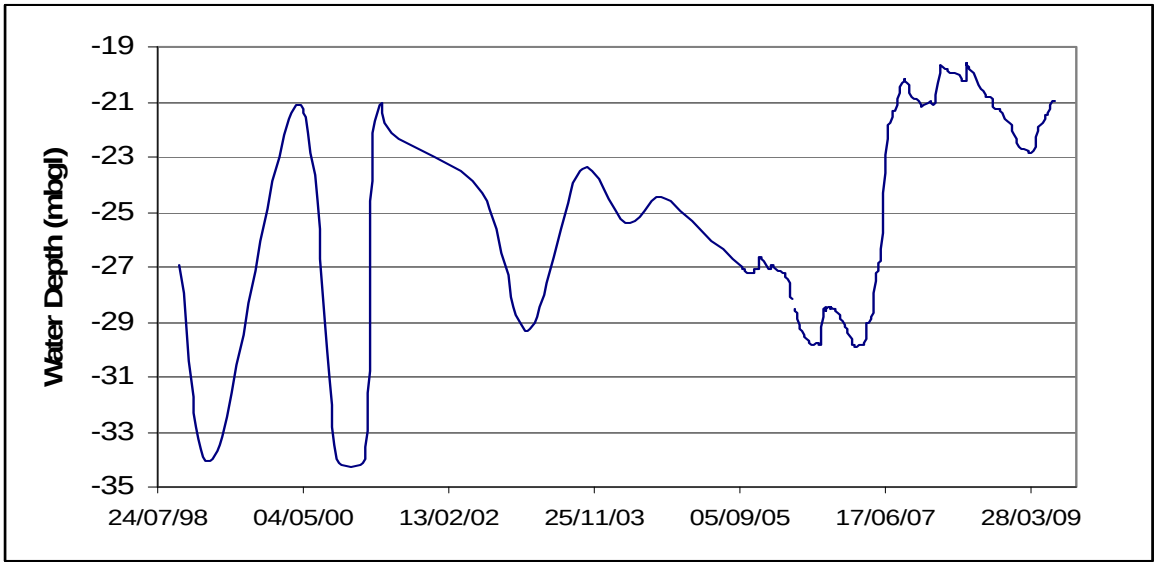


Figure 11 Piezometer 514 Groundwater Levels

Groundwater pressure monitoring indicates that over Panels 501 and 502, vertical interconnected fracturing extended for less than 153m above the Bulli Seam, with a low permeability connection from the lower Bulgo Sandstone to the Bulli Seam goaf. It was interpreted that linked vertical fracturing was unlikely to have extended up into the mid Bulgo Sandstone, however it was potentially affected by horizontal bed separation (Seedsman Geotechnics, 1998).

The open standpipe piezometer P514 (GW102223) was installed to 191m below surface with a (sealed?) intake between 160-188mbgl in November 1998 within the lower Hawkesbury Sandstone and the Newport Formation over the 150m wide, 310-380m deep Panel 514.

Since installation, P514 had a wavering water level between approximately 23m and 34m below surface, then essentially fell from 21 to 30m below surface between April 2001 and March 2007 due to the drought. The standing water level then rose following the start of the rainy period around April 2007 by approximately 10m from 30m to 20m below surface.

The piezometer became blocked between July and August 2009 and was no longer able to be used for equipment access to the water table.

9.3 Bulli Colliery Short Walls

Three 80 - 86m wide short walls (1SW, 2SW, 3SW) with 67m wide pillars were mined in the Bulli Seam adjacent to and under Cataract Reservoir in the Bulli Colliery between 1983 and 1986 for a 230 - 340m depth of cover and 1.9 - 2.6m seam thickness.

A major NE-SW dyke zone with 2 x 5m wide doleritic dykes cutting across the workings corresponded to a pronounced surface lineament, however no evidence of the dyke was seen at surface. The dykes typically had minimal associated seepage into the workings. During mining the workings were typically “dry” (Holla, L. Barclay, E. 2000).

Monitoring of two piezometer arrays installed to the base of the Bulgo Sandstone and the Bulli Seam near the workings indicated that the vertical permeabilities were generally very

low (Bulgo Sandstone horizontal hydraulic conductivity of $7.5x10^{-8}$ – $1.2x10^{-9}$) and that the extraction did not have a significant effect on the vertical permeability of the overburden with the maximum subsidence of 127mm and strains being less than 2.25mm/m.

An upper perched aquifer zone in the Hawkesbury Sandstone showed no response to subsidence, whilst the Bald Hill Claystone and upper Bulgo Sandstone showed a slow response to panel extraction whilst the lower Bulgo Sandstone showed a pronounced response (Reid, P. 1991).

10. SURFACE WATER FIELD INSPECTIONS AND MONITORING

10.1 V Mains, Panel 309 and H Panel Stream Bed Geomorphology

The major creeks in the proposed V Mains, Panel 309 and H Panel mining areas vary along their reach from “losing streams” where the shallow groundwater system is recharged from water in the stream, to “gaining streams” where seepage from shallow sediment groundwater systems and upland swamps, where present, enters the creeks. The classification between “losing” and “gaining” streams also varies depending on the amount of rainfall recharge and the resultant standing water levels in the Hawkesbury Sandstone aquifer at any one time.

Within the V Mains extraction area, the Lizard and Wallandoola creek catchments are separated by a shallow, approximately 10m high watershed, whilst the Panel 309 and H Panel mining areas are overlain by first order tributaries, with Panel 309 draining into Lizard Creek and H Panel draining directly into Cataract Reservoir.

Three distinct channel types can be present:

- Narrow indistinct overgrown channels associated with a low sedge/ heath and a relatively thick sandy riparian soil. The streambed consists of weathered bedrock and/or sandy materials;
- Rock platforms of variable width are usually smooth except for minor depressions on joint planes and occasional potholes. These platforms normally grade to a thinly vegetated sandy soil on either side and usually exhibit the effects of chemical deposition of hydrated iron oxide. This deposition ranges from a slight colouration of the surface strata to intense replacement of the rock fabric; and
- Channels that are erosive into cross-bedded sandstone and exhibit a rough riffle like surface usually with accumulations of boulders and other sediments. These channels are usually bounded by solid rock outcrop.

A number of distinct pool types can also be present:

- Shallow, usually linear, small pools located in depressions formed by joint systems or cross-bedding and sometimes associated with potholes. Accumulated water is usually less saline than that in surrounding pools and probably has little interaction with the local groundwater system;
- Linear pools associated with narrow erosion channels in sandy soil profiles. The soil profile is usually vegetated with heath like species. The downstream end is usually associated with a low rockbar or outcrop;
- Larger pools constrained by a rockbar on the downstream end that can be undercut by erosion and exhibit signs of chemical weathering; and
- Larger pools constrained mainly by sediments on the downstream end. The sediments may extend for a considerable distance downstream.

10.1.1 Wallandoola Creek

Wallandoola Creek intersects and drains to the NNW, whilst a second order, ephemeral tributary drains into Wallandoola Creek from the south west in the middle of the proposed V Mains area.

The main channel is a Schedule 2 stream with 3rd order channel (DIPNR, 2005), along with ephemeral Category 1, 1st to 2nd order tributaries, which are incised into the weathered, massive to cross bedded Hawkesbury Sandstone and erodes into the sandstone as it drains downstream.

It joins the Cataract River approximately 9km (or 12km along the stream reach) NNW of the Study Area, whilst its headwaters are located to the south over the previously longwalled Cordeaux Colliery lease area.

The creek is not regulated by any dams or weirs.

The stream reach falls by approximately 10m over a run of 1250m within the V Mains Area, with an average gradient of 0.8 mm/m.

The stream reach over V Mains is characterised by a reed and sedge filled poorly defined channel as shown in **Plate 6**, with up to approximately 100m of flanking riparian sedge / upland swamp vegetation along and within the stream bed. The sedge / upland swamp areas grade into Scribbly Gum Woodland away from the main creek channel.

No significant iron hydroxide precipitation has been observed within the V Mains stretch of Wallandoola Creek.

Wallandoola Creek has been previously undermined by SW-NE oriented longwall panels within the BHPB Cordeaux workings to the south of the NRE No. 1 lease, however, no specific studies have been conducted on the subsidence effects on stream flow, stream water quality or upland swamps. As a result, it is not possible to indicate whether, or not, subsidence has had an effect on the surface water system over the BHPB panels

The stream bed and banks of the plateau streams are well vegetated, and do not show significant erosion or bank instability.

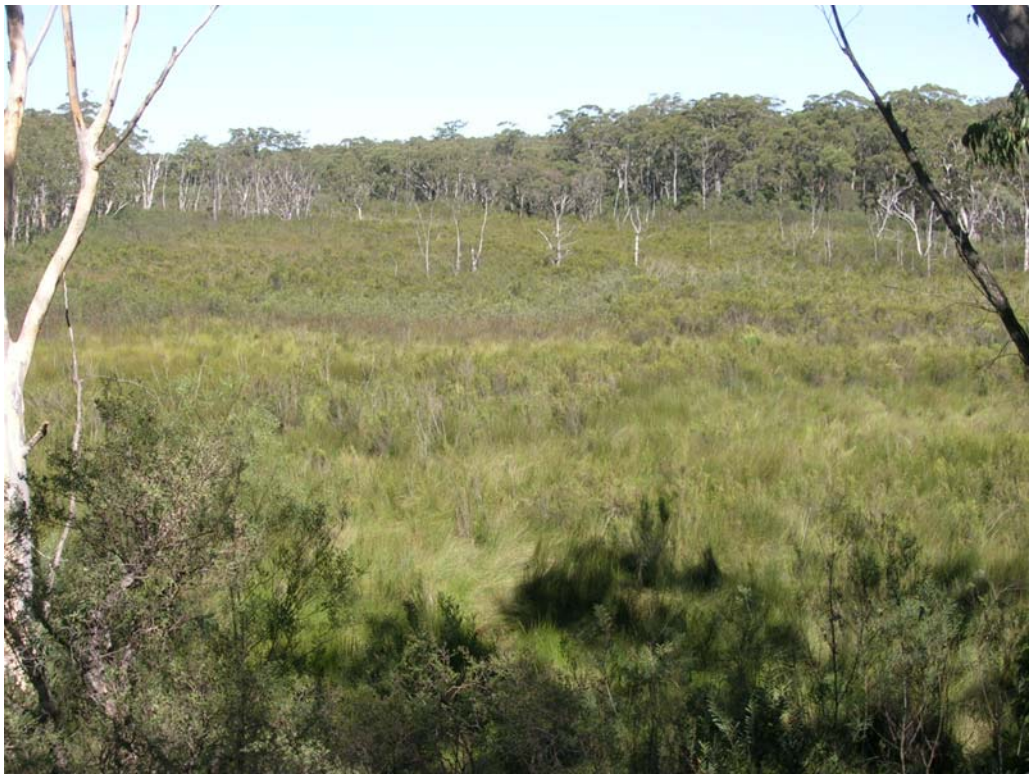


PLATE 6 Wallandoola Creek Valley Fill Swamp Wcvfs1 over V Mains

10.1.2 Lizard Creek

Lizard Creek is located on the eastern periphery of the predicted V Mains 20mm subsidence zone, and does not overly V Mains. The creek essentially drains in a northerly direction.

The main channel of Lizard Creek is a Schedule 2 stream with 3rd order channels (DIPNR, 2005), along with ephemeral Category 1, 1st to 2nd order tributaries, which are incised into the weathered, massive to cross bedded Hawkesbury Sandstone, and erodes into the sandstone as it drains downstream.

Lizard Creek joins the Cataract River approximately 7km (or 8km along the stream reach) NNW of the Study Area, whilst its headwaters are located to the south over the previously longwalled Cordeaux Colliery lease area.

The creek is not regulated by any dams or weirs.

The stream reach falls by approximately 10m over a run of 1400m adjacent to the V Mains Area, with an average gradient of 0.71 mm/m.

The stream near V Mains is characterised by a reed and sedge filled poorly defined channel as shown in **Plate 7**, with up to approximately 100m of flanking riparian sedge / upland swamp vegetation along and within the stream bed. The sedge / upland swamp areas grade into Scribbly Gum Woodland away from the main creek channel

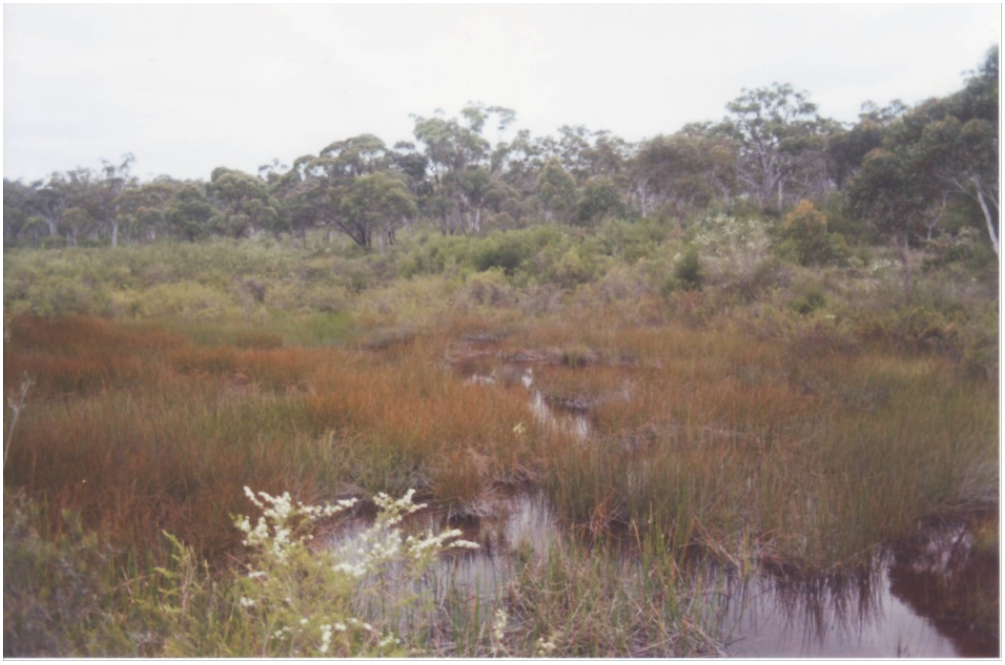


Plate 7 Lizard Creek Valley Fill Swamp Lcvfs1 adjacent to V Mains

Upstream and downstream of the main culvert at Site LC2, Lizard Creek has characteristic iron hydroxide precipitates present within the reed filled sections of the channel.

It has been previously undermined by both east / west and SW / NE oriented longwall panels within the BHPB Cordeaux workings to the south of the NRE No. 1 lease, however, no specific studies have been conducted on the subsidence effects on stream flow, stream water quality or upland swamps. As a result, it is not possible to indicate whether, or not, subsidence has had an effect on the surface water system over the BHPB panels

The stream bed and banks of the plateau streams are generally well vegetated, and do not show significant erosion or bank instability.

10.2 Stream Flow and Pool Depths

10.2.1 Lizard Creek

Volumetric stream flow monitoring has been conducted in Lizard Creek in the vicinity of V Mains since mid September 2009 at LC3, at the culvert crossing on Fire Road 8.

Volumetric flow monitoring is not feasible in the first order, ephemeral tributary of Lizard Creek over Panel 309, or in the first order tributaries draining into Cataract Reservoir over H Panel.

Accurate stream flow monitoring from which comparisons of upstream and downstream catchment volumetric flows can be made is difficult to achieve in Lizard Creek for the following reasons as there is a distinct lack of suitable:

- sites where all stream flow is present as overland flow due to:
    - natural diversions through fissures, joints and washed out bedding planes in the sandstone substrate; or
    - diversion under the natural stream bed through subsidence cracks developed following extraction in the Bulli Seam
- constrictions in the valley floor where all stream flow is constrained into a single channel, rather than split in a number of sub – flow paths, such as in boulder fields or exposed sandstone shelves with large boulders and flow through / out of fissures and washed out bedding planes.

Recorded stream flow volumes as well as pool height monitoring has been conducted at sites LC3, LC5, LC6, LC7 and LC8 as shown in **Figure 12**.

As shown in **Drawing 2**, LC3 is located over essentially unsubsided main headings within the Gujarat lease Bulli Seam workings. Site LC5 is located over the subsided Bulli seam workings panel LW 303, whilst Site LC6 is located over the subsided LW 307.

Site LC7 is located in an unsubsided stream reach to the north and approximately 750m downstream of LW309.

The effect of enhanced pool drainage is apparent on Sites LC5 and LC6 over the old Bulli workings.

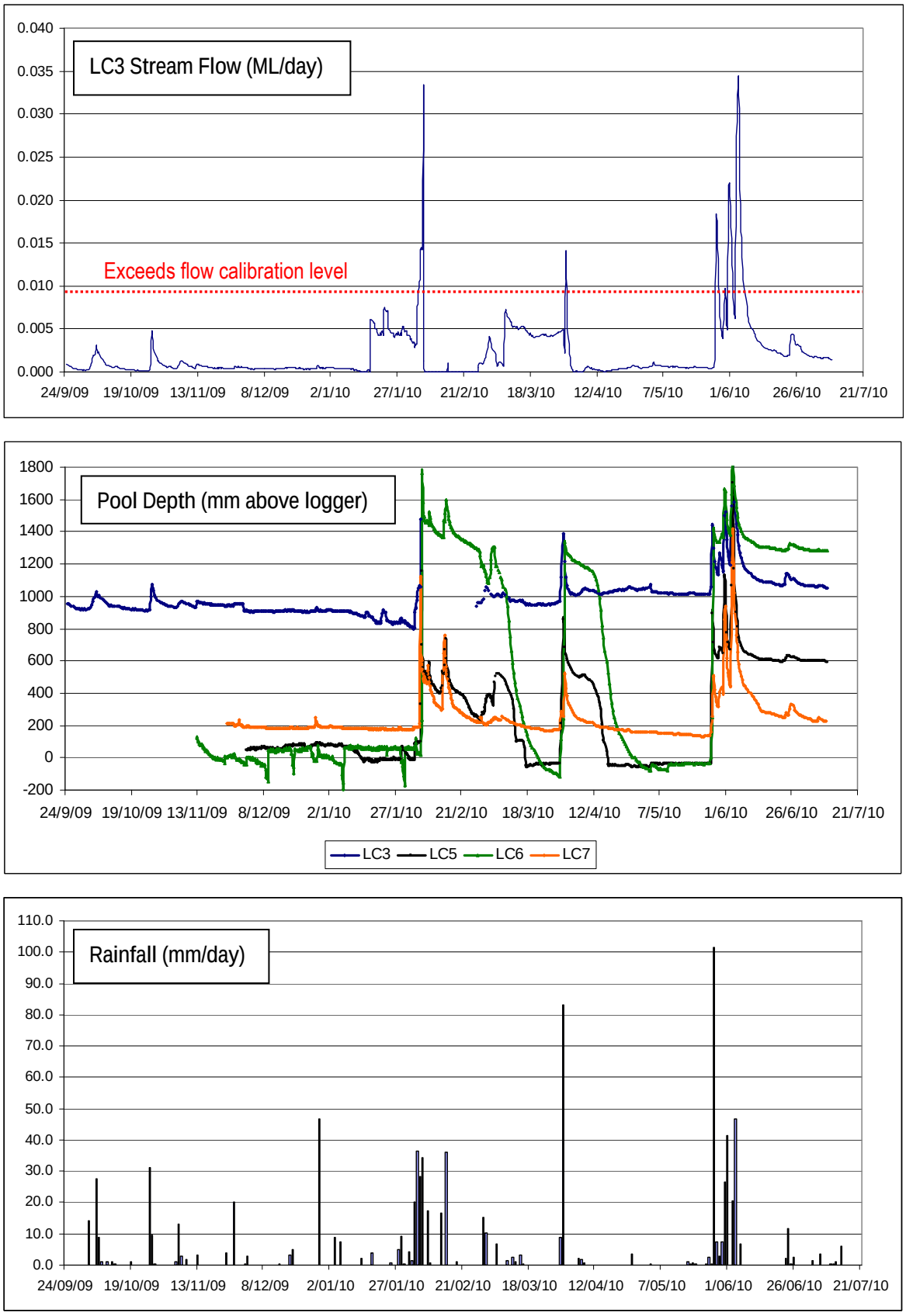


Figure 12 Lizard Creek LC3 Stream Flow and LC3, LC5, LC6 ad LC7 Pool Depths

10.2.2 Wallandoola Creek

Volumetric stream flow monitoring upstream and within the V Mains area is not feasible as there is no distinctive channel within valley fill swamp Wcvfs1, and as a result, the water moves down the creek as a pervasive flow within the swamp, as opposed to within a confined channel.

Due to the stream geomorphology and vegetation limitations, volumetric stream flow monitoring is also not feasible downstream of V Mains. The linear pool between swamps Wcvfs1 and Wcvfs2 does not provide a suitable flow monitoring location, whilst the exposed sandstone substrate sections do not suitably confine the stream so that all of the overland flow can be captured and measured.

In order to provide an observation of any potential change in stream flow in Wallandoola Creek at V Mains, pool height water level monitoring has been conducted at sites WC1 and WC4 as shown in **Figure 13**.

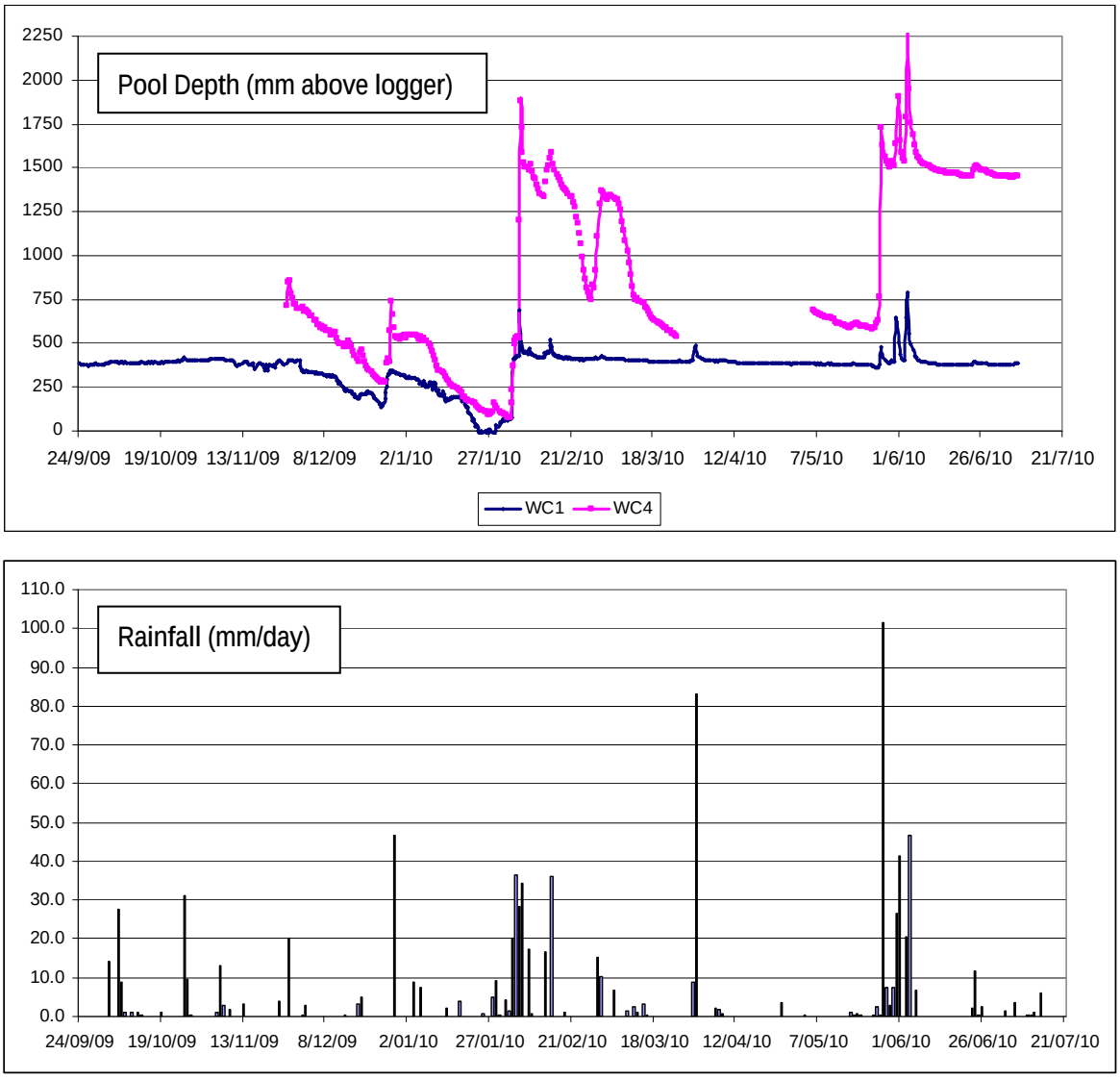


Figure 13 Wallandoola Creek Site WC1 and WC4 Pool Depth

As shown in **Drawing 2**, Site WC1 overlies the BHPB Cordeaux Colliery Bulli Seam longwall subsidence area, whilst Site WC4 lies over the western periphery of the Gujarat lease Bulli Seam longwall LW211 subsidence zone.

Site WC1 does not show an enhanced pool drainage rate, whereas WC4 has an enhanced rate of pool water level reduction, with water observably flowing into a crack located upstream of Waterfall W1 during extended dry periods.

10.3 Stream Water Quality

10.3.1 Wallandoola Creek

The pH in Wallandoola Creek ranges from 3.35 to 6.83, with the median pH of 5.65 located at WC1 over the Cordeaux workings to being marginally more acidic in the valley fill swamp reaches at WC2 and WC3, then rising to 5.75 to 5.95 upstream and downstream of Waterfall W1. The stream's pH is outside the ANZECC 2000 South Eastern Australia Upland Stream criteria.

Wallandoola creek's salinity ranges from 56µS/cm to 199µS/cm and generally rises by approximately 70µS/cm between monitoring the upstream site WC1 and the downstream site WC6. Since regular monitoring began in July 2007, the stream's overall salinity has been rising by between 70 µS/cm and 135µS/cm in confluence with the reducing rainfall runoff in the catchment. The median pH and salinity trend in Wallandoola Creek is shown in **Figure 14**.

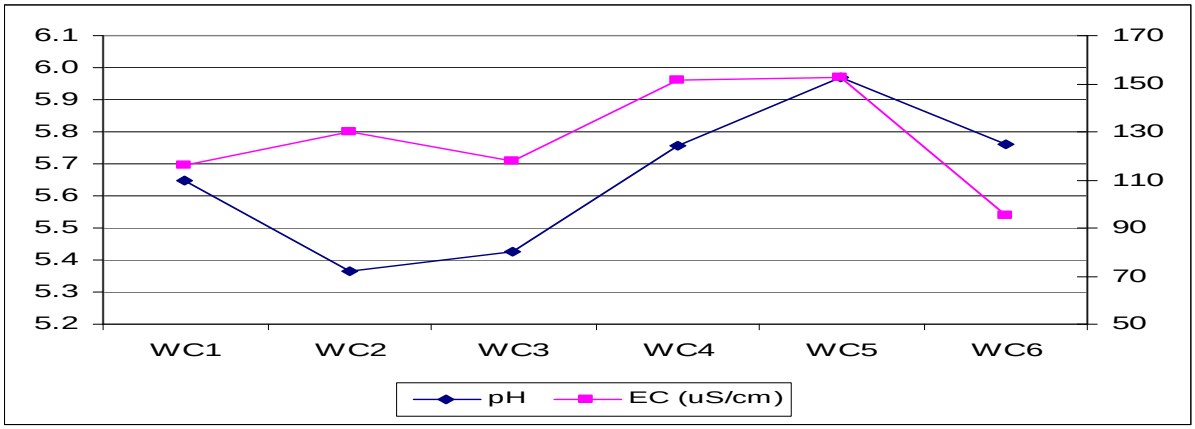
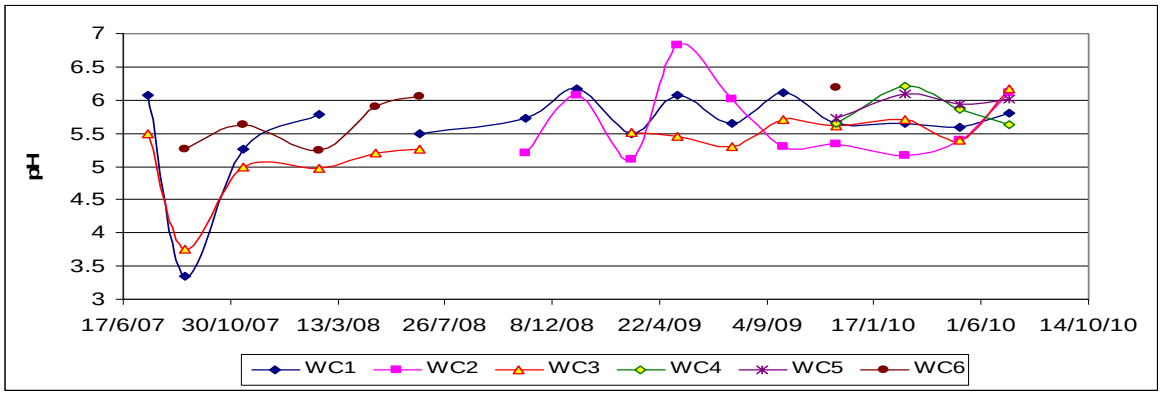


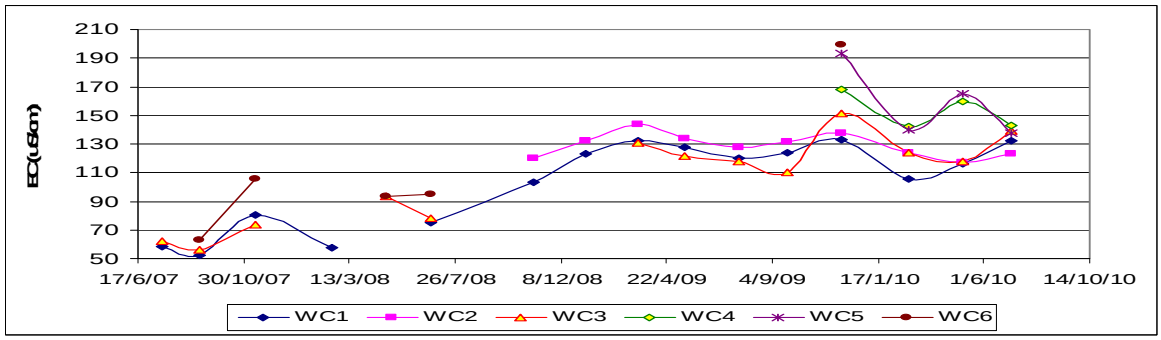
Figure 14 Wallandoola Creek Median Field pH and Salinity

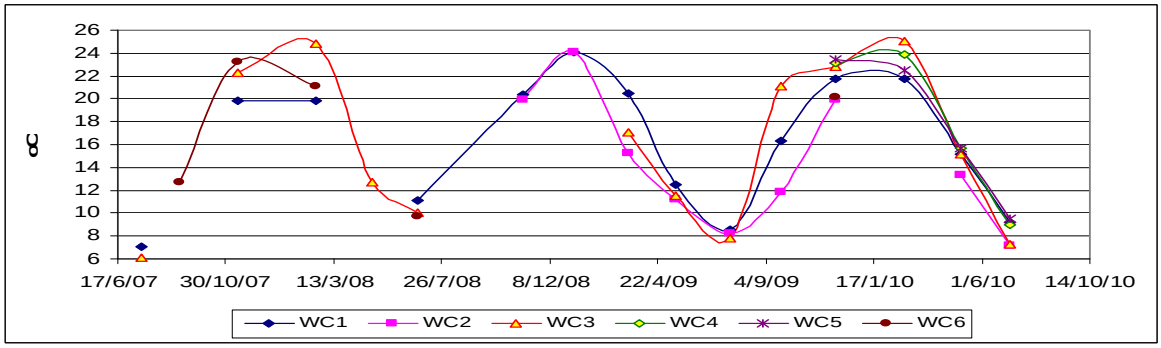
Water quality monitoring initially commenced during September 2001, with regular data collected since July 2007 as shown in **Figure 15**. The main channel within the creek has a perennial flow, whilst the first and second order tributaries are ephemeral and generally dry or have small pools of short duration after rainstorms.

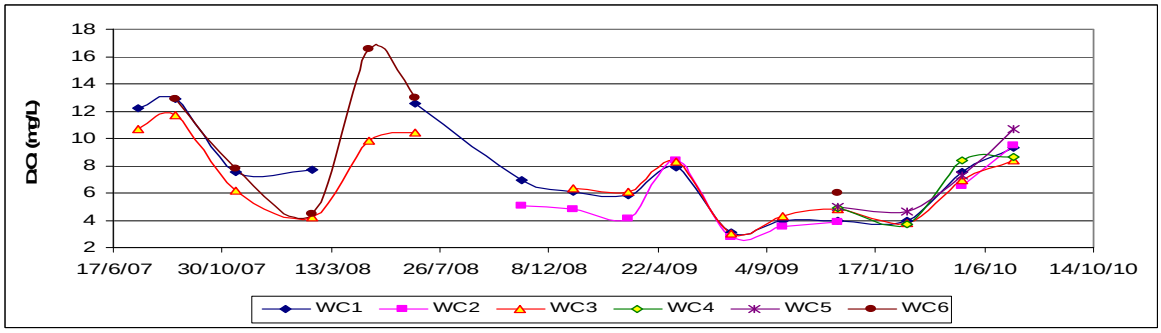
Iron levels in the creek do not show any significant recurring trend with distance downstream apart from an isolated peak in iron oxyhydroxide precipitation at WC4 over Longwalls 209 and 210 near the major bend in the creek. Iron levels discharging downstream of the 200 series longwalls are below 0.5mg/L.

No apparent rise in sulfate levels at any one location are present which would indicate the notable dissolution of sulfuric acid following iron sulfide weathering resulting from subsurface flow through surficial cracks in subsided / cracked Hawkesbury Sandstone.









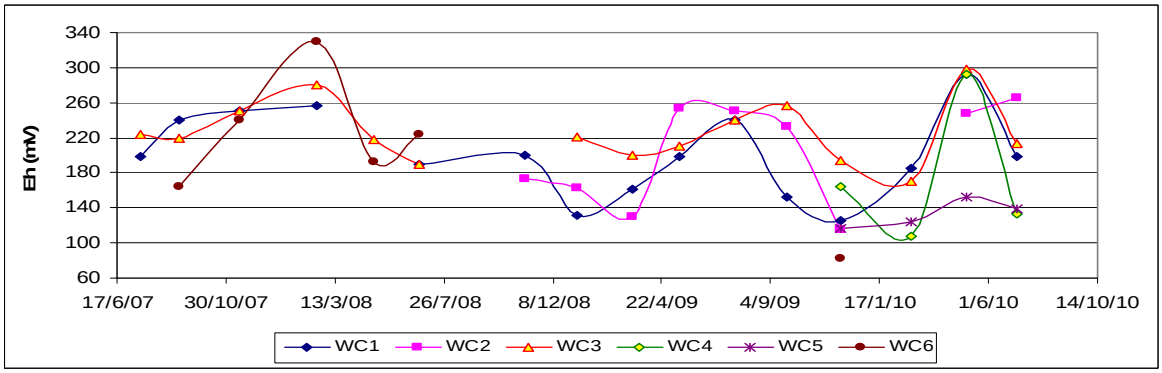


Figure 15 Wallandoola Creek Field Water Chemistry

Monitoring indicates the creek is within the acceptable range for potable water, however it can exceed the ANZECC 2000 95% Species Protection Level for Freshwater Aquatic Ecosystem Guidelines for the following parameters, depending on the flow conditions at the time of sampling;

- filtered zinc at all sites for the majority of the time,
- total nitrogen at some sites for part of the time with no regular pattern,
- total phosphorous occasionally at each site, with no regular pattern and
- filtered aluminium on one occasion at Site WC2.

10.3.2 Lizard Creek

Lizard Creek's pH ranges from 2.50 to 6.83. It shows a general trend to lower acidity downstream apart from between LC5 and LC6 during low flow periods as shown in **Figure 16** where the stream has a subterranean flow component. The stream's pH is outside the ANZECC 2000 South Eastern Australia Upland Stream criteria. Since July 2007 the creek has had a slight overall reduction in acidity by approximately 0.5 to1.0 pH unit.

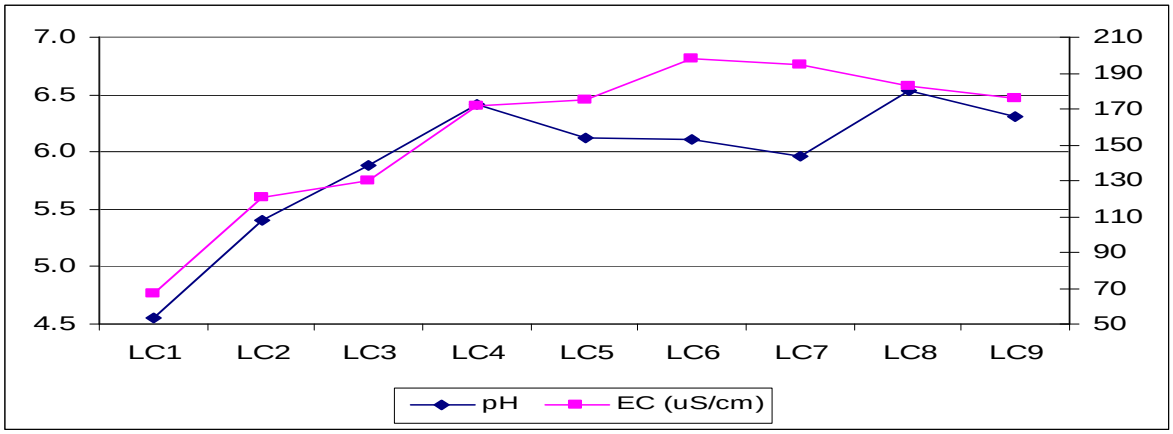


Figure 16 Lizard Creek Median pH and Salinity

Water quality monitoring in Lizard Creek initially commenced in September 2001, with regular data collection since July 2007 as shown in **Figure 17**. The main channel has a predominantly perennial flow, although one reach above and one below the waterfall WL1 can temporarily dry up. The first and second order tributaries are ephemeral and generally dry or have small pools of short duration.

The creek salinity ranges from 19µS/cm to 273µS/cm and generally rises by approximately 60µS/cm between the upstream site LC2 and LC8, outside of the LC5 to LC6 reach. Since regular monitoring began in July 2007, the stream's overall salinity has been rising by approximately 90µS/cm in confluence with the reducing rainfall runoff in the catchment.

Iron levels in the creek show an overall trend to lower concentrations with distance downstream, outside of the isolated peak in iron oxyhydroxide precipitation at LC6. Total and filtered iron levels discharging to Cataract River at LC9 range from 0.09 - 0.85mg/L and 0.01 - 0.13mg/L respectively.

A peak in sulfate is generally identified at LC6 which could represent the upstream dissolution of sulfuric acid following iron sulfide weathering as a result of shallow subsurface flow through cracks in the subsided and cracked Hawkesbury Sandstone during low flow periods. A concurrent bicarbonate peak is also generally observed at LC7.

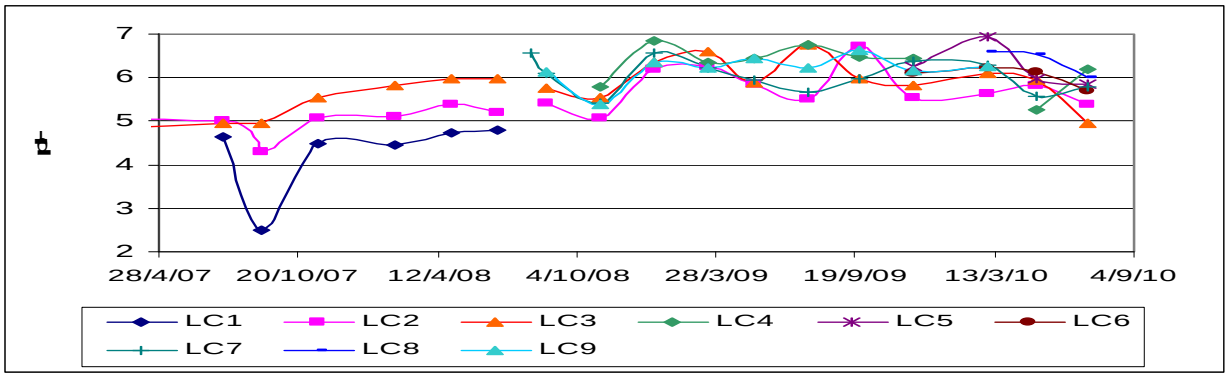
Monitoring indicates the creek is within the acceptable range for potable water, however it is generally outside the ANZECC 2000 South Eastern Australia Upland Stream criteria for pH and can be above the ANZECC 2000 95% Species Protection Level for Freshwater Aquatic Ecosystem Guidelines depending on the flow conditions at the time of sampling for;

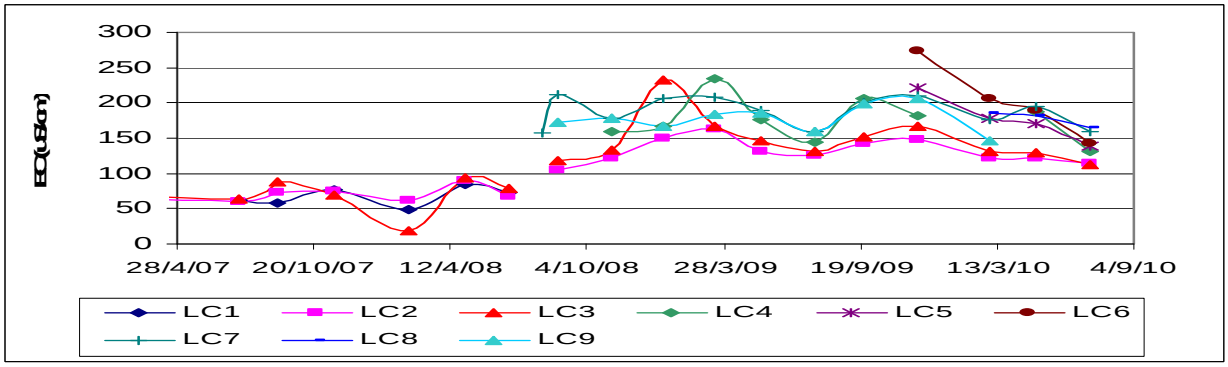
- filtered zinc occasionally at all sites, with a high variability
- total nitrogen and total phosphorous at all sites, infrequently
- filtered copper, very occasionally at LC1,7 and 8, and
- filtered aluminium, very occasionally at LC2 and LC3.

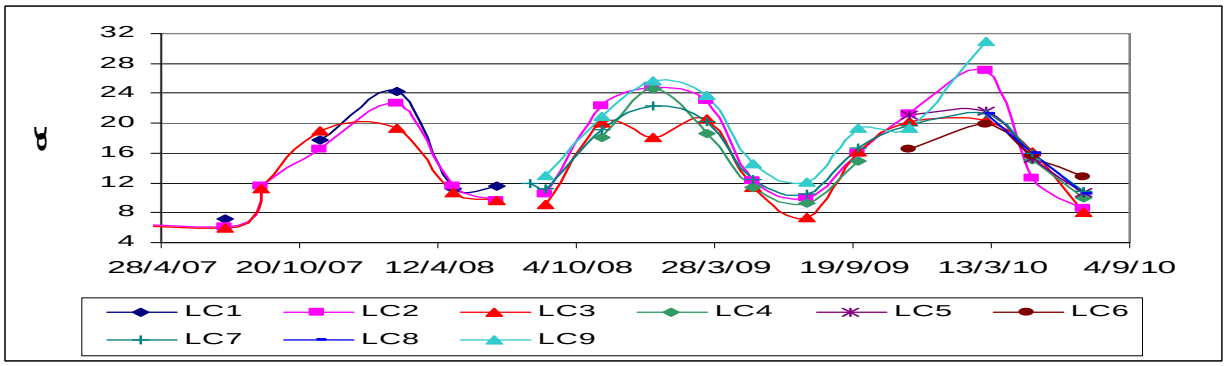
10.3.1 Cumulative Water Quality Impacts in Wallandoola Creek and Lizard Creek

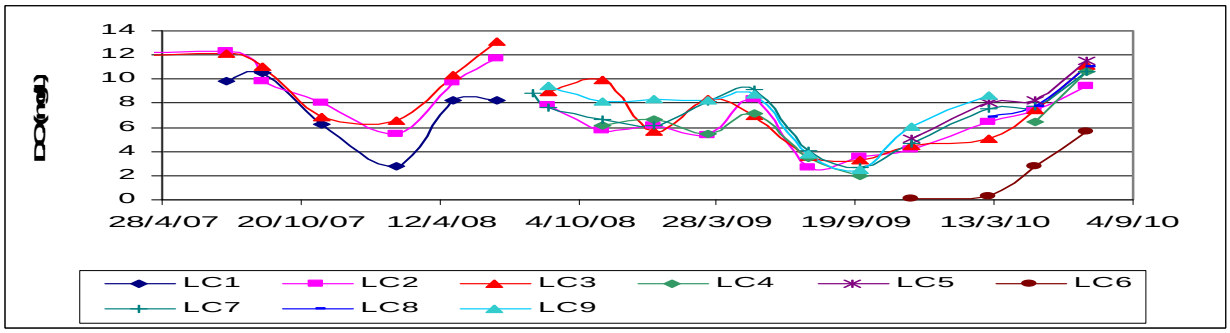
Based on water quality monitoring data from Lizard Creek and Wallandoola Creek, there are no observable cumulative impacts from the southern, adjoining BHPB Cordeaux workings, which are upstream of the proposed workings in the Gujarat lease.

No stream water monitoring data is available within the Cordeaux lease prior to the undermining of Lizard or Wallandoola Creeks by BHPB, and therefore it is not possible to assess whether there were, or the magnitude of, any changes to stream water quality from subsidence at Cordeaux.









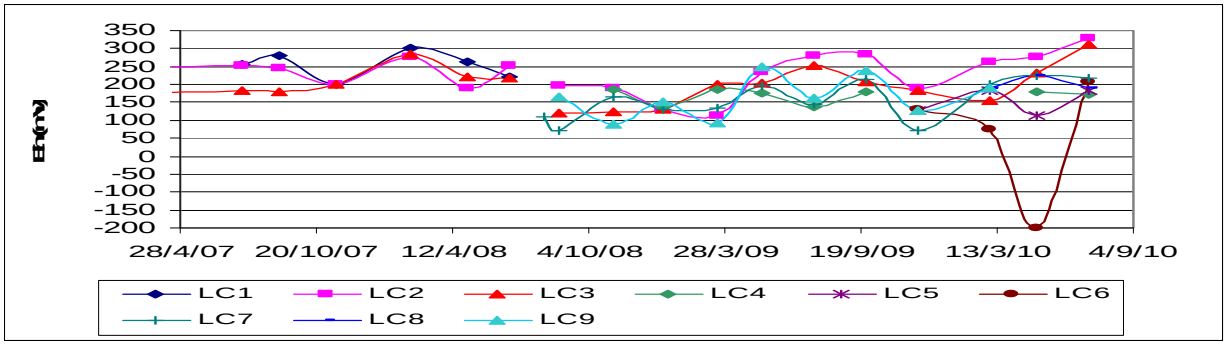


Figure 17 Lizard Creek Field Water Chemistry

10.3.2 Cataract Creek

Cataract Creek's pH ranges from 4.84 to 6.56, with a median pH trend rising from 5.5 to 6.1 down the catchment as shown in **Figure 18**. The stream's pH is outside the ANZECC 2000 South Eastern Australia Upland Stream criteria.

The creek salinity ranges from 101 - 190µS/cm, with the median salinity reducing with distance downstream.

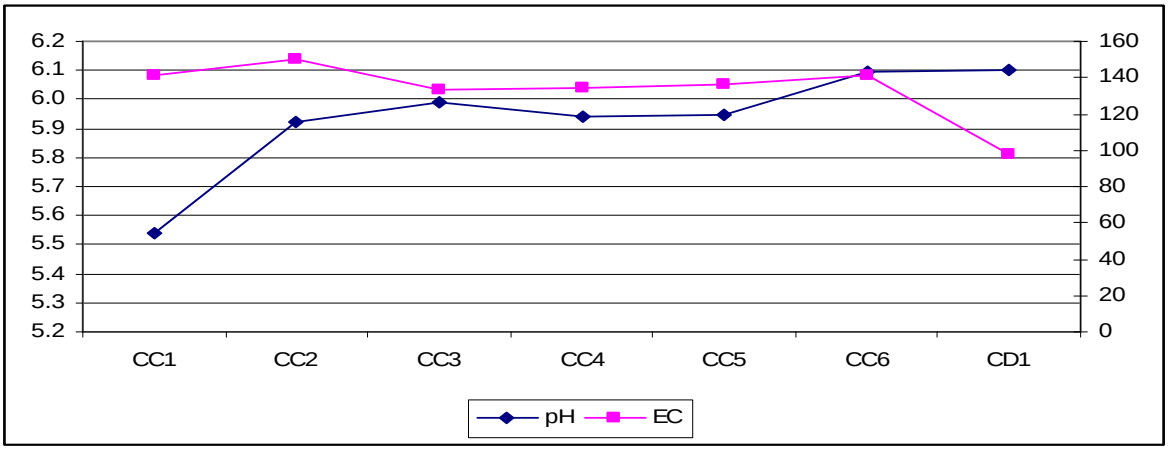


Figure 18 Cataract Creek Median pH and Salinity

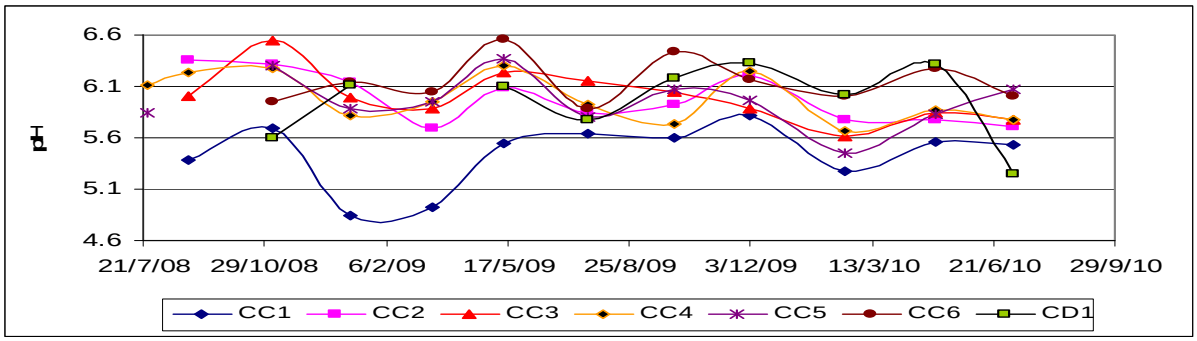
Water quality monitoring in Cataract Creek initially commenced in July 2008 as shown in **Figure 19**. The CC3 and CC4 tributaries which originate to the west of the Illawarra escarpment both have perennial flow as does the main channel at and downstream of CC5.

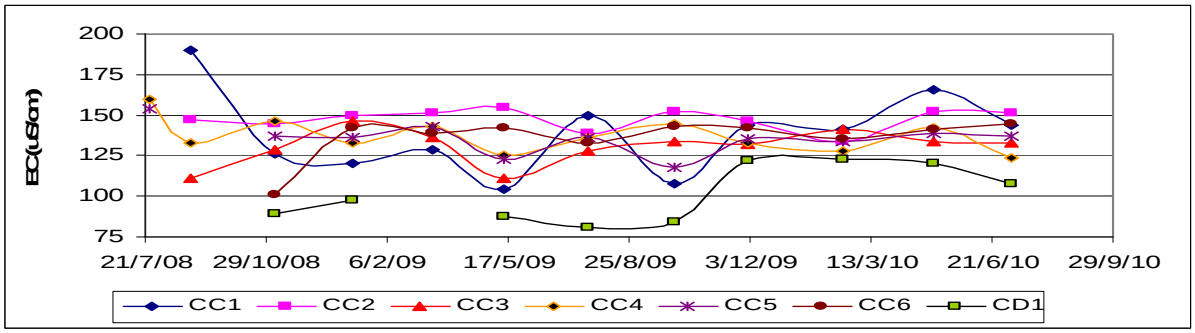
Iron levels are generally higher in the upper headwaters, with total and filtered iron levels ranging from 0.3 - 49mg/L and 0.02 - 0.92mg/L respectively.

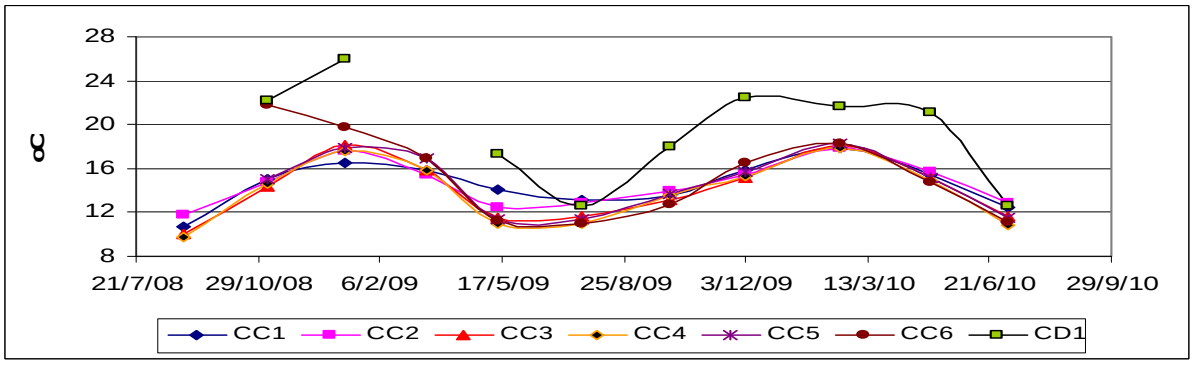
A peak in sulfate is generally identified in the CC2 to CC3 tributary which could represent the dissolution of sulfuric acid following iron sulfide weathering as a result of shallow subsurface flow through cracks in the subsided and cracked basement strata, and / or weathering of the exposed Bald Hill Claystone and overlying shale / claystone dominated units.

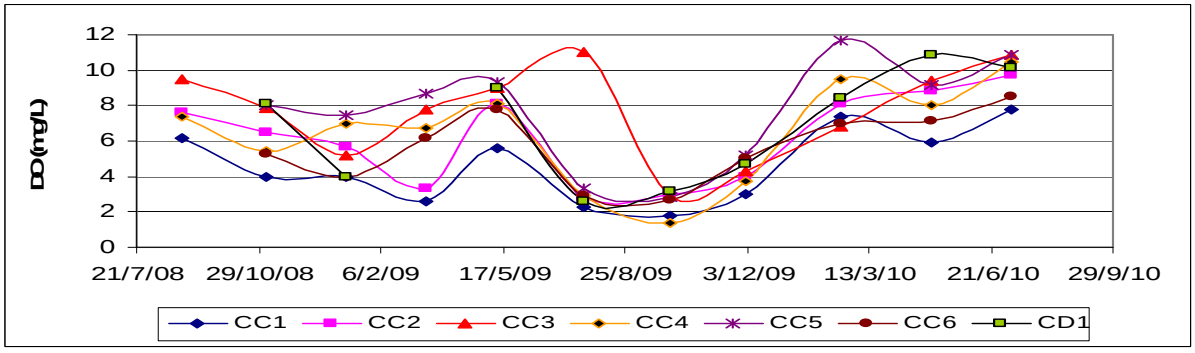
Monitoring indicates the creek is within the acceptable range for potable water, however it is generally outside the ANZECC 2000 South Eastern Australia Upland Stream criteria for pH and can be above the ANZECC 2000 95% Species Protection Level for Freshwater Aquatic Ecosystem Guidelines depending on the flow conditions at the time of sampling for the following:

- filtered zinc at CC1, CC4 and CD1, with a high variability;
- filtered copper at CC1, 4 and 5, very occasionally;
- filtered aluminium at CC1, 4, 5 and 6, very occasionally;
- total phosphorous at all sites, generally; and
- total nitrogen, at all sites, infrequently and with a high variability.









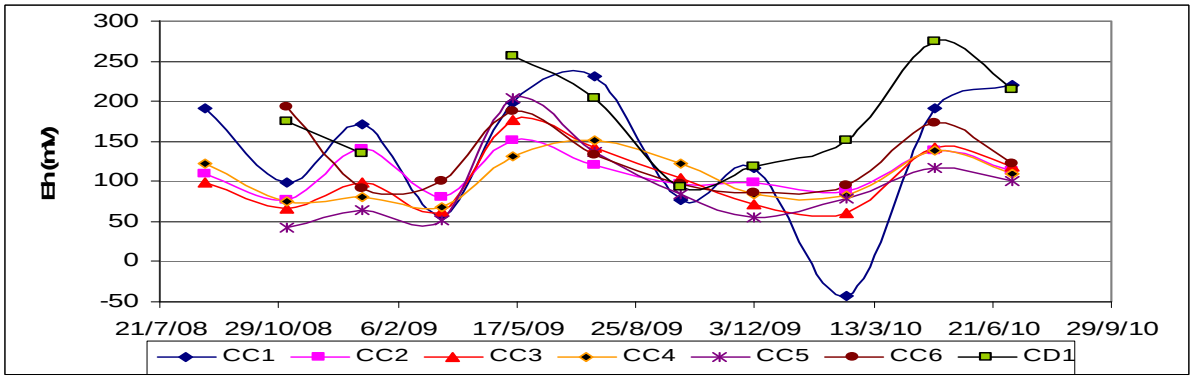


Figure 19 Cataract Creek Field Water Chemistry

10.4 Stream Water Quality Above ANZECC 2000 Criteria In Association With Adverse Stream Flow or Ponding

In general, where adverse subsidence effects are noted on stream flow and stream ponding, there is an associated precipitation of an orange brown coloured iron hydroxide floc, which raises the total and filtered iron content of the stream water.

Although higher concentrations of associated metals and sulfate can occur in the iron floc areas, it is generally not significant, as discussed in the following sections.

10.4.1 Wallandoola Creek

In the section between Site WC3 and WC4, where the ferruginous deposits are observed, the median water quality of filtered zinc and total nitrogen, which are the only above criteria parameters in this stretch, generally improves with flow downstream from WC3 to WC4 as shown below where the median:

- filtered zinc reduces from 0.014 – 0.005mg/L;
- total nitrogen increases from 0.2 – 0.25mg/L;
- whilst pH rises from 5.43 – 5.76; and
- salinity rises from 118 - 151µS/cm.

Between WC4 and WC5, where the creek is affected by subsidence around Waterfall W1 the only above criteria parameter changes are where the median:

- filtered zinc rises from 0.005 – 0.013mg/L;
- total phosphorous reduces from 0.24 – 0.08mg/L;
- whilst pH rises from 5.76 – 5.97; and
- salinity is relatively constant.

Downstream of the Waterfall W1 plunge pool containing Site WC5, Site WC6 parameters above the ANZEC 2000 criteria are median zinc at 0.015mg/L, with a pH of 5.76 and salinity of 95µS/cm.

10.4.2 Lizard Creek

In the section between Site LC3 and LC4, where the headward erosion of valley fill swamp Lcvfs2 as well as the drying out of the sandstone based stream bed can occur, ferruginous deposits are observed in the permanent pool immediately upstream of Waterfall L1, as well as on the waterfall face, but not in the waterfall plunge pool and downstream to Site LC4.

In the LC3 to LC4 reach, the median water quality of above ANZECC 2000 criteria parameters is as discussed below, where the median:

- filtered zinc reduces from 0.006 – 0.003mg/L;
- filtered aluminium reduces from 0.03 – 0.02mg/L;
- total phosphorous rises from 0.01 – 0.02mg/L; and
- whilst pH rises from 5.88 – 6.42 and salinity rises from 130 - 172µS/cm.

Between LC4 and LC5 no adverse effects on stream flow, ponding or water quality is observed.

Between LC5 and LC6, where the creek has enhanced drying out of pools, the above criteria parameter changes observed are where the median:

- filtered zinc reduces from 0.005 – 0.004mg/L;
- total nitrogen reduces from 0.3 – 0.015mg/L;
- total phosphorous remains static around 0.02mg/L; and
- whilst pH acidity remains static around 6.12 and salinity rises from 175 - 198µS/cm.

From LC6, where there is a distinctive ferruginous precipitation at the point of upwelling and a continuum of flow with no adverse effects on pool water levels, to where the stream bed is not underlain by any Bulli Seam workings and has no associated subsidence effects at monitoring sites LC7, LC8 and LC9 (which is upstream of Waterfall L2), the median:

- filtered zinc reduces from 0.004mg/L at LC6 to 0.002mg/L at LC9;
- total nitrogen reduces from 0.15mg/L at LC6 to 0.1mg/L at LC9;
- total phosphorous reduces from 0.02mg/L at LC6 to 0.01mg/L at LC9; and
- whilst pH rises from 6.11 – 6.31 and salinity reduces from 198 - 176µS/cm.

At LC9, which is where Lizard Creek flows over Waterfall L2 and discharges into the Cataract River, the only above ANZECC 2000 parameters have been:

- filtered copper at 0.002mg/L on one occasion;
- filtered zinc at 0.012mg/L on one occasion;
- total phosphorous on three occasions, ranging from 0.03 – 0.13mg/L; and
- with a pH of 6.31 and salinity of 176µS/cm.

10.4.3 Cataract Creek

No adverse effects on stream flow continuity or stream ponding have been observed in Cataract Creek, however, where the ferruginous deposits occur, the stream water quality can exceed ANZECC 2000 criteria between CC1 and CC5 for:

- filtered copper up to 0.004mg/L, very infrequently;
- filtered zinc up to 0.12mg/L, infrequently;
- filtered aluminium up to 0.1, very infrequently;
- total nitrogen up to 1.9mg/L, very occasionally;
- total phosphorous up to 0.27 mg/L, occasionally; and
- with a gradually rising pH with distance downstream from 5.54 – 6.1 and a relatively static salinity of 141µS/cm.

Where Cataract Creek discharges into Cataract Reservoir, the only above criteria parameters at CC6 have been:

- filtered zinc on one occasion at 0.09mg/L;
- filtered aluminium on one occasion at 0.008mg/L;
- total nitrogen on two occasions at 0.4 – 0.6mg/L;
- total phosphorous on three occasions, ranging from 0.04 – 0.08mg/L; and
- with a pH of 6.1 and salinity of 98µS/cm.

11. HYDROGEOLOGICAL INVESTIGATION PROGRAM

Drilling, piezometer installation, low flow pump out tests, falling head tests, packer tests and installation of open standpipe and vibrating wire piezometers, as well as groundwater level and water chemistry monitoring were conducted within the Study Area between 1992 and the present.

The majority of drilling and monitoring was conducted after July 2009 to assess the hydrogeological characteristics of the:

- upland swamps;
- Hawkesbury Sandstone;
- Narrabeen Group lithologies; and
- Illawarra Coal Measures.

To date, groundwater investigations in the Study Area have involved the installation of 6 swamp piezometers, 7 open standpipe and 6 vibrating wire array piezometers as shown in **Drawing 2**, with drilling extending to 325m below surface.

It should be noted that where vibrating wire piezometers were installed, the bores were sealed to surface with cement / bentonite and no NOW licences were required.

All relevant approvals from the Sydney Catchment Authority were also obtained prior to drilling.

11.1 Hydraulic Properties

Low flow (<0.16L/sec) pump out tests of less than 45 minutes duration were conducted in all open standpipe piezometers seated in the upper to middle Hawkesbury Sandstone as shown in **Table 10**.

The hydraulic conductivity of the unconfined to semi confined Hawkesbury Sandstone was analysed using the Jacob Straight Line Method (Jacob, 1950). Although the piezometers were installed in the upper portion of the aquifer and did not fully penetrate the Hawkesbury Sandstone, an indicative hydraulic conductivity was assessed by comparing the transmissivity to the intake interval.

The average hydraulic conductivity for the upper Hawkesbury Sandstone pump out tests (excluding NRE-E) is 0.023m/day. The elevated conductivity in NRE E of 2.07m/day could result from subsidence cracking of the surficial sandstone over the western chain pillar between Longwall 202 and the S3 pillar extraction area.

Table 10 Hawkesbury Sandstone Open Standpipe Piezometer Hydraulic Parameters and Standing Water Levels

Bore	Mining Domain	Total Depth (m)	Intake / Screen (m)	Hydraulic Conductivity (m/day)	Screened Interval Transmissivity (m^2/day)	Standing Water Level (mbgl)
NRE A	LW 4 & 5	47	24 - 47	0.011	0.276	19.21 – 22.37
NRE C	LW 4 & 5	24	18 – 24	0.017	0.121	12.82 – 14.31
NRE D	LW 4 & 5	52	40 - 52	0.038	0.495	27.21 – 30.73
NRE E	V Mains / Panel 309	29	17 - 29	2.07	26.91	11.57 – 11.91
NRE G	V Mains / Panel 309	53	36 - 53	0.043	0.775	29.63 – 30.51
NE3	V Mains / Panel 309	60	48 - 60	0.004	0.052	39.22 – 39.34
P514	V Mains / Panel 309	191	160 - 188	Not tested	Not tested	20.0 – 34.0

Note: # data accuracy needs confirmation

In addition, packer tests over 5.5m intervals were conducted in 6 bores to 281m below surface (SCT Operations, 2009). As shown in **Table 11**, the average packer test hydraulic conductivity of the Hawkesbury Sandstone varies from 0.0131m/day in the upper section to 0.0003m/day in the mid section and 0.0008m/day in the lower horizon. The Bald Hill Claystone averages 0.0298m/day whilst the upper Bulgo Sandstone averages 0.0066m/day and the mid Bulgo Sandstone averages 0.0004m/day.

Based on a combination of on-site tests as well as assessment of regional studies (Heritage Computing, 2009) hydraulic conductivities in the BHP Billiton Bulli Seam proposed workings region vary from 0.026m/day to 1E-06m/day, whilst the western region around Tahmoor (Geoterra, 2009) ranges from 9.26E-06m/day to 1.55E-09m/day. The Dendrobium workings range from 8.64E-1m/day to 8.64E-5m/day (GHD, 2007) as shown in **Figure 20**.

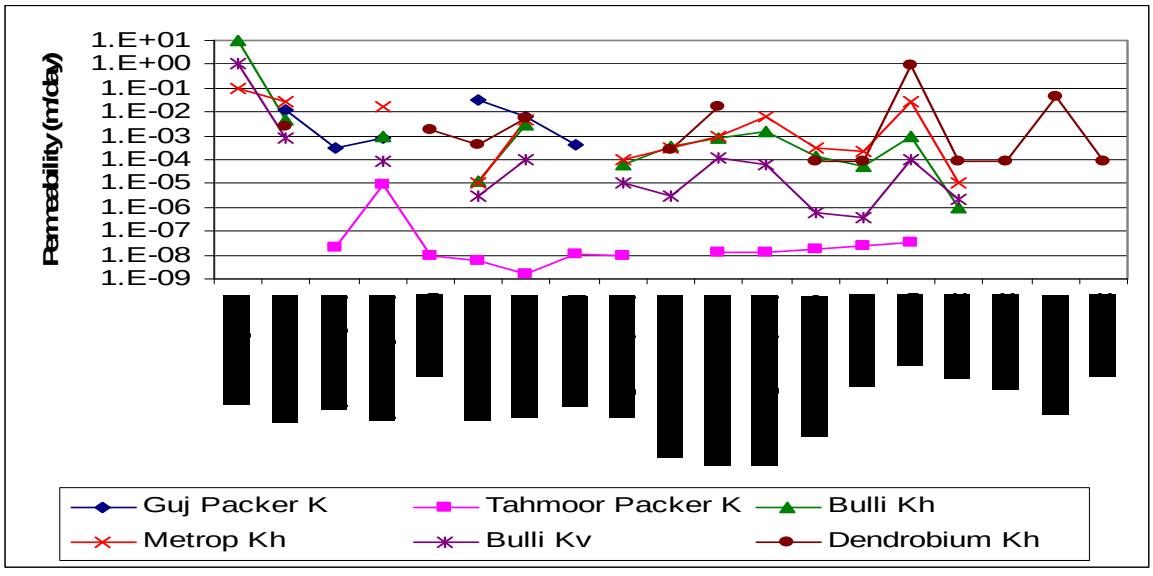


Figure 20 Regional Hydraulic Conductivities Vs Depth

Table 11 NRE No.1 Packer Tests

Borehole	From (m)	To (m)	Interval (m)	K (m/s)	K (m/day)	Median K (m/day)
HAWKESBURY SANDSTONE UPPER						
NRE-A	35	41.5	6.5	1.1E-07	0.00950	**0.0131**
NRE-A	41	47.5	6.5	1.4E-08	0.00121	
NRE-A	48	60	12	1.6E-07	0.01382	
NRE-A	42	60	18	3.1E-09	0.00027	
NRE-D	41	47.5	6.5	2.1E-08	0.00181	
NRE-D	47	53	6	1.5E-07	0.01296	
NRE-D	24.1	30.6	6.5	9.1E-09	0.00079	
NRE-D	30.1	36.6	6.5	0.0E+00	-	
NRE-D	36.1	42.6	6.5	2.6E-08	0.00225	
NRE-E	19	25.5	6.5	6.8E-07	0.05875	
NRE-E	25	30	5	>1e-6		
NRE-G	42	48.5	6.5	6.2E-07	0.05357	
NE3	48.7	55.2	6.5	1.8E-08	0.00156	
NE3	54.7	61.2	6.5	9.6E-09	0.00083	
HAWKESBURY SANDSTONE MID						
NE3	102.7	109.2	6.5	4.8E-09	0.00041	**0.0003**
NE3	108.7	115.2	6.5	2.3E-09	0.00020	
HAWKESBURY SANDSTONE LOWER						
NE3	126.7	133.2	6.5	4.5E-09	0.00039	
NE3	132.7	139.2	6.5	1.9E-08	0.00164	
NRE-D	54.1	60.6	6.5	5.2E-09	0.00045	**0.0008**
NEWPORT FORMATION						
NRE-D	66.1	72.6	6.5	>1e-6		**>1e-6**
BALD HILL CLAYSTONE						
NRE-A	53	59.5	6.5	1.0E-09	0.00009	**0.0298**
NRE-A	59	65.5	6.5	5.4E-07	0.04666	
NRE-B	35.7	42.2	6.5	6.1E-10	0.00005	
NRE-B	41.7	48.2	6.5	1.8E-07	0.01555	
NRE-D	78.1	84.6	6.5	1.5E-06	0.12960	
NRE-D	84.1	90.6	6.5	1.9E-07	0.01642	
NE3	180.7	187.2	6.5	5.0E-09	0.00043	
BULGO SANDSTONE UPPER						
NRE-A	71.8	78.3	6.5	4.5E-09	0.00039	**0.0066**
NRE-A	77.8	84.3	6.5	2.4E-10	0.00002	
NRE-B	59.7	66.2	6.5	2.7E-10	0.00002	
NRE-B	65.7	72.2	6.5	3.0E-08	0.00259	
NRE-D	102.1	108.6	6.5	4.7E-07	0.04061	
NRE-D	108.1	114.6	6.5	0.0E+00		
NE3	210.7	217.2	6.5	4.4E-09	0.00038	
NE3	216.7	223.2	6.5	2.8E-08	0.00242	
BULGO SANDSTONE MID						
NRE-A	128.8	135.3	6.5	0.0E+00		**0.0004**
NRE-A	134.8	141.3	6.5	3.6E-10	0.00003	
NRE-B	113.7	120.2	6.5	8.6E-10	0.00007	
NRE-B	119.7	126.2	6.5	5.3E-10	0.00005	
NRE-D	150.1	156.6	6.5	0.0E+00		
NRE-D	156.1	162.6	6.5	0.0E+00		
NE3	246.7	253.2	6.5	1.4E-09	0.00012	
NE3	252.7	259.2	6.5	2.2E-08	0.00190	

11.2 Groundwater Levels

11.2.1 Upland Swamps

The upland swamps are perched systems that are hydraulically separated and disconnected from the deeper, regional groundwater table in the Hawkesbury Sandstone. They can, however, be connected to shallower, ephemeral seepage from the upper Hawkesbury Sandstone where bedding discontinuities or low permeabilities enhance horizontal flow into a swamp after high rainfall periods.

Depending on the relative height of the ephemeral, perched and regional water tables, groundwater seepage can supplement swamp moisture or, alternatively, unsaturated swamp moisture can seep into the underlying shallow ephemeral sandstone aquifer.

In turn, the shallow bedrock aquifers are also usually ephemeral, and are hydraulically disconnected from the deeper, regional aquifers within the Hawkesbury Sandstone.

The water table within the swamps is dependent on surface inflow after rain and can be supported by ephemeral seepage of near surface groundwater from the Hawkesbury Sandstone. Water storage is usually limited within the clay rich sandy sediments, although can allow relatively small inflows to support a highly variable ephemeral water table in the more organic layers.

Recharge into the Hawkesbury Sandstone shallow aquifer that seeps into a swamp is generally moderated by connate water stored in a swamp, which is also recharged by rainfall recharge. Water can enter a swamp from ephemeral seeps located at the upper and lower section of any topographic or basement steps that may be present.

Episodes of inundation and surface run off within a swamp are directly related to the extent and duration of storm events, with the short term, post storm drainage occurring within indistinct channels or flow paths in the swamp.

Groundwater seepage into a swamp is usually transmitted within the more sandy or peaty layers and can “daylight” where the water table extends to surface.

Water accumulation within a swamp is a balance between:

- surface inflow;
- horizontal seepage and downstream flow;
- swamp storage capacity;
- vertical seepage rates into the lower weathered rock strata; and
- evaporative processes.

Perched groundwater levels within valley fill and headwater swamps have been monitored in the Study Area since July 2006 and range from no standing water after extended dry periods to depths of up to 1.8m below surface as shown in **Figure 21**.

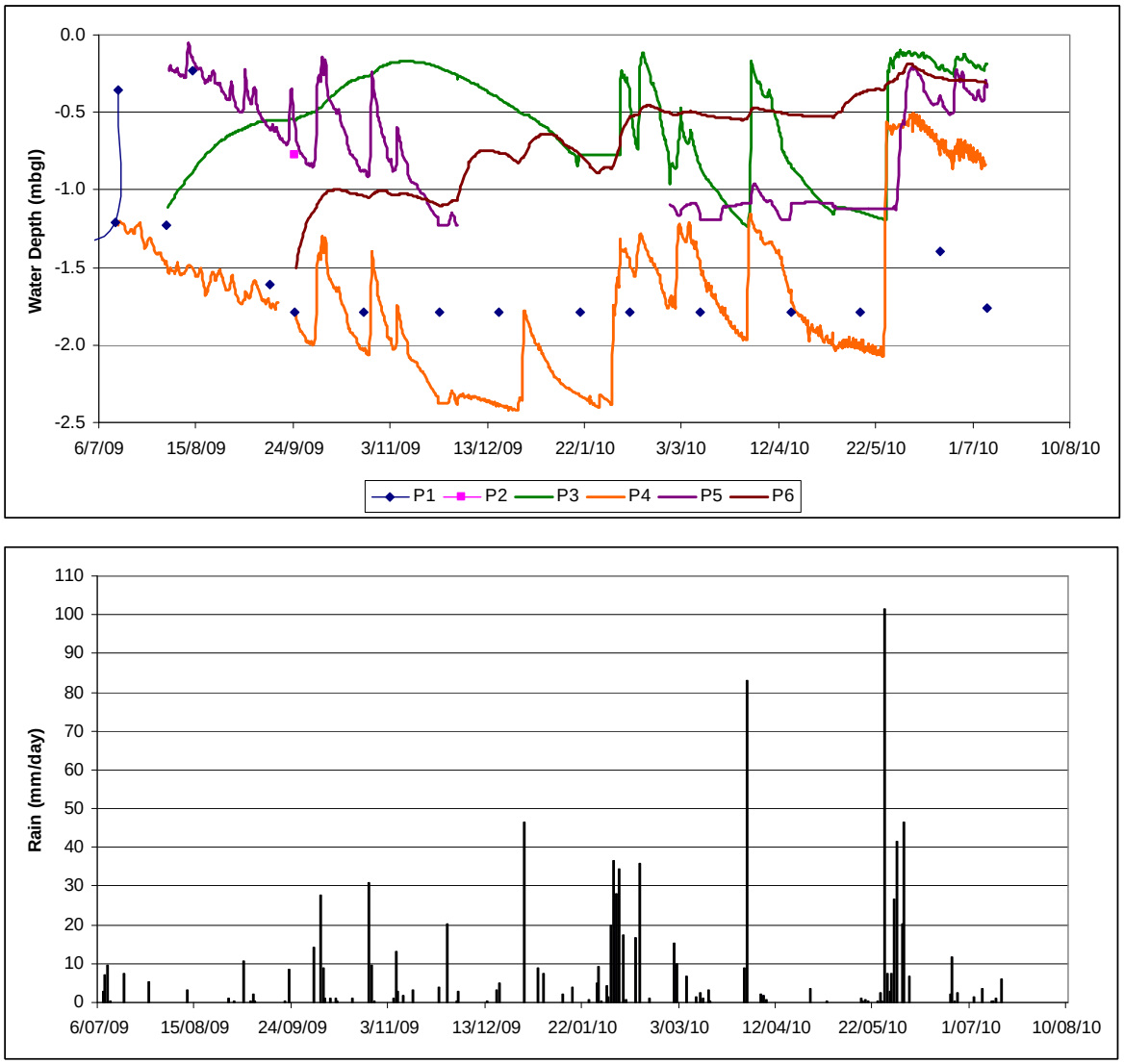


Figure 21 Upland Swamp Standing Water Levels and Rainfall

The headwater swamp water levels (P1 to P5) rise and fall in direct response to the changing patterns of rainfall and dry periods at similar rates.

The anomalous initial water levels in P3 up to late January 2010 were due to clogging of the intake screen, which was purged to enable monitoring of the subsequent water levels.

Recharge generally occurs rapidly in “steps” after rainfall, and to date, albeit with intermittent recharge events, Swamps P3 and P4 have taken up to 4 months to dry out. This “drying” time would shorten for more extended dry periods when the swamp is not intermittently “topped up” and would vary depending on the season in which the drying event occurred.

Paired swamp and Hawkesbury Sandstone monitoring at P5 and NRE-E as shown in **Figure 22** indicates that the two systems are hydraulically separated and that the swamp is more responsive to rainfall / drying events than the Hawkesbury Sandstone.

The valley fill swamp in Wallandoola Creek at P6 (Wcvfs1) has a moderated response to rainfall as it is in direct connection to stream seepage through the Wallandoola Creek stream flow.

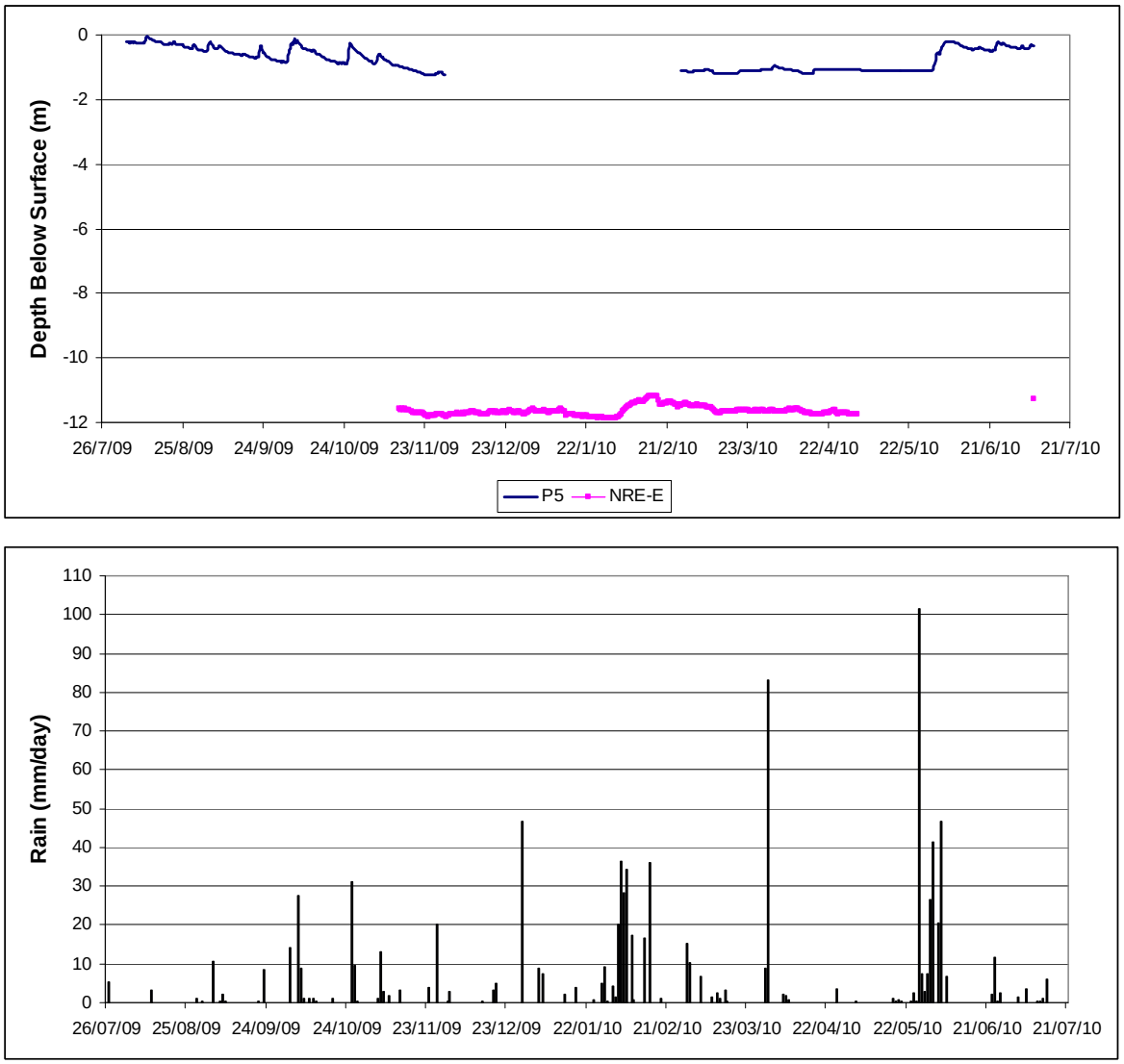


Figure 22 Paired Upland Swamp and Hawkesbury Sandstone Water Levels

11.2.2 Hawkesbury Sandstone Open Standpipe Water levels

Water levels from open standpipe piezometers installed in the upper Hawkesbury Sandstone are shown in **Figure 23** from locations shown in **Drawing 1**.

The piezometers to the east of Cataract Reservoir are significantly more responsive to rainfall than to the west of the reservoir, with eastern group varying by up to 17.05m, whilst the western group vary by up 0.7m as shown in **Table 12**.

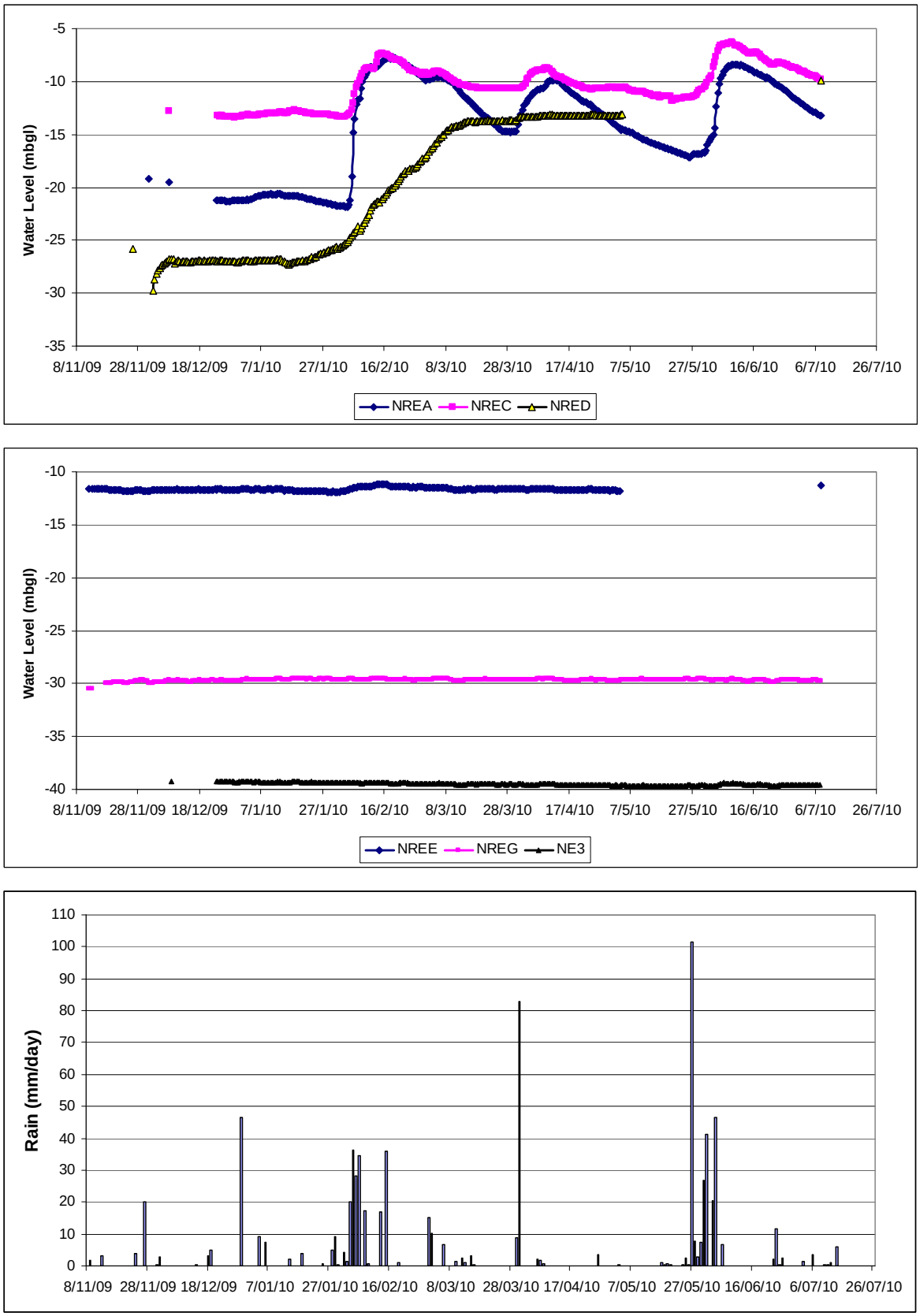


Figure 23 Hawkesbury Sandstone Water Levels and Rainfall

Table 12 Hawkesbury Sandstone Water Level Variability

Piezometer	First Water Intercept (mbgl)	Water Level Range (mbgl)	Water Level Variability (m)
Longwalls 4 & 5			
NRE A	24.0	7.77 - 21.68	13.91
NRE C	18.0	7.49 – 13.30	5.81
NRE D	40.0	9.90 – 26.94	17.04
V Mains & Panel 309			
NRE E	17.0	11.19 – 11.89	0.70
NRE G	36.0	29.56 – 29.89	0.33
NE3	48.0	39.27 – 39.63	0.36

11.2.3 Multi Level Piezometers

Multi level piezometers have been installed at selected depths between the Upper Hawkesbury Sandstone and the Stanwell Park Claystone since July 2009 in three bores to the east of Cataract Reservoir and one (excluding P501, 502 and 514) to the west as summarised in **Table 13**.

The NE3 array augments data collected since 1992 from multi level piezometers over Longwall 501, 502 and 514.

In December 2009 the pressure head in NRE-A rose between the lower Hawkesbury Sandstone and the Bald Hill Claystone indicating a potential groundwater flow up into the Hawkesbury Sandstone, then sequentially reduced below the Bald Hill Claystone indicating a downward flow gradient.

A similar situation is observed between the Newport Formation and the Bald Hill Claystone in NRE-D, where groundwater pressure gradients indicate a potential flow from the Bald Hill Claystone to the Newport Formation, and a downward flow gradient from the Bald Hill Claystone to underlying lithologies.

NRE-B and NE3 show a downward flow gradient through the stratigraphic profile.

Groundwater flow is toward the reservoir in the east of the lease, from the escarpment, whilst to the west, the regional flow is toward the Cataract River in the north and to Cataract Reservoir in the east.

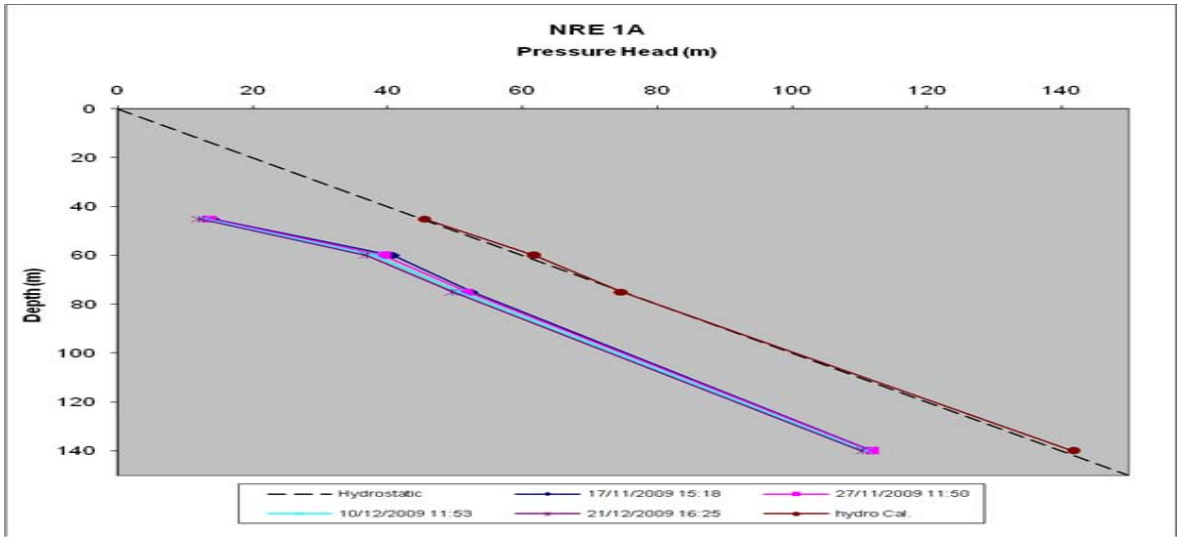
Table 13 Vibrating Wire Piezometer Details

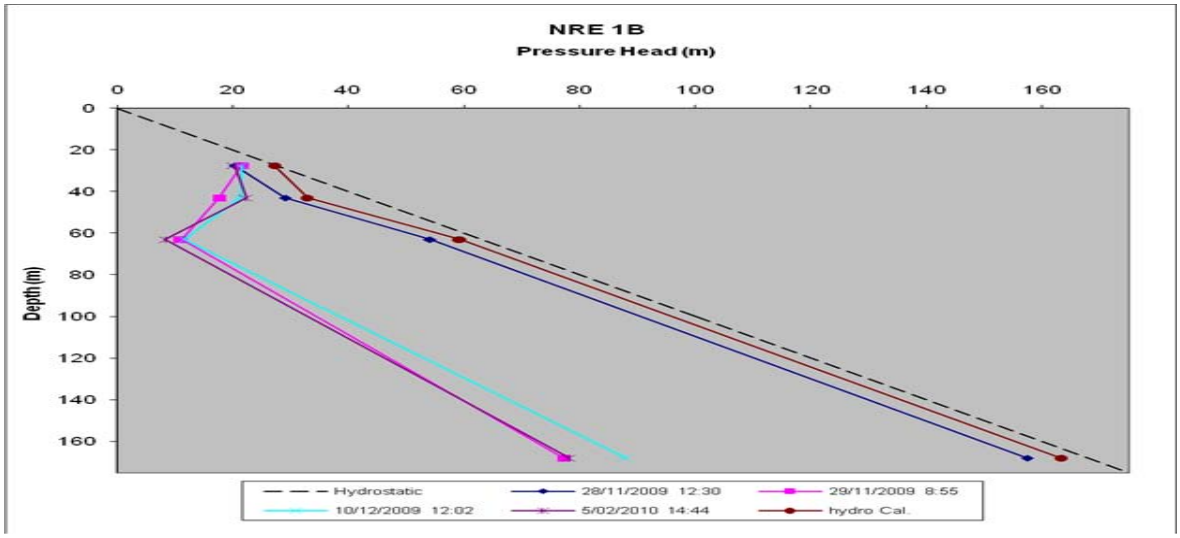
Piezometer Intake Depth (mbg)	Formation	Piezometer Intake Depth (mbg)	Formation
NRE-A		**NRE-B**	
45	Mid Hawkesbury Sandstone	**27.5**	Lower Hawkesbury Sandstone
60	Lower Hawkesbury Sandstone	**43**	Upper Bargo Sandstone
75	Upper Bulgo Sandstone	**63**	Mid Bargo Sandstone
140	Mid Bargo Sandstone	**168**	Stanwell Park Claystone
NRE-D		**NE-3**	
33	Mid Hawkesbury Sandstone	**100**	Mid Hawkesbury Sandstone
60	Lower Hawkesbury Sandstone	**130**	Lower Hawkesbury Sandstone
73	Bald Hill Claystone	**155**	Newport Formation
135	Mid Bargo Sandstone	**255**	Lower Bargo Sandstone

NOTES: mbg metres below ground

The head pressure versus depth plots shown in **Figures 24** and **25** indicate that:

- hydrostatic pressure is present in the overburden at NRE-A down to the upper Bulgo Sandstone with fluctuations in the upper piezometer intakes due to rain events. Limited response to rain events occurs in the Upper Bulgo Sandstone, beneath the Bald Hill Claystone;
- hydrostatic pressure is not present in the Hawkesbury Sandstone and Bald Hill Claystone, although resumes in the Bulgo Sandstone and Stanwell Park Claystone at NRE-B. The response of the intakes to rainfall is not available as a lighting strike destroyed the logger on February 5, 2010. The logger has since been repaired and replaced; and
- hydrostatic pressure is present in the Hawkesbury Sandstone NRE-D, and absent in and below the Bald Hill Claystone and mid Bulgo Sandstone, with very limited fluctuations in the upper piezometer intakes due to rain events. Limited response to rain events occurs in the Upper Bulgo Sandstone, beneath the Bald Hill Claystone.





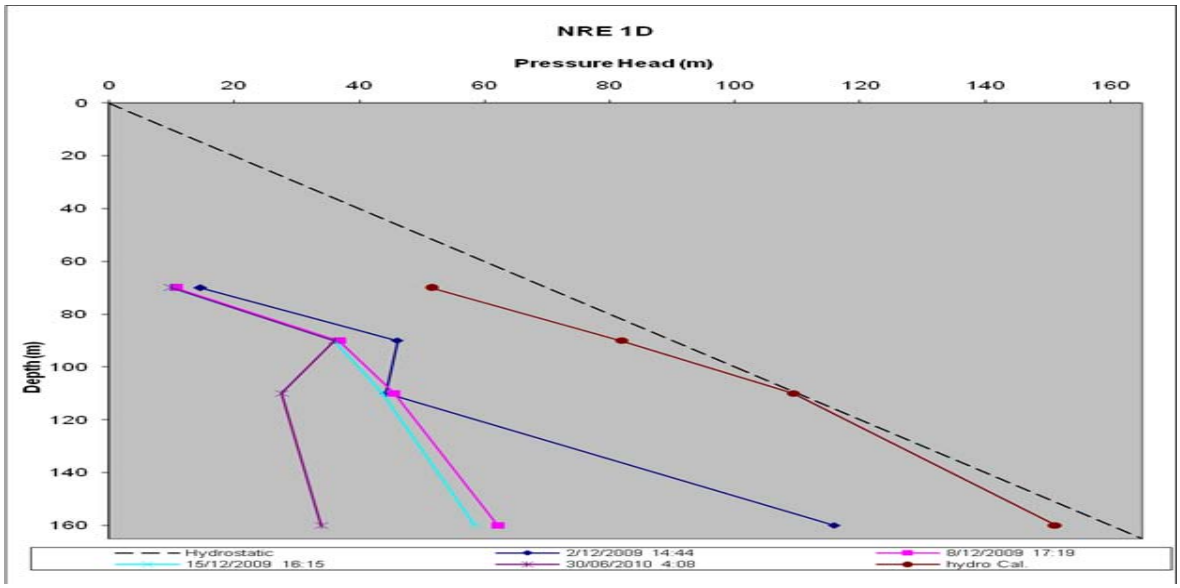
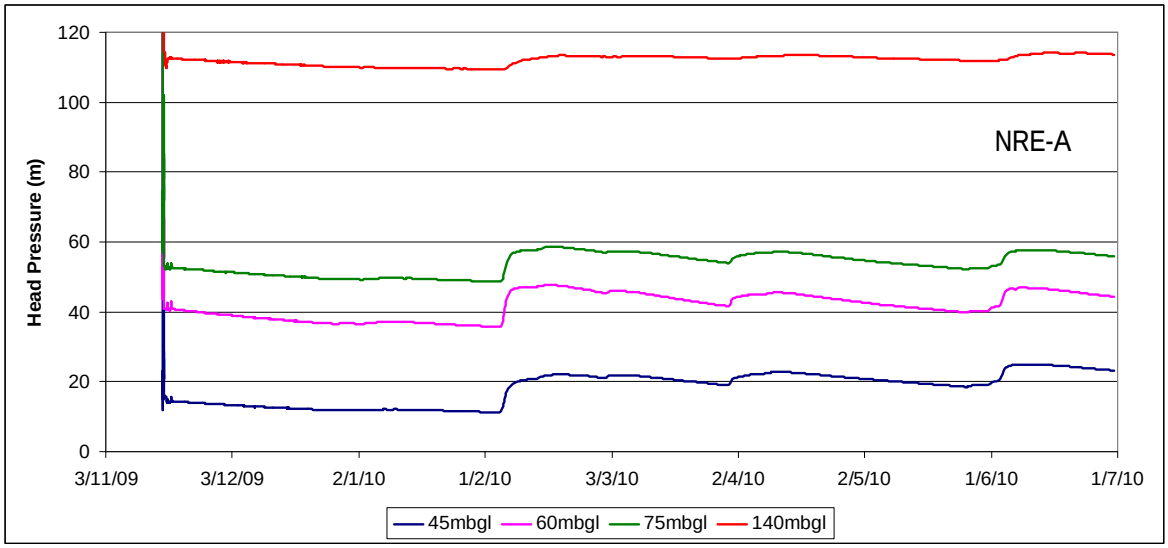
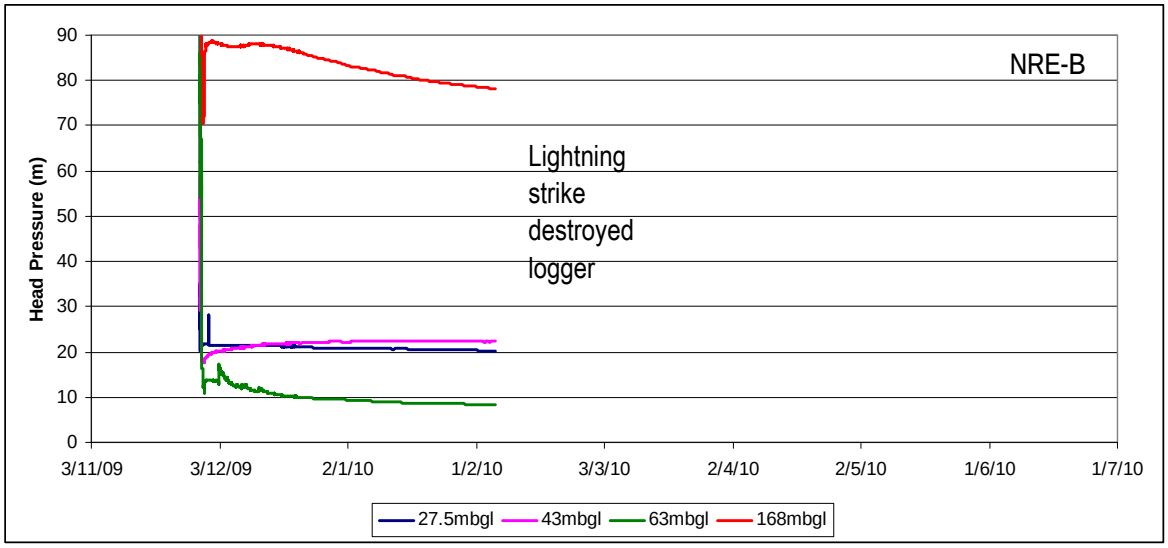


Figure 24 VWP Pressure Head Levels East of Cataract Reservoir





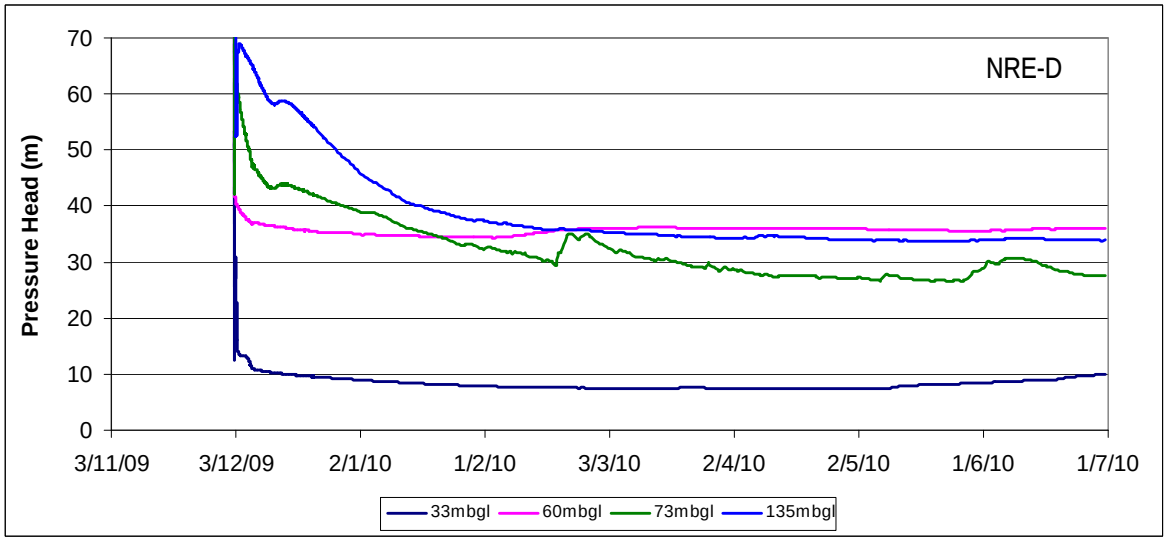


Figure 25 VWP Water Levels East of Cataract Reservoir

Figures 26 and **27** indicate that NE3, which is located to the west of the reservoir near the southern lease boundary, has hydrostatic pressure in the Hawkesbury Sandstone and Bald Hill Claystone, with a depressurisation between the Newport Formation and lower Bulgo Sandstone.

The NE3 piezometer intakes have limited response to rain events.

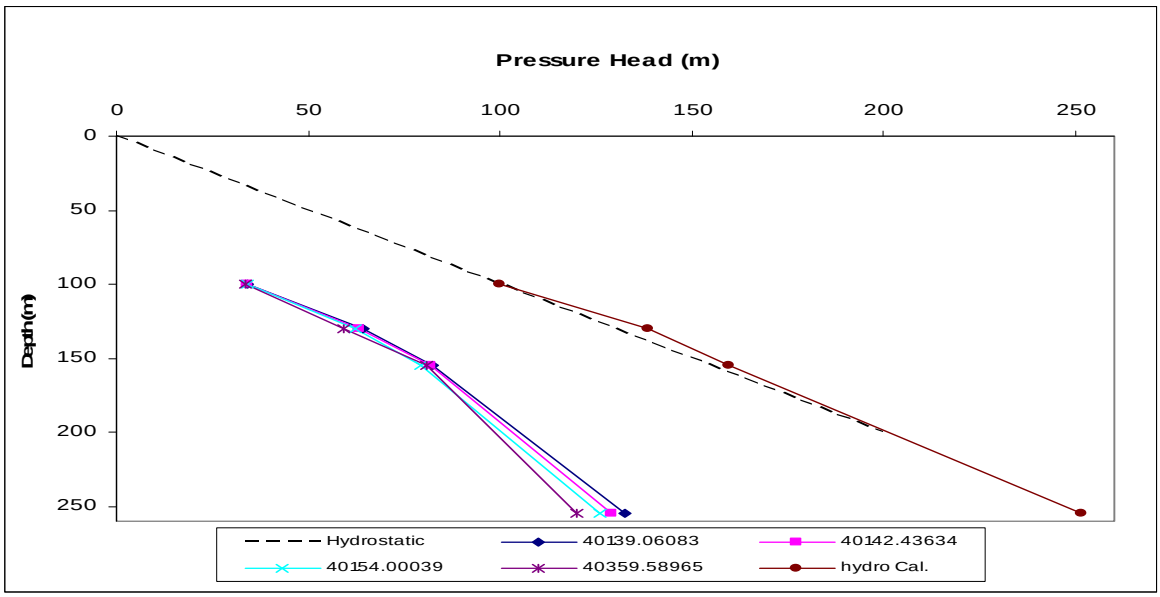


Figure 26 **NE3 VWP Pressure Head West of Cataract Reservoir**

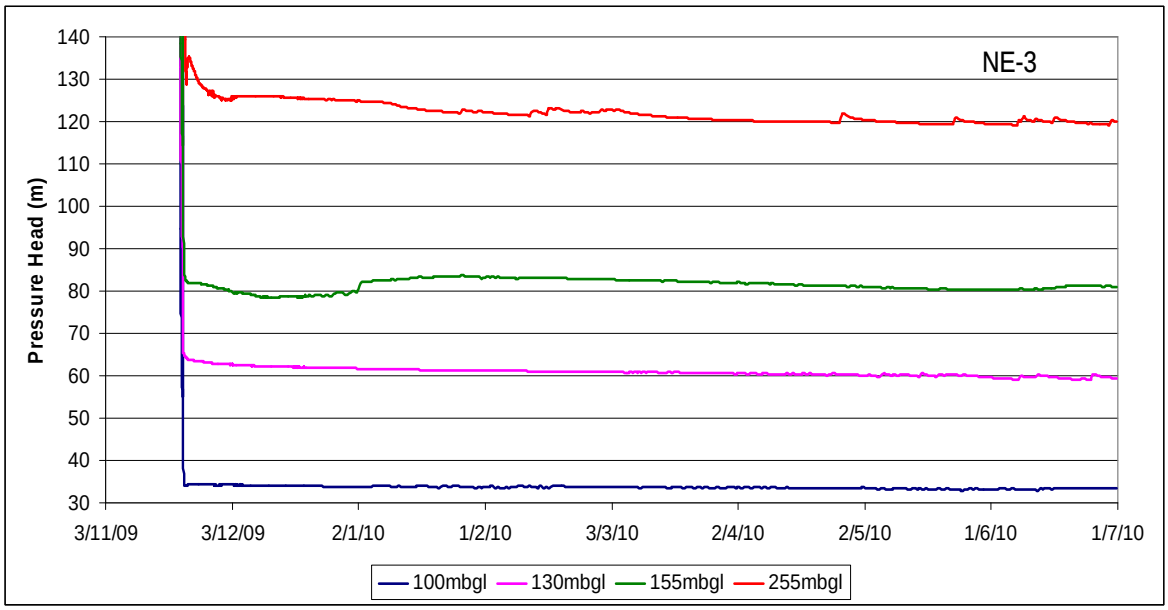


Figure 27 **NE3 VWP Water Levels West of Cataract Reservoir**

11.3 Groundwater Chemistry

11.3.1 General

Groundwater samples are collected, stored and despatched in accordance with AS/NZS 5667 (Standards Australia, 1998) whilst field water quality parameters are measured in the field using Hanna probes and meters which are freshly calibrated with two point pH buffers and EC standards bracketing the expected range, with results corrected to 25^0C.

Sampling of field water is conducted using appropriate decontaminated sample bottles supplied with appropriate additives and labelling as prescribed by NATA protocols. All plastic ware is decontaminated by storing in dilute acetic acid, with the equipment being thoroughly washed with distilled water prior to use. Field filtration is conducted with 0.45 micron filters.

The method of sampling, including the use of blanks and replicates, and analysis methods employed are in accordance with guidelines for sampling and analysis of water and pollutants i.e. (ANZECC, 2000b and DEC NSW, 2004). In all cases, analysis methods employed are those providing adequate limits of resolution as listed in DEC NSW, 2004.

11.3.2 Upland Swamps

Upland swamps in the Study Area have electrical conductivities ranging from 58 – 1121µS/cm, with the salinity varying in relationship to rainfall recharge that occurs prior to sampling, along with the degree of potential upwelling of brackish water from the underlying weathered Hawkesbury Sandstone.

The pH range from 4.23 to 6.01 indicates a longer term trend to becoming more alkaline as observed at P1 and P2 and as shown in **Figure 28**.

There is currently no geochemical differentiation between the headwater swamps (P1 - P5) and the valley fill swamp in Wallandoola Creek at P6.

Monitoring indicates the swamp salinity is generally within the acceptable range for potable water, however is outside the ANZECC 2000 South Eastern Australia Upland Stream criteria for pH and can be above the ANZECC 2000 95% Species Protection Level for Freshwater Aquatic Ecosystem Guidelines for the following parameters:

- filtered copper at P4 (0.003mg/L) and P5D (0.002mg/L);
- filtered zinc at P3 (0.014mg/L), P5U (0.024mg/L), P5D (0.019mg/L) and P6 (0.1mg/L);
- total nitrogen (0.7 - 32mg/L) at all sites; and
- total phosphorous (0.05 – 5.2mg/L) at all sites except P1, where it was less than 0.01mg/L.

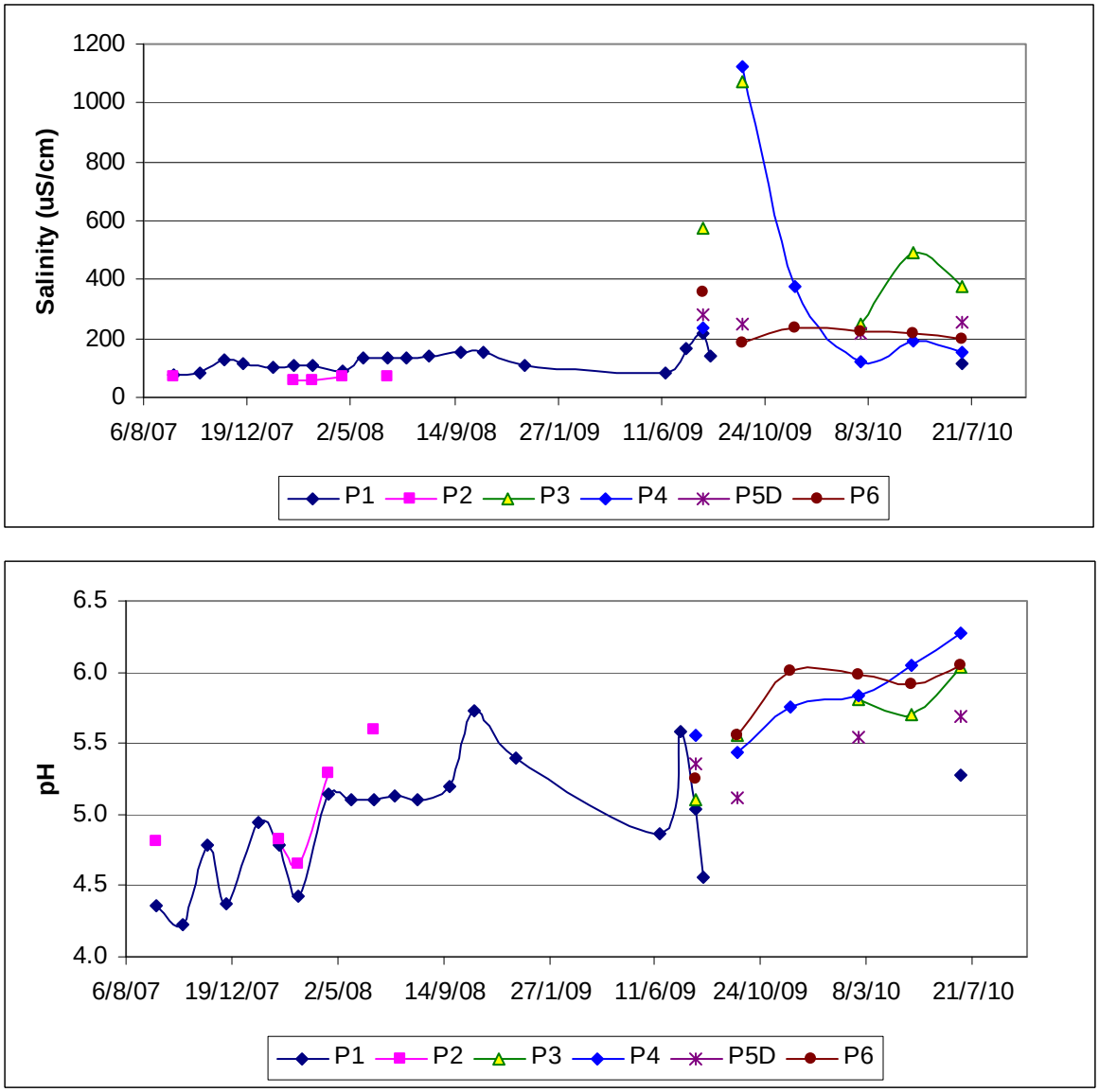


Figure 28 Upland Swamp Field Water Quality

11.3.3 Basement

To date, groundwater within the upper Hawkesbury Sandstone ranges from 106 - 420µS/cm with a pH from 3.37 - 5.45 as shown in **Figure 29**.

The moderate pH acidification and low salinity indicate meteoric rainfall recharge into the Hawkesbury Sandstone, with the salinity and pH range being typical of similar lithologies across the Southern Coalfields.

The shallow basement groundwater would be suitable for drinking after pH modification.

On the basis that the shallow groundwater discharges through seeps into the local streams, monitoring indicates the groundwater salinity is generally within the acceptable range for potable water. However, it is outside the ANZECC 2000 South Eastern Australia Upland Stream criteria for pH and can be above the ANZECC 2000 95% Species Protection Level for Freshwater Aquatic Ecosystem Guidelines for the following parameters:

- filtered copper at NRE-A (0.031mg/L), NRE-C (0.011mg/L) and NRE-G (0.051mg/L);
- filtered zinc at all open bores (0.021 - 0.54mg/L) except NRE-G;
- filtered aluminium at NRE-A (0.28mg/L), NRE-C (0.12mg/L) and NRE-G (0.25mg/L);
- total nitrogen at NRE-D (0.4mg/L) and NRE-G (1mg/L); and
- total phosphorous (0.03 - 0.51mg/L) at all sites except NRE-D and NE3.

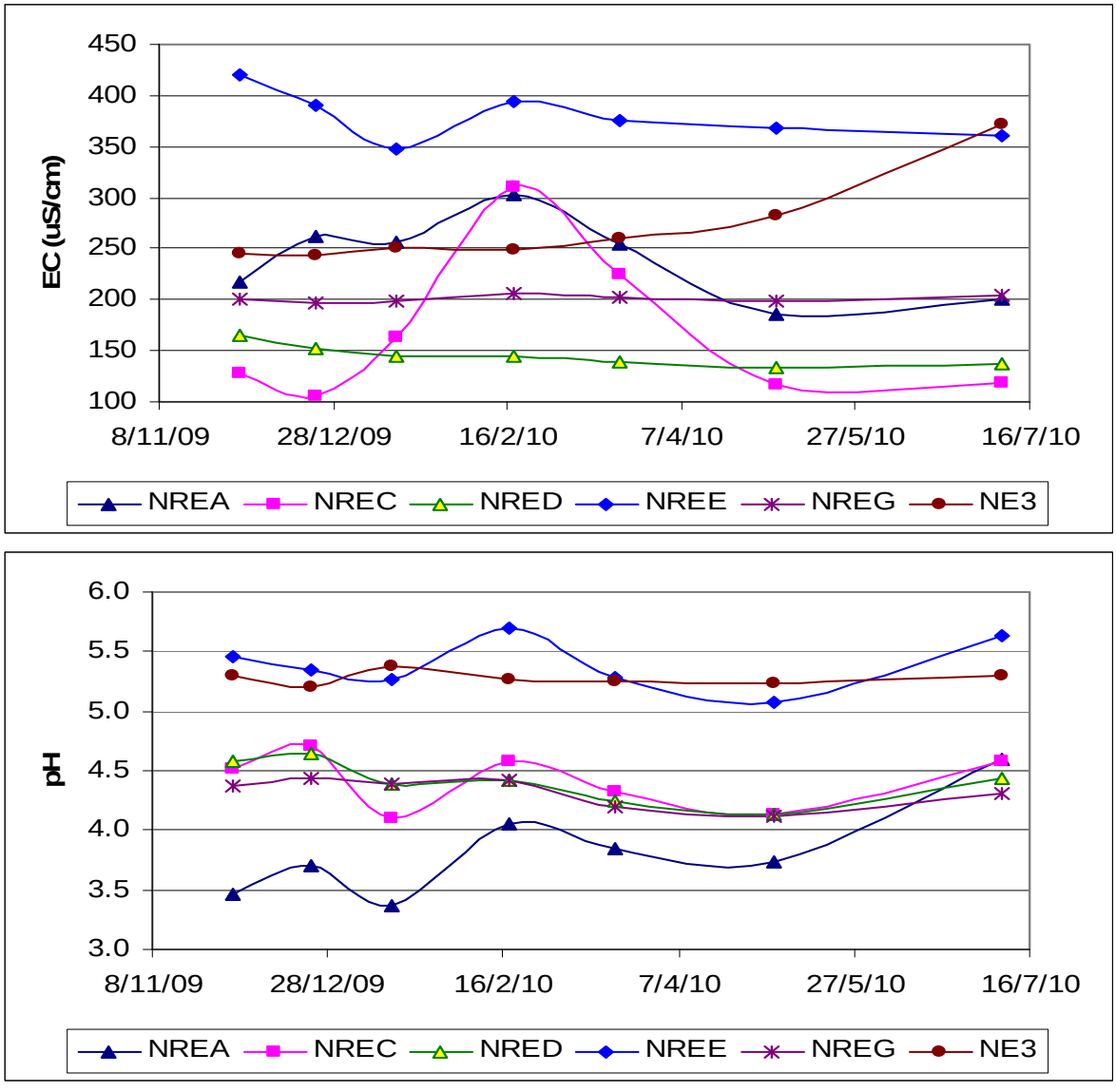


Figure 29 Upper Hawkesbury Sandstone Salinity and pH

12. PREDICTED SUBSIDENCE AND SUBSIDENCE IMPACTS

12.1 V Mains

The maximum subsidence after completion of V Mains, as determined by both the Holla and Barclay as well as the SDPS visualisation methods will be located over the middle to eastern portion of the Project Area (Seedsman Geotechnics Pty Ltd, 2008).

The 20mm subsidence is predicted to extend over the channel of Wallandoola Creek, and very marginally into Lizard Creek as shown in **Table 14** and **Figure 30**.

The goaf is predicted to be approximately 2km long and between 75m to 300m wide and is predicted to be located 165m south of the northern workings and 120m north of the Cordeaux longwalls.

TABLE 14 Maximum Predicted Subsidence

Parameter	V Mains
Vertical subsidence	1.02m
Horizontal Movement	0.43m
Tilt	6.1mm/m
Strain	-6.5 to 3.3mm/m

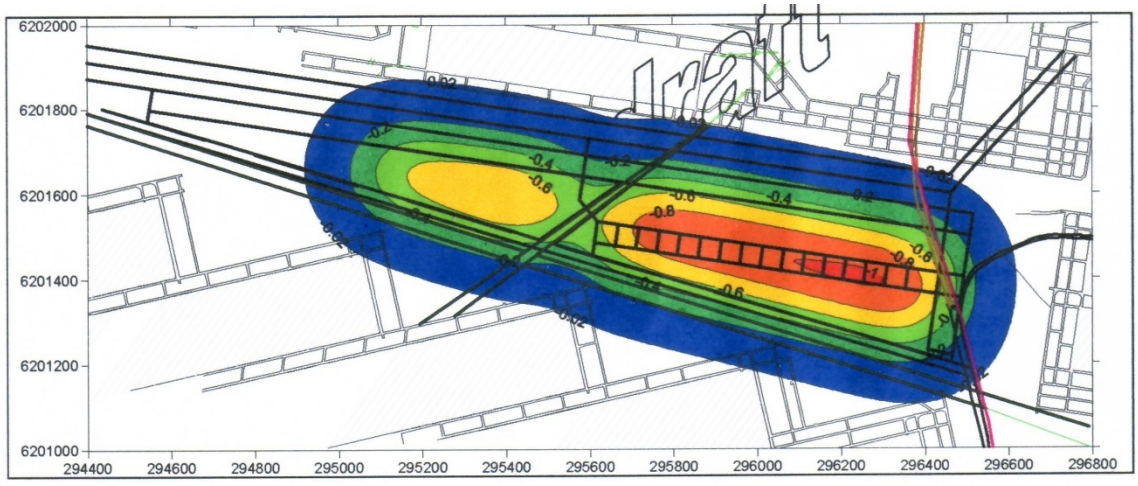


Figure 30 V Main Subsidence (Seedsman Geotechnics Pty Ltd, 2008)

It is predicted that surface subsidence above the narrower western portion of the goaf will not be measureable up to an extraction width of approximately 100m.

In the 200 series longwalls to the north of V Mains, no subsidence was measured with 190m wide panels and 35m wide chain pillars, whilst in the same layout to the north in the 300 series panels, 0.9m of subsidence was recorded. Mining in longwalls to the east of V Mains generated a maximum vertical subsidence of 1.1m for 155m wide longwalls with 30m wide pillars, whilst 205m wide panels in Cordeaux Colliery with 30m wide chain pillars generated 1.2 to 1.3m of subsidence (Seedsman Geotechnics Pty Ltd, 2008).

12.2 309 Panel and H Panel

Subsidence over Panel 309 is predicted to be less than 400mm with strains of between +/- 1mm/m due to the proposed pillar extraction.

12.3 H Panel, Longwalls 4 and 5 Gateroads, Wonga Mains Driveage, P & R Drifts

No observable subsidence, strains or tilts are predicted over the first workings in H Panel, Longwalls 4 and 5 gateroads, Wonga Mains Driveage or P & R Drifts.

12.4 Potential Subsidence Impacts

Potential geomechanical effects generated in the surficial Hawkesbury Sandstone due to generic subsidence can include:

- bending, delamination or lifting of discrete surface sheets of rock into an inverted V due to compression at right angles to the axis of the V, particularly above and immediately behind the active extraction area;
- horizontal stress concentration or mobilisation of natural horizontal stress, mainly in areas of localised topographic highs such as rock bars, with surface shearing, usually along bedding planes, or sliding of one sheet above the other with measurable horizontal and relative vertical displacement of the sheets;
- horizontal and low angle shearing, particularly in cross-bedded sandstone;
- isolated thin sheet shear and failure;
- tensile failure of upper beds, mainly perpendicular to the direction of compression;
- vertical hairline fracturing perpendicular to the axis of horizontal shearing, usually with significant horizontal opening up to several centimetres, but usually with short vertical penetration into the strata. The fracturing can be characterised by iron rich seeps that oxidise on exposure to the air. These seeps are a visible precursor to progressive fracturing in creek areas close to mining activity; and
- isolated fracturing or failure of slabs from underneath overhanging rock shelves where the slabs are located below bedding planes with minimal cohesion or tensile strength across the plane. The rock mass is usually subjected to axial compressive stress which breaks the slab into smaller fragments with insufficient friction to resist gravity.

Based on experience gained during longwall mining in other Southern Coalfield operations, mining under a creek, river valley or gorge can result in horizontal separation of strata in the base of the valley and redistribution of the existing horizontal stresses in the walls and base of the valleys. If the redistributed stress exceeds the bulk shear strength of the strata then relative horizontal shear produces uplift of the valley floor.

Localised weathering patterns may significantly influence the geometry of deformation.

13. POTENTIAL SURFACE WATER IMPACTS

The potential subsidence effects on the surface water environment over the secondary extraction areas of V Mains and Panel 309 are discussed in the fllowing sections.

Due to the lack of subsidence over the proposed first workings of H Panel, Wonga Mains, P & R Drifts and the gateroads of Longwalls 4 and 5, no adverse impacts are anticipated on the parameters discussed in the following sections.

13.1 Stream Flow

13.1.1 Wallandoola Creek

Based on the predicted 0.8m of subsidence, 3.3 - 6.5mm/m of strain and the highly vegetated and sediment covered nature of the valley fill swamp Wcvfs1 stream bed and banks, it is assessed there will be no observable loss of stream flow over V Mains in Wallandoola Creek.

If stream flow diversion does occur, it could manifest through leakage from the base of the swamp, with transfer to shallow, ephemeral, groundwater systems within 10m of the stream surface.

No observable surface water flow depletion has been recognised over previously subsided valley fill swamps in the lease area, and any loss that may occur would be mitigated by the plastic nature of the saturated, weathered sandstone substrate and the high organic sediment cover in the creek.

Based on observations in similar topography to the V Mains area, where there are no gorges or cliffs, the cracked zone depth can extend up to 10m into the bedrock. If cracking is located directly beneath the stream, and as the zone is not anticipated to be hydraulically connected to lower stratigraphic bedrock horizons, based on extrapolation of observations in similar environments, stream flow into the cracks, if it occurs, will re-emerge downstream of the compressional strain zone.

Subsidence cracks are not predicted, however if these did develop, water flow to the new voids may occur as subsidence sequentially develops in the stream valley, with the rate of inflow controlled or modified by the:

- time frame of uplift;
- location of uplift;
- depth and width of cracking in the bedrock; and
- degree of filling in cracks with sediment.

Any modification of stream flow can affect the function and integrity of ecological systems, whilst enhanced recharge from streams to shallow ephemeral aquifers can raise the groundwater table and potentially dry up restricted portions of a stream. As no observable changes to stream flow are anticipated, there will also be no observable ecological changes, particularly in the ephemeral tributary streams.

No significant, observable uplift is predicted within the channel of Wallandoola Creek.

13.1.2 Lizard Creek

Due to the approximate 20mm or less of predicted subsidence, along with low strains and low tilts, no observable loss in stream flow is anticipated in Lizard Creek adjacent to V Mains or in the first order tributary overlying Panel 309.

The proposed mining is anticipated to have a negligible impact on stream flow in the Wallandoola Creek or Lizard Creek catchments.

13.2 Stream Water Quality

Due to the less than 0.8m of predicted subsidence and low associated strains and tilts, along with the lack of observed adverse effects from stream bed cracking due to previous subsidence of up to 1.3m on stream flow and valley fill and headwater upland swamps in the Gujarat and Cordeaux lease areas, it is not anticipated that an observable adverse effect on water quality will occur due to coal extraction and subsidence over the proposed V Mains or Panel 309 mining areas.

Water quality in Wallandoola and Lizard Creeks has historically been highly variable, although is generally outside the ANZECC 2000 (95% protection of aquatic species) trigger level for pH, with Wallandoola Creek ranging from 3.35 to 6.16 and Lizard Creek ranging from 2.50 to 8.5, based on available data.

Filtered zinc generally also exceeds the ANZECC 2000 criteria, ranging from 0.003mg/L to 0.054mg/L in Wallandoola Creek and from <0.001mg/L to 0.065mg/L in Lizard Creek.

To date, filtered nickel has not exceeded the ANZECC 2000 criteria in either stream, whilst filtered aluminium generally does not exceed criteria (based on pH >6.5, which is currently unspecified, although would be significantly lower for pH<6.5), although can reach up to 0.07mg/L in Wallandoola Creek and 0.11mg/L in Lizard Creek.

Total nitrogen and to a lesser degree, total phosphorous can also exceed the ANZECC 2000 criteria due to the large variability of runoff in the catchment.

If additional adverse groundwater seepage to the Wallandoola Creek or Lizard Creek tributaries was to occur, it would be significantly diluted, with the resultant lowering of parameter concentrations in the stream at the point of emergence. This assumes, however that the possible discharge occurs at an isolated identifiable location in a stream, whereas it is equally possible that the seepage may be disseminated at various points along a stream depending on the subsidence induced flow regime, with the resultant additional enhanced dilution, precipitation and adsorption effects described above.

The proposed mining is anticipated to have a negligible impact on stream water quality in the Wallandoola Creek or Lizard Creek catchments.

13.3 Cataract Reservoir and Broughtons Pass Weir Pool

It is considered highly unlikely there would be an adverse effect on the water quality in Catarct Reservoir or the SCA offtake at Broughtons Pass Weir due to the proposed mining.

The proposed mining is anticipated to have a negligible impact on Cataract Reservoir or Broughtons Pass Weir pool.

As it will be mined with first workings only, with no associated subsidence, tilt or strain observed at surface or under the Cataract Reservoir, no adverse effects will occur on Cataract Reservoir due to extraction of H Panel.

13.4 Stream Bed and Bank Stability

A subsidence trough of up to 1.02m deep may develop between, as opposed to within, the Wallandoola and Lizard Creek channels (Seedsman Geotechnics, 2008), whilst the Lizard Creek tributary over Panel 309 will have a less than 400mm deep subsidence trough.

As strains along the watercourses are predicted to be less than 3.3mm/m tensile, with compressive strains less than 6.5mm/m, the creek may experience minor ground movement due to subsidence at V Mains (Seedsman Geotechnics, 2008).

Due to the lack of significant exposed sandstone in the stream beds over V Mains and Panel 309, and if in the extreme case, only minor fracturing of any exposed bedrock and the highly vegetated riparian soil banks in the stream valleys occurs, it is not anticipated that any observable adverse effects on the stream bed or bank sedimentation regime will be observed.

The low degree of subsidence, and the low associated tilts and strains are anticipated to have a negligible impact on stream bed or bank stability in the Wallandoola Creek or Lizard Creek catchments.

13.5 Stream Pools

Although the maximum predicted tilt of 6.1mm/m within V Mains exceeds the stream bed gradient of 0.8mm/m, the tilt would be oriented perpendicular to the reach of the stream, and therefore it is not anticipated that subsidence will oppose the stream gradient and that surface water pondage will not be adversely affected in terms of pool volume or retention time.

The predicted tilts are anticipated to have a negligible impact on stream pools in the Wallandoola Creek or Lizard Creek catchments.

13.6 Upland Swamps

Coal mining and the associated maximum 1.02m of subsidence is not anticipated to directly have an adverse observable effect on the valley fill swamp Wcvfs1.

Swamps, however, can also be affected by variations in factors such as the geomorphic, hydrological, physical and biological processes in effect at the time of undermining, along with the climatic conditions at the time of, and subsequent to, subsidence.

Low water tables during extended dry periods, erosion in localised areas, the effect of bushfires and changes in sediment transport can all adversely affect upland swamps.

The predicted extraction of V Mains is anticipated to have a negligible impact on valley fill swamp Wcvfs1.

13.7 Gas Emissions at Surface

The dilation in the strata immediately beneath the base of a stream due to valley bulging is restricted to the shallow surface strata, up to 20m below the surface and does not provide a direct conduit for the release of gases from underlying, deeper strata.

Emission of gases at the surface is not, normally, a major issue, as the emissions are short lived events and the consequences are generally minor and readily managed.

Due to the previous extraction of the Bulli Seam and the associated subsidence and overburden cracking that may have previously occurred, the proposed secondary extraction of V Mains and Panel 309 are anticipated to have a negligible impact on potential gas emmissions in the Wallandoola Creek or Lizard Creek catchments.

13.8 Potential Surface Water Impacts Summary

Based on the knowledge gained from previous stream monitoring at NRE No.1 and similar coal mines in the Southern Coalfields, the potential effects of subsidence on the surface water system in the NRE No.1 study area is summarised in **Table 15**.

Table 15 Potential Surface Water Impacts Summary

UPLAND SWAMPS
No adverse water level, water seepage or water quality effects on valley fill swamp Wcvfs1
STREAM FLOW
Negligible adverse loss or diversion of stream flow in Wallandoola Creek over swamp Wcvfs1 or in the first order tributary of Lizard Creek over Panel 309. *No impact on streams and tributaries overlying H Panel, Wonga Mains, P & R Drifts and Longwalls 4 and 5 gateroads*
STREAM WATER QUALITY
Negligible adverse impacts on stream water quality in Wallandoola Creek over swamp Wcvfs1 or in the first order tributary of Lizard Creek over Panel 309. *No impact on streams and tributaries overlying H Panel, Wonga Mains, P & R Drifts and Longwalls 4 and 5 gateroads*
CATARACT RESERVOIR AND BROUGHTONS PASS WEIR POOL
No impact on Cataract Reservoir or Broughtons Pass Weir pool water levels, water storage or water quality from the proposed workings
STREAM BED AND BANK STABILITY
No impacts on stream bed and bank stability on streams and tributaries overlying the proposed workings
STREAM POOLS
No impacts on the natural drainage behaviour stream pools overlying the proposed workings
GAS EMISSIONS
No gas emissions at surface over the proposed workings

14. POTENTIAL GROUNDWATER IMPACTS

The potential groundwater system impacts over the secondary extraction areas of V Mains and Panel 309 are discussed in the following sections.

Due to the lack of subsidence over the proposed first workings of H Panel, Wonga Mains, P & R Drifts and the gateroads of Longwalls 4 and 5, no adverse impacts are anticipated on the groundwater system parameters discussed in the following sections.

14.1 Aquifer / Aquitard Interconnection

From piezometer monitoring observations at NRE No.1 and Bulli Colliery, as well as across the Southern Coalfield, it is assessed that hydraulic connection of surface water, shallow perched or the regional Hawkesbury Sandstone aquifers through the Bald Hill Claystone into the underlying aquifers, or the mine workings will not occur above the proposed V Mains or Panel 309 workings.

Mining induced cracking and vertical subsidence of strata over the extraction area can, however, occur in the upper 20m below surface, along with bedding dilation, increased secondary porosity and increased horizontal permeability, without a significant increase in vertical permeability and vertical connectivity below the 20m deep tensional zone to around 100 - 150m below surface.

In the upper 20m, subsidence can alter the pre-mining horizontal flow along or above aquitards to generate a combination of vertical and horizontal flow regimes as aquitards are breached and water drains from higher to lower strata.

Vertical flow continues down the strata until the drainage is restricted by intact aquitards, at which point the flow then resumes its horizontal dominance.

Below the surface 20m deep cracked zone, an increased horizontal flow component can occur due to dilation and bending of strata, even though the layers are not actually breached by vertical cracking. The increased horizontal permeability extends across the subsided area, gradually diminishing as the subsidence and dilation decreases out to the edge of the subsidence zone.

No adverse interconnection of regional aquifers and aquitards is anticipated within 20m of the plateau surface as there are no recorded aquifers in this interval, however there may be an increased rate of recharge into the shallow overburden following rainfall due to the increased secondary porosity and permeability of the cracked sandstone / shales.

This can either result in higher discharge volumes and duration of temporary rain dependent seeps along cliff lines or higher recharge rates to underlying aquifers. The resultant enhanced seepage or vertical recharge patterns depend on which preferential flow path, or paths, develops.

Due to the previous extraction of the Bulli Seam and the associated subsidence and overburden cracking that may have previously occurred, the proposed secondary extraction of V Mains and Panel 309 are anticipated to have a negligible impact on potential gas emmissions in the Wallandoola Creek or Lizard Creek catchments.

14.2 Groundwater Levels

14.2.1 Upland Swamps

Based on the lack of observed adverse effects on water levels and water holding capacity within previously undermined valley fill and headwater swamps at NRE No.1 Colliery, with similar or higher levels of subsidence to that proposed for the extraction of V Mains, it is anticipated that there will be negligible adverse effect on the valley fill swamp WCvfs1 due to mining V Mains.

No swamps overlie the proposed Panel 309 extraction area.

14.2.2 Regional Groundwater

Temporary lowering of the regional piezometric surface over the V Mains and Panel 309 subsidence area due to horizontal dilation of strata may occur due to the increase in secondary porosity and horizontal permeability within the Hawkesbury Sandstone. This effect will be more notable directly over the area of greatest subsidence and dilation, and will dissipate laterally out to the edge of the subsidence zone.

Based on similar observations at NRE No.1 Colliery and across the Southern Coalfields, regional groundwater levels may reduce by up to 15m, and may stay at that reduced level until maximum subsidence develops at a specific location. The duration of the reduced levels depends on the time required to develop maximum subsidence, the time for subsidence effects to migrate away from a location as mining advances to subsequent panels and the time required to recharge the secondary voids.

The degree of groundwater level decline due to subsidence is significantly affected by rainfall recharge to an aquifer. On the basis that the pre mining circumstances of rainfall recharge remain the same, it is anticipated that groundwater levels will recover over a few months as the secondary void space is recharged by rainfall infiltration.

Permanent post mining reduction in water level in the Hawkesbury Sandstone is not anticipated as no new outflow paths from the subsidence area are anticipated as the subsidence areas are not within any eroded gorge sections of the creeks.

14.3 Seepage and Baseflow From Swamp Wcvfs1 to Wallandoola Creek

Lowering of intermittent, perched water levels within the valley fill swamp Wcvfs1 may occur after extraction of V Mains through cracking of the underlying weathered sandstone.

Cracking could enable the pre-mining swamp water level to infiltrate into the underlying sandstone substrate. The current swamp water level observed in P6 is highly variable, and is directly related to rainfall, recharge and the degree of water flowing along Wallandoola Creek, through the swamp.

Based on observation of previously undermined swamps at NRE No.1 and across the Southern Coalfield, it is not anticipated that the seepage volume, duration or baseflow to Wallandoola Creek will be adversely affected.

The proposed secondary extraction of V Mains is anticipated to have a negligible impact on groundwater seepage and baseflow contribution to Wallandoola Creek in valley fill swamp Wcvfs1.

14.4 Stream Flow and Groundwater Interaction

No significant change due to extraction of the proposed workings to groundwater inflow or outflow, to or from Wallandoola Creek over V Mains or the first order Lizard Creek tributary over Panel 309, is anticipated to occur on the basis that the:

- proposed secondary extraction of V Mains and Panel 309 are for relatively small areas which will be mined by pillar extraction, as opposed to longwall mining. The Bulli Seam has already been depressurised by the adjoining Gujarat and BHPB longwalls, first workings and pillar extraction areas;
- minor depressurisation that occurs over the proposed workings will not be transmitted to surface and will not have a depressurisation effect on the overlying streams due to the greater than 460m depth of cover; and
- mining as proposed is predicted to generate constrained deflection, without failure deformation, of the Bulgo Sandstone. On this basis, hydraulic fracture connection from the Bulgo Sandstone to the Hawkesbury Sandstone, through the Bald Hill Claystone is not predicted. This means that connection of the surface water system to the mine workings is not anticipated.

Although hydraulic connection from the surface to seam is not predicted through the Bald Hill Claystone, aquifer inter-connection may be enhanced by the predicted subsidence within the shallow surficial aquifer (<20m below surface) and within the goaf zone up to the mid Bulgo Sandstone.

Surface water drainage from the plateau to the local streams in the Study Area is through ephemeral first and second order gullies. The smaller gullies discharge into the major streams from elevated stream beds after sufficient rain, whilst the majority of rain would infiltrate into the plateau and swamp soils and weathered sandstone.

Recharge to the shallow, and subsequently the deeper regional groundwater system, would occur over an extended delay of months to years. It would occur after the meteoric water has soaked through the plateau's soil and bedrock, with the majority of water discharging from temporary seeps in the swamps and creek beds along the preferential horizontal flow regime in the Hawkesbury Sandstone.

The predominantly horizontal flow regime and restricted vertical recharge is essentially determined by the;

- horizontally bedded strata with preferential flow along bedded zones with coarser grain size,
- claystone/mudstone banding at the base and tops of sedimentary facies which restrict vertical migration and enhance horizontal flow at the base of the more porous unit,
- fracture zones enhancing horizontal flow through the strata, and;
- bedding planes or unconformities located immediately above finer grained sediments or iron rich zones.

Based on interpretation of the paired swamp / upper Hawkesbury Sandstone aquifer drilling and water level monitoring studies at swamp Lcvfs1, groundwater within the plateau over Panel 309 and at swamp Wcvfs1 is assessed to occur as a "losing – disconnected" system. Further downstream, in the incised main channels of Lizard and

Wallandoola Creeks, “gaining – disconnected, or “gaining – connected” ” systems dominate where surface water flows down gradient under gravity to a local main stream bed, and then under gravity along the stream beds to the Cataract River Creeks.

Groundwater seepage to the local streams can occur at isolated iron stained seeps along the creek beds, downgradient of WCvfs1 and Panel 309, where low volume and variable duration seeps discharge for a few days to weeks after significant rainfall. The seeps are generally located at the interface between coarser and underlying finer sandstone or shale layers which restrict vertical flow through the bedrock and enhance lateral flow. Most observed seeps in the local streams are anticipated to flow at less than 1L/sec.

The current interaction between surface water, perched and regional groundwater systems is postulated to be that pre-mining conditions prevail such that in wet periods there is a net contribution of groundwater to the surface system, while in dry conditions there is a net loss of surface water, with the resulting surface flow depending on the relative balance between seepage inflow and outflow.

This balance is expected to vary along the length of the streambeds, and to vary between the “losing – disconnected”, “gaining – disconnected” and “gaining – connected’ stream reaches along both Lizard and Wallandoola Creek catchments.

The surface water and shallow groundwater system is currently hydraulically isolated from the Bulli Seam workings by at least 460m of overburden at V Mains and Panel 309. At present there are two potential aquifer systems following subsidence over the Bulli Seam workings, with an upper subsidence fractured unit in the Hawkesbury Sandstone to approximately 20m below surface, which migrates into a higher permeability, although not vertically connected section in the lower Hawkesbury Sandstone, and a lower system beneath, and seperated by, the Bald Hill Claystone.

A potential change in groundwater seepage and stream baseflow resulting from the effects of subsidence, valley closure and uplift in the base of a valley which increases permeability and the interconnection between the stream bed and banks is schematically shown in **Figure 31**.

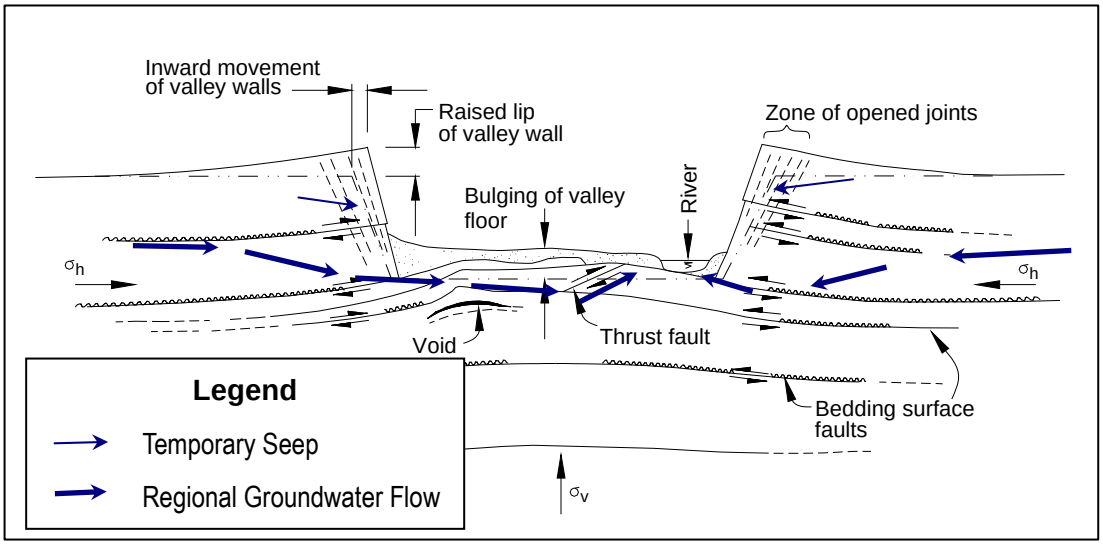


Figure 31 **Schematic Effects on Groundwater Systems** (MSEC, 2006)

14.5 Potential Inflow to Mine Workings

Based on the low permeability of the Bald Hill Claystone and Stanwell Park Claystone aquitards both pre and post mining and the lack of observed water inflow changes to NRE No.1 and other similar Southern Coalfield mines, it is assessed there would be no discernible flow into the proposed workings, even though movement of rock and fracturing will occur in the overburden through;

- fracturing and localised shear on joints and bedding in cliff lines and valley slopes,
- shear on bedding planes at the valley floor,
- subsidence and uplift of the valley floor,
- localised buckling and uplift of blocky strata in the stream bed through horizontal thrusting, and
- fracturing and yield failure of the strata extending up to 150m above the workings, with strata above this zone remaining intact and subsiding by inter laminar shearing on bedding planes.

Loss of stream flow or groundwater to the underlying workings has not been observed in any mines in the Southern Coalfield at similar depths of cover to the proposed V Mains or Panel 309 secondary workings.

Vertical hydraulic connection to the workings is restricted by the Bald Hill Claystone aquitard, which is not breached after subsidence as it is from 150m to 200m below the surface and significantly below the depth of surface cracking and overburden bedding dilation.

The horizontal permeability above the claystone may be enhanced after subsidence, however there is no additional vertical connectivity through the claystone, with the groundwater systems above and below the Claystone remaining separate.

Interpretation of field test data for the Reynolds enquiry (Reynolds, 1977) indicated that vertical flow through the stratigraphy could occur, however it would be too small to measure, with flow in the strata over the workings dominantly in the horizontal direction.

A minimum thickness of unfractured overburden is required to maintain hydraulic separation between a mine and saturated aquifers, with the critical value depending on lithology, structure and topography. The minimum separation has been established through observation and research in NSW mines as ranging from less than 90m up to 150m. The separation distance over V Mains and Panel 309 is well in excess of 150m, where the depth of cover is around 460m.

The Bald Hill Claystone aquitard is situated around 185m to 205m below the plateau, with the upper groundwater system above the claystone being separated from the underlying hydrogeological system.

The shallow, horizontal flow dominated system can discharge into the valley floor or have localised flow through mining induced shear zones on bedding planes at the base of the valley.

14.6 Groundwater Quality

Observations at NRE No.1, and generally across the Southern Coalfields, indicate that groundwater quality within the Hawkesbury Sandstone or upland swamps has not been adversely affected, however there may be increased iron hydroxide precipitation and a lowering of pH if the groundwater is exposed to “fresh” surfaces in the strata with dissolution of unweathered iron sulfide (marcasite).

The degree of iron hydroxide and pH change is difficult to predict, and can range from no observable effect to a distinct discolouration of the Hawkesbury Sandstone groundwater. It should be noted that the sandstone aquifer at NRE No.1 already has significant iron levels.

Acidity (pH) changes of up to 1 order of magnitude may occur, however the change will be reduced where the aquifer has sufficient bicarbonate levels.

Subtle changes may occur with regard to dissolved aluminium, nickel, zinc, iron or manganese levels through oxidation and dissolution of iron sulfide (marcasite) or iron carbonate (siderite) following localised subsidence induced fracturing within the aquifer.

Due to observation of piezometers installed over previous extraction areas in the Bulli Seam at NRE No.1, the proposed secondary extraction of V Mains and Panel 309 is anticipated to have a negligible impact on groundwater quality in the valley fill swamp Wcvfs1 and the regional Hawkesbury Sandstone aquifer.

14.7 Potential Groundwater Impacts Summary

Based on the knowledge gained from the coal exploration drilling, piezometer installation and geotechnical investigations as well as groundwater level and groundwater quality monitoring conducted to date, the potential effects of subsidence on the groundwater system in the study area is summarised in **Table 16**.

The summary is derived through observation of prior subsidence effects at NRE No.1 as well as experience of subsidence on groundwater systems in similar longwall mining situations.

Table 16 Potential Groundwater Impacts Summary

UPLAND SWAMPS
Negligible adverse water level, water seepage or water quality effects on valley fill swamp Wcvfs1
SHALLOW TO MID HAWKESBURY SANDSTONE
Temporary lowering and subsequent recovery of the phreatic surface by up to 15m, with no observable adverse change to water quality, which will be tempered by the existing depressurisation regime from previous mining
DEEP HAWKESBURY SANDSTONE
Temporary lowering and subsequent recovery of the phreatic surface, with no observable adverse change to water quality, which will be tempered by the existing depressurisation regime from previous mining effects
BALD HILL CLAYSTONE
Due to insufficient deflection of the Bulgo Sandstone, the Bald Hill Claystone is predicted to remain intact and as a result, there will be no predicted hydraulic interconnection, or loss of surface water / Hawkesbury Sandstone groundwater into the mine workings
NARRABEEN GROUP AND ILLAWARRA COAL MEASURES
Hydraulic interconnection and depressurisation of the sedimentary overburden under the Bald Hill Claystone up to the mid Bulgo Sandstone, which will be tempered by the existing depressurisation from previous mining
Potential iron hydroxide precipitation and acidification of the interstitial water due to oxidation in aerated groundwater in the sedimentary overburden
MINE INFLOWS
Negligible change to mine inflows as the Bulli and Wongawilli Seam overburden is already depressurised.

15. WATER MONITORING AND MANAGEMENT

A Water Monitoring and Management Plan incorporating detailed provisions for surface water and groundwater data collection, interpretation and reporting has been incorporated into the V Mains Subsidence Management Plan (SMP).

The proposed monitoring and data interpretation is considered best practice for the detection of surface water and groundwater impacts of subsidence within stream beds and the broader sub-catchments, as well as in the shallow and deeper (regional) groundwater systems.

A key aspect of the Plan will deal with the early detection and assessment of subsidence (or uplift) effects within the subject streams and groundwater systems using properly sampled and analysed geochemical and physical data to provide early indication of any subsidence related surface water or groundwater effects.

15.1 Stream Pools

Daily automated monitoring of open standing or pool water depths should be conducted and compared to rainfall in the local area at monitoring sites WC1, WC2 and WC3, which are located upstream, within and downstream of the proposed V Mains 20mm subsidence area.

Monitoring should assess the inputs from catchment runoff and any flow variations within the Study Area before, during and after the V Mains extraction period.

The collected data should review any observable changes that develop, and, subsequently develop a plan to manage any adverse issues, if appropriate.

Due to the lack of suitable monitoring sites over V Mains (as it is a swamp), and due to the ephemeral nature of the tributary over Panel 309, no volumetric flow monitoring will be logistically feasible.

No stream pool monitoring is recommended over Panel 309 as it underlies an ephemeral, first order tributary of Lizard Creek.

No stream pool monitoring is recommended over the proposed first workings as there is predicted to be no subsidence at surface over the first workings.

15.2 Stream Water Quality

Appropriate water quality monitoring should be conducted in both Wallandoola and Lizard Creeks upstream, within and downstream of the Study Area at WC1, WC2 and WC3, as well as LC2, LC3 and LC4 is recommended during the period of extraction, with suitable monitoring in the period before extraction begins.

Water quality related field studies should concentrate initially on regular visits to main channel sites that would be monitored for identifiable inputs from catchment runoff and for all key water quality parameter variation for the duration of mining and for an appropriate period following mining.

Monitoring should be conducted for the following parameters:

- Field pH, electrical conductivity, dissolved oxygen, oxidation / reduction potential and temperature;
- total dissolved solids (TDS);
- Na / Ca / Na / K / SO4 /Mg / Cl / F;
- total alkalinity;
- dissolved organic carbon (DOC);
- total / filterable Fe, Mn, Al;
- filterable Ni, As, Li, Ba, Sr, Cu, Pb, Zn; and
- total nitrogen (TN) and total phosphorous (TP).

Stream water level and sampling should be conducted at all locations on the same day. All samples should be collected in appropriately cleaned and prepared equipment, stored in appropriately cleaned and rinsed sample containers, then transported and analysed according to ANZECC 2000 standards, with 0.45µm filtering and nitric acid preservation to <pH2 for metals samples.

Trigger values for selected pollutants of concern should be set within the context of a Triggers Action Response Plan (TARP) after one year of full data is collected, and where the values are exceeded, the cause and effect of the exceedance should be investigated and a management plan developed if the cause is directly related to mining.

Initial TARPs for the V Mains area would be a pH decline of between 1.5 and 2.0 pH units, an electrical conductivity increase of between 50 µS/cm and 100 µS/cm and an oxidation reduction potential declines from between 150mV and 200 mV.

These would be reviewed following collection of additional baseline data prior to extraction, and additional water quality monitoring sites may need to be established as the monitoring program progresses.

15.3 Stream Bed and Bank Stability

The stream bed and banks are not anticipated to be observably affected over V Mains, Panel 309 or the proposed first workings, however water depths in the stream monitoring sites should be automatically monitored and photographed during site visits, unless access to the sites is deemed temporarily unsuitable.

Subsidence may induce minor bed or bank erosion over the proposed panels, particularly in the headward and downstream sections of the subsidence trough, as well as over the chain pillars.

As the creeks are well vegetated, no significant change is anticipated and it is not envisaged that stream bed or bank remediation will be required.

Any changes to the current state will be visually monitored after significant stream flow events, and if adverse subsidence / uplift effects occur, a specific management and rehabilitation plan should be developed for the affected areas.

15.3.1 Bedload Movement

If erosion occurs in a stream, it may cause a minor increase in potential bedload movement in and downstream of the subsidence area, which will be visually monitored during and after significant flow events.

Significant bedload movement is not anticipated and therefore stream bed or bank management and rehabilitation is not anticipated to be required.

15.3.2 Stream Gradient

It is not anticipated that significant observable change will occur due to subsidence and that stream gradient rehabilitation measures will not be required.

15.3.3 Riparian Vegetation

Vegetation in the stream and banks will be visually monitored over the V Mains and Panel 309 mining areas before and after any stream is undermined, particularly after significant flow events.

As no adverse effect on the riparian vegetation is anticipated, no vegetation rehabilitation measures are anticipated.

15.4 Upland Swamp Groundwater

Monitoring of swamp piezometer P6 should be conducted through use of an automated water level logger within swamp Wcvfs1 to gauge any changes in standing water level and water quality for all key parameters on a bi-monthly basis prior to, and for the duration and an appropriate time following mining.

15.4.1 Standing Water Levels

The piezometer P6 standing water level should be measured automatically, twice daily by pressure transducers and at least bi-monthly by manual dip meter.

Should the standing water level or groundwater quality be unacceptably affected due to subsidence, the Colliery will investigate methods to ameliorate the situation until the water level or water quality recovers.

15.4.2 Groundwater Quality

Piezometer P6 should be used bi-monthly to obtain an appropriately purged, stored and transported groundwater sample to enable ongoing assessment of any subsidence related changes in groundwater quality.

Samples should be analysed for:

- Field pH, electrical conductivity, temperature;
- total dissolved solids (TDS);
- Na / Ca / Na / K / SO4 / Mg / Cl / F;
- total alkalinity;
- total / filterable Fe, Mn, Al;
- filterable Ni, As, Li, Ba, Sr, Cu, Pb, Zn; and
- total nitrogen (TN) and total phosphorous (TP).

Observations should be made on the quantum of iron hydroxide precipitating from the pumped water before and after undermining.

15.5 Mine Inflows

Mine inflows should be monitored through measurement of all water pumped into and out of the NRE No. 1 workings prior to, during and after the proposed mining period.

15.6 Rainfall

Rainfall should be monitored daily at the mine's and the nearest Bureau of Meteorology weather station for the duration of mining.

The variability of pool heights and stream flow in Wallandoola and Lizard Creeks will be monitored by data loggers to assess the rainfall / runoff relationship, with photography used to monitor flow conditions in both creeks as well as their unnamed tributaries.

15.7 Reporting

An end of extraction report will be prepared for the mined panel, which summarises all monitoring over the period. The report will outline any changes in the surface water or groundwater system over the mined out areas.

If required, a meeting will be convened with the relevant stakeholders (DII, DECCW, NOW and SCA) at the mine office to discuss requirements for remediation and ongoing monitoring.

All monitoring and management activities will be reported in the Annual Environmental Management Report (AEMR) in subsequent years.

15.8 Ongoing Monitoring

All results should be reviewed one year after each panel has been completed and an updated ongoing monitoring and remediation program will be developed in association with DII, DECCW, NOW and SCA.

15.9 Quality Assurance and Control

QA/QC should be attained by calibrating all measuring equipment, ensuring that sampling equipment is suitable for the intended purpose, NATA registered laboratories are used for chemical analyses and that site inspections and reporting follow procedures outlined in the ANZECC 2000 Guidelines for Water Quality Monitoring and Reporting.

Field sample collection, storage, despatch, laboratory analysis, interpretation and reporting will be conducted according to ANZECC 2000 requirements.

16. POTENTIAL REMEDIATION OR REHABILITATION MEASURES

16.1 Upland Swamps

While the nature and extent of possible subsidence impacts are considered to be negligible, the range of possible remediation or rehabilitation measures are discussed below.

Potential remediation measures for impacts on upland swamps could include:

- *installation of coir log dam erosion control structures at knick points in a swamp;*

Tilting of the swamp can re-direct runoff leading to scour and erosion or alter water distribution in a swamp. However, no swamps in the Study Area have been assessed with a moderate or higher risk of drainage line alignment change in terms of their erosion and scour potential.

Coir logs can be installed at knick points for construction of small dams, and have been used successfully in swamp rehabilitation in the Blue and Snowy Mountains (BHP Billiton Illawarra Coal, 2009).

A trench is initially cut into the swamp so the first coir logs sits on the substrate or at ground level and is held by wooden stakes and bound with wire. The dam slows the flow and enables siltation behind the log with coir log dams constructed at intervals down the erosion channel. For increased flow filtering, the coir logs can be wrapped in jute fibre matting.

The main objective of siting erosion control structures is to maintain the saturated water level in the soil profile by reversing the hydraulic head to enable water to permeate back into the swamp (BHP Billiton Illawarra Coal, 2009).

The coir log dams can also capture sediment to restore an incised channel to the level of the surrounding intact soil layer and provide a barrier to headward erosion.

- *use of water spreading techniques, involving long lengths of coir logs and hessian `sausages' linked together across a swamp contour such that water flow builds up behind them and seeps through the water spreaders to maintain swamp moisture;*

Maintenance of swamp moisture can be enhanced by installing coir logs and hessian `sausages' linked across a swamp contour to build up water flow and enhance seepage through the spreaders which can be positioned in shallow trenches.

Erosion control and water spreading involves soft-engineering materials that would contribute to and function as part of the swamp system but would degrade and be integrated into the swamp (BHP Billiton Illawarra Coal, 2009).

- *sealing of surface cracks through the use of grouting products*

Where bedrock controlled features within or on the margins of a swamp are impacted from subsidence and there is limited ability for fractures to infill naturally, surface cracks can be sealed with grout, such as small quantities of cement with various additives mixed on-site and placed by hand with bunds used to contain local spillage.

- *injection grouting.*

Grouts and filler materials can be injected to fill voids in fractured strata via hand held drilling equipment to achieve a low permeability layer 1 - 2 m thick below the depth of a controlling rock bar.

Where colluvial soils overlie the sandstone, a grout may be injected through rods to seal voids in or under the soil or peat material.

Implementation of any management measures should be considered with regard to the specific circumstances of the subsidence impact, such as the location, nature and extent of the impact and the assessment of the potential environmental consequences of the remediation technique used.

16.2 Streams

If any adverse impacts occur as a result of subsidence on the streams over the proposed mining, Gujarat should undertake appropriate remediation as agreed to by SCA.

A Stream Rehabilitation Management Plan and Remediation Register should be used to manage implementation of remediation measures in accordance with approval from the SCA.

A potential subsidence impact performance criteria should be that negligible environmental consequences, (no diversion of flow, no change in the natural pool drainage behaviour, minimal iron staining and minimal gas release) will occur over at least 70% of the stream length.

Stream remediation activities should be conducted where monitoring results indicate the subsidence impact performance measure for surface flow and / or pool holding capacity of a pool has been adversely affected due to subsidence, except where the change is due to climatic conditions, has been exceeded. Exceedance of the subsidence impact performance measure will be assessed as a component of the overall Water Management Plan for the proposed longwalls.

Remediation should commence when the-rate of ground movement (as measured regularly) is less than 20 mm/month following mining.

More than one remedial effort may be required at a pool or rock bar as ongoing incremental impacts may result in association with successive longwalls. In addition, the timing of remediation activities will also be influenced by practical considerations, as entry to the creek bed will require surface flow over a particular rock bar to be absent.

Fracture characterisation should be conducted to measure the depth and lateral extent of the sub-surface fracture network at each location requiring remediation. These could include the drilling of cored holes to a depth of approximately 20m to:

- determine the depth of fracturing;
- measure the relative volume of fine versus large void spaces;
- determine the horizontal connectivity between fractures; and
- use of a borehole calliper to identify the location of individual fractures.

The principal management measure that could be used to restore surface flow and pool holding capacity is polyurethane (PUR) grout injection into the fracture network which should reduce the permeability of the rock by filling voids and reducing subsurface flow diversion paths.

Grouting products that could be used include CarboPur (WFA and WF grades), which are products used for consolidation, stabilisation and/or sealing of strata. A grout curtain could be constructed across a rock bar by drilling a line of holes at regular intervals (approximately 2m) and progressively injecting grout down to 20m below surface.

The design of any remediation and rehabilitation strategy must be cognisent of the overall environmental impacts and as such be developed on a case specific basis.

Direct access to a particular section of a stream will determine the remediation necessary and the extent to which it is implemented.

Other potential remediation techniques include:

- hand grouting - sealing cracks exposed at surface using hand applicators;
- shallow pattern grouting - drilling shallow holes with small hand held equipment and low pressure grout injection with a portable pump;
- deep pattern or curtain grouting - drilling deeper holes with air hammer or reverse circulation drilling rigs and higher pressure grouting techniques; and
- deep angle hole cement grouting - remote directional drilling used to access inaccessible sites using the same grouting methods as deep pattern/curtain grouting methods.

The range of techniques will be considered in the design of any stream remediation program. Any technique used will need to be approved by the SCA, DECCW, NSW I&I (Fisheries) and the DoP to the satisfaction of the Director-General of NSW I&I (Mineral Resources).

Where remediation activities involve drilling and grout injection into subsurface fractures, associated activities should involve procedures for the mobilisation, placement and operation of equipment as well as implementation of a necessary environmental management measures. Drilling equipment could include a drill rig and rods, geofabric straw bale filters, tape barriers at access points, air compressors, hoses, compressed air pumps, a Dingo and a drill rig 'A' frame to enable assembly/disassembly.

Injection equipment could include a pneumatic PUR injection pump, diesel-operated compressor, high capacity pressure delivery hoses, static mixing unit/injection gun assembly, injection tubes and packers and a temporary shelter for personnel and equipment.

A range of environmental management measures should be described in a Stream Rehabilitation Management Plan and should be implemented during remediation works. Measures could include:

- management of soil and vegetation disturbance;
- erosion and sediment controls to minimise the potential for downstream effects;
- stream flow diversion and reduction of sub-surface flows during application of grout;
- drill cuttings containment and disposal;
- fuel management;
- management of grouting products and injection operations;
- waste management; and
- transport and handling of equipment and materials.

16.3 Subsidence Impact Management and Contingency Measures

In the event that future water monitoring shows that there has been significant hydrologic or aquatic ecotoxic effects then it is possible that some management and mitigation measures may be required. Management measures may involve alterations to the area of extraction or modifications to the orientation and/or disposition of future mining.

At this time, there are no specific recommendations for stream or groundwater management and rehabilitation over the proposed mining area as the predicted impacts are not anticipated to be significantly adverse.

Ongoing monitoring is required to assess whether any subsidence related physical and / or chemical changes to stream flows, stream water quality and stream integrity occur, as well as to validate predicted impacts on groundwater levels, mine seepage and groundwater water quality.

All relevant rehabilitation actions will be derived in association with the DII, DECCW, NOW and SCA and will be acted upon as appropriate.

At the end of the subject mining, assessment of the field and laboratory data will be completed to determine whether any unanticipated trends are occurring, and a review of measures will be required to address the issue if a subsidence / uplift related trend is apparent.

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LIMITATIONS

This report was prepared in accordance with the scope of services set out in the contract between Geoterra Pty Ltd (Geoterra) and the client, or where no contract has been finalised, the proposal agreed to by the client. To the best of our knowledge the report presented herein accurately reflects the client's requirements when it was printed. However, the application of conditions of approval or impacts of unanticipated future events could modify the outcomes described in this document.

In preparing this report, Geoterra has relied upon information and documentation provided by the client and / or third parties. Geoterra did not attempt to independently verify the accuracy or completeness of that information. To the extent that the conclusions and recommendations in this report are based in whole or in part on such information, they are contingent on its validity. Geoterra assume the client will make their own enquiries in regard to conclusions and recommendations made in this document. Geoterra accept no responsibility for any consequences arising from any information or condition that was concealed, withheld, misrepresented, or otherwise not fully disclosed or available to Geoterra.

The findings contained in this report are the result of discrete / specific methodologies used in accordance with normal practices and standards. To the best of our knowledge, they represent a reasonable interpretation of the general condition of the site in question. Under no circumstances, however, can it be considered that these findings represent the actual state of the site at all points.

Interpretations and recommendations provided in this report are opinions provided for our Client's sole use in accordance with the specified brief. As such they do not necessarily address all aspects of water, soil or rock

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BHPB VWP224
LC9
BHPB VWP 214
LC8
LCT3
LC7
LCT2
NRE G
LC6
P2
C11
WC6
WC7
LCT1
C10
P1
PANEL 309
LC5
LC4
P514
509/510
P3
WC4
WC5
P4
NRE E
NE3
WC3
P5
LC3
WC2
P6
LC2
V MAINS
WCT1
WC1
P502
P501
P Main
H PANEL
NRE C
NRE D
CD1
CC7
CC6
NRE B
CC5
CC4
CC1
CC3
CC2
PANELS 4 AND 5
GATEROADS
NRE A
CATARACT RIVER
CATARACT RESERVOIR
WALLANDOLA CREEK
LIMARD CREEK
BELLAMBI CREEK
CATARACT CREEK
CATARACT RIVER
6 208 000 N
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6 206 000 N
6 205 000 N
6 204 000 N
6 203 000 N
6 202 000 N
6 201 000 N
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6 199 000 N
6 198 000 N
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303 000 E
304 000 E
305 000 E
306 000 E
307 000 E

LEGEND

- STREAM SITES
- PIEZOMETER
- CREEKS

PROJECT:	GUJ3
DRAWN:	A. DAWKINS
DATE:	13 Sept 2010
SCALE:	1:5 000

GUJARAT NRE COKING COAL LTD
NRE No.1 COLLIERY

PROPOSED WORKINGS

GeoTerra

DRAWING 1

BHPB VWP224
LC9
BHPB VWP 214
LC8
LCT3
LC7
LCT2
NRE G
LC6
PANEL 309
P2
C11
LC5
LCT1
C10
P1
LC4
P514
509/510
P3
WC6
WC7
WC4
WC5
P4
P5
LC3
NE3
WC3
NRE E
V MAINS
P502
P501
WC2
P6
LC2
WCT1
WC1
D Main
H PANEL
NRE C
NRE D
CD1
CC7
CC6
CC5
CC4
CC3
CC2
CC1
NRE B
NRE A
LONGWALL 4 & 5 GATEROADS
CATARACT RIVER
RESERVOIR
WALLANDOLA
CREEK
6 208 000 N
6 207 000 N
6 206 000 N
6 205 000 N
6 204 000 N
6 203 000 N
6 202 000 N
6 201 000 N
6 200 000 N
6 199 000 N
6 198 000 N
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289 000 E
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302 000 E
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305 000 E
306 000 E
307 000 E

LEGEND

- STREAM SITES
- PIEZOMETER
- CREEKS

PROJECT:	GUJ1-G-R1
DRAWN:	A. DAWKINS
DATE:	13 Sept 2010
SCALE:	1:5 000

GUJARAT NRE COKING COAL LTD
NRE No.1 COLLIERY

PROPOSED WORKINGS AND OLD BULLI SEAM WORKINGS

GeoTerra

DRAWING 2

BHPB VWP224
LC9
BHPB VWP 214
LC8
LCT3
LC7
LCT2
LC6
NRE G
CATARACT RIVER
WALLANDOLA
LIMARD
CREEK
CATARACT RESERVOIR
P2
C11
WC6
WC7
LCT1
C10
P1
PANEL 309
LC5
LC4
P514
509/510
P3
WC4
WC5
P4
NRE E
LC3
V MAINS
NE3
WC3
P5
P502
P501
WC2
P6
LC2
WCT1
P Main
WC1
H PANEL
NRE C
NRE D
BELLAMBI CREEK
CD1
CC7
CC6
CATARACT CREEK
NRE B
CC5
CC4
CC3
CC1
CC2
LONGWALLS 4 & 5 GATEROADS
CATARACT RIVER
NRE A

289 000 E 290 000 E 291 000 E 292 000 E 293 000 E 294 000 E 295 000 E 296 000 E 297 000 E 298 000 E 299 000 E 300 000 E 301 000 E 302 000 E 303 000 E 304 000 E 305 000 E 306 000 E 307 000 E

6 208 000 N 6 207 000 N 6 206 000 N 6 205 000 N 6 204 000 N 6 203 000 N 6 202 000 N 6 201 000 N 6 200 000 N 6 199 000 N 6 198 000 N 6 197 000 N 6 196 000 N 6 195 000 N

LEGEND

- STREAM SITES
- PIEZOMETER
- CREEKS

PROJECT:	GUJ1-G-R1
DRAWN:	A. DAWKINS
DATE:	13 Sept 2010
SCALE:	1:5 000

GUJARAT NRE COKING COAL LTD
NRE No.1 COLLIERY

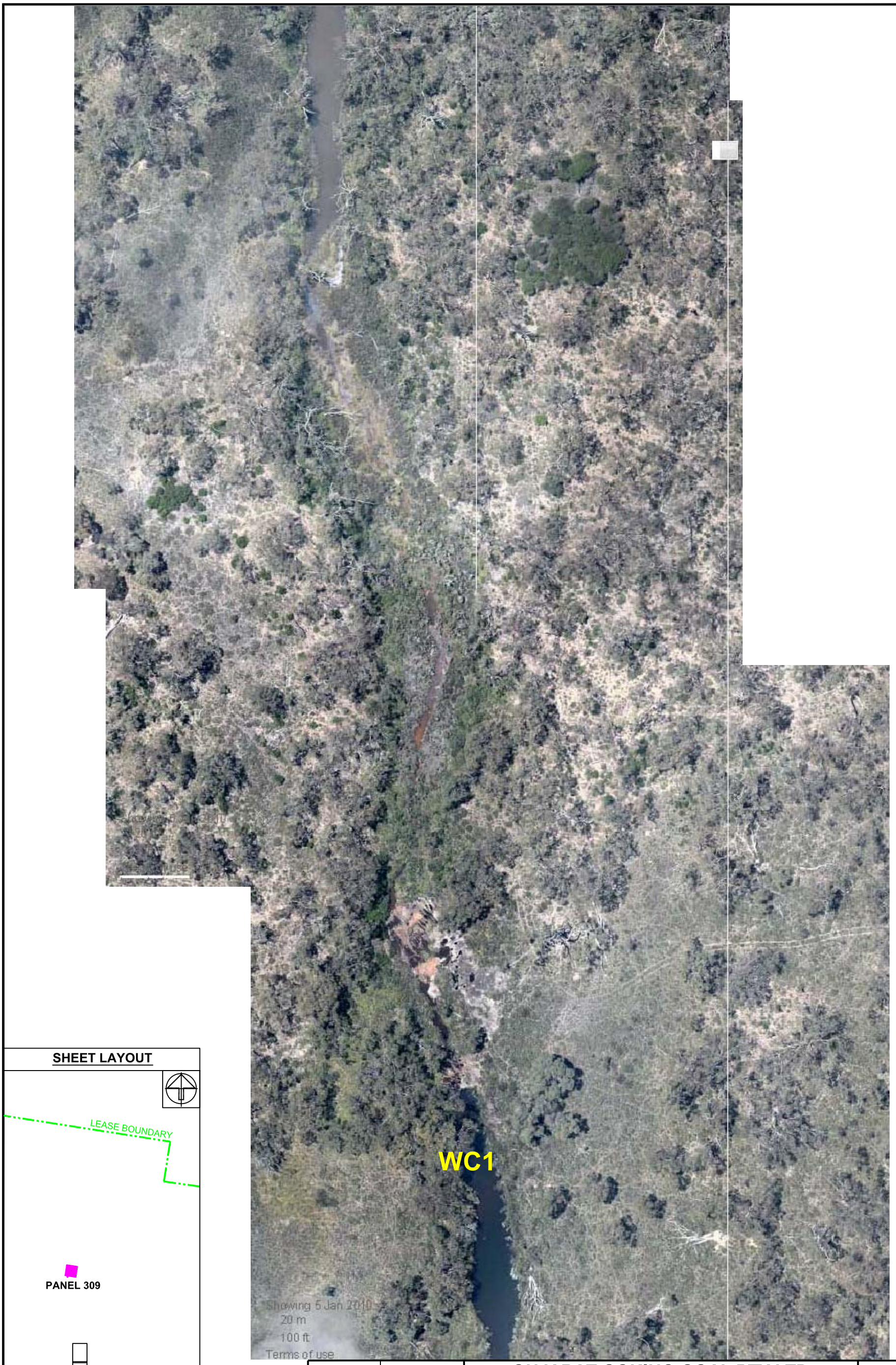
PROPOSED WORKINGS AND OLD BALGOWNIE SEAM WORKINGS

GeoTerra

DRAWING 3

APPENDIX A

WALLANDOOLA AND LIZARD CREEKS 3RD ORDER STREAM PHOTOGRAPHIC MAPPING



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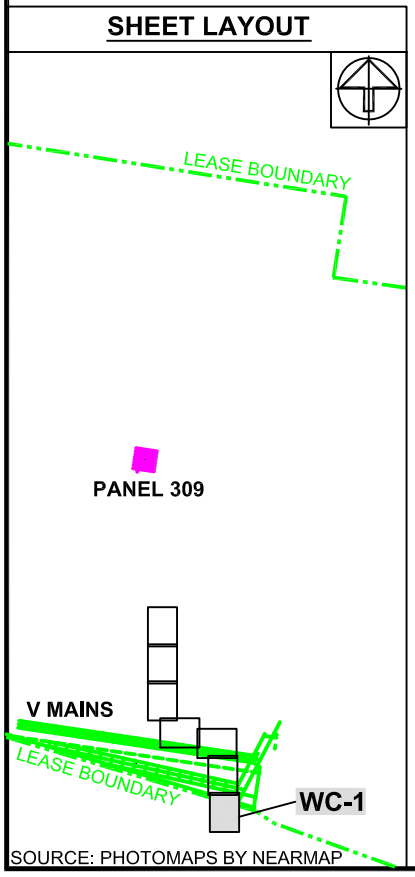


SOURCE: PHOTOMAPS BY NEARMAP

PROJECT:	GUJ1 R1
DRAWN:	A. DAWKINS
DATE:	13 Sept 2010
SCALE:	1:1000

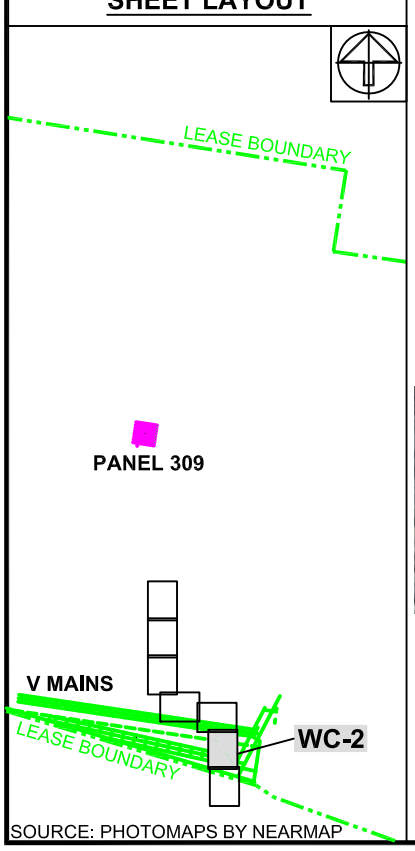
GUJARAT COKING COAL PTY LTD
WONGAWILLI LONGWALL PROJECT
BELLAMBI, NSW

WALLANDOOLA CREEK MAPPING

GeoTerra

FIGURE WC-1

SHEET LAYOUT



SOURCE: PHOTOMAPS BY NEARMAP

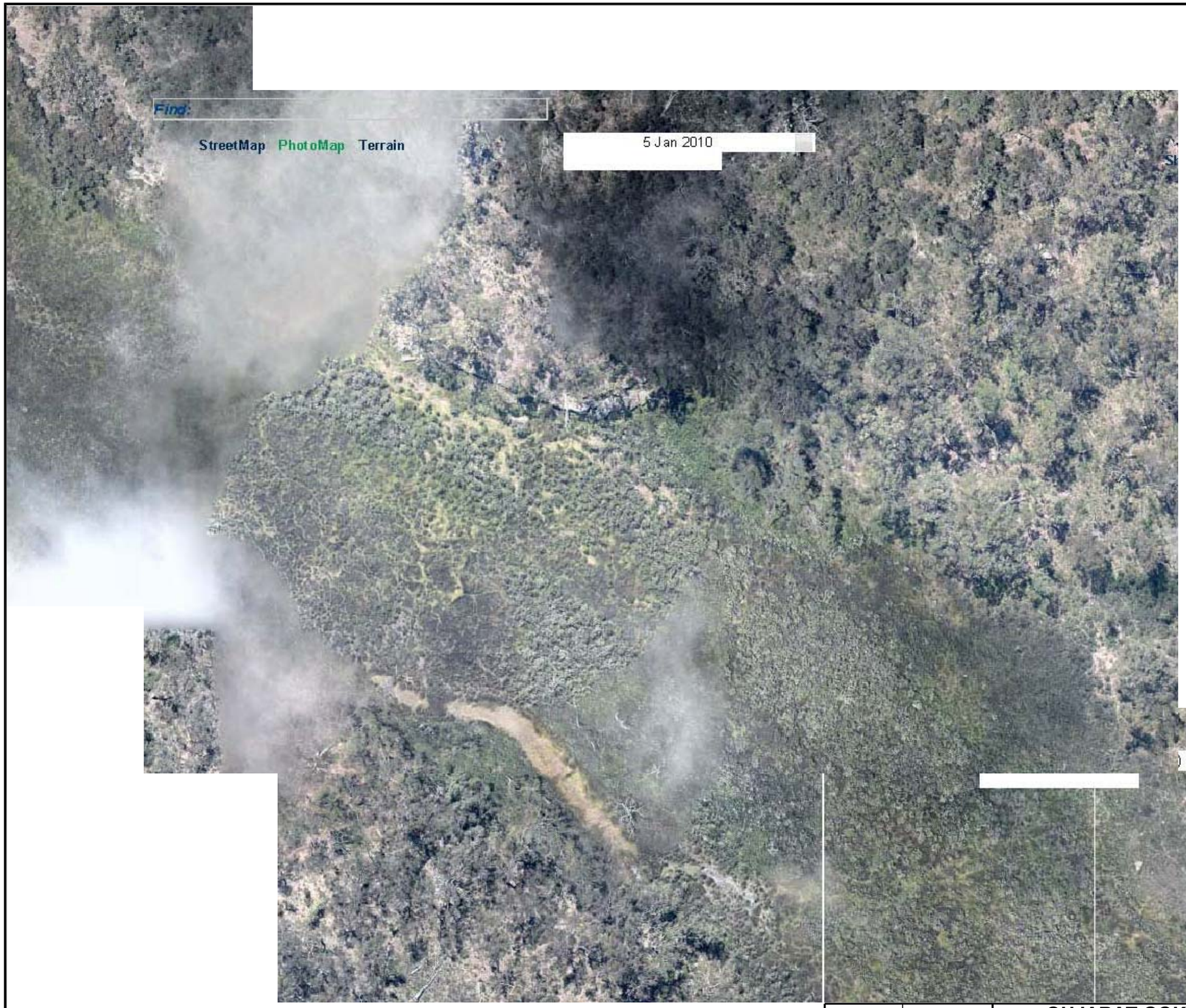
PROJECT:	GUJ1 R1
DRAWN:	A. DAWKINS
DATE:	13 Sept 2010
SCALE:	1:1000

GUJARAT COKING COAL PTY LTD
WONGAWILLI LONGWALL PROJECT
BELLAMBI, NSW

WALLANDOOLA CREEK MAPPING

GeoTerra

FIGURE WC-2



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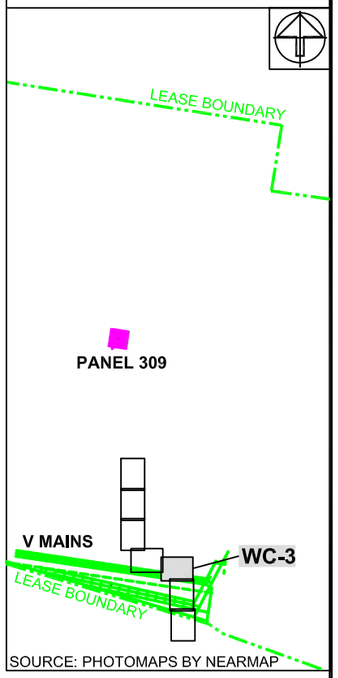


SOURCE: PHOTOMAPS BY NEARMAP

PROJECT:	GUJ1 R1
DRAWN:	A. DAWKINS
DATE:	13 Sept 2010
SCALE:	1:1000

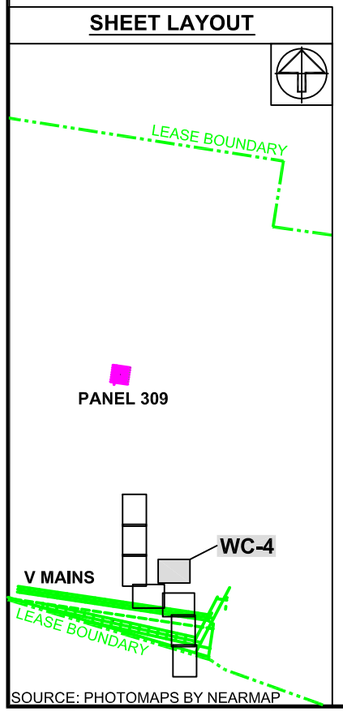
GUJARAT COKING COAL PTY LTD
WONGAWILLI LONGWALL PROJECT
BELLAMBI, NSW

WALLANDOOLA CREEK MAPPING

GeoTerra

FIGURE WC-3

SHEET LAYOUT



SOURCE: PHOTOMAPS BY NEARMAP

PROJECT:	GUJ1 R1
DRAWN:	A. DAWKINS
DATE:	13 Sept 2010
SCALE:	1:1000

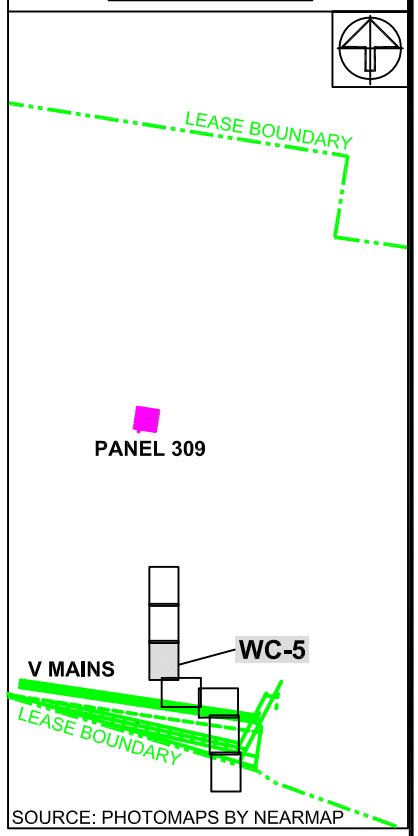
GUJARAT COKING COAL PTY LTD
WONGAWILLI LONGWALL PROJECT
BELLAMBI, NSW

WALLANDOOLA CREEK MAPPING

GeoTerra

FIGURE WC-4

SHEET LAYOUT



SOURCE: PHOTOMAPS BY NEARMAP

Showing 5 Jan 2010
20 m
100 ft
Terms of use

Find

StreetMap PhotoMap Terrain

5 Jan 2010

PROJECT:	GUJ1 R1
DRAWN:	A. DAWKINS
DATE:	13 Sept 2010
SCALE:	1:1000

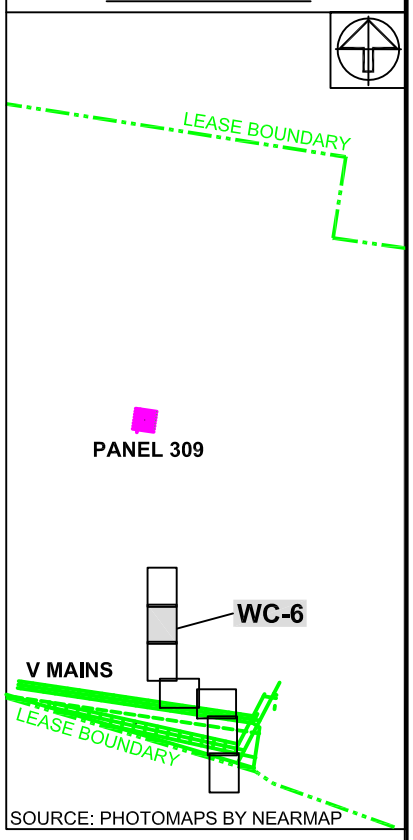
GUJARAT COKING COAL PTY LTD
WONGAWILLI LONGWALL PROJECT
BELLAMBI, NSW

WALLANDOOLA CREEK MAPPING

GeoTerra

FIGURE WC-5

SHEET LAYOUT



SOURCE: PHOTOMAPS BY NEARMAP

PROJECT:	GUJ1 R1
DRAWN:	A. DAWKINS
DATE:	13 Sept 2010
SCALE:	1:1000

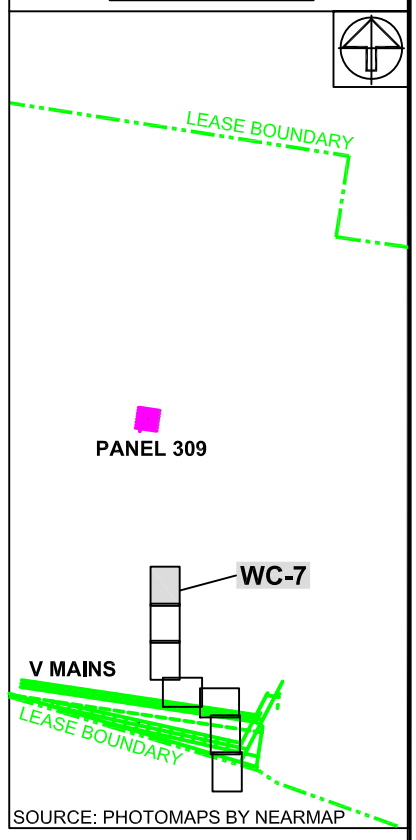
GUJARAT COKING COAL PTY LTD
WONGAWILLI LONGWALL PROJECT
BELLAMBI, NSW

WALLANDOOLA CREEK MAPPING

GeoTerra

FIGURE WC-6

SHEET LAYOUT



SOURCE: PHOTOMAPS BY NEARMAP

PROJECT:	GUJ1 R1
DRAWN:	A. DAWKINS
DATE:	13 Sept 2010
SCALE:	1:1000

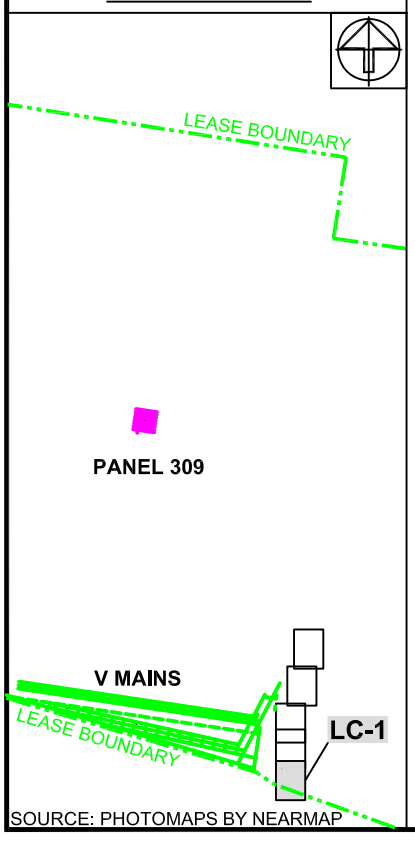
GUJARAT COKING COAL PTY LTD
WONGAWILLI LONGWALL PROJECT
BELLAMBI, NSW

WALLANDOOLA CREEK MAPPING

GeoTerra

FIGURE WC-7

SHEET LAYOUT



SOURCE: PHOTOMAPS BY NEARMAP

PROJECT:	GUJ1 R1
DRAWN:	A. DAWKINS
DATE:	13 Sept 2010
SCALE:	1:1000

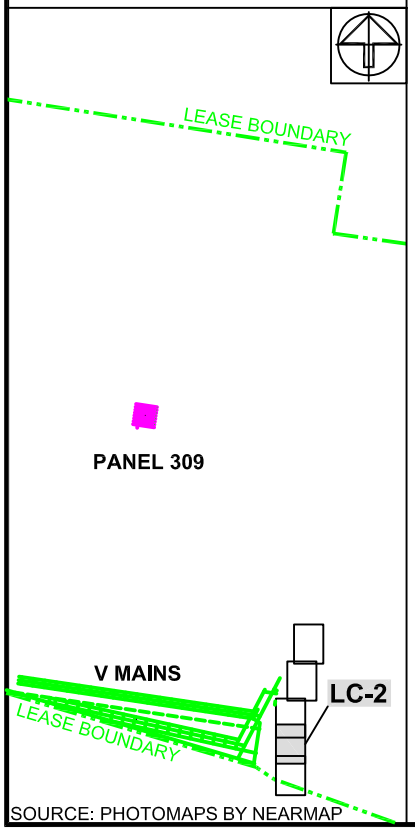
GUJARAT COKING COAL PTY LTD
WONGAWILLI LONGWALL PROJECT
BELLAMBI, NSW

LIZARD CREEK MAPPING

GeoTerra

FIGURE LC-1

SHEET LAYOUT



SOURCE: PHOTOMAPS BY NEARMAP

PROJECT:	GUJ1 R1
DRAWN:	A. DAWKINS
DATE:	13 Sept 2010
SCALE:	1:1000

GUJARAT COKING COAL PTY LTD
WONGAWILLI LONGWALL PROJECT
BELLAMBI, NSW

LIZARD CREEK MAPPING

GeoTerra

FIGURE LC-2

SHEET LAYOUT

SOURCE: PHOTOMAPS BY NEARMAP

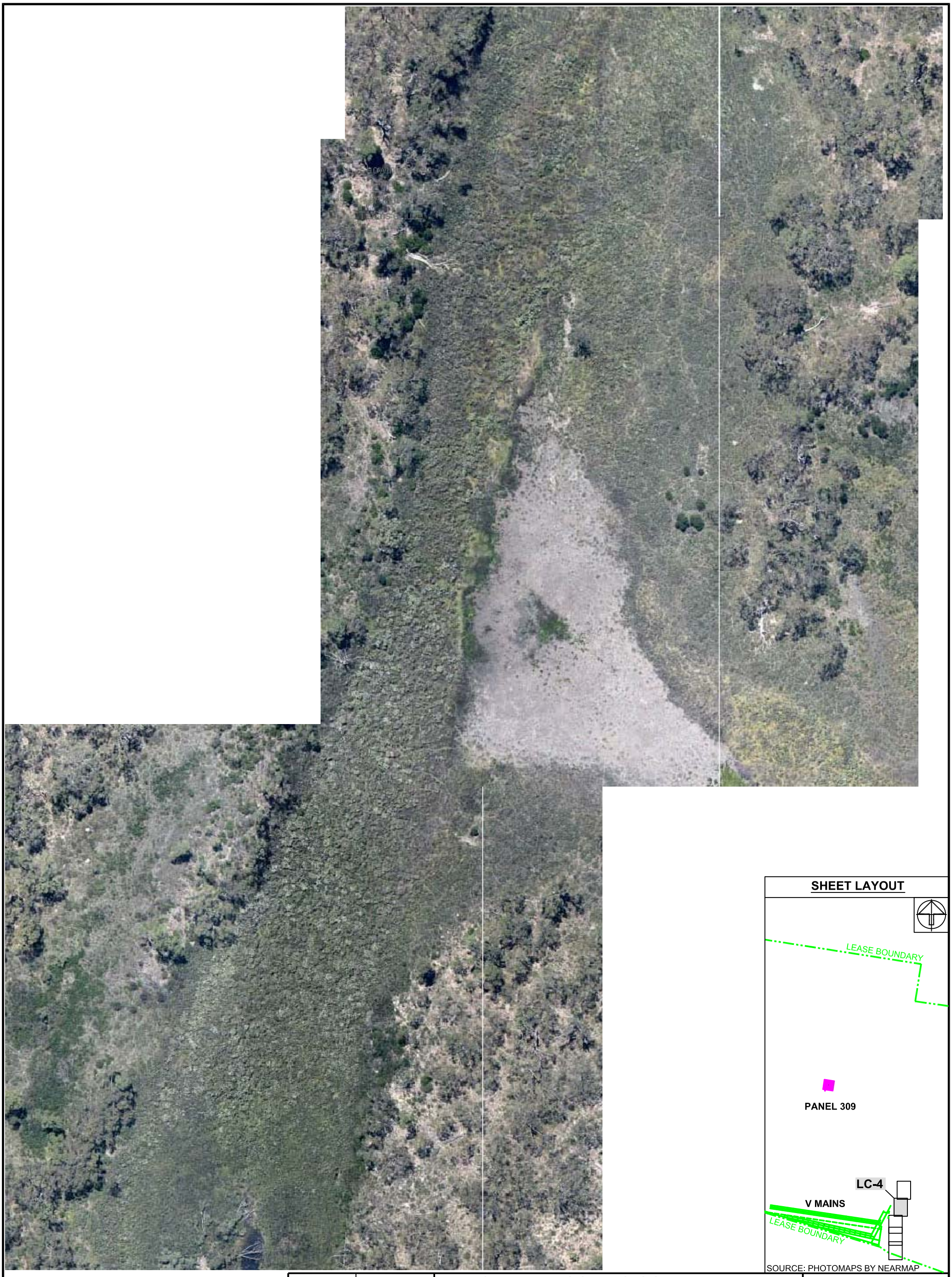
PROJECT:	GUJ1 R1
DRAWN:	A. DAWKINS
DATE:	13 Sept 2010
SCALE:	1:1000

GUJARAT COKING COAL PTY LTD
WONGAWILLI LONGWALL PROJECT
BELLAMBI, NSW

LIZARD CREEK MAPPING

GeoTerra

FIGURE LC-3



PROJECT:	GUJ1 R1
DRAWN:	A. DAWKINS
DATE:	13 Sept 2010
SCALE:	1:1000

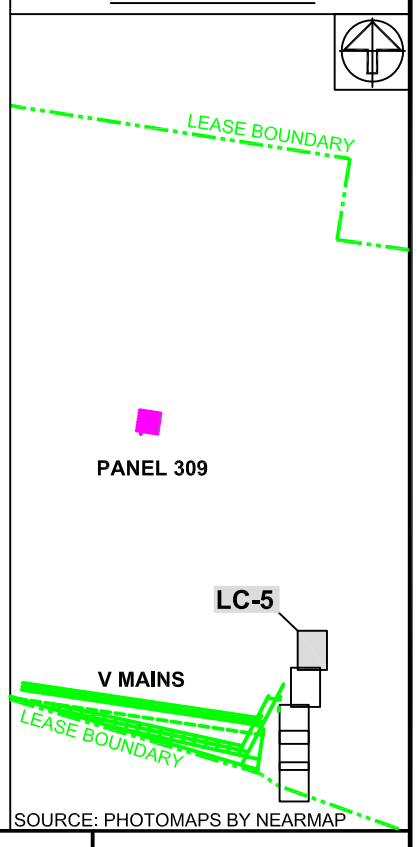
GUJARAT COKING COAL PTY LTD
WONGAWILLI LONGWALL PROJECT
BELLAMBI, NSW

LIZARD CREEK MAPPING

GeoTerra

FIGURE LC-4

SHEET LAYOUT



SOURCE: PHOTOMAPS BY NEARMAP

PROJECT:	GUJ1 R1
DRAWN:	A. DAWKINS
DATE:	13 Sept 2010
SCALE:	1:1000

GUJARAT COKING COAL PTY LTD
WONGAWILLI LONGWALL PROJECT
BELLAMBI, NSW

LIZARD CREEK MAPPING

GeoTerra

FIGURE LC-5

Annex H

Geotechnical Investigation Proposed Preliminary Works Coal Stockpile and Handling Facility Upgrade

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

50 YEARS
AN EXTRAORDINARY JOURNEY

GEOTECHNICAL ASSESSMENT PROPOSED PRELIMINARY WORKS COAL STOCKPILE AND HANDLING FACILITY UPGRADE GUJARAT NRE NO. 1 COLLIERY RUSSELL VALE, NSW

Gujarat NRE Coking Coal Ltd

GEOTWOLL02875AA-AO
1 June 2010

Coffey Geotechnics Pty Ltd ABN 93 056 929 483
118 Auburn Street Wollongong NSW 2500 Australia

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

50 YEARS AN EXTRAORDINARY JOURNEY

1 June 2010

Gujarat NRE Coking Coal Ltd
PO Box 281
FAIRY MEADOW NSW 2519

Attention: Don Jephcott

Dear Sir,

RE: GEOTECHNICAL ASSESSMENT

PROPOSED PRELIMINARY WORKS

COAL STOCKPILE AND HANDLING FACILITY UPGRADE

GUJARAT NRE NO. 1 COLLIERY

RUSSELL VALE, NSW

Coffey Geotechnics Pty .Ltd. is pleased to present this report on our geotechnical assessment of the proposed preliminary works for the Coal Stockpile and Handling Facility Upgrade at the Gujarat NRE No. 1 Colliery at Russell Vale.

This report has been prepared in accordance with Coffey Proposal GEOTWOLL02875AA-PAC, dated

The attached document titled “Important Information about your Coffey Report” should be read in conjunction with this report.

For and on behalf of Coffey Geotechnics Pty Ltd

JON THOMPSON CPEng

Principal

Distribution: Original copy held by Coffey Geotechnics Pty Ltd
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1 PDF electronic copy to Gujarat NRE Minerals Ltd

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Important Information about your Coffey Report

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Figure 1: Site Plan Showing Proposed Preliminary Works

Figures 2a-2e: Site Plans Showing Sections 1 to 5 of Drainage Channel, with approximate Test Pit and Borehole locations

Figure 3: Site Plan Showing Proposed Stockpile, Haul Road and Sizing Plant, with approximate Test Pit and Borehole locations

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Appendices

Appendix A Engineering Logs of Recent Test Pits and Boreholes

Appendix B Engineering Logs Test Pits from Previous Reports

Appendix C Explanation of Terms Used on Test Pit and Borehole Logs

Appendix D Landslide Risk Assessment, AGS 2007,Appendix C

Appendix E: Landslide Risk Management, Important Information about AGS 2007, Appendix C

1 INTRODUCTION AND OBJECTIVES

This report presents the results of a geotechnical assessment, prepared by Coffey Geotechnics Pty Ltd (Coffey) for Gujarat NRE Coking Coal Ltd (Gujarat), in relation to proposed Preliminary Works associated with improvements to the Coal Stockpile and Handling Facility at Gujarat's No. 1 Colliery at Russell Vale, NSW.

1.1 Proposed Preliminary Works

Gujarat is proposing that preliminary works be carried out as shown on plans prepared by JBK Engineering and Mining, JBK Drawing No. 282803, dated April 2010.A layout plan of the proposed works is shown in Figure 1 of this report.

The main elements of the proposed Preliminary Works will comprise the following:-

- Provision of a drainage re-alignment channel around the proposed coal stockpile and handling areas, and continuing to a stilling/dissipation basin at the eastern end of the site;
- Improvements to Bellambi Gully uphill of the stockpile and conveyor;
- Provision of a new Coal Sizing Plant adjacent to the existing Bulli conveyor;
- Provision of a stockpile area for the new Wonga conveyor belt;
- Development of a Heavy Vehicle Haul Road from the Mine Access Road to the western side of the proposed Wonga Stockpile and internal access roads for highway vehicles to the east of the Wonga Stockpile and coal handling facility.

1.2 Assessment Objectives

The objectives of this geotechnical assessment for the Preliminary Works included the following:-

- Provision of information on surface and subsurface conditions within or around the various elements of the preliminary works;
- Provision of preliminary recommendations in relation to geotechnical aspects of the proposed works; including slope stability, batter slopes and earthworks, drainage channel design and watercourse protection, retaining walls, foundations for structural elements, and surface/subsurface drainage;
- Confirm areas where additional investigation is required for final design and construction of the above proposed works.

2 SCOPE OF WORK

The scope of work for this assessment included the following:-

- Discussion of recent subsurface investigation works, comprising test pits and boreholes over the hillside areas to the north and south of the stockpile, in particularly over the hillside to the south of the proposed Wonga Stockpile site where the drainage re-alignment channel for Bellambi Gully is proposed. Relevant recent subsurface information has been included in Appendix A of this report;
- A review of geotechnical data and recommendations from previous reports on the Russell Vale mine site. Relevant information on subsurface conditions has been included in Appendix B of this report;
- Recent site mapping observations by engineers and geologists from Coffey Geotechnics along the existing Bellambi Gully uphill of the coal stockpile and along the proposed route of the drainage re-alignment channel adjacent to and east of the stockpile site.
- Provision of a report, including relevant surface and subsurface information, discussion and recommendations on geotechnical aspects of the proposed Preliminary Works, including landslide risk assessment, re-alignment channel design and watercourse gully protection works, earthworks, retaining walls, batter slopes for excavations and for fill materials, foundation conditions, foundations for the coal sizing plant and for the drainage channel, access roads and surface/subsurface drainage.

3 BACKGROUND INFORMATION

Coffey Partners International, Coffey Geosciences and Coffey Geotechnics have carried out a number of geotechnical assessments within the Gujarat No.1 Colliery at Russell Vale (formerly known as South Bulli Colliery) over the past 20 years. These assessments related to various infrastructure developments or potential redevelopment proposed by previous owners of the colliery.

Geotechnical information from these previous investigations that was considered by Coffey to be relevant to the currently proposed preliminary works has been referred to in this assessment. Subsurface information in the form of test pit or borehole logs, where considered to be representative of current ground conditions, has been included in Appendix B of this report.

Earlier reports by Coffey Partners International and Coffey Geosciences included assessments of the hillside conditions over the lower to midslopes of the escarpment where mine infrastructure and associated drainage works have been in place for many years, in some cases for over 80 years. Management of slope stability, surface water flows and erosion have been key issues for the various Colliery owners since mining commenced. The hillside areas of the escarpment and footslope areas present various levels of landslide risk and the types of landslide that could occur, ranging from small slumps in fill batters and watercourse banks to large scale failure of the coalwash fill in the lower development area and talus/colluvial slopes on the upper escarpment slopes.

4 GENERAL SITE GEOLOGY AND SLOPE STABILITY

4.1 Geology

The 1:50,000 Wollongong Geological Series Sheet indicates that the land in the vicinity of the proposed stockpile, coal sizing plant and Sections 3,4 and 5 of the proposed drainage re-alignment channel is underlain by rock belonging to the 'Sydney Sub Group' of the Illawarra Coal Measures which is of Early to Late Permian geological age. The Sydney Sub Group is described as, 'interbedded quartz lithic sandstone, grey mudrock, carbonaceous mudrock, coal and laminites.

The Geological Series Sheet also indicates that there is an established fault in the vicinity of the ridge above the proposed stockpile and drainage re-alignment channel. The fault is mapped as striking approximately North-West / South-East.

The 1:100,000 Wollongong – Port Hacking Soil Landscape Series Sheet indicates that the areas assessed for the preliminary works as shown in the site plans are located in an area mapped as 'Illawarra Escarpment' soil landscape which is generally underlain by colluvial soils. The limitations of this soil landscape are described as, 'mass movement and rockfall hazard, steep slopes and extreme erosion hazard. Reactive, low wet bearing strength subsoils. Low to moderate soil fertility'.

4.2 Slope Stability

The Woonona Land Stability Map by H.N. Bowman (1970) indicates that the lower part of the preliminary works including the re-alignment channel, sizing plant and stockpile are located in an area mapped as 'Level 2', described as 'Stable land with some minor areas of slope instability. Normally moderately level land which is however underlain by soil which is unstable in certain topographic positions'. The upper part of the site in the Bellambi Gully channel is located in an area mapped as 'Level 6' land, which is described as, 'Essentially unstable land. Best left undeveloped. Some areas may be developed after detailed site evaluation'.

The natural escarpment slopes and steep side slopes of the valley areas within the elevated parts of the Gujarat No.1 Colliery are generally underlain by talus, colluvium and residual soils. These slopes have also been modified significantly by filling and excavations in the past, particularly above the central valley area uphill of the stockpile site where there is a large coalwash fill in the lower development area. Previous studies have mapped the stability of these slopes based on gradient, surface and sub-surface drainage, geology, presence of fill and topographic position in relation to the escarpment.

Slope instability has occurred in the past on these slopes mainly during significant rainfall events that has resulted in blockage of drainage paths and contributed to flooding and erosion of parts of the colliery property and downstream properties.

The historical knowledge of the behaviour of the hillside areas and watercourses over the property (from Coffey and Colliery records) indicates that there are various levels of landslide risk, ranging from low to very high. Where infrastructure has been developed over the hillside areas, various measures have been implemented to manage or mitigate the risk.

5 SITE SURFACE CONDITIONS

5.1 Drainage Channel

The proposed drainage channel essentially includes a new re-alignment channel in the lower area and improvements to the existing alignment uphill of the piped section of Bellambi Gully. There is only a small section of the drainage channel uphill of the existing headwall that follows the natural gully alignment.

The proposed alignment of the drainage channel is intended to divert flows from Bellambi Gully around the floor of the valley and proposed coal stockpile area. The proposed alignment of the drainage channel is shown in Figure 1, Site Plan. Figures 2A to 2E show five sections of the watercourse including the proposed alignment of the drainage re-alignment channel. The site surface conditions for the five sections (Sections 1 to 5) of the existing watercourse and re-alignment channel are discussed as follows.

5.1.1 Section 1-Upper Portion of Bellambi Gully

This section of Bellambi Gully upstream of the Bulli conveyor has been substantially modified by man-made activities over the life of the colliery, and has experienced significant erosion of its floor and banks. This section of Bellambi Gully commences at the outlet of a culvert under the Pit Top haul road where there is a significant fall of about 6m down to the floor of the watercourse gully. The floor of the watercourse continues down to the Bulli conveyor where a piped culvert carries water under the conveyor. Bellambi Gully had been straightened by excavations over this section about 15 to 20 years ago to divert the watercourse around the adjoining coalwash fill in the lower development area to the north.

Significant erosion of the floor and sideslopes of the watercourse gully at this location has occurred in the past, mainly during major rainfall events on the escarpment. Local slumping of the steep banks has occurred particularly where runoff from the emplacement area occurs.

5.1.2 Section 2- Bellambi Gully Below Bulli Conveyor

This section of the watercourse extends from the piped culvert under the Bulli conveyor down a mainly natural gully floor except for a concrete lined area which includes a number of sandstone boulders embedded into the concrete. The remainder of the gully floor and watercourse has a rocky floor comprising mainly including bedrock outcrops, sandstone cobbles and boulders.

Vegetation over the gully and slopes uphill to the east and southeast comprises numerous trees and thick undergrowth.

The watercourse flows to a concrete headwall where the watercourse continues downstream through the existing piped system.

5.1.3 Section 3- Re-alignment Channel Downstream of Culvert Headwall

This section comprises a new headwall and first stage of the proposed re-alignment channel. This section of the proposed re-alignment channel will cross a steep hillside to the southeast and south of the valley floor. Slopes vary from about 10° up to about 30°. The steepest area was covered with thick vegetation.

Parts of the hillside over the alignment of the re-alignment channel and also above and below the channel have been modified by previous excavations and filling. Coffey is aware of previous erosion, seepages and slumping over parts of this slope. It is likely that the seepages originated from water stored in the Dam No.6 near the crest of the ridge.

The drainage channel at this point is positioned about 10m to 15m uphill of the toe of the slope. The proposed position of the new headwall is located about 10m upstream of the existing headwall.

5.1.4 Section 4- Re-alignment Channel East of Stockpile

This section of the re-alignment channel is shown in Figure 2D. At this location the proposed alignment of the channel crosses the sideslopes of the broad ridge about 15m to 20m uphill of the toe of the slope. The slope has been modified somewhat in the past and presently has a relatively uniform grade up to the ridge crest apart from an access road across the slope. The ground surface has a slope of about 7° to 15° across the channel location and over the slopes immediately uphill and downhill of the channel. Vegetation over this area comprised mainly a patchy to thick grass cover.

This section of the channel continues along an access track above a steep batter that is about 5m to 7m high. This batter exposes soil and weak rock, and has experienced some localised slumping and erosion.

Two Sydney Water reservoirs are located on the crest of the ridge uphill of the channel alignment.

5.1.5 Section 5- Re-alignment Channel Eastern End of Section 4 Down to Stilling/Dissipation Basin

This section falls down the slope at about 10° before levelling out over the valley floor near the proposed stilling or dissipation basin. The ground surface over this area has been modified by excavations for the access road and also filling has occurred over the valley floor to variable depths to create the current surface conditions.

5.1.6 Other Drainage Works-Coal Stockpile and Upper Slopes

Existing drainage paths on the upper slopes above the pit top occur along access roads and above the upper storage dams. There is also a re-alignment drain across the slope that diverts runoff to the main Bellambi Gully drainage channel discussed above. This re-alignment drain is generally between about 1m and 2m deep and about 2 to 5m wide. The banks of this channel, where exposed beneath thick vegetation, comprised either fill materials, talus or colluvium. Erosion and slumping of the banks of this re-alignment channel had occurred and in some areas fallen timber and larger rocks obstructed the flow path.

5.2 Coal Sizing Plant

The site for the coal sizing plant is located adjacent to the existing Bulli conveyor about 20m upslope of the storage bin on the lower part of the hillside beneath the conveyor and about 20m uphill of the toe of the slope. The current trestle structure supporting the Bulli Conveyor is a substantially steel framed structure and no obvious signs of distress to this structure were observed. The ground surface around the sizing plant site was covered with coal fines and coal from the conveyor. There is a small terraced area uphill of the sizing plant under the conveyor and a steep batter below this terrace that appears to comprise mainly spill materials from the conveyor and earlier coal stockpiles in the area. During our site observations it was noted that weathered rock was exposed along the uphill (cut batter) side of an access track up the north-western side of the existing conveyor.

5.3 Coal Stockpile and Haul Road Upgrade

The coal stockpile and proposed access/haul road are included in the proposed preliminary works.

The proposed coal stockpile is located centrally within the valley floor about 50m to east (downslope) of the toe of the coalwash fill in the lower development area. The site for the stockpile was covered by the existing coal stockpile at the time of our observations. The hillside area to the west of the stockpile comprises part of an existing access road, drainage collection area and terraced coalwash fill in the lower development area. The emplacement area has been revegetated and has a good cover of trees and undergrowth. Drainage from the emplacement area is directed mainly to the Bellambi Gully re-alignment channel. The slopes to the north of the stockpile site comprise part of the emplacement area and an area covered in thick vegetation. An access road crosses the slope on a cut to fill terrace.

6 SUBSURFACE CONDITIONS

6.1 Drainage Channel

6.1.1 Section 1- Upper Portion of Bellambi Gully

The general subsurface conditions in this upper portion of the drainage channel comprise local fill (mainly coalwash), overlying colluvium and/or talus that comprise cobbles and boulders in a silty to gravelly clay matrix. The fill materials have eroded and collapsed along the northern banks where they occur. The natural soils exposed are generally stiff or very stiff and prone to erosion and slumping when oversteepened. Weathered rock was exposed uphill of the culvert under the haul road and the rock appears to have resisted erosion so that the bed of the watercourse is not deeply scoured in this local area. Downhill of the culvert the drainage channel is deeply eroded and only large boulders over the floor have slowed the erosion process.

6.1.2 Section 2- Bellambi Gully Below Bulli Conveyor

This section of the drainage channel passes through a largely natural gully incised into talus/colluvium with numerous sandstone cobbles and boulders exposed. This is a well defined watercourse with established trees. Some exposures of bedrock were observed over the bed of the watercourse.

6.1.3 Section 3- Re-alignment Channel Downstream of Culvert Headwall

Subsurface investigations have been carried out over the hillside above and below this section of the proposed re-alignment channel, however at this stage there is limited subsurface information on the 'take-off' point from the existing watercourse (uphill of the existing headwall) onto the steep sideslopes of the ridge.

The approximate locations of boreholes and test pits from previous investigations are shown in Figure 2C. The boreholes in this area include CBH111, CBH112, CBH113, CBH114 and Test Pit includes TP21, TP22, TP23, TP24, CTP107 and CTP110. The engineering logs of these test pits and boreholes from the 2009 investigation are presented in Appendix A and the logs of the test pits and boreholes from previous investigations are presented in Appendix B.

The test pits over the lower slopes uphill of the re-alignment channel indicate local fill (remnants from coal stockpiles) overlying stiff to very stiff silty clays up to about 1m thick, with extremely weathered rock of volcanic origin occurring below the residual soils. At the termination depths of between 2m and 3m in these test pits excavator progress was steady, indicating a continuation of the extremely weathered material. Test Pit CTP10 which is closest to the channel alignment encountered a thin layer of fill overlying extremely weathered teschenite with highly weathered teschenite encountered to about 1.65m where excavator refusal occurred. Test Pit CTP107 was excavated near the crest of the ridge above Dam No. 6, and encountered residual clay soils overlying sandstone that was highly weathered at 1.5m and moderately weathered at 1.8m, with slow progress with 22 tonne excavator occurring at the termination depth of 2.5m.

The boreholes at this location encountered fill to depths ranging from about 0.5m to 1.4m, overlying residual soils or extremely weathered rock to depths ranging from about 2m to 3.5m, where highly weathered teschenite, sandstone or siltstone was encountered. Tungsten carbide bit refusal occurred in two of the boreholes. No groundwater inflows were observed in the boreholes drilled on 15 April, 2009.

The boreholes in this area indicate deeper soil cover and weak weathered teschenite occurring on the lower slopes and less weathered siltstones/sandstones occurring on the upper slopes.

6.1.4 Section 4- Re-alignment Channel East of Stockpile

There is limited subsurface information for this section of the proposed re-alignment channel, from earlier investigations, comprising TP19 (Eastern end), and Boreholes B12 and B13 downhill at the approximate locations shown in Figure 2d. Other nearby test pits to the south of the re-alignment channel from previous assessment have been referred to in relation to general geology of the area. The subsurface conditions over Section 4 are also partially exposed in the cut batter at the toe of the slope. Essentially the conditions exposed in the cut batter comprise extremely to highly weathered thinly bedded siltstone or sandstone with carbonaceous shale or coal evident. Some local slumping of this batter has occurred. Test Pit TP19 (from a 1995 investigation) confirms the presence of weak extremely weathered coal occurring within about 1m of the surface near the crest of this batter within or close to the re-alignment channel alignment.

This section of the channel also crosses a shallow gully or depression on the hillside that may include some fill from previous coal stockpiles in the area.

6.1.5 Section 5- Re-alignment Channel Eastern End to Stilling/Detention Basin

The approximate locations of the boreholes and test pits that are close to or within the alignment of the drainage channel are shown in Figure 2e. The logs of these boreholes and test pits are shown in Appendix B.

This eastern section of the proposed drainage re-alignment channel traverses the hillside, falling to a proposed stilling basin or dissipation pond. A previous test pit in the elevated area encountered very stiff to hard clay overlying highly weathered shale at a depth of about 1.3m.

Boreholes B24 and B27 are located within the proposed dissipation pond, and encountered deep coal waste including tailings to depths of about 5m to 7m overlying stiff to very stiff clay to about 7m where weathered sandstone was encountered. The coal waste was assessed as generally medium dense to very dense.

6.2 Coal Sizing Plant

The site for the proposed coal sizing plant is expected to be underlain by fill comprising coal spillages from the existing Bulli conveyor. Colluvium comprising silty to gravelly clay with cobbles and boulders may be encountered beneath the fill. Highly weathered rock was outcropping in a nearby access road cutting, indicating that rock may occur within about 3m to 5m of the surface at the sizing plant site.

6.3 Coal Stockpile and Haul Road Upgrade

Previous subsurface investigations and the recent investigation (2009) by Coffey within or around the proposed coal stockpile encountered fill up to 5.7m deep and rock at about 6.5m. Subsurface conditions are expected to be variable beneath the proposed stockpile, comprising coal and coalwash overlying alluvial and colluvial deposits made up of soils including clays, silts, sands and gravels with some cobbles and boulders. Groundwater inflows would be expected within the fill and underlying natural soils.

The proposed haul road will cross a well defined ridge and over the crest and northern sideslopes we would expect rock to occur at relatively shallow depths of less than 2m except where fill occurs. The rock may comprise sandstone and thinly bedded shales. On the southern sideslopes of the ridge previous investigations and our recent (2009) investigation encountered fill to a depth of 3.7m and rock was encountered to depths of 3.1m to 6.3m.

7 SLOPE STABILITY

7.1 Drainage Channel

The stability of the slopes over the proposed drainage channel (Bellambi Gully) varies considerably from low risk at the eastern end, to high or very high risk over the elevated western end. The types of landslide that may affect the drainage channel in its present condition include the following:-

- Deep seated movement of the soil mass in the steep hillside areas (Sections 1 to 3).
- Oversteepening due to erosion and subsequent collapse of the banks that currently exposed fill and natural soils (Sections 1 and 2).
- Relatively shallow landsliding over the sideslopes of the ridge due to oversteeping of the slope where cut and fill batters occur (Sections 3, 4 and 5).
- Creep movements of the soil mass on the steep slopes.

As the drainage channel passes down moderately steep to steep escarpment slopes underlain by deep colluvial soils in most areas, we expect the risk of landslide activity to remain high over most of this area. Improvements to the existing drainage channel are required to reduce the risk of instability along the banks. Earthworks and retention of the slope for the new re-alignment channel will also be required to reduce the risk of landslide over the slopes above and below the proposed drainage re-alignment channel over Sections 3 to 5.

The risk of deep seated landslide events over the upper slopes adjacent to Sections 1 and 2 of the drainage channel and on the higher escarpment slopes will remain. Damage to the drainage channel resulting from landslides on the steep escarpment slopes could range from minor (e.g. minor displacement or cracking of lining or support structures) to significant (e.g. collapse of banks, failure of protective lining or retention structures and / or blockages caused by debris).

7.2 Proposed Coal Sizing Plant, Stockpile and Haul Road

The coal sizing plant will be located on a steeply sloping area adjacent to the Bulli Conveyor. There is currently a moderate risk of landslide activity in this area, mainly associated with the loose fill. The risk of landslide affecting this structure is considered to be moderate, and some earthworks improvements to the site can be made during development of the proposed structure to reduce the risk of landslide occurring.

The coal stockpile site has been positioned about 50m away from the toe of the re-vegetated coalwash fill in the lower development area. There remains some risk of landslide within the emplacement area, however improvements to surface and subsurface drainage, the revegetation of this area and the provision of a buffer zone between the stockpile and toe of emplacement area will reduce the risk of the stockpile being affected by a landslide in the emplacement area.

The proposed haul road will cross relatively steep slopes that are underlain by locally deep fill (mainly on the southern side) and local instability has occurred on these fill slopes. Site excavations will need to be carefully managed to avoid failures of cut and fill batters during construction.

8 DISCUSSION AND RECOMMENDATIONS

8.1 Drainage Channel

8.1.1 Section 1

Section 1 of the proposed drainage channel comprises an existing section of the drainage channel which is significantly eroded and deeply incised with oversteepened banks that have locally collapsed or at risk of collapsing. This section will require significant remedial works including the following:-

- Lining of the floor to prevent further scouring by use of reno-mattresses, reinforced concrete with energy dissipation structures at culverts. The concrete base will need to have turned down edge beams to key into the natural surface to prevent flows under the slabs and provide resistance to lateral loads. Reno mattress will need to be tied down by anchors extending at least 2m into the bed.
- The banks of the watercourse gully will need to be protected by concrete or gabion walls stepped up the banks and tied into the concrete base. The lining of the banks will need to extend to within 2m of the highest point of each bank and at least 1.5m above the highest expected flow level. The upper 2m of the watercourse banks should be trimmed where possible to batters no steeper than 2H: 1V. These trimmed batters should then be lined with shotcrete.
- The bed and banks of this section of the channel will need to be trimmed to a suitable grade for lining and large sandstone boulders may be re-used for energy dissipation provided they are assessed as durable and are embedded into the concrete base.
- Improvements to the culvert under the haul road and conveyor will be required as well as the flow paths for runoff from the coalwash fill in the lower development area or western fill area. These improvements may include concrete drop structures and/or lined spillways from culvert outlets.

8.1.2 Section 2

Construction of Section 2 will include improvements to the culvert under the Bulli conveyor, possibly including the use of concrete drop structures. Also additional lining of the watercourse will be required at the outlet from the culvert under the conveyor.

The construction of a new headwall will be a key element of the proposed re-alignment channel. The creation of a stilling basin/debris trap in conjunction with the headwall will be required to allow flows to be effectively slowed and diverted from the current flow path into a lined drainage channel. The headwall will need to be keyed into the floor and banks of the watercourse, preferably socketing into rock.

8.1.3 Sections 3 to 5

Sections 3 to 5 will involve the construction of a concrete lined re-alignment channel. The upslope side of the re-alignment channel will need to be designed as a retaining wall. Significant earthworks will be required to re-shape the hillside above and below the drainage channel alignment. The earthworks will be required to reduce the thickness and extent of soil and extremely weathered rock and to provide a bench or terrace within which the drainage channel can be constructed. In some areas the base of the channel may need to be supported on footings socketed into highly to moderately weathered rock. These footings would likely be shear walls/beams aligned perpendicular to the contours.

For Section 3, in particular, the earthwork is expected to extend to the crest of the ridge and will involve the complete removal of Dam No. 6. For the steep section of the slope at the take-off point (western end of Section 3) a cut and cover tunnel may need to be considered. The design of this section should be subject to detailed subsurface investigation of this slope. Removal of up to 3m of soil and extremely weathered rock may be required in some areas to provide a stable bench on which the re-alignment channel can be constructed.

Unretained batters in stiff clay soils or weak rock (extremely weathered or highly weathered with clay bands) should not be steeper than 3H:1V. Unretained batters in highly to moderately weathered rock should not be steeper than 2H:1V.

In some areas stronger rock (slightly weathered) may be encountered (eg.excavations for the drainage channel) that will require ripping or hammering to remove.

Over Section 4 and the upper part of Section 5, there may be steeply sloping cut batters downhill of the channel alignment. These batters may need to be significantly modified by earthworks possibly including some retaining structures, prior to construction of the re-alignment channel.

Energy dissipation will be required along the concrete lined re-alignment channel and before entering the dissipation pond at the eastern end.

Surface water from the slopes above the re-alignment channel will need to be intercepted and piped to the channel. The re-shaped slope will need to be topdressed and re-vegetated following the earthworks. Temporary re-alignments of surface water will be required as the work progresses to prevent deep scouring occurring on the slope during heavy rain.

8.1.4 Diversion Drains above Pit Top Level

There are various diversion drains above the pit top level of the Russell Vale above the fire trail, in the vicinity of the old power station and above the water storage tank to the south of the access road that links the Pit Top with the fire trail. One of these diversion channels directs runoff away from the Pit Top area to the top of the Bellambi Gully (Section 1 of the Drainage channel discussed above).

Ongoing maintenance and improvements to the diversion drains near the old power station has occurred in recent months, however further improvements to the main diversion drain across the slope linking to the Bellambi Gully and to the drainage at the fire trail level will be required. These drains assist in providing erosion protection to the slopes above the Pit Top area during heavy rain.

8.2 Coal Sizing Plant

The coal sizing plant is to be located close to an existing steel framed trestle support for the Bulli Conveyor. This structure has been established for about 50 years, and does not appear to have been affected by slope instability. Rock outcropping on the nearby access road indicates that the existing trestle structure is likely founded on rock.

Based on our site observations and available subsurface information in the vicinity of the site for the proposed sizing plant the development of the plant at the location proposed is considered feasible. Coffey recommend that the structure be supported on bored piles socketed at least 3m into highly to moderately weathered rock with a serviceability bearing capacity of at least 1500kPa at the base of each pile. We would expect the piles to be structurally tied at the surface by a reinforced concrete 'floor' slab or by reinforced concrete tie-beams.

As the sizing plant is likely to be set into a steep slope, earthworks will be required to re-shape the slope and remove loose fill materials. A retaining wall may also be required along the uphill side of the structure.

8.3 Coal Stockpile

The proposed Wonga Coal Stockpile will essentially be located at the current stockpile location. We understand that it is intended to raise the floor of the valley over the stockpile site by placement of select fill in this area. The select fill may comprise coalwash or low plasticity weathered rock materials from the earthworks for the drainage re-alignment channel and the construction of the haul road.

Fill placed in this area will require engineering supervision in accordance with AS3798. The select fill should be placed and compacted in 200mm layers (compacted thickness) to a minimum dry density ratio of 100% Standard (AS1289 5.1.1). Existing loose materials and remains of any previous structures will need to be removed to expose stiff natural soils or dense fill materials before placing any select fill.

8.4 Proposed Haul Road

The proposed alignment of the haul road from the Mine Entrance Road to the stockpile and coal sizing plant crosses a well defined ridge. The southern side slopes of this ridge are steep and the design of this road is expected to require significant excavations and filling to achieve suitable grades and provide adequate support for heavy vehicles. Excavations across the crest area are expected to encounter some local fill overlying natural soils with rock occurring within about 2m below the natural surface.

Batter slopes for the haul road should not be steeper than 2H:1V in very stiff clays or extremely weathered rock, and not steeper than 1H:1V in highly to moderately weathered rock. Batter slopes for well compacted granular fill should not be steeper than 2H:1V. For batter slopes higher than 3m, further design requirements will need to be considered, including benching, drainage measures and possible erosion protection (e.g. by shotcrete).

Coffey should review design drawings for the haul road, including long sections, cross sections and design of batters and surface water drains.

8.5 Proposed Building Works-Bathhouse and Administration Building Area

Coffey understand that the proposed Preliminary Works will include some building works in the vicinity of the existing bathhouse and administration building. The buildings are expected to be generally to the east of the current buildings, extending over the batter below the existing buildings onto the western edge of a large near level terrace that is currently used as a carparking area.
We understand that buildings will generally be of light, flexible construction. The development of these structures will be subject to the following:-

- Geotechnical subsurface investigation of each site to assess foundation conditions and provide advice on suitable footing types and depths;
- Support of the existing steep batter where buildings extend over the batter;
- Advice on type of structure suitable for the foundation conditions encountered.

The general stability of the area close to the existing bathhouse and administration building is considered to be acceptable for the type of construction discussed above. Potential instability of the batter will need to be considered in the design of any structure in this area.

9 GENERAL LIMITATIONS

The findings of this report are the result of discrete/specific methodologies used in accordance with normal practices and standards. To the best of our knowledge, they represent a reasonable interpretation of the general condition of the site. If unusual or unexpected subsurface conditions are encountered during construction, Coffey should be advised and appropriate action taken. Further subsurface investigation will be required over Sections 2 to 5 of the drainage re-alignment channel, sizing plant, building works around the existing bathhouse/admin buildings and haul road prior to the detailed design. The final design of the various structures will need to be reviewed by Coffey.

Photos

Photo Plate 1: Coal Sizing Plant Site

Photo Plate 2: Coal Stockpile Site-near current bin

drawn	**N/A**	coffey geotechnics SPECIALISTS MANAGING THE EARTH	client:	**GUJARAT NRE MINERALS LIMITED**
approved	**JPT**		project:	**GEOTECHNICAL ASSESSMENT OF PRELIMINARY WORKS COAL STOCKPILE AND HANDLING FACILITY UPGRADE GUJARAT NRE MINERALS LIMITED PRINCES HIGHWAY, RUSSELL VALE, NSW**
date	**31/5/2010**			
scale	**NTS**		title:	**SITE PHOTOS**
original size	**A4**		project no: **GEOTWOLL02875AA-AO**	photo no: **PLATES 1 AND 2**

Photo Plate 3: Section 1 – Drainage Channel-Outlet from Culbert Under Haul Road

Photo Plate 4: Section 1 – Drainage Channel-Old Culbert

drawn	**N/A**	coffey geotechnics SPECIALISTS MANAGING THE EARTH	client:	**GUJARAT NRE MINERALS LIMITED**
approved	**JPT**		project:	**GEOTECHNICAL ASSESSMENT OF PRELIMINARY WORKS COAL STOCKPILE AND HANDLING FACILITY UPGRADE GUJARAT NRE MINERALS LIMITED PRINCES HIGHWAY, RUSSELL VALE, NSW**
date	**31/5/2010**		title:	**SITE PHOTOS**
scale	**NTS**			
original size	**A4**		project no: **GEOTWOLL02875AA-AO**	photo no: **PLATES 3 AND 4**

Photo Plate 5: Section 2 – Drainage Channel

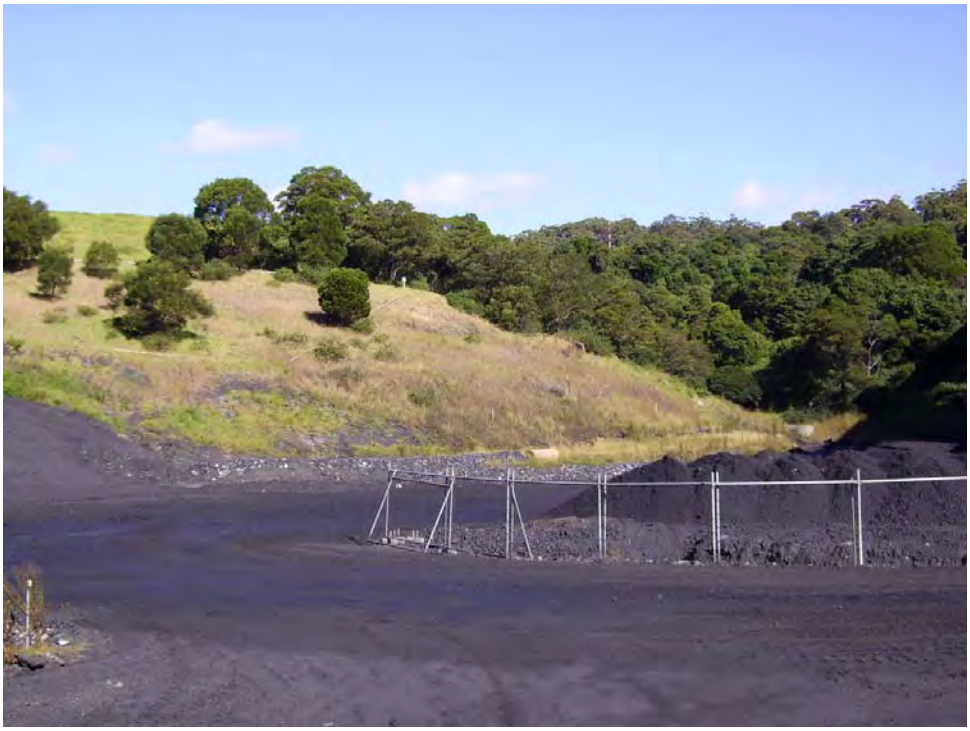


Photo Plate 6: Section 3 – Site of Drainage Channel on Hillside

drawn	**N/A**	coffey geotechnics SPECIALISTS MANAGING THE EARTH	client:	**GUJARAT NRE MINERALS LIMITED**
approved	**JPT**		project:	**GEOTECHNICAL ASSESSMENT OF PRELIMINARY WORKS COAL STOCKPILE AND HANDLING FACILITY UPGRADE GUJARAT NRE MINERALS LIMITED PRINCES HIGHWAY, RUSSELL VALE, NSW**
date	**31/5/2010**		title:	**SITE PHOTOS**
scale	**NTS**			
original size	**A4**		project no: **GEOTWOLL02875AA-AO**	photo no: **PLATES 5 AND 6**

Photo Plate 7: Section 3 – Drainage Channel-crosses grassy hillside

Photo Plate 8: Section 4 – Drainage Channel over lower hillside looking west

drawn	**N/A**	coffey geotechnics SPECIALISTS MANAGING THE EARTH	client:	**GUJARAT NRE MINERALS LIMITED**
approved	**JPT**		project:	**GEOTECHNICAL ASSESSMENT OF PRELIMINARY WORKS COAL STOCKPILE AND HANDLING FACILITY UPGRADE GUJARAT NRE MINERALS LIMITED PRINCES HIGHWAY, RUSSELL VALE, NSW**
date	**31/5/2010**		title:	**SITE PHOTOS**
scale	**NTS**			
original size	**A4**		project no: **GEOTWOLL02875AA-AO**	photo no: **PLATES 7 AND 8**

Photo Plate 9: Section 4 – Drainage Channel-looking west along top of cut batter

Photo Plate 10: Section 4 – Drainage Channel along top of batter-note slump on cut batter

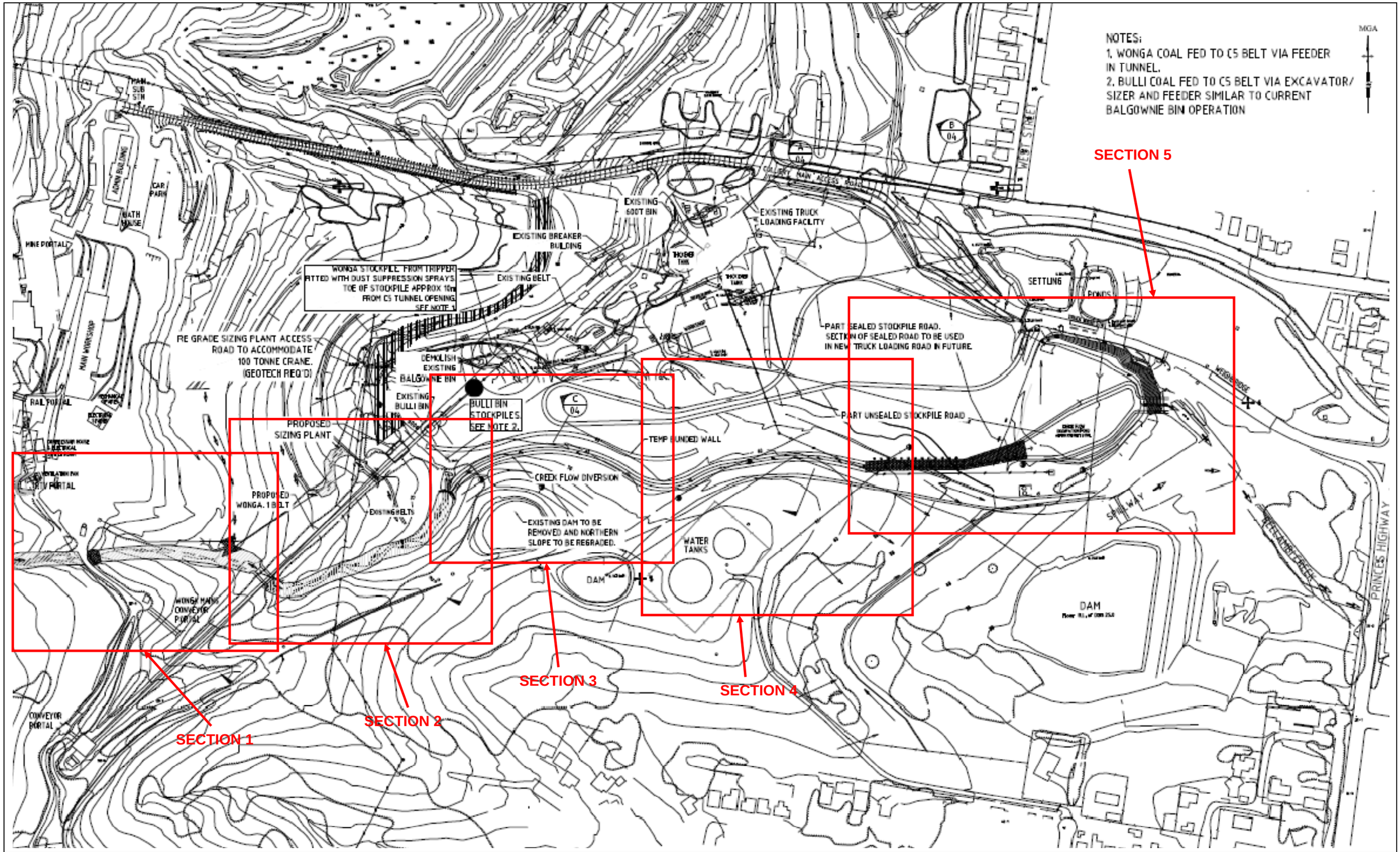
drawn	**N/A**		client:	**GUJARAT NRE MINERALS LIMITED**
approved	**JPT**	coffey geotechnics SPECIALISTS MANAGING THE EARTH	project:	**GEOTECHNICAL ASSESSMENT OF PRELIMINARY WORKS COAL STOCKPILE AND HANDLING FACILITY UPGRADE GUJARAT NRE MINERALS LIMITED PRINCES HIGHWAY, RUSSELL VALE, NSW**
date	**31/5/2010**		title:	**SITE PHOTOS**
scale	**NTS**			
original size	**A4**		project no: **GEOTWOLL02875AA-AO**	photo no: **PLATES 9 AND 10**

Photo Plate 11: Section 5 – Drainage Channel-looking east to proposed dissipation basin

Photo Plate 12: Section 5 – Steep Batter below Drainage Channel-western end of Section 5

drawn	**N/A**	coffey geotechnics SPECIALISTS MANAGING THE EARTH	client:	**GUJARAT NRE MINERALS LIMITED**
approved	**JPT**		project:	**GEOTECHNICAL ASSESSMENT OF PRELIMINARY WORKS COAL STOCKPILE AND HANDLING FACILITY UPGRADE GUJARAT NRE MINERALS LIMITED PRINCES HIGHWAY, RUSSELL VALE, NSW**
date	**31/5/2010**		title:	**SITE PHOTOS**
scale	**NTS**			
original size	**A4**		project no: **GEOTWOLL02875AA-AO**	photo no: **PLATES 11 AND 12**

Figures



revision	description	drawn	approved	date

Horizontal Scale (metres)

Vertical Scale (metres)

drawn	LD
approved	JPT
date	27/05/2010
scale	N.T. S.
original size	A3

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

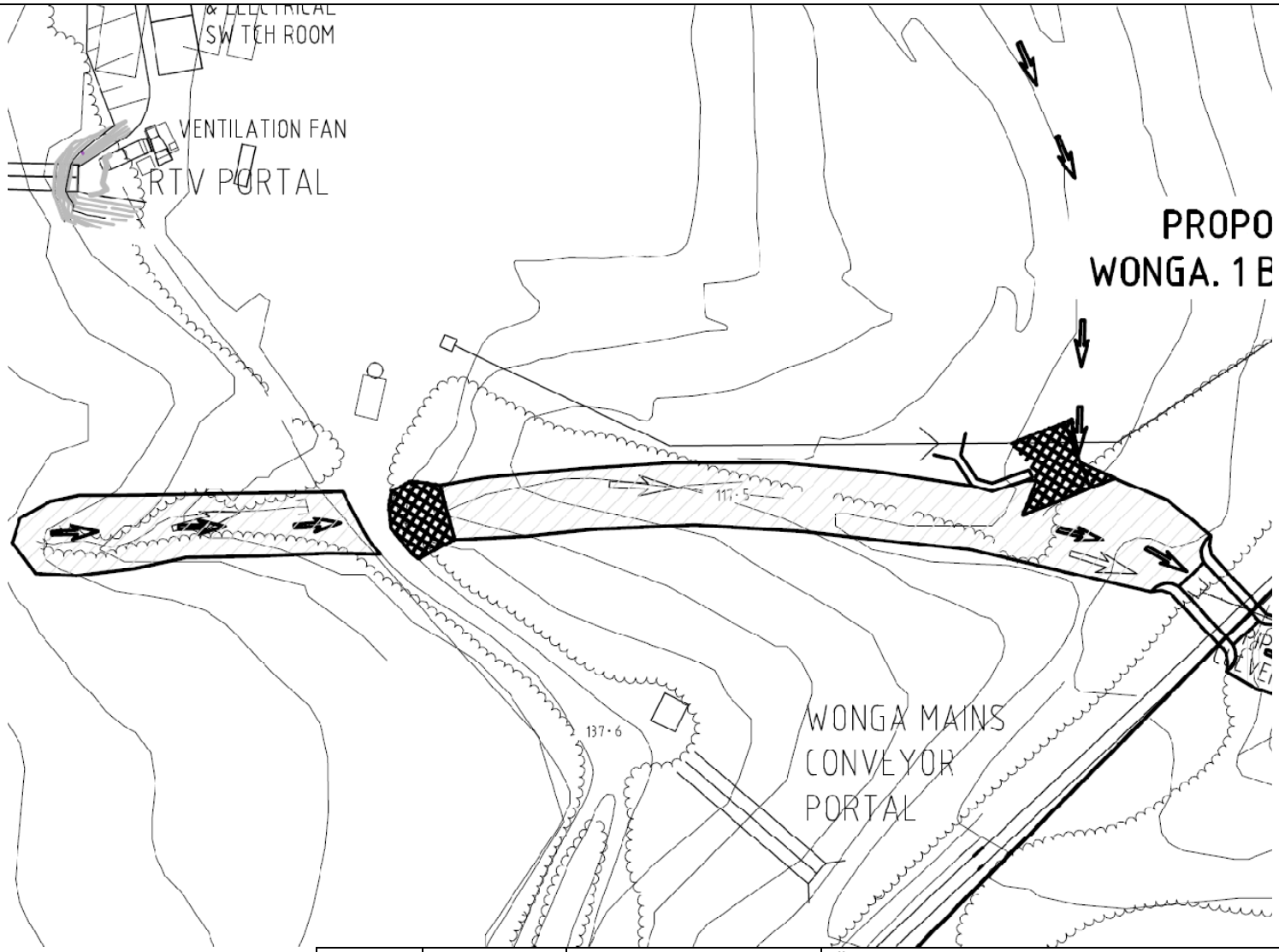
client: GUJARAT NRE MINERALS LIMITED

project: GEOTECHNICAL ASSESSMENT OF PRELIMINARY WORKS, COAL STOCKPILE AND HANDLING FACILITY UPGARDE - GUJARAT NRE MINERALS LIMITED PRINCES HIGHWAY, RUSSELL VALE, NSW

title: SITE PLAN

project no: GEOTWOLL02875AA-AO

figure no: FIGURE 1



drawn	**LD**
approved	**JPT**
date	**24/5/2010**
scale	**NTS**
original size	**A4**

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

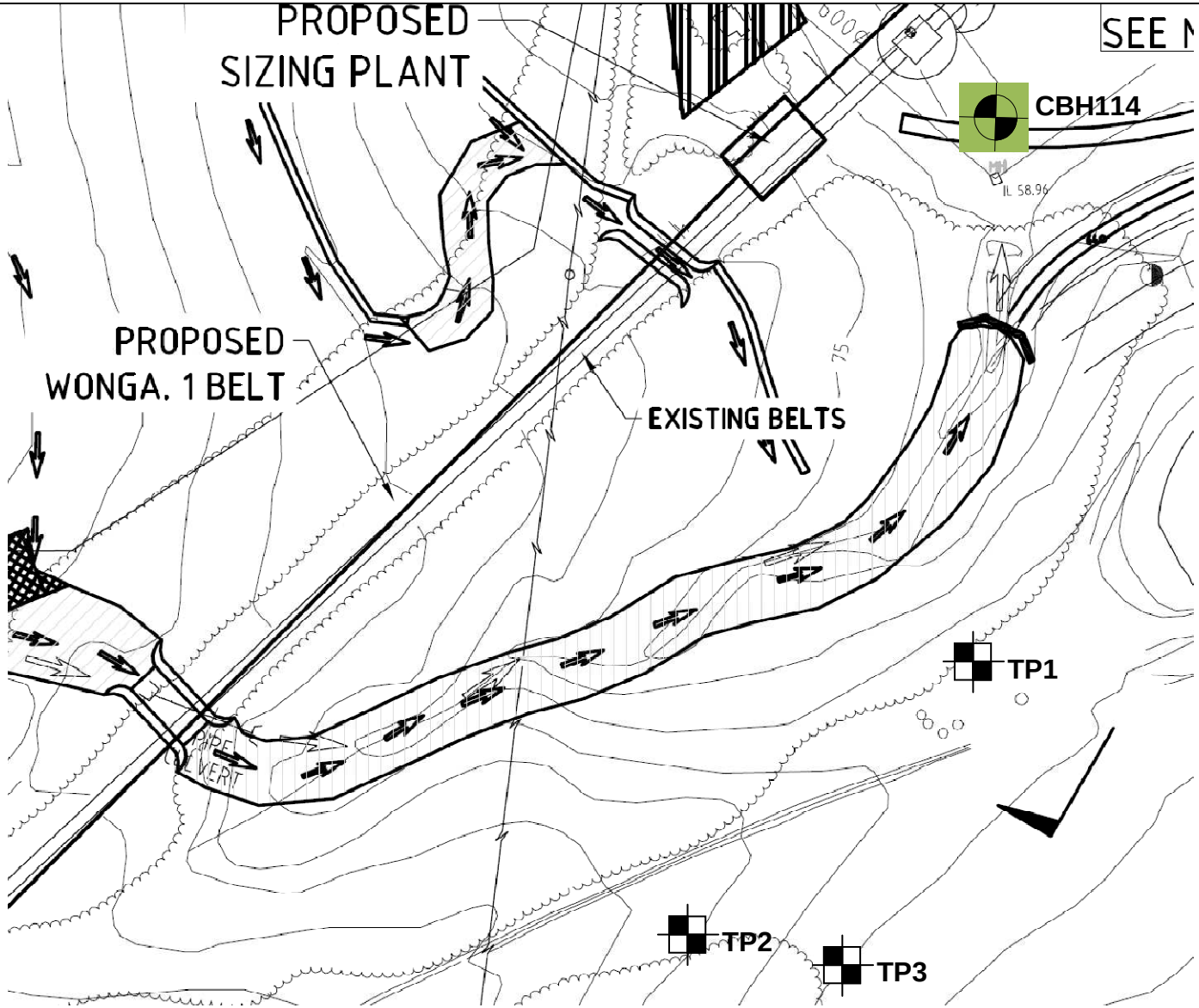
client: **GUJARAT NRE MINERALS LIMITED**

project: **GEOTECHNICAL ASSESSMENT OF PRELIMINARY WORKS COAL STOCKPILE AND HANDLING FACILITY UPGARDE GUJARAT NRE MINERALS LIMITED PRINCES HIGHWAY, RUSSELL VALE, NSW**

title: **SECTION 1**

project no: **GEOTWOLL02875AA-AO**

figure no: **FIGURE 2a**



APPROXIMATE TESTPIT LOCATION REFERENCE SC1001/2-AF, 1995

APPROXIMATE BOREHOLE LOCATION REFERENCE GEOTWOLL02875AA, 2009

drawn	**LD**
approved	**JPT**
date	**24/5/2010**
scale	**NTS**
original size	**A4**

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

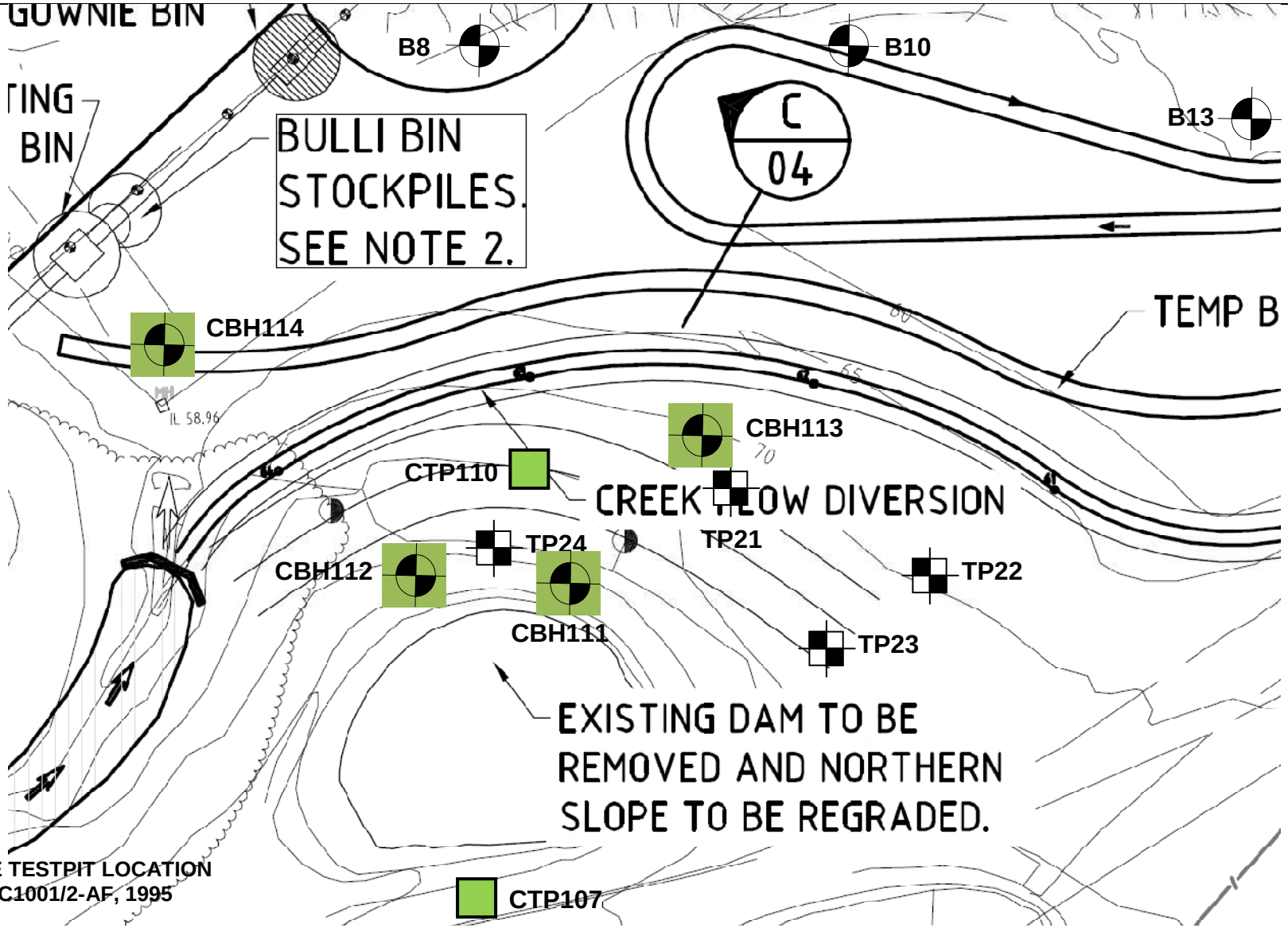
client: **GUJARAT NRE MINERALS LIMITED**

project: **GEOTECHNICAL ASSESSMENT OF PRELIMINARY WORKS COAL STOCKPILE AND HANDLING FACILITY UPGARDE GUJARAT NRE MINERALS LIMITED PRINCES HIGHWAY, RUSSELL VALE, NSW**

title: **SECTION 2**

project no: **GEOTWOLL02875AA-AO**

figure no: **FIGURE 2b**



APPROXIMATE TESTPIT LOCATION REFERENCE SC1001/2-AF, 1995

APPROXIMATE BOREHOLE LOCATION REFERENCE SC1001/2-AF, 1995

APPROXIMATE TESTPIT LOCATION REFERENCE GEOTWOLL02875AA, 2009

APPROXIMATE BOREHOLE LOCATION REFERENCE GEOTWOLL02875AA, 2009

drawn	LD
approved	JPT
date	24/5/2010
scale	NTS
original size	A4

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

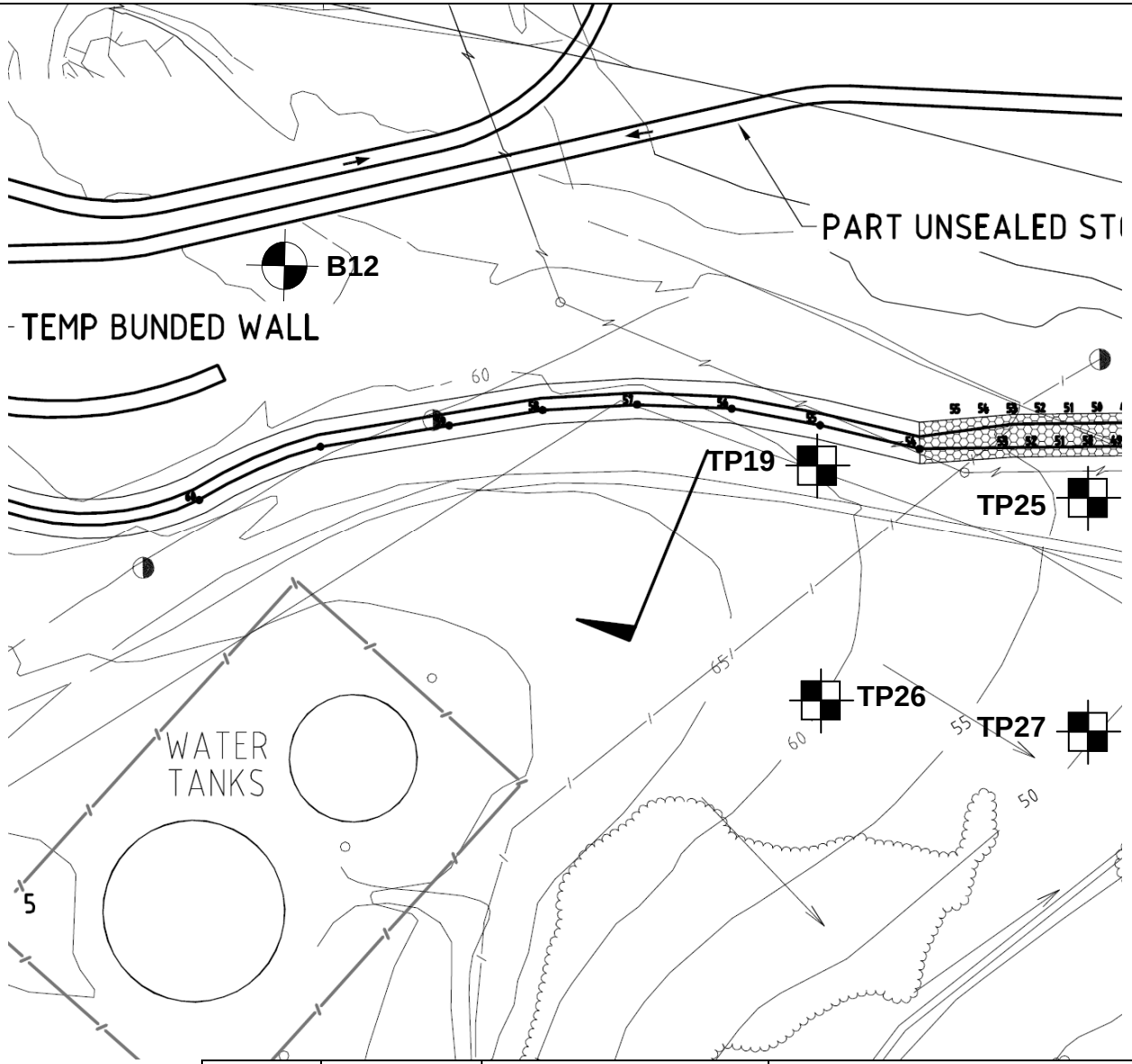
client: GUJARAT NRE MINERALS LIMITED

project: GEOTECHNICAL ASSESSMENT OF PRELIMINARY WORKS
COAL STOCKPILE AND HANDLING FACILITY UPGARDE
GUJARAT NRE MINERALS LIMITED
PRINCES HIGHWAY, RUSSELL VALE, NSW

title: SECTION 3

project no: GEOTWOLL02875AA-AO

figure no: FIGURE 2c



APPROXIMATE TESTPIT LOCATION REFERENCE SC1001/2-AF, 1995

APPROXIMATE BOREHOLE LOACTION REFERENCE SC1001/2-AF, 1995

drawn	**LD**
approved	**JPT**
date	**24/5/2010**
scale	**NTS**
original size	**A4**

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

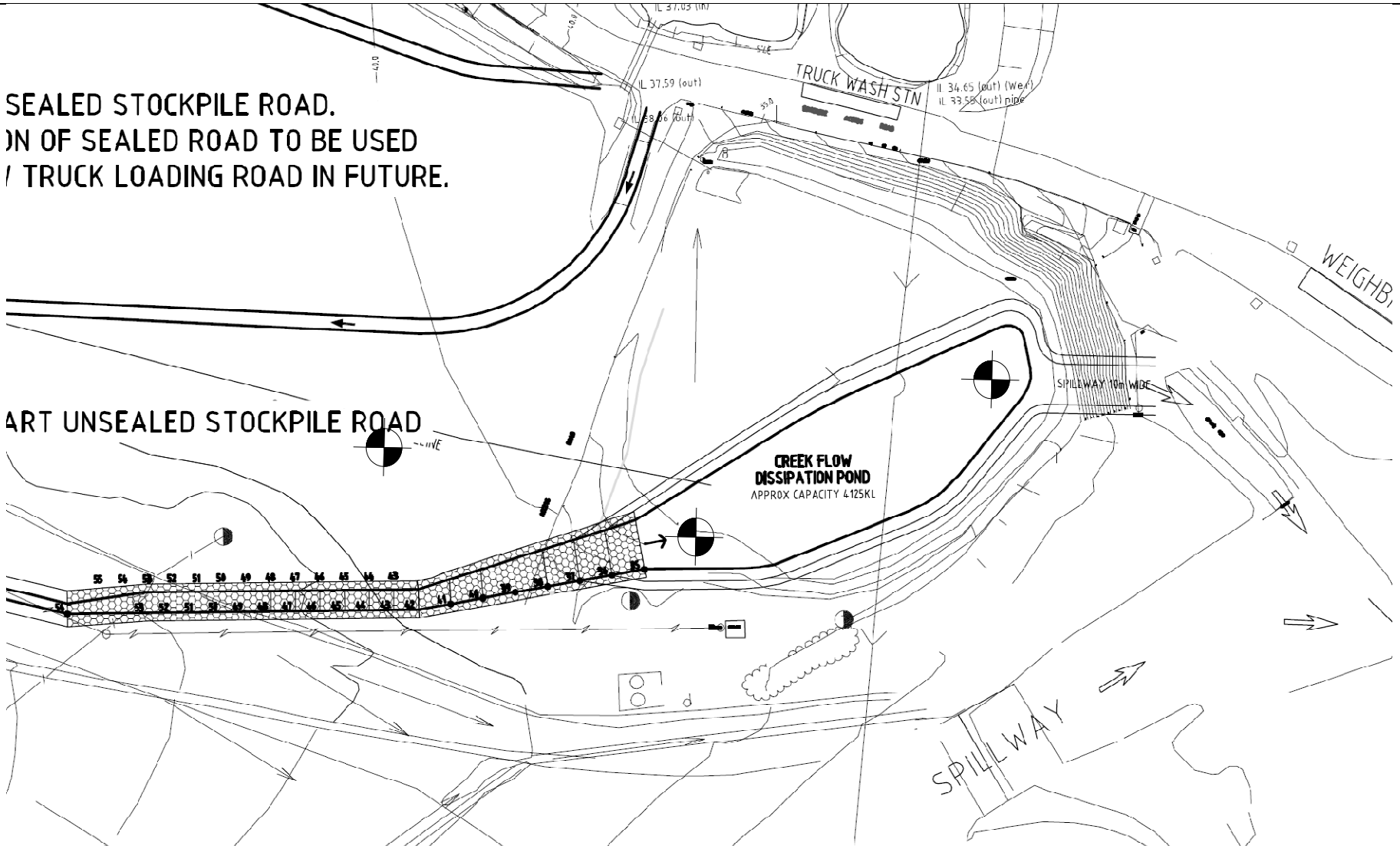
client: **GUJARAT NRE MINERALS LIMITED**

project: **GEOTECHNICAL ASSESSMENT OF PRELIMINARY WORKS COAL STOCKPILE AND HANDLING FACILITY UPGARDE GUJARAT NRE MINERALS LIMITED PRINCES HIGHWAY, RUSSELL VALE, NSW**

title: **SECTION 4**

project no: **GEOTWOLL02875AA-AO**

figure no: **FIGURE 2d**



APPROXIMATE TESTPIT LOCATION
REFERENCE SC1001/2-AF, 1995

APPROXIMATE BOREHOLE LOCATION
REFERENCE SC1001/2-AF, 1995

drawn	**LD**
approved	**JPT**
date	**24/5/2010**
scale	**NTS**
original size	**A4**

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

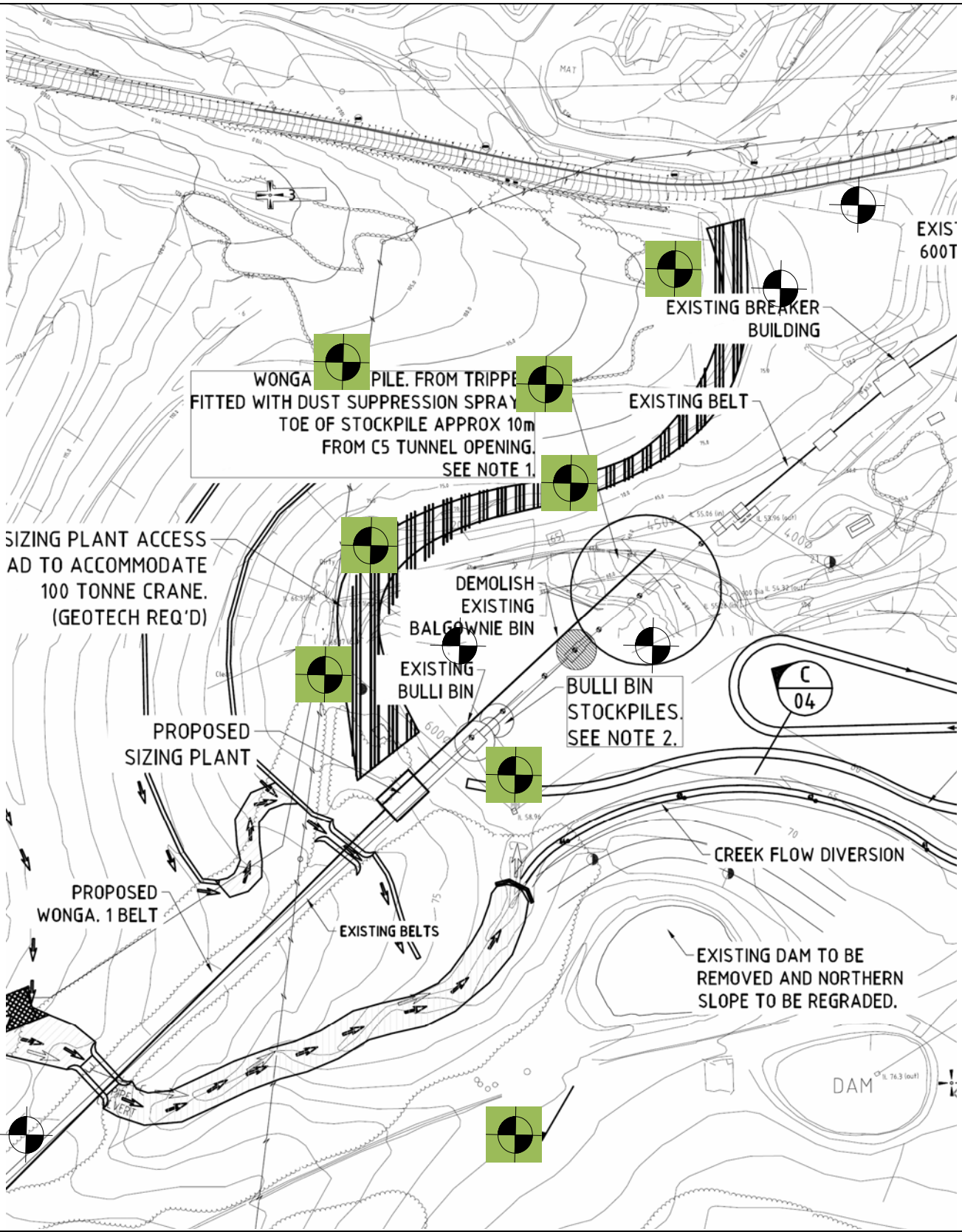
client: **GUJARAT NRE MINERALS LIMITED**

project: **GEOTECHNICAL ASSESSMENT OF PRELIMINARY WORKS COAL STOCKPILE AND HANDLING FACILITY UPGARDE GUJARAT NRE MINERALS LIMITED PRINCES HIGHWAY, RUSSELL VALE, NSW**

title: **SECTION 5**

project no: **GEOTWOLL02875AA-AO**

figure no: **FIGURE 2e**



drawn	**LD**	coffey geotechnics SPECIALISTS MANAGING THE EARTH	client:	**GUJARAT NRE MINERALS LIMITED**
approved	**JPT**		project:	**GEOTECHNICAL ASSESSMENT OF PRELIMINARY WORKS COAL STOCKPILE AND HANDLING FACILITY UPGARDE GUJARAT NRE MINERALS LIMITED PRINCES HIGHWAY, RUSSELL VALE, NSW**
date	**25/5/2010**		title:	**SIZING PLANT AND HAUL ROAD UPGRADE**
scale	**NTS**		project no: **GEOTWOLL02875AA-AO**	figure no: FIGURE 3
original size	**A4**			

Appendix A

Engineering Logs of Recent Test Pits and Boreholes

coffey geotechnics

Engineering Log - Excavation

Excavation No. **CTP100**

Sheet 1 of 1

Project No: **GEOTWOLL02875AA**

Client: ***GUJART NRE MINERALS LTD***

Date started: ***6.4.2009***

Principal:

Date completed: ***6.4.2009***

Project: ***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***

Logged by: ***LD***

Test pit location: ***80 TONNE CRANE PAD SITE***

Checked by: ***JPT***

equipment type and model: 22T EXCAVATOR | Pit Orientation: | Easting: 560305788 m | R.L. Surface: NOT MEASURED

excavation dimensions: 3m long 0.8m wide | Northing: 6195651 m | datum: WGS-84

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
E			NONE OBSERVED	Ds		0.5			**FILL; Sandy SILT:** Dark brown, fine to coarse grained sand with some fine to coarse grained gravel, with angular cobbles up to 200mm.	M	L	×	FILL; TOPSOIL
									FILL; SAND: Fine to coarse grained, black.			×	FILL; COALWASH
						1.0			**SANDSTONE:** Fine to medium grained, banded grey and orange-brown, distinctly laminated at 0 to 5 degrees, very low strength.			×	HW SANDSTONE
						1.5							
						2.0			**SANDSTONE:** Fine to medium grained, banded grey and orange-brown, distinctly laminated at 0 to 5 degrees, very low strength.				MW SANDSTONE
						2.5							
						3.0			Test pit CTP100 terminated at 2.6m				Terminated at 2.6m due to slow but steady progress
						3.5							
						4.0							

Sketch

method
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R ripper
E excavator

support
S shoring N nil

penetration
1 2 3 4
no resistance ranging to refusal

water
water level on date shown
water inflow
water outflow

notes, samples, tests
U_{50} undisturbed sample 50mm diameter
U_{63} undisturbed sample 63mm diameter
D disturbed sample
V vane shear (kPa)
Bs bulk sample
E environmental sample
R refusal

classification symbols and soil description
based on unified classification system

moisture
D dry
M moist
W wet
Wp plastic limit
W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Excavation

Excavation No. **CTP101**

Sheet 1 of 1

Project No: **GEOTWOLL02875AA**

Client: ***GUJART NRE MINERALS LTD***

Date started: ***6.4.2009***

Principal:

Date completed: ***6.4.2009***

Project: ***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***

Logged by: ***LD***

Test pit location: ***80 TONNE CRANE PAD SITE***

Checked by: ***JPT***

equipment type and model: 22T EXCAVATOR | Pit Orientation: | Easting: 560805791 m | R.L. Surface: NOT MEASURED

excavation dimensions: 4m long 0.8m wide | Northing: 6195663 m | datum: WGS-84

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
E			NONE OBSERVED			0.0			**FILL; Sandy SILT:** Black, fine to coarse grained sand, with some fine to coarse grained gravel, with some angular sandstone cobbles up to 100mm.	M	L	×	FILL; TOPSOIL
								SP	**Silty SAND:** Fine to coarse grained, pale brown/pale grey, with many sandstone cobbles, angular up to 200mm		MD/D	×	COLLUVIUM
				Ds		1.0		SP	**Silty Clayey SAND:** Fine to coarse grained, pale brown, low plasticity clay, with some fine to coarse grained gravel.		D	×	XW SANDSTONE
						1.5			**SANDSTONE:** Fine to medium grained, banded grey and orange-brown, distinctly laminated at 0 to 5 degrees, very low strength				HW SANDSTONE
						2.0			**SANDSTONE:** Fine to medium grained, banded grey and orange-brown, distinctly laminated at 0 to 5 degrees, very low strength				MW SANDSTONE
						2.5			Test pit CTP101 terminated at 2.5m				Terminated at 2.5m due to slow but steady progress
						3.0							
						3.5							
						4.0							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration
1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description
based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Excavation

Excavation No. ***CTP102***

Sheet 1 of 1

Project No: ***GEOTWOLL02875AA***

Client: ***GUJART NRE MINERALS LTD***

Date started: ***6.4.2009***

Principal:

Date completed: ***6.4.2009***

Project: ***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***

Logged by: ***LD***

Test pit location: ***80 TONNE CRANE PAD SITE***

Checked by: ***JPT***

equipment type and model: 22T EXCAVATOR | Pit Orientation: | Easting: 560305804 m | R.L. Surface: NOT MEASURED

excavation dimensions: 4m long 0.8m wide | Northing: 6195671 m | datum: WGS-84

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
E			NONE OBSERVED			0.5			**FILL; Sandy SILT:** Dark brown, fine to coarse grained sand with some fine to coarse grained gravel, with some angular cobbles up to 200mm.	M	L	x x	FILL; TOPSOIL
						1.0			**FILL; Sandy Gravelly COBBLES:** Fine to coarse grained, black, angular cobbles up to 200mm, angular, fine to coarse grained angular gravel, fine to coarse grained sand, with some sandstone cobbles and boulders, pale grey, up to 200mm to 400mm.		VD	x	FILL; COALWASH
						1.5							
				Ds		2.0			**FILL; Sandy Gravelly CLAY:** Low to medium plasticity, dark grey/dark brown/orange/brown/grey, fine to coarse grained gravel, fine to coarse grained sand, with some sandstone cobbles up to 200m, with some boulders up to 500mm.	>Wp	St		FILL
						2.5			Test pit CTP102 terminated at 2.5m				Terminated at 2.5m on steady progress
						3.0							
						3.5							
						4.0							

Sketch

method
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R ripper
E excavator

support
S shoring N nil

penetration
1 2 3 4
no resistance ranging to refusal

water
water level on date shown
water inflow
water outflow

notes, samples, tests
U_{50} undisturbed sample 50mm diameter
U_{63} undisturbed sample 63mm diameter
D disturbed sample
V vane shear (kPa)
Bs bulk sample
E environmental sample
R refusal

classification symbols and soil description
based on unified classification system

moisture
D dry
M moist
W wet
Wp plastic limit
W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Excavation

Excavation No. **CTP103**

Sheet 1 of 1

Project No: **GEOTWOLL02875AA**

Client: ***GUJART NRE MINERALS LTD***

Date started: ***6.4.2009***

Principal:

Date completed: ***6.4.2009***

Project: ***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***

Logged by: ***LD***

Test pit location: ***80 TONNE CRANE PAD SITE***

Checked by: ***JPT***

equipment type and model: 22T EXCAVATOR | Pit Orientation: | Easting: 560305813 m | R.L. Surface: NOT MEASURED

excavation dimensions: 3.5m long 0.8m wide | Northing: 6195561 m | datum: WGS-84

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
E			NONE OBSERVED	Ds		0.5		GP	**FILL; Sandy SILT:** Dark brown, fine to coarse grained sand with some fine to coarse grained angular gravel, with some angular cobbles up to 200mm.	M	D	×	FILL; TOPSOIL
											VD		XW SANDSTONE
						1.0			**Clayey Sandy GRAVEL:**Fine to coarse grained, brown, fine to coarse grained sand, low plasticity clay, with a trace of sandstone cobbles to to 200mm, distinctly bedded.				
						1.5			**SANDSTONE:** Fine to medium grained, banded grey and orange-brown, distinctly laminated at 0 to 5 degrees, very low strength				HW SANDSTONE
				Ds		2.0		CL	**Silty CLAY:** Low plasticity, orange/brown, with some fine to coarse grained sand with many fine to coarse grained angular gravel.	>Wp	VSt/H		XW SANDSTONE
				Ds		2.5			**SANDSTONE:** Fine to medium grained, banded grey and orange-brown, distinctly laminated at 0 to 5 degrees, very low strength				MW SANDSTONE
									Test pit CTP103 terminated at 2.5m				Terminated at 2.5m due to slow but steady progress
						3.0							
						3.5							
						4.0							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration
1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description
based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Excavation

Excavation No. **CTP104**

Sheet 1 of 1

Project No: **GEOTWOLL02875AA**

Client: ***GUJART NRE MINERALS LTD***

Date started: ***6.4.2009***

Principal:

Date completed: ***6.4.2009***

Project: ***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***

Logged by: ***LD***

Test pit location: ***80 TONNE CRANE PAD SITE***

Checked by: ***JPT***

equipment type and model: 22T EXCAVATOR | Pit Orientation: | Easting: 560305822 m | R.L. Surface: NOT MEASURED

excavation dimensions: 4.5m long 0.8m wide | Northing: 6195668 m | datum: WGS-84

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa (100 200 300 400)	structure and additional observations
E			NONE OBSERVED			0.5			**FILL; Sandy SILT:** Dark brown, fine to coarse grained sand, with many fine to coarse grained angular gravel fragments, with some low plasticity clay, with some coalwash.	<Wp	L/MD	×	FILL; TOPSOIL
								GP	**Clayey Sandy GRAVEL:**Fine to coarse grained, brown, fine to coarse grained sand, , low plasticity clay, with a trace of sandstone cobbles to to 200mm, distinctly bedded.		D		XW/HW SANDSTONE
						1.0		GP	**Clayey Sandy GRAVEL:** Fine to coarse grained, pale grey, fine to coarse grained sand, low plasticity clay, with a trace of sandstone cobbles to to 200mm, distictly bedded, highly fractured.		VSt/H		XW TESCHENITE (Volcanic Sill)
						1.5			**SANDSTONE:** Fine to medium grained, banded grey and orange-brown, distinctly laminated at 0 to 5 degrees, very low strength				HW SANDSTONE
				Ds		2.0							
				Ds		2.5			**TESCHENITE:** Fine grained, grey, high stength				MW TESCHENITE (Volcanic Sill)
									Test pit CTP104 terminated at 2.5m				Terminated on very slow progress
						3.0							
						3.5							
						4.0							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration
1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description
based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Excavation

Excavation No. **CTP105**

Sheet 1 of 1

Project No: **GEOTWOLL02875AA**

Client: ***GUJART NRE MINERALS LTD***

Date started: ***6.4.2009***

Principal:

Date completed: ***6.4.2009***

Project: ***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***

Logged by: ***LD***

Test pit location: ***80 TONNE CRANE PAD SITE***

Checked by: ***JPT***

equipment type and model: 22T EXCAVATOR | Pit Orientation: | Easting: 560305829 m | R.L. Surface: NOT MEASURED

excavation dimensions: 5m long 0.8m wide | Northing: 6195659 m | datum: WGS-84

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
E			NONE OBSERVED			0.5			**FILL; Sandy SILT:** Dark brown, fine to coarse grained sand, with many fine to coarse grained angular gravel fragments, with some low plasticity clay.	M	L / MD	×	FILL; TOPSOIL
								GP	**Clayey Sandy GRAVEL:** Fine to coarse grained, brown, fine to coarse grained sand, low plasticity clay, with a trace of sandstone cobbles up to 200mm, distictly bedded.		VD		XW SANDSTONE
						1.0			**SANDSTONE:** Fine to medium grained, banded grey and orange-brown, distinctly laminated at 0 to 5 degrees, very low strength				HW SANDSTONE
								CL	**Silty CLAY:** Low plasticity, orange/brown, with many fine to coarse grained angular gravel fragments, and some fine to coarse grained sand.	<Wp	VSt/H		XW TESCHENITE (Volcanic Sill)
				Ds		1.5							
				Ds		2.0			**TESCHENITE:** Fine grained, grey, medium to high strength				HW TESCHENITE (Volcanic Sill)
						2.5							
									Test pit CTP105 terminated at 2.5m				Terminated at 2.5m due to slow to steady progress
						3.0							
						3.5							
						4.0							

Sketch

method
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R ripper
E excavator

support
S shoring N nil

penetration
1 2 3 4
no resistance ranging to refusal

water
water level on date shown
water inflow
water outflow

notes, samples, tests
U_{50} undisturbed sample 50mm diameter
U_{63} undisturbed sample 63mm diameter
D disturbed sample
V vane shear (kPa)
Bs bulk sample
E environmental sample
R refusal

classification symbols and soil description
based on unified classification system

moisture
D dry
M moist
W wet
Wp plastic limit
W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation No. **CTP106**

Sheet 1 of 1

Project No: **GEOTWOLL02875AA**

Client: **GUJART NRE MINERALS LTD**

Date started: **6.4.2009**

Principal:

Date completed: **6.4.2009**

Project: **GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE**

Logged by: **LD**

Test pit location: **80 TONNE CRANE PAD SITE**

Checked by: **JPT**

equipment type and model: 22T EXCAVATOR | Pit Orientation: | Easting: 560305834 m | R.L. Surface: NOT MEASURED

excavation dimensions: 3m long 0.8m wide | Northing: 6495651 m | datum: WGS-84

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
E			NONE OBSERVED			0.0			**FILL; Sandy SILT:** Dark brown, fine to coarse grained sand, with many fine to coarse grained angular gravel fragments, with some low plasticity clay.	M/<Wp	L	×	FILL; TOPSOIL
								CL	**Silty CLAY:** Low plasticity, orange/brown/grey, with many fine to coarse grained angular gravel fragments, fine to coarse grained sand.	<Wp	VSt	×	XW TESCHENITE (Volcanic Sill)
				UBR		0.5						×	
						1.0			**SANDSTONE:** Fine to medium grained, banded grey and orange-brown, distinctly laminated at 0 to 5 degrees, very low strength	M		×	HW SANDSTONE
				Ds		1.5						×	
						2.0			**SANDSTONE:** Fine to medium grained, banded grey and orange-brown, distinctly laminated at 0 to 5 degrees, very low strength				MW SANDSTONE
				Ds		2.5							
						3.0			Test pit CTP106 terminated at 2.6m				Terminated at 2.6m due to slow but steady progress
						3.5							
						4.0							

Sketch

method
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R ripper
E excavator

support
S shoring N nil

penetration
1 2 3 4 no resistance ranging to refusal

water
water level on date shown
water inflow
water outflow

notes, samples, tests
U_{50} undisturbed sample 50mm diameter
U_{63} undisturbed sample 63mm diameter
D disturbed sample
V vane shear (kPa)
Bs bulk sample
E environmental sample
R refusal

classification symbols and soil description
based on unified classification system

moisture
D dry
M moist
W wet
Wp plastic limit
W_L liquid limit

consistency/density index
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

coffey geotechnics

Engineering Log - Excavation

Excavation No. ***CTP107***

Sheet 1 of 1

Project No: ***GEOTWOLL02875AA***

Client: ***GUJART NRE MINERALS LTD***

Date started: ***7.4.2009***

Principal:

Date completed: ***7.4.2009***

Project: ***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***

Logged by: ***LD***

Test pit location: ***DAM NO. 5 AND NO. 6***

Checked by: ***JPT***

equipment type and model: 22T EXCAVATOR | Pit Orientation: | Easting: 560306046 m | R.L. Surface: NOT MEASURED

excavation dimensions: 3m long 0.8m wide | Northing: 6195731 m | datum: WGS-84

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
E			NONE OBSERVED	Ds		0.5		CH	**FILL: Sandy GRAVEL:** Fine to coarse grained, black, fine to coarse grained sand, with some low to medium plasticity clay.	W	L		FILL: COALWASH
									Silty CLAY: High plasticity, orange/brown/cream/grey mottled, with some fine to coarse grained gravel and sand.	>Wp	St		RESIDUAL
						1.0				<Wp	VSt/H		
				Ds		1.5		CH	**Silty CLAY:** High plasticity, pale grey, with some orange staining, with many fine to coarse grained angular gravel fragments.	>Wp	VSt		XW SANDSTONE
									SANDSTONE: Fine to coarse grained, pale grey, with some medium to high plasticity clayey gravel, pale grey, with orange staining, with some fine to coarse grained sand.				HW SANDSTONE
						2.0			**SANDSTONE:** Pale grey, low to medium strength.				MW SANDSTONE
						2.5			Test pit CTP107 terminated at 2.5m				CTP107 terminated at 2.5m on steady to slow progress
						3.0							
						3.5							
						4.0							

Sketch

method
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R ripper
E excavator

support
S shoring N nil

penetration
1 2 3 4
no resistance ranging to refusal

water
water level on date shown
water inflow
water outflow

notes, samples, tests
U_{50} undisturbed sample 50mm diameter
U_{63} undisturbed sample 63mm diameter
D disturbed sample
V vane shear (kPa)
Bs bulk sample
E environmental sample
R refusal

classification symbols and soil description
based on unified classification system

moisture
D dry
M moist
W wet
Wp plastic limit
W_L liquid limit

consistency/density index
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

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Engineering Log - Excavation

Excavation No. ***CTP108***

Sheet 1 of 1

Project No: ***GEOTWOLL02875AA***

Client: ***GUJART NRE MINERALS LTD***

Date started: ***7.4.2009***

Principal:

Date completed: ***7.4.2009***

Project: ***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***

Logged by: ***LD***

Test pit location: ***DAM NO. 5 AND NO. 6***

Checked by: ***JPT***

equipment type and model: 22T EXCAVATOR | Pit Orientation: | Easting: 560306134 m | R.L. Surface: NOT MEASURED

excavation dimensions: 3m long 1.5m wide | Northing: 6195684 m | datum: WGS-84

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
E			NONE OBSERVED			0.0			**FILL; Silty CLAY:** Medium to high plasticity, brown/grey, with many fine to coarse grained angular gravel fragments.	>Wp	St/VSt	×	FILL: TOPSOIL
								ML	**Clayey SILT:** Brown/pale brown, low plasticity clay, with many subrounded sandstone cobble inclusions up to 200mm.	<Wl		×	COLLUVIUM
				Ds		1.0					VSt/H	×	
						1.5						×	
						2.0							
						2.5			**COBBLES & BOULDERS:** Tightly packed, grey, fine grained, very high stength.	D	D		
									Test pit CTP108 terminated at 2.5m				CTP108 terminated at 2.5m due to refusal on rock
						3.0							
						3.5							
						4.0							

Sketch

method
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R ripper
E excavator

support
S shoring N nil

penetration
1 2 3 4 no resistance ranging to refusal

water
water level on date shown
water inflow
water outflow

notes, samples, tests
U_{50} undisturbed sample 50mm diameter
U_{63} undisturbed sample 63mm diameter
D disturbed sample
V vane shear (kPa)
Bs bulk sample
E environmental sample
R refusal

classification symbols and soil description
based on unified classification system

moisture
D dry
M moist
W wet
Wp plastic limit
W_L liquid limit

consistency/density index
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

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Engineering Log - Excavation

Excavation No. ***CTP109***

Sheet 1 of 1

Project No: ***GEOTWOLL02875AA***

Client: ***GUJART NRE MINERALS LTD***

Date started: ***7.4.2009***

Principal:

Date completed: ***7.4.2009***

Project: ***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***

Logged by: ***LD***

Test pit location: ***DAM NO. 5 AND NO. 6***

Checked by: ***JPT***

equipment type and model: 22T EXCAVATOR | Pit Orientation: | Easting: 560306154 m | R.L. Surface: NOT MEASURED

excavation dimensions: 4m long 1.2m wide | Northing: 6195696 m | datum: WGS-84

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
E			NONE OBSERVED			0.5			**FILL: Clayey SILT:** Dark brown, low plasticity clay, with some old plastic.	M	L	×	FILL; TOPSOIL
									FILL; Silty CLAY: Medium to high plasticity, brown/orange/grey mottled, with some fine to coarse grained gravel.	>Wp	St/VSt	× ×	FILL
						1.0			**FILL; Gravelly COBBLES:** Fine to coarse grained, grey, angular sandstone cobbles upto 200mm, fine to coarse grained gravel.		MD		FILL
				Ds		1.5			**FILL; Silty CLAY:** High plasticity, pale grey, with many angular gravel and sandstone cobbles		VSt	× ×	FILL
						2.0			**FILL; Sandy Gravelly CLAY:** High plasticity, black, fine to coarse grained gravel, fine to coarse grained sand.				FILL; COALWASH
				Ds		2.5			**FILL; Clayey SILT:** Pale grey/cream, medium plasticity clay, with some sand and fine to coarse grained gravel.	<Wp	MD		FILL
									Test pit CTP109 terminated at 2.5m				
						3.0							
						3.5							
						4.0							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration
1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description
based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Excavation

Excavation No. **CTP110**

Sheet 1 of 1

Project No: **GEOTWOLL02875AA**

Client: ***GUJART NRE MINERALS LTD***

Date started: ***7.4.2009***

Principal:

Date completed: ***7.4.2009***

Project: ***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***

Logged by: ***LD***

Test pit location: ***DAM NO. 5 AND NO. 6***

Checked by: ***JPT***

equipment type and model: 22T EXCAVATOR | Pit Orientation: | Easting: 560306061 m | R.L. Surface: NOT MEASURED

excavation dimensions: 5m long 1.2m wide | Northing: 6195825 m | datum: WGS-84

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
E			NONE OBSERVED			0.0			**FILL; Sandy Clayey GRAVEL:** Fine to coarse grained, black, low to medium plasticity clay, fine to coarse grained sand.	M	L/MD	×	FILL; COALWASH
								CH		>Wp	VSt/H		XW TESCHENITE (Volcanic Sill)
						0.5			**Silty CLAY:** High plasticity, pale brown/pale grey, with some fine to coarse grained angular gravel, with some fine to coarse grained sand.				
									TESCHENITE: Low to medium strength, fine to coarse grained, massive, highly fractured				HW TESCHENITE (Volcanic Sill)
				Ds		1.0							
						1.5							
						2.0			Test pit CTP110 terminated at 1.65m				CTP110 terminated at 1.65m due to refusal on rock
						2.5							
						3.0							
						3.5							
						4.0							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration
1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description
based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Excavation

Excavation No. **CTP111**

Sheet 1 of 1

Project No: **GEOTWOLL02875AA**

Client: ***GUJART NRE MINERALS LTD***

Date started: ***7.4.2009***

Principal:

Date completed: ***7.4.2009***

Project: ***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***

Logged by: ***LD***

Test pit location: ***STOCKPILE AREA***

Checked by: ***JPT***

equipment type and model: 22T EXCAVATOR | Pit Orientation: | Easting: 560306063 m | R.L. Surface: NOT MEASURED

excavation dimensions: 6m long 2m wide | Northing: 6195805 m | datum: WGS-84

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
E			NONE OBSERVED			0.5			**FILL; Sandy Gravelly CLAY:** High plasticity, fine to coarse grained gravel, fine to coarse grained sand, with some sandstone cobbles up to 200mm, trace of boulders up to 400mm.	>Wp	F/St	×	FILL; COALWASH
						1.0					St	×	
						1.5						×	
						2.0			...Pockets of high plasticity silty clay at 2.1m, orange/pale grey mottled.			×	
						2.5							
						3.0							
						3.5			Test pit CTP111 terminated at 3.4m				CTP 111 terminated at 3.4m in coal wash on steady progress
						4.0							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration
1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description
based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation No. ***CTP112***

Sheet 1 of 1

Project No: ***GEOTWOLL02875AA***

Client: ***GUJART NRE MINERALS LTD***

Date started: ***8.4.2009***

Principal:

Date completed: ***8.4.2009***

Project: ***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***

Logged by: ***LD***

Test pit location: ***STOCKPILE AREA***

Checked by: ***JPT***

equipment type and model: 22T EXCAVATOR | Pit Orientation: | Easting: 560306035 m | R.L. Surface: NOT MEASURED

excavation dimensions: 4m long 0.8m wide | Northing: 6195809 m | datum: WGS-84

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
E			NONE OBSERVED			0.5			**FILL; Sandy GRAVEL:** Fine to coarse grained, black, fine to coarse grained sand, with a trace of low plasticity clay.	M	D		FILL; COALWASH
						1.0							
						1.5			Test pit CTP112 terminated at 1.2m				CTP112 terminated at 1.2m due to services
						2.0							
						2.5							
						3.0							
						3.5							
						4.0							

Sketch

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method

N	natural exposure
X	existing excavation
BH	backhoe bucket
B	bulldozer blade
R	ripper
E	excavator

support

S shoring N nil

penetration

1 2 3 4 — no resistance ranging to refusal

water

water level on date shown

water inflow

water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
V	vane shear (kPa)
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation No. **CTP113**

Sheet 1 of 1

Project No: **GEOTWOLL02875AA**

Client: **GUJART NRE MINERALS LTD**

Date started: **8.4.2009**

Principal:

Date completed: **8.4.2009**

Project: **GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE**

Logged by: **LD**

Test pit location: **STOCKPILE AREA**

Checked by: **JPT**

equipment type and model: 22T EXCAVATOR | Pit Orientation: | Easting: 560306054 m | R.L. Surface: NOT MEASURED

excavation dimensions: 5m long 0.5m wide | Northing: 6195997 m | datum: WGS-84

excavation information						material substance						
method	penetration 1 2 3	support	water	notes samples, tests, etc	RL / depth metres	graphic log	classification symbol	material — soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa (100 200 300 400)	structure and additional observations
E			NONE OBSERVED		0.0			**FILL; Gravelly SILT:** Black, fine to coarse grained angular gravel, with some fine to coarse grained sand, with some low plasticity clay.	<Wp	St	×	FILL; COALWASH
									M	MD		FILL
					0.5		ML	**FILL; Clayey GRAVEL:** Fine to coarse grained, pale grey/orange/brown/cream/black, medium to high plasticity clay, with some fine to coarse grained angular gravel.	<Wp	St	×	TOPSOIL
							CH	**Clayey SILT:** Dark brown, low plasticity clay, with some fine to coarse grained sand, with some fine to coarse grained angular gravel.	>Wp	VSt/H	×	RESIDUAL
					1.0			**Silty CLAY:** High plasticity, orange/brown/pale grey mottled, with some fine to coarse grained angular gravel, with some fine to coarse grained sand.			×	
				Ds	1.5			**SANDSTONE:** Fine to medium grained, low strength.				HW SANDSTONE: Some XW bands
					2.0							
					2.5							
				Ds				Test pit CTP113 terminated at 2.7m				Terminated at 2.7m on steady to slow progress
					3.0							
					3.5							
					4.0							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration
1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description
based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Excavation

Excavation No. **CTP114**

Sheet 1 of 1

Project No: **GEOTWOLL02875AA**

Client: ***GUJART NRE MINERALS LTD***

Date started: ***8.4.2009***

Principal:

Date completed: ***8.4.2009***

Project: ***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***

Logged by: ***LD***

Test pit location: ***STOCKPILE AREA***

Checked by: ***JPT***

equipment type and model: 22T EXCAVATOR | Pit Orientation: | Easting: 560305982 m | R.L. Surface: NOT MEASURED

excavation dimensions: 5m long 0.8m wide | Northing: 6196028 m | datum: WGS-84

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
E			NONE OBSERVED			0.5		ML	**Clayey SILT:** Dark brown, low plasticity clay, with some fine to coarse grained sand, with some fine to coarse grained angular gravel, with many angular sandstone cobble inclusions up to 200mm.	M	St	× ×	TOPSOIL
				Ds		1.0		CL/CH	**Silty CLAY:** Medium to high plasticity, brown, with some fine to coarse grained sand, with some fine to coarse grained angular gravel, with some angular sandstone cobbles up to 200mm.	>Wp	VSt	× × ×	RESIDUAL
				Ds		1.5			**SANDSTONE:** Fine to medium grained, low strength.				HW SANDSTONE
						2.0			**SANDSTONE:** Grey, high strength.				MW SANDSTONE
						2.5			Test pit CTP114 terminated at 2.3m				Terminated at 2.3m on very slow progress
						3.0							
						3.5							
						4.0							

Sketch

method
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R ripper
E excavator

support
S shoring N nil

penetration
1 2 3 4
no resistance ranging to refusal

water
water level on date shown
water inflow
water outflow

notes, samples, tests
U_{50} undisturbed sample 50mm diameter
U_{63} undisturbed sample 63mm diameter
D disturbed sample
V vane shear (kPa)
Bs bulk sample
E environmental sample
R refusal

classification symbols and soil description
based on unified classification system

moisture
D dry
M moist
W wet
Wp plastic limit
W_L liquid limit

consistency/density index
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

coffey geotechnics

Engineering Log - Excavation

Excavation No. **CTP115**

Sheet 1 of 1

Project No: **GEOTWOLL02875AA**

Client: ***GUJART NRE MINERALS LTD***

Date started: ***8.4.2009***

Principal:

Date completed: ***8.4.2009***

Project: ***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***

Logged by: ***LD***

Test pit location: ***FIRE DAM / PIT TOP DAM***

Checked by: ***JPT***

equipment type and model: 22T EXCAVATOR | Pit Orientation: | Easting: 560305374 m | R.L. Surface: NOT MEASURED

excavation dimensions: 4m long 0.8m wide | Northing: 6195599 m | datum: WGS-84

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa (100 200 300 400)	structure and additional observations
E		N	NONE OBSERVED			0.0		ML	**SILT:** Dark brown/Black , with some fine to coarse grained angular gravel, with a trace of fine to coarse grained sand and cobbles up to 200mm.	M	St	×	TOPSOIL
						0.5		ML	**Clayey SILT:** Brown , low plasticity clay, with some fine to coarse grained sand and angular gravel and some cobbles up to 300mm, with trace boulders up to 300mm	<Wl	VSt/H	×	COLLUVIUM
						1.0		CL	**Silty CLAY:** Mottled brown/pale grey, low to medium plasticity clay, with some fine to coarse grained sand and angular gravel and some cobbles up to 200mm	<Wp		×	
				D		1.5						×	
						2.0		CL	**Silty Gravelly CLAY:** Mottled brown/pale grey, low to medium plasticity clay, fine to coarse grained angular gravel, with some fine to coarse grained sand				
				D		2.5							
						3.0							
						3.5			Test pit CTP115 terminated at 3.1m				Terminated on slow progress
						4.0							

Sketch

method
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

support
- S shoring
- N nil

penetration
1 2 3 4 — no resistance ranging to refusal

water
- water level on date shown
- water inflow
- water outflow

notes, samples, tests
- U_{50} undisturbed sample 50mm diameter
- U_{63} undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

classification symbols and soil description
based on unified classification system

moisture
- D dry
- M moist
- W wet
- Wp plastic limit
- W_L liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Excavation

Excavation No. **CTP116**

Sheet 1 of 1

Project No: **GEOTWOLL02875AA**

Client: ***GUJART NRE MINERALS LTD***

Date started: ***8.4.2009***

Principal:

Date completed: ***8.4.2009***

Project: ***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***

Logged by: ***LD***

Test pit location: ***CRAM DAM***

Checked by: ***JPT***

equipment type and model: 22T EXCAVATOR | Pit Orientation: | Easting: 560305389 m | R.L. Surface: NOT MEASURED

excavation dimensions: 3m long 1m wide | Northing: 6196669 m | datum: WGS-84

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa (100 200 300 400)	structure and additional observations
E			▶			0.5		CL/CH	**Silty Sandy CLAY:** Medium to high plasticity, grey/orange/brown mottled, fine to coarse grained sand, with some fine to coarse grained angular gravel, with some sandstone cobbles up to 200mm, with some boulders up to 400mm.	>Wp	F/St	× × ×	COLLUVIUM
						1.0		CL/CH	**Sandy CLAY:** Medium to high plasticity, brown/pale grey mottled, fine to coarse grained sand, with some boulders up to 300mm.	>Wp	St	× ×	
				Ds		1.5						×	
						2.0							
						2.5							
						3.0			Test pit CTP116 terminated at 2.6m				Terminated at 2.6m on steady progress
						3.5							
						4.0							

Sketch

method
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R ripper
E excavator

support
S shoring N nil

penetration
1 2 3 4 — no resistance ranging to refusal

water
water level on date shown
water inflow
water outflow

notes, samples, tests
U_{50} undisturbed sample 50mm diameter
U_{63} undisturbed sample 63mm diameter
D disturbed sample
V vane shear (kPa)
Bs bulk sample
E environmental sample
R refusal

classification symbols and soil description
based on unified classification system

moisture
D dry
M moist
W wet
Wp plastic limit
W_L liquid limit

consistency/density index
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

coffey geotechnics

Engineering Log - Excavation

Excavation No. **CTP117**

Sheet 1 of 1

Project No: **GEOTWOLL02875AA**

Client: ***GUJART NRE MINERALS LTD***

Date started: ***8.4.2009***

Principal:

Date completed: ***8.4.2009***

Project: ***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***

Logged by: ***LD***

Test pit location: ***CRAM DAM***

Checked by: ***JPT***

equipment type and model: 22T EXCAVATOR | Pit Orientation: | Easting: 560305399 m | R.L. Surface: NOT MEASURED

excavation dimensions: 3m long 0.8m wide | Northing: 6196723 m | datum: WGS-84

excavation information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
E			▶	Ds		0.5		CL/CH	**Silty Sandy CLAY:** Medium to high plasticity, grey/orange/brown mottled, fine to coarse grained sand, with some fine to coarse grained angular gravel, with some sandstone cobbles up to 200mm, with some boulders up to 400mm.	>Wp	S	× × × × ×	COLLUVIUM
								CH	**Sandy CLAY:** High plasticity, brown/pale grey mottled, fine to coarse grained sand, with some fine to coarse grained angular gravel, with some boulders up to 1m.	>Wp	St	× ×	
						1.0							
						1.5							
						2.0							
						2.5							
						3.0			Test pit CTP117 terminated at 2.7m				Terminated at 2.7m on steady progress
						3.5							
						4.0							

Sketch

method
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R ripper
E excavator

support
S shoring N nil

penetration
1 2 3 4 no resistance ranging to refusal

water
water level on date shown
water inflow
water outflow

notes, samples, tests
U_{50} undisturbed sample 50mm diameter
U_{63} undisturbed sample 63mm diameter
D disturbed sample
V vane shear (kPa)
Bs bulk sample
E environmental sample
R refusal

classification symbols and soil description
based on unified classification system

moisture
D dry
M moist
W wet
Wp plastic limit
W_L liquid limit

consistency/density index
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

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Engineering Log - Borehole

Borehole No. **CBH100**
Sheet 1 of 1
Project No: **GEOTWOLL02875AA**

Client: ***GUJART NRE MINERALS LTD***
Date started: ***8.4.2009***
Principal:
Date completed: ***8.4.2009***
Project: ***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***
Logged by: ***DH***
Borehole Location: ***CRAM DAM***
Checked by: ***JPT***

drill model and mounting: GEMCO210B TRAILER | Easting: 560305407 | slope: -90° | R.L. Surface: NOT MEASURED
hole diameter: 100 mm | Northing 6196668 | bearing: | datum: WGS-84

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
ADV						0		CL/ML	**Sandy CLAY/Sandy SILT:** Low plasticity/liquid limit, brown, fine to medium grained sand, with some roots.	<Wp	S		TOPSOIL
ADT				SPT 6,6,7 N*=13		1		CL	**Sandy CLAY:** Low plasticity, orange brown/brown, red and white mottled, fine to medium grained sand, with some silt, with some roots.		St		COLLUVIUM
				SPT 7,10,12 N*=22		2					H	×	
			After 1 day	SPT 4,R,- N=R		3		CH	**Sandy CLAY:** Medium to high plasticity, orange-brown, grey, black mottled, fine to medium grained sand, with a trace of sandstone cobbles, with several flecks of timber. ...SPT refusal on sandstone cobble @ 3.27m, cobble is ~ 200mm. TC bit used to drill through cobble.	Wp			SPT at 3.0m (4,10/120mm, -)
						4			...Consistancy becomes variable from 3.5m, varies from Stiff to Very Stiff, also high water content, but no free water in hole.	>Wp/Wp	St/VSt		
ADV			After 2hours	SPT 4,6,7 N*=13		5						× × × ×	
				SPT 5,8,9 N*=17		6						× × ×	
			After 15minutes			7			... Some gravelly pockets from 7.0m to 7.8m. ...Note: Water inflow in gravel bands from 7.0m.				
				SPT 5,11,R N=R		8			...SPT bouncing on gravel/cobbles.				SPT at 7.5m (5,11,3/40mm)
									Borehole CBH100 terminated at 7.84m				End on steady progress

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix e.g. ADT

support: M mud, C casing, N nil

penetration: 1 2 3 4 — no resistance ranging to refusal

water: 10/1/98 water level on date shown; water inflow; water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Borehole

Borehole No.	***CBH101***
Sheet	1 of 1
Project No:	***GEOTWOLL02875AA***
Client:	***GUJART NRE MINERALS LTD***
Date started:	***8.4.2009***
Principal:	
Date completed:	***8.4.2009***
Project:	***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***
Logged by:	***DH***
Borehole Location:	***CRAM DAM***
Checked by:	***JPT***

drill model and mounting:	GEMCO210B TRAILER	Easting:	560305421	slope:	-90°	R.L. Surface:	NOT MEASURED
hole diameter:	100 mm	Northing	6196675	bearing:		datum:	WGS-84

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa (100 200 300 400)	structure and additional observations
ADV						0			**FILL; Sandy CLAY:** Low plasticity, brown/white, red and grey mottles, fine to medium grained sand, with some silt, with a trace of gravel, with a trace of roots, with a trace of charcoal.	<Wp	H		FILL; DAM EMBANKMENT
				SPT 4,4,6 N*=10		1							
				SPT 6,8,8 N*=16		2							
				SPT 5,7,10 N*=17		3							
								CL	**Sandy CLAY:** Low to medium plasticity, pale grey, white/orange brown mottles, fine to medium grained sand.		VSt		COLLUVIUM
				SPT 4,5,7 N*=12		4							
				SPT 4,6,7 N*=13		5							
								CL	**Sandy CLAY:** Medium plasticity, brown, black, pale grey mottled, fine to medium grained sand, with a trace of charcoal.	>Wp	St/VSt		
				SPT 3,3,5 N*=8		6							
				SPT 4,4,7 N*=11		7			...With a trace of gravel @ 6.8m, fine grained, subangular.				
			After 10mins			8			Borehole CBH101 terminated at 7.5m				End on steady progress with V-Bit. Note: CBH101 backfilled with cement and water slurry.

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix e.g. ADT

support

M mud N nil
C casing

penetration

1 2 3 4 — no resistance ranging to refusal

water

10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Borehole

Borehole No.	***CBH102***
Sheet	1 of 2
Project No:	***GEOTWOLL02875AA***
Client:	***GUJART NRE MINERALS LTD***
Date started:	***8.4.2009***
Principal:	
Date completed:	***9.4.2009***
Project:	***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***
Logged by:	***DH***
Borehole Location:	***CRAM DAM***
Checked by:	***JPT***

drill model and mounting:	GEMCO210B TRAILER	Easting:	560305420	slope:	-90°	R.L. Surface:	NOT MEASURED
hole diameter:	100 mm	Northing	6196689	bearing:		datum:	WGS-84

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa (100 200 300 400)	structure and additional observations
ADV						0			**FILL; Sandy CLAY:** Medium plasticity, brown, white/red brown and orange brown mottles, with some silt, with a trace of fine to coarse grained gravel.	<Wp	H		FILL; DAM EMBANKMENT
				SPT 4,R,- N=R									SPT at 0.5m (4,5/80mm,-)
						1			...SPT bouncing on pieces of gravel/sandstone cobbles.				
				SPT 9,9,7 N*=16									
						2			...becoming brown from 2.0m.				
			▶							Wp	St/VSt		
				SPT 4,5,9 N*=14									
						3							
								CL	**Sandy CLAY:** Medium plasticity, pale grey and orange brown mottles, fine to medium grained sand, with a trace of rootlets.				COLLUVIUM
				SPT 3,4,5 N*=9									
						4							
				SPT 3,5,6 N*=11									
						5							
				SPT 2,4,5 N*=9									
						6							
			▶					CH	**Silty Sandy CLAY:** High plasticity, grey, with a trace of brown mottling, with a trace of roots.	>Wp	St		Moderate water inflow from 6.2m to 8.5m.
				SPT 2,3,5 N*=8									
						7							
								CH	**Sandy CLAY:** High plasticity, grey, orange brown mottles, fine to medium grained sand, with a trace of fine grained gravel, with a trace of charcoal.		St/VSt		
				SPT 3,6,7 N*=13									
						8							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit
*bit shown by suffix e.g.	ADT

support

M mud N nil
C casing

penetration

1 2 3 4 — no resistance ranging to refusal

water

10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Borehole

Borehole No. **CBH102**

Sheet 2 of 2

Project No: **GEOTWOLL02875AA**

Client: **GUJART NRE MINERALS LTD**

Date started: **8.4.2009**

Principal:

Date completed: **9.4.2009**

Project: **GEOTECH. INVESTIGATION FOR SURFACE OP'S UPGRADE**

Logged by: **DH**

Borehole Location: **CRAM DAM**

Checked by: **JPT**

drill model and mounting: GEMCO210B TRAILER | Easting: 560305420 | slope: -90° | R.L. Surface: NOT MEASURED

hole diameter: 100 mm | Northing 6196689 | bearing: | datum: WGS-84

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
ADV						9		CH	**Sandy CLAY:** High plasticity, grey, orange brown mottles, fine to medium grained sand, with a trace of fine grained gravel, with a trace of charcoal. *(continued)*	>Wp	St/VSt	×	
				SPT 5,8,11 N*=19		10					VSt	×	Material is drier from 8.5m, but still >Wp
				SPT 4,7,10 N*=17		11			...Some red brown mottlung from 11.5m.			×	
				SPT 4,5,7 N*=12		12			...Pockets of fine to medium grained gravel, subangular @ 12.2m and 12.4m.			×	
			After 10mins			13			Borehole CBH102 terminated at 12.45m				Terminated at 12.45m on steady progress with V-Bit, Note: CBH102 backfilled with cement slurry
						14							
						15							
						16							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit
*bit shown by suffix e.g.	ADT

support

M mud N nil
C casing

penetration

1 2 3 4 no resistance ranging to refusal

water

10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Borehole

Borehole No.	***CBH103***
Sheet	1 of 1
Project No:	***GEOTWOLL02875AA***
Client:	***GUJART NRE MINERALS LTD***
Date started:	***9.4.2009***
Principal:	
Date completed:	***9.4.2009***
Project:	***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***
Logged by:	***DH***
Borehole Location:	***CRAM DAM***
Checked by:	***JPT***

drill model and mounting:	GEMCO210B TRAILER	Easting:	560305424	slope:	-90°	R.L. Surface:	NOT MEASURED
hole diameter:	100 mm	Northing	6196715	bearing:		datum:	WGS-84

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
ADV						0			**FILL; Sandy CLAY:** Medium plasticity, red brown, fine to medium grained sand, with a trace of fine to medium grained gravel, with a trace of flecks of charcoal, with a trace of silt.	<Wp	VSt/H	×	FILL; DAM EMBANKMENT
				SPT 5,7,7 N*=14		1						×	Note: Bulk sample taken next to hole from 0.6m to 1.3m (For pinhole dispersion test)
				SPT 5,8,9 N*=17		2							
				SPT 5,10,11 N*=21		3						×	
			▶						**FILL; Sandy CLAY:** Low to medium plasticity, brown with black mottling, fine to medium grained sand, with a trace of fine grained gravel (sandstone), with a trace of red mottling.	Wp	VSt		Minor seepage at 3.2m to 4.0m
				SPT 4,6,8 N*=14		4						×	
										<Wp	VSt/H		
				SPT 4,8,10 N*=18		5						×	
			▶					CL	**Sandy CLAY:** Medium plasticity, orange brown, red brown mottled, with a trace of fine to medium grained sand, with a trace of fine to medium grained subangular gravel, with a trace of rootlets.	>Wp	F/St	×	COLLUVIUM (Higher water content from 5.1m)
				SPT 3,2,3 N*=5		6						×	
									...Pockets of fine to coarse grained gravel from 6.5m.				
				SPT 3,4,7 N*=11		7						×	
						8			Borehole CBH103 terminated at 7.45m				Terminated at 7.45m on steady progress with V-Bit, Note: CBH103 backfilled with cement slurry

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit
*bit shown by suffix e.g.	ADT

support

M mud N nil
C casing

penetration

1 2 3 4 — no resistance ranging to refusal

water

10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Borehole

Borehole No.	***CBH104***
Sheet	1 of 1
Project No:	***GEOTWOLL02875AA***
Client:	***GUJART NRE MINERALS LTD***
Date started:	***9.4.2009***
Principal:	
Date completed:	***9.4.2009***
Project:	***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***
Logged by:	***DH***
Borehole Location:	***FIRE DAM / PIT TOP DAM***
Checked by:	***JPT***

drill model and mounting:	GEMCO210B TRAILER	Easting:	560305406	slope:	-90°	R.L. Surface:	NOT MEASURED
hole diameter:	100 mm	Northing	6195743	bearing:		datum:	WGS-84

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
ADT									**FILL; Sandy GRAVEL:** Fine to coarse grained, black, subangular to angular, fine to coarse grained sand.	D	D		FILL; DAM EMBANKMENT (COALWASH)
ADV			▶	SPT 3,5,8 N*=13		1			**FILL; Silty Sandy CLAY:** Medium to high plasticity, brown, orange brown and red mottled, fine to medium sand, with some fine to medium grained gravel.	<Wp	H	×	FILL; DAM EMBANKMENT
										>Wp	St/VSt		
				SPT 3,5,3 N*=8		2						×	
												×	
						3		CL	**Gravelly Sandy CLAY:** Medium plasticity, red, brown, orange mottled, fine to medium grained sand, localised soft zones, fine to coarse grained gravel, subangular. ...Soft zone from 3.3m to 3.4m. ...Cobbles encountered at 3.4m, approx 100mm.		F/St		COLLUVIUM
				SPT 2,2,3 N*=5									
				SPT 2,3,4 N*=7		4						×	
												×	
				SPT 2,3,4 N*=7		5						×	
						6			Borehole CBH104 terminated at 5.45m				Terminated at 5.45m on steady progress with V-Bit, Note: CBH104 backfilled with cement slurry
						7							
						8							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix
e.g. ADT

support

M mud N nil
C casing

penetration

1 2 3 4 — no resistance ranging to refusal

water

10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Borehole

Borehole No.	***CBH105***
Sheet	1 of 1
Project No:	***GEOTWOLL02875AA***
Client:	***GUJART NRE MINERALS LTD***
Date started:	***14.4.2009***
Principal:	
Date completed:	***14.4.2009***
Project:	***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***
Logged by:	***LD***
Borehole Location:	***STOCKPILE AREA***
Checked by:	***JPT***

drill model and mounting:	GEMCO210B TRAILER	Easting:	560305948	slope:	-90°	R.L. Surface:	NOT MEASURED
hole diameter:	100 mm	Northing	6195932	bearing:		datum:	WGS-84

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
ADT		N							**FILL; Sandy GRAVEL:** Pale grey, fine to coarse grained gravel, with fine to coarse grained sand.	M	VD		CRUSHED SANDSTONE FILL
									FILL; Sandy GRAVEL: Black, fine to coarse grained gravel, with fine to coarse grained sand and some cobbles up to 200mm.	M	VD		COALWASH FILL
				SPT 11,20,16 N*=36		1							
				SPT 3,4,3 N*=7		2							
ADV				SPT 9,6,6 N*=12		3			**Sandy CLAY:** Medium to high plasticity, pale grey, with fine to coarse grained sand and some fine to coarse grained angular gravel.	>Wp	St/VSt	×	COLLUVIUM/ ALLUVIUM
									...colour change to pale grey/pale brown.				
				SPT 3,6,11 N*=17		4			...colour change to mottled brown/orange/pale grey.			× ×	
ADT									**SANDSTONE:** Pale grey/pale brown, fine to medium grained, low strength.				HIGHLY WEATHERED SANDSTONE
						5			Borehole CBH105 terminated at 4.52m				Terminated on very slow progress with the Tungsten Carbide bit.
						6							
						7							
						8							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit
*bit shown by suffix	
e.g.	ADT

support

M mud N nil
C casing

penetration

1 2 3 4 — no resistance ranging to refusal

water

10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Borehole

Borehole No.	***CBH106***
Sheet	1 of 2
Project No:	***GEOTWOLL02875AA***
Client:	***GUJART NRE MINERALS LTD***
Date started:	***16.4.2009***
Principal:	
Date completed:	***16.4.2009***
Project:	***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***
Logged by:	***LD***
Borehole Location:	***STOCKPILE AREA***
Checked by:	***JPT***

drill model and mounting:	GEMCO210B TRAILER	Easting:	560306020	slope:	-90°	R.L. Surface:	NOT MEASURED
hole diameter:	100 mm	Northing	6195950	bearing:		datum:	WGS-84

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
ADT		N		SPT 1,2,R N*=R		1			**FILL; Sandy GRAVEL:** Fine to coarse grained, black, fine to coarse grained sand, with some cobbles up to 200mm.	M	VD		COAL WASH FILL
				SPT 4,12,R N*=R		2		CL/CH	**Sandy CLAY:** Medium to high plasticity, mottled pale grey/pale brown, with some fine to coarse angular gravel, some cobbles up to 200mm.	>Wp	VSt/H		COLLUVIUM/ALLUVIUM
ADV				SPT 3,5,7 N*=12		3						×	
												×	
				SPT 5,8,12 N*=20		4		ML	**Clayey SILT:** Mottled brown/orange/pale grey, medium to high plasticity clay, some fine to coarse grained sand, some fine to coarse angular gravel.	<Wl	H		EXTREMELY WEATHERED SILTSTONE/ SANDSTONE
												×	
						5			...colour change to dark grey/dark brown/pale grey.		VSt/H		
				SPT 8,13,10 N*=23								×	
			2.00pm			6						×	
				SPT 5,3,13 N*=16					**SANDSTONE:** Pale grey/pale brown, fine to coarse grained sand, some fine to coarse angular quartz gravel, low strength.				HIGHLY WEATHERED SANDSTONE
						7			Borehole CBH106 continued as cored hole				
						8							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit
*bit shown by suffix	
e.g.	ADT

support

M mud N nil
C casing

penetration

1 2 3 4 — no resistance ranging to refusal

water

10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Cored Borehole

Borehole No. **CBH106**
Sheet 2 of 2
Project No: **GEOTWOLL02875AA**

Client: **GUJART NRE MINERALS LTD**
Date started: **16.4.2009**
Principal:
Date completed: **16.4.2009**
Project: **GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE**
Logged by: **LD**
Borehole Location: **STOCKPILE AREA**
Checked by: **JPT**

drill model & mounting: GEMCO210B TRAILER | Easting: 560306020 | slope: -90° | R.L. Surface: NOT MEASURED
hole diameter: 100 mm | Drilling fluid: | Northing: 6195950 | bearing: | datum: WGS-84

drilling information | **material substance** | **rock mass defects**

method	core-lift	water	RL	depth metres	graphic log core recovery	material: rock type; grain characteristics, colour, structure, minor components	weathering alteration	estimated strength VL L M H VH EH	$Is_{(50)}$ MPa D- diametral A- axial	RQD %	defect spacing mm 30 100 300 1000 3000	defect description: type, inclination, planarity, roughness, coating, thickness — particular / general
		2.00pm		1								
				2								
				3								
				4								
				5								
				6		Continued from non-cored borehole						
				7		**NO CORE**				0		From 6.68m to 7.92m, highly Fractured, approximately 10 - 50mm defect spacing, recovered as gravel
						TESCHENITE: medium grained, grey	MW/SW					
						NO CORE				0		
				8		**TESCHENITE:** medium grained, grey	MW/SW					

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method

DT	diatube
AS	auger screwing
AD	auger drilling
RR	roller/tricone
CB	claw or blade bit
NMLC	NMLC core
NQ, HQ, PQ	wireline core

CBH106 terminated at 7.92m

casing used

barrel withdrawn

graphic log/core recovery

core recovered - graphic symbols indicate material

no core recovered

water

10/1/98 water level on date shown

water inflow

partial drill fluid loss

complete drill fluid loss

25 water pressure test result (lugeons) for depth interval shown

weathering

FR	fresh
SW	slightly weathered
MW	moderately weathered
HW	highly weathered
XW	extremely weathered
DW	distinctly weathered (covers MW and HW)

strength

VL	very low
L	low
M	medium
H	high
VH	very high
EH	extremely high

defect type

JT	joint
PT	parting
SM	seam
SZ	sheared zone
SS	sheared surface
CS	crushed seam

planarity

PL	planar
CU	curved
UN	undulating
ST	stepped
IR	irregular

roughness

VR	very rough
RO	rough
SO	smooth
SL	slickensided

coating

CN	clean
SN	stained
VN	veneer
CO	coating

coffey geotechnics

Engineering Log - Borehole

Borehole No.	***CBH107***
Sheet	1 of 1
Project No:	***GEOTWOLL02875AA***
Client:	***GUJART NRE MINERALS LTD***
Date started:	***14.4.2009***
Principal:	
Date completed:	***14.4.2009***
Project:	***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***
Logged by:	***LD***
Borehole Location:	***STOCKPILE AREA***
Checked by:	***JPT***

drill model and mounting:	GEMCO210B TRAILER	Easting:	560305991	slope:	-90°	R.L. Surface:	NOT MEASURED
hole diameter:	100 mm	Northing	6195987	bearing:		datum:	WGS-84

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
ADT		N	NONE OBSERVED						**FILL; Sandy GRAVEL:** Black, fine to coarse grained gravel, fine to coarse grained sand, with some cobble intrusions up to 200mm.	M	VD		COALWASH FILL
										M	VD		FILL
									FILL; Gravelly SAND: Brown, fine to coarse grained sand, fine to coarse angular gravel.	Wl	St/Vst		COLLUVIUM
ADV				SPT 3,5,4 N*=9		1			**Silty SAND:** Fine to coarse grained, orange/pale brown.			×	
											H		
				SPT 5,6,9 N*=15					**Silty SAND:** Fine to coarse grained, orange/pale brown.	D	D		EXTREMELY WEATHERED SANDSTONE
						2							
ADT									**SANDSTONE:** Fine to medium grained, Orange/pale brown, some subrounded gravel inclusions, low strength.				HIGHLY WEATHERED SANDSTONE
						3							
						4							
						5							
						6							
									Borehole CBH107 terminated at 6m				Terminated on steady progress
						7							
						8							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit
*bit shown by suffix e.g.	ADT

support

M mud N nil
C casing

penetration

1 2 3 4 — no resistance ranging to refusal

water

10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description
based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Borehole

Borehole No. **CBH108**

Sheet 1 of 1

Project No: **GEOTWOLL02875AA**

Client: **GUJART NRE MINERALS LTD**

Date started: **14.4.2009**

Principal:

Date completed: **14.4.2009**

Project: **GEOTECH. INVESTIGATION FOR SURFACE OP'S UPGRADE**

Logged by: **LD**

Borehole Location: **STOCKPILE AREA**

Checked by: **JPT**

drill model and mounting: GEMCO210B TRAILER | Easting: 560306134 | slope: -90° | R.L. Surface: NOT MEASURED

hole diameter: 100 mm | Northing 6195684 | bearing: | datum: WGS-84

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
ADT		N	NONE OBSERVED	SPT 5,10,10 N*=20		1			**FILL; Sandy GRAVEL:** Fine to coarse grained, black/ pale grey, fine to coarse grained sand, many cobbles up to 200mm diameter, some concrete boulders	D	VD		COALWASH FILL
				SPT 5,7,9 N*=16		2							
ADV				SPT 2,4,6 N*=10		3		CL-CH	**Sandy CLAY:** medium to high plasticity, brown, fine to coarse grained sand, some fine to medium grained angular gravel	>Wp	St/VSt	× × ×	COLLUVIUM
				SPT 7,17,16 N*=33		4							
						5			**TESCHENITE:** fine to coarse grained, brown to grey, low to strength			×	HIGHLY WEATHERED TESCHENITE (Some extremely weathered bands)
						6			Borehole CBH108 terminated at 5.35m				Terminated on very slow progress
						7							
						8							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix e.g. ADT

support

M mud N nil

C casing

penetration

1 2 3 4 no resistance ranging to refusal

water

10/1/98 water level on date shown

water inflow

water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Borehole

Borehole No.	***CBH109***
Sheet	1 of 1
Project No:	***GEOTWOLL02875AA***
Client:	***GUJART NRE MINERALS LTD***
Date started:	***15.4.2009***
Principal:	
Date completed:	***15.4.2009***
Project:	***GEOTECH. INVESTIGATION FOR SURFACE OP'S UPGRADE***
Logged by:	***LD***
Borehole Location:	***STOCKPILE AREA***
Checked by:	***JPT***

drill model and mounting:	GEMCO210B TRAILER	Easting:	560306154	slope:	-90°	R.L. Surface:	NOT MEASURED
hole diameter:	100 mm	Northing	6195696	bearing:		datum:	WGS-84

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
ADT		N	NONE OBSERVED						**FILL; Sandy CLAY:** medium to high plasticity, brown, fine to coarse grained sand	>Wp	VSt		FILL
									FILL; Gravelly SAND: Fine to coarse grained, black, fine to coarse angular gravel	M	VD		COALWASH (FILL)
				SPT 6,R,- N*=R		1							
				SPT 3,5,7 N*=12		2		CH	**CLAY:** high plasticity, mottled brown/ grey, some fine to medium grained sand	>Wp	VSt		RESIDUAL
ADV				SPT 8,R,- N*=R		3		SW	**Clayey SAND:** Fine to medium grained, mottled brown/orange/grey, high plasticity clay, with some fine to medium subrounded gravel.	M	VD		EXTREMELY WEATHERED SANDSTONE
ADT						4			**SANDSTONE:** Fine to medium grained, mottled brown/orange/grey, low strength.				HIGHLY WEATHERED SANDSTONE
									SANDSTONE: Fine to medium grained, mottled brown/orange/grey, medium strength.				MODERATELY WEATHERED SANDSTONE
						5			Borehole CBH109 terminated at 4.84m				Terminated on slow progress
						6							
						7							
						8							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit
*bit shown by suffix	
e.g.	ADT

support

M mud N nil
C casing

penetration

1 2 3 4 — no resistance ranging to refusal

water

10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Borehole

Borehole No.	***CBH110***
Sheet	1 of 2
Project No:	***GEOTWOLL02875AA***
Client:	***GUJART NRE MINERALS LTD***
Date started:	***16.4.2009***
Principal:	
Date completed:	***16.4.2009***
Project:	***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***
Logged by:	***LD***
Borehole Location:	***STOCKPILE AREA***
Checked by:	***JPT***

drill model and mounting:	GEMCO210B TRAILER	Easting:	560305764	slope:	-90°	R.L. Surface:	NOT MEASURED
hole diameter:	100 mm	Northing	6195892	bearing:		datum:	WGS-84

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
ADT		N							**FILL; Silty CLAY:** High plasticity, mottled brown/orange/black,with some fine to coarse grained sand.	>Wp	St		FILL
										M	VD		COALWASH (FILL)
				SPT 15,15,14 N*=29		1			**FILL; Gravelly SAND:** Fine to coarse grained, black, fine to coarse angular gravel, some low plasticity clay and some cobbles up to 200mm.				
											D/VD		
				SPT 7,9,8 N*=17		2							
						3							
				SPT 10,12,10 N*=22									
						4			**FILL; Sandy CLAY:** High plasticity, black, fine to coarse grained sand and some fine to medium grained angular gravel.	>Wp	St		COALWASH (FILL)
ADV				SPT 4,5,10 N*=15		5		SW	**Clayey SAND:** Fine to coarse grained, mottled brown/orange/grey, , high plasticity clay, with some fine to medium subrounded quartz gravel.	M	D		EXTREMELY WEATHERED SANDSTONE
						6			**SANDSTONE:** Fine to medium grained, mottled brown/orange/grey, low to medium strength.				HIGHLY WEATHERED SANDSTONE
ADT						7							
						8		CH	**Sandy CLAY:** High plasticity, black, fine to coarse grained sand, with some fine to medium angular gravel.	>Wp	St		COAL

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix e.g. ADT

support

M mud N nil
C casing

penetration

1 2 3 4 — no resistance ranging to refusal

water

10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Borehole

Borehole No.	***CBH110***
Sheet	2 of 2
Project No:	***GEOTWOLL02875AA***
Client: ***GUJART NRE MINERALS LTD***	Date started: ***16.4.2009***
Principal:	Date completed: ***16.4.2009***
Project: ***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***	Logged by: ***LD***
Borehole Location: ***STOCKPILE AREA***	Checked by: ***JPT***

drill model and mounting: GEMCO210B TRAILER | Easting: 560305764 | slope: -90° | R.L. Surface: NOT MEASURED

hole diameter: 100 mm | Northing 6195892 | bearing: | datum: WGS-84

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
ADT		N				9		CH	**Sandy CLAY:** High plasticity, black, fine to coarse grained sand, with some fine to medium angular gravel. *(continued)* ...Interbedded shale zones throughout coal (Wongawilli Seam, variable drilling progress.	>Wp	St		
			▶	Bs							W		
						10							
						11			Borehole CBH110 terminated at 10.65m				Terminated on slow progress
						12							
						13							
						14							
						15							
						16							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix e.g. ADT

support

M mud N nil
C casing

penetration

1 2 3 4 — no resistance ranging to refusal

water

10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Borehole

Borehole No.	***CBH111***
Sheet	1 of 1
Project No:	***GEOTWOLL02875AA***
Client: ***GUJART NRE MINERALS LTD***	Date started: ***15.4.2009***
Principal:	Date completed: ***15.4.2009***
Project: ***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***	Logged by: ***LD***
Borehole Location: ***DAM NO. 5 AND NO. 6***	Checked by: ***JPT***

drill model and mounting: GEMCO210B TRAILER | Easting: 560306063 | slope: -90° | R.L. Surface: NOT MEASURED

hole diameter: 100 mm | Northing 6195805 | bearing: | datum: WGS-84

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
ADT		N	NONE OBSERVED			0			**FILL; Silty CLAY:** Medium to high plasticity clay, mottled brown/orange/red/grey, with some fine to coarse grained sand.	>Wp	VSt	× × ×	FILL
				SPT 3,5,7 N*=12		1							
ADV				SPT 5,10,14 N*=24		2		SC	**Clayey SAND:** Fine to medium grained, pale brown/orange/pale grey, low plasticity clay, with traces of rootlets and old vegetation.	M	D/VD		EXTREMELY WEATHERED SANDSTONE
									SANDSTONE: Fine to medium grained, pale brown/orange/pale grey, low strength.				HIGHLY WEATHERED SANDSTONE
				SPT 30,R N*=R		3							
ADT						4			**SILTSTONE:** Sub-horizontally laminated, grey/orange, low strength.				HIGHLY TO MODERATELY WEATHERED SILTSTONE
									TESCHENITE: Fine to coarse grained, grey, medium strenth, highly fractured.				MODERATELY WEATHERED TESCHENITE
						5			Borehole CBH111 terminated at 4.77m				Terminated on very slow progress
						6							
						7							
						8							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix e.g. ADT

support

M mud N nil
C casing

penetration

1 2 3 4 — no resistance ranging to refusal

water

10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Borehole

Borehole No.	***CBH112***
Sheet	1 of 1
Project No:	***GEOTWOLL02875AA***
Client:	***GUJART NRE MINERALS LTD***
Date started:	***15.4.2009***
Principal:	
Date completed:	***15.4.2009***
Project:	***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***
Logged by:	***LD***
Borehole Location:	***DAM NO. 5 AND NO. 6***
Checked by:	***JPT***

drill model and mounting:	GEMCO210B TRAILER	Easting:	560306035	slope:	-90°	R.L. Surface:	NOT MEASURED
hole diameter:	100 mm	Northing	6195809	bearing:		datum:	WGS-84

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
ADT		N	NONE OBSERVED						**FILL; Gravelly SAND:** black, fine to coarse grained, fine to coarse grained angular gravel, some medium to high plasticity clay.	M	D		COALWASH FILL
									FILL; Silty CLAY: Medium to high plasticity, mottled brown/grey, with some fine to coarse grained sand, with some angular gravel.	>Wp	VSt	×	FILL
				SPT 4,6,10 N*=16		1			...gravel content increasing, some cobbles up to 200mm.			×	
								SC	**Clayey SAND:** Fine to medium grained, pale brown/orange/pale grey/red, low plasticity clay.	M	D/VD		EXTREMELY WEATHERED SANDSTONE
ADV				SPT 11,14,16 N*=30		2			**SANDSTONE:** Fine to medium grained, pale brown/orange/pale grey, low strength.				HIGHLY WEATHERED SANDSTONE
								CL/CH	**Sandy CLAY:** Medium to high plasticity, pale grey, white fine to coarse grained sand with some orange stains.	<Wp	VSt/H		EXTREMELY WEATHERED TESCHENITE
				SPT 6,11,R N*=R		3						×	
ADT									**TESCHENITE:** Fine to coarse grained, pale grey, medium strength, some high strength bands.				HIGHLY WEATHERED TESCHENITE
				D		4							
				D					**TESCHENITE:** Fine to coarse grained, dark grey, very high strength.				MODERATELY TO SLIGHTLY WEATHERED TESCHENITE
						5			Borehole CBH112 terminated at 4.83m				TC Refusal on basalt
						6							
						7							
						8							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix e.g. ADT

support

M mud N nil
C casing

penetration

1 2 3 4 — no resistance ranging to refusal

water

10/1/98 water level on date shown

water inflow

water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Borehole

Borehole No.	***CBH113***
Sheet	1 of 2
Project No:	***GEOTWOLL02875AA***
Client: ***GUJART NRE MINERALS LTD***	Date started: ***15.4.2009***
Principal:	Date completed: ***15.4.2009***
Project: ***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***	Logged by: ***LD***
Borehole Location: ***DAM NO. 5 AND NO. 6***	Checked by: ***JPT***

drill model and mounting: GEMCO210B TRAILER | Easting: 560306087 | slope: -90° | R.L. Surface: NOT MEASURED

hole diameter: 100 mm | Northing 6195831 | bearing: | datum: WGS-84

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
ADT		N	NONE OBSERVED						**FILL; Gravelly SAND:** Fine to medium grained, black, fine to coarse angular gravel.	M	D		COALWASH FILL
								SW	**SAND:** Fine to coarse grained, black, with some low plasticity clay, some fine to medium subrounded gravel, some medium coarse angular gravel and some cobbles up to 200mm.		VD		EXTREMELY WEATHERED TESCHENITE
ADV				SPT 9,22,R N*=R		1							
				SPT 14,13,R N*=R		2			**TESCHENITE:** Fine to coarse grained, pale/grey/brown, medium strength, with some high strength bands.				HIGHLY WEATHERED TESCHENITE
				D					Borehole CBH113 continued as cored hole				
						3							
						4							
						5							
						6							
						7							
						8							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit
*bit shown by suffix	
e.g.	ADT

support

M mud N nil
C casing

penetration

1 2 3 4 — no resistance ranging to refusal

water

10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Cored Borehole

Borehole No.	***CBH113***
Sheet	2 of 2
Project No:	***GEOTWOLL02875AA***
Client:	***GUJART NRE MINERALS LTD***
Date started:	***15.4.2009***
Principal:	
Date completed:	***15.4.2009***
Project:	***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***
Logged by:	***LD***
Borehole Location:	***DAM NO. 5 AND NO. 6***
Checked by:	***JPT***

drill model & mounting: GEMCO210B TRAILER | Easting: 560306087 | slope: -90° | R.L. Surface: NOT MEASURED

hole diameter: 100 mm Drilling fluid: | Northing: 6195831 | bearing: | datum: WGS-84

drilling information | **material substance** | **rock mass defects**

method	core-lift	water	RL	depth metres	graphic log core recovery	material: rock type; grain characteristics, colour, structure, minor components	weathering alteration	estimated strength VL L M H VH EH	$Is_{(50)}$ MPa D- diametral A- axial	RQD %	defect spacing mm 30 100 300 1000 3000	defect description: type, inclination, planarity, roughness, coating, thickness — particular	general
		NONE OBSERVED		1									
				2		Continued from non-cored borehole							
				3		**NO CORE**				0			
						TESCHENITE Medium grained, grey	MW/SW						
						NO CORE				0			
						TESCHENITE Medium grained, grey	MW/SW						
						NO CORE				0		— From 2.52m to 5.5m, highly fractured, approximately 10 - 50mm defect spacing, recovered as gravel	
						TESCHENITE Medium grained, grey	MW/SW						
				4		**NO CORE**				0			
						TESCHENITE Medium grained, grey	MW/SW						
						NO CORE				0			
						TESCHENITE Medium grained, grey	MW/SW						
						NO CORE				0			
						TESCHENITE Medium grained, grey	MW/SW						
				5		**NO CORE**				25			
						TESCHENITE Medium grained, grey	MW/SW						
						NO CORE				50			
						TESCHENITE Medium grained, grey	MW/SW						
						CBH113 terminated at 5.5m							
				6									
				7									
				8									

method

DT	diatube
AS	auger screwing
AD	auger drilling
RR	roller/tricone
CB	claw or blade bit
NMLC	NMLC core
NQ, HQ, PQ	wireline core

core-lift

- casing used
- barrel withdrawn

graphic log/core recovery

- core recovered - graphic symbols indicate material
- no core recovered

water

- 10/1/98 water level on date shown
- water inflow
- partial drill fluid loss
- complete drill fluid loss
- 25 water pressure test result (lugeons) for depth interval shown

weathering

FR	fresh
SW	slightly weathered
MW	moderately weathered
HW	highly weathered
XW	extremely weathered
DW	distinctly weathered (covers MW and HW)

strength

VL	very low
L	low
M	medium
H	high
VH	very high
EH	extremely high

defect type

JT	joint
PT	parting
SM	seam
SZ	sheared zone
SS	sheared surface
CS	crushed seam

planarity

PL	planar
CU	curved
UN	undulating
ST	stepped
IR	irregular

roughness

VR	very rough
RO	rough
SO	smooth
SL	slickensided

coating

CN	clean
SN	stained
VN	veneer
CO	coating

coffey geotechnics

Engineering Log - Borehole

Borehole No.	***CBH114***
Sheet	1 of 1
Project No:	***GEOTWOLL02875AA***
Client: ***GUJART NRE MINERALS LTD***	Date started: ***15.4.2009***
Principal:	Date completed: ***15.4.2009***
Project: ***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***	Logged by: ***LD***
Borehole Location: ***DAM NO. 5 AND NO. 6***	Checked by: ***JPT***

drill model and mounting: GEMCO210B TRAILER | Easting: 560305988 | slope: -90° | R.L. Surface: NOT MEASURED

hole diameter: 100 mm | Northing 6195829 | bearing: | datum: WGS-84

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
ADV		N	NONE OBSERVED						**FILL; Gravelly SAND:** Fine to coarse grained, black, fine to coarse gravel, with some low plasticity clay.	M	L/MD		COAL (STOCKPILE)
								CH	**CLAY:** Brown, high plasticity clay.	>Wp	F/St		RESIDUAL
				SPT 2,6,7 N*=13		1		SW	**Clayey SAND:** Fine to coarse grained, mottled brown/orange, with some high plasticity clay.	M	D/VD	×	EXTREMELY WEATHERED SANDSTONE
				SPT 5,7,8 N*=15		2			**SANDSTONE:** Fine to medium grained, low strength.			×	HIGHLY WEATHERED SANDSTONE
ADT									Borehole CBH114 terminated at 2.07m				Terminated with TC refusal
						3							
						4							
						5							
						6							
						7							
						8							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix e.g. ADT

support

M mud N nil
C casing

penetration

1 2 3 4 — no resistance ranging to refusal

water

10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Borehole

Borehole No.	***CBH115***
Sheet	1 of 1
Project No:	***GEOTWOLL02875AA***
Client:	***GUJART NRE MINERALS LTD***
Date started:	***16.4.2009***
Principal:	
Date completed:	***16.4.2009***
Project:	***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***
Logged by:	***LD***
Borehole Location:	***STOCKPILE AREA***
Checked by:	***JPT***

drill model and mounting:	GEMCO210B TRAILER	Easting:	560305916	slope:	-90°	R.L. Surface:	NOT MEASURED
hole diameter:	100 mm	Northing	6195870	bearing:		datum:	WGS-84

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
ADT		N							**FILL; Gravelly SAND:** Black, fine to coarse angular gravel, with some cobbles up to 200mm.	M	VD		COALWASH FILL
ADV				SPT 4,3,3 N*=6		1		CH	**CLAY:** High plasticity, mottled brown/grey.	>Wp	St	×	RESIDUAL
			►	SPT 3,5,4 N*=9		2		SW	**Sandy CLAY:** High plasticity, mottled brown/orange/grey, fine to coarse grained sand, with some fine to coarse angular sandstone gravel.	M W	D	×	EXTREMELY WEATHERED SANDSTONE
				SPT 4,6,R N*=R		3			**SANDSTONE:** Fine to medium grained, mottled brown/orange/grey, medium strength.			×	HIGHLY WEATHERED SANDSTONE
ADT						4			Borehole CBH115 terminated at 3.43m				Terminated with TC refusal
						5							
						6							
						7							
						8							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix e.g. ADT

support

M mud N nil
C casing

penetration

1 2 3 4 — no resistance ranging to refusal

water

10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Borehole

Borehole No.	***CBH116***
Sheet	1 of 1
Project No:	***GEOTWOLL02875AA***
Client:	***GUJART NRE MINERALS LTD***
Date started:	***8.4.2009***
Principal:	
Date completed:	***8.4.2009***
Project:	***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***
Logged by:	***LD***
Borehole Location:	***FIRE DAM / PIT TOP DAM***
Checked by:	***JPT***

drill model and mounting:	GEMCO210B TRAILER	Easting:	560305367	slope:	-90°	R.L. Surface:	NOT MEASURED
hole diameter:	100 mm	Northing	6195615	bearing:		datum:	WGS-84

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
ADT		N	NONE OBSERVED	SPT 2,4,2 N*=6		1			**FILL; Silty Sandy CLAY:** Medium to high plasticity, mottled brown/orange/grey/red, fine to coarse sand, with some fine to coarsesub rounded and angular gravel.	>Wp	St		EMBANKMENT FILL Bulk Sample between 0.2 and 1.5m
				SPT 2,5,2 N*=7		2							
				SPT 1,4,4 N*=8		3		CH	**Silty Sandy CLAY:** Medium to high plasticity, mottled brown/orange/grey/red, with some black flecks and some medium to high weathered sandstone gravel and cobbles.		VSt		COLLUVIUM
				SPT 4,7,8 N*=15		4							
				SPT 3,6,7 N*=13		5							
						6			Borehole CBH116 terminated at 5.95m				Terminated on steady progress
						7							
						8							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit
*bit shown by suffix e.g.	ADT

support

M mud N nil
C casing

penetration

1 2 3 4 — no resistance ranging to refusal

water

10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

BOREHOLE GW2875AA-MASTER COPY.GPJ COFFEY.GDT 1.6.10

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Engineering Log - Borehole

Borehole No.	***CBH117***
Sheet	1 of 1
Project No:	***GEOTWOLL02875AA***
Client:	***GUJART NRE MINERALS LTD***
Date started:	***8.4.2009***
Principal:	
Date completed:	***8.4.2009***
Project:	***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***
Logged by:	***LD***
Borehole Location:	***FIRE DAM / PIT TOP DAM***
Checked by:	***JPT***

drill model and mounting:	GEMCO210B TRAILER	Easting:	560305389	slope:	-90°	R.L. Surface:	NOT MEASURED
hole diameter:	100 mm	Northing	6195653	bearing:		datum:	WGS-84

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa (100 200 300 400)	structure and additional observations
ADT		N							**FILL; Silty Sandy CLAY:** Medium plasticity clay, fine to medium grained sand, with some fine to coarse angular gravel.	<Wp	St		FILL Bulk Sample between 0 and 0.6m
				SPT 5,10,15 N*=25		1			**FILL; Sandy Clayey GRAVEL:** Fine to coarse sandstone gravel, black, medium to high plasticity clay, fine to coarse grained sand, sandstone boulder approximately 300mm diameter at 1.2m depth.	M	D		FILL Bulk Sample between 0.6 and 1.5m
				SPT 5,8,8 N*=16		2		CH	**Sandy CLAY:** Medium to high plasticity, black, fine to coarse grained sand, with some fine to medium subrounded gravel, some sandstone cobblers up to 200mm. Sandstone boulder approximately 300mm diameter at 2.9m.	<Wp	VSt	×	COLLUVIUM
			►			3				W	St		
				SPT 3,3,4 N*=7		4							
				SPT 4,9,7 N*=16		5							
						6			Borehole CBH117 terminated at 6m				terminated on steady progress
						7							
						8							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix e.g. ADT

support

M mud N nil
C casing

penetration

1 2 3 4 — no resistance ranging to refusal

water

10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Borehole

Borehole No.	***CBH118***
Sheet	1 of 2
Project No:	***GEOTWOLL02875AA***
Client: ***GUJART NRE MINERALS LTD***	Date started: ***8.4.2009***
Principal:	Date completed: ***8.4.2009***
Project: ***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***	Logged by: ***LD***
Borehole Location: ***FIRE DAM / PIT TOP DAM***	Checked by: ***JPT***

drill model and mounting: GEMCO210B TRAILER | Easting: 560305403 | slope: -90° | R.L. Surface: NOT MEASURED

hole diameter: 100 mm | Northing 6195693 | bearing: | datum: WGS-84

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetrometer kPa 100 200 300 400	structure and additional observations
ADT		N	NONE OBSERVED						**FILL; Gravelly SAND:** Fine to coarse grained, black, fine to coarse grained angular gravel.	M	D		COAL WASH FILL
				SPT 9,17,18 N*=35		1			**FILL; Silty Sandy CLAY:** Medium to high plasticity, orange/brown/grey/red, fine to coarse sand, with some fine to medium grained gravel.	<Wp	VSt/H		EMBANKMENT FILL
								CH	**Sandy CLAY:** Medium to high plasticity, orange/brown/grey/red, fine to coarse grained sand, with some fine to medium grained gravel.		VSt/H		Bulk Sample between 0.8 and 1.2m COLLUVIUM
				SPT 8,9,12 N*=21		2							
						3			...at 3.5m colour change to brown.				
				SPT 7,14,18 N*=32				CH	**Sandy CLAY:** Medium to high plasticity, orange/brown/grey/red mottled black flecks, fine to coarse grained sand, with some medium to highly weathered sandstone gravel and some cobbles.		H		
				SPT 13,R N*=R		4							SPT refusal at 4.2m
									...at 4.7m color change to brown.	>Wp			
				SPT 4,6,9 N*=15		5							
						6							
				SPT 4,7,8 N*=15									
						7							
				SPT 4,8,13 N*=21									
						8		CH	**Sandy CLAY:** Medium to high plasticity, orange/brown/grey/red, fine to coarse grained sand, with some highly weathered sandstone and quartz gravel.		St		EXTREMELY WEATHERED SANDSTONE

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix e.g. ADT

support

M mud N nil
C casing

penetration

1 2 3 4 — no resistance ranging to refusal

water

10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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coffey geotechnics

Engineering Log - Borehole

Borehole No.	***CBH118***
Sheet	2 of 2
Project No:	***GEOTWOLL02875AA***
Client:	***GUJART NRE MINERALS LTD***
Date started:	***8.4.2009***
Principal:	
Date completed:	***8.4.2009***
Project:	***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***
Logged by:	***LD***
Borehole Location:	***FIRE DAM / PIT TOP DAM***
Checked by:	***JPT***

drill model and mounting:	GEMCO210B TRAILER	Easting:	560305403	slope:	-90°	R.L. Surface:	NOT MEASURED
hole diameter:	100 mm	Northing	6195693	bearing:		datum:	WGS-84

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
ADT		N	NONE OBSERVED	SPT 8,9,11 N*=20		9		CH	**Sandy CLAY:** Medium to high plasticity, orange/brown/grey/red, fine to coarse grained sand, with some highly weathered sandstone and quartz gravel. *(continued)*	>Wp	St	× × ×	
				Bs				CH	**Gravelly CLAY:** Medium plasticity, some brown/orange mottled, fine to coarse grained subangled/angular gravel.				EXTREMELY WEATHERED SILTSTONE
									SANDSTONE: Fine to medium grained, grey, low to medium strength.				HIGHLY WEATHERED SANDSTONE
									Borehole CBH118 terminated at 9.1m				Terminated on steady progress
						10							
						11							
						12							
						13							
						14							
						15							
						16							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix e.g. ADT

support

M mud N nil
C casing

penetration

1 2 3 4 — no resistance ranging to refusal

water

10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description

based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

coffey geotechnics

Engineering Log - Borehole

Borehole No.	***CBH119***
Sheet	1 of 1
Project No:	***GEOTWOLL02875AA***
Client:	***GUJART NRE MINERALS LTD***
Date started:	***8.4.2009***
Principal:	
Date completed:	***8.4.2009***
Project:	***GEOTECH. INVEST. FOR SURFACE OP'S UPGRADE***
Logged by:	***LD***
Borehole Location:	***FIRE DAM / PIT TOP DAM***
Checked by:	***JPT***

drill model and mounting: GEMCO210B TRAILER | Easting: 560305429 | slope: -90° | R.L. Surface: NOT MEASURED

hole diameter: 100 mm | Northing 6195724 | bearing: | datum: WGS-84

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
ADT		N	NONE OBSERVED						**FILL; Gravelly SAND:** Fine to coarse grained, black fine to coarse grained angular gravel, with some low plasticity clay to 0.1m.	M	D		COALWASH FILL
				SPT 5,5,7 N*=12		1			**FILL; Silty Sandy CLAY:** Medium to high plasticity, orange/brown/grey, fine to coarse grained sand, with some fine to medium grained angular gravel.	<Wp	VSt/H		EMBANKMENT FILL
				SPT 3,5,7 N*=12		2						×	
				SPT 7,10,11 N*=21		3						×	
												×	
				SPT 11,18,19 N*=37		4		CL	**Gravelley Sandy CLAY:**Medium plasticity, grey, brown, orange mottled, fine to medium grained sand, fine to coarse grained gravel.				COLLUVIUM
				SPT 9,14,17 N*=31		5							
						6							
				SPT 9,14,17 N*=31									
						7			Borehole CBH119 terminated at 6.45m				Terminated on steady to slow progress.
						8							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix e.g. ADT

support: M mud, C casing, N nil

penetration: 1 2 3 4 — no resistance ranging to refusal

water: 10/1/98 water level on date shown; water inflow; water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description based on unified classification system

moisture

D	dry
M	moist
W	wet
Wp	plastic limit
W_L	liquid limit

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

Appendix B

Engineering Logs Test Pits from Previous Reports

Coffey Partners International Pty. Ltd.
ACN 003 692 019

engineering log - excavation

COFFEY

pit no: TP1

sheet 1 of 1

office job no: SC1001/2

client:	FORBES RIGBY PTY LTD	pit commenced:	30-01-95
principal:	BELLAMBI COLLIERIES	pit completed:	30-01-95
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	logged by:	BMcD
pit location:	SEE PLAN	checked by:	AHH
equipment type and model:	PC220 KOMATSU	R.L. Surface	NOT MEASURED
excavation dimensions:	4.2 m long 0.75 m wide	orientation: 100	datum:

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L. / depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
E							SW	FILL: fine to coarse grained, dark grey, black, Gravelly SAND	M	VL		Coal waste washings Surface slope 4/280 deg Contact with topsoil 11/280 deg
							CI	TOPSOIL: medium plasticity, dark grey, Sandy CLAY	>Wp	VSt		
							CH	SILTY CLAY: high plasticity, orange, brown,				RESIDUAL
					1		CI	GRAVELLY CLAY: medium plasticity to high plasticity, mottled grey, orange, brown, gravel is slightly weathered shale, horizontal lamination				Extremely Weathered Shale
								SHALE: highly weathered, grey, orange, estimate very low strength				Highly Weathered Rock
					2		CH	SILTY CLAY: medium plasticity to high plasticity, yellow, grey, orange, some gravel	>Wp	H		Extremely Weathered Seam dips ~10/130 deg
								SHALE: highly weathered, estimate low to medium strength, lamination horizontal				
					3			Pit TP1 Terminated at 2.90m Not refusal				
					4							

METHOD
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R bulldozer ripper
- E excavator
- HA hand auger
- HT diatube

SUPPORT
SH shoring SC shotcrete
Nil no support
RB rockbolts

PENETRATION
1 2 3 4 little resistance ranging to very slow progress

WATER
- O none observed
- X not measured
- water level
- water outflow
- water inflow

SAMPLES, TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- VS vane shear
- DP dynamic penetrometer
- FD field density
- WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

CONSISTENCY/DENSITY INDEX
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

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Coffey Partners International Pty. Ltd.
ACN 003 692 019

engineering log - excavation

COFFEY

pit no: TP2
sheet 1 of 1

office job no: SC1001/2

client:	FORBES RIGBY PTY LTD	pit commenced:	30-01-95
principal:	BELLAMBI COLLIERIES	pit completed:	30-01-95
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	logged by:	BMcD
pit location:	SEE PLAN	checked by:	AMM
equipment type and model:	PC220 KOMATSU	R.L. Surface:	NOT MEASURED
excavation dimensions:	3.6 m long 0.7 m wide	orientation: 145	datum:

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
E								SC	TOPSOIL: fine grained, dark grey, black, Clayey SAND	M	L		Surface slope 15/145 deg
								CH	SILTY CLAY: high plasticity, dark brown, trace to some gravel (latite)	>Wp	VS	× ×	RESIDUAL/COLLUVIUM?
				U50				SC	GRAVELLY CLAYEY SAND: fine to coarse grained, yellow, brown, dark brown,		VD		Extremely Weathered Latite
						1			BASALT: (LATITE): massive, highly to extremely weathered, estimate very low to medium strength				Excavates as Gravelly SAND
									Pit TP2 Terminated at 1.80m Near refusal				
						2							
						3							
						4							

METHOD
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R bulldozer ripper
E excavator
HA hand auger
HT diatube

SUPPORT
SH shoring SC shotcrete
Nil no support
RB rockbolts

PENETRATION
1 2 3 4 — little resistance ranging to very slow progress

WATER
D none observed
¥ not measured
water level
water outflow
water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
VS vane shear
DP dynamic penetrometer
FD field density
WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

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Job: SC1001/2

Location: South Bulli Colliery

Test Pit No: TP3

Coffey Partners International Pty. Ltd.
ACN 003 692 019

engineering log - excavation

COFFEY

pit no: TP3

sheet 1 of 1

client:	FORBES RIGBY PTY LTD	office job no:	SC1001/2
principal:	BELLAMBI COLLIERIES	pit commenced:	30-01-95
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	pit completed:	30-01-95
pit location:	SEE PLAN	logged by:	BMcD
		checked by:	AHH
equipment type and model:	PC220 KOMATSU	R.L.Surface:	NOT MEASURED
excavation dimensions:	6.8 m long 0.75 m wide	orientation: 140	datum:

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L. / depth metres	graphic log	classification symbol	material: soil type; plasticity or particle characteristics; colour, secondary and minor components	moisture condition	consistency / density index	hand penetrometer kPa (100 200 300 400)	structure and additional observations
E							GW	FILL: fine to medium grained, black, Sandy GRAVEL	M	L		Coalwash
							CI	TOPSOIL: medium plasticity to high plasticity, black, Sandy CLAY	>Wp	St / VSt	X	Surface slope 15/140 deg
							CH	SILTY CLAY: high plasticity, mottled dark brown, orange, grey, some fine gravel and roots or branches		H	X	COLLUVIUM/RESIDUAL
					1			SANDSTONE: fine to medium grained, yellow, grey, orange,			X	Massive, highly weathered, estimate low strength
								Pit TP3 Terminated at 1.40m Not refusal, slow progress				
					2							
					3							
					4							

METHOD
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R bulldozer ripper
- E excavator
- HA hand auger
- HT diatube

SUPPORT
SH shoring SC shotcrete
Nil no support
RB rockbolts

PENETRATION
1 2 3 4 — little resistance ranging to very slow progress

WATER
- O none observed
- ✕ not measured
- water level
- water outflow
- water inflow

SAMPLES, TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- VS vane shear
- DP dynamic penetrometer
- FD field density
- WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

CONSISTENCY/DENSITY INDEX

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Job: SC1001/2

Location: South Bulli Colliery

Test Pit No: TP19

Coffey Partners International Pty. Ltd.
ACN 003 692 019

engineering log - excavation

COFFEY

pit no: TP19

sheet 1 of 1

office job no: SC1001/2

client:	FORBES RIGBY PTY LTD	pit commenced:	19-01-95
principal:	BELLAMBI COLLIERIES	pit completed:	19-01-95
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	logged by:	BMcD
pit location:	SEE PLAN	checked by:	AMW
equipment type and model:	PC220 KOMATSU	R.L. Surface:	NOT MEASURED
excavation dimensions:	2.1 m long 0.75 m wide	orientation: 170	datum:

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L. / depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency / density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
E							CH	TOPS MP-HP dark brown, grey, brown, Silty CLAY	>Wp	St		Rootlets
							CH	CLAY: high plasticity, brown,		VSt		RESIDUAL massive, some roots
							CH	CLAY: high plasticity, black,		St		Extremely Weathered Coal
							CI	SILTY CLAY: medium plasticity, light grey, green	D			Extremely Weathered Mudstone
					1			COAL: Highly to extremely weathered, very low, extremely low strength				
								MUDSTONE: fine, light green grey orange, laminated. Bedding 3/290 deg Some carbonaceous layers. Highly weathered, medium to low strength				
								Pit TP19 Terminated at 1.70m				
					2			Not refusal				
					3							
					4							

METHOD
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R bulldozer ripper
- E excavator
- HA hand auger
- HT diatube

SUPPORT
SH shoring SC shotcrete
Nil no support
RB rockbolts

PENETRATION
1 2 3 4 — little resistance ranging to very slow progress

WATER
- 0 none observed
- X not measured
- water level
- water outflow
- water inflow

SAMPLES, TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- VS vane shear
- DP dynamic penetrometer
- FD field density
- WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

CONSISTENCY/DENSITY INDEX
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

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engineering log - excavation

COFFEY

pit no: TP21

sheet 1 of 1

office job no: SC1001/2

client:	FORBES RIGBY PTY LTD	pit commenced:	19-01-95
principal:	BELLAMBI COLLIERIES	pit completed:	19-01-95
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	logged by:	BMcD
pit location:	SEE PLAN	checked by:	AMW
equipment type and model:	PC220 KOMATSU	R.L. Surface:	NOT MEASURED
excavation dimensions:	2.5 m long 0.75 m wide	orientation: 030	datum:

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L. / depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
E			D				GW	FILL: fine to medium grained, black, Sandy GRAVEL	M	L		Coal from old stockpile
							SW	GRAVELLY SAND: fine to medium grained, brown, grey, some silt. Gravel is high strength, slightly weathered, latite core stones	D	VD		Extremely to highly weathered. Latite
					1			increase in core stones				
					2			becoming highly weathered rock				
								Pit TP21 Terminated at 2.10m not refusal				
					3							
					4							

METHOD
- N natural exposure
- X existing excavation
- BK backhoe bucket
- B bulldozer blade
- R bulldozer ripper
- E excavator
- HA hand auger
- HT diatube

SUPPORT
- SK shoring SC shotcrete
- Nil no support
- RB rockbolts

PENETRATION

1 2 3 4 — little resistance ranging to very slow progress

WATER
- 0 none observed
- ✗ not measured
- water level
- water outflow
- water inflow

SAMPLES, TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- VS vane shear
- DP dynamic penetrometer
- FD field density
- WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION

based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

CONSISTENCY/DENSITY INDEX
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

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COFFEY

pit no TP22

sheet 1 of 1

engineering log - excavation

office job no: SCJ001/2

client:	FORBES HIGBY PTY LTD	pit commenced:	19-01-95
principal:	BELLAMBI COLLIERIES	pit completed:	19-01-95
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	logged by:	BMcD
pit location:	SEE PLAN	checked by:	AMW
equipment type and model:	PC220 KOMATSU	R.L. Surface:	NOT MEASURED
excavation dimensions:	2.5 m long 0.75 m wide	orientation: 080	datum:

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L. / depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
E			▽		0		GW	FILL: fine to medium grained, black, Silty Sandy GRAVEL	M	L		Remnants of coal stockpile Surface slope 6/050 deg
					1			contact ~5/100 deg	M			
							CH	SILTY CLAY: medium plasticity to high plasticity, green grey	>Wp	VSt	×	RESIDUAL, Polished fissures at all angles some Fe coat
							SC	CLAYEY SAND: fine grained, green grey contact ~5/295 deg	M	VD	×	
					2		SW	SILTY SAND: fine to medium grained, orange, brown, some gravel				Extremely Weathered latite
							SW	GRAVELLY SAND: fine to medium grained, orange, brown, gravel rounded, high strength latite				
								Pit TP22 Terminated at 2.20m Not refusal				
					3							
					4							

METHOD
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R bulldozer ripper
- E excavator
- HA hand auger
- HT diatube

SUPPORT
SH shoring SC shotcrete
Nil no support
RB rockbolts

PENETRATION
1 2 3 4 — little resistance ranging to very slow progress

WATER
- D none observed
- ✕ not measured
- ▽ water level
- water outflow
- water inflow

SAMPLES, TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- VS vane shear
- DP dynamic penetrometer
- FD field density
- WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

CONSISTENCY/DENSITY INDEX
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

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engineering log - excavation

COFFEY

pit no: TP23

sheet 1 of 1

office job no: SC1001/2

client:	FORBES RIGBY PTY LTD	pit commenced:	19-01-95
principal:	BELLAMBI COLLIERIES	pit completed:	19-01-95
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	logged by:	BMcD
pit location:	SEE PLAN	checked by:	AMM
equipment type and model:	PC220 KOMATSU	R.L. Surface:	NOT MEASURED
excavation dimensions:	2.7 m long 0.75 m wide	orientation:	datum:

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
E								GW	FILL: fine to medium grained, black, Sandy GRAVEL	W			Coal contact 5/000 deg
								CI	TOPSOIL: low plasticity to medium plasticity, dark brown, Sandy CLAY	>Wp			Rootlets
								CH	SILTY CLAY: high plasticity, orange, brown,		St		RESIDUAL
								CH	CLAY: high plasticity, green grey, trace of gravel, fine to medium		VSt		
				U50		1		SC	SILTY CLAYEY SAND: fine grained, green grey, brown	M	VD		
								SW	SILTY SAND: fine to medium grained, brown, orange, some gravel				Extremely Weathered latite
						2		SW	GRAVELLY SAND: fine to medium grained, brown, orange, gravel fine to coarse latite core stones				
									Pit TP23 Terminated at 2.40m Not refusal				
						3							
						4							

METHOD
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R bulldozer ripper
- E excavator
- HA hand auger
- MT diatube

SUPPORT
- SH shoring SC shotcrete
- Nil no support
- RB rockbolts

PENETRATION

1 2 3 4 — little resistance ranging to very slow progress

WATER
- O none observed
- ✗ not measured
- water level
- water outflow
- water inflow

SAMPLES, TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- VS vane shear
- DP dynamic penetrometer
- FD field density
- WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION

based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

CONSISTENCY/DENSITY INDEX
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

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Job: SC1001/2

Location: South Bulli Colliery

Test Pit No: TP24

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engineering log - excavation

pit no: TP24
sheet 1 of 1

office job no: SC1001/2

client:	FORGES RIGBY PTY LTD	pit commenced:	19-01-95
principal:	BELLAMBI COLLIERIES	pit completed:	19-01-95
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	logged by:	BMcD
pit location:	SEE PLAN	checked by:	AMH
equipment type and model:	PC220 KOMATSU	R.L. Surface:	NOT MEASURED
excavation dimensions:	3.1 m long 0.75 m wide	orientation: 100	datum:

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L. / depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
E							GW	FILL: fine to medium grained, black, Sandy GRAVEL	W	L		Remnant coal stockpile
							CI	FILL: medium plasticity to high plasticity, brown, orange, grey, Silty Sandy CLAY, some gravel	>Wp	St	X	Dam embankment fill
							CI	FILL: medium plasticity to high plasticity, light grey, Gravelly CLAY			X	Ripped shale
					1		CI	SANDY CLAY: medium plasticity to high plasticity, orange, brown, grey, some fine gravel shale CLAY: yellow grey, high plasticity, 0 05m thick at contact with fill		VSt	X	RESIDUAL/COLLUVIUM
					2		SW	GRAVELLY SAND: fine to medium grained, brown, orange, some silt		VD		Extremely Weathered latite silt
								BASALT: (LATITE) highly weathered, green grey clay seams and vesicular rock				Weathered Rock
					3			MUDSTONE: carbonaceous fine grained, highly weathered, very low strength, bedding 4/285 deg				
								SILTSTONE: light green grey, laminated, medium strength, slightly weathered				
								Pit TP24 Terminated at 3.30m Not refusal				
					4							

METHOD
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R bulldozer ripper
E excavator
HA hand auger
HT diatube

SUPPORT
SH shoring SC shotcrete
Nil no support
RB rockbolts

PENETRATION
1 2 3 4 — little resistance ranging to very slow progress

WATER
D none observed
✱ not measured
▽ water level
water outflow
water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
VS vane shear
DP dynamic penetrometer
FD field density
WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

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COFFEY

pit no TP25

sheet 1 of 1

engineering log - excavation

office job no: SC1001/2

client:	FORBES RIGBY PTY LTD	pit commenced:	25-01-95
principal:	BELLAMBI COLLIERIES	pit completed:	25-01-95
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	logged by:	BMcD
pit location:	SEE PLAN	checked by:	AMM
equipment type and model:	PC220 KOMATSU	R.L. Surface:	NOT MEASURED
excavation dimensions:	3.5 m long 0.75 m wide	orientation: 100	datum:

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
E								CH	TOPSOIL: medium plasticity to high plasticity, dark grey, black, Silty CLAY	>Wp	VSt		Rootlets
				U50				CH	SILTY CLAY: high plasticity, brown, grey, dark grey, black, layers				RESIDUAL
											H		Extremely Weathered Mudstone and Coal
						1		CH	SILTY CLAY: medium plasticity to high plasticity, grey, some fine gravel				Extremely Weathered Shale
									SHALE: fine, grey, orange,				Highly Weathered, estimate low to medium strength
									Pit TP25 Terminated at 1.60m Not refusal				
						2							
						3							
						4							

METHOD
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R bulldozer ripper
- E excavator
- HA hand auger
- HT diatube

SUPPORT
- SH shoring SC shotcrete
- Nil no support
- RB rockbolts

PENETRATION

1 2 3 4 — little resistance ranging to very slow progress

WATER
- D none observed
- ¥ not measured
- water level
- water outflow
- water inflow

SAMPLES, TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- VS vane shear
- DP dynamic penetrometer
- FD field density
- WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION

based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

CONSISTENCY/DENSITY INDEX
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

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Job: SC1001/2
Location: South Bulli Colliery

Test Pit No: TP26

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engineering log - excavation

COFFEY

pit no: TP26
sheet 1 of 1

client:	FORBES RIGBY PTY LTD	office job no:	SC1001/2
principal:	BELLAMBI COLLIERIES	pit commenced:	25-01-95
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	pit completed:	25-01-95
pit location:	SEE PLAN	logged by:	BMcD
		checked by:	AMW
equipment type and model:	PC220 KOMATSU	R.L. Surface:	NOT MEASURED
excavation dimensions:	4.2 m long 0.75 m wide	orientation: 120	datum:

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L. / depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/ density index	hand penetrometer kPa 150 200 300 450	structure and additional observations
E					0		CH	TOPSOIL: high plasticity, dark grey, black, Silty CLAY	>Wp	St	×	trace latite, core stones
							CH	SILTY CLAY: high plasticity, dark brown,			×	RESIDUAL/COLLUVIUM?
					1						×	
							SC	CLAYEY SAND: fine to coarse grained, yellow, brown,	M	VD	×	Extremely Weathered Latite
							SM	SILTY SAND: fine grained, grey, yellow, brown,	D			
								MUDSTONE: fine grained, grey, black, carbonaceous lamination ~3 deg/305 deg				Highly Weathered estimate low to very low strength
					2			COAL: fine grained, brown, black,				
								MUDSTONE: fine grained, grey, black, carbonaceous				
								MUDSTONE: fine grained, light grey,				estimate low to medium strength
								Pit TP26 Terminated at 2.60m				
					3			Not refusal				
					4							

METHOD
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R bulldozer ripper
E excavator
HA hand auger
HT diatube

SUPPORT
SH shoring SC shotcrete
Nil no support
RB rockbolts

PENETRATION
1 2 3 4 — little resistance ranging to very slow progress

WATER
0 none observed
✗ not measured
▽ water level
water outflow
water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
VS vane shear
DP dynamic penetrometer
FD field density
WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

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Job: SC1001/2

Location: South Bulli Colliery

Test Pit No: TP27

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engineering log - excavation

pit no: TP27
sheet 1 of 1

office job no: SC1001/2

client:	FORGES RIGBY PTY LTD	pit commenced:	25-01-95
principal:	BELLAMBI COLLIERIES	pit completed:	25-01-95
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	logged by:	BMcD
pit location:	SEE PLAN	checked by:	AMW
equipment type and model:	PC220 KOMATSU	R.L. Surface:	NOT MEASURED
excavation dimensions:	3.1 m long 0.75 m wide	orientation: 095	datum:

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L. / depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
E							CH	TOPSOIL: high plasticity, dark grey, black, Silty CLAY, some coarse gravel	M	St		
							CH	SILTY CLAY: high plasticity, mottled brown, grey, orange, trace of gravel (sandstone, mudstone, basalt)	>Wp			SLIDE DEBRIS open, 'crumbly' texture
							CH	SILTY CLAY: high plasticity, brown, grey, grey, orange, layers trace of shale gravel		H		RESIDUAL massive texture
					1		CH	GRAVELLY CLAY: medium plasticity to high plasticity, mottled grey, orange, layers gravel is shale horizontal lamination				Extremely Weathered Rock
								SHALE: fine grey, orange, laminated				Highly Weathered estimate low to medium strength
								Pit TP27 Terminated at 1.70m Not refusal				
					2							
					3							
					4							

METHOD
N natural exposure
X existing excavation
BH backhoe bucket
B bulldozer blade
R bulldozer ripper
E excavator
HA hand auger
HT diatube

SUPPORT
SH shoring SC shotcrete
Nil no support
RB rockbolts

PENETRATION
1 2 3 4 — little resistance ranging to very slow progress

WATER
D none observed
X not measured
water level
water outflow
water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
VS vane shear
DP dynamic penetrometer
FD field density
WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

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Job: SC1001/2

Location: South Bulli Colliery

Test Pit No: TP43

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engineering log - excavation

COFFEY

pit no: TP43

sheet 1 of 1

client:	FORBES RIGBY PTY LTD	office job no:	SC1001/2
principal:	BELLAMBI COLLIERIES	pit commenced:	20-01-95
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	pit completed:	20-01-95
pit location:	SEE PLAN	logged by:	BMCO
		checked by:	AMW
equipment type and model:	PC220 KOMATSU	R.L. Surface:	NOT MEASURED
excavation dimensions:	2.8 m long 0.75 m wide	orientation: 300	datum:

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L. / depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency / density index	hand penetrometer kPa (100, 200, 300, 400)	structure and additional observations
E							CI	TOPSOIL: medium plasticity, dark grey, black, Silty CLAY	>Wp	St		Roots Surface slope 5/120 deg
							CH	SILTY CLAY: medium plasticity to high plasticity, mottled grey, orange, yellow, contact 3/120 irregular				RESIDUAL
					1			SHALE: fine, light grey & orange, extremely low to low strength layers, horizontally laminated				Highly to extremely weathered rock
					2			Pit TP43 Terminated at 2.00m Not refusal				
					3							
					4							

METHOD
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R bulldozer ripper
- E excavator
- HA hand auger
- HT diatube

SUPPORT
SH shoring SC shotcrete
Nil no support
RB rockbolts

PENETRATION
1 2 3 4 — little resistance ranging to very slow progress

WATER
- D none observed
- ✗ not measured
- water level
- water outflow
- water inflow

SAMPLES, TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- VS vane shear
- DP dynamic penetrometer
- FD field density
- WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

CONSISTENCY/DENSITY INDEX
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

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Job: SC1001/2
Location: South Bulli Colliery

Test Pit No: TP44

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engineering log - excavation

COFFEY

pit no: TP44
sheet 1 of 1

office job no: SC1001/2

client:	FORBES RIGBY PTY LTD	pit commenced:	24-01-95
principal:	BELLAMBI COLLIERIES	pit completed:	24-01-95
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	logged by:	BMcD
pit location:	SEE PLAN	checked by:	AMH
equipment type and model:	PC220 KOMATSU	R.L.Surface:	NOT MEASURED
excavation dimensions:	3.5 m long 0.75 m wide	orientation: 120	datum:

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
E								CI	TOPSOIL: medium plasticity to high plasticity, dark brown, grey, Silty CLAY	M	S / VSt		Roots Surface slope 16/120 deg
								CH	SILTY CLAY: medium plasticity to high plasticity, dark brown, some sand and fine gravel	>Wp	H		COLLUVIUM/RESIDUAL?
						1		SW	GRAVELLY SAND: fine to coarse grained, brown, grey. contact with mudstone ~5 deg/290 deg		VD		Extremely Weathered Latite
						2			MUDSTONE: fine dark grey, & black, carbonaceous				Highly to Slightly Weathered, estimate medium strength
						3			Pit TP44 Terminated at 2.30m Near refusal				
						4							

METHOD
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R bulldozer ripper
- E excavator
- HA hand auger
- HT diatube

SUPPORT
SH shoring SC shotcrete
Nil no support
RB rockbolts

PENETRATION
1 2 3 4 — little resistance ranging to very slow progress

WATER
- D none observed
- ✗ not measured
- water level
- water outflow
- water inflow

SAMPLES, TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- VS vane shear
- DP dynamic penetrometer
- FD field density
- WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

CONSISTENCY/DENSITY INDEX
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

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Job: SC1001/2

Location: South Bulli Colliery

Test Pit No: TP45

Coffey Partners International Pty. Ltd.
ACN 003 692 019

engineering log - excavation

COFFEY

pit no: TP45
sheet 1 of 1

client:	FORBES RIGBY PTY LTD	office job no:	SC1001/2
principal:	BELLAMBI COLLIERIES	pit commenced:	24-01-95
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	pit completed:	24-01-95
pit location:	SEE PLAN	logged by:	BMcD
		checked by:	AMW
equipment type and model:	PC220 KOMATSU		
excavation dimensions:	3.1 m long 0.75 m wide	orientation: 100	R.L.Surface: NOT MEASURED datum:

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L. depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
E							CI	TOPSOIL: medium plasticity, dark grey, black, Silty CLAY	>Wp	St		Roots Surface slope 10/120 deg
							CH	GRAVELLY CLAY: medium plasticity to high plasticity, brown, grey, & grey, orange, some sand and silt		VSt		RESIDUAL/COLLUVIUM?
				Bs						H		
				U50	1							
							GC	CLAYEY GRAVEL: fine to medium grained, light grey, orange, brown, gravel layers of highly to slightly weathered siltstone	M	VD		Extremely Weathered Siltstone
								SILTSTONE: fine, light grey, orange, indistinct bedding 5/300 deg, blocky fracture				Highly to Slightly Weathered, estimate medium to high strength
					2			Pit TP45 Terminated at 2.00m Near refusal				
					3							
					4							

METHOD
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R bulldozer ripper
- E excavator
- HA hand auger
- HT diatube

SUPPORT
SH shoring SC shotcrete
Nil no support
RB rockbolts

PENETRATION
1 2 3 4 — little resistance ranging to very slow progress

WATER
- O none observed
- X not measured
- water level
- water outflow
- water inflow

SAMPLES, TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- VS vane shear
- DP dynamic penetrometer
- FD field density
- WS water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

CONSISTENCY/DENSITY INDEX
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

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engineering log - borehole

borehole no: B7
sheet 1 of 1

office job no: SC1001/2

client:	FORBES RIGBY PTY. LTD.	hole commenced:	1.2.1995
principal:	BELLAMBI COLLIERIES	hole completed:	2.2.1995
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	logged by:	JAF
borehole location:	SEE PLAN	checked by:	
drill model and mounting:	EDSON 3000 - TRUCK MOUNTED	slope:	-90 DEG
hole diameter:	100mm	bearing:	
R.L.Surface:	56.4 m		
datum:	AHD		

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L. / depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/ density index	hand penetrometer KPa 100 200 300 400	structure and additional observations
AOT		C			56			FILL: COAL WASTE	M	VD		FILL
					1			FILL: COAL WASTE & CLAY (Boulder 2.90 to 3.30m) (Basalt Boulder 3.50 to 3.70m)	W	D		
				5 ,5 ,6 Nx= 11	55							
					2							
					54							
RR					3					VD		
					53					MD		
				D						VD		
NMLC		C			4		CH	GRAVELLY CLAY: high plasticity, mottled light brown, brown, & grey, gravel is angular sandstone to >50mm some boulders	M	H		COLLUVIUM
				D	52							
		Nil			5							
					51		GC	CLAYEY GRAVEL coarse grained, mottled light brown, brown, & dark grey, gravel is SANDSTONE & BASALT to >200mm				
				D	6							
								SILTSTONE: banded grey, & dark grey, medium strength				SLIGHTLY WEATHERED SILTSTONE
					50							
				D	7			Borehole B7 Terminated at 6.95 m				
					49							
					8							

METHOD
- AS auger screwing*
- AD auger drilling*
- RR roller/tricone
- W washbore
- CT cable tool
- HA hand auger
- DT diatube
- *bit shown by suffix
- B blank bit
- V V bit
- T TC bit
- e.g. ADT

SUPPORT
- Nil no support
- M mud
- C casing

PENETRATION 1 2 3 4 — little resistance ranging to very slow progress

WATER
- * not measured
- 0 none observed
- water level
- water outflow
- water inflow

SAMPLES, TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- N standard penetration test:
- Nx SPT + sample recovered
- Nc SPT with solid cone
- VS vane shear
- PM pressuremeter
- DP dynamic penetrometer
- WS water sample
- PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

CONSISTENCY/DENSITY INDEX
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

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engineering log - borehole

borehole no: 88
sheet 1 of 2

office job no: SC1001/2

client:	FORBES RIGBY PTY. LTD.	hole commenced:	31.1.1995
principal:	BELLAMBI COLLIERIES	hole completed:	1.2.1995
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	logged by:	MF
borehole location:	SEE PLAN	checked by:	
drill model and mounting:	EDSON 3000 - TRUCK MOUNTED	slope: -90 DEG	R.L. Surface: 58.6 m
hole diameter:	100mm	bearing:	datum: AHD

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics; colour, secondary and minor components	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
ADT		C	D		58	1			FILL: COAL WASTE with some CLAY LUMPS and BASALT BOULDERS	M	D		FILL
				10 ,- ,- N*=R	57	2					VD		
					56	3			FILL: CLAY GRAVEL and BOULDERS (BASALT BOULDERS from 5.70 to 5.95m)		MD		
				5 ,4 ,4 N*= 8	55	4							
					54	5					VD		
				4 ,6 ,8 N*= 14	53	6					MD		
NMLC		TIN		D	52	7		GC	CLAYEY GRAVEL: coarse grained, brown, basalt boulders.		H		COLLUVIUM/FILL?
											D		
									Continued as cored borehole from 6.55 m				
					51	8							

METHOD
AS auger screwing*
AD auger drilling*
AR roller/tricone
W washbore
CT cable tool
HA hand auger
DT dialube
*bit shown by suffix
B blank bit
V V bit
T TC bit
e.g. ADT

SUPPORT
Nil no support M mud
C casing

PENETRATION
1 2 3 4
little resistance ranging to very slow progress

WATER
* not measured 0 none observed
water level
water outflow
water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Ds bulk sample
E environmental sample
N standard penetration test:
N* SPT + sample recovered
Nc SPT with solid cone
VS vane shear
PM pressuremeter
DP dynamic penetrometer
WS water sample
PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

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engineering log - cored borehole

borehole no: 88
sheet 2 of 3

office job no: SC1001/2

client:	FORBES RIGBY PTY. LTD	hole commenced	31.1.1995
principal:	BELLAMBI COLLIERIES	hole completed:	1.2.1995
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	logged by:	JAF
borehole location:	SEE PLAN	checked by:	
drill model and mounting:	EDSON 3000 - TRUCK MOUNTED	slope: -90 DEG	R.L.Surface: 58.6 m
barrel type and length:	NMLC - 3.0m fluid: WATER	bearing:	datum: AHD

drilling information					rock substance							rock mass defects		
method	case-lift	water	R.L.	depth metres	graphic log core loss	substance description: rock type; grain characteristics; colour, structure, minor components	weathering	Est. Strength (EL VL L M H VH EH)	point load test Is(50) MPa	RQD %	defect spacing mm (20 60 200 600 2000 6000)	defect description: type, inclination planarity, roughness, coating, thickness; unless otherwise noted defects follow general description below
NMLC			58	1								
			57	2								
			56	3								
			55	4								
			54	5								
			53	6								
			52			Continued from non-core borehole						
						BASALT: BOULDER						
				7		NO CORE 0.27m						
						SILTSTONE: brown, becoming mottled brown, grey, distinct bedding, 0deg	EW / HW / EW					7.05 to 7.45 very broken and jointed
			51			NO CORE 0.30m						
				8		SILTSTONE: banded dark grey, light grey, & brown, distinct bedding, 0 deg Some interbedded fine SANDSTONE	EW					7.95 to 8.05 very broken EW

General Defect Description:
5.70 TO 10.52 BEDDING PARTINGS

METHOD
DT diatube
AS auger screwing
AD auger drilling
RR roller/tricone
NMLC core drilling
NO, HO, PQ core drilling
casing used
barrel withdrawn

WATER
water level
water inflow
0 none observed
* not measured
Drilling Water
partial loss
complete loss

POINT LOAD TEST
D -diametral I -irregular
A -axial

GRAPHIC LOG/CORE LOSS
core recovered (hatching indicates material)
no core recovered

WEATHERING
FR -fresh
SW -slightly
MW -moderately
HW -highly
EW -extremely

STRENGTH
EL -extremely low
VL -very low
L -low
M -medium
H -high
VH -very high
EH -extremely high

DEFECTS
JT -joint
PT -parting
SM -seam
PL -planar
CV -curved
IR -irregular
RO -rough
SO -smooth
SL -slickensided

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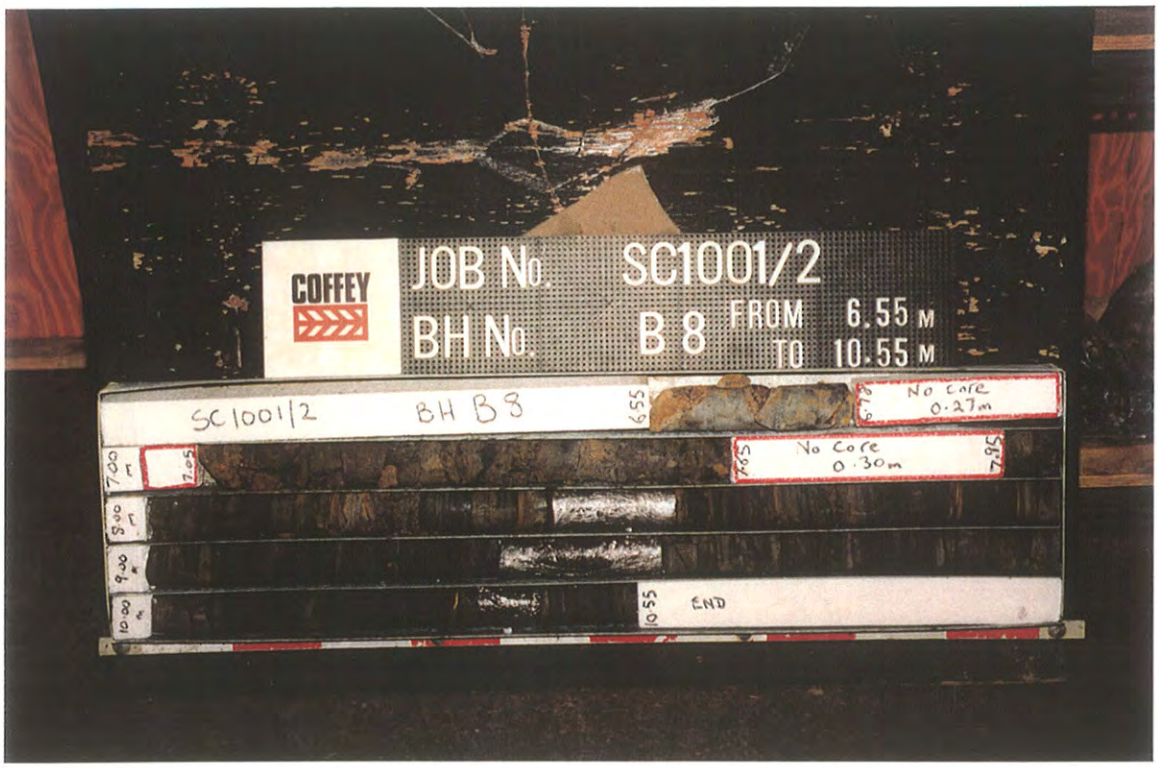
COFFEY
JOB No. SC1001/2
BH No. B 8
FROM 6.55 M
TO 10.55 M
SC1001/2 BH B8
No core 0.27m
No Core 0.30m
END

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ACN 003 692 019

engineering log - cored borehole

borehole no: 88
sheet 3 of 3

office job no: SC1001/2

client:	FORBES RIGBY PTY. LTD	hole commenced:	31.1.1995
principal:	BELLAMBI COLLIERIES	hole completed	1.2.1995
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	logged by:	JAF
borehole location:	SEE PLAN	checked by:	
drill model and mounting:	EDSON 3000 - TRUCK MOUNTED	slope: -90 DEG	R.L Surface 58.6 m
barrel type and length:	NMLC - 3.0m	fluid: WATER bearing:	datum: AHD

drilling information					rock substance				rock mass defects		
method	case-lift	water	R.L.	depth metres	graphic log core loss	substance description rock type: grain characteristics colour, structure, minor components	weathering	Est. Strength EL VL L M H VH EH	point load test Is(50) MPa	RQD %	defect spacing mm 30 100 300 1000 3000	defect description type, inclination planarity, roughness, coating, thickness unless otherwise noted defects follow general description below
NMLC			50	9		SILTSTONE: banded dark grey, light grey, & brown, distinct bedding, 0 deg Some interbedded fine SANDSTONE	MW SW					JT 85 deg IR smooth clean 8.15 to 8.30 very jointed and broken with CW SM s CW SM 20mm 9.20 to 9.28 JT s to 45 deg to 90 deg
			49	10		INTERLAMINATED SILTSTONE & SANDSTONE: fine grained, dark grey, grey, laminated 0-5deg						JT 30 deg PL RO clean CW SM (30 deg) 5mm 9.88/9.89/9.96 JT 60 deg PL smooth, crush infill JT 30 deg PL smooth clean 10.16 to 10.22 very jointed and broken JT 30 deg PL smooth clean DT 45 deg PL smooth clean
			48			Borehole 88 terminated at 10.55m						
			47	11								
			46	12								
			45	13								
			44	14								
			43	15								
				16								

General Defect Description:

METHOD
DT diatube
AS auger screwing
AD auger drilling
RR roller/tricone
NMLC, NO, HQ, PQ core drilling
casing used
barrel withdrawn

WATER
water level
water inflow
O none observed
* not measured
Drilling Water
partial loss
complete loss

POINT LOAD TEST
D -diametral I -irregular
A -axial

GRAPHIC LOG/CORE LOSS
core recovered (hatching indicates material)
no core recovered

WEATHERING
FR -fresh
SW -slightly
MW -moderately
HW -highly
EW -extremely

STRENGTH
EL -extremely low
VL -very low
L -low
M -medium
H -high
VH -very high
EH -extremely high

DEFECTS
JT -joint
PT -parting
SM -seam
PL -planar
CV -curved
IR -irregular
RO -rough
SO -smooth
SL -slickensided

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Coffey Partners International Pty. Ltd.
ACN 003 692 019

engineering log - borehole

borehole no: 89
sheet 1 of 2

office job no: SC1001/2

client:	FORBES RIGBY PTY. LTD.	hole commenced:	13.2.1995
principal:	BELLAMBI COLLIERIES	hole completed:	13.2.1995
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	logged by:	JAF
borehole location:	SEE PLAN	checked by:	
drill model and mounting:	EDSON 3000 - TRUCK MOUNTED	slope:	-90 DEG
hole diameter:	100mm	bearing:	
R.L Surface:	NOT MEASURED	datum:	NOT MEASURED

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L. / depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
ADT		C	D		1			FILL: COAL WASTE	M	D		FILL
RR		Nil		16,9,10 N*= 19	2		CH	CLAY: high plasticity, light grey-brown,	>Wp	VSt	X	RESIDUAL
					3		SC	CLAYEY SAND: fine grained, light brown, friable cementation. Some SILT	D	VD		EXTREMELY WEATHERED SANDSTONE
				N*=R	4			Continued as cored borehole from 3.95 m				
					5							
					6							
					7							
					8							

METHOD
- AS auger screwing*
- AD auger drilling*
- RR roller/tricone
- W washbore
- CT cable tool
- HA hand auger
- DT diatube
- *bit shown by suffix
- B blank bit
- V V bit
- T TC bit
- e.g. ADT

SUPPORT
- Nil no support
- M mud
- C casing

PENETRATION 1 2 3 4 — little resistance ranging to very slow progress

WATER
- * not measured
- 0 none observed
- water level
- water outflow
- water inflow

SAMPLES, TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- N standard penetration test:
- N* SPT + sample recovered
- Nc SPT with solid cone
- VS vane shear
- PM pressuremeter
- DP dynamic penetrometer
- WS water sample
- PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

CONSISTENCY/DENSITY INDEX
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

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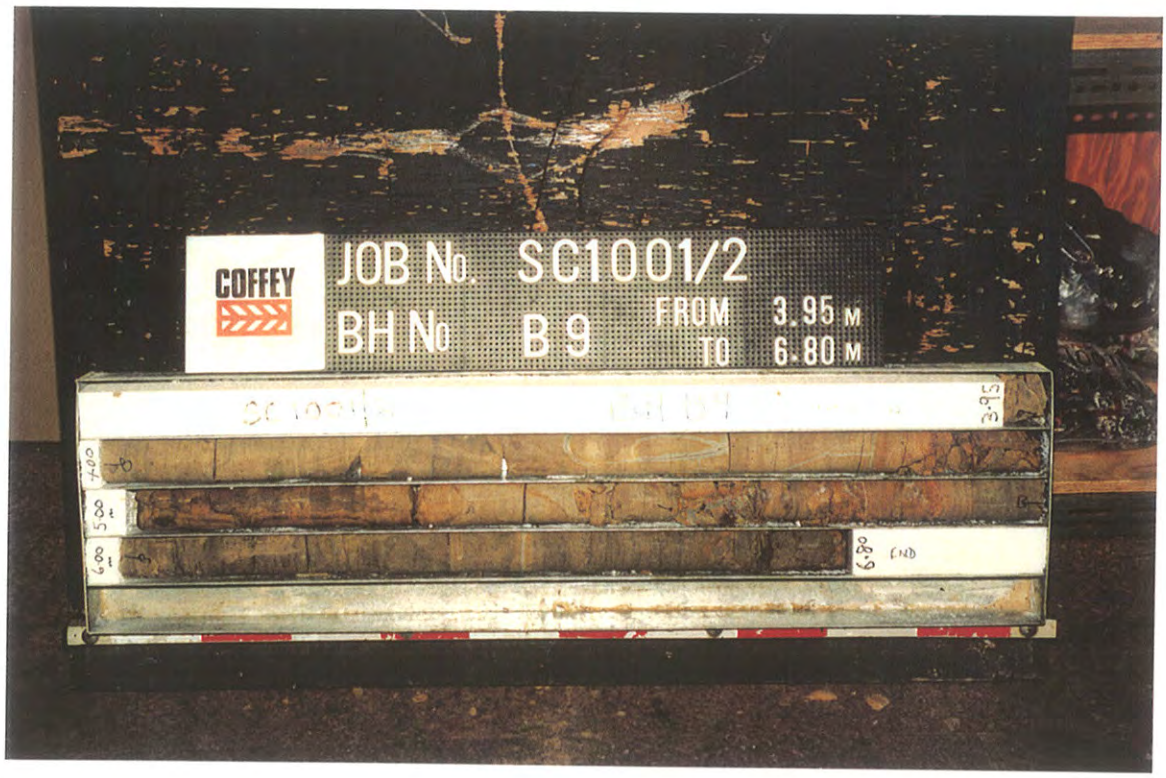
COFFEY
JOB No. SC1001/2
BH No B 9
FROM 3.95 M
TO 6.80 M
3.95
END

Coffey Partners International Pty. Ltd.
ACN 003 692 019

engineering log - cored borehole

borehole no: 89
sheet 2 of 2

office job no: SC1001/2

client:	FORBES RIGBY PTY. LTD.	hole commenced:	13.2.1995
principal:	BELLAMBI COLLIERIES	hole completed:	13.2.1995
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	logged by:	JAF
borehole location:	SEE PLAN	checked by:	
drill model and mounting:	EDSON 3000 - TRUCK MOUNTED	slope: -90 DEG	R.L Surface NOT MEASURED
barrel type and length:	NMLC - 3.0m fluid: WATER	bearing:	datum: NOT MEASURED

drilling information					rock substance					rock mass defects		
method	case-lit	water	R.L.	depth metres	graphic log core loss	substance description: rock type; grain characteristics; colour, structure, minor components	weathering	Est. Strength (EL VL L M H VH EH)	point load test Is(50) MPa	RQD %	defect spacing mm (20 60 200 600 2000)	defect description: type, inclination planarity, roughness, coating, thickness; unless otherwise noted defects follow general description below
				1								
				2								
				3								
				4		Continued from non-core borehole						
NMLC				5		SANDSTONE: fine grained, light grey-brown, banded brown, distinct bedding, 0 deg	SW / MW / HW / SW					JT 30 deg PL RO clean 4 41/4 65 4.85 to 5.10 JT s 90 deg IR RO Fe 5.42 to 5.60 J s 90 deg IR RO Fe 5.60 to 5.90 Numerous JT s to 90 deg and some EW SM s JT 60 deg PL smooth clean JT 45 deg IR RO clean 6.65 to 6.80 JT 90 deg IR RO Fe and CLAY infill
				6								
				7		Borehole B9 Terminated at 6.80 m						
				8								

General Defect Description:
3.95 TO 6.80m BEDDING PARTINGS

METHOD
DT diatube
AS auger screwing
AD auger drilling
RR roller/tricone
NMLC core drilling
NQ, HQ, PQ core drilling
casing used
barrel withdrawn

WATER
water level
water inflow
D none observed
* not measured
Drilling Water
partial loss
complete loss

POINT LOAD TEST
D -diametral I -irregular
A -axial

GRAPHIC LOG/CORE LOSS
core recovered (hatching indicates material)
no core recovered

WEATHERING
FR -fresh
SW -slightly
MW -moderately
HW -highly
EW -extremely

STRENGTH
EL -extremely low
VL -very low
L -low
M -medium
H -high
VH -very high
EH -extremely high

DEFECTS
JT -joint
PT -parting
SM -seam
PL -planar
CV -curved
IR -irregular
RO -rough
SO -smooth
SL -slickensided

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ACN 003 692 019

engineering log - borehole

borehole no: B10
sheet 1 of 2

office job no: SC1001/2

client:	FORBES RIGBY PTY LTD	hole commenced:	30/01/95
principal:	BELLAMBI COLLIERIES	hole completed:	30/01/95
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	logged by:	JAF
borehole location:	SEE PLAN	checked by:	
drill model and mounting:	EDSON 3000-TRUCK	slope: -90 DEG	R.L.Surface: 55.4 m
hole diameter:	100mm	bearing:	datum: AHD

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
ADT		Nil			55	0			FILL: COAL WASTE & GRAVEL	M	VD		FILL
				10 , 6 , 7 Nx= 13	54	1			FILL: COAL WASTE, CLAY, SAND & GRAVEL		D		
					53	2			FILL: COAL WASTE		VD		
				16 , 17 , 17 Nx= 34	52	3							
				4 , 4 , 6 Nx= 10	51	4			FILL: CLAY, COAL WASTE & GRAVEL		MD		
					50	5							
				26 , - , - Nx> 50	49	6		CH	CLAY: medium to high plasticity, mottled brown, & dark brown, Some friable and non-friable cementation	>Wp	H		RESIDUAL
			30.1.1995	12 , - , - Nx=R	48	7							
						8							

METHOD
- AS auger screwing*
- AD auger drilling*
- RR roller/tricone
- W washbore
- CT cable tool
- HA hand auger
- DT diatube
- *bit shown by suffix
- B blank bit
- V V bit
- T TC bit
- e.g. ADT

SUPPORT
Nil no support M mud
C casing

PENETRATION
1 2 3 4 little resistance ranging to very slow progress

WATER
* not measured 0 none observed
- water level
- water outflow
- water inflow

SAMPLES, TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- N standard penetration test:
- Nx SPT + sample recovered
- Nc SPT with solid cone
- VS vane shear
- PM pressuremeter
- DP dynamic penetrometer
- WS water sample
- PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

CONSISTENCY/DENSITY INDEX
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

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ACN 003 692 019

engineering log - borehole

borehole no: B10
sheet 2 of 2

office job no: SC1001/2

client:	FORBES RIGBY PTY LTD	hole commenced:	30/01/95
principal:	BELLAMBI COLLIERIES	hole completed:	30/01/95
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	logged by:	JAF
borehole location:	SEE PLAN	checked by:	
drill model and mounting:	EOSON 3000-TRUCK	slope: -90 DEG	R.L.Surface: 55.4 m
hole diameter:	100mm	bearing:	datum: AHD

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
ADT				NX=R	47	9			SANDSTONE: fine grained, brown, & dark red-brown, Non-friable cementation.	W	H		EXTREMELY TO HIGHLY WEATHERED SANDSTONE
					46	10							
				D	45	11			SANDSTONE: fine grained, light grey, & grey.	M			MODERATELY TO SLIGHTLY WEATHERED SANDSTONE/SILTSTONE
					44	12			Borehole B10 Terminated at 11.05 m TC BIT REFUSAL AT 11.05m				
					43	13							
					42	14							
					41	15							
					40	16							

METHOD
- AS auger screwing*
- AD auger drilling*
- AR roller/tricone
- W washbore
- CT cable tool
- HA hand auger
- DT diatube
- *bit shown by suffix
- B blank bit
- V V bit
- T TC bit
- e.g. ADT

SUPPORT
- Nil no support
- M mud
- C casing

PENETRATION 1 2 3 4
- little resistance
- ranging to
- very slow progress

WATER
- X not measured
- O none observed
- water level
- water outflow
- water inflow

SAMPLES, TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- N standard penetration test:
- Nx SPT + sample recovered
- Nc SPT with solid cone
- VS vane shear
- PM pressuremeter
- DP dynamic penetrometer
- WS water sample
- PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

CONSISTENCY/DENSITY INDEX
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

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ACN 003 692 019

engineering log - borehole

borehole no: B11
sheet 1 of 2

office job no: SC1001/2

client:	FORBES RIGBY PTY. LTD.	hole commenced	10.2.1995
principal:	BELLAMBI COLLIERIES	hole completed.	13.2.1995
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	logged by:	JAF
borehole location:	SEE PLAN	checked by:	
drill model and mounting:	EDSON 3000 - TRUCK MOUNTED	slope:	-90 DEG
hole diameter:	100mm	bearing:	
		R.L. Surface:	NOT MEASURED
		datum:	NOT MEASURED

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L. / depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics; colour, secondary and minor components	moisture condition	consistency / density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
ADT		C	D		0			FILL: COAL WASTE CLAY and GRAVEL	M	MD		FILL
				5 , 10 , 11 N*= 21	1		CH	SILTY CLAY: high plasticity, mottled light brown, & brown. Trace of fine sand	<Wp	H		RESIDUAL
					2							
							CL	SANDY CLAY: low plasticity, light brown. Trace of fine gravel Sand is fine grained	D			EXTREMELY WEATHERED SANDSTONE
				26 , - , - N*> 50	3							"TC" bit refusal at 3.3m
NMLC		Nil					GC	CLAYEY GRAVEL. Fine to coarse grained, mottled light brown, & dark grey. Some sand Gravel is Basalt and Sandstone to >100mm.		VD		EXTREMELY WEATHERED BASALT AND SANDSTONE
				D	4							
				D								
				D	5							
				D	6							
					7			BASALT: fine grained, dark grey, HIGH STRENGTH with numerous vertical joints ironstained				SLIGHTLY WEATHERED BASALT
					8							

METHOD
AS auger screwing*
AD auger drilling*
AR roller/tricone
W washbore
CT cable tool
HA hand auger
DT diatube
*bit shown by suffix
B blank bit
V V bit
T TC bit
e.g. ADT

SUPPORT
Nil no support M mud
C casing

PENETRATION
1 2 3 4
little resistance ranging to very slow progress

WATER
* not measured 0 none observed
water level
water outflow
water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
N standard penetration test:
Nx SPT + sample recovered
Nc SPT with solid cone
VS vane shear
PM pressuremeter
DP dynamic penetrometer
WS water sample
PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

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Coffey Partners International Pty. Ltd.
ACN 003 692 019

engineering log - borehole

borehole no: B11
sheet 2 of 2

office job no: SC1001/2

client:	FORBES RIGBY PTY. LTD.	hole commenced:	10.2.1995
principal:	BELLAMBI COLLIERIES	hole completed:	13.2.1995
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	logged by:	JAF
borehole location:	SEE PLAN	checked by:	GWJ
drill model and mounting:	EDSON 3000 - TRUCK MOUNTED	slope: -90 DEG	R.L. Surface: NOT MEASURED
hole diameter:	100mm	bearing:	datum: NOT MEASURED

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
NMLC				0		9			BASALT: fine grained, dark grey, HIGH STRENGTH with numerous vertical joints ironstained.		VD		SLIGHTLY WEATHERED BASALT
				0					Borehole B11 Terminated at 9.60 m				
						10							
						11							
						12							
						13							
						14							
						15							
						16							

METHOD
- AS auger screwing*
- AD auger drilling*
- RR roller/tricone
- W washbore
- CT cable tool
- HA hand auger
- DT diatube
- *bit shown by suffix
- B blank bit
- V V bit
- T TC bit
- e.g. ADT

SUPPORT
- Nil no support
- M mud
- C casing

PENETRATION
1 2 3 4
little resistance
ranging to
very slow progress

WATER
- * not measured
- 0 none observed
- water level
- water outflow
- water inflow

SAMPLES, TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- N standard penetration test:
- N* SPT + sample recovered
- Nc SPT with solid cone
- VS vane shear
- PM pressuremeter
- DP dynamic penetrometer
- WS water sample
- PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

CONSISTENCY/DENSITY INDEX
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

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ACN 003 692 019

engineering log - borehole

borehole no: B12
sheet 1 of 2

office job no: SC1001/2

client:	FORBES RIGBY PTY LTD	hole commenced:	31/01/95
principal:	BELLAMBI COLLIERIES	hole completed:	31/01/95
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	logged by:	JAF
borehole location:	SEE PLAN	checked by:	
drill model and mounting:	EDSON 3000-TRUCK	slope: -90 DEG	R.L.Surface: 53.5 m
hole diameter:	100mm	bearing: NOT MEASURED	datum: AHD

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
ADT		Nil	D		53				FILL: COAL WASTE	M	MD		FILL
						1			FILL: CLAY, SAND, COAL WASTE & GRAVEL		D		
				7,9,9 N*= 18	52								
						2							
					51								
				6,6,8 N*= 14		3							
					50								
						4			SILTSTONE: banded brown, & grey, friable cementation		H		EXTREMELY TO HIGHLY WEATHERED SILTSTONE
					49								
				NX=R		5							
					48								
						6							
				NX=R	47								
						7			SILTSTONE: grey, & light grey, Non-friable cementation	D			MODERATELY TO SLIGHTLY WEATHERED SILTSTONE
					46								
						8							

METHOD
- AS auger screwing*
- AD auger drilling*
- RR roller/tricone
- W washbore
- CT cable tool
- HA hand auger
- DT diatube
- *bit shown by suffix
- B blank bit
- V V bit
- T TC bit
- e.g. ADT

SUPPORT
- Nil no support
- M mud
- C casing

PENETRATION
1 2 3 4 — little resistance ranging to very slow progress

WATER
- * not measured
- 0 none observed
- water level
- water outflow
- water inflow

SAMPLES, TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- N standard penetration test:
- Nx SPT + sample recovered
- Nc SPT with solid cone
- VS vane shear
- PM pressuremeter
- DP dynamic penetrometer
- WS water sample
- PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

CONSISTENCY/DENSITY INDEX
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

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engineering log - borehole

borehole no: B12
sheet 2 of 2

office job no: SC1001/2

client:	FORBES RIGBY PTY LTD	hole commenced:	31/01/95
principal:	BELLAMBI COLLIERIES	hole completed:	31/01/95
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	logged by:	JAF
borehole location:	SEE PLAN	checked by:	
drill model and mounting:	EDSON 3000-TRUCK	slope:	-90 DEG
hole diameter:	100mm	bearing:	NOT MEASURED
		R.L. Surface:	53.5 m
		datum:	AHD

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L. depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
ADT				D	45			SILTSTONE: grey, & light grey, Non-friable cementation		H		MODERATELY TO SLIGHTLY WEATHERED SILTSTONE
								Borehole B12 Terminated at 8.45 m				
					9 44			TC BIT REFUSAL AT 8.45m				
					10 43							
					11 42							
					12 41							
					13 40							
					14 39							
					15 38							
					16							

METHOD
AS auger screwing*
AD auger drilling*
RR roller/tricone
W washbore
CT cable tool
HA hand auger
DT diatube
*bit shown by suffix
B blank bit
V V bit
T TC bit
e.g. ADT

SUPPORT
Nil no support M mud
C casing

PENETRATION
1 2 3 4
little resistance
ranging to
very slow progress

WATER
✗ not measured 0 none observed
water level
water outflow
water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
N standard penetration test:
Nx SPT + sample recovered
Nc SPT with solid cone
VS vane shear
PM pressuremeter
DP dynamic penetrometer
WS water sample
PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

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engineering log - borehole

COFFEY

Borehole no: B13
sheet 1 of 2

office job no: SC1001/2

client:	FORBES RIGBY PTY LTD	hole commenced:	31/01/95
principal:	BELLAMBI COLLIERIES	hole completed:	31/01/95
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	logged by:	JAF
borehole location:	SEE PLAN	checked by:	BMM
drill model and mounting:	EDSON 3000-TRUCK	slope:	-90 DEG
hole diameter:	100mm	bearing:	NOT MEASURED
		R.L.Surface:	53.9 m
		datum:	AHD

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
AOT		C	D						FILL: COAL WASTE	M	MD		FILL
					53	1			FILL: CLAY, COAL WASTE, SAND & GRAVEL		D		
				4 ,5 ,6 N*= 11									
					52	2							
RR				5 ,6 ,10 N*= 16	51	3							
					50	4							
								CH	CLAY: medium to high plasticity, mottled brown, light brown, dark brown, & grey. Trace of fine sand	>Wp	H		COLLUVIUM/RESIDUAL?
				3 ,5 ,9 N*= 14	49	5							
					48	6		CH	CLAY: medium to high plasticity, banded brown, & light brown, becoming brown, & dark grey, Friable cementation	<Wp			EXTREMELY WEATHERED CLAYSTONE
				20 ,6 ,- N*=R	47	7							
					46	8			Continued as Cored Borehole at 7.90m				

METHOD
AS auger screwing*
AD auger drilling*
RR roller/tricone
W washbore
CT cable tool
HA hand auger
DT diatube
*bit shown by suffix
B blank bit
V V bit
T TC bit
e.g. AOT

SUPPORT
Nil no support M mud
C casing

PENETRATION
1 2 3 4
1 little resistance
2 ranging to
3 very slow progress
4

WATER
* not measured O none observed
water level
water outflow
water inflow

SAMPLES & FIELD TESTS
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
N standard penetration test:
N* SPT + sample recovered
Nc SPT with solid cone
VS vane shear
PM pressuremeter
DP dynamic penetrometer
WS water sample
PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

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ACN 003 692 019

engineering log - cored borehole

borehole no: B13
sheet 2 of 3

office job no: SC1001/2

client:	FORBES RIGBY PTY. LTD	hole commenced:	31.1.1995
principal:	BELLAMBI COLLIERIES	hole completed:	31.1.1995
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	logged by:	JAF
borehole location:	SEE DRAWING No. SC1001/2-1	checked by:	
drill model and mounting:	EDSON 3000 - TRUCK	slope: -90 DEG	R.L.Surface: 53.9 m
barrel type and length:	NMLC - 3.0m fluid: WATER	bearing:	datum: AHD

drilling information | rock substance | rock mass defects

method	case-lift	water	R.L.	depth metres	graphic log core loss	substance description (rock type: grain characteristics, colour, structure, minor components)	weathering	Est. Strength (EL VL L M H VH EH)	point load test Is(50) MPa	RQD %	defect spacing mm (30 100 300 1000 3000)	defect description (type, inclination planarity, roughness, coating, thickness; unless otherwise noted defects follow general description below)
			53	1								
			52	2								
			51	3								
			50	4								
			49	5								
			48	6								
			47	7								
			46	8		Continued from non-core borehole						
						NO CORE 0.10m	MW					

General Defect Description:
9.90-11.50m Bedding Partings

METHOD
- DT diatube
- AS auger screwing
- AD auger drilling
- RR roller/tricone
- NMLC core drilling
- NQ, HQ, PQ core drilling
- casing used
- barrel withdrawn

WATER
- water level
- water inflow
- D none observed
- * not measured
- Drilling Water: partial loss
- complete loss

POINT LOAD TEST
- D -diametral
- I -irregular
- A -axial

GRAPHIC LOG/CORE LOSS
- core recovered (hatching indicates material)
- no core recovered

WEATHERING
- FR -fresh
- SW -slightly
- MW -moderately
- HW -highly
- EW -extremely

STRENGTH
- EL -extremely low
- VL -very low
- L -low
- M -medium
- H -high
- VH -very high
- EH -extremely high

DEFECTS
- JT -joint
- PT -parting
- SM -seam
- PL -planar
- CV -curved
- IR -irregular
- RO -rough
- SO -smooth
- SL -slickensided

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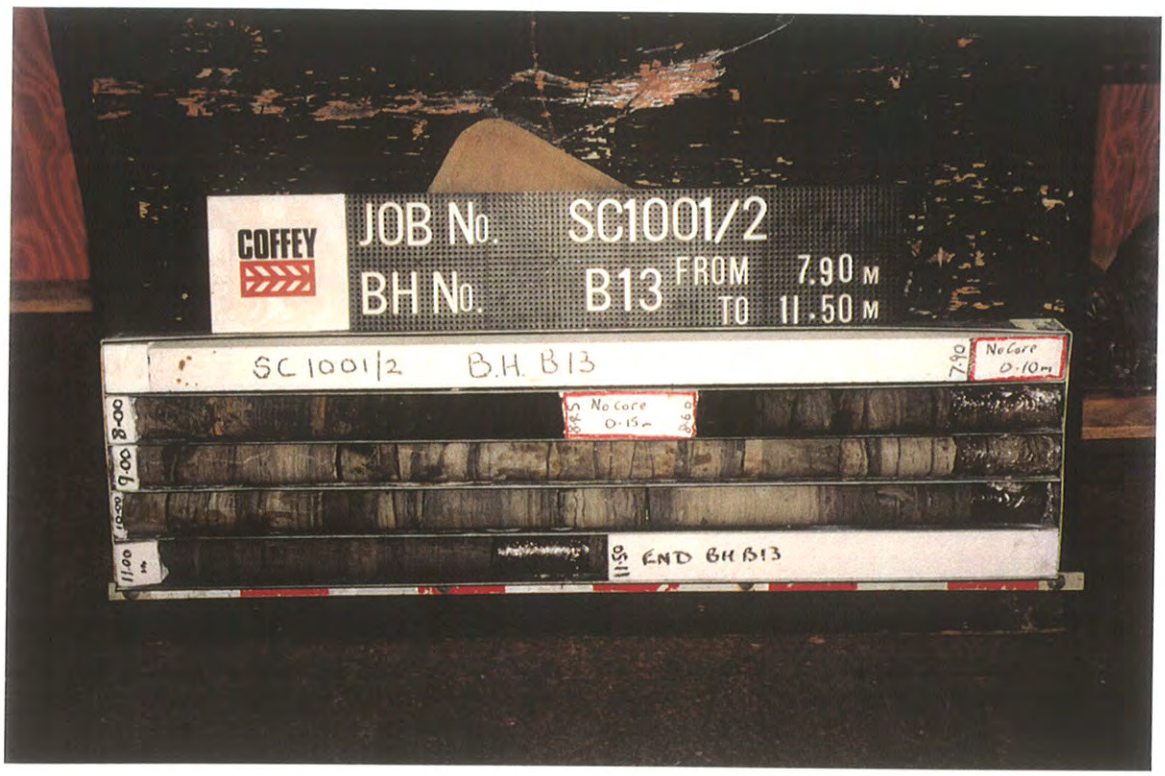
COFFEY
JOB No. SC1001/2
BH No. B13 FROM 7.90 M
TO 11.50 M
SC1001/2 B.H. B13
7.90
No Core 0-10m
No Core 0-15m
8.00
9.00
10.00
11.00
END BH B13

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ACN 003 692 019

engineering log - cored borehole

borehole no: B13
sheet 3 of 3

office job no: SC1001/2

client:	FORBES RIGBY PTY. LTD	hole commenced:	31.1.1995
principal:	BELLAMBI COLLIERIES	hole completed:	31.1.1995
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	logged by:	JAF
borehole location:	SEE DRAWING No. SC1001/2-1	checked by:	
drill model and mounting:	EDSON 3000 - TRUCK	slope: -90 DEG	R.L.Surface: 53.9 m
barrel type and length:	NMLC - 3.0m fluid: WATER	bearing:	datum: AHD

drilling information | rock substance | rock mass defects

method	case-lift	water	R.L.	depth metres	graphic log core loss	substance description (rock type: grain characteristics colour, structure, minor components)	weathering	Est. Strength (EL VL L M H VH EH)	point load test Is(50) MPa	RQD %	defect spacing mm (30 100 300 1000 3000)	defect description (type, inclination planarity, roughness, coating, thickness unless otherwise noted defects follow general description below)
NMLC			45	9		CLAYSTONE: dark grey, mottled brown, distinct bedding, 0deg	EW					8.20 to 8.35 Very broken
						COAL: black, distinct bedding, 0deg						
						NO CORE: 0.15m						8.60 to 8.78 Broken and jointed
						COAL: black, distinct bedding,	EW					
						CLAYSTONE: dark grey, distinct bedding, 0deg	SW					
			44	10		INTERLAMINATED SILTSTONE & SANDSTONE: fine grained, banded light grey, & dark grey, distinct bedding, 0deg						
			43	11								10.78 10.80 Joints 20deg PL smooth clean
			42	12		Borehole B13 Terminated at 11.50m						
			41	13								
			40	14								
			39	15								
			38	16								

General Defect Description:
7.90-11.50m Bedding Partings

METHOD
OT diatube
AS auger screwing
AD auger drilling
AR roller/tricone
NMLC core drilling
NQ, HQ, PQ core drilling
casing used
barrel withdrawn

WATER
water level
water inflow
O none observed
X not measured
Drilling Water
partial loss
complete loss

POINT LOAD TEST
D -diametral I -irregular
A -axial

GRAPHIC LOG/CORE LOSS
core recovered (hatching indicates material)
no core recovered

WEATHERING
FR -fresh
SW -slightly
MW -moderately
HW -highly
EW -extremely

STRENGTH
EL -extremely low
VL -very low
L -low
M -medium
H -high
VH -very high
EH -extremely high

DEFECTS
JT -joint
PT -parting
SM -seam
PL -planar
CV -curved
IR -irregular
RO -rough
SO -smooth
SL -slickensided

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engineering log - borehole

borehole no: 821
sheet 1 of 2

client:	FORBES RIGBY PTY. LTD.	office job no:	SC1001/2
principal:	BELLAMBI COLLIERIES	hole commenced:	6.2.1995
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	hole completed:	6.2.1995
borehole location:	SEE PLAN	logged by:	JAF
		checked by:	
drill model and mounting:	EDSON 3000 - TRUCK MOUNTED	slope:	-90 DEG
hole diameter:	100mm	bearing:	
		R.L. Surface:	NOT MEASURED
		datum:	NOT MEASURED

method	penetration 1 2 3 4	support	water*	samples, tests, etc	R.L. depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
ADT		Nil	6.2 95	5 ,5 ,7 N*= 12	1			FILL: COAL WASTE	M	D		FILL
					2			FILL: COAL WASTE CLAY and GRAVEL				
									W			
				4 ,3 ,3 N*= 6	3							
					4			FILL: SAND GRAVEL COAL WASTE and CLAY		MD		
							CH	SANDY CLAY: medium to high plasticity, mottled brown and light brown. Sand is fine to coarse. Trace of SANDSTONE GRAVEL	>Wp	St		COLLUVIUM/ALLUVIUM?
				2 ,5 ,7 N*= 12	5						X	
					6		CH	CLAY: high plasticity, banded brown and grey, 100mm BANDS of SILTSTONE/CLAYSTONE	<Wp	H		EXTREMELY TO HIGHLY WEATHERED SILTSTONE
					7							
					8							

METHOD
- AS auger screwing*
- AD auger drilling*
- RR roller/tricone
- W washbore
- CT cable tool
- HA hand auger
- DT diatube
- *bit shown by suffix
- B blank bit
- V V bit
- T TC bit
- e.g. ADT

SUPPORT
- Nil no support
- M mud
- C casing

PENETRATION
1 2 3 4
little resistance
ranging to
very slow progress

WATER
- * not measured
- O none observed
- water level
- water outflow
- water inflow

SAMPLES, TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- N standard penetration test.
- Nx SPT + sample recovered
- Nc SPT with solid cone
- VS vane shear
- PM pressuremeter
- DP dynamic penetrometer
- WS water sample
- PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

CONSISTENCY/DENSITY INDEX
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

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COFFEY

borehole no: 821
sheet 2 of 2

engineering log - borehole

office job no: SC1001/2

client:	FORBES RIGBY PTY. LTD.	hole commenced:	6.2.1995
principal:	BELLAMBI COLLIERIES	hole completed:	6.2.1995
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	logged by:	JAF
borehole location:	SEE PLAN	checked by:	
drill model and mounting:	EDSON 3000 - TRUCK MOUNTED	slope: -90 DEG	R.L. Surface: NOT MEASURED
hole diameter:	100mm	bearing:	datum: NOT MEASURED

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L. depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
ADT					9		CH	CLAY: high plasticity, banded brown and grey, 100mm BANDS of SILTSTONE/CLAYSTONE		H		EXTREMELY TO HIGHLY WEATHERED SILTSTONE
								SILTSTONE: grey and dark grey,	D			SLIGHTLY WEATHERED SILTSTONE/CLAYSTONE
								Borehole B21 Terminated at 9.25 m				
					10							
					11							
					12							
					13							
					14							
					15							
					16							

METHOD
- AS auger screwing×
- AD auger drilling×
- RR roller/tricone
- W washbore
- CT cable tool
- HA hand auger
- DT diatube
- ×bit shown by suffix
- B blank bit
- V V bit
- T TC bit
- e.g. ADT

SUPPORT
- Nil no support
- M mud
- C casing

PENETRATION 1 2 3 4
- little resistance
- ranging to
- very slow progress

WATER
- × not measured
- O none observed
- water level
- water outflow
- water inflow

SAMPLES, TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- N standard penetration test:
- Nx SPT + sample recovered
- Nc SPT with solid cone
- VS vane shear
- PM pressuremeter
- DP dynamic penetrometer
- WS water sample
- PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

CONSISTENCY/DENSITY INDEX
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

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engineering log - borehole

borehole no: B24
sheet 1 of 2

office job no: SC1001/2

client:	FORBES AIGBY PTY. LTD.	hole commenced:	7.2.1995
principal:	BELLAMBI COLLIERIES	hole completed:	7.2.1995
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	logged by:	JAF
borehole location:	SEE PLAN	checked by:	GWD
drill model and mounting:	EDSON 3000 - TRUCK MOUNTED	slope: -90 DEG	R.L. Surface: 38.0 m
hole diameter:	100mm	bearing:	datum: AHD

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
ADT		C			38				FILL: COAL WASTE	M	D		FILL
													BACKFILLED TAILINGS DAM?
					37	1				W	MD		
			▽ 7.2.95										
				3 ,3 ,4 N*= 7	36	2							
					35	3							
				4 ,4 ,4 N*= 8									
					34	4							
									FILL: FINE COAL TAILINGS	M	S		
					33	5							
RR		NIL						CH	CLAY: high plasticity, mottled light grey and light brown,	>Wp	VSt		ALLUVIUM
				4 ,6 ,7 N*= 13									
					32	6							
								CH	SANDY CLAY: medium to high plasticity, banded grey and dark grey, Sand is fine grained				RESIDUAL
				4 ,5 ,16 N*= 21	31	7							
								CL	SANDY CLAY: low plasticity, banded dark grey, grey and brown, Sand is fine grained, Friable cementation	<Wp	H		EXTREMELY WEATHERED SANDSTONE/SILTSTONE
									SANDSTONE: fine to medium grained, banded dark grey and grey, With interbedded SILTSTONE				MODERATELY TO SLIGHTLY WEATHERED SANDSTONE
					30	8							

METHOD
AS auger screwing×
AD auger drilling×
RR roller/tricone
W washbore
CT cable tool
HA hand auger
DT diatube
×bit shown by suffix
B blank bit
V V bit
T TC bit
e.g. ADT

SUPPORT
Nil no support M mud
C casing

PENETRATION
1 2 3 4
little resistance
ranging to
very slow progress

WATER
* not measured O none observed
▽ water level
water outflow
water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
N standard penetration test:
Nx SPT + sample recovered
Nc SPT with solid cone
VS vane shear
PM pressuremeter
DP dynamic penetrometer
WS water sample
PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

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engineering log - borehole

borehole no: B24
sheet 2 of 2

office job no: SC1001/2

client:	FORBES RIGBY PTY. LTD.	hole commenced:	7.2.1995
principal:	BELLAMBI COLLIERIES	hole completed:	7.2.1995
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	logged by:	JAF
borehole location:	SEE PLAN	checked by:	
drill model and mounting:	EDSON 3000 - TRUCK MOUNTED	slope: -90 DEG	R.L.Surface: 38.0 m
hole diameter	100mm	bearing:	datum: AHD

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L. / depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
					30			SANDSTONE: fine to medium grained, banded dark grey and grey, With interbedded SILTSTONE		H		MODERATELY TO SLIGHTLY WEATHERED SANDSTONE
AS					29 9			Borehole B24 Terminated at 8.40 m				
					28 10							
					27 11							
					26 12							
					25 13							
					24 14							
					23 15							
					22 16							

METHOD
AS auger screwingx
AD auger drillingx
RR roller/tricone
W washbore
CT cable tool
HA hand auger
DT diatube
xbit shown by suffix
B blank bit
V V bit
T TC bit
e.g. ADT

SUPPORT
Nil no support M mud
C casing

PENETRATION
1 2 3 4
little resistance ranging to very slow progress

WATER
x not measured 0 none observed
water level
water outflow
water inflow

SAMPLES, TESTS, ETC
U undisturbed sample (mm)
D disturbed sample
Bs bulk sample
E environmental sample
N standard penetration test:
Nx SPT + sample recovered
Nc SPT with solid cone
VS vane shear
PM pressuremeter
DP dynamic penetrometer
WS water sample
PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
O dry
M moist
W wet
Wp plastic limit
Wl liquid limit

CONSISTENCY/DENSITY INDEX
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

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engineering log - borehole

borehole no: 827
sheet 1 of 2

office job no: SC1001/2

client:	FORBES RIGBY PTY. LTD.	hole commenced:	8.2.1995
principal:	BELLAMBI COLLIERIES	hole completed:	8.2.1995
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	logged by:	JAF
borehole location:	SEE PLAN	checked by:	
drill model and mounting:	EDSON 3000 - TRUCK MOUNTED	slope: -90 DEG	R.L.Surface: 38.3 m
hole diameter:	100mm	bearing:	datum: AHD

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
ADT		C		12, 15, 17 N*= 32	38	0			FILL: COAL WASTE	M	VD		FILL
					37	1							
					36	2							
					35	3							
					34	4							
				8, 7, 7 N*= 14	33	5					MD		
					32	6							
					31	7							
						8							

METHOD
- AS auger screwing*
- AD auger drilling*
- RR roller/tricone
- W washbore
- CT cable tool
- HA hand auger
- DT diatube
- *bit shown by suffix
- B blank bit
- V V bit
- T TC bit
- e.g. ADT

SUPPORT
- Nil no support
- M mud
- C casing

PENETRATION
1 2 3 4 — little resistance ranging to very slow progress

WATER
- * not measured
- 0 none observed
- water level
- water outflow
- water inflow

SAMPLES, TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- N standard penetration test:
- Nx SPT + sample recovered
- Nc SPT with solid cone
- VS vane shear
- PM pressuremeter
- DP dynamic penetrometer
- WS water sample
- PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

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- St stiff
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- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

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engineering log - borehole

COFFEY

borehole no: 827

sheet 2 of 2

office job no: SC1001/2

client:	FORBES RIGBY PTY. LTD.	hole commenced:	8.2.1995
principal:	BELLAMBI COLLIERIES	hole completed:	8.2.1995
project:	SOUTH BULLI COLLIERY GEOTECHNICAL INVESTIGATION	logged by:	JAF
borehole location:	SEE PLAN	checked by:	
drill model and mounting:	EDSON 3000 - TRUCK MOUNTED	slope:	-90 DEG
hole diameter:	100mm	bearing:	
		R.L.Surface:	38.3 m
		datum:	AHD

method	penetration 1 2 3 4	support	water	samples, tests, etc	R.L.	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
					30				FILL: CLAY, GRAVEL & COAL WASTE				
BR		NIL		6 ,11 ,20 Nx= 31				CL	SANDY CLAY: low plasticity, dark grey, Some roots. Sand is fine to medium.	>Wp	St		ALLUVIUM
					29	9		CL	SANDY CLAY: low plasticity, mottled light grey, & light brown, Sand is fine.	<Wp	H	X	RESIDUAL - EXTREMELY WEATHERED SANDSTONE/SILTSTONE
					28	10			SANDSTONE: fine to medium grained, dark grey, & grey, Some interbedded SILTSTONE				SLIGHTLY WEATHERED SANDSTONE
									Borehole 827 Terminated at 10.65 m				
					27	11							
					26	12							
					25	13							
					24	14							
					23	15							
						16							

METHOD
- AS auger screwing×
- AD auger drilling×
- RR roller/tricone
- W washbore
- CT cable tool
- HA hand auger
- DT diatube
- ×bit shown by suffix
- B blank bit
- V V bit
- T TC bit
- e.g. ADT

SUPPORT
- Nil no support
- M mud
- C casing

PENETRATION
1 2 3 4 — little resistance ranging to very slow progress

WATER
- × not measured
- 0 none observed
- water level
- water outflow
- water inflow

SAMPLES, TESTS, ETC
- U undisturbed sample (mm)
- D disturbed sample
- Bs bulk sample
- E environmental sample
- N standard penetration test:
- Nx SPT + sample recovered
- Nc SPT with solid cone
- VS vane shear
- PM pressuremeter
- DP dynamic penetrometer
- WS water sample
- PZ piezometer

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
based on unified classification system

MOISTURE
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

CONSISTENCY/DENSITY INDEX
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

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Appendix C

Explanation of Terms Used on Test Pit and Borehole Logs

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Soil Description Explanation Sheet (1 of 2)

DEFINITION:

In engineering terms soil includes every type of uncemented or partially cemented inorganic or organic material found in the ground. In practice, if the material can be remoulded or disintegrated by hand in its field condition or in water it is described as a soil. Other materials are described using rock description terms.

CLASSIFICATION SYMBOL & SOIL NAME

Soils are described in accordance with the Unified Soil Classification (UCS) as shown in the table on Sheet 2.

PARTICLE SIZE DESCRIPTIVE TERMS

NAME	SUBDIVISION	SIZE
Boulders		>200 mm
Cobbles		63 mm to 200 mm
Gravel	coarse	20 mm to 63 mm
	medium	6 mm to 20 mm
	fine	2.36 mm to 6 mm
Sand	coarse	600 μm to 2.36 mm
	medium	200 μm to 600 μm
	fine	75 μm to 200 μm

MOISTURE CONDITION

Dry Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through hands.

Moist Soil feels cool and darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.

Wet As for moist but with free water forming on hands when handled.

CONSISTENCY OF COHESIVE SOILS

TERM	UNDRAINED STRENGTH s_u (kPa)	FIELD GUIDE
Very Soft	<12	A finger can be pushed well into the soil with little effort.
Soft	12 - 25	A finger can be pushed into the soil to about 25mm depth.
Firm	25 - 50	The soil can be indented about 5mm with the thumb, but not penetrated.
Stiff	50 - 100	The surface of the soil can be indented with the thumb, but not penetrated.
Very Stiff	100 - 200	The surface of the soil can be marked, but not indented with thumb pressure.
Hard	>200	The surface of the soil can be marked only with the thumbnail.
Friable	–	Crumbles or powders when scraped by thumbnail.

DENSITY OF GRANULAR SOILS

TERM	DENSITY INDEX (%)
Very loose	Less than 15
Loose	15 - 35
Medium Dense	35 - 65
Dense	65 - 85
Very Dense	Greater than 85

MINOR COMPONENTS

TERM	ASSESSMENT GUIDE	PROPORTION OF MINOR COMPONENT IN:
Trace of	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component.	Coarse grained soils: <5% Fine grained soils: <15%
With some	Presence easily detected by feel or eye, soil properties little different to general properties of primary component.	Coarse grained soils: 5 - 12% Fine grained soils: 15 - 30%

SOIL STRUCTURE

ZONING		CEMENTING	
Layers	Continuous across exposure or sample.	Weakly cemented	Easily broken up by hand in air or water.
Lenses	Discontinuous layers of lenticular shape.	Moderately cemented	Effort is required to break up the soil by hand in air or water.
Pockets	Irregular inclusions of different material.		

GEOLOGICAL ORIGIN

WEATHERED IN PLACE SOILS

Extremely weathered material	Structure and fabric of parent rock visible.
Residual soil	Structure and fabric of parent rock not visible.

TRANSPORTED SOILS

Aeolian soil	Deposited by wind.
Alluvial soil	Deposited by streams and rivers.
Colluvial soil	Deposited on slopes (transported downslope by gravity).
Fill	Man made deposit. Fill may be significantly more variable between tested locations than naturally occurring soils.
Lacustrine soil	Deposited by lakes.
Marine soil	Deposited in ocean basins, bays, beaches and estuaries.

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Soil Description Explanation Sheet (2 of 2)

SOIL CLASSIFICATION INCLUDING IDENTIFICATION AND DESCRIPTION

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 60 mm and basing fractions on estimated mass)							USC	PRIMARY NAME
COARSE GRAINED SOILS More than 50% of materials less than 63 mm is larger than 0.075 mm	(A 0.075 mm particle is about the smallest particle visible to the naked eye)	GRAVELS More than half of coarse fraction is larger than 2.36 mm	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.			GW	GRAVEL
				Predominantly one size or a range of sizes with more intermediate sizes missing.			GP	GRAVEL
			GRAVELS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)			GM	SILTY GRAVEL
				Plastic fines (for identification procedures see CL below)			GC	CLAYEY GRAVEL
		SANDS More than half of coarse fraction is smaller than 2.36 mm	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate sizes			SW	SAND
				Predominantly one size or a range of sizes with some intermediate sizes missing.			SP	SAND
			SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below).			SM	SILTY SAND
				Plastic fines (for identification procedures see CL below).			SC	CLAYEY SAND
FINE GRAINED SOILS More than 50% of material less than 63 mm is smaller than 0.075 mm			IDENTIFICATION PROCEDURES ON FRACTIONS <0.2 mm.					
		SILTS & CLAYS Liquid limit less than 50	**DRY STRENGTH**	**DILATANCY**	**TOUGHNESS**			
			None to Low	Quick to slow	None		ML	SILT
			Medium to High	None	Medium		CL	CLAY
			Low to medium	Slow to very slow	Low		OL	ORGANIC SILT
		SILTS & CLAYS Liquid limit greater than 50	Low to medium	Slow to very slow	Low to medium		MH	SILT
			High	None	High		CH	CLAY
			Medium to High	None	Low to medium		OH	ORGANIC CLAY
HIGHLY ORGANIC SOILS			Readily identified by colour, odour, spongy feel and frequently by fibrous texture.				Pt	PEAT

• Low plasticity – Liquid Limit w_L less than 35%. • Medium plasticity – w_L between 35% and 50%. • High plasticity – w_L greater than 50%.

COMMON DEFECTS IN SOIL

TERM	DEFINITION	DIAGRAM
PARTING	A surface or crack across which the soil has little or no tensile strength. Parallel or sub parallel to layering (eg bedding). May be open or closed.	
JOINT	A surface or crack across which the soil has little or no tensile strength but which is not parallel or sub parallel to layering. May be open or closed. The term 'fissure' may be used for irregular joints <0.2 m in length.	
SHEARED ZONE	Zone in clayey soil with roughly parallel near planar, curved or undulating boundaries containing closely spaced, smooth or slickensided, curved intersecting joints which divide the mass into lenticular or wedge shaped blocks.	
SHEARED SURFACE	A near planar curved or undulating, smooth, polished or slickensided surface in clayey soil. The polished or slickensided surface indicates that movement (in many cases very little) has occurred along the defect.	

TERM	DEFINITION	DIAGRAM
SOFTENED ZONE	A zone in clayey soil, usually adjacent to a defect in which the soil has a higher moisture content than elsewhere.	
TUBE	Tubular cavity. May occur singly or as one of a large number of separate or inter-connected tubes. Walls often coated with clay or strengthened by denser packing of grains. May contain organic matter	
TUBE CAST	Roughly cylindrical elongated body of soil different from the soil mass in which it occurs. In some cases the soil which makes up the tube cast is cemented.	
INFILLED SEAM	Sheet or wall like body of soil substance or mass with roughly planar to irregular near parallel boundaries which cuts through a soil mass. Formed by infilling of open joints.	

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Rock Description Explanation Sheet (1 of 2)

The descriptive terms used by Coffey are given below. They are broadly consistent with Australian Standard AS1726-1993.

DEFINITIONS: Rock substance, defect and mass are defined as follows:

Rock Substance	In engineering terms roch substance is any naturally occurring aggregate of minerals and organic material which cannot be disintegrated or remoulded by hand in air or water. Other material is described using soil descriptive terms. Effectively homogenous material, may be isotropic or anisotropic.
Defect	Discontinuity or break in the continuity of a substance or substances.
Mass	Any body of material which is not effectively homogeneous. It can consist of two or more substances without defects, or one or more substances with one or more defects.

SUBSTANCE DESCRIPTIVE TERMS:

ROCK NAME	Simple rock names are used rather than precise geological classification.
PARTICLE SIZE	Grain size terms for sandstone are:
Coarse grained	Mainly 0.6mm to 2mm
Medium grained	Mainly 0.2mm to 0.6mm
Fine grained	Mainly 0.06mm (just visible) to 0.2mm
FABRIC	Terms for layering of penetrative fabric (eg. bedding, cleavage etc.) are:
Massive	No layering or penetrative fabric.
Indistinct	Layering or fabric just visible. Little effect on properties.
Distinct	Layering or fabric is easily visible. Rock breaks more easily parallel to layering of fabric.

CLASSIFICATION OF WEATHERING PRODUCTS

Term	Abbreviation	Definition
Residual Soil	**RS**	Soil derived from the weathering of rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely Weathered Material	**XW**	Material is weathered to such an extent that it has soil properties, ie, it either disintegrates or can be remoulded in water. Original rock fabric still visible.
Highly Weathered Rock	**HW**	Rock strength is changed by weathering. The whole of the rock substance is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Some minerals are decomposed to clay minerals. Porosity may be increased by leaching or may be decreased due to the deposition of minerals in pores.
Moderately Weathered Rock	**MW**	The whole of the rock substance is discoloured, usually by iron staining or bleaching , to the extent that the colour of the fresh rock is no longer recognisable.
Slightly Weathered Rock	**SW**	Rock substance affected by weathering to the extent that partial staining or partial discolouration of the rock substance (usually by limonite) has taken place. The colour and texture of the fresh rock is recognisable; strength properties are essentially those of the fresh rock substance.
Fresh Rock	**FR**	Rock substance unaffected by weathering.

Notes on Weathering:

1. AS1726 suggests the term "Distinctly Weathered" (DW) to cover the range of substance weathering conditions between XW and SW. For projects where it is not practical to delineate between HW and MW or it is judged that there is no advantage in making such a distinction. DW may be used with the definition given in AS1726.
2. Where physical and chemical changes were caused by hot gasses and liquids associated with igneous rocks, the term "altered" may be substituted for "weathering" to give the abbreviations XA, HA, MA, SA and DA.

ROCK SUBSTANCE STRENGTH TERMS

Term	Abbrev-iation	Point Load Index, $I_{s(50)}$ (MPa)	Field Guide
Very Low	**VL**	Less than 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with a knife; pieces up to 30mm thick can be broken by finger pressure.
Low	**L**	0.1 to 0.3	Easily scored with a knife; indentations 1mm to 3mm show with firm bows of a pick point; has a dull sound under hammer. Pieces of core 150mm long by 50mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium	**M**	0.3 to 1.0	Readily scored with a knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.
High	**H**	1 to 3	A piece of core 150mm long by 50mm can not be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High	**VH**	3 to 10	Hand specimen breaks after more than one blow of a pick; rock rings under hammer.
Extremely High	**EH**	More than 10	Specimen requires many blows with geological pick to break; rock rings under hammer.

Notes on Rock Substance Strength:

1. In anisotropic rocks the field guide to strength applies to the strength perpendicular to the anisotropy. High strength anisotropic rocks may break readily parallel to the planar anisotropy.
2. The term "extremely low" is not used as a rock substance strength term. While the term is used in AS1726-1993, the field guide therein makes it clear that materials in that strength range are soils in engineering terms.
3. The unconfined compressive strength for isotropic rocks (and anisotropic rocks which fall across the planar anisotropy) is typically 10 to 25 times the point load index $I_{s(50)}$. The ratio may vary for different rock types. Lower strength rocks often have lower ratios than higher strength rocks.

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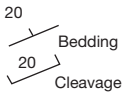
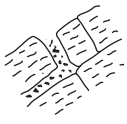
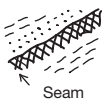
Rock Description Explanation Sheet (2 of 2)

COMMON DEFECTS IN ROCK MASSES Term	Definition	Diagram	Map Symbol	Graphic Log (Note 1)
Parting	A surface or crack across which the rock has little or no tensile strength. Parallel or sub parallel to layering (eg bedding) or a planar anisotropy in the rock substance (eg, cleavage). May be open or closed.			 (Note 2)
Joint	A surface or crack across which the rock has little or no tensile strength. but which is not parallel or sub parallel to layering or planar anisotropy in the rock substance. May be open or closed.			 (Note 2)
Sheared Zone (Note 3)	Zone of rock substance with roughly parallel near planar, curved or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects. Some of the defects are usually curved and intersect to divide the mass into lenticular or wedge shaped blocks.			
Sheared Surface (Note 3)	A near planar, curved or undulating surface which is usually smooth, polished or slickensided.			
Crushed Seam (Note 3)	Seam with roughly parallel almost planar boundaries, composed of disoriented, usually angular fragments of the host rock substance which may be more weathered than the host rock. The seam has soil properties.			
Infilled Seam	Seam of soil substance usually with distinct roughly parallel boundaries formed by the migration of soil into an open cavity or joint, infilled seams less than 1mm thick may be described as veneer or coating on joint surface.			
Extremely Weathered Seam	Seam of soil substance, often with gradational boundaries. Formad by weathering of the rock substance in place.			

DEFECT SHAPE TERMS	
Planar	The defect does not vary in orientation
Curved	The defect has a gradual change in orientation
Undulating	The defect has a wavy surface
Stepped	The defect has one or more well defined steps
Irregular	The defect has many sharp changes of orientation

Note: The assessment of defect shape is partly influenced by the scale of the observation.

ROUGHNESS TERMS	
Slickensided	Grooved or striated surface, usually polished
Polished	Shiny smooth surface
Smooth	Smooth to touch. Few or no surface irregularities
Rough	Many small surface irregularities (amplitude generally less than 1mm). Feels like fine to coarse sand paper.
Very Rough	Many large surface irregularities (amplitude generally more than 1mm). Feels like, or coarser than very coarse sand paper.

COATING TERMS	
Clean	No visible coating
Stained	No visible coating but surfaces are discoloured
Veneer	A visible coating of soil or mineral, too thin to measure; may be patchy
Coating	A visible coating up to 1mm thick. Thicker soil material is usually described using appropriate defect terms (eg, infilled seam). Thicker rock strength material is usually described as a vein.

BLOCK SHAPE TERMS	
Blocky	Approximately equidimensional
Tabular	Thickness much less than length or width
Columnar	Height much greate than cross section

Notes on Defects:

1. Usually borehole logs show the true dip of defects and face sketches and sections the apparent dip.
2. Partings and joints are not usually shown on the graphic log unless considered significant.
3. Sheared zones, sheared surfaces and crushed seams are faults in geological terms.

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Appendix D

Landslide Risk Assessment, AGS 2007, Appendix C

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

APPENDIX C: LANDSLIDE RISK ASSESSMENT

QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

QUALITATIVE MEASURES OF LIKELIHOOD

Approximate Annual Probability		Implied Indicative Landslide Recurrence Interval		Description	Descriptor	Level
Indicative Value	Notional Boundary					
10^{-1}	$5x10^{-2}$	10 years	20 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}	$5x10^{-3}$	100 years	200 years	The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	$5x10^{-4}$	1000 years	2000 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10^{-4}	$5x10^{-5}$	10,000 years	20,000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	$5x10^{-6}$	100,000 years	200.000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}		1,000,000 years		The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

Note: (1) The table should be used from left to right; use Approximate Annual Probability or Description to assign Descriptor, not *vice versa*.

QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY

Approximate Cost of Damage		Description	Descriptor	Level
Indicative Value	Notional Boundary			
200%	100%	Structure(s) completely destroyed and/or large scale damage requiring major engineering works for stabilisation. Could cause at least one adjacent property major consequence damage.	CATASTROPHIC	1
60%	40%	Extensive damage to most of structure, and/or extending beyond site boundaries requiring significant stabilisation works. Could cause at least one adjacent property medium consequence damage.	MAJOR	2
20%	10%	Moderate damage to some of structure, and/or significant part of site requiring large stabilisation works. Could cause at least one adjacent property minor consequence damage.	MEDIUM	3
5%	1%	Limited damage to part of structure, and/or part of site requiring some reinstatement stabilisation works.	MINOR	4
0.5%		Little damage. (Note for high probability event (Almost Certain), this category may be subdivided at a notional boundary of 0.1%. See Risk Matrix.)	INSIGNIFICANT	5

Notes: (2) The Approximate Cost of Damage is expressed as a percentage of market value, being the cost of the improved value of the unaffected property which includes the land plus the unaffected structures.

(3) The Approximate Cost is to be an estimate of the direct cost of the damage, such as the cost of reinstatement of the damaged portion of the property (land plus structures), stabilisation works required to render the site to tolerable risk level for the landslide which has occurred and professional design fees, and consequential costs such as legal fees, temporary accommodation. It does not include additional stabilisation works to address other landslides which may affect the property.

(4) The table should be used from left to right; use Approximate Cost of Damage or Description to assign Descriptor, not vice versa

APPENDIX C: – QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY (CONTINUED)

QUALITATIVE RISK ANALYSIS MATRIX – LEVEL OF RISK TO PROPERTY

LIKELIHOOD		CONSEQUENCES TO PROPERTY (With Indicative Approximate Cost of Damage)				
	Indicative Value of Approximate Annual Probability	1: CATASTROPHIC 200%	2: MAJOR 60%	3: MEDIUM 20%	4: MINOR 5%	5: INSIGNIFICANT 0.5%
A – ALMOST CERTAIN	10^{-1}	VH	VH	VH	H	M or L (5)
B - LIKELY	10^{-2}	VH	VH	H	M	L
C - POSSIBLE	10^{-3}	VH	H	M	M	VL
D - UNLIKELY	10^{-4}	H	M	L	L	VL
E - RARE	10^{-5}	M	L	L	VL	VL
F - BARELY CREDIBLE	10^{-6}	L	VL	VL	VL	VL

Notes: (5) For Cell A5, may be subdivided such that a consequence of less than 0.1% is Low Risk.
(6) When considering a risk assessment it must be clearly stated whether it is for existing conditions or with risk control measures which may not be implemented at the current time.

RISK LEVEL IMPLICATIONS

Risk Level		Example Implications (7)
VH	VERY HIGH RISK	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low; may be too expensive and not practical. Work likely to cost more than value of the property.
H	HIGH RISK	Unacceptable without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to Low. Work would cost a substantial sum in relation to the value of the property.
M	MODERATE RISK	May be tolerated in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce the risk to Low. Treatment options to reduce to Low risk should be implemented as soon as practicable.
L	LOW RISK	Usually acceptable to regulators. Where treatment has been required to reduce the risk to this level, ongoing maintenance is required.
VL	VERY LOW RISK	Acceptable. Manage by normal slope maintenance procedures.

Note: (7) The implications for a particular situation are to be determined by all parties to the risk assessment and may depend on the nature of the property at risk; these are only given as a general guide.

Appendix E

Landslide Risk Management, Important Information about AGS 2007

coffey

Landslide Risk Management

Important Information about AGS 2007 Appendix C (1 of 2)

INTRODUCTION

This sheet provides important information on the following Appendix C which has been copied from "Practice note guidelines for landslide risk management 2007". The "Practice Note" and accompanying "Commentary" (References 1 & 2, hereafter referred to as AGS2007) are part of a series of documents on landslide risk management prepared on behalf of, and endorsed by, the Australian Geomechanics Society. These documents were primarily prepared to apply to residential or similar development.

It should be noted that AGS2007 define landslides as "the movement of a mass of rock, debris or earth down a slope". This definition includes falls, topples, slides, spreads and flows from both natural and artificial slopes.

LANDSLIDE LIKELIHOOD ASSESSMENT

The assessment of the likelihood of landsliding requires evidence-based judgements.

Judging how often and how much an existing landslide will move is difficult. Judging the likelihood of a new landslide occurring is even harder. Records of past landslides can provide some information on what has happened, but are invariably incomplete and often provide little or no guidance on less frequent events that may occur. Often judgements have to be made about the likelihood of infrequent events with serious consequences, with little or no help from historical records. Slope models, which reflect evidence-based knowledge of how a slope was formed, how it behaved in the past and how it might behave in the future, are used to support judgements about what might happen. Because of the difficulties in assessing landslide likelihood, different assessors may make different judgements when presented with the same information.

The likelihood terms in Appendix C can be taken to imply that it is possible to distinguish between low probability events (e.g. between events having a probability of 1 in 10,000 and 1 in 100,000). In many circumstances it will not be possible to develop defensibly realistic judgements to do so, and so joint terms need to be used (e.g. Likely or Possible). For further discussion on landslide likelihood and other matters see References 3, 4 and 5.

CONSEQUENCES OF LANDSLIDES

There can be direct (e.g. property damage, injury / loss of life) and indirect (e.g. litigation, loss of business confidence) consequences of a landslide. The assessment of the importance (seriousness) of the consequences is a value judgement best made by those most affected (e.g. client, owner, regulator, public). The main role of the expert is usually to understand and explain what and who might be affected, and what damage or injury might occur.

Appendix C implies that we can anticipate total cost (direct and indirect) of landslide damage to about half an order of magnitude (e.g. the difference between $30,000 and $100,000). This involves predicting the location, size, travel distance and speed of a landslide, the response of a building (often before it has been built), the nature and the extent of damage, repair costs as well as indirect consequences such as legal costs, accommodation etc. There can be other direct and indirect consequences of a landslide which can be difficult to anticipate, let alone quantify and cost. The situation is analogous to the cost of work place accidents where the hidden costs can range from less than one to more than 20 times the visible direct costs (Reference 5).

In many circumstances it will not be possible to develop defensibly realistic judgements to enable use of a single consequence descriptor from Appendix C, and so joint terms need to be used (e.g. Minor or Medium). In our experience, explicit descriptions of potential consequences (e.g. rocks up to 0.5m across may fall on a parked car) help those affected to make their own judgements about the seriousness of the consequences.

RISK MATRIX

The main purpose of a risk matrix is to help rank risks, set priorities and help the decision making process. The risk terms should be regarded only as a guide to the relative level of risk as they are the product of an evidence-based quantitative judgement of likelihood and a value judgement about consequences, both of which involve considerable uncertainty. Different assessors may arrive at different judgements on the risk level.

Using Appendix C, many existing houses on sloping land will be assessed to have a Moderate Risk.

coffey

Landslide Risk Management
Important Information about AGS 2007 Appendix C (2 of 2)

RISK LEVEL IMPLICATIONS

In general, it is the responsibility of the client and/or owner and/or regulatory authority and/or others who may be affected to decide whether to accept or treat the risk. The risk assessor and/or other advisers may assist by making risk comparisons, discussing treatment options, explaining the risk management process, advising how others have reacted to risk in similar situations, and making recommendations. Attitudes to risk vary widely and risk evaluation often involves considering more than just property damage (e.g. environmental effects, public reaction, political consequences, business confidence etc).

The risk level implications in Appendix C represent a very specific example and are unlikely to be generally applicable. In our experience the typical response of regulators to assessed risk is as follows:

Assessed risk	**Typical response of client/ owner/ regulator/ person affected**
Very High, High [1]	Treats seriously. Usually requires action to reduce risk. Will generally avoid development.
Moderate	May accept risk. Usually looks for ways to reduce risk if reasonably practicable.
Low, Very Low [1]	Usually regards risk as acceptable. May reduce risk if reasonably practicable.

1 The distinctions between Very High and High and between Low and Very Low risks are usually used to help set priorities.

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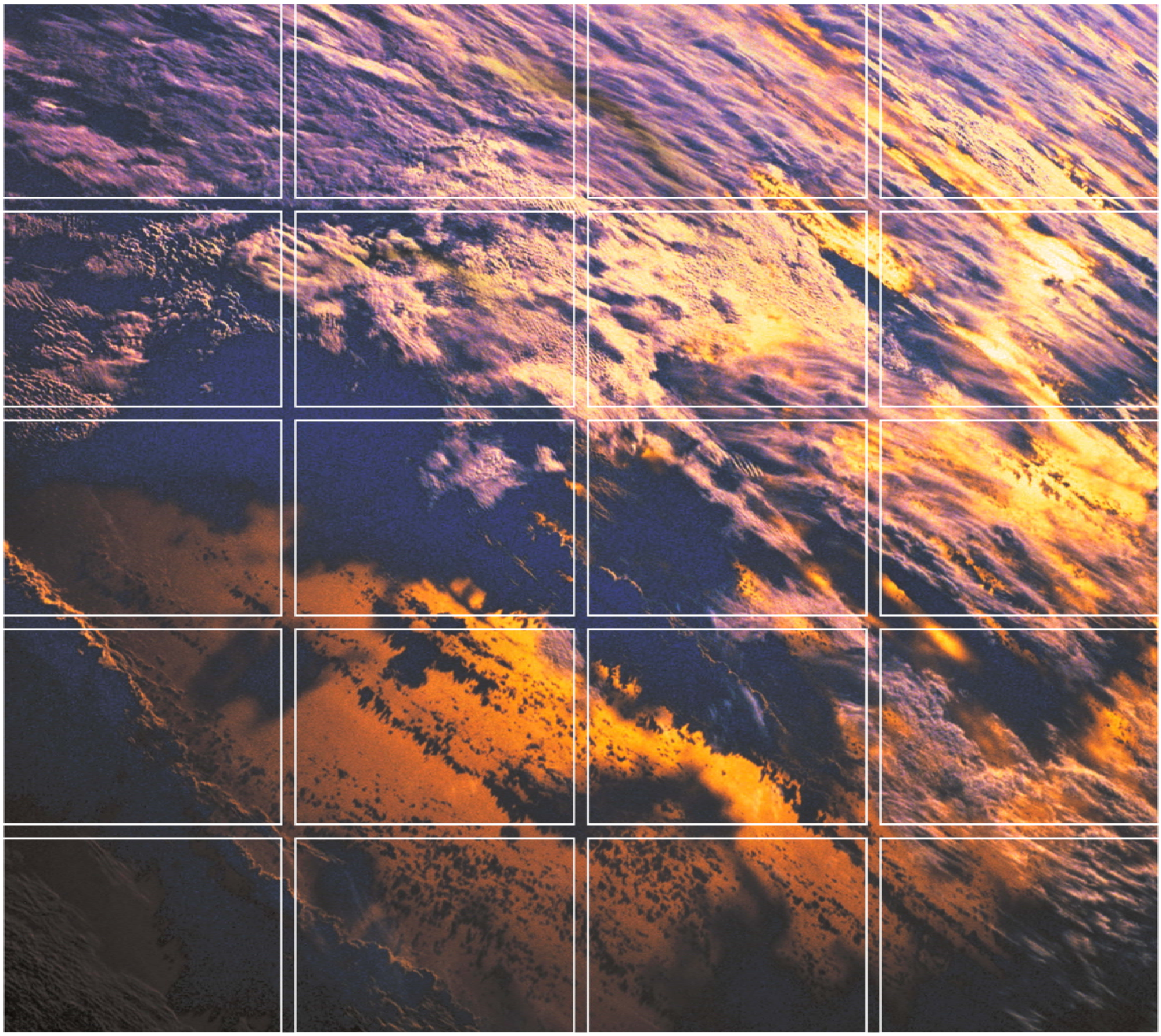
Annex I

NRE No.1 Colliery
Preliminary Work Air Quality Assessment



NRE No. 1 Colliery – Preliminary Works

Air Quality Assessment

Gujarat NRE Coking Coal Limited

May 2010

0079383AQ-RP01

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Approved by:	*Christine Allen*
Position:	Project Manager
Signed:	
Date:	*31 May, 2010*
Approved by:	*Mike Shelly*
Position:	Project Director
Signed:	
Date:	*31 May, 2010*

Environmental Resources Management Australia Pty Ltd Quality System

0079383RP01_AQ_Final Draft

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This report was prepared in accordance with the scope of services set out in the contract between Environmental Resources Management Australia Pty Ltd ABN 12 002 773 248 (ERM) and the Client. To the best of our knowledge, the proposal presented herein accurately reflects the Client's intentions when the report was printed. However, the application of conditions of approval or impacts of unanticipated future events could modify the outcomes described in this document. In preparing the report, ERM used data, surveys, analyses, designs, plans and other information provided by the individuals and organisations referenced herein. While checks were undertaken to ensure that such materials were the correct and current versions of the materials provided, except as otherwise stated, ERM did not independently verify the accuracy or completeness of these information sources

FINAL DRAFT REPORT

Gujarat NRE Coking Coal Limited

NRE No. 1 Colliery – Preliminary Works
Air Quality Assessment

May 2010

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1 INTRODUCTION

1.1 OVERVIEW

This report has been prepared by Environmental Resources Management Pty Ltd (ERM) on behalf of Gujarat NRE Coking Coal ltd (NRE). This air quality assessment forms part of the Environmental Assessment for the NRE No. 1 Colliery Preliminary Works Project (the Project).

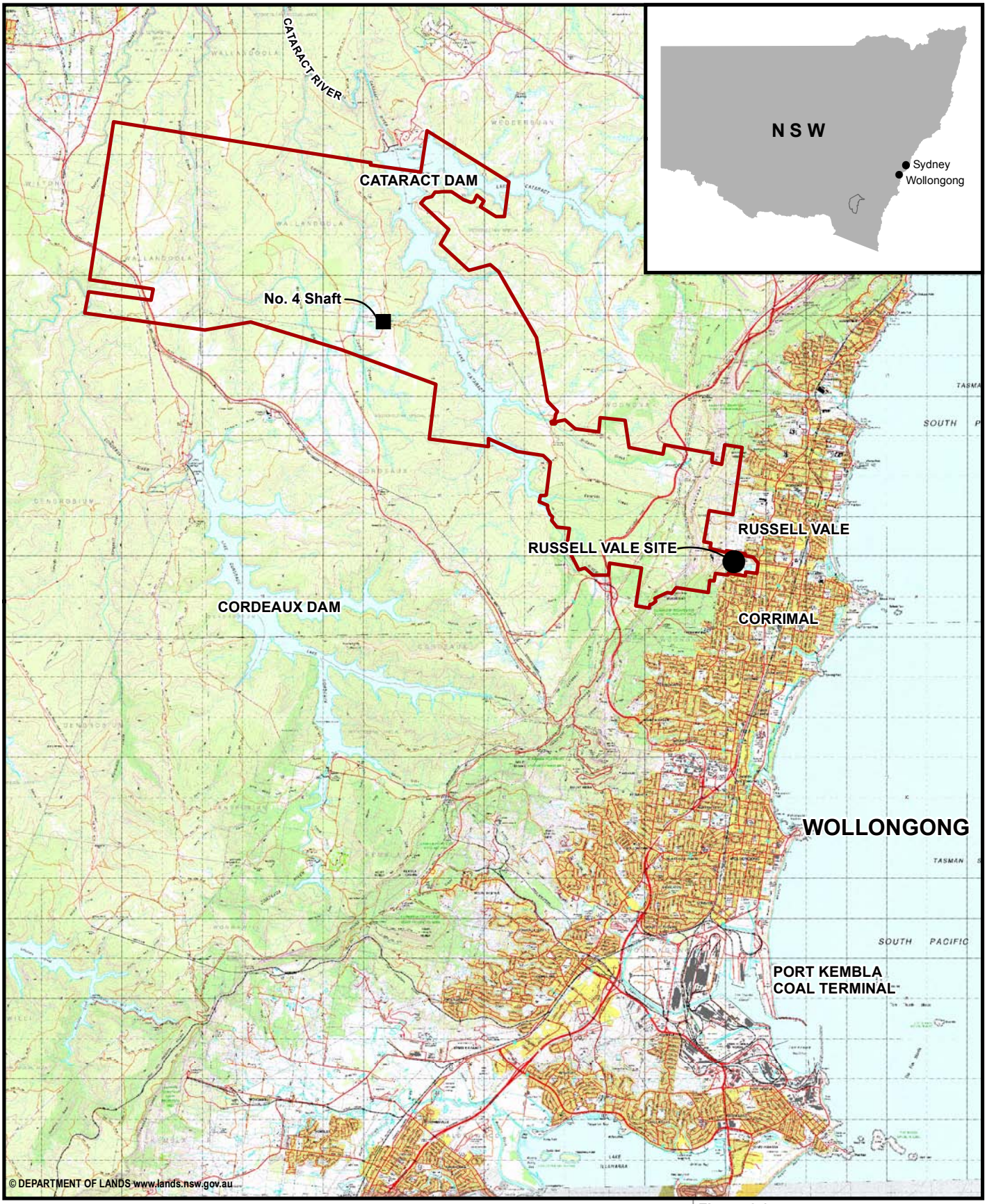
Gujarat NRE proposes to extend mining at their underground operation at Russell Vale (*Figure 1.1*).

The proposal seeks approval for:

- continuing operation of the Colliery, including:
  - augmenting, upgrading and using the existing infrastructure; and
  - extracting remnant coal reserves within existing mining areas;
- extracting up to 1 million tonnes of run-of-mine coal a year from the Bulli and Wongawilli Seams for a period of three years; and
- transporting run-of mine coal from the mine via truck haulage.

This report has been developed in accordance with the Director-General's Requirements (DGRs) and Department of Environment and Climate Change and Water's (DECCW's) assessment requirements, which are as follows:

- a consideration of the air quality impacts that the infrastructure operations could have on the local airshed; and
- a consideration of the air quality impacts that coal haulage by trucks could have in the areas along the coal transport corridor.



Legend

Project Application Area

Figure 1.1
Locality Map

Client:	Gujarat NRE Coking Coal Limited	
Project:	NRE No. 1 Colliery Preliminary Works Air Quality Assessment	
Drawing No:	0079383s_PWAQ_G001_R0.mxd	
Date:	03/06/2010	Drawing size: A4
Drawn by:	JF	Reviewed by: MK
Scale:	Refer to Scale Bar	

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2 PROJECT DESCRIPTION

2.1 EXISTING OPERATIONS

2.1.1 Underground Mining

Current workings are in the Bulli seam and include pillar extraction in the Wonga West area ("200" longwall series in the south and "300" longwall series in the north), first workings in the "P" Panel in the central portion of the site (between Wonga East and West) and the 'P & R' drifts drivage to the east of the 200 longwall series.

There are no current workings in the Balgownie seam.

Current workings in the Wongawilli seam constitute the Wonga Mains drivage. The development of this roadway has begun at the Russell Vale site and will connect the proposed Wonga East and Wonga West longwall areas.

Figure 2.1 shows the previous and current workings at NRE No.1 Colliery.

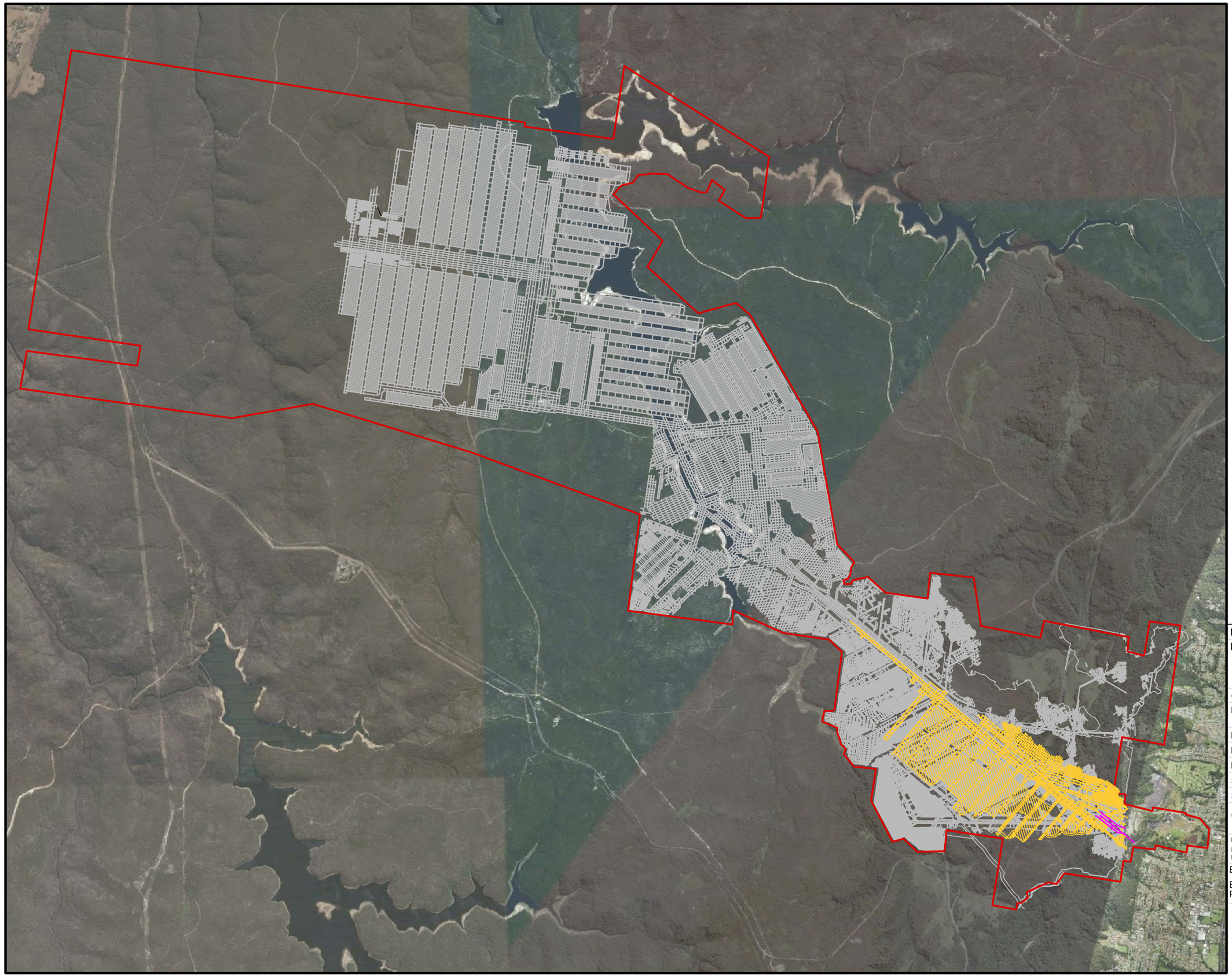

Figure 2.1

Existing and Current Workings

Client:	Gujarat NRE Coking Coal Limited		
Project:	NRE No.1 Colliery Preliminary Works Air Quality Assessment		
Drawing No:	0079383s_PWAQ_A004_R0.dwg		
Date:	03/06/2010	Drawing Size:	A3
Drawn By:	JF	Reviewed By:	MK
Source:	-		
Scale:	Refer to scale bar		

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2.1.2 ROM Coal Production and Handling

Current production at NRE No.1 Colliery is approximately 1 mtpa. Coal handling facilities are shown on *Figure 2.2* and *Figure 2.3*.

ROM coal is transported from the working face to the surface via an underground belt conveyor/ vibrating feeder complex. There are two decline conveyors which transport coal via an overland belt conveyor from the portal to the stockpile area at the Russell Vale site. These belts are referred to as the Bulli decline belt and the Balgownie decline belt. Both belt conveyors are partially enclosed, to reduce dust emissions.

Coal from the Bulli decline belt is deposited into a coal bin at the base of the decline. Clearance holes in the bin allow the coal to be deposited on the ground. Coal is then pushed up using a dozer to form the stockpile. The stockpile area has a capacity of up to 315,000t. From the stockpile coal is then loaded through a vibrating screen sizer using an excavator. The coal is processed through the vibrating screen sizer and deposited onto C5 conveyor in the reclaim tunnel, which delivers coal to the Bradford Breaker.

The Bradford Breaker, is currently in a state of disrepair and the deck plates have been removed to allow coal to bypass the breaker.

From the Bradford Breaker, coal travels along the C6 conveyor to the top of a 600 tonne bin. The 600 tonne bin is in line to provide surge capacity to the reclaim system. A 'Hornet' vibrating feeder at the base of the bin deposits the coal onto the C7 conveyor, which transports coal to the truck loading bins.

The truck loading bin consists of three separate bins, of which only one is currently used. The second bin is filled via overflow from the first bin, and the third bin is unable to be filled in its current arrangement.

Dust suppression at the Russell Vale site is managed using a number of means according to weather and operational demands. These means include: an automatically controlled fixed stockpile spray system around the ROM stockpile area; a mobile water truck that is used throughout the site; a section of roadside sprays; a truck wash that is used for all heavy vehicles as they depart the site; a road sweeper that can be used on all sealed surfaces; and fixed water sprays at selected points on a number of surface and underground conveyor systems. Water for these purposes is supplied from recycled sources including mine water and treated stormwater. Sprays are used almost daily in one form or another depending on relevant demands.

Legend

Project Application Area

Figure 2.2
Russell Vale Site

Client:	Gujarat NRE Coking Coal Limited	
Project:	NRE No. 1 Colliery Preliminary Works Air Quality Assessment	
Drawing No:	0079383s_PWAQ_G002_R0.mxd	
Date:	03/06/2010	Drawing size: A3
Drawn by:	JF	Reviewed by: MK
Scale:	Refer to Scale Bar	

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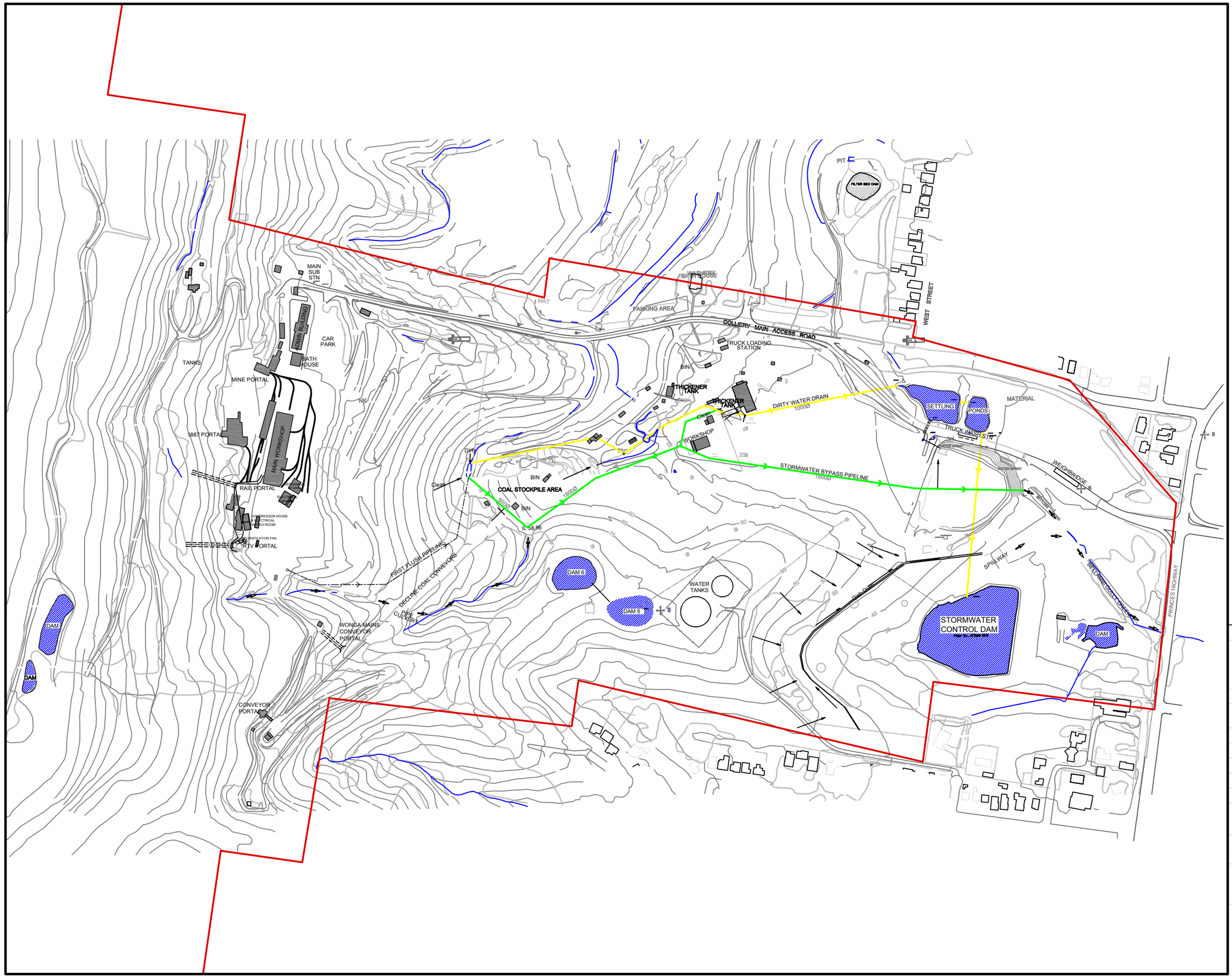

Legend

- Project Application Area
- Dam
- Buildings
- Waterway
- Dirty Water Flows
- Clean Water Flows

Figure 2.3

Existing Coal Handling Facilities Layout

Client:	Gujarat NRE Coking Coal Limited		
Project:	NRE No.1 Colliery Preliminary Works Air Quality Assessment		
Drawing No:	0079383s_PWAQ_A002_R0.dwg		
Date:	03/06/2010	Drawing Size:	A3
Drawn By:	JF	Reviewed By:	MK
Source:	Olsen Environmental Consulting Ref: DP-3673.dwg		
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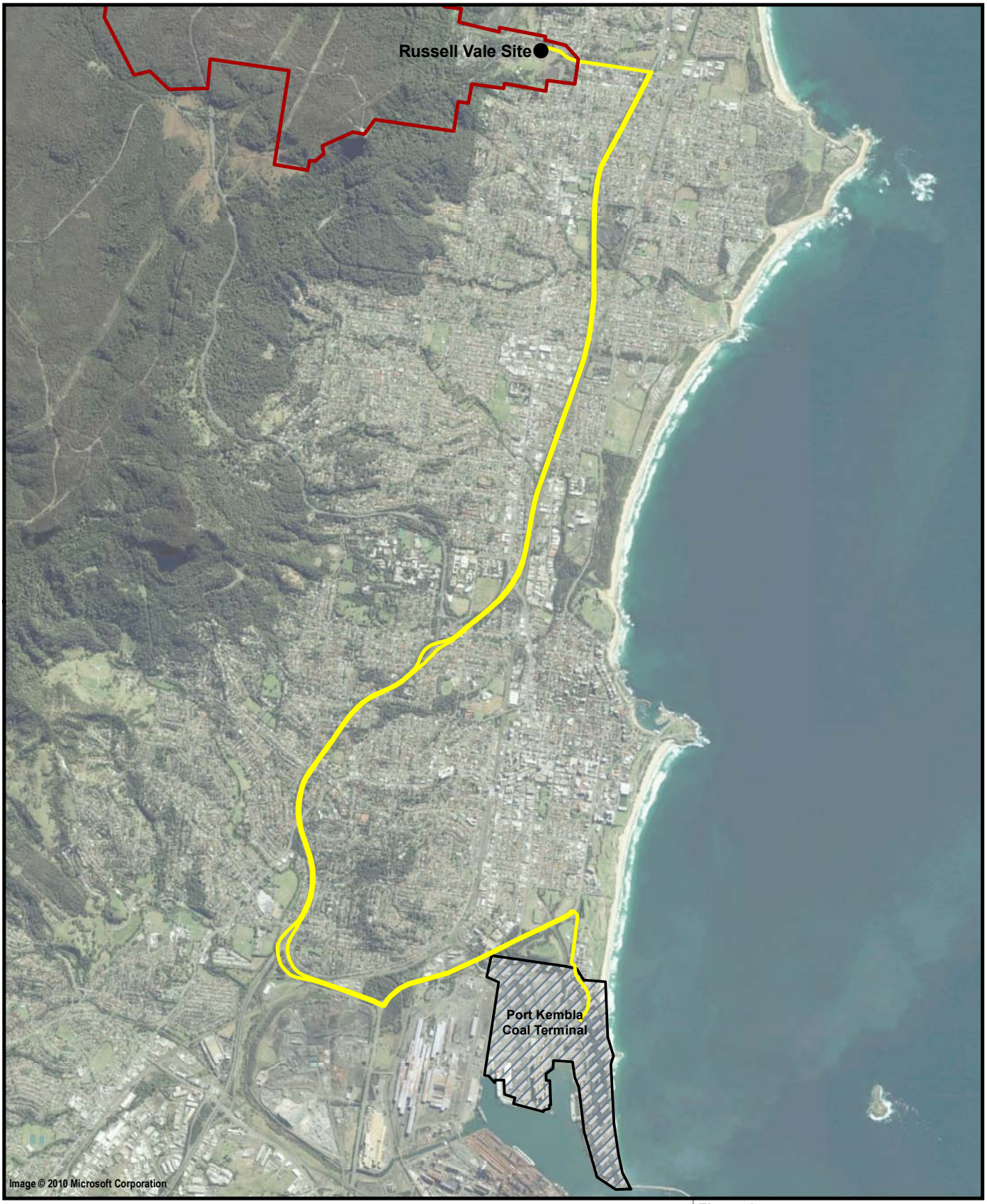
2.1.3 Product Coal Transport

Coal is currently transported, unwashed, by truck from NRE No.1 Colliery to Port Kembla Coal Terminal (PKCT) for shipment to India. Coal transport trucks generally operate between the hours of 7.00am and 6.00pm five days per week (Monday to Friday) and 8.00am to 6.00pm Saturdays. A small number of trucks are occasionally loaded from the stockpile between 6pm and 10pm Monday to Friday. Average truck loads are approximately 34 tonnes, with up 134 loaded trucks leaving the site each day.

Trucks leave the site travelling east via Bellambi Lane to the Northern Distributor. Trucks then travel south along the Northern Distributor and on to the Southern Freeway. From the Freeway trucks travel east along Masters Road and Springhill Road to PKCT. The transport routes from NRE No.1 Colliery to PKCT are shown on *Figure 2.4*. Trucks are operated by Brindles Transport.



Legend

- Project Application Area
- Port Kembla Coal Terminal
- Coal Transport Route

Figure 2.4
Coal Transport Route

Client:	Gujarat NRE Coking Coal Limited	
Project:	NRE No.1 Colliery Preliminary Works Air Quality Assessment	
Drawing No:	0079383s_PWAQ_G003_R0.mxd	
Date:	03/06/2010	Drawing size: A4
Drawn by:	JF	Reviewed by: MK
Scale:	Refer to Scale Bar	

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2.2 *PROPOSED COAL HANDLING FACILITIES*

ROM coal will continue to be transported from the working face to the surface at the Russell Vale site in accordance with the existing operations Bulli seam coal will continue to be transported via the Bulli seam belt to the stock pile.

The Balgownie belt and storage bin will be removed and a newly designed Wongawilli decline belt will be constructed on a similar alignment. The conveyor will be partially enclosed to minimise dust emissions.

A new screening and sizing plant and temporary short stack out conveyor will be constructed at the end of the Wongawilli decline belt to deliver Wongawilli seam coal to the existing stockpile. The stockpile will continue to be managed with dust suppression sprays. Stockpile operations will continue in accordance with existing practices. A new containment bund will be constructed on the southern side of the stockpile to improve stockpile management.

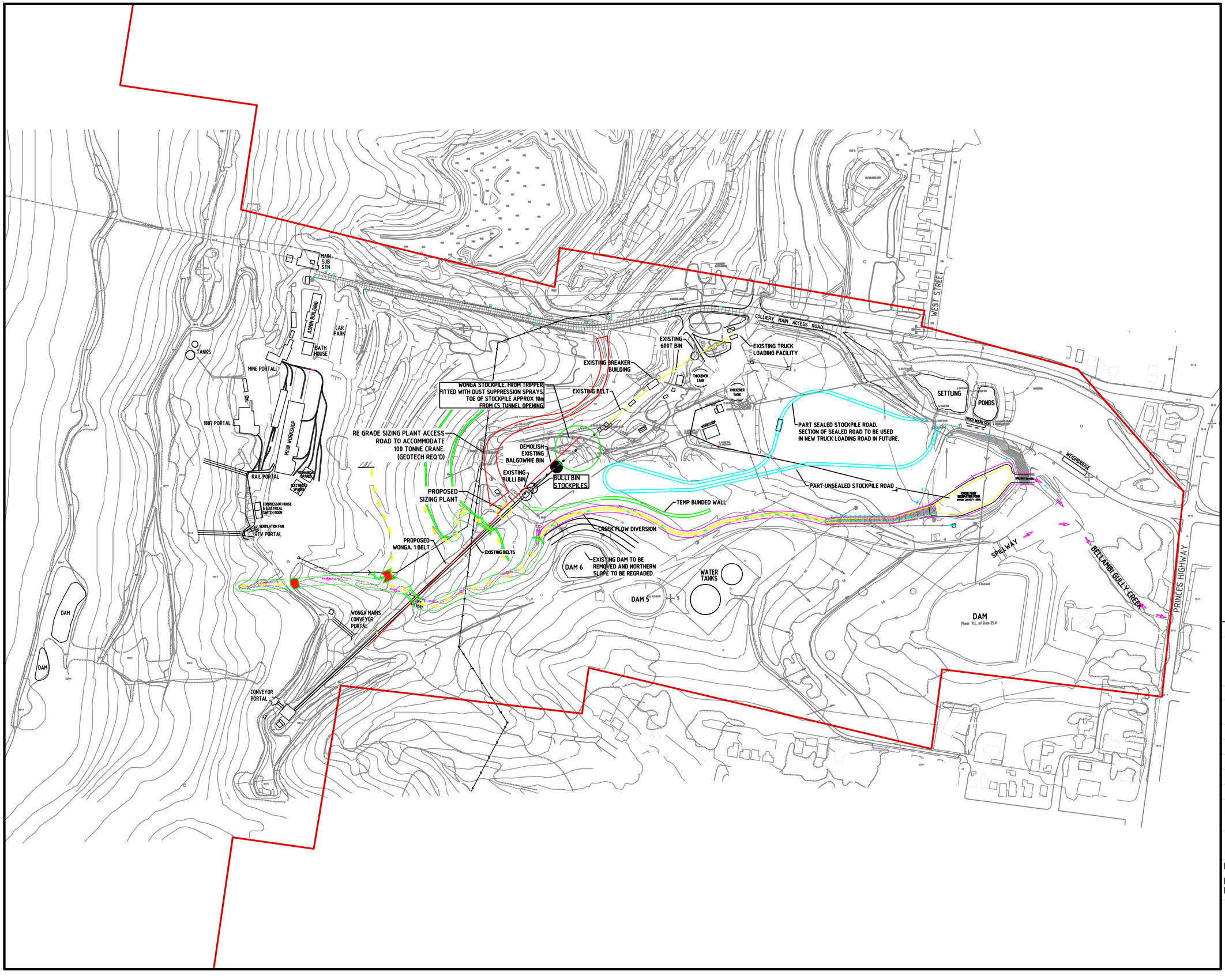
Existing truck loading facilities will be used for day time loading, however, a new internal haul road will be developed, with access from the colliery main access road to the stockpile area. This will be used for evening trucking where trucks will be loaded directly from the stockpile. The new internal haul route will be unsealed from the main access (via load out at the ROM stockpile) to new truck wash and then sealed from truck wash onwards. Dust suppression sprays will be fitted on the unsealed portion of the road.

A new truck wash facility will be installed on the exit of the new internal haulage road. Trucks will enter the wheel wash once loaded and dry on site over sealed roads before exiting. The existing truck wash will be used on entry to the site by trucks using the existing truck loading a facilities.

Appropriate acoustic screening and bunding will be provided.

Proposed coal handling facility upgrades are shown on *Figure 2.5.*

There will be no changes to facilities at No.4 Shaft.



Legend

Project Application Area

Figure 2.5

Proposed Surface Facility Upgrades

Client:	Gujarat NRE Coking Coal Limited		
Project:	NRE No.1 Colliery Preliminary Works Air Quality Assessment		
Drawing No:	0079383s_PWAQ_A005_R0.dwg		
Date:	03/06/2010	Drawing Size:	A3
Drawn By:	JF	Reviewed By:	MK
Source:	JBK Engineering & Mining		
Scale:	Refer to scale bar		

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2.3 *PRODUCT TRANSPORT*

In accordance with existing operations, unwashed coal will continue to be loaded into trucks for haulage to PKCT and loading into ships. Truck load-out facilities as described in *Section 2.1.2* will remain unchanged for the day time operations.

Proposed coal transport operations will be between 7.00am to 6.00pm Monday to Friday and 8.00am to 6.00 pm on Saturday and Sunday. A small number of trucks will be loaded from the stockpile between 6.00pm and 10.00pm Monday to Friday

3 AIR QUALITY LEGISLATION AND ASSESSMENT GUIDELINES

3.1 POTENTIAL AIR QUALITY ISSUES

The main potential air quality issues resulting from this Project are particulate emissions associated with:

- handling of coal;
- wind erosion from coal stockpiles; and
- haulage of coal offsite.

Both major and minor emission sources are addressed in *Chapter 5*. The following sections outline the air quality pollutants assessed for this Project and the regulatory framework associated with these potential emissions.

The main potential air quality issues as a result of the mining activities are:

- total suspended particulates (TSP);
- particulate matter less than 10 microns (PM_{10}); and
- deposited dust.

3.2 RELEVANT NSW REGULATORY FRAMEWORK

The air quality assessment was carried out in accordance with the *Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in New South Wales*, DECC, August 2005.

3.3 NATIONAL ENVIRONMENT PROTECTION MEASURES

The National Environment Protection Measure (Ambient Air Quality) 1998 (NEPM) is a Commonwealth Government initiative which aims to achieve nominated standards of air quality within ten years. Air quality standards for six major air pollutants (carbon monoxide, nitrogen dioxide, photochemical oxidants, sulfur dioxide, lead and small airborne particles) have been set.

All states and territories, including NSW, have adopted the NEPM air quality goals for pollutants. The criterion relating to potential emissions from the Project are outlined in *Table 3.1*. This standard is legally binding on all levels of government. Measurement and concentration averaging periods are based on critical exposure times for health impacts and are thus different for various pollutants. The NEPM criterion has been incorporated into the DECCW impact assessment criteria.

Table 3.1 NEPM (Ambient Air Quality) Standards

Pollutant	Averaging Period	Maximum Concentration	Maximum Allowable Exceedances
Particles as PM_{10}	24 hour	50 µg/m^3	5 days in a year.

The DECCW publish impact assessment criteria for air pollutants in their document *"Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in New South Wales" (revised 2005).* This document is referred to in *Part 4: Emission of Air Impurities from Activities and Plant* in the *Protection of the Environment Operations (Clean Air) Regulation (2002)*. Industry has an obligation to ensure compliance with the requirements specified in this Regulation.

The impact assessment criteria relevant to the Project are presented in *Table 3.2*. These are the criteria, against which the predicted ground level concentrations of pollutants generated by the Project are compared.

Table 3.2 DECCW Impact Assessment Criteria

Pollutant	Averaging Period	Concentration
PM_{10}	24 hours	50 µg/m^3
	Annual	30 µg/m^3
Total Suspended Particulates	Annual	90 µg/m^3
Deposited Dust	Annual	2 g/m^2/month

- Source: *"Approved Methods for the Modelling and Assessment of Air Pollutants in NSW" (NSW DECC, 2005)*
- Source: *"National Environnent Protection Measure (Ambient Air)" (Amendment 2003)*

4 EXISTING ENVIRONMENT

4.1 LOCAL AREA

The Project Application Area (PAA) is approximately 8 km north of Wollongong and 70 km south of Sydney, within the local government areas (LGAs) of Wollongong and Wollondilly in the Illawarra region of NSW.

Part of the eastern portion of the lease is located on the Illawarra Escarpment. Within the PAA, the lip of the Escarpment reaches up to 400m Australian Height Datum (AHD) and slopes steeply down to the foothills at approximately 30m AHD. The steep slopes of the escarpment are heavily vegetated.

The Russell Vale site is located on the lower slopes and foothills of the Escarpment at approximately 140m AHD. The Russell Vale site is bounded by the Princes Highway to the east, with residential areas of Russell Vale and Corrimal to the east and south respectively.

4.2 GENERAL METEOROLOGICAL CONDITIONS

Meteorology plays a major role in determining the location and scale of off-site impacts of air pollutant activities. Air dispersion modelling requires information about the dispersion characteristics of the area. In particular, data is required on wind direction, wind speed, temperature, atmospheric stability and mixing height.

Meteorological files suitable for modelling using AERMOD have been prepared by ERM. The file utilises data on wind speed, wind direction and ambient temperature from an Automatic Weather Station (AWS) operated and maintained by the DECCW located in Wollongong, approximately 6 kilometres (km) south of the site.

Information as to the development of the meteorological file is included in *Annex A*.

4.3 CLIMATE

Long term climatic data is available from a Bureau of Meteorology (BoM) weather station located, approximately 12 km south of the site.

Table 4.1 presents temperature, humidity and rainfall data from this weather station, which consists of monthly average 9am and 3pm readings. Monthly averages of maximum and minimum temperatures are also presented. Rainfall data consists of mean monthly rainfall and the average number of rain days per month.

On average, January is the warmest month in Bellambi with a mean daily maximum of 24.7^{o}C. The coolest month is July with a mean daily minimum temperature of 10^{o}C.

The mean annual rainfall in Bellambi is 1039 mm. The mean number of annual rain days over this period is 94.8 days. On average, February is the wettest month with a mean monthly rainfall of 137.7 mm, while September is the driest month with an average of 57.6 mm.

Table 4.1 Climatic Data for Bellambi (1988 – 2009)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Maximum Temperature													
Mean (°C)	24.7	24.9	23.9	22.2	19.7	17.7	16.8	17.9	20.1	21.7	22.0	24.1	21.3
Daily Minimum Temperature													
Mean (°C)	19.0	19.2	18.0	15.4	13.0	11.0	10.0	10.4	12.4	14.0	15.4	17.5	14.6
9 am Mean													
Temperature (°C)	21.8	21.9	20.7	19.4	16.6	14.4	13.4	14.4	16.7	18.4	18.7	20.8	18.1
Humidity (%)	75	76	74	66	63	62	60	57	59	61	72	71	66
3 pm Mean													
Temperature (°C)	23.1	23.3	22.5	20.7	18.4	16.5	15.8	16.5	18.1	19.2	20.1	22.3	19.7
Humidity (%)	72	74	71	67	61	59	56	55	61	64	70	69	65
Rainfall													
Mean (mm)	62.1	137.7	85.1	100.8	93.4	93.9	85.8	98.8	57.6	74.9	87.3	63.9	1039
Raindays													
Mean (Number)	9.3	9.4	9.3	7.7	7.0	7.5	6.8	5.9	6.8	7.4	9.5	8.2	94.8

1. Station number 068228; Latitude 34.37 S; Longitude 150.93 E
2. Source - Bureau of Meteorology, Commonwealth of Australia.

4.4 BACKGROUND CONCENTRATIONS

Background air quality is a measure of the existing air quality in the absence of the project activity. The background air quality is due to sources (natural or man made) other than the site. It is important to consider background air quality when considering cumulative impacts on sensitive receptors in the area.

4.4.1 Particulate Matter

The DECCW 2005 guidelines detail the need to obtain ambient monitoring data that includes at least one year of continuous measurement and is contemporaneous with the meteorological data used in the dispersion modelling.

In the absence of daily monitoring data for Russell Vale, the closest site at which the DECCW monitors particulate matter is at Wollongong, approximately 6 km south of the site. The station is located on Gipps Street, just north of the Wollongong city centre. It is anticipated that in lieu of site specific measurements, that the Wollongong monitoring data will be representative of ambient particulate concentrations at Russell Vale.

The Wollongong station continuously measures PM_{10} concentrations. Daily data for January to December 2007 has been provided by the DECCW.

To undertake a cumulative assessment of annual PM_{10} ground level concentrations, the annual average of the 24 hour Wollongong records has been used. The annual average PM_{10} concentration estimated from this data is 19.7 $\mu g/m^3$.

A background concentration for TSP has been estimated at 50.4 $\mu g/m^3$, based on a particle size distribution with PM_{10} being approximately 39.1% of TSP (SPCC, 1986, see Section 6.2.8).

4.4.2 Dust Deposition

Due to the lack of DECCW provided dust deposition data in the area, background concentrations have not been included in the model.

5 EMISSIONS INVENTORY

5.1 OVERVIEW

This impact assessment predicts the potential particulate impacts from the Project. These impacts are considered in isolation and in the context of existing sources in the area (cumulative impacts). The sections below outline the activities which have the potential to generate dust emissions.

5.2 ESTIMATED EMISSIONS FROM NRE NO.1 COLLIERY

The following sections provide an outline of activities on site which are expected to generate particulate emissions. A detailed emission inventory is presented in *Annex B*.

5.2.1 ROM Coal Stockpile

The ROM coal extracted from underground mining is transferred to the stockpile area via conveyor. The ROM coal is then stockpiled at the stockpile area before being transferred to the truck loader via conveyor, although evening truck loading will be directly from the stockpile. Water sprays will continue to be used on these stockpiles to minimise dust on an as needed basis.

Wind erosion is expected to generate dust from the ROM coal stockpile, which has been included in the dispersion model.

5.2.2 Loading Haul Trucks

Dust will be generated as a result of dumping coal into haul trucks via overhead loaders for transport offsite. Evening truck loading will be directly from the stockpile.

5.2.3 On Site Haul Roads

Dust will be generated as a result of the movement of haul trucks around the site.

5.2.4 *Hauling Coal on Haul Route*

There is potential for dust to be generated as a result of trucks hauling coal offsite along the haul route. Since NRE trucks make up a larger proportion of heavy vehicular traffic along Bellambi Lane and a small proportion along the rest of haul route, the focus has been Bellambi Lane. Dust generated as a result of the movement of trucks hauling coal along Bellambi Lane could potentially be caused due to inadequate load covers, entrained dust and drip waste. These are only potentially sources and will not necessarily occur.

Following discussions with DECCW this emissions source has not been included in modelling. This issue will be dealt with through management measures as described in *Section 8.3*

5.2.5 *Conveyor Transfer of ROM Coal to the Stockpile Area*

The conveyor will be fully enclosed, minimising the potential for dust generation. Emissions from the conveyor are anticipated to be minor compared to other sources considered and have therefore not been included in the model.

5.2.6 *Screening and Sizing Plant*

The screening and sizing plant will be fully enclosed, minimising the potential for dust generation. Emissions from the screening and sizing plant are anticipated to be minor compared to other sources considered and have therefore not been included in the model.

5.2.7 *Transfer and Handling of Coal at the Stockpile Area*

ROM coal will be conveyed from the surface stockpile area to the truck load out using uncovered conveyors. The truck load outs are covered on the sides and top only since it is a drive through open front and back bin arrangement. Emissions will occur at the stockpile area and at the truck load outs.

5.2.8 *Bulldozing at the Stockpile Area*

Bulldozers will generate particulate emissions as a result of disturbance and moving of material within the stockpile area. As such, bulldozers working on the ROM stockpile have been included in the dispersion modelling assessment.

5.2.9 Excavating at the Stockpile Area

Excavators will generate particulate emissions as a result of disturbance and moving of material within the stockpile area. As such, excavators working on the ROM stockpile have been included in the dispersion modelling assessment.

5.2.10 Emissions from Blasting

Blasting for this Project is undertaken occasionally underground at a low maximum instantaneous charge. Blasting is episodic and minor in magnitude and therefore emissions from blasting have not been included in the dispersion model.

5.2.11 Ventilation Shafts

Ventilation shafts are located in a catchment area away from any sensitive receptors, and only minor emissions are expected, therefore these emissions have not been included in the dispersion model.

6 DISPERSION MODELLING ASSESSMENT

6.1 MODELLING METHODOLOGY

The AMS/EPA Regulatory Model (AERMOD) is a state of the science local scale model widely used around the world. AERMOD serves as a replacement for ISCST3 and is applicable to rural and urban areas, flat and complex terrain, surface and elevated releases, and multiple sources (including, point, area and volume sources). Every effort has been made to avoid model formulation discontinuities wherein large changes in calculated concentrations result from small changes in input parameters.

AERMOD is a steady-state plume model. In the stable boundary layer (SBL), the concentration distribution is assumed to be Gaussian in both the vertical and horizontal. In the convective boundary layer (CBL), the horizontal distribution is assumed to be Gaussian, but the vertical distribution is described with a bi-Gaussian probability density function. Additionally, in the CBL, AERMOD treats "plume lofting" whereby a portion of plume mass, released from a buoyant source, rises to and remains near the top of the boundary layer before becoming mixed into the CBL. AERMOD also tracks any plume mass that penetrates into elevated stable layer, and then allows it to re-enter the boundary layer when and if appropriate.

AERMOD incorporates, with a new simple approach, current concepts about flow and dispersion in complex terrain. Where appropriate the plume is modelled as either impacting and/or following the terrain. This approach has been designed to be physically realistic and simple to implement while avoiding the need to distinguish among simple, intermediate and complex terrain, as is required by present regulatory models. As a result, AERMOD removes the need for defining complex terrain regimes; all terrain is handled in a consistent and continuous manner that is simple, while still considering the dividing streamline concept in stable stratified conditions.

One of the major improvements that AERMOD brings to applied dispersion modelling is its ability to characterize the planetary boundary layer (PBL) through both surface and mixed layer scaling. AERMOD constructs vertical profiles of required meteorological variables based on measurements and extrapolations of those measurements using similarity (scaling) relationships. Vertical profiles of wind speed, wind direction, turbulence, temperature, and temperature gradient are estimated using all available meteorological observations. AERMOD was designed to run with a minimum of observed meteorological parameters. AERMOD requires only a single surface (generally, 10m) measurement of wind speed (reference wind speed), direction and ambient temperature (reference temperature). Like ISC3, AERMOD also needs observed cloud cover. However, AERMOD also requires the full morning upper air sounding (RAWINSONDE). ISC3 required only the morning and afternoon mixing heights derived from that sounding. In addition, AERMOD needs surface characteristics (surface roughness, Bowen ratio, and albedo) in order to construct its PBL profiles.

Unlike existing regulatory models, AERMOD accounts for the vertical inhomogeneity of the PBL. This is accomplished by "averaging" the parameters of the actual PBL into "effective" parameters of an equivalent homogenous PBL.

Surface characteristics in the form of albedo, surface roughness and Bowen ratio, plus standard meteorological observations (wind speed, wind direction and temperature), are input to AERMET. AERMET then calculates the PBL parameters: friction velocity (u*), Monin-Obukhov length (L), convective velocity scale (w*), temperature scale (θ*), mixing height (zi), and surface heat flux (H). These parameters are then passed to the AERMOD interface where similarity expressions (in conjunction with measurements) are used to calculate vertical profiles of wind speed (u), lateral and vertical turbulent fluctuations (σv, σw), potential temperature gradient (dθ/dz), potential temperature (θ), and the horizontal Lagrangian time scale (TLy). AERMET was used in the present study to create model-ready input files (as described in Annex A).

The AERMIC terrain pre-processor AERMAP uses gridded terrain data (where requested) to calculate a representative terrain-influence height (hc), also referred to as the terrain height scale. The terrain height scale, which is uniquely defined for each receptor location, is used to calculate the streamline height. Terrain data was not included due to the nature of the sources. There will be no point sources located at the mine, and volume and area source contributions to overall concentrations are not influenced by terrain features.

Building wake effects are flow lines that cause a plume to be forced downwards much sooner than it would have had the building not been there. This can result in higher ground level concentrations on the leeward side of obstructions. AERMOD contains algorithms to determine the effects of building downwash on plume dispersion. AERMOD cannot account for building wakes from area and volume sources. As such, building wakes have not been included in this modelling assessment and in any event are not expected to generate a significant effect at this mine site.

6.1.1 Model Receptors

A Cartesian grid has been set-up with the centre positioned at 306000E, 6196000N and grid receptors at regularly spaced intervals starting at 50 metres, and increasing to intervals of 500 metres, out to a distance of 5 kilometres from the mine.

The DECCW define a sensitive receptor as a location where people are likely to work or reside; this may include dwellings, schools, hospitals, churches or offices.

A representative sample of nearby residences was chosen as discrete receptors in the modelling assessment. These receptors were chosen to ensure that all directions were covered. A detailed list of discrete representative receptors is presented in *Table 6.1*.

Table 6.1 Discrete Receptor Locations

Receptor	Description	Coordinates (MGA zone 56)	
		Easting	Northing
R1	6 Broker St.	306516	6196055
R2	29 West St.	306470	6196085
C5	Taylor Place	305889	6195417
C1	48 Lyndon St – West	305949	6195521
C2	48 Lyndon St.	306081	6195570
C3	Midgley St.	306558	6195596
R4	4 Broker St.	306746	6195951
C6	Robson St., Logger 2	306187	6195291
C4	Bloomfield Ave., Logger 3	306322	6195424
R3	Moreton St., Logger 1	306568	6196087

The locations of the sensitive receptors are shown in *Figure 6.1*.

Legend

- Project Application Area
- Sensitive Receptor

Receptors

R1	6 Broker St.
R2	29 West St.
C5	Taylor Place
C1	48 Lyndon St – West
C2	48 Lyndon St.
C3	Midgley St.
R4	4 Broker St.
C6	Robson St., Logger 2
C4	Bloomfield Ave., Logger 3
R3	Moreton St., Logger 1

Figure 6.1
Receptor Locations

Client:	Gujarat NRE Coking Coal Limited	
Project:	NRE No. 1 Colliery Preliminary Works Air Quality Assessment	
Drawing No:	0079383s_PWAQ_G004_R0.mxd	
Date:	03/06/2010	Drawing size: A3
Drawn by:	JF	Reviewed by: MK
Scale:	Refer to Scale Bar	

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6.1.2 Background Concentrations

A discussion of background concentrations included in this assessment is presented in *Section 4.5.*

6.1.3 Dust Deposition

Assessment of dust deposition requires information relating to particle size and density, to enable AERMOD to account for gravitational settling. It is anticipated that the particle size distribution would be as follows:

- 7.9µm – PM_{10}; and
- 79µm – TSP PM

Particle density is assumed to be 1.0 grams per cubic centimetre.

Dust deposition has been estimated for the 1 month averaging period to allow comparison with the DECCW impact assessment criteria, as specified in *Table 3-2*.

6.2 MODEL INPUT DATA

The following information was collected for volume sources:

- source location coordinates;
- source length, width and height; and
- contaminant emission rates.

Annex C provides summaries of the model input data used for this assessment.

7 RESULTS

7.1 SHORT TERM (24 HOUR) IMPACTS - PM_{10}

The dispersion modelling assessment uses 'contemporaneous' meteorological and monitoring data – they both cover the period January-December 2007. This allows the (incremental) ground level concentrations predicted by the dispersion model on a given day to be added to the background data recorded at Wollongong on the same day for a cumulative assessment.

The Wollongong monitoring data has three recorded measurements (58.5, 51.6 and 50.6 $\mu g/m^3$) in excess of the NSW assessment criterion of 50$\mu g/m^3$. These data have therefore been excluded from this assessment in accordance with DECCW guidelines. The maximum 24 hour PM_{10} concentration (below the NSW criterion) recorded at Wollongong between the January and December 2007 was 49.0 $\mu g/m^3$, on the 4th of March 2007.

Table 7-1 details the highest predicted 24 hour incremental ground level concentrations of PM_{10} for each sensitive receptor, with the corresponding background concentration recorded at the Wollongong monitoring station on that day.

Table 7.1 Maximum Predicted Incremental 100th Percentile Ground Level Concentrations for PM_{10} (24 hour average)

Receptor	Date	Incremental Concentration Modelled ($\mu g/m^3$)	Background Concentration Measured ($\mu g/m^3$)	Cumulative Concentration ($\mu g/m^3$)	Criterion ($\mu g/m^3$)
R1	11-Jun	5.68	7.10	12.78	50
R2	11-Jun	7.78	7.10	14.88	50
C5	17-Feb	13.85	18.90	32.75	50
C1	4-Apr	26.17	19.10	45.27	50
C2	21-May	14.24	10.20	24.44	50
C3	25-Apr	3.91	11.50	15.41	50
R4	17-Jul	3.42	8.40	11.82	50
C6	21-May	6.17	10.2	16.37	50
C4	5-Jun	6.66	13.7	20.36	50
R3	11-Jun	5.16	7.10	12.26	50

1. Background is recorded at the Wollongong DECCW monitoring station
2. Incremental – ground level concentration from the development in isolation
3. Cumulative – ground level concentrations from the development including background concentrations
4. Bold figures indicate an exceedance of the criterion

Table 7.2 details the periods during the year that the predicted 24 hour incremental ground level concentrations of PM_{10}, including the background concentration, exceeded the NSW criterion at sensitive receptors. Most of these events occurred on March 4, when the background concentration was 98% of the criterion level. One sensitive receptor had three additional occurrences greater than the criterion for a total of four, less than the allowable five exceedances.

Table 7.2 Predicted Exceedances of the NSW Criterion for PM_{10} (24 hour average)

Receptor	Date	Incremental Concentration Modelled (µg/m³)	Background Concentration Measured (µg/m³)	Cumulative Concentration (µg/m³)	Criterion (µg/m³)
R1	4-Mar	1.23	49.00	**50.23**	50
C5	4-Mar	1.39	49.00	**50.39**	50
C5	30-Jan	5.15	46.90	**52.05**	50
C1	4-Mar	2.22	49.00	**51.22**	50
C1	7-Jan	10.43	42.80	**53.23**	50
C1	30-Jan	6.17	46.90	**53.07**	50
C1	4-May	10.32	42.60	**52.92**	50
C2	4-Mar	2.28	49.00	**51.28**	50
C2	30-Jan	6.11	46.90	**53.01**	50
R4	4-Mar	2.09	49.00	**51.09**	50

1. Background is recorded at the Wollongong DECCW monitoring station
2. Incremental – ground level concentration from the development in isolation
3. Cumulative – ground level concentrations from the development including background concentrations
4. Bold figures indicate an exceedance of the criterion

7.2 *LONG TERM (MONTHLY & ANNUAL) IMPACTS – PM_{10} AND TSP*

Table 7-3 shows the incremental (site only) and cumulative (site + background) concentrations for pollutants which are assessed against an annual averaging period in accordance with the DECCW guidelines on the sensitive receptors.

Table 7.3 Annual Average Dispersion Modelling Pollutant Concentration and Deposition Rates, at sensitive receptors

Receptor	PM_{10} Incremental	PM_{10} Cumulative (incremental +background 19.7 µg/m³)	TSP Incremental	TSP Cumulative (incremental + background – 50.6 µg/m³)	Dust Deposition Incremental
	µg/m³	µg/m³	µg/m³	µg/m³	g/m²/month
R1	1.43	21.13	4.3	54.9	0.04
R2	1.66	22.36	5.0	55.6	0.04
C5	2.73	22.43	8.5	59.1	0.08
C1	4.71	24.41	14.7	65.3	0.15
C2	4.05	23.75	12.6	63.2	0.16
C3	1.12	20.82	3.4	54.0	0.03
R4	0.88	20.58	2.7	53.3	0.02
C6	1.30	22.00	4.0	54.6	0.04
C4	1.46	22.16	4.5	55.1	0.04
R3	1.24	21.94	3.7	54.3	0.03
Criteria	**-**	**30**	**-**	**90**	**2.0**

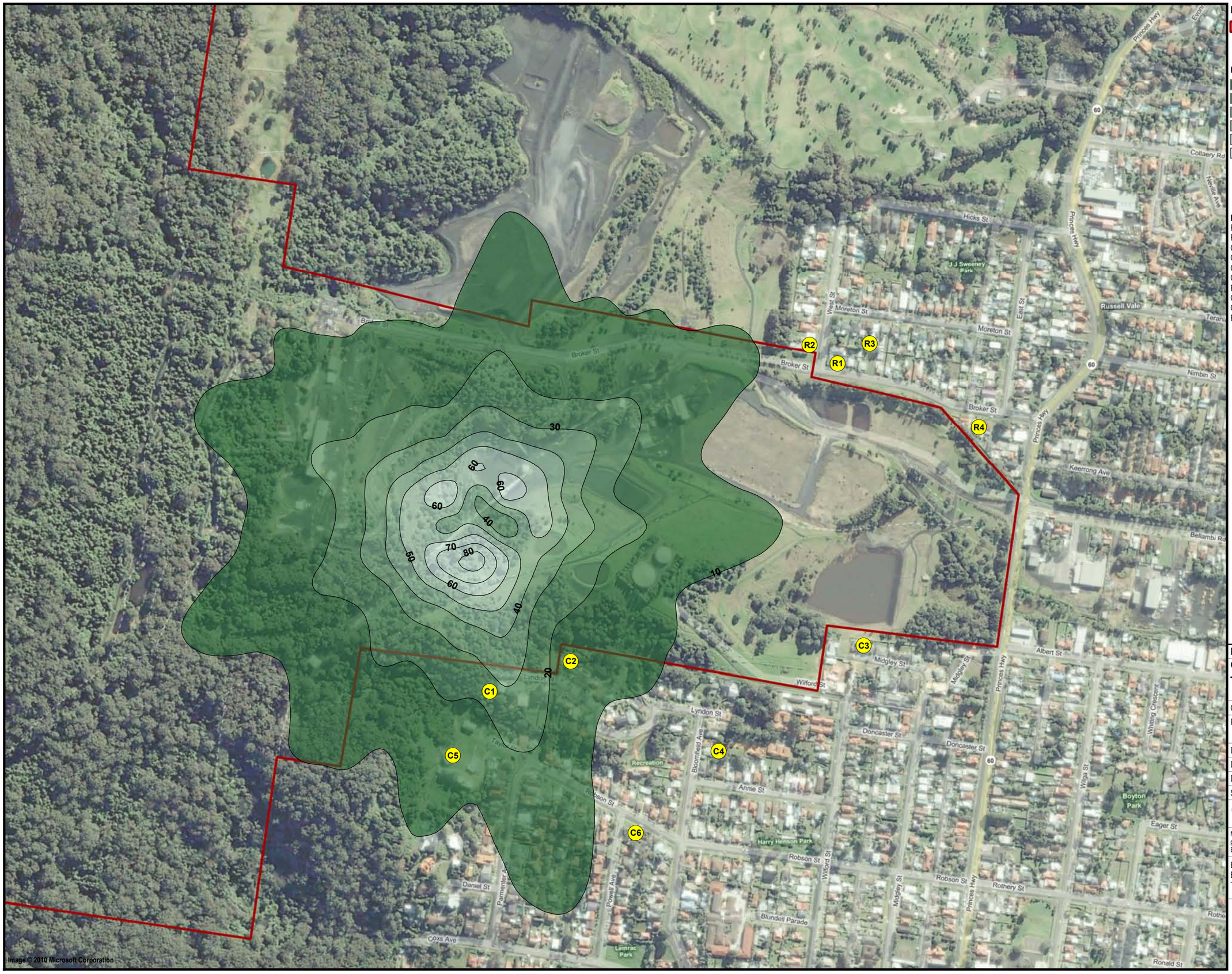
1. Increment – Concentration resulting from site activities at a modelled sensitive receptors
2. Cumulative – Concentration resulting from site activities plus ambient background concentration

7.3 *RESULTS SUMMARY*

The results presented in Table 7-3 show that the predicted air quality impacts of the site are below the DECCW nominated criteria when considered in isolation. The PM_{10} 24 hour criterion is exceeded when emissions are considered in conjunction with existing background concentrations, but the maximum number of exceedances (four at sensitive receptors) are less than the allowable five annual exceedances.

In addition, the concentration contours presented in *Figure 7.1* to *Figure 7.3* show that the predicted concentrations are localised around the site and decrease rapidly with distance.

The dust deposition rates at the identified receptors are all below the DECCW impact assessment criterion of 2g/m^2/month. Given the nature of the surrounding environment, with a lack of significant dust generating sources, it is unlikely that the receptors would experience dust impacts that exceed the cumulative impact assessment criterion of 4g/m^2/month.



Legend

- Project Application Area
- Sensitive Receptor

PM10 Concentration (µg/m³)

- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- >60

Receptors

R1	6 Broker St.
R2	29 West St.
C5	Taylor Place
C1	48 Lyndon St – West
C2	48 Lyndon St.
C3	Midgley St.
R4	4 Broker St.
C6	Robson St., Logger 2
C4	Bloomfield Ave., Logger 3
R3	Moreton St., Logger 1

Figure 7.1
Concentration Contours – PM10 Maximum 24 hour Average

Client:	Gujarat NRE Coking Coal Limited	
Project:	NRE No. 1 Colliery Preliminary Works Air Quality Assessment	
Drawing No:	0079383s_PWAQ_G005_R0.mxd	
Date:	03/06/2010	Drawing size: A3
Drawn by:	JF	Reviewed by: MK
Scale:	Refer to Scale Bar	

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Legend

- Project Application Area
- Sensitive Receptor

PM10 Concentration (µg/m³)

- 6 - 10
- 10 - 14
- 14 - 18
- 18 - 22
- >22

Receptors

R1	6 Broker St.
R2	29 West St.
C5	Taylor Place
C1	48 Lyndon St – West
C2	48 Lyndon St.
C3	Midgley St.
R4	4 Broker St.
C6	Robson St., Logger 2
C4	Bloomfield Ave., Logger 3
R3	Moreton St., Logger 1

Figure 7.2

Concentration Contours – PM10 Annual Average

Client:	Gujarat NRE Coking Coal Limited	
Project:	NRE No. 1 Colliery Preliminary Works Air Quality Assessment	
Drawing No:	0079383s_PWAQ_G006_R0.mxd	
Date:	03/06/2010	Drawing size: A3
Drawn by:	JF	Reviewed by: MK
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Legend

- Project Application Area
- Sensitive Receptor

TSP Concentration (µg/m³)

- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- >60

Receptors

R1	6 Broker St.
R2	29 West St.
C5	Taylor Place
C1	48 Lyndon St – West
C2	48 Lyndon St.
C3	Midgley St.
R4	4 Broker St.
C6	Robson St., Logger 2
C4	Bloomfield Ave., Logger 3
R3	Moreton St., Logger 1

Figure 7.3

Concentration Contours – TSP Annual Average

Client:	Gujarat NRE Coking Coal Limited	
Project:	NRE No. 1 Colliery Preliminary Works Air Quality Assessment	
Drawing No:	0079383s_PWAQ_G007_R0.mxd	
Date:	03/06/2010	Drawing size: A3
Drawn by:	JF	Reviewed by: MK
Scale:	Refer to Scale Bar	

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8 DISCUSSION AND CONCLUSIONS

8.1 OVERVIEW

Table 8.1 presents a summary of the maximum predicted incremental ground level concentrations for the modelled receptor where highest concentrations were predicted.

Table 8.1 Maximum Incremental Ground Level Concentrations

Pollutant	Maximum Increment[1]	Background[2]	Cumulative	Criteria[3]	% of Criteria
Sensitive Receptors					
PM_{10} – 24 hour ($\mu g/m^3$)[4]	2.28	49.00	**51.28**	50	**103%**
PM_{10} – 24 hour ($\mu g/m^3$)[5]	26.17	19.10	45.27	50	90.5%
PM_{10} – Annual ($\mu g/m^3$)	4.71	19.7	24.41	30	81.4%
TSP – Annual ($\mu g/m^3$)	14.7	50.6	65.30	90	72.6%
Dust Deposition – Annual (g/m^2/month)	0.16	-	-	2	8%

1. Maximum increment has been estimated based on dispersion modelling.
2. Background data derived from the DECCW Wollongong TEOM monitoring data
3. Criteria are sourced from DECCW (2005) *"Approved Methods for the Modelling and Assessment of Air Pollutants in NSW"*
4. Predicted concentration on day of maximum background (contemporaneous data presented in *Table 7.1)*
5. Predicted concentration on day of maximum incremental concentration

8.2 RESULTS SUMMARY

8.2.1 Short Term (24 Hour Average) Impacts

PM_{10} – Short term (24 hour) average

The predicted ground level concentrations of PM_{10} (24 hour average) are below the DECCW nominated criteria when considered in isolation. The PM_{10} 24 hour criterion is exceeded on four occasions over the year when emissions are considered in conjunction with existing background concentrations.

The PM_{10} cumulative assessment uses monitoring data from Wollongong which is contemporaneous with the meteorological data used in the dispersion modelling. The highest background recorded at Wollongong (below the NSW criterion) was 49.0 $\mu g/m^3$, and the maximum increment predicted by the modelling on that day was 2.28 $\mu g/m^3$ (at Receptor 1), giving a cumulative impact of 51.28 $\mu g/m^3$, representing 103% of the DECCW criteria.

The highest predicted incremental concentration at any sensitive receptor was 26.17 µg/m^3 predicted at Receptor 1. The background data recorded at Wollongong on that day was 19.10 µg/m^3, and the cumulative impact of 45.27 µg/m^3 represents 90.5% of the relevant criteria.

The NEPM guidance for PM_{10} 24 hour concentrations indicates that the criterion of 50 µg/m^3 may be exceeded 5 times in a calendar year. Given the extents of the data used in the assessment, the cumulative assessment undertaken using contemporaneous background data indicates that the mine is in compliance with NEPM guidelines.

8.2.2 Long Term (Annual and Monthly Average) Impacts

Total Suspended Particulates (TSP) – Long term (annual) average

The predicted ground level concentrations of TSP (annual average) comply with the NSW assessment criterion of 90 µg/m^3 at existing sensitive receptors.

The maximum predicted incremental TSP concentration was 14.7 µg/m^3. The background level derived from monitoring data at Wollongong for 2007 was 50.6 µg/m^3, and the cumulative impact of 65.3 µg/m^3 represents 72.6% of the criterion.

Particulate Matter Less Than 10 Micron (PM_{10}) – Long term (annual) average

The maximum predicted incremental PM_{10} (annual average) concentration was 4.71 µg/m^3 at Receptor 1. The average background recorded at Wollongong for 2007 was 19.7 µg/m^3, and the cumulative impact of 24.41 µg/m^3 represents 81.4% of the criteria.

Dust Deposition

The predicted incremental ground level dust deposition rates comply with the NSW assessment criterion of an increment of 2g/m^2/month at modelled sensitive receptors. The maximum predicted increment was 0.16 g/m^2/month, which represents 8% of the incremental criteria.

Due to the lack of available DECCW provided background dust deposition data for the assessment area, a cumulative impact assessment is not possible. Given the nature of the existing environment, and a lack of neighbouring significant potential dust sources, it is considered unlikely that cumulative impacts will exceed the cumulative dust assessment criterion of 4g/m^2/month.

8.3 MANAGEMENT AND MITIGATION

A number of management measures are already in place at this facility to reduce the generation of particulate emissions. These measures are outlined as follows.

Nature of the Material

The inherent properties, including a high moisture content (estimated at 7%), of the coal being extracted reduce potential for dust emissions to atmosphere compared to other extracted materials.

Materials Handling

Coal is transported on site using a network of covered conveyors. This results in much lower emissions of dust, than using onsite haul trucks to transport material to the ROM pad.

Management of Exposed Areas

Exposed areas will consist of one main stockpile area up to a maximum of 2 hectares in area and the smaller storage yard/top flat area (~0.6 hectares). Water sprays will continue to be used on these areas to minimise air borne dust on an as needs basis.

Offsite Transport

Offsite transport will consist of the use of trucks. The trucks will be covered before leaving the site in order to minimize the potential for dust impacts due to product loss through wind erosion. To ensure dust emissions along coal haul routes are effectively managed, a truck wash will be utilized which is expected to drop emissions to negligible levels.

NRE No. 1 has also committed to re–enforce the Driver's Code of Conduct, through continuing driver education (tool box talks). The code of conduct includes mitigation measures such as mandatory covering of trucks. NRE also proposes to trial alternative truck washing systems which may include wheel washing before departure from the site so that drip waste on public roads is minimised.

8.4 CONCLUSIONS

A review and assessment has been conducted of the potential impacts to air quality associated with the current operation and throughput of the NRE No. 1 Coal Mine. The assessment has been conducted in accordance with the relevant DECCW guidelines.

The results of modelling indicate:

- the project is predicted to comply with the long term DECCW air quality impact criteria for PM_{10}, TSP and dust at all receptors for all scenarios;
- the project is predicted to exceed maximum 24 hour average PM_{10} criterion on four days at one sensitive receptor, which is within the allowable five day exceedance limit; and,
- the highest predicted incremental concentration of PM10 (24 hour average) at modelled sensitive receptors was 26.17 µg/m3 representing 52.3% of the nominated criteria (50 µg/m3);

The project would therefore have no significant impact on the long term air quality parameters of dust deposition, annual average PM_{10} and TSP.

While a maximum of four exceedances of the DECCW short term air quality criteria (maximum PM_{10} 24 hour average concentration) of 50 $\mu g/m^3$ is predicted it unlikely that the project would have a significant impact on local air quality due to the following:

- the project was not the primary contributor for any of the exceedances. These predicted cumulative exceedances would largely result from windblown salt and other operations in and around the area;
- the modelling considers that a range of activities occur concurrently during the one 24 hour period, which can be considered a 'worst case' approximation of emissions from site activities. The maximum 24 hour increments are predicted when this worst case activity level coincides with worst case meteorological conditions.

Concentration contours show that the highest impacts are centred around the site, with the predicted concentrations decreasing rapidly beyond the site boundary, with minimal impacts predicted beyond 1000 m.

A number of management measures, many of which are already in use, are proposed to ensure that emissions to the local air-shed are minimised.

Annex A

Meteorological Data

AERMET is the meteorological pre-processor for AERMOD. AERMET uses surface and upper air sounding data from nearby weather stations to develop two files — a surface parameters file (.sfc) and a profile file (.pfl). Most of the parameters contained in the surface file and required for the AERMOD modelling analysis are calculated internally by AERMET. These include mixing heights (convective and mechanical) and boundary layer scaling parameters related to atmospheric stability (friction velocity, convective velocity scale, Monin-Obukhov length scale). The profile file contains measured parameters including wind speed and direction, temperature, and turbulence parameters including sigma-theta (horizontal turbulence) and sigma-w (vertical turbulence). The profile file is designed to accommodate measurements at multiple levels, but in the present case contains only one measurement level.

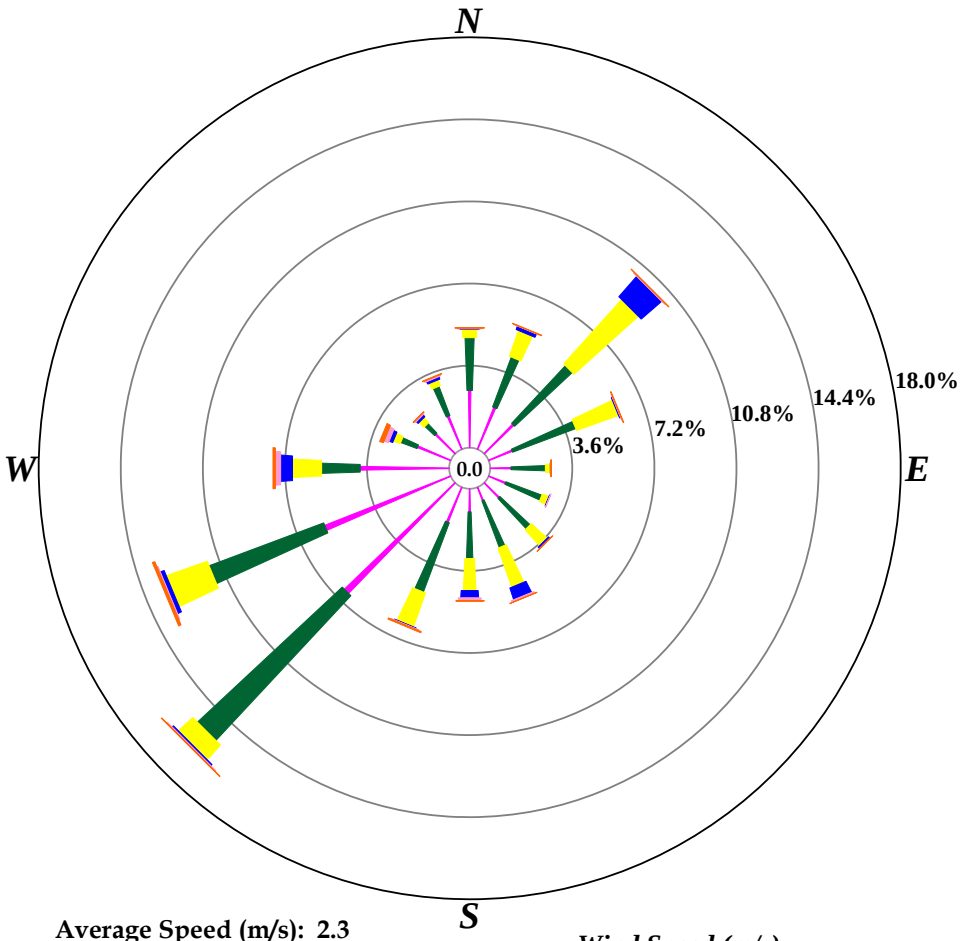
Data on wind speed, wind direction, ambient temperature, and sigma-theta were obtained from an Automatic Weather Station (AWS) operated and maintained by the DECCW located in Wollongong, approximately 6 kilometres (km) south of the site for calendar year 2007. AERMET also uses a single upper air sounding on a daily basis to determine convective boundary layer parameters including the convective mixing height. Mixing height calculations are accomplished in AERMET by estimating heat flux, and then estimating the degree to which the stable night-time boundary layer suppresses mixing height growth. AERMET furthermore requires cloud cover information to assist in making heat flux calculations. ERM looked for the closest available sounding station to the site for which soundings are available for the correct time period representing the required morning sounding. The Sydney International Airport is a sounding station but did not have sufficient data available; Williamstown, further up the coast to the northeast of the site, was found to have sufficient data and was used as input to AERMET. Cloud cover data were available from the Sydney airport, and these data were used to complete the inputs to AERMET.

AERMET requires that surface characteristics surrounding the meteorological data collection site be quantified and input into the model. Specifically, values of surface roughness, albedo, and bowen ratio must be characterized in order for AERMET to calculate the necessary parameters that are used to determine boundary layer stability. EPA published suggested values of surface roughness, albedo, and bowen ratio for a variety of land use classifications. These suggested values are found in the AERSURFACE User's Guide. This guide was used to specify values for the Wollongong site, namely bowen ratio = 0.5; albedo = 0.6; rouchness length = 0.5.

AERMET was run with the inputs specified here, and the surface and profile files produced by AERMET were used in the modelling.

A wind rose based on the Wollongong 2007 data is displayed in Figure A.1

Figure A.1 Wind Rose: Wollongong, 2007



Annex B

Model Inputs

Model Inputs

Model ID	Source Type	Description	Utm-East	Utm-North	Release Height	Y-init	Z-init
			m	m	m	m	m
A1	volume	Bullibin Stockpile	305889	6195768	5	2.09	4.65
A2	volume	Wongwa Stockpile	305928	6195802	5	8.8	4.65
B	volume	Conveyor Transfer - Portal	305677	6195576	5	2	4.65
C	volume	Conveyor Unloading to Bullibin Stockpile	305889	6195768	5	2	4.65
D	volume	Conveyor Unloading to Wongwa Stockpile	305928	6195802	5	2	4.65
F1	volume	Transfer - Loading Bins to Road Trucks	306057	6195902	5	2	4.65
F2	volume	Transfer - Loading Bins to Road Trucks	306059	6195896	5	2	4.65
1	volume	Paved Road (unloaded)	306062	6195901	5	63.26	4.65
2	volume	Paved Road (unloaded)	306184	6195864	5	63.26	4.65
3	volume	Paved Road (unloaded)	306299	6195808	5	63.26	4.65
4	volume	Paved Road (unloaded)	306422	6195748	5	63.26	4.65
5	volume	Paved Road (loaded)	306062	6195901	5	63.26	4.65
6	volume	Paved Road (loaded)	306184	6195864	5	63.26	4.65
7	volume	Paved Road (loaded)	306299	6195808	5	63.26	4.65
8	volume	Paved Road (loaded)	306422	6195748	5	63.26	4.65
A2A	volume	Dozing on Wongwa	305928	6195802	5	25.58	4.65
A2B	volume	Excavator on Wongwa	305928	6195802	5	25.58	4.65
F3	volume	Transfer - Stockpile to Road Trucks	305949	6195778	5	2	4.65
101	volume	Stockpile Road (loaded and unloaded)	306228	6195824	5	63.26	4.65
102	volume	Stockpile Road (loaded and unloaded)	306115	6195846	5	63.26	4.65
103	volume	Stockpile Road (loaded and unloaded)	305993	6195780	5	63.26	4.65
104	volume	Stockpile Road (loaded and unloaded)	306034	6195768	5	63.26	4.65
105	volume	Stockpile Road (loaded and unloaded)	306144	6195788	5	63.26	4.65
106	volume	Stockpile Road (loaded and unloaded)	306226	6195802	5	63.26	4.65

Annex C

Emission Estimation

Emission Estimates

		Emission Factors			Activity Level (A)		OpHrs	Area		Emissions (kg/day)		Emissions (g/s)			Emissions (g/s)	
Source Description	**Source Type**	**TSP**	**PM10**	**Units**	**Rate**	**Units**	**hrs/day**	**m^2**	**ha**	**TSP**	**PM10**	**TSP**	**PM10**	**Mitigation**	**TSP**	**PM10**
Conveyor Transfer - conveyorportal	volume	0.00032	0.00015	kg/t	4000	tonnes/day	24	n/a	n/a	1.3	0.6	0.015	0.007	watersprays	0.007	0.003
Conveyor unloading to Bullibin stockpile	volume	0.004	0.0017	kg/t	4000	tonnes/ day	24	n/a	n/a	16.0	6.8	0.185	0.079	heavy ^{water}sprays	0.046	0.020
Conveyor unloading to ROM stockpile	volume	0.004	0.0017	kg/t	4000	tonnes/ day	24	n/a	n/a	16.0	6.8	0.185	0.079	heavy ^{water}sprays	0.046	0.020
Transfer - loading bins into road trucks***	volume	0.0004	0.00017	kg/t	4000	tonnes/day	11	n/a	n/a	1.6	0.7	0.040	0.017	watersprays	0.020	0.009
Haulage from loading bins to site boundary - sealed road (loaded)*	volume	0.0157184	0.007606	kg/VKT	44	VKT/day	11	n/a	n/a	0.7	0.3	0.017	0.008	water sprays	0.009	0.004
Haulage from site boundary to loading bins -sealed road (unloaded)*	volume	0.0114486	0.006579	kg/VKT	44	VKT/day	11	n/a	n/a	0.5	0.3	0.013	0.007	water sprays	0.006	0.004
Transfer - stockpile into ^{road}trucks	volume	0.0004	0.00017	kg/t	666.7	tonnes/ day	4	n/a	n/a	0.3	0.1	0.019	0.008	water sprays	0.009	0.004
Haulage on stockpile road		0.0114486	0.006579	kg/hr	6	VKT/day	11	n/a	n/a	0.1	0.0	0.002	0.001	heavy water spray	0.00043	0.00025
Dozer on ROM stockpile	volume	17	4	kg/hr	n/a	n/a	6.6	n/a	n/a	30.9	7.3	1.299	0.306	heavy water sprays	0.325	0.076
E,cavator on ROM stockpile	volume	0.029	0.014	kg/t	2400	tonnes/ day	9	n/a	n/a	26.1	12.6	0.302	0.146	heavy ^{water}sprays	0.076	0.036
Wind erosion - ^{Bullibin}stockpile	volume	0.44	0.22	kg/ha/hr	0.008	hectares	24	81	0.008	0.0	0.0	0.00004	0.00002	water sprays	0.000021	0.000010
Wind erosion - ^{ROM}stockpile	volume	0.44	0.22	kg/ha/hr	0.144	hectares	24	1444	0.144	0.1	0.0	0.0007	0.0004	water sprays	0.0004	0.0002

* Assuming ma,imum 220 movements per day (110 trips per day) and based on 0.4 km each way from bins to Princes Highway 44 VKT/day

** Assuming ma,imum 48 movements per day (24 trips per day) and based on 0.25 km each way on stockpile road 6 VKT/day

*** Emissions split between two loadout points

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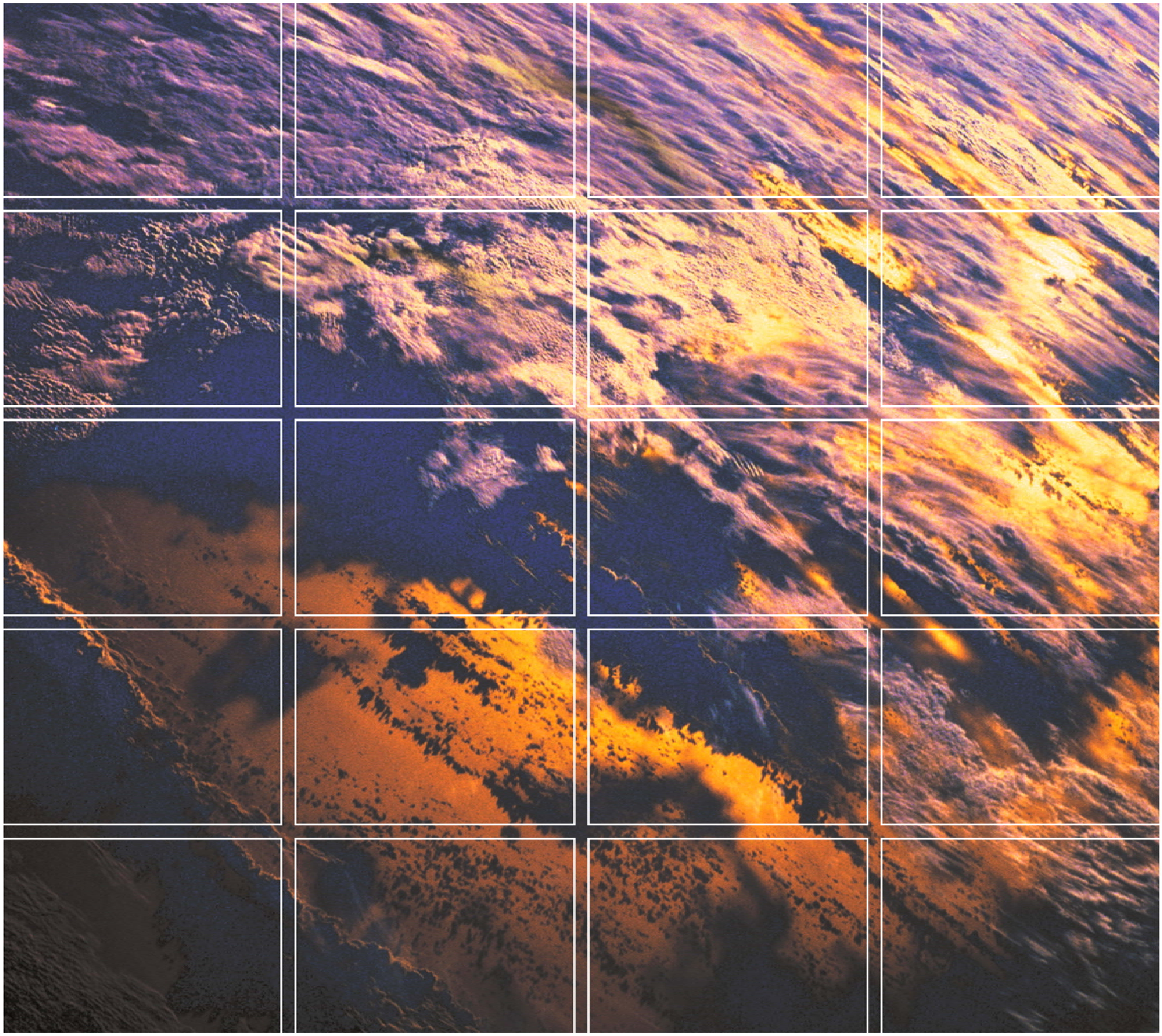
Annex J

NRE No.1 Colliery Preliminary Work Acoustic Assessment



NRE No.1 Colliery

Preliminary Works Noise Assessment

Gujarat NRE Coking Coal Limited

October 2010

0079383 Final

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Date:	*1 October, 2010*
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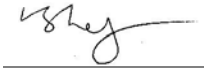
Position:	Partner
Signed:	
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FINAL REPORT

Gujarat NRE Coking Coal Limited

NRE No.1 Colliery
Preliminary Works Noise Assessment

October 2010

Reference: 0079383

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1 INTRODUCTION

1.1 BACKGROUND

Environmental Resources Management Australia Pty Ltd (ERM) was engaged to undertake a noise impact assessment for the continuation of mining and upgrade of associated surface facilities as part of Stage 1 of a major expansion of NRE No. 1 Colliery in the Southern Coalfield (the 'Project'). NRE No. 1 Colliery is located at Russell Vale, to the west of Bellambi, in the Illawarra region of New South Wales (NSW). A noise impact assessment was conducted to identify potential acoustic impacts associated with Colliery operation and traffic generating activities associated with the Project. This assessment was prepared to support the Environmental Assessment (EA) required by the Director-General of the Department of Planning as part of the Part 3A application process.

This assessment has been undertaken in accordance with the Department of Environment and Climate Change and Water (DECCW) (formerly the NSW EPA) Industrial Noise Policy (EPA, 2000) (hereafter referred to as the "INP"). Traffic generation associated with the proposal on public roads is assessed in accordance with the DECCW's Environmental Criteria for Road Traffic Noise (EPA, 1999) (hereafter referred to as the "ECRTN"). Construction noise has been assessed in accordance with the DECCW's Interim Construction Noise Guidelines (2009).

A glossary of terms, definitions and abbreviations used in this report is provided in *Annex A*.

1.2 OBJECTIVES AND ASSESSMENT METHODOLOGY

The Director General's Requirements (DGR's) for the Project relating to noise are:

> ***Noise*** *– including on-site construction and operational noise and off site road noise and vibration impacts from the haulage of coal along the coal transport corridor to Port Kembla Coal Terminal, paying particular attention to sensitive receivers along Bellambi Lane.*

With the DGR's in mind, the assessment included the following:

- quantification of existing acoustic environment and characterisation of existing influences on the local noise climate including local meteorological conditions with potential to affect noise propagation;
- determination of Project Specific Noise Levels (PSNL) in accordance with INP methodology;

- identification of noise sources, equipment sound power levels and operating times and locations for significant noise generating plant and equipment;

- development of a noise model using topographical data for the region and proposed development plans to predict noise levels from the operations;

- assessment of whether predicted construction, operation, road traffic and cumulative noise levels are acceptable;

- assessment of potential vibration impacts associated with coal transport from the operations.

Further details of the INP assessment methodology used in this NIA are provided in *Annex B*.

1.3 SITE DESCRIPTION

The Project Application Area (PAA) is approximately 8 km north of Wollongong and 70 km south of Sydney, within the local government areas (LGAs) of Wollongong and Wollondilly in the Illawarra region of NSW.

Part of the eastern portion of the lease is located on the Illawarra Escarpment. Within the PAA, the lip of the Escarpment reaches up to 400m Australian Height Datum (AHD) and slopes steeply down to the foothills at approximately 30m AHD. The steep slopes of the escarpment are heavily vegetated.

The Russell Vale site is located on the lower slopes and foothills of the Escarpment at approximately 140m AHD. The Russell Vale site is bounded by the Princes Highway to the east, with residential areas of Russell Vale and Corrimal to the east and south respectively.

The study area for this assessment focuses on the surrounds of the Russell Vale site as detailed in *Chapter 3.*

2 EXISTING OPERATIONS

2.1 COAL HANDLING FACILITIES

The existing surface infrastructure at the Russell Vale site is shown in *Figure 2.1* and includes:

- administration offices and amenities;
- maintenance workshops;
- car parking areas and internal sealed and unsealed roads;
- two portal entries, one for personnel and materials and another for the belt road which conveys coal to the surface;
- three new portal entries (currently under construction), for a new high capacity coal conveyor system, a rubber tyre vehicle transport road and a track road for rail mounted transports, respectively;
- run-of-Colliery (ROM) stockpile area and reclaim tunnel;
- two decline belt conveyors from the belt portal to the ROM stockpile area;
- breaker building (disused) and conveyor to the truck load-out bins;
- truck load-out facilities;
- vehicle wash;
- weigh bridge;
- water treatment and management facilities;
- fuel and oil storage facilities.

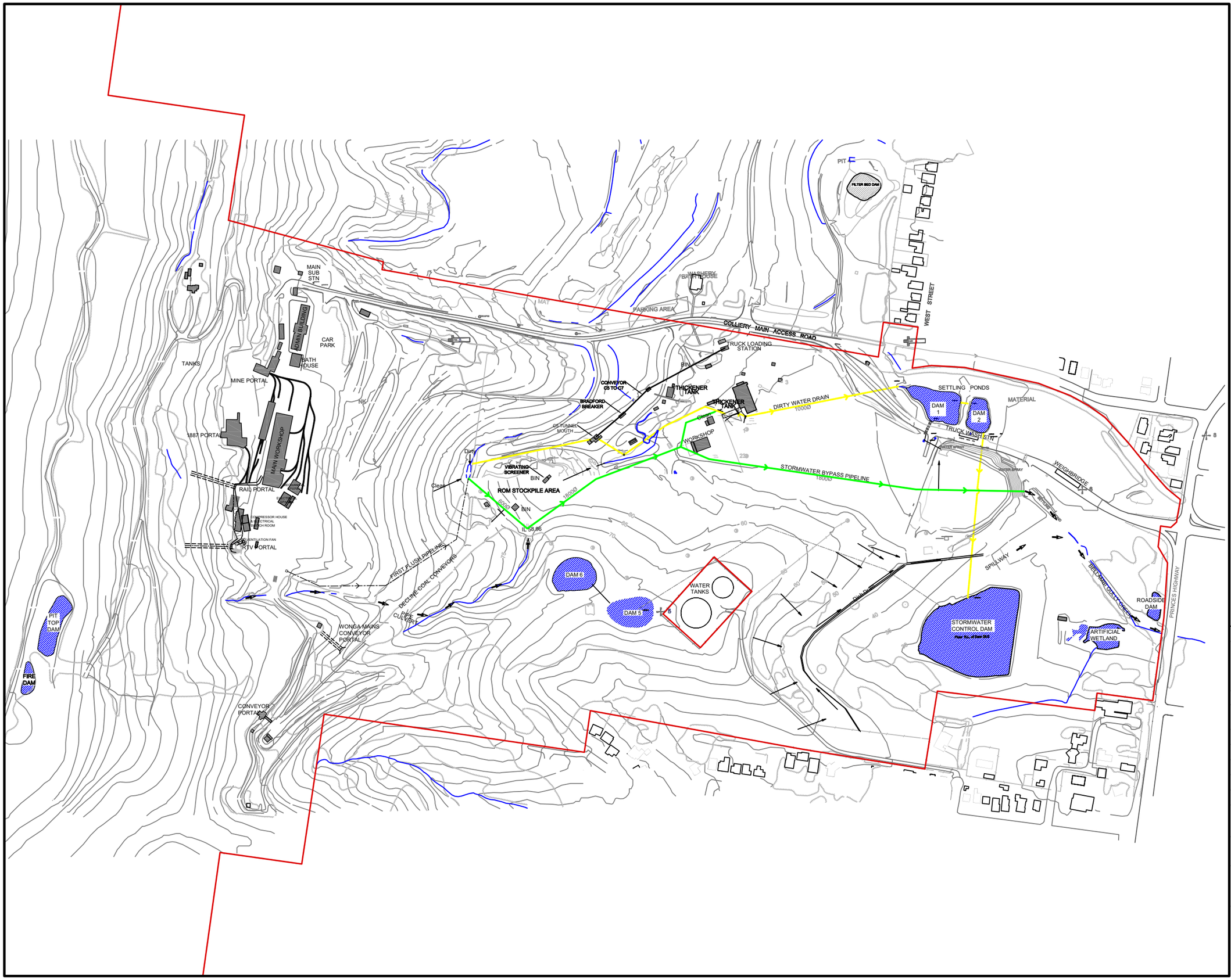
2.2 COAL TRANSPORT

Coal is currently transported, unwashed, by truck from NRE No.1 Colliery to PKCT for shipment to India. Coal transport trucks generally operate between the hours of 7.00am and 6.00pm five days per week (Monday to Friday) and 8.00am to 6.00pm Saturdays. A small number of trucks are occasionally loaded between 6.00 pm and 10.00 pm Monday to Friday.

Trucks leave the site travelling east via Bellambi Lane to the Northern Distributor and then travel south on to the Southern Freeway to Masters Road and Springhill Road to PKCT. The transport routes from NRE No.1 Colliery to PKCT are shown on *Figure 2.2*.

The Northern Distributor has recently been extended to Bulli, to the north-east of the Russell Vale site. This provides an arterial road connection around the haulage transport route for the existing Russell Vale operations.

The roads surrounding the Russell Vale Site and the haul route to PKCT are currently subject to Colliery-related traffic. This includes heavy vehicles for deliveries and coal transport and light vehicles for movement of staff, contractors and visitors. The regional road network, including the Northern Distributor, is also subject to heavy vehicle traffic from other industry and coal Collieries in the region.



Legend

- Project Application Area
- Dam
- Buildings
- Waterway
- Dirty Water Flows
- Clean Water Flows

Figure 2.1
Existing Coal Handling Facilities Layout

Client:	Gujarat NRE Coking Coal Limited		
Project:	NRE No.1 Colliery Preliminary Works Noise Assessment		
Drawing No:	0079383s_PW_Noi_A002_R1.dwg		
Date:	08/09/2010	Drawing Size:	A3
Drawn By:	NS	Reviewed By:	MK
Source:	Olsen Environmental Consulting Ref: DP-3673.dwg		
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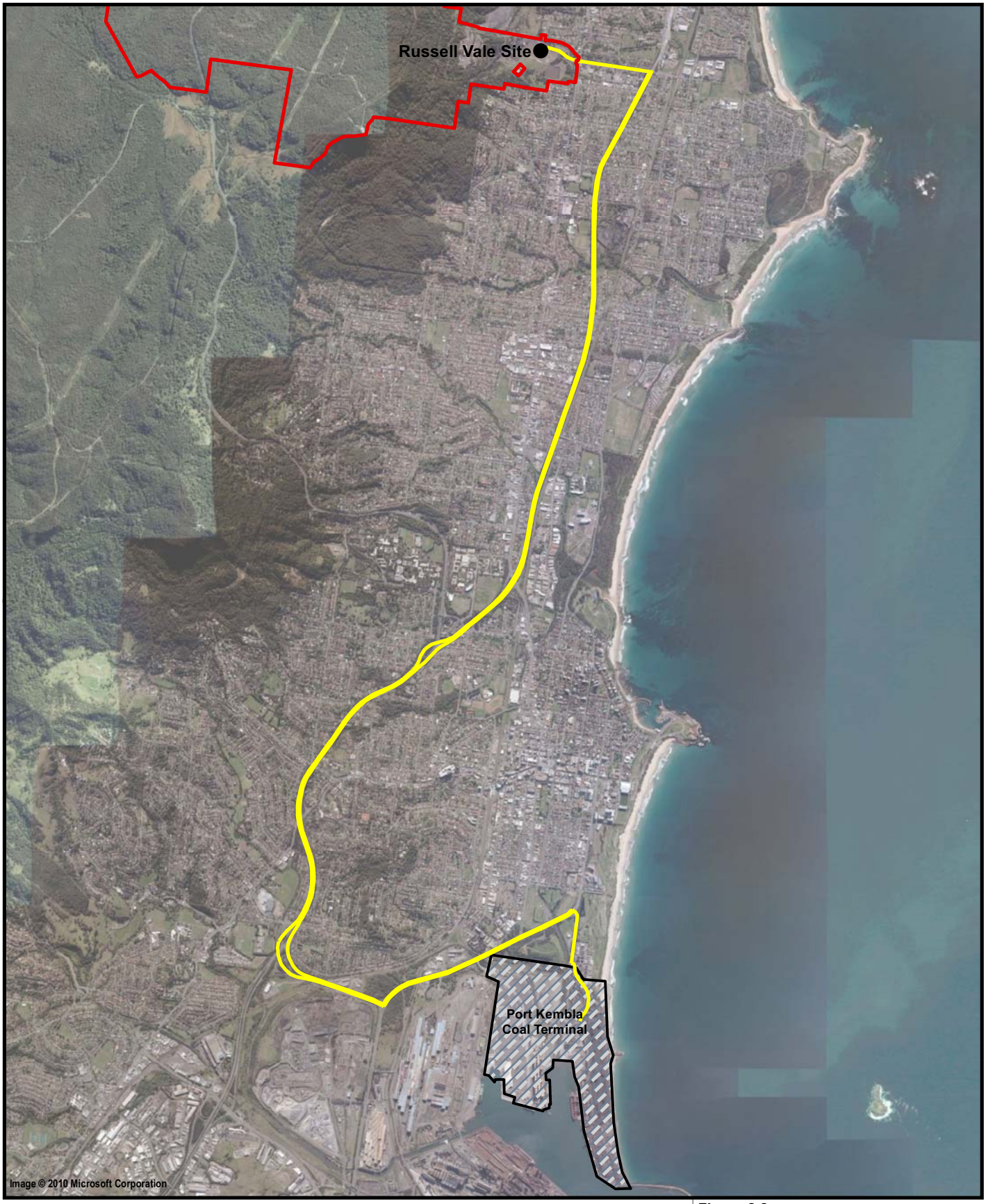

Legend

- Project Application Area
- Port Kembla Coal Terminal
- Coal Transport Route

Figure 2.2

Coal Transport Route

Client:	Gujarat NRE Coking Coal Limited
Project:	NRE No.1 Colliery Preliminary Works Noise Assessment
Drawing No:	0079383s_PW_Noi_GIS008_R1.mxd
Date:	03/09/2010 Drawing size: A4
Drawn by:	NS Reviewed by: MK
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3 PROPOSED OPERATIONS

3.1 COAL HANDLING FACILITIES

ROM coal will continue to be transported from the working face to the surface at the Russell Vale site in accordance with the existing operations as described in *Section 2.1*. Bulli seam coal will continue to be transported via the Bulli seam belt to the stockpile.

The Balgownie belt and storage bin will be removed and a newly designed Wongawilli decline belt will be constructed on a similar alignment. The conveyor will be fully enclosed to minimise dust emissions. A temporary short stack out conveyor will be constructed at the end of the Wongawilli decline belt to deliver Wongawilli seam coal to the existing stockpile.

The existing Bulli conveyor will be decommissioned and demolished upon completion of the new driveage, in mid to late 2012.

A new screening and sizing station will be constructed at the end of the decline just before the existing Bulli bin. Coal will be transferred from the sizing station to both the Bulli bin stockpile and the Wongawilli stockpile via a conveyor and tripper arrangement.

These facilities will be integrated into the existing coal clearance system. Stage 1 works will require a stockpiling capacity of approximately 60,000-80,000 tonnes. The stockpile will continue to be managed with dust suppression sprays.

This stockpile arrangement will include the capability to push out coal from the stockpile and additional storage. A temporary bund wall will be constructed south of the stockpile to provide a barrier to prevent wet weather coal slumps from travelling into the surface drainage system.

Existing truck loading facilities will be used for day time loading, however, a new internal haul road will be developed, with access from the Colliery main access road to the stockpile area. This will be used for evening trucking where trucks will be loaded directly from the stockpile. The majority of the new internal haul route will be unsealed from the main access road and past the stockpile. The last section of the road will be sealed. Water trucks and dust suppression sprays will be used on the unsealed portion of the road.

Trucks will be washed prior to leaving the site.

Appropriate acoustic screening and bunding will be provided (see *Chapter 14*).

Proposed coal handling facility upgrades are shown on *Figure 3.1*.

3.2 *COAL TRANSPORT*

The proposed coal transport activities will continue in accordance with existing operations, with unwashed coal to be loaded into trucks for haulage to PKCT. Truck load-out facilities as described in *Section 2.1* will remain unchanged for day time operations.

Proposed coal transport operations will be between 7.00am to 6.00pm Monday to Friday and 8.00am to 6.00 pm on Saturdays. Trucking will occur on Sundays between 8.00am and 6.00pm when required. A small number of trucks will be loaded from the stockpile between 6.00pm and 10.00pm Monday to Friday.

Trucking in the evenings Monday to Friday and trucking on Sunday will only be used in rare circumstances to achieve shipping deadlines

Average truck loads are approximately 34 tonnes, with up to 134 loaded trucks leaving the site each day.

Bellambi Lane is an east-west road linking Gujarat NRE No. 1 Mine, the Princes Highway, the Northern Distributor and Bellambi Railway Station. The section used for coal haulage is between Gujarat NRE No. 1 Mine and Northern Distributor.

3.3 *HOURS OF OPERATION*

Operations such as coal handling, maintenance and coal production will be conducted 24 hours a day, 7 days a week. Transport of coal will be restricted between 7.00am and 10.00pm as described in *Section 3.2*.

3.4 *NOISE SENSITIVE RECEIVERS*

The nearest receivers to the proposed development are located to the north and north-east in Broker and West Streets, Russell Vale; to the south-east in Midgley Street, Lyndon Street and Taylor Street to the south in Corrimal. Representative receiver locations were chosen to provide an indication of the extent of potential noise emissions associated with the proposed development.

Noise monitoring and assessment locations were selected as representative areas for the noise sensitive receivers. *Figure 3.2* presents representative area locations, and noise monitoring locations are presented in *Table 3.1.*

Table 3.1 Noise Sensitive Receiver Locations

ID	Location	INP Classification	Coordinates (MGA zone 56)		RL m, AHD
			Easting	Northing	
C1	48 Lyndon St (west) Corrimal	Suburban	305949	6195521	65.55
C2	48 Lyndon St Corrimal	Suburban	306081	6195570	62.56
C3	Midgley St Corrimal	Suburban	306558	6195596	37.18
C4	Bloomfield Avenue Corrimal	Suburban	306322	6195424	45.27
C5	Taylor Place Corrimal	Suburban	305889	6195417	90.91
C6	Robson St Corrimal	Suburban	306187	6195291	55.08
R1	6 Broker St Russell Vale	Suburban	306516	6196055	36.86
R2	29 West St Russell Vale	Suburban	306470	6196085	39.02
R3	Moreton St Russell Vale	Suburban	306568	6196087	34.85
R4	4 Broker St Russell Vale	Suburban	306746	6195951	29.19

Legend

Project Application Area

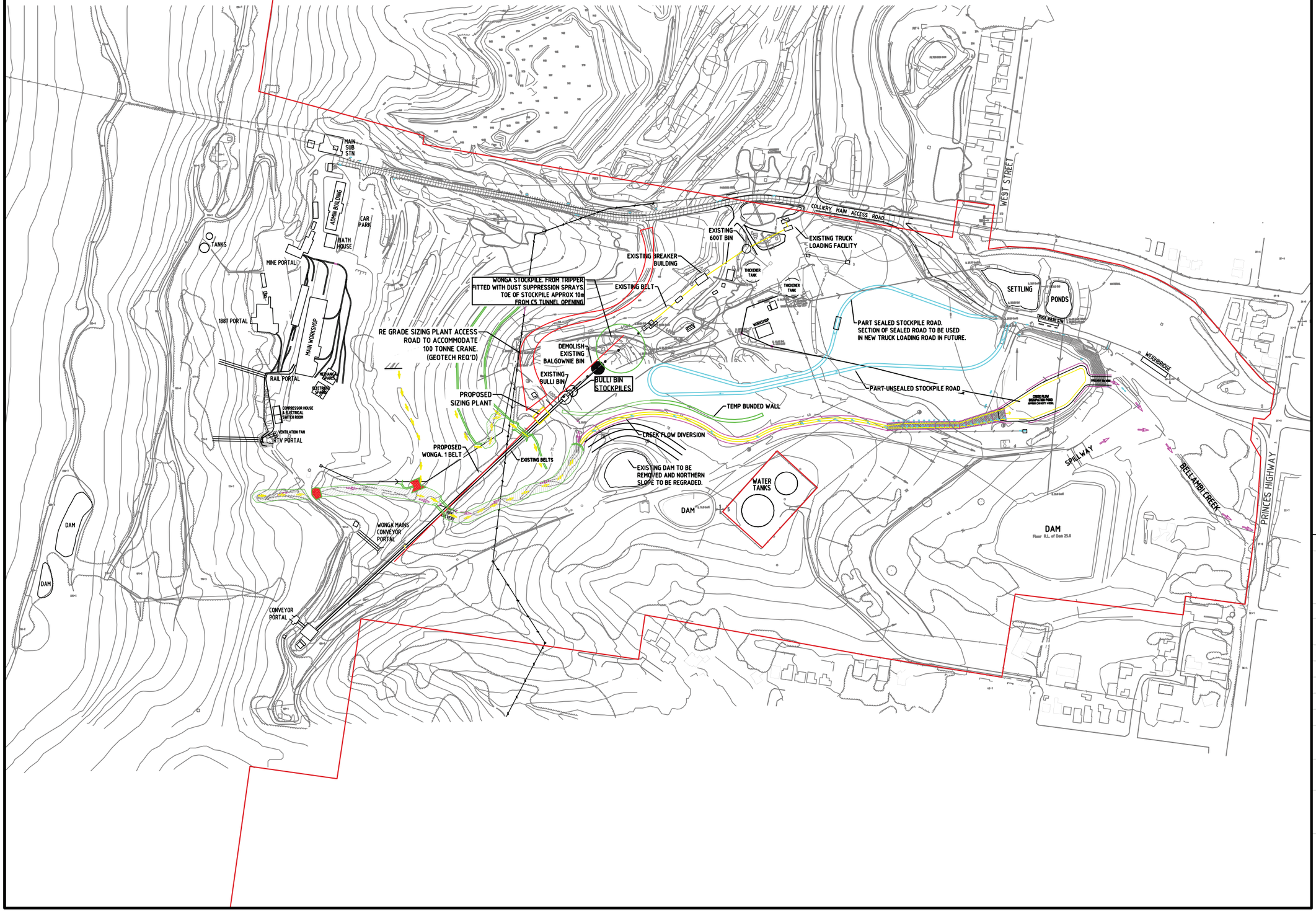

Figure 3.1

Proposed Surface Facility Upgrades

Client:	Gujarat NRE Coking Coal Limited		
Project:	NRE No.1 Colliery Preliminary Works Noise Assessment		
Drawing No:	0079383h_PW_Noi_A005_R1.dwg.cdr		
Date:	24/09/2010	Drawing Size:	A3
Drawn By:	NS	Reviewed By:	MK
Source:	JBK Engineering & Mining		
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Legend

- Project Application Area
- Receiver Location
- Representative Receiver Location

Source:

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Suffix	*Revisions*	*Date*	*Init*
R0	Preliminary Issue	25-05-10	JD
R1		09-09-10	JD

Figure 3.2

Noise Sensitive Receivers and Representative Areas

Client:	Gujarat NRE Coking Coal Limited	
Project:	NRE No.1 Colliery Preliminary Works Noise Assessment	
Drawing No:	0079383h_PW_Noi_004_R0.cdr	
Date:	09/09/2010	Drawing size: A4
Drawn by:	JD	Reviewed by: MK
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4.1 UNATTENDED CONTINUOUS NOISE MONITORING

Noise monitoring was undertaken by ERM using continuous noise loggers from 1 December 2008 to 25 December 2008 to determine existing ambient noise environment at the receiver locations identified in *Figure 3.2*. These locations represent the nearest residential receiver areas. Details of the noise monitoring schedule are presented in *Table 4.1*. The background (L_{A90}) and amenity (L_{Aeq}) noise levels within the residential receiver areas adjacent to the study area were assessed using the results of this monitoring.

The continuous noise loggers recorded:

- date, time and temperature;
- ambient background, L_{A90} noise levels and amenity, $L_{Aeq, 15min}$ noise levels;
- maximum and minimum noise levels; and
- statistical noise levels representative of the noise environment.

Table 4.1 Background Noise Monitoring

Representative Locality	Logger Serial No.	Measurement Started	Measurement Stopped
R3 - Moreton Street, Russell Vale	194684	14:55 1/12/2008	15:53 23/12/2008
C4 - Bloomfield Avenue, Corrimal	194685	16:50 1/12/2008	0:15 23/12/2008
C6 - Robson Street, Corrimal	194698	17:02:19 1/12/2008	0:45:00 23/12/2008

The Rating Background Level (RBL), intrusiveness criteria and amenity criteria for monitoring locations were determined in accordance with INP methodology.

A summary of the results of the unattended continuous noise monitoring are provided in *Table 14.2*. Noise data during any periods of rainfall and/or wind speeds in excess of 5 m/s (18 km/h) at the microphone were discarded in accordance with INP weather-affected data exclusion methodology.

Table 4.2 Summary of Existing Ambient Background Noise Levels

Representative Area	Description [1]	Rating Background Noise Level (RBL), LA90 dB(A) [2]	LAeq, Period, dB(A) [3]
R3 - Moreton St, Russell Vale	Daytime	38	53
	Evening	34	49
	Night	32	47
C4 - Bloomfield Ave, Corrimal	Daytime	37	53
	Evening	36	53
	Night	32	47
C6 - Robson St, Corrimal	Daytime	39	63
	Evening	38	55
	Night	36	51

1. For Monday to Saturday, Daytime 7.00 am - 6.00 pm; Evening 6.00 pm - 10.00 pm; Night-time 10.00 pm - 7.00 am. On Sundays and Public Holidays, Daytime 8.00 am - 6.00 pm; Evening 6.00 pm - 10.00 pm; Night-time 10.00 pm - 8.00 am. Morning Shoulder is from 6.00 am - 7.00 am Monday - Saturday.
2. LA90 represents the level exceeded for 90 per cent of the interval period and is referred to as the average minimum or background noise level.
3. LAeq index corresponds to the level of noise equivalent to the energy average of noise levels occurring over a measurement period

4.2 ROAD TRAFFIC NOISE MONITORING

Unattended noise monitoring was undertaken to determine existing road traffic noise levels along Bellambi Lane. Noise monitoring, conducted some three months after the opening of the Northern Distributor extension consisted of a series of unattended continuous measurements conducted between 22 February 2010 and 4 March 2010 at 63 Bellambi Lane and 99 Bellambi Lane using environmental noise loggers. Graphs presenting the L_{eq}, L_1, L_{10} and L_{90} noise levels at 63 and 99 Bellambi Lane are presented in *Annex C*. These graphs also show the periods when trucks were operating. During the monitoring period the trucks operated on four (4) days, 22, 23 and 26 February and 2 March 2010 from 0700 to 1800.

The results of the unattended continuous noise monitoring at the two locations on Bellambi Lane are summarised in *Table 4.3*. The summary includes the L_{eq} or the average noise energy calculated over a fifteen hour period ($L_{eq, 15hr}$) and a one hour period ($L_{eq, 1hr}$).

Table 4.3 Summary of Existing Road Noise Levels

Location	Leq, 15hr dB(A)	Leq, 1hr Day, dB(A)
63 Bellambi Lane	65	67
99 Bellambi Lane	63	64

4.3 METEOROLOGICAL CONDITIONS

Noise propagation over distance can be significantly affected by the prevailing weather conditions. Source to receiver winds, the presence of temperature inversions and drainage flow effects can enhance received noise levels. To account for these phenomena, the INP specifies meteorological analysis procedures to determine the prevalent weather conditions that enhance noise propagation in a particular area, with a view to determining whether they can be described as a feature of the project area.

Wind

Wind has the potential to increase noise impacts at a receiver when it is light and stable and blows from the direction of the noise source. As the strength of the wind increases the noise produced by the wind usually obscures noise from most industrial and transport sources.

The prevailing wind directions in the area have been determined in accordance with Section 5 of the INP. The prevailing wind directions during 1 January 2008 to 3 September 2009 for Wollongong (Weather Station 68241), NSW have been analysed. The INP requires that winds below 3m/s with an occurrence greater than 30 per cent of the time be assessed. The results of this analysis shown in *Table 4.4* indicate there are no prevailing winds.

Table 4.4 INP Prevailing Wind Analysis Summary

DAYTIME					
Period	**Calm**	**Wind Direction**	**0.5 to 2 m/s**	**2 to 3 m/s**	**0.5 to 3 m/s**
Summer	0.4%	ESE±45	1.0%	2.8%	3.8%
Autumn	1.8%	ESE±45	1.8%	4.2%	6.0%
Winter	1.2%	WNW±45	1.8%	3.4%	5.1%
Spring	0.7%	NNE±45	1.1%	3.0%	4.0%
EVENING					
Period	**Calm**	**Wind Direction**	**0.5 to 2 m/s**	**2 to 3 m/s**	**0.5 to 3 m/s**
Summer	0.8%	NNW±45	2.0%	2.8%	4.8%
Autumn	3.0%	WNW±45	4.6%	12.6%	17.1%
Winter	1.4%	W±45	4.6%	11.0%	15.6%
Spring	2.6%	NW±45	2.6%	5.8%	8.3%
NIGHT TIME					
Period	**Calm**	**Wind Direction**	**0.5 to 2 m/s**	**2 to 3 m/s**	**0.5 to 3 m/s**
Summer	4.3%	W±45	5.5%	8.6%	14.0%
Autumn	2.6%	W±45	5.6%	13.2%	18.8%
Winter	1.6%	W±45	5.0%	9.1%	14.0%
Spring	4.1%	W±45	4.4%	8.9%	13.3%

Temperature Inversion

Temperature inversions, when they occur, have the ability to increase noise levels by focusing sound waves. Temperature inversions occur predominantly at night during the winter months. For a temperature inversion to be considered as significant it needs to occur for approximately 30 percent of the total night-time (i.e. the evening and night time periods) during winter, or approximately two nights per week. Temperature inversions are generally determined based on the occurrence of atmospheric stability classes, with moderate and strong inversions corresponding to atmospheric stability categories F and G respectively.

Meteorological data was assessed in accordance with INP methodology to determine the likelihood of temperature inversions during the night-time period. These results are presented in *Table 4.5*..

Table 4.5 ***Inversion Analysis Summary – Frequency of Stability Classes during Winter Evening and Night time Periods***

Pasquill-Gifford Stability Class	Frequency of Stability Class [1]
A	0.0%
B	0.0%
C	0.0%
D	70.8%
E	15.1%
F	10.7%
G	3.4%
F & G	14.1%

This assessment found that the frequency of occurrence of F and G atmospheric stability categories is less than 30 per cent of the winter evening and night time periods. Therefore, the effects of temperature inversions have not been considered in this NIA.

Drainage Flow

In areas where temperature inversions are a feature of the meteorological environment, drainage flow winds may occur. Drainage flows may occur when a development is at a higher altitude than a residential receiver with no intervening topography. When source to receiver winds occur during a temperature inversion, noise levels may be increased due the focusing of sound waves at the receiver. Drainage flow winds are not considered to be applicable for this assessment as temperature inversions are not considered to be a feature of the area.

5 PROJECT-SPECIFIC NOISE LEVELS

5.1 OPERATIONAL NOISE CRITERIA

Noise emission design criteria for the Project have been established with reference to the INP as outlined in *Annex B*. This involved assessment of amenity noise criteria based on land use and the intrusiveness of proposed industrial noise sources.

The acoustic environment in the vicinity of Russell Vale site is classified as suburban by the NSW INP. A suburban environment is typically an area that has local traffic with characteristically intermittent traffic flows or with some limited commerce or industry. This area has the following characteristics:

- decreasing noise levels in the evening period ;and
- evening ambient noise levels defined by the natural environment and infrequent human activity.

Therefore the 'suburban' assessment criteria have been adopted at the potentially affected receivers nearest the proposed development area.

The relevant intrusive and amenity noise criterion and resulting operational project-specific noise levels for the residential receivers surrounding the Russell Vale site, with respect to the background noise monitoring locations, are presented in *Table 5.1*.

Table 5.1 Project-Specific Noise Levels[1]

Receivers	Period [2]	RBL LA90	Intrusive Criteria LAeq, 15min	INP Recommended LAeq	Adjusted [3] Amenity Criteria LAeq, Period	PSNL LAeq, 15min
R1 R2 R3 R4	Daytime	38	43	55	55	43
	Evening	34	39	45	45	39
	Night	32	37	40	40	37
C1 C2 C3 C4	Daytime	37	42	55	55	42
	Evening	36	41	45	45	41
	Night	32	37	40	40	37
C5 C6	Daytime	39	44	55	55	44
	Evening	38	43	45	45	43
	Night	36	41	40	40	40

1. All levels are dB(A)
2. Daytime 7.00 am to 6.00 pm; Evening 6.00 pm to 10.00 pm; Night 10.00 pm to 7.00 am. On Sundays and Public Holidays, Daytime 8.00 am to 6.00 pm; Evening 6.00 pm to 10.00 pm; Night-time 10.00 pm to 8.00 am
3. Recommended LAeq refers to an adjusted amenity criterion which accounts for existing industrial noise.

5.2 SLEEP DISTURBANCE

The DECCW has acknowledged that the relationship between maximum noise levels and sleep disturbance is not currently well defined.

While the INP does not specify a criterion for assessing sleep disturbance, the ENCM (1994) recommends that the $L_{1,\,1min}$ noise level from a source should not exceed the existing background noise by more than 15 dB. Depending on the measured background noise, the sleep disturbance criteria for the quietest location could be as low as 45 dB(A) $L_{1,\,1min}$.

The relevant sleep disturbance criterion for the residential receivers surrounding the area is presented in *Table 5.2*.

Table 5.2 Sleep Disturbance Criteria

Representative Locality	Representative Receivers	RBL LA90, 15min, dB(A) [1]	Noise Level LA90, 15min, dB(A)
R3 - Moreton St, Russell Vale	R1, R2, R3, R4	32	47
C4 - Bloomfield Ave, Russell Vale	C1, C2, C3, C4	32	47
C6 - Robson St, Russell Vale	C5, C6	36	51

Note 1: Night time only

5.3 *ROAD TRAFFIC NOISE CRITERIA*

Coal haulage trucks exit the site onto Bellambi Lane and the road network via the Southern Freeway onto Masters Road and Springhill Road to PKCT.

Due to recent extension of the Northern Distributor to Bulli, Bellambi Lane would now be considered to be a collector road for the purpose of this assessment; hence road traffic impacts along Bellambi Lane will be indicative of worst-case noise impacts relating to traffic noise.

Road traffic noise criteria are set out in the Environmental Criteria for Road Traffic Noise (ECRTN) (DECCW, 1999). These criteria are based on the functional categories applied by the RTA to the subject roads.

The relevant road traffic noise criteria for the roads associated with the proposed operations are provided in *Table 5.3*.

Table 5.3 Road Traffic Noise Criteria

Type of Development	**Criteria**		**Where Criteria are Already Exceeded**
	Day 7.00am - 10.00pm	Night 10.00pm - 7.00am	
Northern Distributor	60 dB(A) LAeq, 15hr	55 dB(A) LAeq, 9hr	Where feasible, existing noise levels should be mitigated to meet the noise criteria. Examples of applicable strategies include appropriate location of private access roads; regulating times of use; using clustering; using 'quiet' vehicles; and using barriers and acoustic treatments. In all cases, traffic arising from the development should not lead to an increase in existing noise levels of more than 2 dB.
Bellambi Lane	60 dB(A) LAeq, 1hr	55 dB(A) LAeq, 1hr	

5.4 CONSTRUCTION NOISE

5.4.1 *Justification For The Application Of Interim Construction Noise Guideline (ICNG)*

The aim of the ICNG is to provide guidance on managing construction works to minimise noise, including air and ground borne noise and blasting, from construction works noise regulated by DECCW, and is used to assist DECCW in setting statutory conditions in licences. Construction regulated by DECCW under the Protection of the Environment Operations Act 1997 (POEO Act) includes scheduled development work that will enable scheduled activities to be carried out (Section 47 of the POEO Act). The ICNG criteria are presented in *Table 5.4*.

Normally, noise from construction associated with quarrying and mining is not assessed by the ICNG, and would be assessed in accordance with the NSW INP (EPA 2000). It is understood that the ICNG is not intended to be applied to construction associated with quarrying and large open cut Collieries.

However, the type of construction activities to be undertaken as part of this Project would be considered to as "normal construction" activities and is the focus of the ICNG. Hence, for this assessment the noise goals have been determined in accordance with the ICNG.

A quantitative assessment methodology has been adopted for the potential construction noise impacts associated with the proposed development,. This methodology is detailed in Section 4 of the Guideline and involves the prediction of construction noise levels associated with the proposed development and assessment against the criteria defined in the Guideline.

Where construction noise is audible at residential premises, Section 2.2 of the Guideline recommends that construction should be limited to the following times:

- Monday to Friday, 7:00 am to 6:00 pm;
- Saturday, 8:00 am to 1:00 pm, otherwise 7:00 am to 1:00 pm if inaudible at residential premises; and
- No construction on Sundays or public holidays.

Although not mandatory these operational hours are a primary form of construction noise management adopted by the DECCW. In conjunction with typical 'feasible' and 'reasonable' measures (refer the Guideline) to minimise noise impacts – "feasible work practices are practical to implement, while reasonable work practices take into account the balance of costs and benefits and community views".

The criteria for noise from construction are assessed at residential properties and the noise management levels described in *Section 5.4.2*, derived in accordance with the Guideline, would be applicable during the proposed construction works.

5.4.2 Construction Noise Criteria

The ICNG sets out procedures to identify and address the impacts of construction noise on residences and other sensitive land uses. It does this by presenting assessment approaches that are tailored to the scale of construction projects and indicating how work practices can be modified to minimise noise. The ICNG provides detailed advice on the range of work practices and regulatory approaches to manage construction noise.

Table 5.4 Construction Noise Criteria at Residential Receivers

Noise Management Level	Noise Level
Noise affected	RBL + 10dB
Highly noise affected	75 dB(A)

Therefore, the L_{Aeq} noise level during construction should not exceed the background L_{A90} level by more than 10 dB. The proposed project specific construction noise criteria are presented in *Table 5.5*.

Table 5.5 Project Specific Construction Noise Criteria

Representative Locality	RBL, LA90 [1]	Noise Level LAeq, 15min, dB(A) [1]
R3 - Moreton St, Russell Vale	38	48
C4 - Bloomfield Ave, Russell Vale	37	47
C6 - Robson St, Russell Vale	39	49

1. Assuming construction is during day time hours only

5.5 VIBRATION CRITERIA

Environmental Noise Management - Assessing vibration: a technical guideline (DECCW 2006) presents preferred and maximum vibration values for use in assessing human responses to vibration from continuous, impulsive and intermittent sources. Potential vibration sources include movement of coal trucks. This type of vibration is assessed on the basis of vibration dose levels for intermittent events.

The acceptable vibration dose values for intermittent vibration at residences during daytime periods are presented in *Table 5.6*.

Table 5.6 Acceptable vibration dose values (VDV) for intermittent vibration (m/s $^{1.75}$)

Location	Daytime[1]	
	Preferred Value, m/s$^{1.75}$	**Maximum Value, m/s$^{1.75}$**
Residences	0.20	0.40

1. Daytime is 7.00am to 10.00pm.

6 EQUIPMENT DESIGN AND MITIGATION

6.1 EQUIPMENT DESIGN

Due to the close proximity of the Russell Vale site to residences in Russell Vale and the Corrimal area, the implementation of low noise equipment will be essential to meet the appropriate INP noise goals. The acoustic design parameters for acoustically significant plant and equipment for the Project are shown in *Table 6.1*.

Table 6.1 Sound Power Levels by Equipment Type

Equipment	SWL dB(A)
New Conveyors	70 dB(A) per metre
Existing Conveyors	82 dB(A) per metre
Conveyor Drive Assemblies (enclosed, inclusive of motor, coupling, gearbox and oil coolers)	94
Mine Ventilation Fan & Outlet	103
Sizing Tower (enclosed)	99
Existing Reclaim tunnel Fans	108
Compressor House	80
Pumphouse	84
Dozer (mitigated)	109
Excavator	106

6.2 ADDITIONAL MITIGATION MEASURES

Based on the outcomes of preliminary modelling, the following mitigation measures were incorporated in the model:

- a 3 m high barrier/ bund on the north side of the haul route to south of Broker Street, Russell Vale across the intersection with West Street; and
- a 3.6 m high roadside barrier on the north side of the haul route from the weighbridge to Princes Hwy.

The locations of these mitigation measures are presented in *Figure 6.1*.

Legend

- Project Application Area
- Barrier Location

Source:

Image © 2009 Google TM/Digital Globe

Suffix	*Revisions*	*Date*	*Init*
R0	Preliminary Issue	25-05-10	JD
R1		09-09-19	JD

Figure 6.1

Location of Mitigation Measures

Client:	Gujarat NRE Coking Coal Limited	
Project:	NRE No.1 Colliery Preliminary Works Noise Assessment	
Drawing No:	0079383h_PW_Noi_005_R1.cdr	
Date:	09/09/2010	Drawing size: A4
Drawn by:	JD	Reviewed by: MK
Scale:	Refer to Scale Bar	

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0 100 200m

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7 NOISE MODELLING METHODOLOGY

7.1 NOISE MODELLING

Noise level predictions must take into account all significant noise sources associated with the operation of the proposed coal handling facility. One method of determining the impact of numerous noise sources at a receiver is to develop a computer noise model of the proposed operations using a commercially available software package. The model used for this assessment was Version 7.01 of Brüel & Kjær Predictor Type 7810 computer noise modelling software using ISO9613.1 and 9613.2 Industry (International method for general purpose) noise propagation algorithms with CONCAWE meteorological factors for predicting noise impacts from industrial noise sources.

The model incorporated identifiable and significant noise source data, meteorological data, surrounding terrain characteristics and the barrier effects of proposed barriers. The model uses this information to predict the contributed noise levels from the proposed operations at the nearest potentially affected receivers.

7.2 METEOROLOGICAL PARAMETERS

The noise model was used to predict noise levels based on the meteorological conditions presented in *Table 7.1*.

Table 7.1 Site Specific Meteorological Conditions

Assessment Conditions	Temperature °C	Wind Speed / Direction	Relative Humidity	Temperature Gradient
Daytime – Calm	15 °C	n/a	60%	n/a
Evening – Calm	15 °C	n/a	80%	n/a
Night – Calm	10 °C	n/a	90%	n/a

7.3 OPERATIONAL NOISE SOURCES

Sound Power Levels (SWL) of acoustically significant plant and equipment associated with the proposed development as presented in *Table 6.1* have been incorporated into the noise model.

7.4 *OPERATING EQUIPMENT*

The operation will involve material handling facilities including the run of Colliery (ROM) delivery system, stacking, stockpiling and reclaim system and the truck loading facilities.

7.5 *OPERATIONAL MODELLING SCENARIOS*

The noise model was run for daytime, evening and night time operations based on normal operations with the proposed haul road for evening period ROM stockpile loading. The modelling incorporated the assumptions outlined in *Table 7.2*.

Table 7.2 Normal Operations – Equipment Use and Operating Hours

Equipment	Hours of operation	% of time operating	Comment
1x dozer	7.00 am to 6.00 pm Mon to Fri 8.00 am to 6.00 pm Sat	60% of operational hours	The dozer will push sized coal into the re-claim points for loading into the trucks via the existing truck loading infrastructure
1x excavator 345	7.00 am to 10.00 pm	60% of operational hours	-
Existing conveyors	24x7	100%	Covered
Proposed conveyor	24x7	100%	Enclosed
New sizer	27x7	100%	Enclosed
Existing truck loader	7.00 am to 6.00 pm Mon to Fri 8.00 am to 6.00 pm Sat	100% of daytime hours	10 trucks per hour
Evening operating loading from ROM stockpile	6.00 pm to 10.00 pm	100% evening hours	6 trucks per hour along revised haul route

The model assumes that all acoustically significant plant and equipment operates simultaneously.

8 OPERATIONAL NOISE ASSESSMENT

8.1 OPERATIONAL NOISE ASSESSMENT

8.1.1 Operational Noise Levels

The noise model was used to calculate noise levels from operations, as outlined in Section *7.5,* at the nearest residential receiver locations under the meteorological conditions described in *Table 7.1.* This scenario is considered to represent the worst-case scenario of surface operations as all plant and equipment is operational. The predicted noise contours around the Russell Vale site for each operating period are presented in *Figure 8.1.*

The single point calculation results for the proposed operational periods are presented in *Table 8.1* and are compared to the respective PSNLs.

Table 8.1 Calculated Operational Noise Levels

ID	Daytime Calm		Evening Calm		Night Calm	
	Predicted Level	**PSNL LAeq, 15min**	**Predicted Level**	**PSNL LAeq, 15min**	**Predicted Level**	**PSNL LAeq, 15min**
C1	38	42	37	41	37	37
C2	39	42	38	41	**38**	37
C3	39	42	37	41	36	37
C4	37	42	37	41	36	37
C5	40	44	40	43	40	40
C6	37	44	36	43	36	40
R1	43	43	**40**	39	**39**	37
R2	**44**	43	**40**	39	**39**	37
R3	43	43	**40**	39	**40**	37
R4	42	43	39	39	**38**	37

Note : All levels are dB(A)

Exceedances presented in bold text.

The results in *Table 8.1* indicate that noise levels from normal operations incorporating noise mitigation measures would comply with relevant PSNLs at most receivers for day and evening periods.

Minor exceedances of less than 1dB(A) are predicted at one receiver during day periods and three (3) receivers during evening periods in Russell Vale.

Minor exceedances of 3dB(A) or less are predicted during night time periods at five (5) receivers in Russell Vale and Corrimal.

The noise levels reported would require validation from attended noise monitoring upon commencement of operations.

The major contributing noise sources at these locations are the existing conveyors. The results indicate that in order to achieve further noise reductions during the night time period mitigation of the existing conveyors would be required. It is noted that the existing Bulli conveyor will be decommissioned and demolished upon completion of the new drivage, in mid to late 2012.

8.1.2 Contributing Residual Noise Sources

Moreton Street (R3) is predicted to experience noise levels up to 3 dB(A) over the PSNLs. This location receives direct line of sight exposure to the site operations.

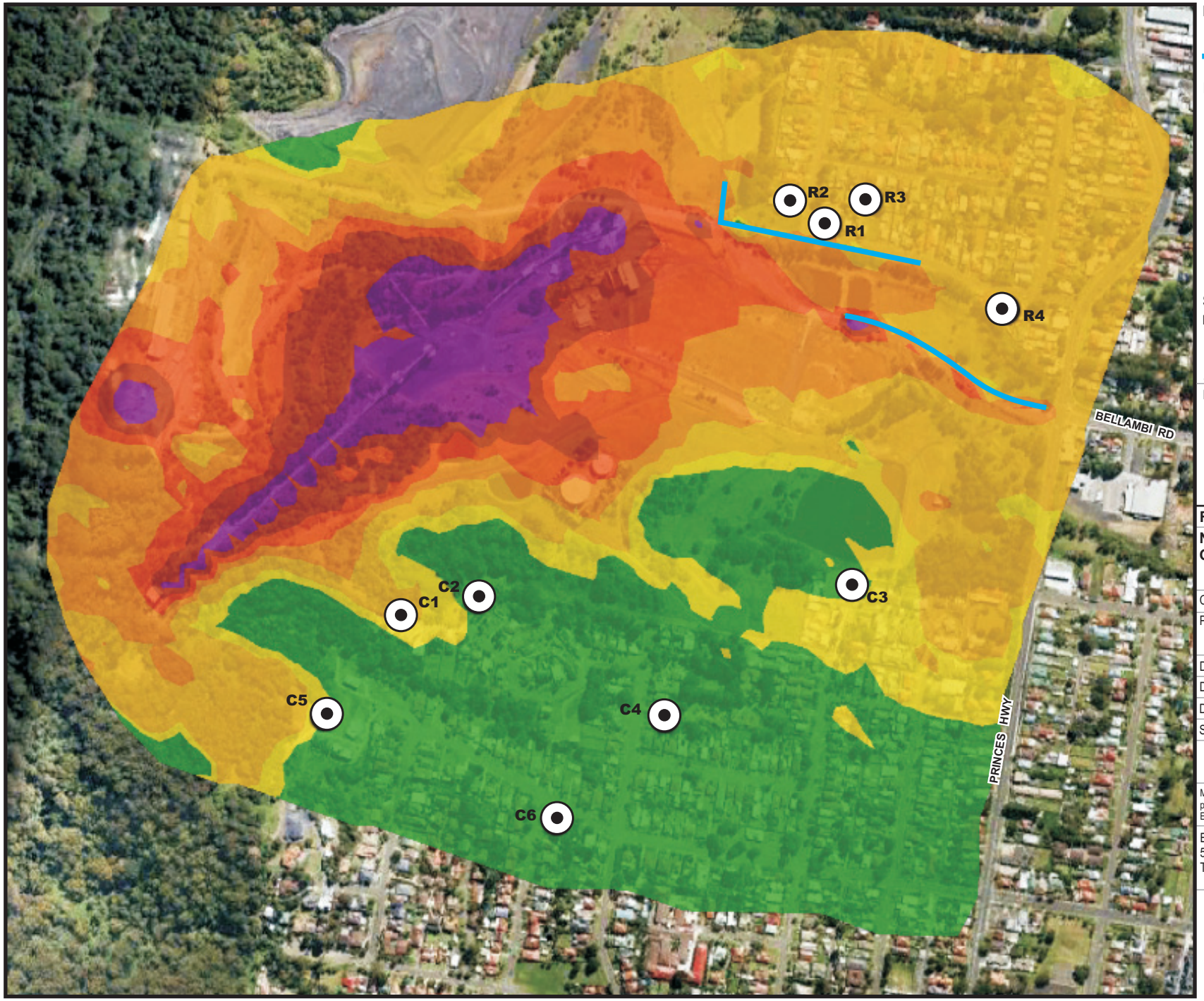
Assuming implementation of the mitigation measures described the major contributing noise sources at Moreton Street (R3) are as follows:

- existing conveyors;
- dozer reversing (daytime only);
- conveyor to rill tower;
- existing decline conveyor;
- truck loadout (daytime only);
- dozer pushing (daytime only);
- excavator (daytime only); and
- tunnel fans.

The received noise level at R3 is due to the contribution of existing and proposed operations, and requires the implementation of further mitigation measures or replacement of existing equipment. This will be achieved through the decommissioning of the Bulli conveyor, scheduled for mid to late 2012.

8.1.3 Sleep Disturbance

Noise levels associated with the Project are predicted to be less than 47 dB(A) at all receivers during night time periods, which complies with the sleep disturbance criteria for each representative area as outlined in *Table 5.2*.



Legend

Receiver Location

Barrier Location

Noise Levels

99dBA
65dBA
60dBA
55dBA
50dBA
44dBA
42dBA
35dBA

Source:

Image © 2009 Google TM/Digital Globe

Suffix	*Revisions*	*Date*	*Init*
R0	Preliminary Issue	25-05-10	JD

Figure 8.1

Noise Contours for Normal Operations - Calm Conditions

Client:	Gujarat NRE Coking Coal Limited	
Project:	NRE No.1 Colliery Preliminary Works Noise Assessment	
Drawing No:	0079383h_PW_Noi_006_R0.cdr	
Date:	25/05/2010	Drawing size: A4
Drawn by:	JD	Reviewed by: MK
Scale:	Refer to Scale Bar	

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9 ROAD TRAFFIC NOISE ASSESSMENT

9.1 COLLECTOR AND LOCAL ROADS

Unattended noise monitoring was undertaken to determine the contribution of Project-related road traffic noise levels along Bellambi Lane. To quantify the effect of traffic from the existing Project operations, noise levels were measured at 63 and 99 Bellambi Lane between 22 February and 4 March 2010. The results of these measurements are presented in *Annex C* and show when Project related trucks were, and were not in operation. This is discussed in *Section 4*.

The recorded noise levels (refer to *Section 4.2*) indicate that noise levels at receivers along Bellambi Lane currently exceed the relevant ERCTN criteria (*Table 5.3*). Therefore any increase in existing levels due to Project-related traffic must be less than 2 dB(A) (refer to *Table 5.3*) to comply with relevant criteria.

The results of the measurements, with and without Project trucks are summarised in *Table 9.1* and presented as the L_{Aeq} calculated over a fifteen hour period ($L_{Aeq, 15hr}$) and a one hour period ($L_{Aeq, 1hr}$).

Table 9.1 Existing Road Traffic Noise Levels

Location	Description	Leq, 15hr, dB(A)	Leq, 1hr Day, dB(A)
63 Bellambi Lane	Project-related Trucks Operating	65.3	67.1
	Project-related Trucks Not Operating	65.3	67.5
	Difference	**0.0**	**- 0.3**
99 Bellambi Lane	Project-related Trucks Operating	62.6	64.4
	Project-related Trucks Not Operating	61.7	63.9
	Difference	**- 0.9**	**0.5**

The results of the road traffic noise monitoring indicate that Project-related truck movements do not contribute significantly to daytime traffic noise along Bellambi Lane, with noise levels varying by less than 1 dB(A) when Project-related trucks are operational. Therefore road traffic impacts associated with the Project will be minimal and comply with relevant criteria as there will be no changes to road transportation.

To verify the findings of the noise logging, traffic counts were completed on Bellambi Lane, west of the northern distributor, between 30 August and 6 September 2010. A summary of the traffic volumes on Bellambi Lane are presented in *Table 9.2*.

Table 9.2 ***Comparison of Traffic Volumes post Northern distributor extension - Bellambi Lane between Northern Distributor and Princes Highway***

Time Period	Year	Total Vehicles, including coal trucks		
		Northbound Traffic	Southbound Traffic	Two Way Traffic
Average Weekday	2009 (actual count pre NDE)	7111	7269	14380
	2010 (actual counts post NDE)	3077	2616	5693
	% Difference pre NDE and post NDE	-56.7	-64.0	-60.4
Saturday	2009 (actual count pre NDE)	6940	7502	14442
	2010 (actual counts post NDE)	2598	2102	4700
	% Difference pre NDE and post NDE	-62.6	-72.0	-67.5
Sunday	2009 (actual count pre NDE)	5151	5585	10736
	2010 (actual counts post NDE)	1869	1548	3417
	% Difference pre NDE and post NDE	-63.7	-72.3	-68.2

The average percentage of heavy vehicles during this period was 4% and the average speed 54km/h. The 85th percentile speed was 61km/h. The maximum number of truck loads during the survey period was 110 (220 trips) on a weekday and 115 (130 trips) on Saturday, 4 September. There were no recorded truck movements on a Sunday (29 August or 5 September). Project related trucks made up 4% and 6% of the recorded post NDE traffic counts on Bellambi Lane for the respective average weekday and Saturday. Recorded truck movements between 29 August and 9 September 2010 are presented in *Table 9.3*.

Table9.3 Recorded Truck Movements during Traffic Survey Period

Date	Day	Number of Project Trucks loads (trips)
29 August 2010	Sunday	0
30 August 2010	Monday	0
31 August 2010	Tuesday	109 (118)
1 September 2010	Wednesday	109 (118)
2 September 2010	Thursday	110 (120)
3 September, 2010	Friday	0
4 September 2010	Saturday	115 (130)
5 September 2010	Sunday	0
6 September 2010	Monday	0
7 September 2010	Tuesday	91 (182)
8 September 2010	Wednesday	0
9 September 2010	Thursday	26 (52)

The traffic data presented in *Table 9.2* and *9.3* have been used to assess the validity of the measured noise levels on Bellambi Lane. Road traffic noise calculations, based on the traffic counts, have been completed in accordance with the procedures set out in the *Calculation of Road Traffic Noise* (CoRTN, UK DoT, 1988). This procedure is referenced in the Department of Environment, Climate Change and Water's (DECCW – formerly the EPA) *Environmental Criteria for Road Traffic Noise* (1999).

The CoRTN prediction methodology presents results in terms of $L_{10,18\text{-hour}}$. The traffic count data presented in *Table 9.2* has been converted from AADT to an 18-hour time period and a correction of -3 dB applied to convert predicted CoRTN $L_{10,18\text{-hour}}$ levels to $L_{Aeq,15\text{-hour}}$ levels for comparison with the baseline noise measurements presented in *Table 9.1*.

The results of calculated road traffic noise, based on the measured traffic volumes, are presented in *Table 9.4*.

Table 9.4 Calculated Road Traffic Noise Levels ($L_{Aeq, 15\text{-}hour}$), dB

Time Period	Predicted Road Traffic Noise based on 2009 Actual count Pre NDE	Predicted Road Traffic Noise based on 2010 Actual post NDE
Average weekday	65.7	61.9
Saturday	65.7	61.4
Sunday	64.4	60.0
Measured Level on Bellambi Lane *(Table 4.3)*	**62.6 – 65.3 dB** with Project related trucks operating; and **61.7 – 65.3 dB** without Project related trucks.	

Predicted noise levels, based on actual 2010 post NDE traffic volumes on Bellambi Lane range between 60.0 and 61.9 dB(A). The measured range was 62.6 and 65.3 dB when trucks were operating, and 61.7 and 65.3 dB when project trucks were not operating. Although on the lower end of the range, the predicted levels based on traffic volumes are comparable with the actual measured noise levels.

In general terms, road traffic needs to increase by 25% (or decrease by 20%) to change road traffic noise by 1 dB(A). Two way road traffic for an average weekday since the construction of the Northern Distributor has resulted in a reduction of 60% in road traffic on Bellambi Lane. Project related trucks contributed up to 4% of traffic on Bellambi Lane during the weekday, and no more than 6% on a Saturday during the traffic survey period.

Predicted road traffic noise levels, based on measured traffic volumes are comparable with the measured noise levels on Bellambi Lane reported in the noise assessment. Project truck movements do not contribute significantly to daytime traffic noise along Bellambi Lane.

10 CUMULATIVE NOISE IMPACT ASSESSMENT

The INP allows assessment of the potential cumulative noise impacts associated with existing and future developments by defining appropriate noise emission criteria with respect to maintaining the noise amenity at residential receivers and considering applicable consent limits. The cumulative impact of the Project has been assessed in relation to preserving the noise amenity at the nearest residential receivers.

As discussed in Appendix 2, the NSW Industrial Noise Policy (INP) prescribes detailed calculation routines for establishing "project specific" $L_{Aeq,\ 15min}$ intrusive criteria and $L_{Aeq,\ Period}$ amenity criteria at potentially affected receivers for a development (in isolation).

Potential cumulative noise impacts from existing and successive resource developments are embraced by the INP procedures by ensuring that the appropriate noise emission criteria (and approved limits) are established with a view to maintaining acceptable noise amenity levels for residences.

The recommended amenity noise levels for all receiver areas are 50 dB(A) $L_{Aeq,\ Day}$, 45 dB(A) $L_{Aeq,\ Eve}$ and 40 dB(A) $L_{Aeq,\ Night}$.

Predicted intrusive noise levels from the Project are below 50 dB(A) $L_{Aeq,\ 15min}$ during daytime periods, and 40 dB(A) $L_{Aeq,\ 15min}$ during evening and night time periods at the nearest residential receivers,.

Hence, the cumulative $L_{Aeq,\ Period}$ noise emission would not add to existing noise levels and would comply with INP amenity criteria during all operating periods for all residential receivers.

11 CONSTRUCTION NOISE ASSESSMENT

11.1 CONSTRUCTION PHASE

It is anticipated that the construction phase will extend over a period of approximately 9 months. This phase will involve the following activities:

- site preparation and construction earthworks;
- construction and sealing of haul roads; and
- construction of site facilities.

11.1.1 Construction Noise Sources

The model involved the simulation of typical construction methods for industrial developments, assuming construction hours are limited to those outlined by ICNG.

Construction activities will include site preparation, earthworks, construction of access roads and site facilities. The civil works phase activities will involve the use of typical machinery and equipment as shown in *Table 11.1*. Construction operations will occur during normal daytime hours.

The predicted noise levels assume attenuation from geometrical spreading only and neutral meteorological conditions (zero wind and temperature gradients). Other factors such as ground effects, air absorption and shielding due to natural topography and other nearby buildings have not been considered, hence the results are conservative.

Table 11.1 Typical Plant Noise Levels

Plant/Activity	Sound Power Level , dB(A)
Grader (CAT 24H)	112
Dozer (CAT D6R)	110
Excavator (CAT 345B)	106
Dump truck	110
Mobile Crane	105

11.1.2 Predicted Construction Noise Levels

Noise emissions from construction activities were incorporated into the noise model to determine potential noise impacts at the nearest residential receivers during the daytime period.

The sources were modelled at locations to present worst-case construction activities, with sources associated with construction of the new haul road situated at closest proximity to the receivers in Russell Vale.

The single point calculation results for the proposed construction activities are presented in *Table 11.2* and are compared to the respective construction noise criteria.

Table 11.2 Predicted Construction Noise Levels

Representative Area	Predicted Level, LAeq, 15min, dB(A)	Construction Noise Criteria LAeq, 15min, dB(A) [1]
R1	48	48
R2	47	48
R3,	46	48
R4	43	48
C1	39	47
C2	38	47
C3	41	47
C4	37	47
C5	39	49
C6	37	49

1. Assuming construction is during day time hours only.

The results presented in *Table 11.2* indicate that construction noise levels are predicted to comply with the DECCW's construction noise criteria (2009) at all residential receiver locations.

11.1.3 Noise Mitigation

Construction will be limited to Monday to Saturday and all residents will be notified of the start of works. Where feasible, mitigated site equipment will be used to minimise environmental noise emissions. Any complaints regarding environmental noise emissions will be investigated and responded to in an appropriate manner.

Personal protective equipment, such as ear protection, may be required by contractors operating particular machinery on site, or if there is numerous plant operating simultaneously.

All works will be undertaken in accordance with the DECCW's Interim Construction Noise Guideline (2009).

12 VIBRATION ASSESSMENT

Potential vibration sources include the day time movement of heavy vehicles as part of coal delivery operations.

The proposed coal transport route passes local residences, in particular along Bellambi Lane. Based on historical assessments for similar vehicle movements and receiver offset distances, vibration levels at this distance are expected to be less than 0.2 mm/s, which is considered to represent the human threshold of perception of vibration. As a result vibration impacts associated with truck movements are predicted to comply with DECCW criteria and are expected to have minimal impact on the community.

13 CONCLUSION

13.1 OPERATIONAL NOISE

The operational noise levels from the Project incorporating low noise design and additional noise mitigation measures would generally comply with relevant PSNLs at most receivers for day and evening periods. Minor exceedances of less than 1dB(A) are predicted at one receiver (R1) during the daytime period and at three (3) receivers (R1-R3) during evening period in Russell Vale. Minor exceedances of 3 dB(A) or less are predicted during night time periods at five (5) receivers in Russell Vale and Corrimal (R1-R4 and C5).

These exceedances are not expected to be noticeable and are expected to be quantified on compliance monitoring as part of the ongoing noise management plan for the site.

The cumulative noise impact of the Project is considered to comply with INP criteria.

13.2 SLEEP DISTURBANCE

The predicted noise levels meet the recommended DECCW sleep disturbance noise goals at the nearest residential receivers.

13.3 ROAD TRAFFIC NOISE

It is considered that road traffic noise levels along Bellambi Lane will be unchanged therefore comply with the requirements of the ECRTN.

13.4 CONSTRUCTION NOISE

Construction noise levels are predicted to comply with the requirements of DECCW's ICNG construction noise criteria (2009) at all residential receiver locations.

13.5 VIBRATION

Vibration impacts associated with onsite and offsite coal haulage are predicted to comply with the requirements of DECCW's intermittent vibration criteria (2006).

13.6 RECOMMENDATIONS

13.7 MITIGATION MEASURES

Based on the operating conditions modelled, it was found that to achieve compliance to within 2-3 dB(A) of the PSNLs for all operating periods, the following mitigation measures are required:

- 3 m high barrier to the south of Broker Street near the intersection with West Street, subject to powerline constraints; and
- 3.6 m high barrier to the north of the internal access road from weighbridge to the Princes Hwy.

These results, coupled with the proposed demolition of the Bulli conveyer indicate that the mitigation measures recommended are reasonable and practicable for the proposed stage of development of the site.

Minor exceedances of less than 1 dB(A) may occur at some receivers during the daytime and evening period with potential exceedances of up to 3dB(A) predicted during the night time period. However, it is considered that these exceedances would need to be confirmed upon the commencement of operations from attended noise monitoring and further measures to be undertaken would involve mitigation of existing plant.

Given that this phase of works is a preliminary phase prior to relocation of key noise-generating plant and infrastructure (such as the existing conveyors and truck loadout) further from the affected receivers, it is considered that these measures provide reasonable mitigation for this stage of operations.

13.8 NOISE MANAGEMENT PLAN

It is recommended that an operational Noise Management Plan (NMP) be developed to specifically address potential noise impacts associated with the proposed operations at the nearest receivers.

The NMP should outline methods and procedures to manage the following:

- results of the regular noise monitoring program on-site and within the surrounding area;
- response to any complaints or issues raised by the owner of the affected residence; and
- noise mitigation measures and operating procedures to ensure compliance with noise goals.

Noise monitoring data from the early stages of Project operations should be utilised to calibrate an operational specific noise model, to refine the potential predicted noise impacts during the worst case scenario.

The ability to monitor noise emissions during the early operating scenario where noise levels are predicted to comply with the criteria will enable pro-active noise management methods and suitable noise mitigation methods to be implemented during the worst case operational scenario.

13.9 NOISE MONITORING PROGRAM

It is recommended that an operational noise monitoring program be developed to monitor noise emissions from the proposed operations to determine ongoing compliance with PSNLs and to identify any further feasible noise mitigation measures that can be implemented.

The monitoring program should be implemented during periods of maximum production to confirm the acoustic performance of the proposed operations. Further monitoring would be undertaken as a result of any complaints received during the life of the proposed operations.

13.10 REPORTING

The results of the noise monitoring program should be reviewed by the operations manager to assess compliance with the goals outlined in *Section 5* and reported in accordance with any requirements of the development consent or Environment Protection Licence required for the Project under the POEO Act.

REFERENCES

NSW Environment Protection Authority 1994, Environmental Noise Control Manual.

NSW Environment Protection Authority 2000, New South Wales Industrial Noise Policy.

Department of Environment and Climate Change, INP application notes – July 2006.

Department of Environment and Climate Change, Environmental Criteria for Road Traffic Noise (1999).

Department of Environment and Climate Change (July, 2009). Interim Construction Noise Guidelines.

Annex A

Glossary of Terms, Definitions and Abbreviations

A.1 GLOSSARY AND DEFINITIONS - ACOUSTICS

1/3 Octave	Single octave bands divided into three parts
Octave	A division of the frequency range into bands, the upper frequency limit of each band being twice the lower frequency limit.
ABL	Assessment background level - A single-figure background level representing each assessment period – day, evening and night (that is, three assessment background levels are determined for each 24-h period of the monitoring period). It is determined by taking the lowest 10th percentile of the L_{90} level for each assessment period.
Airblast	Sound wave from blasting (overpressure).
Ambient Noise	The noise associated with a given environment. Typically a composite of sounds from many sources located both near and far where no particular sound is dominant.
A Weighting	A standard weighting of the audible frequencies designed to reflect the response of the human ear to noise.
dB(A), dBA	Decibels A-weighted.
dB(Z), dB(L)	Decibels Linear or decibels Z-weighted.
Decibel (dB)	The units of sound level and noise exposure measurement where a step of 10 dB is a ten-fold increase in intensity or sound energy and actually sounds a little more than twice as loud.
Hertz (Hz)	The measure of frequency of sound wave oscillations per second - 1 oscillation per second equals 1 hertz.
L_{A10}	The percentile sound pressure level exceeded for 10% of the measurement period with 'A' frequency weighting calculated by statistical analysis. Typically used to assess the impact of an existing operation on a receiver area and is referred to as the cumulative noise levels at the receiver attributable to the noise source.
L_{A90}	Background Noise Level. The percentile sound pressure level exceeded for 90% of the measurement period with 'A' frequency weighting calculated by statistical analysis.
L_{Max}	The maximum of the sound pressure levels recorded over an interval of 1 second.

$L_{A1, 1min}$	The measure of the short duration high-level noises that cause sleep arousal. The noise level is measured as the percentile sound pressure level that is exceeded 1 per cent of measurement period with 'A' frequency weighting calculated by statistical analysis during a measurement time interval of 1 minute.
$L_{Aeq,t}$	Equivalent continuous sound pressure level - The value of the sound pressure level of a continuous steady noise that, a measurement interval of time (t), has the same mean square sound pressure as the sound under consideration whose level varies with time. Usually measured in dB with 'A' weighting.
L_{An}	Percentile level - A measure of the fluctuation of the sound pressure level which is exceeded 'n' per cent of the observation time.
MIC	Maximum explosive charge mass (kg) detonated per delay (any 8ms interval).
PVS (mm/s)	Peak Vector Sum.
PPV (mm/s)	Peak Particle Velocity.
RBL	Rating background level - The overall single figure background level representing each assessment period over the whole monitoring period determined by taking the median of the ABLs found for each assessment period.
SD (m)	The scaled distance for airblast and ground vibration from the charge to the receiver.
SPL, Lp	Sound pressure level - The basic measure of noise loudness. The level of the root-mean-square sound pressure in decibels given by: $SPL = 10.\log10 (p/p_o)^2$ where p is the rms sound pressure in pascals and p_o is the sound reference pressure at 20 μPa. decibels.
SWL, Lw	Sound power level - A measure of the energy emitted from a source as sound and is given by: $SWL = 10.\log10 (W/W_o)$ where W is the sound power in watts and W_o is the sound reference power at 10^{-12} watts.

Annex B

INP Assessment Methodology

B.1 NOISE IMPACT ASSESSMENT PROCEDURES

B.1.1 Industrial Noise Policy

Responsibility for the control of noise emissions in NSW is vested in Local Government and the DECC. The Industrial Noise Policy (INP) released by DECC in December 2000, provides a framework and methodology for deriving limit conditions for consent and licence conditions. Using this policy the DECC regulates premises that are scheduled under the *Protection of the Environment Operations Act, 1997* (POEO Act).

The specific INP objectives are:

- to establish noise criteria that would protect the community from excessive intrusive noise and preserve amenity for specific land uses;
- to use the criteria as the basis for deriving project-specific noise levels;
- to promote uniform methods to estimate and measure noise impacts, including a procedure for evaluating meteorological effects;
- to outline a range of mitigation measures that could be used to minimise noise impacts;
- to provide a formal process to guide the determination of feasible and reasonable noise limits for consent or licence conditions that reconcile noise impacts with the economic, social and environmental considerations of industrial development; and
- to carry out functions relating to the prevention, minimisation and control of noise from premises scheduled under the POEO Act.

The INP is designed for large and complex industrial sources and outlines processes designed to strike a feasible and reasonable balance between the operation of industrial activities and the protection of the community from noise levels that are intrusive or unpleasant.

The application of the INP involves the following processes:

- determining the project-specific noise levels (PSNL) from intrusiveness and amenity based measurement of the existing background and ambient noise levels;
- predicting or measuring the noise levels produced by the development; and
- comparing the predicted noise levels with the project-specific noise levels and assessing impacts.

Where the project-specific noise levels are predicted to be exceeded the INP provides guidelines on the assessment of feasible and reasonable noise mitigation strategies, including:

- 'weighing up' the benefit of the development against the social and environmental costs resulting from the noise impacts;
- establishment of achievable and agreed noise limits for the development in consultation with the consent authority; and
- undertaking performance monitoring of environmental noise levels to determine compliance with the consent and licence conditions.

B.1.2 DECCW Assessment Methodology

There are two criteria to consider when establishing project-specific noise levels for the assessment of industrial noise sources. These criteria are:

- the intrusive noise criterion, which is based on the background noise level plus 5 dB. The background noise level, or Rating Background Level (RBL), is determined in accordance with Section 3 of the INP and is based on the use of noise monitoring data to establish the assessable background noise levels; and
- the noise amenity criterion, which is based on the recommended noise levels in the INP for prescribed land use. The recommended acceptable and maximum ambient noise levels are outlined in Table 2.1 of the INP. Table 2.2 of the INP outlines the requirements for developments where the existing noise level from industrial noise sources is close to the acceptable noise level.

The relevant tables in Section 2 of the INP relating to the amenity criteria relevant to the Project are presented in *Table B.1* and *Table B.2*.

Table B.1 Amenity Criteria – Recommended L_{Aeq} Noise Levels from Industrial Noise Sources

Type of Receiver	Indicative Noise Amenity Area	Time of Day	Recommended LAeq Noise Level	
			Acceptable	Recommended Maximum
Residence	Rural	Day	50 dB(A)	55 dB(A)
		Evening	45 dB(A)	50 dB(A)
		Night	40 dB(A)	45 dB(A)
	Suburban	Day	55 dB(A)	60 dB(A)
		Evening	45 dB(A)	50 dB(A)
		Night	40 dB(A)	45 dB(A)
	Urban	Day	60 dB(A)	65 dB(A)
		Evening	50 dB(A)	55 dB(A)
		Night	45 dB(A)	50 dB(A)
	Urban/Industrial Interface - for existing situations only	Day	65 dB(A)	70 dB(A)
		Evening	55 dB(A)	60 dB(A)
		Night	50 dB(A)	55 dB(A)
Area specifically reserved for passive recreation	All	When in use	50 dB(A)	55 dB(A)
Active recreation area (School playground, golf course)	All	When in use	55 dB(A)	60 dB(A)
Commercial premises	All	When in use	65 dB(A)	70 dB(A)
Industrial premises	All	When in use	70 dB(A)	75 dB(A)

Note 1: For Monday to Saturday, Daytime 7.00 am - 6.00 pm; Evening 6.00 pm - 10.00 pm; Night-time 10.00 pm - 7.00 am On Sundays and Public Holidays, Daytime 8.00 am - 6.00 pm; Evening 6.00 pm - 10.00 pm; Night-time 10.00 pm - 8.00 am.

Note 2: The LAeq index corresponds to the level of noise equivalent to the energy average of noise levels occurring over a measurement period.

Table B.1 ***Modification to Acceptable Noise Level (ANL) to Account for Existing Levels of Industrial Noise***

Total Existing LAeq Noise Level from Industrial Noise Sources	Maximum LAeq Noise Level for Noise from New Sources Alone, dB
≥ Acceptable noise level plus 2 dB	If existing noise level is likely to decrease in future acceptable noise level minus 10 dB If existing noise level is unlikely to decrease in future existing noise level minus 10 dB
Acceptable noise level plus 1 dB	Acceptable noise level minus 8 dB
Acceptable noise level	Acceptable noise level minus 8 dB
Acceptable noise level minus 1 dB	Acceptable noise level minus 6 dB
Acceptable noise level minus 2 dB	Acceptable noise level minus 4 dB
Acceptable noise level minus 3 dB	Acceptable noise level minus 3 dB
Acceptable noise level minus 4 dB	Acceptable noise level minus 2 dB
Acceptable noise level minus 5 dB	Acceptable noise level minus 2 dB
Acceptable noise level minus 6 dB	Acceptable noise level minus 1 dB
< Acceptable noise level minus 6 dB	Acceptable noise level
Note 1: ANL = recommended acceptable LAeq noise level for the specific receiver.	

In assessing the noise impacts from industrial sources at residential receivers both criteria are considered. For each period (day, evening and night) the most stringent of either the intrusive or amenity criteria becomes the limiting criterion and forms the project-specific noise level for the industrial source.

If the existing ambient noise level is close to the acceptable noise level, a new source must be controlled to preserve the amenity of the surrounding area. If the overall noise level from the industrial source already exceeds the acceptable noise level for the affected area, the L_{Aeq} noise level from a new source should meet the conditions set out in Table 2.2 of the INP.

B.1.3 INP Project-Specific Criteria

The INP states that the criteria outlined in *Table B.1* and *B.2* have been selected to protect at least 90 per cent of the population living in the vicinity of industrial noise sources from the adverse effects of noise for at least 90 per cent of the time. Provided the criteria in the INP are achieved, it is unlikely that most people would consider the resultant noise levels excessive.

Table B.3 presents the methodology for assessing noise levels which may exceed the INP project-specific noise assessment criteria.

Table B.2 Noise Impact Assessment Methodology

Assessment Criterion	Project-Specific Criteria	Noise Management Zone	Noise Affectation Zone
Intrusive	Rating background level plus 5 dB	≤ 5 dB above project-specific criteria	≥ 5 dB above project-specific criteria
Amenity	INP based on existing industrial level	≤ 5 dB above project-specific criteria	≥ 5 dB above project-specific criteria

For the purposes of assessing the potential noise impacts the project-specific, management and affectation criteria are further defined in the following sections.

Project-Specific Criteria

Most people in the broader community would generally consider exposure to noise levels that achieve the project-specific criteria acceptable.

Noise Management Zone

Depending on the degree of exceedance of the project-specific criteria (1 dB to 5 dB) noise impacts in this zone could range from negligible to moderate. It is recommended that management procedures be implemented including:

- prompt response to any issues of concern raised by community;
- noise monitoring on-site and within the community;
- refinement of on-site noise mitigation measures and plant operating procedures where practical;
- consideration of acoustical mitigation at receivers; and
- consideration of negotiated agreements with property holders.

Noise Affectation Zone

Exposure to noise levels corresponding to this zone (more than 5 dB above project-specific criteria) may be considered unacceptable by some property holders and implementation of the following measures may be required:

- discussions with relevant property holders to assess concerns and provide solutions;
- implementation of acoustical mitigation at receivers; and
- negotiated agreements with property holders.

B.1.4 Assessing Sleep Disturbance

The DECCW has acknowledged that the relationship between maximum noise levels and sleep disturbance is not well defined. Criteria for assessing sleep disturbance have not been defined under the INP but it is assumed that compliance with the INP will minimise the potential for sleep arousal. Notwithstanding, sleep arousal has been assessed using the guidelines set out in Section 19-3 of the DECCW's Environmental Noise Control Manual (ENCM) (DECC, 1994).

To avoid the potential for sleep disturbance the ENCM recommends that the $L_{A1,1min}$ of the noise source should not exceed the background noise level (L_{A90}) by more than 15 dB(A). This is based on measurement outside the bedroom window of the receiver during the night-time hours (10.00 pm to 7.00 am).

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Annex K

NRE No. 1 Mine V Mains Area - Effects Of Mine Subsidence On Aquatic Habitats And Biota

Cardno Ecology Lab

Shaping the Future

Marine and Freshwater Studies

NRE No 1 Mine V Mains Area

Effects of Mine Subsidence on Aquatic Habitats and Biota

Job Number: EL0809061 A

Prepared for ERM (Australia) Pty Ltd

Final June 2009

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Cover Image: Bellambi Creek. Photographer Doug Hazell, Cardno Ecology Lab

Document Control

Job Number	Status	Date	Author		Reviewer	
EL0809061 A	Draft	13 March 2009	Theresa Dye	TAD	Doug Hazell	DH
	Final	24 June 2009	Theresa Dye	TAD		

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Executive Summary

Background

Gujarat NRE Minerals Limited (Gujarat) proposes to use pillar extraction methods to extract coal from a remnant section of the Bulli Seam located within the V Mains area of the NRE No. 1 Mine at Russell Vale, in the Southern Coalfield. Environmental Resources Management, Australia (ERM), on behalf of Gujarat, commissioned Cardno Ecology Lab Pty Ltd to describe the existing aquatic habitats and biota potentially subject to impacts from the proposed mining and to provide an assessment of the likelihood and significance of these impacts, with recommendations for ongoing monitoring prior to, during and after mining . This assessment will be included in the Subsidence Management Plan (SMP) currently being prepared for submission to the Department of Primary Industries Minerals and Petroleum (DPIMP), as part of the approval process required to extend the mine.

Overview of Aquatic Habitats and Biota

The Application Area is traversed by the main channel and an ephemeral tributary of Wallandoola Creek. The eastern end of the Application Area is situated 100-160 m to the west of the upper reach of Lizard Creek. Both watercourses drain into Cataract River between Broughtons Pass Weir and Cataract Dam. The surrounding land is moderately to gently undulating and relatively undisturbed due to the inclusion of the greater Cataract River catchment within the Metropolitan Special Area. Wallandoola Creek is poorly defined within the Application Area and dominated by swamp vegetation, with only a few small permanent pools. The unnamed tributary that traverses the Application Area is characterised by small areas of semi-permanent aquatic habitat. The reach of Lizard Creek adjacent to the Application Area is characterised by extended, shallow, reed-filled pools bounded by isolated sandstone ridges. The most upstream area of significant permanent aquatic habitat in Lizard Creek is situated approximately 120 m east of the Application Area and is characterised by headwater swamp habitat. The downstream reaches of these watercourses are characterised by deeply incised sandstone gorges with cascades and waterfalls.

The quality of water in Wallandoola Creek and Lizard Creek has been assessed in the vicinity of V Mains, but not directly above the Application Area as there was not suitable permanent water courses present. The water sampling was undertaken at locations immediately down stream of the application area and these are appropriate for the study of the water quality and the possible impacts that might arise from mining. The water quality has generally been found to be within the acceptable range for potable water, except for pH, which was below the ANZECC 2000 guidelines. The filtered zinc, copper, aluminium, total nitrogen and phosphorus levels have on occasion been above the 95% species protection level for freshwater aquatic ecosystem guidelines.

The baseline aquatic ecology surveys showed that permanent aquatic habitats in the headwater swamp sections of the creeks immediately downstream and to the east of the Application Area support instream aquatic macrophytes, such as ribbonweed (*Vallisneria gigantea*) and spikerush (*Eleocharis* sp.), and native sedge (*Juncus* sp.). In spring 2007, the macroinvertebrate fauna in this region of the two creeks was

categorized as significantly impaired relative to the AUSRIVAS reference condition, with only 20 taxa being recorded in Wallandoola Creek and 23 in Lizard Creek. No fish were caught in the upper reaches of Wallandoola Creek and Lizard Creek, however, native freshwater crayfish (*Euastacus* sp.) were observed.

Assessment of Impacts

The mine-induced subsidence predictions for the V-Mains Area indicate that there are unlikely to be observable adverse effects on stream flow or water quality. It is consequently highly unlikely that there would be any observable flow-on effects on aquatic habitats or their biota within or immediately downstream of the Application Area.

There is, however, a possibility of a localised increase in the natural stream gradient, because the maximum predicted tilt exceeds the gradient of the creeks flowing through the Application Area. This, in turn, could lead to an increase in flow rate, migration of flow channels, erosion of the stream bank and bed, and reduction in the volume and retention time of pools. The mobilization of sediment could reduce the quality of some of the habitats available for occupation by aquatic biota. The changes in pool volume and retention time could decrease the connectivity between habitats, particularly during periods of low flow. The impact on aquatic biota within the Application Area could be locally significant within a small 300m reach of the watercourse directly above the mine area, because there are only a few small, permanent pools within this section of Wallandoola Creek and a few small areas of semi-permanent aquatic habitat within its unnamed tributary. This represents only a very small proportion of the local aquatic habitat. The relatively large pools 300m downstream in Wallandoola Creek would be largely unaffected.

Three threatened species, Adam's Emerald Dragonfly (*Archaeophya adamsi*), Sydney Hawk Dragonfly (*Austrocordulia leonardi*) and Macquarie Perch (*Macquaria australasica*) could potentially occur within the Application Area. A formal assessment of impacts is not considered necessary for Sydney Hawk Dragonfly, because the nearest suitable habitat is in the Cataract River, which is beyond the influence of mining. Nor is one considered necessary for Macquarie Perch, because the waterfalls that occur on the creeks downstream of the Application Area would prevent upstream passage of this fish. The headwater swamp section of Wallandoola Creek that flows through the Application Area does not contain suitable habitat for Adam's Emerald Dragonfly. There does, however, appear to be a limited amount of suitable habitat, in the form of cascade-riffles, available in the sandstone gorge sections of Wallandoola and Lizard Creeks downstream of the Application Area. Although a seven-part test has been included for Adam's Emerald Dragonfly, a species impact statement is not considered necessary, because there is no suitable habitat within the Application Area.

Recommendations for Monitoring

The strategic review of the environmental impacts of underground coal mining in the Southern Coalfield recommends that monitoring should be undertaken prior to, during and after mining within the Application Area and at comparable control locations outside the area affected by mining. The nearest permanent aquatic habitats suitable for monitoring the aquatic ecology of Wallandoola Creek and Lizard Creek is located within the headwater swamp region of the creeks approximately 300

m downstream and 120 m to the east of the Application Area, respectively. The monitoring sites that were established in these regions are thus only suitable for assessment of far-field effects of the mine. As a precautionary measure, it is recommended that additional observations of aquatic habitats be made and surveys of aquatic macroinvertebrates be undertaken only in the headwater swamp regions of the potential impact and control locations during and after mining. If changes in the depth and quality of the water within Wallandoola Creek and Lizard Creek that are greater than anticipated on the basis of the subsidence predictions are detected, an immediate survey of aquatic macroinvertebrates should be triggered at the monitoring sites within the headwater swamp region of all four creeks.

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1 Introduction

1.1 Background and Aims

Gujarat NRE Minerals Limited (Gujarat) proposes to use pillar extraction methods to extract coal from a remnant section of the Bulli Seam located within the V Mains area of the NRE No. 1 Mine at Russell Vale, in the Southern Coalfield. The remnant section of coal is situated between the longwall panels of the former Cordeaux Colliery and the 200 series longwall panels of the former South Bulli Colliery (now NRE No. 1 Colliery). The extraction of coal from this remnant block has the potential to impact on aquatic habitats and biota within watercourses located within, and downstream of, the mine area.

Environmental Resources Management, Australia (ERM), on behalf of Gujarat, commissioned Cardno Ecology Lab Pty Ltd (formerly The Ecology Lab) to describe the existing aquatic habitats and biota potentially subject to impacts from the proposed mining and to provide an assessment of the likelihood and significance of these impacts, with recommendations for ongoing monitoring prior to, during and after mining. This assessment is to be included in the Subsidence Management Plan (SMP) for the 'Application Area' currently being prepared by ERM, on behalf of Gujarat, for submission to the Department of Primary Industries Mineral Resources (DPIM), as part of the required approval process. The 'Application Area' is defined as the surface area within the wedge shape block of remnant coal ranging from 75 m to 340 m wide and approximately 2 km in length referred to as the V Mains.

1.2 Legislative Context

1.2.1 Mining Act 1992

Primary regulatory control of mining is exercised by the Department of Primary Industry Minerals and Petroleum (DPIMP) through the provisions of the *Mining Act* 1992 and the conditions attached to mining leases granted under the provisions of that Act. The NSW Government introduced a new subsidence management policy and approvals process in 2004 with the objective of improving the assessment, management and regulation of subsidence effects due to underground coal mining (NSW DPI 2006). The policy and approvals process requires mining operators to prepare a Subsidence Management Plan (SMP) to provide for the protection of important natural and built features.

1.2.2 Fisheries Management Act 1994

The *Fisheries Management Act* 1994 *(FM Act)* provides for the declaration and listing of threatened species of fish and marine vegetation, endangered populations and ecological communities and key threatening processes. One of the major features of this legislation is the integration of threatened aquatic species into the development control processes under the *Environmental Planning and Assessment Act* 1979 (*EP& A Act*) (see Section 1.2.4).

1.2.3 Threatened Species Conservation Act 1995

The *Threatened Species Conservation Act* (*TSC Act*), administered by the NSW Department of Environment and Climate Change, outlines the protection of threatened species, populations, communities and critical habitat in New South Wales. The *TSC Act* also identifies key threatening processes that increase the risk of extinction of species and recommends strategies for enhancing the recovery of threatened species and abatement of key threatening processes. Alteration of habitat following subsidence due to longwall mining is listed as a key threatening process. The Minister of the Environment has determined that the SMP process addresses this key threatening process and that a Threat Abatement Plan is unnecessary (NSW DPI 2006).

1.2.4 Environmental Assessment and Planning Act 1979

The *EP&A Act* sets out the factors to be considered in a preliminary assessment of whether a development is likely to have significant effects on threatened species. Seven factors are considered in a process referred to as the Seven-Part Test. The test is a series of questions, the answers to which assist in determining whether a planned action will significantly affect threatened species, populations, ecological communities or their habitats. The Seven-Part Test is relevant only if there is a likelihood of one or more threatened species occurring in the area affected by the proposal. If the approval agency, on the basis of the Seven-Part Test, determines that the proposal is likely to significantly affect threatened species, populations, ecological communities or their habitats, a Species Impact Statement (SIS) must be prepared as part of the environmental assessment process for SMP approval of the proposal under Part 5 of the EP&A Act.

1.2.5 Environmental Protection and Biodiversity Conservation Act 1999

The Commonwealth Government's instrument for national environmental protection is the *Environmental Protection and Biodiversity Conservation Act 1999* (*EPBC Act*). Under the *EPBC Act*, any action which has, will have, or is likely to have a significant impact on a matter of national environmental significance, or is undertaken on Commonwealth land is defined as a controlled action and as such requires approval by the Minister for the Environment. The *EPBC Act* has provisions for the listing of threatened species and threatened ecological communities and requires proponents to consider impacts on threatened species.

2 Overview of Aquatic Habitats and Biota within the Application Area Sampling Design

The overview of aquatic habitats and biota in within and in the vicinity of the Application Area draws upon two studies of aquatic ecology undertaken previously in the V Mains area:

- NRE No. 1 Mine – V Mains Aquatic Ecology Baseline Monitoring Program June-August 2007 Survey Baseline Progress Report 1(The Ecology Lab 2007); and
- NRE No. 1 Mine – V Mains. Aquatic Ecology Baseline Monitoring Program Baseline Report (The Ecology Lab 2008).

Reference is also made to the surface water and groundwater assessment for V Mains prepared by Geoterra (2009).

2.1 Physical Setting

The V Mains area of NRE No. 1 Mine is located within the Cataract River Catchment of the Upper Hawkesbury – Nepean River system. The natural environment in this area is relatively undisturbed due to the restrictions on access and development arising from the inclusion of the greater Cataract River catchment within the Metropolitan Special Area administered by Sydney Catchment Authority (SCA). The landscape is moderately to gently undulating within the V-Mains Area, but characterised by rolling to steep hills further downstream (Geoterra 2009). The 'Application Area' is traversed by the main channel and an ephemeral tributary of Wallandoola Creek. The eastern end of the Application Area is situated 100-160 metres to the west of the upper reach of Lizard Creek. This creek will not be undermined by the V Mains. Both watercourses drain into the reach of the Cataract River located between Broughtons Pass Weir and Cataract Dam.

The upper reach of Wallandoola Creek traverses the eastern side of the Application Area and the unnamed tributary crosses the western side of the area. The reach of the creek drops approximately 10 m over the 1250 m stretch within the Application Area and has an average gradient of 0.8 mm/m (Geoterra 2009). The upper reach of Lizard Creek situated to the east of the Application Area drops approximately 10 m over the 1400 m stretch adjacent to the Application Area and has an average gradient of 0.71 mm/m (Geoterra 2009). There is also a valley infill swamp area (also referred to as a headwater swamp) along the riparian channel periphery of Wallandoola Creek within the Application Area (Geoterra 2009).

The reaches of Wallandoola and Lizard Creek immediately downstream of the Application Area are characterised by headwater swamps, with relatively low gradient (The Ecology Lab 2008). DECC considers the cluster of headwater swamps associated with Wallandoola Creek to be significant because they provide large contiguous areas of similar habitat (NSW Planning 2008). Further downstream, the stream gradient increases and watercourses are characterised by deeply incised sandstone gorges. There are numerous cascades and waterfalls on these creeks between the proposed mining area and their confluence with the Cataract River.

2.2 Water Quality

The quality of water within the reaches of Wallandoola Creek and Lizard Creek in the vicinity of the V Mains Area has been assessed on several occasions since September 2001 (Australian Water Technologies 2001; Seedsman Geotechnics 2001; Geoterra 2002; The Ecology Lab 2008). Regular monitoring has also been undertaken at several locations between July 2007 and July 2008 (ERM 2008). None of these monitoring sites are located within the Application Area.

The regular monitoring undertaken since July 2007 indicates that the water in these creeks was generally within the acceptable range for potable water, except for pH, which was lower (i.e. more acidic) than the ANZECC 2000 default trigger values (Geoterra 2009). The measurements of pH taken in both the headwater swamp and sandstone gorge regions of these creeks during August and November 2007 were also below the trigger values (The Ecology Lab 2008). It should, however, be noted that relatively acid streams are quite common in the Hawkesbury Sandstone watercourses of the Southern Highlands and Illawarra. The Ecology Lab (2008) also noted that turbidity levels in both creeks were generally below the lower trigger value during both sampling periods and that in November the dissolved oxygen concentration was below the lower ANZECC trigger value, particularly in Lizard Creek. The regular monitoring program also showed that on some occasions the filtered zinc, copper and aluminium and total nitrogen and phosphorus levels were above the 95% species protection level for freshwater aquatic ecosystem guidelines.

2.3 Aquatic Habitats

The information on the aquatic habitats in the upper reaches of Wallandoola Creek and Lizard Creek presented below is derived from The Ecology Lab (2008) and Geoterra (2009).

2.3.1 Wallandoola Creek

The section of Wallandoola Creek traversing the Application Area is poorly defined and dominated by swamp vegetation with only a few small permanent pools (The Ecology Lab 2008). There are two small areas of semi-permanent aquatic habitat within the section of the unnamed tributary of Wallandoola Creek traversing the Application Area (The Ecology Lab 2007). At the upstream end of this location, there is a pool (approximately 15 m long, 3 m wide with a maximum depth of 2 m) with swamp habitat. At the downstream end of this location, the outflow from the swamp flowed over a bedrock cascade into a small pool.

The Ecology Lab (2007) noted a series of large pools (> 100 m long x 10 m wide) approximately 300 m downstream (north) of the Application Area. The substratum at this location is dominated by sandstone bedrock, but gravel, sand and silt are also present. There are several deep (approximately 3 m) holes in the bedrock which would provide permanent refuge habitat during extended dry periods. There are several aquatic habitat features within this location, including snags, overhanging bank vegetation, rock crevices, earthen banks and beds of aquatic plants. The pools are backed up behind isolated exposed sandstone ledges and there is a small (< 0.5 m) drop from upstream to downstream pools (Geoterra 2009). The stream banks are up to 1.0 m high and vegetated by riparian sedge or upland swamp. There is no

sign of significant erosion, bank instability and no significant iron floc within the section of the creek traversing the Application Area.

The watercourse approximately 250 m north of the western extent of the proposed mining area is characterised by sandstone gorge habitat (The Ecology Lab 2008). At the upstream end of this location, there is shallow flow over a 10 m wide section of sandstone bedrock. There are a few holes (approximately 1.5 m deep) containing sand in the bedrock. The upstream and downstream ends of this location are separated by a waterfall, which is approximately 15 m high and has a large plunge pool at its base. At the downstream end of the location, there are large boulders interspersed with small pools containing some sand and gravel. Further downstream, there is a moderate size pool (approximately 30 m long and 7 m wide with a maximum depth of 1.2 m) with a sandy substratum and some large sandstone boulders. The banks are lined with a variety of native grasses and shrubs. Iron staining, a feature which is often observed in streams in Hawkesbury Sandstone areas, is present throughout this location. There are several aquatic habitat features within this location, including cascade-riffles, snags, overhanging bank vegetation, rock crevices, earthen banks and beds of aquatic plants.

2.3.2 Lizard Creek

The reach of Lizard Creek to the east of the Application Area is characterised by extended, shallow, reed-filled pools bounded by isolated sandstone ridges (Geoterra 2009). Most of the banks are <0.5 m high and vegetated by flanking riparian sedge or upland swamps. Iron floc is present within the reed-filled sections of the channel upstream and downstream of the of the No. 4 Shaft access road crossing.

The most upstream area of significant permanent aquatic habitat identified by the Ecology Lab (2008) is situated at the point of outflow from the headwater swamp approximately 300 m upstream of the No. 4 Shaft access road crossing. At the upstream end of this location, there is a series of gentle cascades over bedrock substratum with one small pool with a maximum depth of 1.5 m. Approximately 300 m downstream of this, there are two large pools with a maximum depth of 3 m separated by a large stand of spikerush (*Eleocharis* sp.). The substratum varies between sandstone bedrock, and deposits of sand and silt in the pools. The aquatic habitats within this location include snags, overhanging bank vegetation, rock crevices, earthen banks and aquatic plants.

The unnamed tributaries of Lizard Creek are small ephemeral watercourses with very little permanent aquatic habitat (The Ecology Lab 2008).

2.4 Aquatic Macrophytes

No published information is available on the distribution of aquatic macrophytes within or in the vicinity of the watercourses in the Application Area. The species found instream and along the creek banks at the study sites investigated during the baseline surveys are recorded in The Ecology Lab (2008).

2.4.1 Wallandoola Creek

Numerous instream aquatic macrophytes, including ribbonweed (*Vallisneria gigantea*) and spikerush (*Eleocharis* sp.), were observed within the large pools in the

headwater swamp location. The native sedge *Juncus* sp. was common along the banks of these pools. At the sandstone gorge location, ribbonweed was observed instream while native plants, such as *Juncus* sp., sawsedge (*Gahnia* sp.), and numerous small ferns, were found along the stream banks.

2.4.2 Lizard Creek

At the headwater swamp location, ribbonweed and spikerush were observed instream and native sedge *Juncus* sp. was common along the banks. At the sandstone gorge location, ribbonweed was found instream while *Juncus* sp., *Gahnia* sp., and numerous small ferns, were observed along the bank.

2.5 Aquatic Macroinvertebrates

During the baseline surveys, a rapid assessment method based on the AUSRIVAS protocol and a quantitative sampling methodology was used to collect macroinvertebrates from the edges of pools at sites in the headwater swamp and sandstone gorge regions of Wallandoola and Lizard Creeks (The Ecology Lab 2008). A full complement of AUSRIVAS samples was collected in November, but only two sites were sampled in August. The results from the quantitative samples are not described, because they focus on temporal changes and spatial differences among creeks rather than the structure of assemblages in the individual creeks.

It should be noted that aquatic macroinvertebrates are susceptible to naturally occurring environmental such as drought, bush fire and flood. These can effect the assemblage of species within a watercourse and this may be reflected in AUSRIVAS results.

2.5.1 Wallandoola Creek

In November 2007, slightly fewer macroinvertebrate fauna were collected from the upstream end (17) than from the downstream end (20) of the headwater swamp location. The fauna at the upstream end of the headwater swamp was assessed as being significantly impaired (i.e. had fewer families than expected, while that at the downstream end was rated as equivalent to the AUSRIVAS reference condition (i.e. had most or all the expected families). At the sandstone gorge location, 16 taxa were collected at each sampling site. The fauna at both of these sites was rated as significantly impaired.

Growns *et al.* (1997) sampled the macroinvertebrate fauna associated with riffles and pool edge habitats at a site within Wallandoola Creek as part of an assessment of the cost and efficiency of six methods of sample processing. This study showed that there were slightly more macroinvertebrate families in the pool edge (21) than in the riffle sample (18). The Stream Invertebrate Grade Number – Average Level (SIGNAL) scores derived from the data indicates that the water at the study site was unpolluted.

2.5.2 Lizard Creek

In November 2007, slightly more macroinvertebrate fauna were collected from the upstream end (23) than from the downstream end (21) of the headwater swamp location. The fauna at the upstream end lacked a greater number of families with a

50% expected probability of occurrence (OE50 taxa score = 0.59) than the downstream end (OE50 taxa score = 0.81). Despite this, the AUSRIVAS predictive model rated the fauna at both sites as significantly impaired. Slightly fewer taxa were collected from the upstream (17) than the downstream end (19) of the sandstone gorge location. The AUSRIVAS predictive model rated the fauna at these sites as being significantly impaired and equivalent to the AUSRIVAS reference condition, respectively.

The macroinvertebrates associated with the edge habitat at a site in Lizard Creek adjacent to Fire Road 8 were also sampled in spring 2004 as part of Sydney Catchment Authority's Macroinvertebrate Monitoring Program: 2004 undertaken by (Ecowise 2005). The AUSRIVAS bands and SIGNAL2 scores for this site indicate respectively that the fauna was significantly impaired and the water was probably moderately polluted.

2.6 Fish

No fish were caught in the upper reaches of Wallandoola Creek and Lizard Creek during the initial baseline survey, undertaken using a backpack electrofisher and baited traps (The Ecology Lab 2007). However, native freshwater crayfish (*Euastacus* sp.) were observed and their burrows were found at both of the locations surveyed in each creek.

The fish sampling undertaken as part of the "Audit of Sydney Drinking Water Catchment 2007" indicated that three endemic species were present within Wallandoola Creek and that five endemic, one translocated and one introduced species were present in the Cataract River, downstream of Cataract Dam (DECC 2007). The only information given about the identity of the fish caught in these watercourses was that Macquarie Perch (*Macquaria australasica*), a species listed as vulnerable under the *FM Act*, was caught in the Cataract River at Jordans Pass.

The Ecology Lab (2003 and 2005) caught three native species, Macquarie Perch, Flathead Gudgeon (*Philypnodon grandiceps*), and Australian Smelt (*Retropinna semoni*) and one introduced species, the Mosquito Fish (*Gambusia holbrooki*) in the Cataract River between Cataract Dam and Broughtons Pass Weir. They also noted that native freshwater crayfish (*Euastacus* sp.) were present throughout this reach of the river.

3 Assessment of Impacts

3.1 Description of Proposed Works

Gujarat NRE Minerals Limited (Gujarat) proposes to use pillar extraction methods to extract coal from a 2.5 m thick remnant section of the Bulli Seam located within the V Mains area of the NRE No. 1 Mine at Russell Vale. The extraction of the remnant section of the Bulli Seam will result in a wedge-shaped goaf, approximately 2 km long and between 75 m and 300 m wide (Seedsman Geotechnics 2009). This goaf will be situated 165 m from the goaf edge of the 200 series of the South Bulli longwall panels, and 120 m from the Cordeaux longwalls.

The proposed works will undermine a section of the upper reach of Wallandoola Creek and of an unnamed tributary of this creek, but not Lizard Creek. The reaches of Wallandoola Creek to the north and south of NRE No. 1 Mine have been undermined previously by the longwall panels of the former South Bulli Colliery and Cordeaux Colliery, respectively. The reach of Lizard Creek to the east of the Application Area has also been undermined previously by the longwall panels of Cordeaux Colliery. The effects of the extraction of these longwalls on stream flow, water quality and the upland swamps associated with Wallandoola and Lizard Creeks were not documented.

3.2 Physical Impacts Associated with Mine Subsidence

The principal physical impact resulting from underground coal mining is subsidence (lowering of the surface above areas that are mined) (Booth *et al.* 1998, Holla and Barclay 2000). The maximum subsidence predictions for the V-Mains area estimated by Seedsman Geotechnics (2009) are as follows:

- Vertical movement of 1.02 m;
- Horizontal movement of 0.43 m;
- Tilt of 6.1 mm/m;
- Curvature of -0.05-0.09 km^{-1}; and
- Horizontal strain of -6.5 mm/m to 3.3 mm/m.

Systematic impacts are expected to dominate, because the overlying terrain is relatively flat with few rocky outcrops (Seedsman Geotechnics 2009). The greatest vertical movement is expected to occur over the middle to eastern half of the Application Area (Seedsman Geotechnics 2009). The predicted subsidence is of similar magnitude to that observed in the adjacent Cordeaux and South Bulli collieries.

3.3 Impacts on Creeks

3.3.1 Alterations to Flow

Mining-induced subsidence has the potential to alter flow in the creeks by:

- diverting surface water flows through fractures and joints in the bedrock into subterranean flows;
- draining water in pools and ponds through fractures and joints in rock bars;
- reducing inflow into pools as a result of upstream diversion of surface flows into the near surface groundwater system; and
- creating inter-connected cracks between the seam and surface which lead to loss of surface water into the mine.

Extraction of the remnant block from the Application Area is not expected to result in any observable loss of surface water, because the predicted horizontal strains (-6.5 mm/m to 3.3 mm/m) are too small to cause tensile cracking of stream rock bars and the depth of the extraction will prevent the formation of inter-connected cracks between the surface and seam (Seedsman Geotechnics 2009).

If diversion of surface water does occur, it will most likely be due to either leakage of pools through rock bars or transfer to shallow, near-surface, ephemeral, groundwater systems (Geoterra 2009). These losses are likely to be transient, because stream flow will deposit the sediment that occurs within these creeks into the fractures in rock bars.

3.3.2 Water Quality

Fracturing of bedrock and diversion of flows has the potential to alter water quality by:

- Increasing groundwater discharge to streams;
- Lowering dissolved oxygen and pH levels;
- Elevating concentrations of dissolved iron, nickel, aluminium, zinc and manganese, sulphate and salinity through weathering of newly-exposed rock faces;
- Increasing rainfall recharge through cracked Wianamatta Shale and discharge out of the interface between shale and Hawkesbury sandstone;
- Elevating salinity and decreasing oxygen concentrations in pools through reduction in their depth, enhanced evaporation and stagnation; and
- Facilitating periodic emission of gases, such as methane, into watercourses.

The occurrence of orange-brown iron staining, resulting from dissolution of iron sulphide or iron carbonate, exposed when sandstone fractures, and emission of gas bubbles are likely to be the most conspicuous changes in stream water. It should be noted that precipitation of iron hydroxide also occurs within streams that are not affected by mining.

As subsidence arising from the mining of V-Mains is not expected to have any observable effects on stream flow or have adverse effects on upland swamps in the

NRE No 1 Mine Area, there is unlikely to be any observable adverse effects on water quality (Geoterra 2009).

3.3.3 Aquatic Habitats and Biota

As subsidence arising from the mining of V-Mains is not expected to have any conspicuous effects on stream flow or water quality, it is highly unlikely that there would be any observable flow-on effects on aquatic habitats or their biota within or immediately downstream of the Application Area.

There is, however, a possibility of a localised increase in the natural stream gradient, because the maximum predicted tilt (6.1 mm/m) within the Application Area exceeds the stream bed gradient of Wallandoola Creek (0.8mm/m) and Lizard Creek (0.71 mm/m). The increase in gradient could lead to an increase in flow rate, migration of flow channels and erosion of the stream bank and bed erosion (NSW Planning 2008). If erosion occurs, the quality of some of the habitats available for occupation by aquatic biota would decline. An increase in the stream gradient could also lead to a reduction in the volume and retention time of pools within the Application Area (Geoterra 2009). This could affect the continuity of the watercourses by decreasing the connectivity between habitats, particularly during periods of low flow. As there are only a few small, permanent pools within this section of Wallandoola Creek and a few small areas of semi-permanent aquatic habitat within its unnamed tributary, the impact on aquatic biota could be locally significant within a small 300m reach of the watercourse directly above the mine area. This represents only a very small proportion of the local aquatic habitat. If there is a localised increase in the stream gradient, the relatively large pools with deep holes that occur in Wallandoola Creek 300m downstream of the Application Area, should continue to provide permanent refuge habitat.

3.4 Impacts on Upland Swamps

In the Southern Coalfield, little is known about the impact of mine-induced subsidence on upland swamps (NSW Department of Planning 2008). There is also no generally accepted technique for prediction of subsidence impacts on swamps. It is thought that subsidence may cause tensile cracking and tensile/shear movement of joint and bedding planes in the rocks below headwater swamps, as it does in streams and rivers. These movements, in turn, could lead to a drop in the perched water table, loss of standing pools and drainage of swamps into the fracture network of the underlying watercourse. Drainage of swamps could facilitate erosion and scouring during high flow events, increase vulnerability to fire damage, result in changes in associated vegetation and have adverse effects on water quality. These changes, in turn, could lead to the loss of both aquatic and terrestrial components of swamp ecology. The impact of subsidence on groundwater systems could also change the water table and water chemistry of headwater swamps.

A drop in the perched water table and/or drainage of headwater swamps could decrease the extent of the permanent aquatic habitats situated at or close to the point of outflow of the headwater swamps, such as the large pools in Wallandoola Creek situated approximately 300 m downstream of the proposed mining development. There would also be a reduction in downstream flow within the upper

reaches of these creeks. On the basis of the maximum subsidence predictions, Geoterra (2009) have concluded that extraction of coal from the V-Mains area will not have any observable adverse effects on upland swamps.

3.5 Sensitive Aquatic Features

3.5.1 Threatened Species

A review of the information that is available on the geographic distribution of aquatic organisms listed as threatened under state and federal legislation indicates that three threatened species could potentially occur within the Application Area. These species are:

- Adam's Emerald Dragonfly (*Archaeophya adamsi*), listed as vulnerable under the *FM Act;*
- Sydney Hawk Dragonfly (*Austrocordulia leonardi*), listed as endangered under the *FM Act;*
- Macquarie Perch (*Macquaria australasica*), listed as vulnerable under the *FM Act* and listed as endangered under the *EPBC Act*.

3.5.1.1 Adam's Emerald Dragonfly

Adam's Emerald Dragonfly is extremely rare, having been collected only in small numbers at a few locations in the greater Sydney region (NSW DPI 2005). There are no records of Adam's Emerald Dragonfly occurring south of Sydney despite active collecting in the Hawkesbury-Nepean River catchment (Fisheries Scientific Committee 2008) and no records of this species occurring within Wallandoola or Lizard Creek catchments or the greater Cataract River catchment. No specimens were found in the headwater swamp or sandstone gorge location within these creeks surveyed during the baseline studies.

Adam's Emerald Dragonfly has a predominantly aquatic life cycle. The larvae live for approximately seven years before metamorphosing into adults, which fly away from water to mature, but then return to water to breed (NSW DPI 2005a). The adults are believed to live for only a few months. The larvae of Adam's Emerald Dragonfly inhabit small creeks with gravel or sandy bottoms and are typically found in narrow shaded riffle zones with moss and extensive riparian vegetation. The baseline surveys indicated that there was suitable habitat for Adam's Emerald Dragonfly, albeit of limited extent, within Wallandoola and Lizard Creek close to the proposed mine area. Although the current distribution records suggest that this species is unlikely to occur within the Application Area, a Seven-Part Test has been prepared as part of the environmental assessment of this project (see Appendix 1), because there is potential habitat for this species close to the Application Area.

3.5.1.2 Sydney Hawk Dragonfly

Sydney Hawk Dragonfly is extremely rare, having been collected in small numbers at only a few locations in a small area south of Sydney, from Audley to Picton (NSW DPI 2005b). There are no records of this species occurring within Wallandoola or

Lizard Creek catchments or the greater Cataract River catchment. No specimens were found in the headwater swamp or sandstone gorge location within these creeks surveyed during the baseline studies.

This species spends most of its life as an aquatic larva, before metamorphosing and emerging from the water as an adult, which lives for only a few weeks. The larvae of Sydney Hawk Dragonfly appear to have specific habitat requirements, including deep, cool, slow-flowing water in rocky rivers with steep sides (NSW DPI 2005b). Relative environmental stability appears to be an important habitat feature, with rapid variation in water level and flow rate likely to have a negative effect on the suitability of habitat for larvae (G. Theischinger, pers. comm.).

The nearest watercourse to the proposed mine area containing suitable habitat for the Sydney Hawk Dragonfly is likely to be the Cataract River, which is beyond the influence of significant subsidence impacts. An assessment of impact is therefore unnecessary for this species.

3.5.1.3 Macquarie Perch

Macquarie Perch has been recorded within the reach of the Cataract River between Broughtons Pass Weir and the Cataract Dam, into which Lizard Creek and Wallandoola Creek flow from the proposed mine area (DECC 2007). It is, however, highly unlikely that Macquarie Perch would be present in the proposed mine area, because the waterfalls that occur over sandstone cliffs between these creeks and the Cataract River constitute substantial barriers to the upstream passage of fish. In view of this, there is no need to consider the impacts of the proposed mine on this species.

3.5.2 Sensitive Aquatic Habitats

None of the aquatic reserves declared under the *FM Act*, proclaimed Ramsar or nationally important wetlands occur above or proximal to the proposed Application Area, hence there is no need to assess the effects of the proposed mine area on sensitive aquatic habitats.

4 Recommendations for Monitoring

4.1 General Principles

The strategic review of the environmental impacts of underground coal mining in the Southern Coalfield recommends that baseline monitoring of ecological characteristics should be undertaken several times in the 18-24 month period prior to the commencement of mining (NSW Department of Planning 2008). This monitoring should be undertaken within the Application Area and at comparable control locations outside the area affected by mining. This time frame is needed to gain an understanding of natural temporal variability, particularly in the biological characteristics monitored. Further monitoring of the physical, chemical and biological characteristics of the same set of headwater swamps and creeks should be undertaken during and after mining. The adoption of this so-called BACI (before/after, control/impact) type of sampling design in the monitoring program will enable the use of advanced statistical procedures that can distinguish subsidence-induced impacts from natural temporal variability (Green 1979, Underwood 1991, 1992, 1993, 1994; Keough and Mapstone 1995).

4.2 Aquatic Ecology Monitoring Program

The baseline aquatic ecology monitoring for the V-Mains area undertaken in winter and spring 2007 focused on water quality, aquatic macroinvertebrates and fish within headwater swamp and sandstone gorge habitats in two potential impact creeks (Wallandoola and Lizard) and two control creeks (Loddon and an unnamed tributary of Cataract Dam) (The Ecology Lab 2007 and 2008). None of the sites surveyed are located within the Application Area (Figure 1). The nearest permanent aquatic habitats of sufficient extent for monitoring of aquatic ecology within Wallandoola Creek and Lizard Creek were located within the headwater swamp region of the creeks approximately 300 m downstream and 120 m to the east of the Application Area, respectively. The monitoring sites that were established at these locations appear to be outside the predicted 20 mm subsidence zone and thus suitable only for assessment of far-field effects of the mine.

The assessment of impacts indicates that mining of V-Mains is unlikely to have any observable adverse effects on aquatic habitats and biota. Despite this and as a precautionary measure, it is recommended that additional observations of aquatic habitats should be made and surveys of aquatic macroinvertebrates should be undertaken in the headwater swamp regions of potential impact and control creeks during and after mining. Further monitoring at the locations within the sandstone gorge region is considered unnecessary because of their distance from the Application Area. Additional monitoring of fish is unlikely to be productive because they appear to be scarce.

If the regular water quality monitoring program detects changes in the depth and quality of the water within Wallandoola Creek and Lizard Creek that are greater than anticipated on the basis of the subsidence predictions, an immediate survey of aquatic macroinvertebrates should be triggered at the monitoring sites within the headwater swamp region of all four creeks. The information gained from the control

creeks will enable changes due to mining to be distinguished from those due to natural temporal variation.

5 Acknowledgements

This report was written by Dr Theresa Dye and reviewed by Doug Hazell.

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7 Figures

Figure 1: Aquatic ecology monitoring sites in Wallandoola Creek and Lizard Creek in the vicinity of the V mains area.

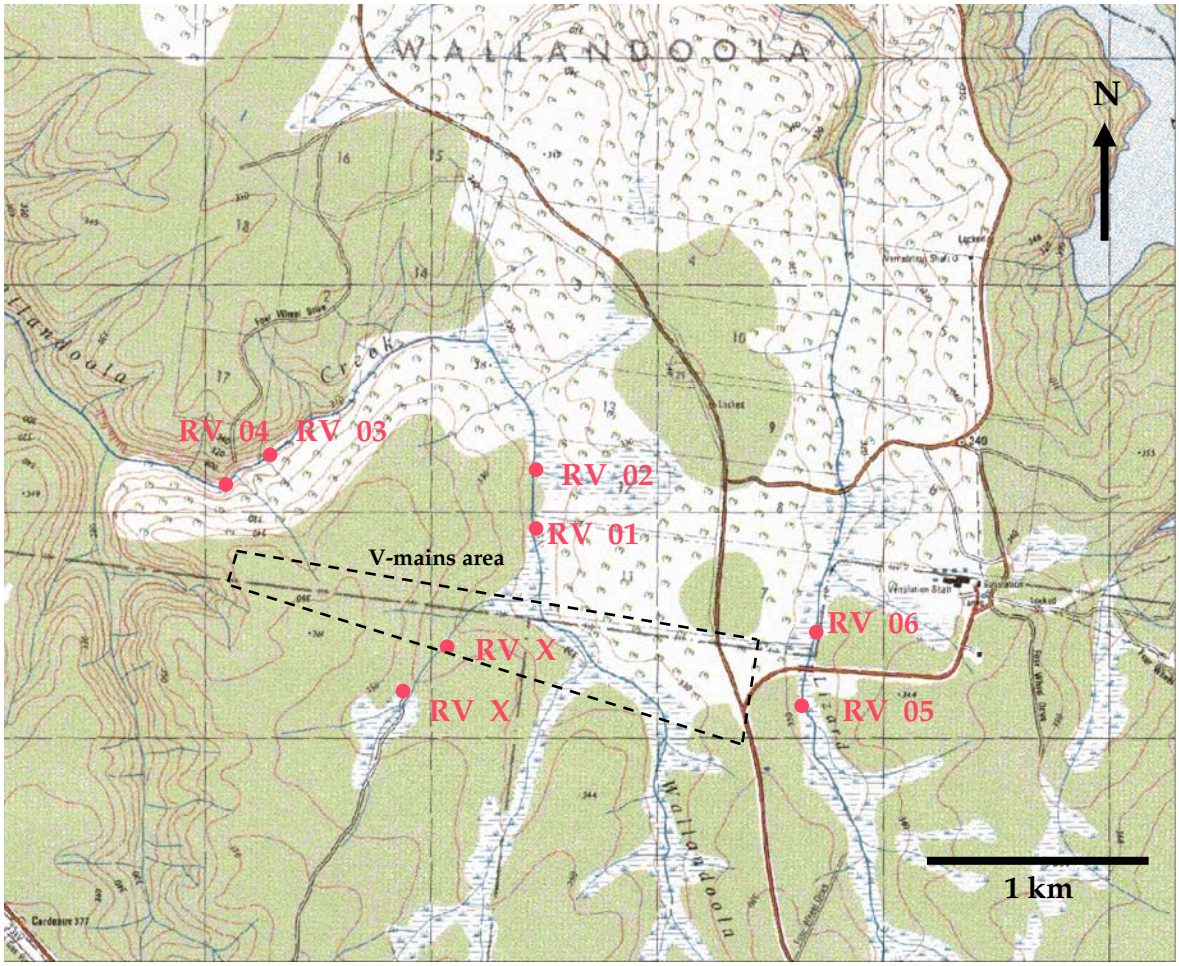


Figure 1: Aquatic ecology monitoring sites in Wallandoola Creek and Lizard Creek in the vicinity of the V-mains area.

8 Appendix

Appendix 1: Seven Part Test for the Adam's Emerald Dragonfly in relation to the proposed mining of the V-Mains Area.

Appendix 1. Seven Part Test for the Adam's Emerald Dragonfly in Relation to the Proposed Mining of the V-Mains Area.

a. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

The larvae of Adam's Emerald Dragonfly are aquatic and relatively long-lived (i.e. can survive for seven years). They inhabit small creeks with gravel or sandy bottoms and are typically found in narrow, shaded riffle zones with moss and riparian vegetation (NSW DPI 2005a). The headwater swamp section of Wallandoola Creek that traverses the Application Area does not appear to contain aquatic habitats suitable for Adam's Emerald Dragonfly. There does, however, appear to be a limited amount of suitable habitat, in the form of cascade-riffles, in the sandstone gorge sections of Wallandoola and Lizard Creeks downstream of the Application Area. Disturbances that result in significant alteration of this habitat could potentially have an adverse effect on the life cycle of this dragonfly, if they are present. As the sandstone gorge sections of these creeks are downstream of the predicted 20 mm subsidence zone for the V Mains area, the proposed mining is unlikely to have an adverse effect on the life cycle of Adam's Emerald Dragonfly.

b. *In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.*

There are no threatened populations of Adam's Emerald Dragonfly listed on the Threatened Species Schedules of the FM Act.

c. *In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to placed at risk of extinction.

Adam's Emerald Dragonfly is not part of an endangered ecological community listed on the Threatened Species Schedules of the FM Act.

d. *In relation to the habitat of a threatened species, population or ecological community:*

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The proposed mining is unlikely to result in the removal, fragmentation or modification of habitat for Adam's Emerald Dragonfly, because none occurs within the predicted 20 mm subsidence zone for the V Mains area.

e. *whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).*

There are no areas of critical habitat for Adam's Emerald Dragonfly listed on the NSW Register of Critical Habitat.

f. *whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan*.

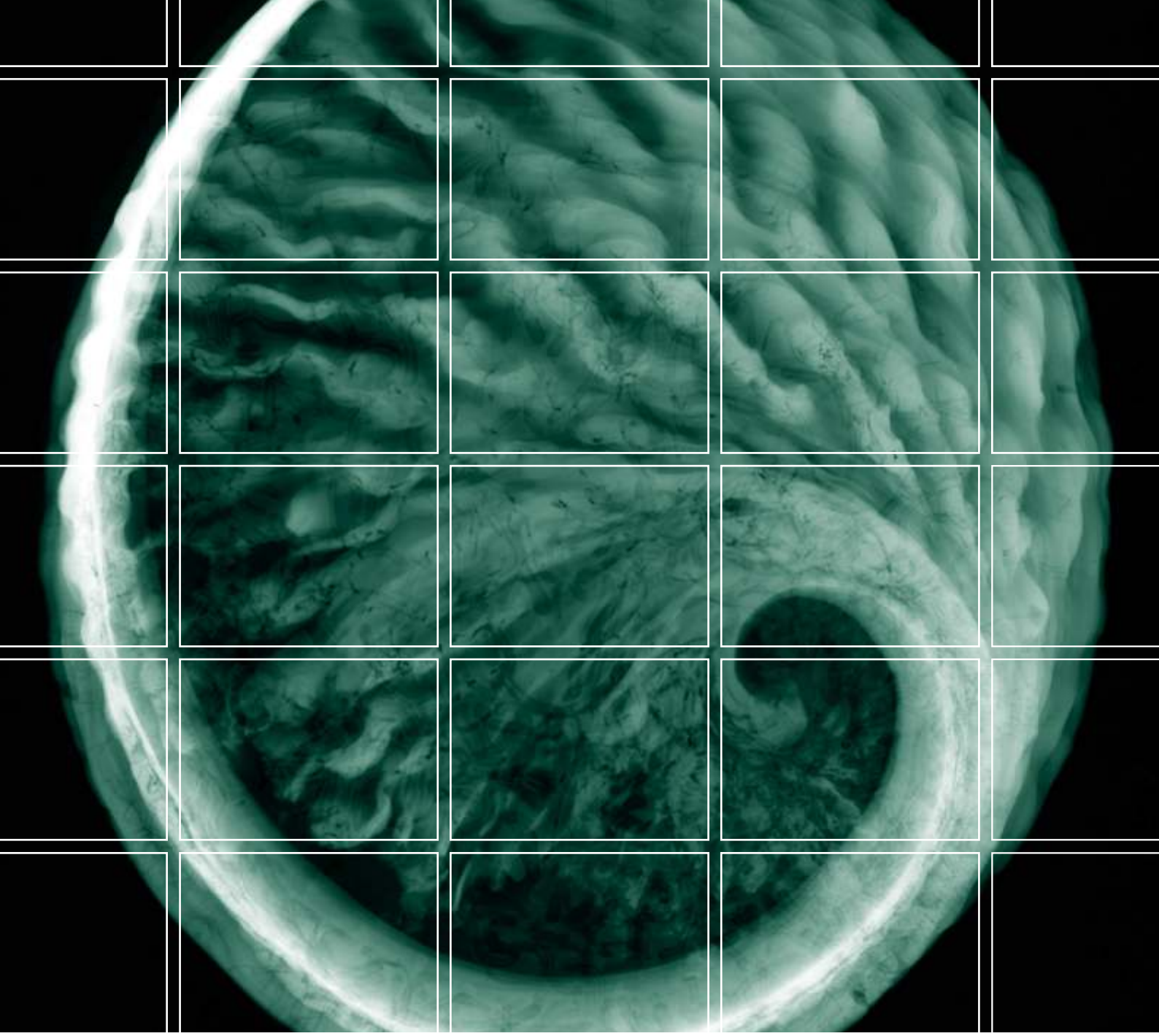
At present there is no recovery or threat abatement plan for Adam's Emerald Dragonfly.

Conclusion

The headwater swamp section of Wallandoola Creek that flows through the Application Area does not appear to contain suitable habitat for Adam's Emerald Dragonfly. There does, however, appear to be a limited amount of suitable habitat, in the form of cascade-riffles, available in the sandstone gorge sections of Wallandoola and Lizard Creeks downstream of the Application Area. As this habitat is not expected to be affected by the proposed mining, the preparation of a species impact statement is not considered necessary for Adam's Emerald Dragonfly.

Annex L

V Mains Terrestrial Flora And Fauna Assessment



V Mains

Terrestrial Flora and Fauna Assessment

for Gujarat NRE Minerals Ltd

September 2009

0090757 Ecology Final
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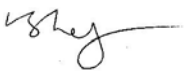
Approved by:	*Christine Allen*
Position:	Project Manager
Signed:	
Date:	*July, 2009*
Approved by:	*Mike Shelly*
Position:	Project Partner
Signed:	
Date:	*July 2009*

Environmental Resources Management Australia Pty Ltd Quality System

This report was prepared in accordance with the scope of services set out in the contract between Environmental Resources Management Australia Pty Ltd ABN 12 002 773 248 (ERM) and the Client. To the best of our knowledge, the proposal presented herein accurately reflects the Client's intentions when the report was printed. However, the application of conditions of approval or impacts of unanticipated future events could modify the outcomes described in this document. In preparing the report, ERM used data, surveys, analyses, designs, plans and other information provided by the individuals and organisations referenced herein. While checks were undertaken to ensure that such materials were the correct and current versions of the materials provided, except as otherwise stated, ERM did not independently verify the accuracy or completeness of these information sources

FINAL REPORT

Gujarat NRE Minerals Ltd

V-mains
Terrestrial Flora and Fauna Assessment

September 2009

Reference: 0090757 Ecology Final

Environmental Resources Management Australia
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1 INTRODUCTION

Environmental Resources Management Australia Pty Ltd (ERM) was commissioned by Gujarat NRE to assess the potential flora and fauna impacts of the proposed extraction of coal within the V-mains at NRE No. 1 Colliery (*Figure 1.1)*. This will also allow Gujarat NRE to establish a reliable baseline condition of terrestrial biota and habitats prior to extraction.

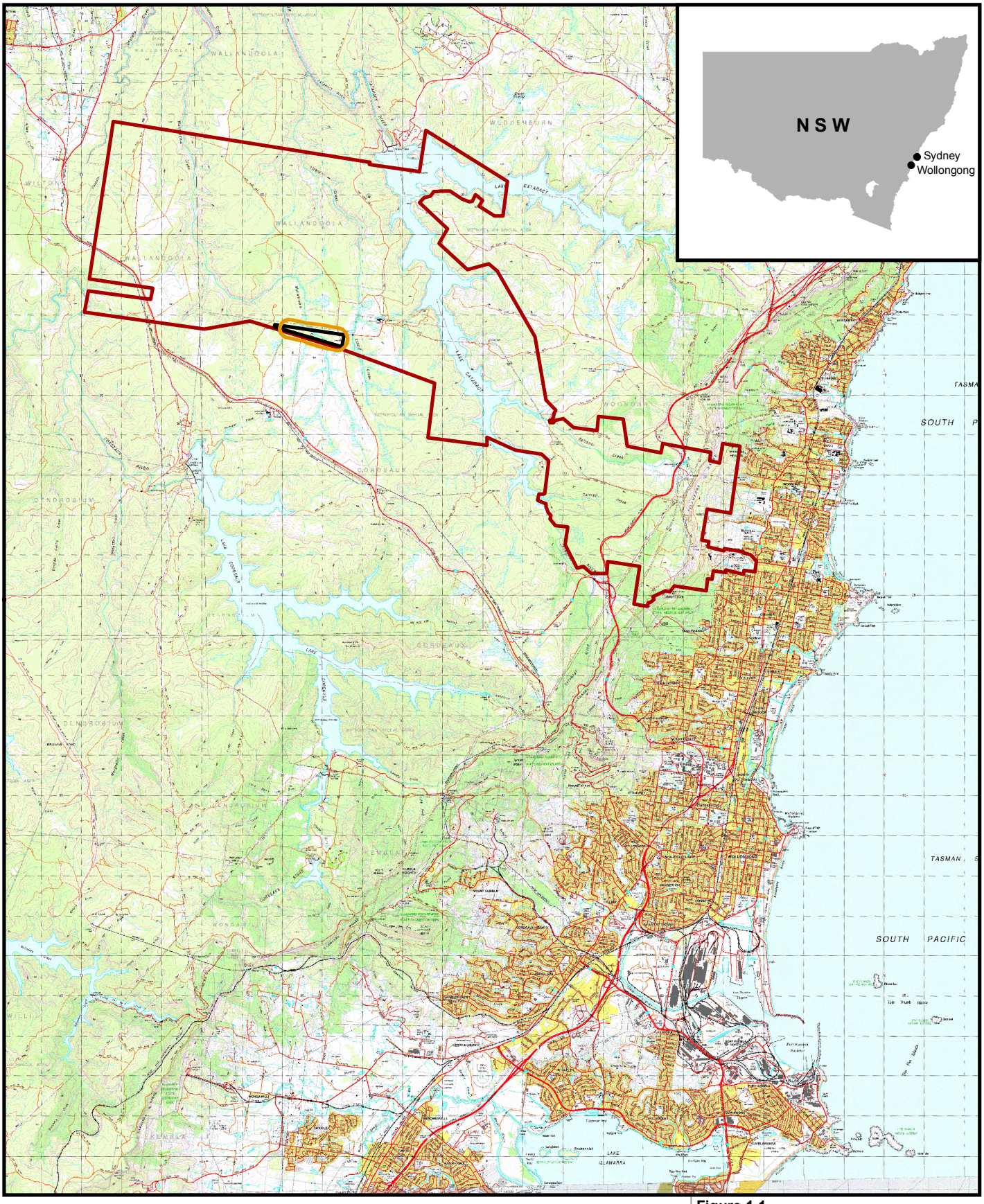
The assessment will accompany the Subsidence Management Plan and has been undertaken in order to satisfy the requirements set out in the *Guideline for Applications for Subsidence Management Approval* (NSW DMR 2003).

The Application Area (or subsidence impact zone) is defined by the 'Guideline for Applications for Subsidence Management Approvals' as the surface area that is likely to be affected by the proposed underground coal mining and is generally considered to be no less than the surface area defined by the depth of cover, angle of draw of 35 degrees and the limit of the proposed extraction area (NSW DMR 2003).

1.1 PURPOSE OF THE REPORT

The purpose of this assessment was to:

- identify and describe the conservation significance of vegetation communities, flora species, fauna habitats and fauna species;
- assess the type and degree of impacts of mining on native flora and fauna, any threatened species, endangered populations or ecological communities considered likely to occur in the Application Area;
- identify mitigation measures to avoid or minimise the extent of potential impacts; and
- provide a benchmark against which future changes to habitats and biota can be compared.



Legend

- V-Mains Application Area
- Mine Lease Area
- Predicted Subsidence Footprint

Figure 1.1
Study Area Location

Client:	Gujarat NRE Ltd	
Project:	V-Mains SMP	
Drawing No:	0090757s_EC_GIS02_R0.mxd	
Date:	28/07/2009	Drawing size: A4
Drawn by:	JF	Reviewed by: MK
Projection:	GCS GDA 1994	
Scale:	Refer to Scale Bar	

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0 1,000 2,000 3,000m

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1.2 *DESCRIPTION OF THE APPLICATION AREA*

The proposed V-mains mining area is approximately 13 kilometres northwest of Thirroul to the north of Wollongong. The mining lease has been transferred from BHP Billiton's Cordeaux and Elouera mining lease to form part of the current mining lease for Gujarat NRE's No. 1 Colliery. The entire area overlying the extraction area is within the catchment for the Cataract Reservoir and consists mainly of natural bushland, creeks and minor wetlands. This area is designated as a Schedule 1 Restricted Access Area (Metropolitan Special Area), administered by the Sydney Catchment Authority (SCA). Bushfire has passed through most of the Application Area within the past two years (Ecology Lab 2008).

1.3 *PROPOSED MINING*

Gujarat NRE proposes to mine the 2.5 m thick Bulli seam within the V-mains at a depth of between 445 m in the west and 460 m in the east of the site. Access to the V-mains will be provided via extension of the underground travelling roadways from existing workings.

Mine development in the V-mains will take place in two stages:

- Stage 1 is initial board and pillar workings to establish roadways. This would involve minimal subsidence (less than 20 millimetres) and therefore not require a Subsidence Management Plan (SMP); and

- Stage 2 is pillar extraction that will result in a goaf that is wedge shaped, approximately two kilometres long and between 75 m and 300 m wide (Seedsman Geotechnics Pty Ltd 2008). Surface subsidence above the narrower parts of the goaf (<100 m wide) will not be measurable. At widths of 300 m, predicted subsidence will increase to around 1125 mm. Associated maximum tilt is predicted to be 6 mm/m. strains are in the range of 6.5 mm/m to 3.3 mm/m respectively (Seedsman Geotechnics 2008).

2 EXISTING ENVIRONMENT

2.1 SOILS AND TOPOGRAPHY

The soils of the V-mains Application Area are a mixture of the Maddens Plains and Lucas Heights landscapes.

The Maddens Plains soil landscapes consist of moderately to gently undulating rises on plateau surfaces with widespread dells, or upland swamps/wetlands. Local relief ranges from 10 to 40 m with valley slope gradients of up to 10%. The dominant landform elements are broad, usually waterlogged drainage depressions with scattered rock outcrops (ERM 2006).

The Lucas Heights landscapes consist of gently undulating plateau surfaces and ridges 200 to 1,000 m wide, with level to gently inclined slope gradients of less than 10%. Local relief is less than 30 m and rock outcrops are absent. Lateritic podzolic soils can be present within the Lucas Heights profile, which would be a source of dissolved iron into stream waters.

The topographic map does not show any significant cliff lines within the Application Area. However, there are exposed outcrops and sandstone shelfs throughout the site.

2.2 CATCHMENT AND SURFACE WATER

The Application Area is located within the Nepean River catchment, on land that forms part of Sydney's drinking water catchment. It is located approximately 2 km west of Lake Cataract and 3.5 kilometres north east of Lake Cordeaux.

The majority of the site is located within the Wallandoola Creek catchment, which flows to the Cataract River approximately one kilometre upstream of Broughtons Pass. A small section at the eastern end of the V-mains area lies within the Lizard Creek catchment, which flows to the Cataract River approximately one kilometre downstream of Appin Falls. (The Ecology Lab 2008).

Both Lizard Creek and Wallandoola Creek flow through the site in a northerly direction. Both waterways are heavily vegetated with reeds and low scrub.

2.3 *GROUNDWATER*

A shallow groundwater resource occurs within the unconsolidated swamp sediments, but is likely to be perched and is not hydraulically connected to the deeper groundwater resources within the bedrock aquifer (ERM 2006).

2.4 *REGIONAL AND LOCAL CONNECTIVITY*

The V-mains Application Area supports a large area of unfragmented woodland, heathland and swamps, and forms part of the greater Woronora catchment. The Application Area is therefore considered to be well connected to habitat for flora and fauna both locally and regionally.

3 METHODOLGY

3.1 LITERATURE REVIEW

Various sources of published information are available on the flora and fauna of the Application Area and surrounding areas. The following documents were reviewed in the preparation of this assessment.

Biosis Research (2008): Biosis Research prepared a Flora and Fauna Assessment to accompany a Subsidence Management Plan (SMP) application for several proposed Longwalls and the Pillar Extraction Area at NRE Wongawilli Colliery, which is to the south of the current Application Area. No threatened ecological communities were recorded in the study area. One threatened plant species, *Pultenaea aristata,* was recorded in large numbers within and adjacent to the study area and habitat was identified for a further eight threatened plant species. Nine threatened or migratory animal species were recorded in the study area. The assessments of significance undertaken by Biosis (2008) concluded that the proposal was likely to have a significant impact on local populations of Littlejohn's Tree Frog (*Litoria littlejohni*), Giant Burrowing Frog (*Heleioporous australiacus*) and the Red-crowned Toadlet (*Pseudophryne australis*). A Species Impact Statement (SIS) for those species was recommended. However, in 2009, Biosis updated these findings, and concluded that there would be no significant impacts to these species and that no SIS would be required.

***Environmental Resources Management Pty Ltd (2006)*:** ERM undertook a desktop assessment and field surveys within the Application Area in April 2006. Shale Sandstone Transition Forest (an Endangered Ecological Community under the NSW *Threatened Species Conservation Act 1995* (TSC Act)) was recorded in the north east and the western portion of the site. Fauna species observed included Wombats (*Vombatus ursinus*), Red-bellied Black Snake (*Pseudechis porphyriacus*), skinks (*Egernia* sp.), macropods and a variety of native birds. Follow up surveys in June and August 2006 confirmed the presence of the threatened Powerful Owl (*Ninox strenua*) and Gang-gang Cockatoo (*Calocephalon fimbriatum*) within the site.

Kevin Mills and Associates Pty Ltd (2005)*:* Kevin Mills and Associates assessed the impact of mine subsidence (up to 200 mm) on flora and fauna within the No.4 Shaft, NRE Colliery at Wilton in the Shire of Wollondilly, approximately four kilometres north-east of the current Application Area. One threatened plant species, Shining Guinea Flower (*Hibbertia nitida*), was recorded. No threatened fauna species were recorded during the assessment, although they were considered likely to be present within the survey area. Kevin Mills and Associates (2005) concluded that the predicted subsidence from the proposed underground mining was unlikely to have a significant impact on flora and fauna.

***Umwelt Pty Ltd (2004)**:* Umwelt assessed the ecological impacts of mine subsidence (up to 880 mm) and mining induced fracturing (1.5 mm/m) within the T&W Mains, approximately four kilometres north of the current Application Area. No threatened flora or fauna species were recorded during the assessment, although the assessment area was considered to provide suitable habitat for a range of threatened species. The proposal was not expected to lead to significant impacts on diversity of the recorded flora within the assessment area. Similarly, whilst minor impacts to foraging resources and hydrology may occur, these were not expected to be significant or to impact on the survival of fauna species.

***Kevin Mills and Associates Pty Ltd (1995)**:* Kevin Mills and Associates undertook a flora and fauna assessment of a number of survey lines within the NRE No.1 Colliery mine lease area. The southern most survey point was approximately three kilometres north of the current Application Area. Three threatened flora species (*H. nitida*, Prickly Bush-pea (*P. aristata*) and Hairy Geebung (*Persoonia hirsuta*) were recorded.

The Ecology Lab (2008): The Ecology Lab undertook baseline investigations of aquatic habitat and biota in watercourses within the V Mains area of the NRE No. 1 Mine at Russell Vale in the Southern Coalfield. Water quality was found to be typical of Hawkesbury sandstone environments (relatively acidic) and showed expected seasonal variation of dissolved oxygen and temperature. Fish sampling did not capture any threatened or non-threatened fish species at any sampling sites. However, two listed threatened species, Macquarie Perch (*Macquaria ausrtalasica*) and the Sydney Hawk Dragonfly (*Austrocordulia leonardi)*, are known to, or likely to be present in watercourses downstream of the mine area. The report identifies potential impacts of proposed mining activities to the aquatic habitats and water quality in the mine area as well as downstream and recommends a monitoring regime to be undertaken during and post mining.

3.1.1 Database Searches

A search of the Department of Environment and Climate Change (DECC) Wildlife Atlas database was conducted to obtain records of threatened flora and fauna within a 10 kilometre radius of the Application Area. A search of the on-line database maintained by the Commonwealth Department of the Environment, Water, Heritage and the Arts (DEWHA) was conducted in order to identify the likely presence of nationally listed threatened or migratory species or threatened ecological communities (or their habitats) within the locality.

All flora and fauna database records were analysed to determine the likelihood that threatened flora and fauna could occur within habitats of the Application Area.

3.2 *VEGETATION SURVEY AND MAPPING*

The NSW National Parks and Wildlife Service (NPWS) (2004) mapped the native vegetation communities present within the Woronora, O'Hare's and Metropolitan Catchment Areas and this mapping provided a basis for the vegetation surveys undertaken as part of this assessment.

Key features such as vegetation structure, dominant plant species and geological/topographical features were recorded in the field and compared to the NPWS (2004) descriptions, to confirm or not the presence of the mapped vegetation communities. The boundaries of each vegetation community were recorded in the field using a handheld GPS unit and later compared to the NPWS (2004) mapping.

Several areas of the site were difficult to access and survey due to the density of the vegetation. The distribution of vegetation communities within these areas was assessed using the NPWS (2004) mapping, aerial photograph interpretation and observations made in the field where possible.

3.3 *FAUNA HABITAT*

Habitat diversity for native fauna was assessed during the field investigations and information recorded was supplemented with existing site information. Habitat use of the site by fauna was documented through analysis of tracks, scats, diggings and other traces. Traces of threatened and significant species that might occur within the site were the focus of the surveys. Searches were conducted for the following:

- whitewash, prey remains and owl pellets;
- characteristic scats, tracks and diggings;
- trees scratches consistent with arboreal mammals; and
- other secondary indicators of fauna such as runways through vegetation.

3.4 *FAUNA SURVEYS*

Prior to fauna surveys being undertaken, an assessment of the known and potential fauna assemblages of the site was made using database records, previous reports and habitat requirements of native fauna species. Targeted surveys were then undertaken across the site in June 2006, August 2006 and November 2008. The locations of all fauna surveys are shown in *Figure 3.1* and *Figure 3.2*.

3.4.1 Terrestrial and Arboreal Mammal Trapping

Vegetation maps and previous studies were used to identify and assess the distribution of habitat types within the Application Area. These preliminary findings were used to focus surveys in suitable habitat for threatened mammal species known, or expected to occur, within the site.

Trapping

In 2006, 40 Elliott A traps were placed along four separate transects. Thirty cage traps were also placed along four transects (seven traps per transect along two transects and eight traps per transect along two transects) (see *Figure 3.1*). All traps were set for four consecutive nights. This gave a total of 120 trap nights for the cage traps, and 160 trap nights for the Elliott A traps.

During the 2008 survey period, a total of 40 Elliott A traps were placed in suitable ground habitat along three transects (lines of traps) (one transect having twenty traps and two transects having 10 traps each), with twenty Elliott B traps mounted on brackets on trees approximately two metres above the ground along two separate transects (*Figure 3.2*). All traps were set for three consecutive nights, totalling 180 trap nights.

Traps were placed at approximately 10 metre intervals along each transect. Traps were baited with peanut butter, honey and rolled oats. The cage traps were also baited with sardines. Dry leaves and other plant material or hessian sacks were used as bedding and a plastic bag placed over the Elliott traps in inclement weather in order to keep any captured animals dry and warm.

Traps were checked early each morning, closed and then reopened at dusk to prevent any non-target animals (such as skinks) entering the traps during the day.

Hair Tubes

Forty hair tubes were set along four 100 m transects and left in situ for 14 days during the June 2006 survey period to detect the presence of bandicoots, macropods, quolls or other terrestrial mammals. This gave a total of 560 trap nights. Hair funnels were baited with a peanut butter or sardine mixture. Collected hairs were sent to Barbara Triggs of Dead Finish, Genoa, Victoria for identification.

3.4.2 Microchiropteran Bat Surveys

An Anabat echolocation call detector was used to record bat calls during the 2006 and 2008 survey periods. All bat surveys commenced within one hour of dusk.

Two Anabat detectors with delay units were left overnight for three consecutive nights in June 2006. The detectors were left within six separate locations adjacent to Lizard Creek and within areas of Exposed Sandstone Scribbly Gum Woodland and Shale Sandstone Transition Forest.

An Anabat detector with delay units was left overnight for two consecutive nights in November 2008 and sampled the Shale Sandstone Transition Forest and adjacent to Wallandoola Creek (*Figure 3.2*). Bat calls were analysed by Glenn Hoye of Fly By Night Bat Surveys Pty Ltd.

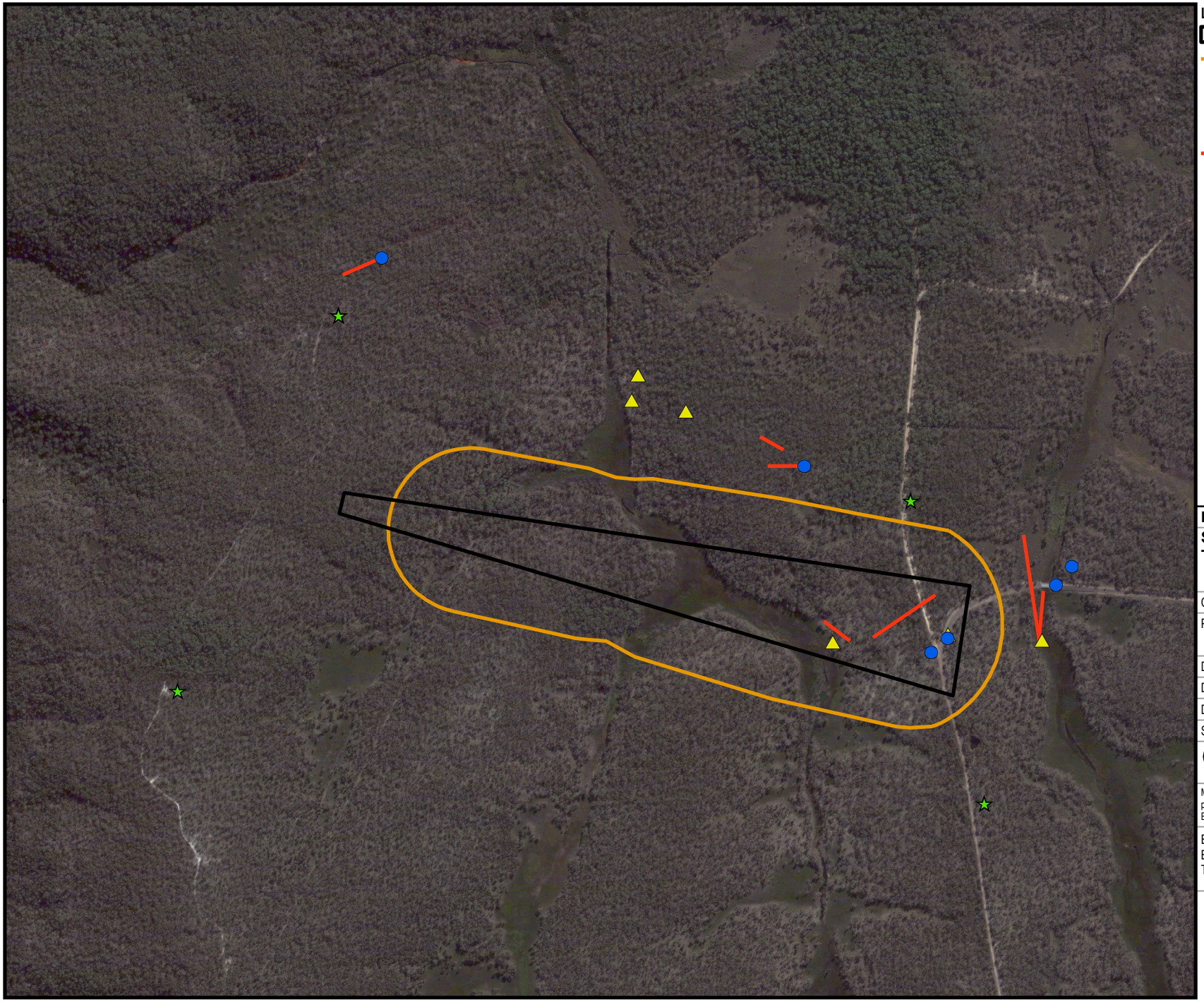

Figure 3.1

Spotlighting, Call Playback and Trapping Survey Locations 2006

Client:	Gujarat NRE Minerals Limited
Project:	V-Mains SMP
Drawing No:	0090757s_EC_GIS01a_R0.mxd
Date:	07/09/2009
Drawing size:	A4
Drawn by:	JF
Reviewed by:	MK
Scale:	Refer to Scale Bar

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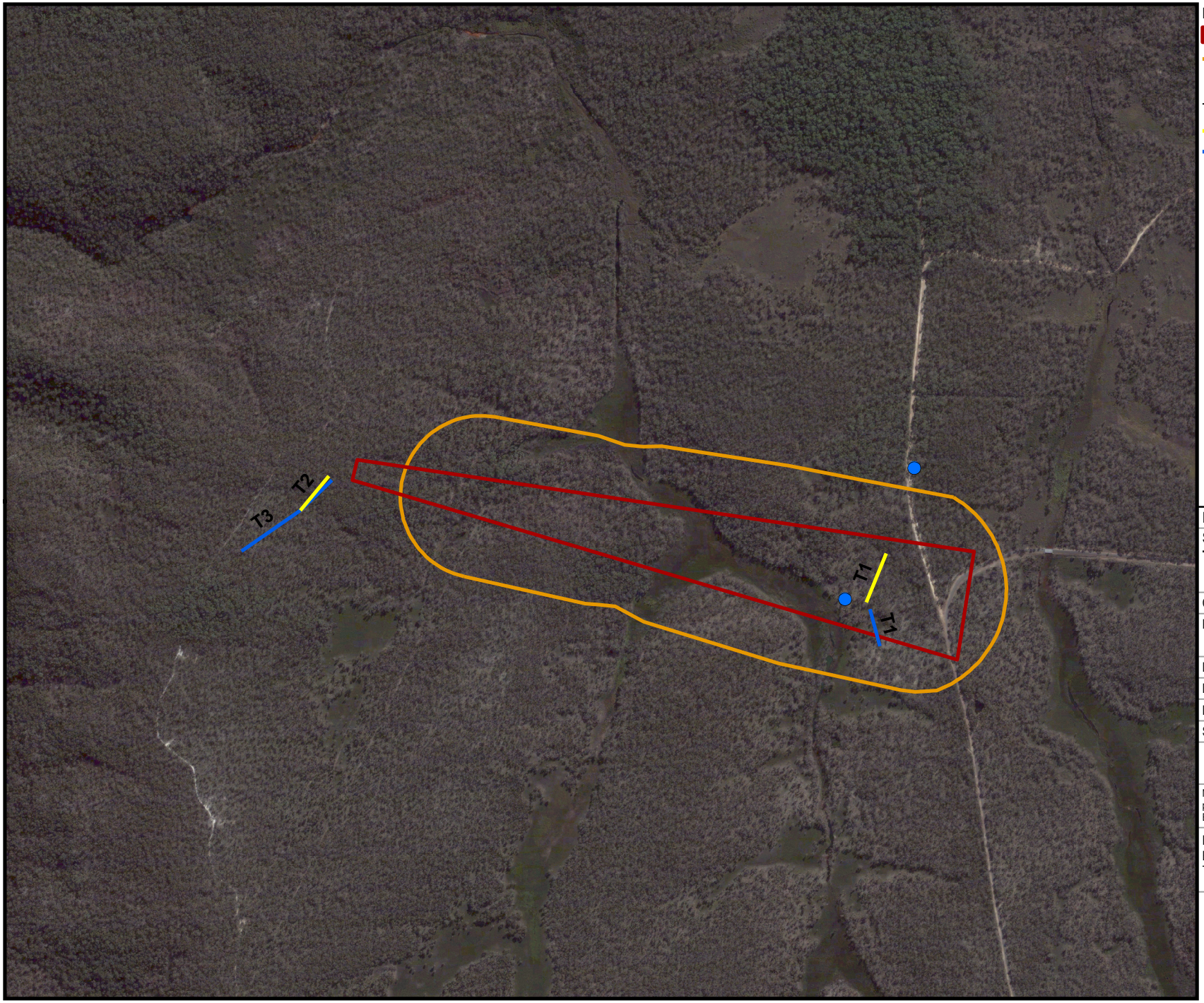

Legend

- V-Mains Application Area
- Predicted 20mm Subsidence Extent
- Anabat Location

Transects

- Arboreal
- Ground

Figure 3.2

Spotlighting, Call Playback and Trapping Survey Locations 2008

Client:	Gujarat NRE Minerals Limited
Project:	V-Mains SMP
Drawing No:	0090757s_EC_GIS004a_R0.mxd
Date:	07/09/2009
Drawing size:	A4
Drawn by:	JF
Reviewed by:	MK
Scale:	Refer to Scale Bar

N

0 150 300 450 m

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3.4.3 Birds

Diurnal avifauna transects were undertaken between 20 and 22 June 2006 and 8 to 11 August 2006. Surveys were conducted during periods of high activity, particularly early morning.

Opportunistic sightings of bird species were recorded across the site between the 20 and 22 June 2006, 8 to 11 August 2006 and 11 to 14 November 2008. All bird species heard and/or observed throughout the survey period were recorded.

Owl Call Playback

Nocturnal owl call playback sessions to detect Powerful Owl, Sooty Owl (*Tyto tenebricosa*), Barking Owl (*Ninox connivens*) and Masked Owl (*T. novaehollandiae*) were undertaken between 7 and 10 August 2006. Owl call playback was conducted in five locations (*Figure 3.1*). Forty owl call playback sessions were conducted over four nights.

Nocturnal owl call playback sessions to detect Powerful Owl, Sooty Owl and Masked Owl were undertaken between 12 and 13 November 2008. Owl call playback was conducted in two locations. Six call playback sessions were conducted over two nights.

3.4.4 Amphibians

Diurnal and nocturnal active searches for amphibians were undertaken in areas of suitable habitat between 20 and 23 June 2006 and 12 to 14 November 2008. Auditory and visual records of frogs were noted during these searches. Call playback was also undertaken.

In 2006, a total of 4.5 person hours was dedicated to active diurnal amphibian searches. Call playback was also undertaken at various sites adjacent to Wallandoola and Lizard Creeks *(see Figure 3.1*).

3.4.5 Reptiles

Reptiles were surveyed by actively searching suitable habitat over the entire survey period in both June 2006 and November 2008. Ground debris and rocks were overturned and replaced during the searches. In 2006, eight hours and forty minutes were dedicated to active herpetofauna diurnal searches. Opportunistic sightings were also recorded.

3.4.6 Spotlighting

Spotlighting was undertaken over four nights on the 20 to 22 June 2006 and two nights on 12 and 13 November 2008. Species targeted included the Yellow-bellied Glider, owls and microchiropteran bats. Total person hours for spotlighting in 2006 was 8.2 hours. In 2008, survey effort was approximately four hours.

4 SURVEY RESULTS

4.1 WEATHER CONDITIONS DURING 2008 SURVEY PERIOD

Weather data was obtained from the Bureau of Meteorology (BoM) Bellambi weather station approximately 10 kilometres to the south-east of the Application Area.

Weather during the 2008 surveys was generally fine and warm, although heavy rain fell on the evening of 14 November 2008 (recorded as 15 November by BOM). In 2006, there was rain on all days.

Table 4.1 Weather Conditions during the Survey Period

Parameter	Survey Period				
	11/11/08	*12/11/08*	*13/11/08*	*14/11/08*	*15/11/08*
Temperature 9 am (°C)	20.2	20.4	21.4	21.8	16.7
Relative Humidity 9 am (%)	64	65	74	78	92
Wind Direction 9am (°)	SSE	N	NE	NE	SSE
Wind Speed 9am (km/hr)	9	24	24	19	28
Cloud Cover am (8ths of sky)	1	4	0	0	8
Min Temperature (°C)	14.9	15.7	18.5	18.9	16.6
Max Temperature (°C)	22.9	24.4	23.2	23.9	19.2
Rainfall (mm)	0	0	0	0	8.2
Temperature 3pm (°C)	22.0	23.0	22.9	21.3	19.0
Relative Humidity 3pm (%)	50	68	73	79	86
Wind Direction 3pm (°)	NE	NE	NE	N	SSE
Wind Speed 3pm (km/hr)	20	28	37	22	15
Cloud Cover pm (8ths of sky)	0	0	0	0	8
Source: Bureau of Meteorology (BoM)					

4.2 FLORA

4.2.1 Vegetation Communities

Five vegetation communities were identified within the Application Area as described below. *Figure 4.1* shows the location of each vegetation community within the Application Area.

Sandstone Gully Peppermint Forest

This vegetation community is a tall dry shrubby forest which occurs on sheltered slopes and gullies (NPWS 2004) and was noted within the central portion of the Application Area, west of Wallandoola Creek.

Dominant overstorey species include Sydney Peppermint (*Eucalyptus piperita*) and Red Bloodwood (*Corymbia gummifera*). Common species within the diverse shrub layer include Hairpin Banksia (*Banksia spinulosa* var. *spinulosa*), Smooth Geebung (*Persoonia levis*), Narrow-leaf Geebung (*P. linearis*), Juniper Wattle (*Acacia ulicifolia*), Tantoon (*Leptospermum polygalifolium*) and Sunshine Wattle (*Acacia terminalis*). Common understorey and groundcover species include Spiny-headed Mat-rush (*Lomandra longifolia*), Upright Panic (*Entolasia stricta*), Paroo Lily (*Dianella caerulea*), Variable Sword-sedge (*Lepidosperma laterale*), Woolly Xanthosia (*Xanthosia pilosa*) and Curly-wig (*Caustis flexuosa*) (NPWS 2004).

Transitional Shale Stringybark Forest (Shale Sandstone Transition Forest)

This community is reported to be a moderately tall forest that generally occurs in drier areas (NPWS 2004) and was noted in two small patches, at the eastern and western extents of the Application Area. It is a component of the larger endangered ecological community Shale Sandstone Transition Forest (listed as endangered under the TSC Act).

Dominant overstorey species include White Stringybark (*Eucalyptus globoidea*), Thin-leaved Stringybark (*Eucalyptus eugenioides*) and Grey Gum (*Eucalyptus punctata*). The understorey is shrubby and contains a mix of Banksias, Tea-trees, and Geebungs. Groundcover species include Spiny-headed Mat-rush (*Lomandra longifolia*), Cane Wire-grass (*Aristida ramosa*), Bordered Panic (*Entolasia marginata*) and Upright Panic (*Entolasia stricta*) (NPWS 2004).

Exposed Sandstone Scribbly Gum Woodland

This vegetation community is open woodland that occurs on ridges and exposed slopes (NPWS 2004) and was noted as the dominant community across the Application Area.

Dominant trees include Scribbly Gums (*Eucalyptus racemosa*, *Eucalyptus sclerophylla, Eucalyptus haemastoma*) with Stringybark (*Eucalyptus oblonga*), Red Bloodwood (*Corymbia gummifera*) and Silvertop Ash (*Eucalyptus sieberi*). Mid-storey species include Hairpin Banksia (*Banksia spinulosa* var. spinulosa), Paperbark Tea-tree (*Leptospermum trinervium*), Juniper Wattle (*Acacia ulicifolia*) and Finger Hakea (*Hakea dactyloides*). The sparse groundcover includes species such as Blue Mat-rush (*Lomandra glauca*), Upright Panic (*Entolasia stricta*), Blue Dampiera (*Dampiera stricta*) and Curly-wig (*Caustis flexuosa*) (NPWS 2004).

Upland Swamps: Fringing Eucalypt Woodland

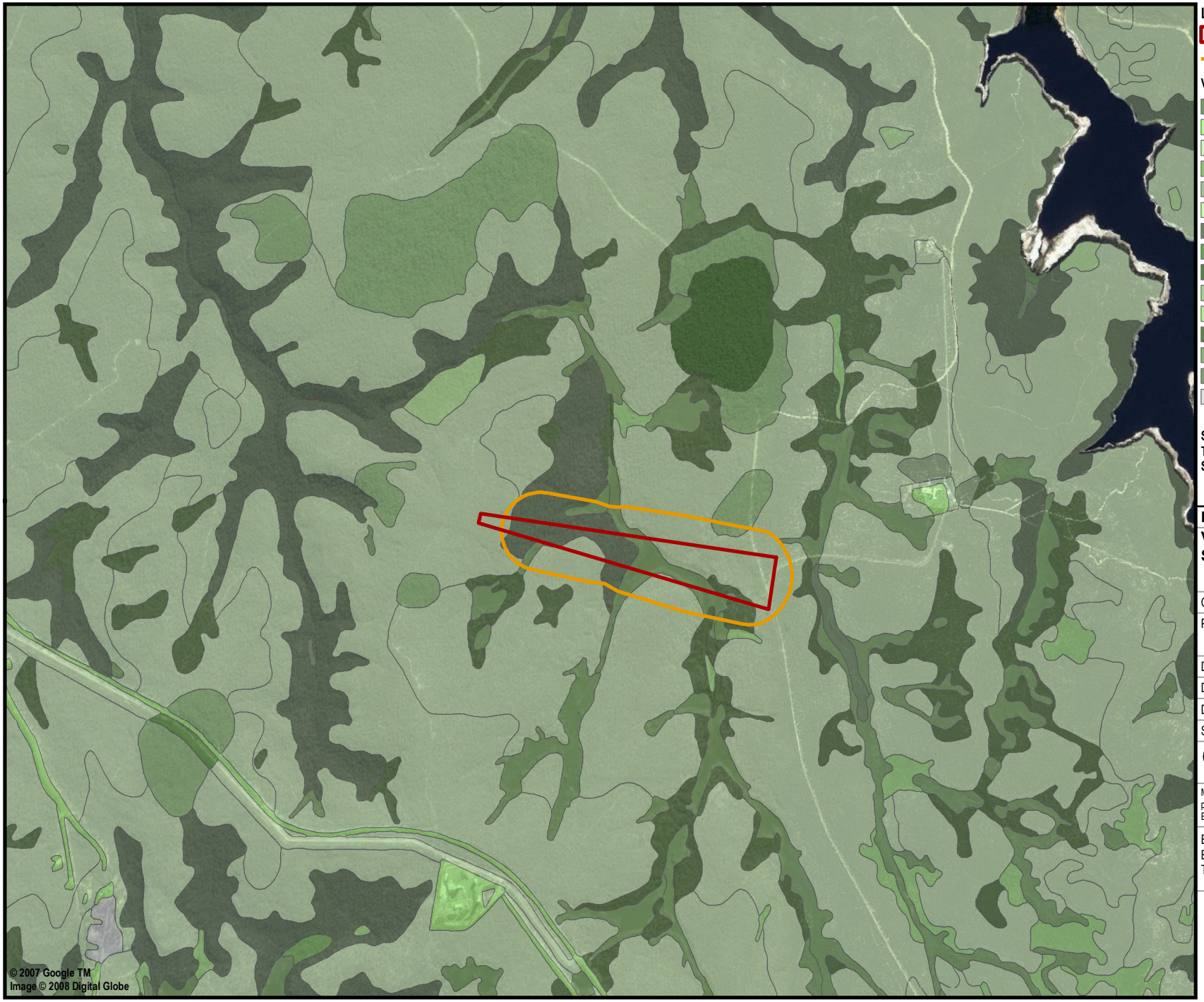
This community occurs adjacent to Lizard Creek and Wallandoola Creek.

It consists of very open woodland with scattered Stringybark (*Eucalyptus oblonga*), Narrow-leaved Scribbly Gum (*Eucalyptus racemosa*) and Silvertop Ash (*Eucalyptus sieberi*). Common midstorey species include Heath-leaved Banksia (*Banksia ericifolia* subsp. *ericifolia*), Fern-leaved Banksia (*Banksia oblongifolia*) and Finger Hakea (*Hakea dactyloides*). Dominant understorey species include Slender Twine-rush (*Leptocarpus tenax*) and Pink Swamp Heath (*Sprengelia incarnata*) (NPWS 2004).

Upland Swamps: Sedgeland-Heath Complex

This community contains a low dense cover of sedges and small shrubs in low depressions or adjacent to upland swamps (NPWS 2004) and was noted along Wallandoola Creek and its tributaries, and along the banks of Lizard Creek.

Dominant shrub species include *Baeckea imbricata,* Pink Swamp Heath (*Sprengelia incarnata*), Blunt-leaf Heath (*Epacris obtusifolia*), *Symphionema paludosum* and Swamp Boronia (*Boronia parviflora*). Common understorey species include Slender Twine-rush (*Leptocarpus tenax*), Zig-zag Bog-sedge (*Schoenus brevifolius*) and *S. paludosus* (NPWS 2004).



Legend

- V-Mains Application Area
- Predicted Subsidence Footprint

Vegetation Community

- Artificial Wetlands
- Cleared
- Exposed Sandstone Scribbly Gum Woodland
- Nepean Sandstone Gully Forest
- O'Hares Creek Shale Forest
- Rock Plate Heath-Mallee
- Sandstone Gully Peppermint Forest
- Transitional Shale Dry Ironbark Forest
- Transitional Shale Open Blue Gum Forest
- Transitional Shale Stringybark Forest
- Upland Swamps: Banksia Thicket
- Upland Swamps: Fringing Eucalypt Woodland
- Upland Swamps: Sedgeland-Heath Complex
- Upland Swamps: Tea-Tree Thicket
- Weeds and Exotics

Source:
The Native Vegetation of the Woronora, O'Hares and Sydney Metropolitan Catchments (NPWS, 2003)

Figure 4.1

Vegetation Communities within the Site

Client:	Gujarat NRE Minerals Limited
Project:	V-Mains SMP
Drawing No:	0090757s_EC_GIS01a_R0.mxd
Date:	07/09/2009
Drawing size:	A4
Drawn by:	JF
Reviewed by:	MK
Scale:	Refer to Scale Bar

N

0 300 600 900m

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4.2.2 Threatened Flora Species

Figure 4.2 shows threatened flora species previously recorded within a ten kilometre radius of the site, whilst *Table 4.2* indicates the likelihood of their occurrence within the Application Area.

No threatened flora species have been observed within the Application Area during the various surveys although it is recognised that potential habitat is available for the following nine flora species:

- *Acacia baueri* subsp. *aspera;*
- Bargo Geebung *(Persoonia bargoensis);*
- *Epacris purpurascens var. purpurascens;*
- Deane's Melaleuca (*Melaleuca deanei*);
- Hairy Geebung *(Persoonia hirsuta* subsp. *evoluta);*
- Needle Geebung *(Persoonia acerosa);*
- Prickly Bush-pea *(Pultenaea aristata);*
- Small-flower Grevillea *(Grevillea parviflora* subsp. *parviflora);* and
- Woronora Beard-heath *(Leucopogon exolasius).*

4.2.3 Endangered Ecological Communities

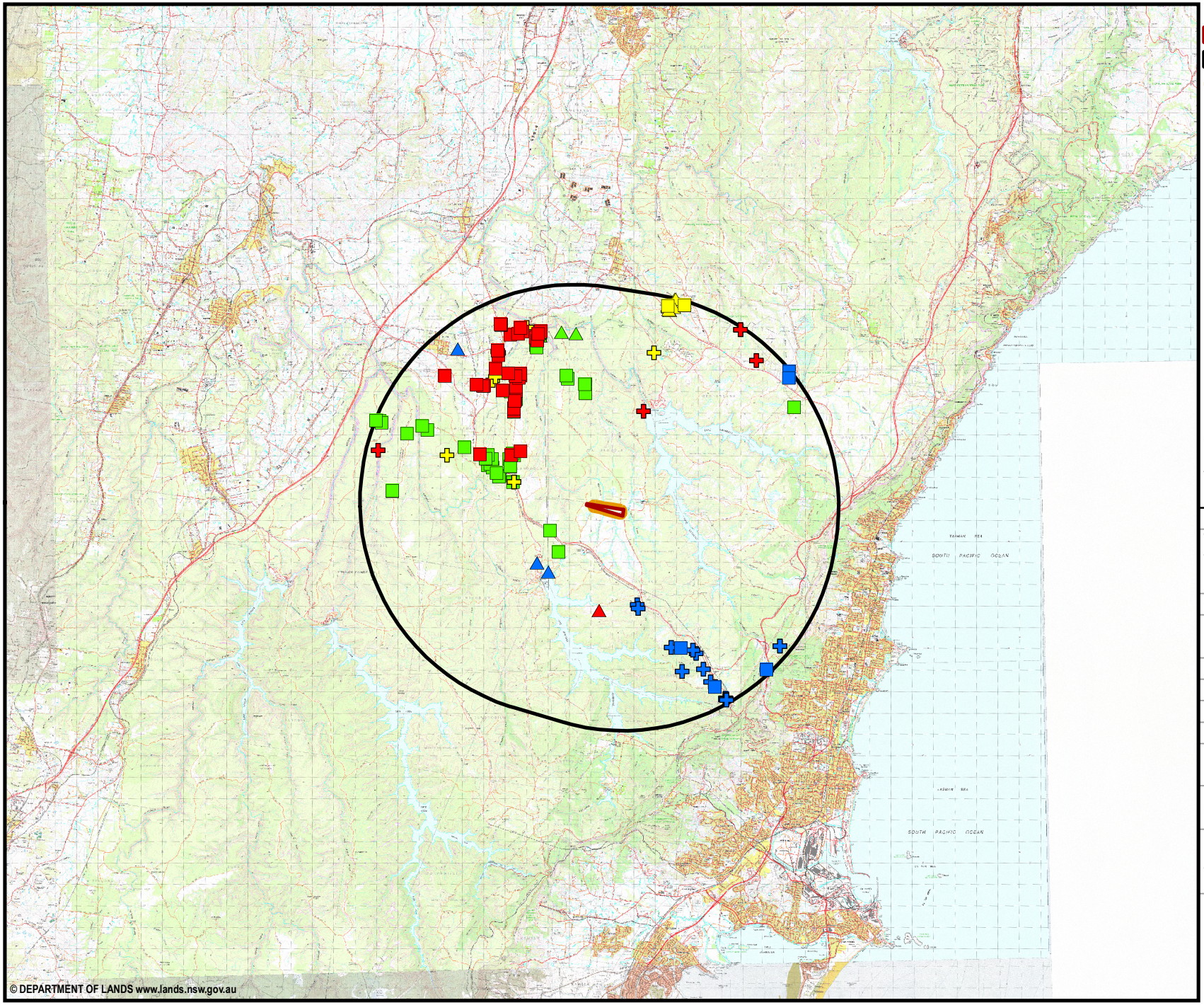
The Transitional Shale Stringybark Forest recorded within the Application Area forms part of the Shale Sandstone Transition Forest complex as listed under Part 3 of Schedule 1 of the TSC Act.

Shale-Sandstone Transition Forest occurs at the edges of the Cumberland Plain where shale rock and clay soils gradually change to sandstone. The dominant canopy species are Forest Red Gum (*Eucalyptus tereticornis*), Grey Gum (*E. punctata*), stringybarks (*E. globoidea*, *E. eugenoides*) and ironbarks (*E. fibrosa* and *E. crebra*).

Before European settlement, Shale-Sandstone Transition Forest was extensive at the edges of the Cumberland Plain and covered 43,990 hectares. Today, it is reduced to 22.6 percent of its original extent in an area bounded by Sackville to the north, Mulgoa to the west, Wilton to the south and Revesby to the east (NPWS 2004). Shale-Sandstone Transition Forest occurs in the Bankstown, Baulkham Hills, Blacktown, Campbelltown, Hawkesbury, Liverpool, Parramatta, Penrith, Sutherland and Wollondilly local government areas.

The greatest threat to Shale-Sandstone Transition Forest is clearing for agriculture and urban/rural residential development. Other threats include grazing, mowing, rubbish dumping, weed invasion and frequent fire (NPWS 2004).

The proposal is not expected to impact on this community. No other endangered ecological communities occur within the Application Area.



Legend

- V-Mains Application Area
- 10km Buffer of V-Mains
- Predicted Subsidence Footprint
- Acacia baueri subsp. aspera
- Epacris purpurascens var. purpurascens
- Persoonia hirsuta subsp. evoluta
- Bargo Geebung
- Brown Pomaderris
- Bynoe's Wattle
- Hairy Geebung
- Needle Geebung
- Prickly Bush-pea
- Rainforest Cassia
- Small-flower Grevillea
- Woronora Beard-heath

Source:
NSW National Parks and Wildlife Service
Atlas of NSW Wildlife

Figure 4.2
Threatened Flora Species within 10Km of the Site

Client:	Gujarat NRE Minerals Limited	
Project:	V-Mains SMP	
Drawing No:	0090757s_EC_GIS03a_R0.mxd	
Date:	07/09/2009	Drawing size: A4
Drawn by:	JF	Reviewed by: MK
Scale:	1:250,000	

N

0 3 6 9km

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Table 4.2 Likelihood of Threatened Flora Species and Communities

Common/Scientific Name	TSC Act	EPBC Act	Preferred Habitat*	Likelihood of Occurrence and Potential for Impact	7-part Test Required?
Flora					
Acacia baueri subsp. *aspera*	V	V	Populations occur in low, damp heath, often on exposed rocky outcrops over a wide range of climatic and topographical conditions between 400-900 m AHD. Appears to require open conditions - rarely observed where there is any shrub or tree canopy development. Habitat characteristics vary considerably between sites in the Blue Mountains and the coastal sandstone plateaus.	Moderate. The species is found in damp heath on rocky outcrops and could occur within the study area. However, all of the damp heath areas within the study area have a dense growth of rushes, shrubs and fringing woodland and do not provide preferred habitat conditions. The species has also been assessed by NPWS (2003) as being unlikely to be significantly impacted by subsidence.	No.
Epacris purpurascens var. *purpurascens*	V	-	This species is found in a wide range of habitats most of which have a strong shale soil influence. These include drainage depressions supporting wet heath within or adjoining shale cap communities.	Moderate. The species is found within drainage depressions supporting wet heath and these could be impacted by cracking and draining due to subsidence. However the species is found in a wide range of habitats and therefore it would be unlikely to rely solely on the drainage lines of the site or be impacted by subsidence (NPWS 2003).	No.
Small-flower Grevillea *Grevillea parviflora* subsp. *parviflora*	V	V	Crests or upper slopes in lightly clayey soils in woodlands, often with laterite soils. It has been recorded in a range of ecological communities including Shale Sandstone Transitional Forest (Endangered Ecological Community).	Moderate. There is suitable habitat within the site. However, the habitats in which the species would be found will not be significantly impacted by subsidence.	No.

Common/Scientific Name	TSC Act	EPBC Act	Preferred Habitat*	Likelihood of Occurrence and Potential for Impact	7-part Test Required?
Bargo Geebung *Persoonia bargoensis*	E	V	Restricted to a small area on the western edge of the Woronora Plateau. Grows in woodland to dry sclerophyll forest on sandstone and clayey laterite on heavier, well drained, loamy, gravelly soils of the Hawkesbury Sandstone and Wianamatta Shale in the catchments of the Cataract, Cordeaux and Bargo River. Species often associated with light disturbance and found along vehicle tracks and cleared areas.	Moderate. There is suitable habitat within the site. However, the habitats in which the species would be found will not be significantly impacted by subsidence.	No.
Hairy Geebung *Persoonia hirsuta*	E	E	Occurs in woodlands and dry sclerophyll forest on sandstone or very rarely on shale. This species is patchily distributed on the Central Coast and Tablelands of NSW, in an area bounded by Putty, Glen Davis and Gosford in the North, and Royal National Park and Hill Top in the South.	Moderate. There is suitable habitat within the site. However, the habitats in which the species would be found will not be significantly impacted by subsidence.	No.
Brown Pomaderris *Pomaderris brunnea*	V	V	Open forest, confined to the Colo and upper Nepean River Catchments.	Low. Lack of preferred habitat and if present, habitat would not be impacted by subsidence.	No
Bynoe's Wattle *Acacia bynoeana*	E	V	Occurs in heath and dry sclerophyll forest, typically on sand and sandy clay, often with ironstone gravels and is usually very infertile and well-drained. Often grows among rock platforms. Also found in open and slightly disturbed sites such as trail margins, edges of roadsides, grading spoil mounds and in recently burnt patches.	Low. Lack of preferred habitat and if present, habitat would not be impacted by subsidence.	No.

Common/Scientific Name	TSC Act	EPBC Act	Preferred Habitat*	Likelihood of Occurrence and Potential for Impact	7-part Test Required?
Needle Geebung *Persoonia acerosa*	V	V	Grows in heath, low woodland or dry sclerophyll forest on sandstone, in well drained soils. Prefers ridgetops and plateaux. Species frequently occurs on disturbance margins, such as roadsides.	Moderate. There is suitable habitat within the site. However, the habitats in which the species would be found will not be significantly impacted by subsidence.	No.
Rainforest Cassia *Senna acclinis*	E		Grows in or on the edges of subtropical and dry rainforest.	Low. Lack of suitable habitat and does not occur in habitats that could be impacted by subsidence.	No.
Woronora Beard-heath *Leucopogon exolasius*	V	V	Prefers woodlands on sandstone and is often associated with rocky hillsides and creek lines.	Moderate. The species is not reliant on the habitats that could be impacted by subsidence. i.e swamps and creeks or ridgelines, being found in a range of habitats.	No.
Deane's Melaleuca *Melaleuca deanei*	V	V	Grows in heath on sandstone.	Moderate. There is suitable habitat within the site. However, the habitats in which the species would be found will not be significantly impacted by subsidence.	No.
Prickly Bush-pea *Pultenaea aristata*	V	V	Grows in moist, dry sclerophyll woodland to heath on sandstone; Helensburg to Mt Keira. Flowering has been recorded in winter and spring.	High. Potential habitat may be impacted by surface cracking and water loss as a result of subsidence due to longwall mining. The species is also vulnerable to track clearing activities.	Yes.
Endangered Ecological Community					
Cumberland Plain Woodland	E	Cr E	Occurs on the clay soils derived from shale on the undulating Cumberland Plain in central New South Wales.	Low. Not recorded within the site.	No
Turpentine-Ironbark Forest in the Sydney Basin Bioregion	E	E	Occurs in moderately wet sites, with an annual rainfall of 800-1100 mm per year, and on clay soils derived from Wianamatta shale.	Low. Not recorded within the site.	No

Common/Scientific Name	TSC Act	EPBC Act	Preferred Habitat*	Likelihood of Occurrence and Potential for Impact	7-part Test Required?
Shale/Sandstone Transition Forest	E	E	Occurs on areas transitional between the clay soils derived from Wianamatta Shale and the sandy soils derived from Hawkesbury Sandstone on the margins of the Cumberland Plain.	Low. Community is present. This community is independent of groundwater and not likely to be significantly impacted by subsidence. Changes to species composition are unlikely to occur. Therefore not considered likely to be impacted.	No
** preferred habitat is a summary of literature reviewed and is not the sole information relied on for assessment of occurrence or impact*					
Status in NSW as per Schedules 1 and 2 of TSC Act: E = Endangered; V = Vulnerable. Status as per EPBC Act: E = Endangered; V = Vulnerable; Cr E = Critically Endangered					

4.3 FAUNA

A list of species recorded at the site is provided as *Annex A* and are discussed below.

4.3.1 Species Recorded on Site (2006 and 2008 Assessment)

Mammals

A total of 19 mammal species were recorded by ERM within the Application Area during the 2006 and 2008 site assessments. Macropod scats were found within all habitats, with the most commonly observed species being the Eastern Grey Kangaroo (*Macropus giganteus*) and Swamp Wallaby. Wombat scats were also common across the site.

Sugar Gliders (*Petaurus breviceps*) were recorded within the forested portions of the site, with Eastern Pygmy-possum (*Cercartetus nanus*) records restricted to the areas of Scribbly Gum woodland. The Eastern Pygmy-Possum is a threatened species listed under the TSC Act and has been further assessed in *Table 4.3*. These species were detected by spotlighting and arboreal trapping.

A range of insectivorous bats were detected across the site including Gould's Wattled Bat (*Chalinolobus gouldii*), Chocolate Wattled Bat (*Chalinolobus morio*), Greater Broad-nosed Bat (*Scoteanax rueppellii*), Little Forest Bat (*Vespadelus vulturnus*), White-striped Mastiff Bat (*Tadarida australis*) and Long-eared Bat (*Nyctophilus* sp.).

The Eastern Freetail Bat (*Mormopterus norfolkensis*), Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*), Eastern Falsistrelle (*Falsistrellus tasmaniensis*) and Greater Broad-nosed Bat (*Scoteanax rueppellii*) were also recorded and are all threatened species. These bats have been further assessed in *Table 4.3*.

Two introduced species were recorded within the site; European Red Fox (*Vulpes vulpes*) was recorded through scat analysis and one House Mouse (*Mus musculus*) was trapped in the 2006 surveys.

Birds

A total of 63 bird species were recorded on the site (refer to *Annex A*). The majority of these species are widespread and/or abundant species that commonly occur in woodland, heathland, regrowth vegetation and various other habitats. No introduced species were recorded.

Four threatened birds have been confirmed within the Application Area during the various surveys; Brown Treecreeper (*Climacteris picumnus*), Gang-gang Cockatoo, Powerful Owl and Marbled Frogmouth (*Podargus ocellatus*). The presence of these species on site has been further assessed in *Table 4.3.*

Reptiles and Amphibians

Very few reptiles were detected (refer to *Annex A*), which may reflect the sites recent fire history. Species detected include the Red-bellied Black Snake, Eastern Brown Snake (*Pseudonaja textilis*), Copper-tailed Skink (*Ctenotus taeniolatus*) and Lesueur's Velvet Gecko (*Oedura lesueurii*).

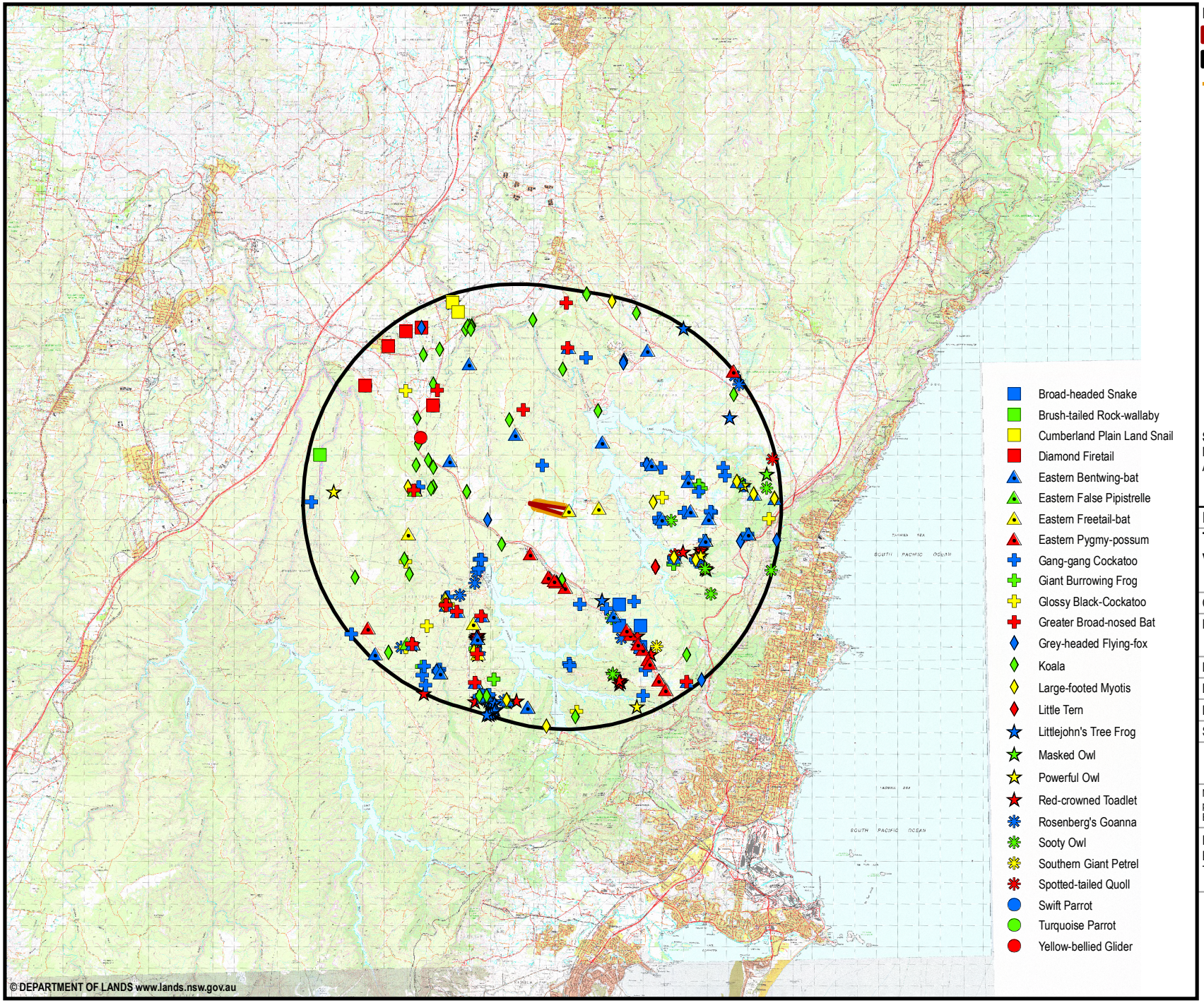
Amphibian activity was high along the creeks, swamps and ephemeral pools that had formed along the small tracks. Species recorded were Common Eastern Froglet, Eastern Banjo Frog, Peron's Tree Frog (*Litoria peronii*), Red-backed Brood Frog (*Pseudophryne coriacea*), Leseur's Frog (*Litoria lesueuri*) and Smooth Toadlet (*Uperoleia laevigata*). None of these species are listed as threatened. No threatened frogs were recorded by ERM on the site.

4.3.2 Threatened Fauna Species

A number of threatened fauna species have been previously recorded within 10 kilometres of the site (*Table 4.3*), with nine species confirmed to occur within the Application Area in the 2006 and 2008 surveys. The threatened species recorded were:

- Eastern Pygmy Possum;
- Brown Treecreeper;
- Gang-gang Cockatoo;
- Marbled Frogmouth;
- Powerful Owl;
- Eastern Bent-wing Bat;
- Eastern False Pipistrelle;
- Eastern Freetail Bat; and
- Greater Broad-nosed Bat.

All of the above species are listed as Vulnerable under the TSC Act and have been further assessed in *Table 4.3*. None of the species are listed as threatened under the EPBC Act.



Source:
NSW National Parks and Wildlife Service
Atlas of NSW Wildlife

Figure 4.3
Threatened Fauna Species within 10Km of the Site

Client:	Gujarat NRE Minerals Limited	
Project:	V-Mains SMP	
Drawing No:	0090757s_EC_GIS06a_R0.mxd	
Date:	07/09/2009	Drawing size: A4
Drawn by:	JF	Reviewed by: MK
Scale:	1:250,000	

N

0 3 6 9km

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Table 4.3 Likelihood of Threatened Fauna Species occurring On Site

Common/Scientific Name	TSC Act	FM Act	EPBC Act	Preferred Habitat*	Likelihood of Occurrence and Impact	7-part Test Required?
Birds						
Brown Treecreeper *Climacteris picumnus*	V		-	Drier forests and woodlands particularly among fallen timber.	**Present.** Potential impacts on vegetation within drier woodlands and forests within the Application Area are considered to be minimal, but may include tree tilt or fall. These impacts are considered unlikely to significantly affect the habitat available for foraging, roosting or shelter.	No
Diamond Firetail *Stagonopleura guttata*	V		-	Found in grassy eucalypt woodlands, including box-gum woodlands and snow gum woodlands. Often found in riparian areas (rivers and creeks), and sometimes in lightly wooded farmland.	Moderate. Potential impacts on vegetation within woodlands and riparian areas within the Application Area are considered to be minimal, but may include tree tilt or fall. These impacts are considered unlikely to significantly affect the habitat available for foraging, roosting or shelter.	No
Gang-gang Cockatoo *Callocephalon fimbriatum*	V		-	In summer, generally found in tall mountain forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests. In winter, this species moves to lower altitudes, preferring more open eucalypt forests and woodlands, particularly in box-ironbark assemblages, or in dry forest in coastal areas. This species favours old growth attributes for nesting and roosting.	**Present.** Impacts may include loss of foraging habitat (through tree tilting/ collapse caused by subsidence) and nesting and roosting habitat (loss of hollow bearing trees through tilting/ collapse caused by subsidence). Tree loss through subsidence is anticipated to be minor within the Application Area, and to represent only a small proportion of the total available habitat for the species.	No
Glossy Black-cockatoo *Calyptorhynchus lathami*	V		-	Found in forests on sites with low soil-nutrient status, reflecting distribution of *Casuarina* spp. and *Allocasuarina* spp. Prefers drier forest types with less rugged landscapes. Feeds exclusively on seeds from the wood cones of she-oaks. Requires forest with tree hollows for breeding.	Moderate. Impacts may include loss of foraging habitat (through Sheoak tilting/ collapse caused by subsidence) and nesting and roosting habitat (loss of hollow bearing trees through tilting/ collapse caused by subsidence). Tree loss through subsidence is anticipated to be minor within the Application Area, and to represent only a small proportion of the total habitat available.	No

Common/Scientific Name	TSC Act	FM Act	EPBC Act	Preferred Habitat*	Likelihood of Occurrence and Impact	7-part Test Required?
Marbled Frogmouth *Podargus ocellatus*	V		-	Subtropical rainforest in deep, wet, sheltered gullies. Less frequently occurs in higher elevation temperate rainforests and wet eucalypt forest with a well-developed rainforest understorey.	**Present.** Impacts may include loss of foraging, roosting and nesting habitat (through tree tilting/ collapse caused by subsidence). Tree loss through subsidence is anticipated to be minor within the Application Area, and to represent only a small proportion the total available habitat.	No
Masked Owl *Tyto novaehollandiae*	V		-	Dry sclerophyll forest and woodland with a low sparse understorey, foraging in open or partly cleared land. Roosting and nest sites in large tree hollows in sheltered aspects.	Low. Impacts may include loss of foraging habitat (through tree tilt/ collapse caused by subsidence) and nesting and roosting habitat (loss of hollow bearing trees through tilting/ collapse caused by subsidence). Tree loss through subsidence is anticipated to be minor within the Application Area, and to represent only a small proportion the total available habitat .	No
Powerful Owl *Ninox strenua*	V			Mountain forests, gullies and forest margins; sparser hilly woodlands, coastal forests, woodland, scrub.	**Present.** Impacts may include loss of foraging habitat (through tree tilt/ collapse caused by subsidence) and nesting and roosting habitat (loss of hollow bearing trees through tilting/ collapse caused by subsidence). Tree loss through subsidence is anticipated to be minor within the Application Area, and to represent only a small proportion the total available habitat.	No
Regent Honeyeater *Xanthomyza phrygia*	E		E,M	Nomadic species following rich sources of nectar, primarily winter flowering species.	Low. Preferred seasonal habitat is limited within the Application Area and this species is unlikely to be dependant on the resources present.	No
Sooty Owl *Tyto tenebricosa*	V		-	Closed and tall open forests with dense understorey, especially gullies. Active in the canopy, avoids cleared areas.	Low. Due to the large home range of the Sooty Owl and the limited amount of potential habitat disturbance (i.e tree tilt/ fall).	No.
Swift Parrot *Lathamus discolor*	E		E	Migratory species frequenting eucalypt forest and woodland, following winter flowering eucalypts (eg. swamp mahogany). Breeds in Tasmania.	Low. Preferred seasonal habitat is limited within the Application Area, with no breeding habitat available. The potential impact of the proposed development is considered to be minor given the high mobility of this species and the limited amount of habitat disturbance (tree loss/ tilt).	No

Common/Scientific Name	TSC Act	FM Act	EPBC Act	Preferred Habitat*	Likelihood of Occurrence and Impact	7-part Test Required?
Turquoise Parrot *Neophema pulchella*	V		-	Eucalypt woodland and open forest with groundcover of grasses and low understorey of shrubs. Usually associated with mixed assemblage of native pine Callitris and a variety of Eucalyptus spp. including, White Box, Yellow Box, Blakey's Red Gum, Red Box, Red stringy-bark, Bimble box and Mulga Ironbark. Nests in hollows of small trees, dead eucalypts or in holes, stumps or fenceposts.	Low. Preferred seasonal habitat is limited within the Application Area, with no breeding habitat available. The potential impact of the proposed development is considered to be minor given the high mobility of this species and the limited amount of habitat disturbance (tree loss/ tilt).	No
Mammals						
Eastern Bentwing-bat *Miniopterus schreibersii oceanensis*	V		-	Roosts in caves, old mines, stormwater channels; forages above the forest canopy.	**Present.** Potential impact on roosting habitat within caves through cliff collapse, rockfall and cracking.	Yes.
Eastern False Pipistrelle *Falsistrellus tasmaniensis*	V		-	Uncommon resident in tall forest on the Great Dividing Range and adjacent coastal plains. Roosts in tree hollows.	**Present.** Impacts may include loss of roosting habitat (loss of hollow bearing trees through tilting/ collapse caused by subsidence). Tree loss through subsidence is anticipated to be minor within the Application Area, and to represent only a small proportion the total habitat available for Eastern False Pipistrelle	No
Eastern Freetail-bat *Mormopterus norfolkensis*	V		-	Wide range of forested habitats including rainforest to dry open forest. Roosts in tree hollows and under loose bark.	**Present.** Impacts may include loss of roosting habitat (loss of hollow bearing trees through tilting/ collapse caused by subsidence). Tree loss through subsidence is anticipated to be minor within the Application Area, and to represent only a small proportion the total habitat available for Eastern Freetail-bat.	No
Large-eared Pied Bat *Chalinolobus dweryi*	V		V	Roosts in caves. Variety of habitat types including dry and wet sclerophyll forest and tall open eucalypt forest with a rainforest sub-canopy.	Moderate. Potential impact on roosting habitat within caves through cliff collapse, rock fall and cracking.	Yes
Large-footed Myotis *Myotis adversus*	V		-	Roosts in caves, tunnels, under bridges and in dense vegetation. Forages over nearby lakes, rivers, large streams.	Moderate. Potential impact on roosting habitat within caves through cliff collapse, rock fall and cracking.	Yes
Eastern Pygmy Possum *Cercartetus nanus*	-		V	Wet and dry eucalypt forest, subalpine woodland, coastal banksia woodland and wet heath.	**Present.** Habitats for the species are considered unlikely to be significantly impacted by subsidence.	No

Common/Scientific Name	TSC Act	FM Act	EPBC Act	Preferred Habitat*	Likelihood of Occurrence and Impact	7-part Test Required?
Greater Broad-nosed Bat *Scoteanax rueppellii*	V		-	The open canopy above rivers and creeks utilised during foraging and roosting occurs in tree hollows.	**Present.** Impacts may include loss of foraging habitat (through tree tilt/ collapse caused by subsidence) and nesting and roosting habitat (loss of hollow bearing trees through tilting/ collapse caused by subsidence). Tree loss through subsidence is anticipated to be minor within the Application Area, and to represent only a small proportion the total available habitat	No
Grey-headed Flying-fox *Pteropus poliocephalus*	V		V	Forages on fruits, blossoms and nectar of eucalypts. In early summer roosts in large groups (camps) in forests or mangroves.	Moderate. Foraging habitat unlikely to be significantly impacted.	No
Brush-tailed Rock-wallaby *Petrogale penicillata*	E		V	Occupy north facing cliffs in dry eucalypt forest and woodland. They shelter in rock crevices, caves or overhangs during the day, feeding in grassy areas above and below the cliffs in the evening.	Low. Lack of suitable habitat.	No
Koala *Phascolarctos cinereus*	V		-	Forests typically on high nutrient soils characterised by presence of preferred Eucalypt feed trees.	Moderate. Preferred feed trees, particularly Scribbly Gums were noted across much of the Application Area. Impacts may include loss of foraging habitat (loss of feed trees through tilting/ collapse caused by subsidence). Tree loss through subsidence is anticipated to be minor within the Application Area (particularly given the large amount of Scribbly Gum Woodland present on the site), and to represent only a small proportion the total habitat available for Koala.	No
Long-nosed Potoroo (SE Mainland) *Potorous tridactylus tridactylus*	V		V	Coastal heath and wet and dry sclerophyll forests. Major habitat requirement is thick ground cover where soil is light and sandy. Digs small holes in earth while foraging (Strahan 1995).	Moderate. Habitat present but the species unlikely to be impacted by subsidence.	No
Southern Brown Bandicoot *Isoodon obesulus obesulus*	E		E	Heathy forest, shrubland and woodland which is usually supported by well-drained soils. A mosaic of post-fire vegetation is an important component of the species' habitat.	Moderate. Habitat present but the species unlikely to be impacted by subsidence.	No.
Spotted-tail Quoll *Dasyurus maculatus*	V		V	Wide range of forested habitats including rainforest, open forest, coastal heath, riparian forest. Nests in caves, hollow logs or tree hollows.	Moderate. Potential impact on nesting habitat within caves through cliff collapse, rock fall and cracking.	Yes

Common/Scientific Name	TSC Act	FM Act	EPBC Act	Preferred Habitat*	Likelihood of Occurrence and Impact	7-part Test Required?
Yellow-bellied Glider *Petaurus australis*	V		-	Tall open sclerophyll forest with mature trees that provide tree hollows for breeding; a mix of eucalypts, eucalypt nectar and sap, honeydew, manna, pollen and invertebrates under decorticating bark.	Moderate. Impacts may include loss of foraging and breeding habitat (loss of trees through tilting/ collapse caused by subsidence). Tree loss through subsidence is anticipated to be minor within the Application Area, and to represent only a small proportion the total habitat available for Yellow-bellied Glider.	No
Reptiles						
Broad-headed Snake *Hoplocephalus bungaroides*	E		V	Woodland, open woodland/ heath communities on Sandstone within the Sydney Basin. They utilise rock crevices and exfoliating sheets of weathered sandstone on exposed cliff edges during autumn, winter and spring, and shelter in hollows in large trees within 200 m of escarpments in summer.	High. Suitable habitat present within rock crevices and exfoliating sheets of weathered sandstone on exposed cliff edges. Potential impact on foraging habitat through cliff collapse, rockfall and cracking and alteration or destruction of rock shelters through surface cracking.	Yes
Rosenberg's Goanna *Varanus rosenbergi*	V		-	Ground-dwelling species. Termite mounds used as breeding chambers. Inhabits coastal heaths. Shelters in burrows, hollow logs and rock crevices. Coastal heaths, humid woodlands and wet and dry sclerophyll forests. Isolated population in coastal NSW.	High. Suitable shelter and foraging habitat present within rock crevices, burrows etc. Potential impact on rock shelters and burrows through surface cracking.	Yes
Frogs						
Giant Burrowing Frog *Heleioporous australiacus*	V		V	Northern population in sandstone ridgetop habitat and broader upland valleys in these locations it is associated with small headwater creek lines and along slow flowing to intermittent creeklines. The vegetation is woodland, open woodland and heath and can also be associated with 'hanging swamp' seepage lines and where small pools form from the collected water.	High. Potential impact on creek lines due to surface cracking caused by subsidence.	Yes
Green and Golden Bell Frog *Litoria aurea*	E		V	In NSW the species occupies disturbed habitats and breeds largely in ephemeral ponds.	Unlikely. Lack of suitable habitat.	No
Littlejohn's Tree Frog *Litoria littlejohni*	V		V	Restricted to sandstone woodland and heath communities at mid to high altitude. It lives in both the tree canopy and on the ground, and it has been seen sheltering under rocks on high exposed ridges during summer.	Moderate. Potential impact on rock shelters through surface cracking.	Yes

Common/Scientific Name	TSC Act	FM Act	EPBC Act	Preferred Habitat*	Likelihood of Occurrence and Impact	7-part Test Required?
Red-crowned Toadlet *Pseudophryne australis*	V		-	Known only from Triassic sandstones of the Sydney Basin. Favoured habitats for shelter are between flat sandstone rocks (bush-rock). Prefer permanent soaks with dense vegetation rather than permanently flowing streams (feeder-creeks).	Moderate. Potential impact on rock shelters through surface cracking and on permanent soaks.	Yes.
Stuttering Frog *Mixophyes balbus*	E		V	Rainforest, Antarctic beech and wet sclerophyll forests (Cogger 2000). The species depends on freshwater streams and riparian vegetation for breeding and habitation. The southern portion of the Stuttering Frog's range is separated from the northern portion by the Hunter Valley.	Unlikely. Lack of suitable habitat	No.
Fish						
Macquarie Perch *Macquaria australiasica*	V		E	A riverine, schooling species. It prefers deep, rocky holes with considerable cover. Spawning occurs just above riffles (shallow running water). Populations may survive in impoundments if able to access suitable spawning sites.	Unlikely. Numerous substantial barriers to fish passage in the form of waterfalls over sandstone cliffs exist between the Cataract River and Lizard and Wallandoola Creeks. Macquarie Perch unlikely to be present upstream of these barriers (The Ecology Lab 2008	No
Trout Cod *Maccullochella macquariensis*	E		E	Found close to cover and in relatively fast currents, especially in fairly deep water close to the bank, and often congregate around large woody debris (snags).	Unlikely. Lack of suitable habitat.	No
Invertebrates						
Cumberland Plain Land Snail *Meridolum corneovirens*				Primarily inhabits Cumberland Plain Woodland (an endangered ecological community). This community is a grassy, open woodland with occasional dense patches of shrubs. Snail lives under litter of bark, leaves and logs, or shelters in loose soil around grass clumps. Occasionally shelters under rubbish.	Unlikely. Lack of suitable habitat.	No
Sydney Hawk Dragonfly *Austrocordulia leonardi*		E		Deep, cool, slow-flowing water in rocky rivers with steep sides. Relative environmental stability appears to be an important habitat feature, with rapid variation in water level and flow rate likely to have a negative effect on the suitability of habitat for larvae.	Low. The nearest watercourse to the Application Area containing suitable habitat for the Sydney Hawk Dragonfly is likely to be the Cataract River, which is beyond the influence of significant subsidence impacts (The Ecology Lab 2008).	No

Common/Scientific Name	TSC Act	FM Act	EPBC Act	Preferred Habitat*	Likelihood of Occurrence and Impact	7-part Test Required?
Giant Dragonfly *Petalura gigantean*	E			Occurs in permanent wetlands, both coastal and upland, permanent swamps and bogs with some free water and open vegetation. Larvae occupy permanent long chambered burrows, built under swamps. The larvae emerge from the terrestrial entrances at night and in wet weather, in search of insects and other arthropods to eat. Larvae are not known to swim and avoid open water.	High. Suitable habitat in swamps for adults and larvae.	Yes
Status in NSW as per Schedules 1 and 2 of TSC Act: E = Endangered; V = Vulnerable. Status as per EPBC Act: E = Endangered; V = Vulnerable; M = Migratory ** preferred habitat is a summary of literature reviewed and is not the sole information relied on for assessment of occurrence or impact*						
NB: Pelagic and Marine species have been omitted from consideration due to lack of habitat						

4.4 *MAJOR HABITAT FEATURES*

The V-mains Application Area is relatively undisturbed and provides a mosaic of habitat types for native flora and fauna. Disturbance is generally limited to minor access tracks and the No. 8 fire trail, which provides access to the No.4 Shaft and SCA lands to the north. All vegetated areas of the site are dominated by native flora.

Forest and woodland areas provide habitat for a diversity of fauna species. Trees are of various ages, providing fauna with a range of shelter and foraging resources. Tree hollows were observed within both forest and woodland areas and provide nesting and shelter habitat for a range of arboreal mammals and birds.

Fallen branches and logs are relatively abundant within the forest and woodland areas, providing resources for ground-dwelling mammal, birds and reptiles. The occurrence of dense ground vegetation interspersed with open areas provides preferred habitat for ground mammals such as bandicoots and small bird species.

Lizard and Wallandoola Creeks flow northwards through the site. The presence of fringing vegetation and pools of various depths along the length of the watercourses provides a diversity of habitats for amphibian and aquatic species, as well as fresh water resources for terrestrial species. Aquatic habitat in these creeks has been assessed separately by The Ecology Lab (2008).

The habitats for threatened terrestrial and arboreal fauna that are most likely to be impacted by subsidence include creeks, streams and their tributaries, upland swamps and rocky habitats. These habitat types are discussed in more detail below.

4.4.1 *Creeks, Streams and Tributaries*

Wallandoola Creek, Lizard Creek and associated ephemeral tributaries occur within the Application Area. Both creeks are in good condition and provide a range of habitats and resources for birds, small ground-dwelling mammals, reptiles and amphibians.

The creeks contain numerous and varied habitat features, including snags, overhanging bank vegetation, cascade-riffles, rock crevices and earthen banks. These features provide suitable habitat for aquatic species such as fish (galaxids and smelt) and freshwater crayfish (*Euastacus* sp.). Freshwater crayfish were observed within both Wallandoola Creek and Lizard Creek and numerous burrows were present along the stream banks (The Ecology Lab 2008). Dense riparian vegetation along the creeks provides preferred habitat for a variety of amphibians and reptiles.

Wallandoola Creek and Lizard Creek provide permanent aquatic habitat, in the form of deep pools, whilst the tributaries of these creeks are ephemeral and contain limited aquatic habitat (The Ecology Lab 2008).

4.4.2 Upland Swamps

Upland swamps within the site provide foraging and sheltering habitat for birds (e.g. Eastern Spinebill), mammals (e.g. Swamp Wallaby (*Wallabia bicolor*) and Common Wombat) and frogs (e.g. Common Eastern Froglet (*Crinia signifera*) and Eastern Banjo Frog (*Limnodynastes dumerilii*). Upland swamps also provide breeding habitat for species such as the Giant Dragonfly (*Petalura gigantea*). Reliance of fauna on upland swamps also increases during low rainfall periods (NSW Scientific Committee 2005), increasing their significance in the local area.

4.4.3 Rocky Habitats

Rocky sandstone outcrops and overhangs are found throughout the Application Area, particularly along the creek edges. Cliffs and overhangs provide shelter and nesting sites for a number of fauna species. Rocky outcrops provide shelter for snakes and geckos. Similarly, rock overhangs may provide habitat for mammals such as insectivorous bats and Brown Antechinus. Bird species may nest on elevated sandstone ledges (e.g. Superb Lyrebird) or under overhangs (e.g. Rock Warbler).

The Southern Coalfield's significant natural features include rivers and higher order streams, associated sandstone river gorges, major cliff lines and upland swamps. The area also contains important flora, fauna and aquatic ecosystems, many listed threatened species, populations and endangered ecological communities and a significant number of Aboriginal heritage sites (DoP 2008). Aquatic ecosystems and Aboriginal heritage have been assessed separately by specialist consultants.

The most direct environmental impact of underground mining is subsidence, which causes changes in the level of the ground surface. Predicted maximum subsidence is up to 1000 millimetres (Seedsman Geotechnics 2009). Seedsman Geotechnics (2009) states that maximum tilts of six millimetres/metre and horizontal strains of 3.3 millimetres/metre in tension and 6.5 millimetres/metre in compression are expected to develop over part of the Application Area as a result of the proposed mining.

As described in the *Strategic Review of the Impacts of Underground Coal Mining on Natural Features in the Southern Coalfields of NSW* (DoP 2008), subsidence impacts are principally tensile and shear cracking of the rock mass and localised buckling of strata caused by valley closure and upsidence but also include subsidence depressions or troughs. As a depression/ trough is formed, the ground surface is subjected to certain tilts and strains depending on the geology, depth of cover, panel dimensions and position above the panel.

It is generally recognised that the impacts of subsidence due to longwall mining on terrestrial ecosystems (including Transitional Shale Stringybark Forest) are likely to be less significant than those experienced by aquatic dependant ecosystems (DECC 2007a). Primary effects of subsidence on such communities are likely to be associated with changes in soil-moisture content, and the relationships between this indicator and subsidence are still poorly understood (DECC 2007a). Similarly, impacts to threatened flora from subsidence due to longwall mining are not predicted to be as significant as those for threatened fauna.

Potential impacts to flora and fauna from subsidence include tree tilt, alterations to watertable levels, impacts to water quality and surface water flows and cracking and/or collapse of cliffs and rocky areas. Potential direct and indirect impacts from subsidence are discussed in greater detail in *Table 5.1*.

Table 5.1 Potential Impacts to Flora and Fauna from Subsidence

Natural Feature	Physical Subsidence Impact	Potential Impact to Flora/ Fauna
Vegetation	Permanent tree tilt of up to 6mm/m due to subsidence.	Tree tilt/ fall causing damage to adjacent vegetation and loss of fauna habitat.
Rivers (creeks, streams, tributaries).	Surface cracking due to subsidence.	Loss of surface flows or water levels (increased frequency, duration and magnitude of drying aquatic habitats).
		Drying of river pools, instream macrophyte beds and wetlands leading to loss of aquatic or instream habitats.
		Loss of longitudinal connectivity (connectivity between pools and riffles) may reduce fauna migration opportunities.
		Changes to water quality (increased iron oxides, manganese, sulphides and electrical conductivity, and lower dissolved oxygen).
		Reduced diversity of instream habitat due to the growth of iron-oxidising bacteria which can also be seen as a rusty-coloured mass in the water.
		Release of gas into the water column - oxidation of gas may lead to death of riparian vegetation and instream fauna.
	Water-rock chemical interactions along new flow pathways.	Changes in water quality / quantity in streams and creeks
	Tilting of stream beds.	Stream bank and bed erosion which may lead to: • Toppling of trees due to tilt. • Impacts on tree roots from strain.
	Ponding in subsidence troughs	Waterlogging of vegetation.
Upland Swamps	Draining of perched water table and loss of swamp soil moisture due to cracking of clay or shale seals which typically underlie upland swamps.	Loss of swamp vegetation dependent on high soil moisture or change of species composition
		Loss of fauna, including threatened species dependent on swamp ecosystems.
		Loss of water purification and flow regulation function for downstream ecosystems.
		Increased susceptibility to fire which may increase impacts to swamp dependent species.
		Gullying and erosion of swamps, exacerbating the draining of water from swamp soils.

Natural Feature	Physical Subsidence Impact	Potential Impact to Flora/ Fauna
Groundwater	Localised upsidence in the stream below swamp.	Change in swamp vegetation communities
	Depressurisation of groundwater from the coal seam	Lowering of the watertable beyond the reach of plants
	Cracking of rock bars, draining of rock pools.	Subsiding vegetation into the groundwater zone
Rocky habitats	Surface cracking within cliffs	Loss of habitat for cliff dependent species and damage to riparian vegetation.
		Large cracks may act as temporary pitfall for reptiles and small mammals.
	Cliff collapse and rockfall	Loss of habitat for cliff dependent species (e.g. loss of roosts for bats and nest sites for cliff-nesting birds).
	Cracking and movement within rocks below swamps	Potential drop in perched water table leading to: • Loss of standing pools, with impacts on amphibians and fish. • Change in swamp vegetation communities. • Draining/ drying of springs, soaks and dams.
	Surface cracking	Alter and possibly destroy rock shelters and burrows.

5.1 POTENTIAL IMPACTS TO SIGNIFICANT NATURAL FEATURES WITHIN THE APPLICATION AREA

5.1.1 Creeks, Streams and Tributaries

In general, the majority of subsidence impacts to significant natural features are associated with valley closure and upsidence effects, leading to impacts to rivers and significant streams, and in particular the cracking of stream beds and underlying strata.

The streams of the Southern Coalfields are considered a high priority for protection if they have some or all of the following characteristics: perennial or intermittent/ephemeral with pools; a diverse array of instream habitats that provide for feeding, breeding or drought refugia and/or they support threatened species, iconic species or a high diversity of species (DECC 2007a). The reaches of Wallandoola and Lizard Creek within the Application Area are generally characterised by extended pools backed up behind isolated exposed sandstone ledges, often with less than 0.5 metre drop from the upstream to the downstream pools. Neither creek shows significant erosion or bank stability (Geoterra 2009). Lizard Creek, Wallandoola Creek and its tributaries are all considered to be significant natural features and are considered a high priority for protection.

Within the Application Area the subsidence deformations induced by mining will be applied to relatively flat terrain with very few rock outcrops. Therefore, systematic impacts will dominate and there will be few dis-ordered movements. Similarly, there will be no identifiable valley closure or upsidence deformations. The predicted strains are in the range of +3 mm/m to -6 mm/m. These levels are not sufficient to cause tensile cracking in solid rock. The tensile strains may cause existing joints in sandstone to open slightly (approximately 2 mm) (Seedsman Geotechnics 2009).

Without cracking of solid rock, there is no potential for loss of surface water and it is highly unlikely that there would be any observable flow-on effects on aquatic habitats, or their biota, within or immediately downstream of the Application Area (Cardno Ecology Lab 2009). In addition, the depth of the extraction is such that there will be no inter-connected cracks from the seam to the surface (Seedsman Geotechnics 2009).

There is a possibility of a localised increase in the natural stream gradient due to the maximum predicted tilt exceeding the gradient of the creeks flowing through the Application Area (Cardno Ecology Lab 2009). This could lead to an increase in flow rate, migration of flow channels, erosion of the stream bank and bed, and reduction in the volume and retention time of pools (Cardno Ecology Lab 2009). The changes in pool volume and retention time could decrease the connectivity between habitats, particularly during periods of low flow. Cardno (2009) states that the impacts to aquatic biota within the Application Area could be locally significant within a small 300m reach of the watercourse directly above the mine area, because there are only a few small, permanent pools within this section of Wallandoola Creek. However, this represents only a very small proportion of the local aquatic habitat (Cardno Ecology Lab 2009).

5.1.2 Upland Swamps

Upland Swamps are defined by the Department of Natural Resources (DNR) (2009 online) as vegetated freshwater wetlands that occur in shallow basins, being located in low hills or mountains. They include shallow marshes, sedge swamps, "hanging" swamps, wet heaths and peat swamps. Hanging swamps are those formed where groundwater discharge occurs as a result of impermeable layers in the bedrock. Swamps may also occur on valley-fill deposits eroded from the surrounding ridges (DNR online 2009). No hanging swamps have been identified within the application area.

Upland swamps rely on groundwater, rainfall and runoff from a local catchment for their source of water. They may hold water permanently, or may fill on a seasonal or intermittent basis.

Upland swamps are important parts of catchments because they absorb water and allow runoff for long periods after rainfall has ceased. Clearing and draining of swamps alters wetland hydrology and habitat values (DNR online). Swamps have a major role in regulating the flow and water quality of perennial streams. Upland swamps in this region are diverse and are key habitats for a wide variety of fauna including many threatened species such as the Giant Burrowing Frog and Red-crowned Toadlet.

DECC (2007a) has recognised four large clusters of upland swamps on the plateau areas that are considered to have particular significance in providing large contiguous areas of related habitat. Wallandoola Creek forms one of these important clusters and includes those areas mapped within the Application Area. The effect of mining-induced surface cracking on upland swamps can be severe, where the swamps are in effect perched water tables dependent on ponded rainfall on top of thin clay or shale floors. Rupturing of these seals is likely where they rest on bare rock rather than deep soil, or where they occur close to cliffs (DECC 2007a). These perched water tables are easily fractured and drained by the tensile strains above an advancing subsidence wave, putting at risk upland swamps and other groundwater dependent ecosystems in its path (DECC 2007a).

Geoterra (2009) indicates that "in-valley" upland swamps are located along the riparian channel periphery of Wallandoola Creek. There are no "hanging" swamps within the Application Area (Geoterra 2009).

The impacts from the mining of the Application Area are not expected to crack solid rock (Seedsman Geotechnics 2009), with impacts predicted to be the slight opening of existing sandstone joints. Without cracking of solid rock, there is no potential for loss of surface water and it is highly unlikely that there would be any observable flow-on effects on aquatic habitats, or their biota, within or immediately downstream of the Application Area (Cardno Ecology Lab 2009). In addition, the depth of the extraction is such that there will be no inter-connected cracks from the seam to the surface (Seedsman Geotechnics 2009), and therefore impacts to groundwater and groundwater dependent ecosystems (swamps) within the area are not expected. Consequently the species that rely on these swamps for habitat such as the Giant Dragonfly (if it occurs there) should not experience significant impacts from subsidence.

5.1.3 Rocky Habitats

The Application Area contains small cliffs/ledges and rocky outcrops that provide potential habitat for the threatened Broad-headed Snake, and other species of reptile.

Seedsman Geotechnics (2009) predicts the strains on the rocky outcrops to be in the range of +3 mm/m to -6 mm/m. These levels are not sufficient to cause tensile cracking in solid rock. The tensile strains may cause existing joints to open slightly.

6 THREATENED SPECIES IMPACT ASSESSMENT

This report has considered the general impacts of the proposal to native flora and fauna (impacts including tilt, strain, clearing, erosion and alterations to surface water flows) in Chapter 5. This chapter of the report provides a summary of the findings of Seven-part tests conducted to assess the impacts of the proposal to threatened flora, threatened fauna and endangered ecological communities. *Annex B* provides the detailed seven part tests.

6.1 INTRODUCTION

A number of threatened flora and fauna are considered likely, or moderately likely to occur within the site (see *Table 4.2* and *Table 4.3*). However, many of these species are unlikely to be impacted by alterations to habitats as a result of subsidence. Consequently, the decision to assess a threatened species under Part 5(a) of the EP& A Act is a combination of the likelihood of occurrence, and the likelihood of impact.

The threatened species identified as occurring (or likely to occur) within the site and potentially impacted by the proposal include:

- Broad-headed Snake;
- Red-crowned Toadlet;
- Rosenberg's Goanna;
- Giant Burrowing Frog;
- Littlejohn's Tree Frog;
- Spotted-tailed Quoll;
- Giant Dragonfly;
- Large-footed Myotis;
- Large-eared Pied Bat; and
- Eastern Bentwing-bat.

These species were subsequently assessed using the seven-part test of significance. The results of the seven-part test assessments concluded no significant impacts expected for all species.

7 MITIGATION AND CONCLUSION

This section of the report provides the management and mitigation measures to be implemented as part of the proposal in order to avoid, minimise and mitigate potential impacts to native flora and fauna. A concluding statement is also provided.

7.1 AVOIDANCE

There are currently minimal feasible economic alternatives to mining in the proposed Application Area. However, the pillar extraction mining method as proposed has the potential to be modified should subsidence impacts significantly change from what has been predicted. In 2007 a map of 'ecological risk management zones' was provided to NRE for consideration and these areas included upland swamp communities, creek lines and riparian zones, significant fauna habitats and endangered ecological communities and an additional buffer zone of 250 metres around these areas. The risk management zones provide/d the subsidence engineers and mine managers with an understanding of the locations of sites of ecological significance within the Application Area and an opportunity to reassess the mine plans based upon this information.

7.2 MITIGATION

Measures to mitigate potential impacts from subsidence are recommended to assist in the amelioration of impacts. These include:

- if fracturing does occur, remediation should be implemented as soon as possible. Methods could include grouting. All remediation works undertaken should be controlled in an Environmental Management Plan (EMP);
- if fracturing occurs leading to loss of surface water these areas should be prioritised for remediation;
- if significant cracking occurs in vegetated areas then measures such as temporary fencing should be implemented. This will ensure that fauna are not injured or trapped; and
- prior to any remediation works, advice should be sought from an ecologist regarding the potential impacts of such remediation works to plant and animal populations within the area.

A distinct advantage of the type of mining method (pillar extraction) is that progressive monitoring can be use to limit further extraction should the need or opportunity arise. The nature and extent of any remediation will be determined by monitoring and direct consultation with relevant government agencies including DECC and SCA. The potential for remediation measures to induce a greater adverse impact over and above that attributable to mine subsidence must be balanced with the potential for natural remediation to occur.

7.2.1 Monitoring

Monitoring of the important habitat areas (such as the upland swamps, creeks and rocky habitats) should occur pre and post mining. Although not expected, this will enable the detection of any significant impacts to these habitats, and allow for targeted remediation.

Additional fauna surveys in suitable seasons to detect the threatened frogs and the Giant Dragonfly, the species predicted to be most at risk if impacts from subsidence do occur, should be undertaken to obtain population information and distributions, should any of the species be detected. This will also allow for targeted remediation and adaptive management if subsidence does impact important areas for these species and varies from impact level as predicted.

7.3 CONCLUSION

Based on the Seedsman (2009), Geoterra (2009), Cardno (2009) and ERM field survey and assessments, the current proposal is not expected to have significant impacts on threatened species. Additional surveys and pre and post mining monitoring are recommended to assist in the identification of any impacts and targeted remediation, if impacts occur.

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Annex A

Fauna Species Recorded Within Site

Common Name	Scientific Name
Birds	
Australian King-Parrot	*Alisterus scapularis*
Australian Magpie	*Gymnorhina tibicen*
Australian Raven	*Corvus coronoides*
Australian Wood Duck	*Chenonetta jubata*
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*
Brown Thornbill	*Acanthiza pusilla*
Brown Treecreeper	*Climacteris picumnus*
Brown-headed Honeyeater	*Melithreptus brevirostris*
Buff-rumped Thornbill	*Acanthiza reguloides*
Channel-billed Cuckoo	*Scythrops novaehollandiae*
Chestnut-rumped Heathwren	*Hylacola pyrrhopygia*
Crimson Rosella	*Platycercus elegans*
Diamond Dove	*Geopelia cuneata*
Eastern Rosella	*Platycercus eximius*
Eastern Spinebill	*Acanthorhynchus tenuirostris*
Eastern Whipbird	*Psophodes olivaceus*
Eastern Yellow Robin	*Eopsaltria australis*
Fairy Martin	*Hirundo ariel*
Fan-tailed Cuckoo	*Cacomantis flabelliformis*
Golden Whistler	*Pachycephala pectoralis*
Grey Butcherbird	*Cracticus torquatus*
Grey Currawong	*Strepera versicolor*
Grey Fantail	*Rhipidura fuliginosa*
Grey Shrike-thrush	*Colluricincla harmonica*
Laughing Kookaburra	*Dacelo novaeguineae*
Lewin's Honeyeater	*Meliphaga lewinii*
Little Wattlebird	*Anthochaera chrysoptera*
Marbled Frogmouth	*Podargus ocellatus*
Masked Lapwing	*Vanellus miles*
New Holland Honeyeater	*Phylidonyris novaehollandiae*
Noisy Friarbird	*Philemon corniculatus*
Noisy Miner	*Manorina melanocephala*
Olive-backed Oriole	*Oriolus sagittatus*
Pheasant Coucal	*Centropus phasianus*
Pied Currawong	*Strepera graculina*
Powerful Owl	*Ninox strenua*
Quail	*Coturnix sp.*
Red Wattlebird	*Anthochaera carunculata*
Scarlet Robin	*Petroica multicolor*
Silvereye	*Zosterops lateralis*
Southern Boobook	*Ninox novaeseelandiae*
Southern Emu-wren	*Stipiturus malachurus*

Common Name	Scientific Name
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*
Spotted Pardalote	*Pardalotus punctatus*
Striated Pardalote	*Pardalotus striatus*
Tree Martin	*Hirundo nigricans*
Variegated Fairy-wren	*Malurus lamberti*
Wedge-tailed Eagle	*Aquila audax*
Weebill	*Smicrornis brevirostris*
Welcome Swallow	*Hirundo neoxena*
White-browed Scrubwren	*Sericornis frontalis*
White-cheeked Honeyeater	*Phylidonyris nigra*
White-eared Honeyeater	*Lichenostomus leucotis*
White-naped Honeyeater	*Melithreptus lunatus*
White-throated Nightjar	*Eurostopodus mystacalis*
White-throated Treecreeper	*Cormobates leucophaeus*
White-winged Chough	*Corcorax melanorhamphos*
Willie Wagtail	*Rhipidura leucophrys*
Yellow Thornbill	*Acanthiza nana*
Yellow-faced Honeyeater	*Lichenostomus chrysops*
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*
Yellow-tailed Black-Cockatoo	*Calyptorhynchus funereus*
Yellow-tufted Honeyeater	*Lichenostomus melanops*
Mammals	
Chocolate Wattled Bat	*Chalinolobus morio*
Eastern Bent-wing Bat	*Miniopterus schreibersii oceanensis*
Eastern Broad-nosed Bat	*Scotorepens orion*
Eastern Falsistrelle	*Falsistrellus tasmaniensis*
Eastern Freetail-bat	*Mormopterus norfolkensis*
Eastern Grey Kangaroo	*Macropus giganteus*
Eastern Pygmy-possum	*Cercartetus nanus*
European Red Fox	*Vulpes vulpes*
Gould's Wattled Bat	*Chalinolobus gouldii*
Greater Broad-nosed Bat	*Scoteanax rueppellii*
House Mouse	*Mus musculus*
Large Bent-wing Bat	*Miniopterus schreibersii*
Large Forest Bat	*Vespadelus darlingtoni*
Little Forest Bat	*Vespadelus vulturnus*
Long-eared Bat	*Nyctophilus sp.*
Sugar Glider	*Petaurus breviceps*
Swamp Wallaby	*Wallabia bicolor*
White-striped Mastiff Bat	*Tadarida australis*
Common Wombat	*Vombatus ursinus*

Common Name	Scientific Name
Reptiles	
Copper-tailed Skink	*Ctenotus taeniolatus*
Eastern Brown Snake	*Pseudonaja textilis*
Lesueur's Velvet Gecko	*Oedura lesueurii*
Red-bellied Black Snake	*Pseudechis porphyriacus*
Skink	*Egernia sp.*
Unidentified Elapid	
Amphibians	
Common Eastern Froglet	*Crinia signifera*
Eastern Banjo Frog	*Limnodynastes dumerilii*
Lesueur's Frog	*Litoria lesueuri*
Peron's Tree Frog	*Litoria peronii*
Red-backed Brood Frog	*Pseudophryne coriacea*
Smooth Toadlet	*Uperoleia laevigata*

Annex B

Seven Part Tests

B.1 BROAD-HEADED SNAKE (HOPLOCEPHALUS BUNGAROIDES) (E TSC ACT, V EPBC ACT)

The Broad-headed Snake is largely confined to Triassic and Permian sandstones, including the Hawkesbury, Narrabeen and Shoalhaven groups, within the coast and ranges in an area within approximately 250 kilometres of Sydney. The species is nocturnal, sheltering in rock crevices and under flat sandstone rocks on exposed cliff edges during Autumn, Winter and Spring. In Summer, the species moves from sandstone rocks to shelters in hollows in large trees within 200 metres of escarpments, breeding during January to March.

This assessment identified potential habitat for the Broad-headed Snake as rock crevices and flat sandstone rocks and tree hollows within areas of Sandstone Gully Peppermint Forest and Exposed Sandstone Scribbly Gum Woodland in the Application Area.

a) *In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*

The subsidence deformations induced by the mining will be applied to relatively flat terrain with very few rock outcrops. The predicted strains are not sufficient to cause tensile cracking in solid rock. However, may cause existing joints to open slightly (Seedsman 2009). If impacts on wintering habitat through surface cracking of sandstone outcrops were to occur, there is a large amount of habitat (exposed sandstone outcrops) available for the Broad-headed Snake within the Application Area.

This habitat is found along the length of the creeklines within areas mapped as Sandstone Gully Peppermint Forest and Exposed Sandstone Scribbly Gum Woodland (See *Figure 4.1*) The extent of disturbance from subsidence to these habitats is predicted to be low. In combination with the abundance of the habitat type within the immediate area, it is considered unlikely that the proposal will significantly impact the winter habitats of the species.

Hollow-bearing trees used as summer habitat are not expected to be impacted by the proposal.

It is considered unlikely that the proposal will have an adverse effect on the life cycle of Broad-headed Snake to the extent that a viable local population is likely to be placed at risk of extinction.

b) *In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*

Not applicable to a species.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable to a species.

d) In relation to the habitat of a threatened species, population or ecological community:

(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The proposed activities will not involve the removal of Exposed Sandstone Scribbly Gum Woodland and Sandstone Gully Peppermint Forest within the Application Area. If these habitats were modified through mine subsidence, the impacts are expected to be minor (e.g tree tilt or minor depressions) although the location and extent of potential subsidence is unknown.

(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

It is unlikely that the proposal would result in areas of habitat becoming isolated for the Broad-headed Snake. The opening of existing joints will not result in areas that could not be traversed by the species. Habitat connectivity will be retained within the Application Area and locality.

(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

The Application Area contains suitable sheltering, foraging and breeding resources for Broad-headed Snake in the form of exposed sandstone outcrops, rocky crevices and overhangs and hollow-bearing trees (and prey species). The sheltering habitats, in particular the rocky areas, although considered extensive within the study area, are naturally restricted in their distribution. Therefore any confirmed areas of habitat would be considered important in both the regional and local context, particularly as the species also has a restricted distribution.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

Critical habitat has not been declared for the species.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

There is currently no recovery plan or threat abatement plan for the Broad-headed Snake. However, the DEC has prepared 22 Priority Actions to help recover this species. Those relevant to the proposal are outlined below:

- Habitat Rehabilitation/Restoration and/or Regeneration: undertake artificial or replacement rock initiatives to replace or supplement lost habitat; and

- Retain woodland adjacent to sandstone escarpments, particularly large hollow-bearing trees.

Subsidence will not lead to a loss of habitat through opening of existing joints within sandstone outcrops and no surface rock will be removed from the Application Area. Artificial or replacement rock initiatives are not considered necessary as part of the current proposal.

g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

'*Alteration of habitat following subsidence due to longwall mining*' is listed as Key Threatening Processes (KTP) under the TSC Act.

The proposal is likely to result in the operation of this KTP in relation to Broad-headed Snake habitat (rocky outcrops) within the Application Area. However, as indicated, there is a large amount of exposed sandstone outcrop habitat available within the Application Area, and the level of disturbance from subsidence to rocky outcrops is anticipated to be low.

It is considered unlikely that this KTP would significantly impact Broad-headed Snake individuals or populations within the Application Area.

B.2 RED-CROWNED TOADLET (PSEUDOPHRYNE AUSTRALIS) (V TSC ACT)

The Red-crowned Toadlet prefers periodically wet drainage lines below sandstone ridges on which the predominant vegetation is dry open forests. Breeding occurs in dense vegetation and debris beside ephemeral creeks and gutters, where eggs are laid in moist leaf litter. The Red-crowned Toadlet disperses outside the breeding season to shelter under rocks and logs on sandstone ridges and to forage amongst thick piles of leaf litter (DEC 2009). The species utilisation of the ground litter layer may result in them being significantly affected by fire and other activities that cause the destruction of the leaf litter layer (NPWS 2001).

Red-crowned Toadlets are sensitive to changes in pH outside of the range 5.5 to 6.5 and have not been recorded breeding in sites that are even mildly polluted nor in permanently flowing watercourses. Most of this species' life is spent under some form of cover, such as rocks, deep leaf-litter, or in rock crevices (NPWS 2001).

It is known that sandstone exfoliations are particularly important to this species, so activities that impact on this habitat have the potential to affect the species (NPWS 2001).

The Red-crowned Toadlet requires specific breeding conditions: small nests are formed within moist leaf litter, then rain flushes the embryos from the nest and tadpoles complete development within transient pools (NPWS 2001). The timing of follow up rain events and duration of temporary pools is critical to reproductive success (NPWS 2001). Recruitment is usually low.

The presence of Wallandoola and Lizard Creeks and associated tributaries, sandstone ridges and leaf litter within the Application Area provides potential foraging, breeding and sheltering habitat for the Red-crowned Toadlet. Plant communities that may provide potential habitat for this species include Exposed Sandstone Scribbly Gum Woodland, Upland Swamps: Banksia Thicket and Upland Swamps: Fringing Eucalypt Woodland.

Impacts to this species may include loss of habitat through alterations in water flow regimes, reduced water quality through sedimentation, and loss of connectivity between pools.

a) *In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*

The Red-crowned Toadlet has a specialised terrestrial reproductive strategy and a reliance on ephemeral water flow means that it may be particularly vulnerable to a range of activities that impact on hydrology or water quality. This includes impacts of runoff, pollution and changes in pH (NPWS 2001).

Red-crowned Toadlets do not usually live along permanent flowing water courses, instead preferring permanently moist soaks or areas of dense ground vegetation or litter along or near non-perennial first or second order drainage systems that are adjacent to ridges, are ephemeral in nature, and commonly called 'feeder-creeks'. These feeder creeks channel water from ridges, benches, cliffs and slopes to perennial streams in the gullies below. Such watercourses are dry or reduced to scattered shallow pools or ponds for much of the year, and have sustained flow for only a few weeks following thunderstorms. Under natural conditions these feeder creeks have high water quality and low nutrient loads (NPWS 2001).

Given these preferences, the area of potential habitat for the Red-crowned Toadlet within the Application Area would include the areas of drainage that feed Wallandoola Creek, riparian vegetation, sandstone outcrops and Upland Swamps. These habitats provide potential foraging, sheltering and breeding resources for the Red-crowned Toadlet.

Potential impacts to the species could occur through a loss of habitat (eg drying of a swamp or ephemeral creeklines) or significant alterations to habitats (through pollution or other environmental changes). Seedsman Geotechnics (2009) states that the predicted strains from the proposed works are not sufficient to cause tensile cracking in solid rock; without cracking there is no potential for loss of surface water. In addition, the depth of the extraction is such that there will be no inter-connected cracks from the seam to the surface. Therefore no impacts to the upland swamps or feeder creeks are expected.

There is a possibility of a localised increase in the natural stream gradient within the upper section of Wallandoola Creek, due to the maximum predicted tilt exceeding the gradient of the creeks flowing through the Application Area (Cardno Ecology Lab 2009). This could result in localised alterations in water flow regimes, reduced water quality through sedimentation, and loss of connectivity between pools.

However, it is unlikely that the Red-crowned Toadlet would rely on these permanent pools, as it prefers ephemeral water flow. In addition there is an abundance of pools in the upper reaches of the creek and it is unlikely that all pools will be affected. Given the extent of potential habitat within the Application Area and localisation of the impact area the proposal is not considered to have an adverse effect on the lifecycle of Red-crowned Toadlet.

b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

Not applicable to a species.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable to a species.

d) In relation to the habitat of a threatened species, population or ecological community:

(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and

Potential habitats for the Red-crowned Toadlet occur in the Sandstone Gully Peppermint Forest, Upland Swamps Exposed Sandstone Scribbly Gum Woodland and Rock Plate Heath-Mallee within the Application Area. The exact location and extent of potential subsidence impacts to Red-crowned Toadlet habitats within the Application Area is unknown. However based on the subsidence predictions it is highly unlikely that all of this habitat would be impacted by subsidence.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The area predicted to be impacted is located within the upper section of Wollandoola Creek. Due to the Red-crowned Toadlet's reliance on ephemeral water flow and the extent of potential habitat downstream and in the surrounding swamps, an area of Red-crowned Toadlet habitat is not considered to become fragmented or isolated from other areas of habitat.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the Locality.

The catchment of the Woronora Plateau has been identified by the DECC (2005) as being of extreme importance to the overall survival of the Red-crowned Toadlet and it is considered that "any future declines from this stronghold will jeopardise the survival of the species as a whole" (DEC 2005).

Cardno Ecology lab (2009) states that the impact to aquatic biota within the Application Area could be locally significant within a small 300m reach of the watercourse directly above the mine area, due to there being only a few small, permanent pools within this section of Wallandoola Creek. However, the Red-crowned Toadlet does not rely on permanent pools, preferring ephemeral water flow and feeder creeks. Therefore, given the extent of preferred habitat within the Application Area, the area to be impacted is not considered to be of high importance.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

Critical habitat has not been declared for the species.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

There is currently no recovery plan or threat abatement plan for the Red-crowned Toadlet. However, the DECC has prepared 14 Priority Actions to help recover this species. Those relevant to the proposal are outlined below:

- Retain and protect habitat and buffers around habitat, particularly vegetation on upper slopes and ridges; and
- Habitat Rehabilitation/restoration and/or regeneration.

g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

'*Alteration of habitat following subsidence due to longwall mining*' is listed as Key Threatening Processes (KTP) under the TSC Act. Seedsman Geotechnics (2009) state that the subsidence deformations induced by the mining will be applied to relatively flat terrain with very few rock outcrops. Therefore, systematic impacts will dominate and there will be few dis-ordered movements and alteration of habitat for the Red-crowned Toadlet.

'*Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands*' is also listed as KTP under the TSC Act. Geoterra (2009) stated that there is no potential for loss of surface water within the Application Area and as there will be no cracking or surface water loss, impacts of cracking and drying to groundwater and swamps are not expected.

B.3 SPOTTED-TAILED QUOLL (DASYURUS MACULATUS) (V TSC ACT, E EPBC ACT)

The Spotted-tailed Quoll uses a variety of habitats such as sclerophyll forest and woodlands, heath and rainforest. Its habitat requirements include den sites, an abundance of food and large areas of intact vegetation (DECC 2005a). The Spotted-tailed Quoll nests in caves, hollow logs, rock crevices, boulder piles, rocky cliff faces and tree hollows. The Spotted-tailed Quoll is highly mobile, with females occupying home ranges up to about 750 hectares and males up to 3500 hectares. The species usually traverse their ranges along densely vegetated creek lines (DECC 2005a).

Potential foraging, shelter and den site habitat for Spotted-tailed Quoll within the Application Area includes caves, hollow logs, rock crevices, rocky cliff faces, boulder piles and tree hollows within areas of Sandstone Gully Peppermint Forest, Exposed Sandstone Scribbly Gum Woodland, Upland Swamps: Fringing Eucalypt Woodland, Upland Swamps: Sedgeland-Heath Complex, Upland Swamps: Banksia Thicket and Upland Swamps: Tea-Tree Thicket. The Spotted-tailed Quoll could traverse the Application Area via Wallandoola and Lizard Creeks and associated tributaries.

a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,

The Spotted-tailed Quoll uses hollow-bearing trees, fallen logs, small caves, rock crevices, boulder fields and rocky-cliff faces as den sites. Surface cracking within cliffs and overhangs and rock fall has the potential to destroy sheltering and den sites. However, Seedman Geotechnics (2009) state that the predicted strains are not sufficient to cause tensile cracking in solid rock.

The proposed activities will not involve the removal of Sandstone Gully Peppermint Forest or Exposed Sandstone Scribbly Gum Woodland. However, hollow bearing trees within these vegetation communities may be modified through tree tilt/ loss caused by mine subsidence. It is anticipated that any loss of hollow-bearing trees (and therefore current or potential den sites) would only represent a small proportion of available hollow-bearing trees within the Application Area. In addition, the Spotted-tailed Quoll is a very mobile species with the ability to use a diverse range of habitats for sheltering and dens.

It is considered that the life cycle of the Spotted-tailed Quoll will not be affected by the proposal.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

Not applicable to a species.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

(iii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable to a species.

d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The proposal will not involve the direct removal of habitat for the Spotted-tailed Quoll. Habitats that may be modified by the proposal include sheltering and den sites and foraging habitat. However, habitat modification (for example, loss of hollow bearing trees) is expected by be minor and localised. Spotted-tailed Quoll is a highly mobile species, and it is anticipated that individuals could readily relocate to unmodified areas of habitat.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

Given the mobility of the Spotted-Tailed Quill it is considered unlikely that the potential impacts of the proposal will result in fragmentation or isolation of habitats for the species.

Given that the proposal will not involve the direct removal of Spotted-tailed Quoll habitat, habitat connectivity will be retained within the Application Area and locality.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

The Application Area represents a large area of intact vegetation. It also contains suitable sheltering, foraging and breeding resources for this species in the form of hollow-bearing trees, fallen logs, small caves, rock crevices, boulder fields and rocky-cliff faces. However, potential habitat within the study area is not considered vital to the long-term survival of Spotted-tailed Quoll in the locality. In addition, any potential impacts from the proposal to areas of potential habitat are considered to be minimal for this species.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

Critical habitat has not been declared for the species.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

There is currently no recovery plan or threat abatement plan for the Spotted-tailed Quoll. However, the DECC has prepared 32 Priority Actions to help recover this species. Those relevant to the proposal are outlined below:

- Retain and protect large, forested areas with hollow logs and rocky outcrops, particularly areas with thick understorey or dense vegetation along drainage lines; and

- Habitat requirements of Spotted-tailed Quolls to be adequately conserved within environmental planning instruments and through other legislative protection mechanisms.

g) *whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*

'*Alteration of habitat following subsidence due to longwall mining*' is listed as Key Threatening Processes (KTP) under the TSC Act.

The proposal is likely to result in the operation of this KTP in relation to Spotted-tailed Quoll sheltering habitat and den sites within the Application Area. However, the level of disturbance to rock crevices and hollow-bearing trees from subsidence is anticipated to be low and to be localised.

'*Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands*' is also listed as KTP under the TSC Act. Localised increase in natural stream gradient potentially leading to an increase in flow rate and migration of flow channels may potentially impact on Spotted-tailed Quoll foraging habitat. However, any impacts are anticipated to be localised and unlikely to significantly impact on Spotted-tailed Quoll given the mobile nature of this species.

It is considered unlikely that either KTP would significantly impact Spotted-tailed Quoll individuals or populations within the Application Area.

B.4 ROSENBERG'S GOANNA (VARANUS ROSENBERGI) (V TSC ACT)

Rosenberg's Goanna is found in heath, open forest and woodland (DECC 2005a). The species shelters in hollow logs, burrows (which they may dig for themselves, or they may use other species' burrows, such as rabbit warrens), rock crevices and sandstone outcrops. Termite mounds are a critical habitat component for Rosenberg's Goanna as the species nests in termite mounds (DECC 2005a). Individuals require large areas of habitat.

Potential habitat within the Application area includes hollow logs, sandstone outcrops and rock crevices within areas of Sandstone Gully Peppermint Forest and Exposed Sandstone Scribbly Gum Woodland.

a) *In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*

Termite mounds are a critical habitat component for Rosenberg's Goanna as the species nests within the mounds. Rosenberg's Goanna also shelters in hollow logs, burrows, rock crevices and sandstone outcrops.

The subsidence deformations induced by the mining will be applied to relatively flat terrain with very few rock outcrops. Seedman Geotechnics (2009) states that the predicted strains are not sufficient to cause tensile cracking in solid rock and may cause existing joints to open slightly. If impacts on habitat through rock falls and fracturing of sandstone outcrops were to occur, there is a large amount of habitat (exposed sandstone outcrops) available for the Rosenberg's Goanna within the Application Area. Nesting habitat such as termite mounds is considered unlikely to be significantly impacted by the proposal.

It is considered unlikely that the proposal will have an adverse effect on the life cycle of Rosenberg's Goanna to the extent that a viable local population is likely to be placed at risk of extinction.

b))In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

Not applicable to a species.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Not applicable to a species.

(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable to a species.

d) In relation to the habitat of a threatened species, population or ecological community:

(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The proposed activities will not involve the removal of Exposed Sandstone Scribbly Gum Woodland, Upland Swamps: Banksia Thicket and Upland Swamps: Fringing Eucalypt Woodland, or direct disturbance to creek lines, sandstone ridges and leaf litter within the Application Area. However, these habitats may be modified through mine subsidence. Although the location and extent of potential subsidence is unknown based on the subsidence predictions it is highly unlikely that all of this habitat would be impacted by subsidence.

(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposal is unlikely to cause fragmentation or isolation of vegetation communities given that no vegetation removal will occur. Similarly, rocky and sandstone habitats are currently isolated throughout the Application Area. The proposal is considered unlikely to result in further fragmentation or isolation of rocky or sandstone habitats.

Given that the proposal will not involve the direct removal of Rosenberg's Goanna habitat, habitat connectivity will be retained within the Application Area and locality.

(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

Rosenberg's Goanna has not been recorded within the Application Area. However, the species has been recorded within the locality. The Application Area contains large areas of undisturbed vegetation communities such as Exposed Sandstone Scribbly Gum Woodland which provide habitat resources for the species.

Given the large area of available habitat (and potential habitat resources) within the Application Area it is considered that the Application Area would be considered important to the species, if it occurs there.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

Critical habitat has not been declared for the species.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

There is currently no recovery plan or threat abatement plan for the Rosenberg's Goanna. However, the DECC has prepared nine Priority Actions to help recover this species. Those relevant to the proposal are outlined below:

- Do not fragment known habitat with clearing, roads or other development;
- Retain and protect heath, woodland and forest remnants within the known distribution of the species; and
- Ensure remnant populations remain connected or linked to each other; in cases where remnants have lost connective links, re-establish links by revegetating sites to act as stepping stones for dispersal.

g) *Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*

'*Alteration of habitat following subsidence due to longwall mining*' is listed as Key Threatening Processes (KTP) under the TSC Act.

The proposal has the potential to result in the operation of this KTP in relation to Rosenberg's Goanna sheltering habitat within the Application Area. However, the level of disturbance to rock crevices and burrows from subsidence is anticipated to be low and to be localised.

B.5 GIANT BURROWING FROG (HELEIOPOROUS AUSTRALIACUS) (V TSC ACT)

The Giant Burrowing Frog is found in hanging swamps on sandstone shelves and beside perennial non-flooding creeks (Daly 1996; Webb 1993) in the northern part of its range. The species is also associated with sandy soil on sandstone ridges that support heath vegetation (Mahony 1993). Giant Burrowing Frog is found in sand or rock based streams and less frequently in constructed dams. Giant Burrowing Frog has been reported to occur in a wide range of forest communities in the southern part of its range. The species often spends significant periods of time underground during unfavourable conditions and to avoid detection during the day (NPWS 2001).

Foraging, sheltering and breeding habitat for the Giant Burrowing Frog within the Application Area includes heath vegetation, feeder creeks and soaks associated with Wallandoola and Lizard Creeks and Upland Swamps.

a) *In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*

The Giant Burrowing Frog breeds throughout the year, generally following heavy rains (Penman *et al.* 2004). Mating occurs in ephemeral pools and slow or standing water such as small soaks formed in eroded sandstone drainage lines (Mahony 1993; Watson & Martin 1973).

Seedsman Geotechnics (2009) states that the predicted strains from the proposed works are not sufficient to cause tensile cracking in solid rock, without cracking there is no potential for loss of surface water. In addition, the depth of the extraction is such that there will be no inter-connected cracks from the seam to the surface.

There is a possibility of a localised increase in the natural stream gradient, within a few small permanent pools within the upper section of Wallandoola Creek. This is due to the maximum predicted tilt exceeding the gradient of the creeks flowing through the Application Area (Cardno Ecology Lab 2009), which could result in alterations in water flow regimes, reduced water quality through sedimentation, and loss of connectivity between pools. The abundance of pools within the upper reaches of the creek means that it is highly unlikely that all pools would be affected by tilt and drying, and downstream pools will be unaffected. The Giant Burrowing Frog would not rely solely on the area predicted to be to be affected in Wallandoola Creek.

However, given the extent of potential habitat within the Application Area, localisation of the impact area and the ability of the species to live underground in unfavourable conditions, it is considered unlikely that the predicted tilt impacts will have an adverse effect on the lifecycle of the Giant Burrowing Frog to the extent that one or more populations within the Application Area may be placed at risk of local extinction.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

Not applicable to a species.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Not applicable to a species.

(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable to a species.

d) In relation to the habitat of a threatened species, population or ecological community:

(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The subsidence deformations induced by the mining will be applied to relatively flat terrain with very few rock outcrops. Seedman Geotechnics (2009) states that the predicted strains are not sufficient to cause tensile cracking in solid rock. However the strain may cause existing joints to open slightly. If impacts to non-breeding shelter were to occur, there is a large amount of habitat (exposed sandstone outcrops) available for the Giant Burrowing Frog within the Application Area.

Tilting may lead to a localised increase in the natural stream gradient, within a few small permanent pools within the upper section of Wallandoola Creek, resulting in alterations in water flow regimes and reduced water quality through sedimentation.

(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The area to be impacted is located within the upper section of Wollandoola Creek containing only a permanent pools and is considered unlikely to result in fragmentation or isolation of rocky or sandstone habitats.

The Giant Burrowing Frog can travel several hundred metres from non-breeding areas to creeks to breed (NPWS 2001). Therefore, an area of Giant Burrowing Frog habitat will not become fragmented or isolated from other areas of habitat.

(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

The Giant Burrowing Frog is considered an uncommon resident within the Greater Southern Sydney region (DECC 2005b). In addition, DECC (2005b) states that the protection of Upland Swamps and associated creeks is paramount to the survival of the Giant Burrowing Frog on the Woronora Plateau. Given the above, Giant Burrowing Frog habitat within the Application Area would be considered to be of high importance to the long-term survival of the species, if it occurs there.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

Critical habitat has not been declared for the species.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

There is currently no recovery plan or threat abatement plan for the Giant Burrowing Frog. However, the DECC has prepared 24 Priority Actions to help recover this species. Those relevant to the proposal are outlined below:

- Retain native vegetation and minimise ground disturbance where the species occurs.

g) *Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*

'*Alteration of habitat following subsidence due to longwall mining*' is listed as Key Threatening Processes (KTP) under the TSC Act. Giant Burrowing Frog breeding, foraging and sheltering habitats such as creeks and rocky habitats are particularly susceptible to the impacts of subsidence. However, the level of disturbance subsidence is anticipated to be low and to be localised.

'*Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands*' is also listed as KTP under the TSC Act. Loss of stream flow and reduced surface water pondage may potentially impact on Giant Burrowing Frog breeding habitat. However, the area to be impacted is located within the upper section of Wallandoola Creek containing only a few small permanent pools.

B.6 LITTLEJOHN'S TREE FROG (LITORIA LITTLEJOHNI) (V TSC ACT, E EPBC ACT)

The Littlejohn's Tree Frog inhabits forest, coastal woodland and heath (White & Ehmann 1997), but the species is not associated with any specific vegetation types (Lemckert 2004). Breeding habitat includes temporary pools in forested areas, deep permanent pools of slow creeks (in hanging swamps) or slow, rock-lined rivers (White and Ehmann 1997).

Non-breeding habitat is unknown, but may include leaf litter and low shrubs. Littlejohn's Tree Frog may also be arboreal (Hero *et al.* 2002). Potential habitat within the Application Area includes pools in Wallandoola and Lizard Creeks and associated tributaries and leaf litter and shrubs in adjacent vegetation communities.

a) *In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*

Littlejohn's Tree Frog breeds in temporary pools in forested areas, deep permanent pools of slow creeks (in hanging swamps) or slow, rock-lined rivers (White and Ehmann 1997).

Seedsman Geotechnics (2009) states that the predicted strains from the proposed works are not sufficient to cause tensile cracking in solid rock, without cracking there is no potential for loss of surface water. In addition, the depth of the extraction is such that there will be no inter-connected cracks from the seam to the surface.

There is, however, a possibility of a localised increase in the natural stream gradient, within a few small permanent pools within the upper section of Wallandoola Creek, due to the maximum predicted tilt exceeding the gradient of the creeks flowing through the Application Area (Cardno Ecology Lab 2009). This could result in alterations in water flow regimes, reduced water quality through sedimentation, and loss of connectivity between pools.

It is unknown whether Wallandoola Creek or Lizard Creek would currently constitute preferred habitat, as despite the presence of some deep pools, in the upper reaches the water is not slow-flowing during periods of rain. The species would be more likely to inhabit areas downstream, where the creekbeds widen and the water flow is less rapid.

It is predicted that the reach of the Wallandoola creek to be potentially impacted by the proposal would be unlikely to constitute preferred habitat for the species. If the species did currently use the pools in the upper reaches for breeding, it is possible that it could be impacted by drying of pools or reduced retention time of water. However, there is also an abundance of pools within the upper reaches and if impacts did occur, they would not impact on all potential breeding sites. The species could move to other suitable pools, or to downstream habitats.

Therefore the life cycle of the species is unlikely to be impacted to such an extent such that a viable local population of the species is likely to be placed at risk of extinction,

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

Not applicable to a species.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Not applicable to a species.

(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable to a species.

d) In relation to the habitat of a threatened species, population or ecological community:

(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The extent of modification to Littlejohn's Tree Frog habitat within the Application Area is unknown. However it is predicted to occur only in the upper reaches of Wallandoola Creek.

(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

Littlejohn's Tree Frog dispersal is limited (DECC 2005b). Accordingly, Littlejohn's Tree Frog is considered a localised species and small scale fragmentation or isolation within or adjacent to areas of breeding habitat may impact this species. However, the extent to which the species could move along Wallandoola Creek is not known and the species could move to other areas downstream, within Lizard Creek, or into adjacent pools.

(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

Littlejohn's Tree Frog is extremely rare within the Woronora Plateau DECC (2005b). DECC (2005b) also states that known Littlejohn's Tree Frog breeding sites should be treated as being of high conservation value and clearing and disturbance to breeding habitat or degradation of water quality should be avoided.

Whilst Littlejohn's Tree Frog has not been recorded within the Application Area, it is known to contain potential habitat for this species. Accordingly, habitat for Littlejohn's Tree Frog within the Application Area is considered of high importance to the species.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

Critical habitat has not been declared for the species.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

There is currently no recovery plan or threat abatement plan for the Little John's Tree Frog. However, the DECC has prepared 13 Priority Actions to help recover this species. Those relevant to the proposal are outlined below:

- Retain riparian native vegetation.

g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

'Alteration of habitat following subsidence due to longwall mining' is listed as Key Threatening Processes (KTP) under the TSC Act. Littlejohn's Tree Frog breeding habitats such as creeks are particularly susceptible to the impacts of subsidence.

'Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands' is also listed as KTP under the TSC Act. Alterations to water flow regimes may potentially impact on Littlejohn's Tree Frog breeding habitat.

B.7 GIANT DRAGONFLY (PETALURA GIGANTEAN) (E TSC ACT)

Giant Dragonfly is found in permanent swamps and bogs with some free water and open vegetation (DECC 2005). Adults Giant Dragonfly spend most of their time settled on low vegetation on or adjacent to the swamp (DECC 2005b). Eggs are deposited in moist soils amongst swampy vegetation and larvae dig long branching burrows under the swamp (DECC 2005b).

Potential habitat for Giant Dragonfly within the Application Area includes upland swamps and associated vegetation communities such as Fringing Eucalypt Woodland, Banksia Thicket, Sedgeland-Heath Complex and Tea-Tree Thicket.

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,

Giant Dragonfly deposit eggs in moist soils amongst swampy vegetation and build burrows under upland swamps (DECC 2005b). The proposed activities will not involve the removal of, Tea-Tree Thicket, Upland Swamps: Banksia Thicket and Upland Swamps: Fringing Eucalypt Woodland, or loss of surface water or ground water. Therefore, the proposal is unlikely to have an adverse effect on the lifecycle of the Giant Dragonfly to the extent that one or more populations within the Application Area may be placed at risk of local extinction.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

Not applicable to a species.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Not applicable to a species.

(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable to a species.

d) In relation to the habitat of a threatened species, population or ecological community:

(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The proposed activities will not involve direct removal, disturbance or modification to potential habitat of the Giant Dragonfly, upland swamps, within the Application Area.

(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

Giant Dragonfly dispersal is limited (DECC 2005b) and may not occur between swamps. However, upland swamp habitats are already currently isolated from other swamps by eucalypt woodlands and forests throughout the Application Area. There are no predicted impacts to swamps within the Application Area.

The proposal is therefore considered unlikely to result in further fragmentation or isolation of upland swamp habitats.

(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

Giant Dragonfly has not been recorded within the Application Area. However, upland swamps within the Application Area contain suitable breeding habitat for this species. Accordingly, habitat for Giant Dragonfly within the Application Area would be considered of high importance to the species, should it occur there.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

Critical habitat has not been declared for the species.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

There is currently no recovery plan or threat abatement plan for the Giant Dragonfly. However, the DECC has prepared 15 Priority Actions to help recover this species. Those relevant to the proposal are outlined below:

- Prepare EIA guidelines addressing the impacts of developments (including degradation of groundwater resources) upon sensitive wetland habitats.

g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

'*Alteration of habitat following subsidence due to longwall mining*' is listed as Key Threatening Processes (KTP) under the TSC Act. Giant Dragonfly breeding, foraging and sheltering habitats within upland swamps are particularly susceptible to the impacts of subsidence. However, the level of disturbance subsidence is anticipated to be low and to be localised.

'*Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands*' is also listed as KTP under the TSC Act. The area to be impacted is located within the upper section of Wollandoola Creek containing only a few small permanent pools and will not result in the draining of perched water table and loss of swamp soil moisture impacting on potential breeding habitat for the Giant Dragonfly.

B.8 CAVE DWELLING MICROBATS: EASTERN BENTWING-BAT (MINIOPTERUS SCHREIBERSII OCEANENSIS), LARGE-EARED PIED BAT (CHALINOLOBUS DWERYI) AND LARGE-FOOTED MYOTIS (MYOTIS ADVERSUS) (V TSC ACT , V EPBC ACT (LARGE-EARED PIED BAT))

The Eastern Bentwing-bat, Large-eared Pied Bat and Large-footed Myotis are cave-roosting bat species. The Eastern Bentwing-bat and Large-eared Pied Bat also raise young in maternity roosts. These species have been grouped together due to their similar habitat requirements.

The Eastern Bentwing-bat roosts in caves, derelict mines, storm-water tunnels, buildings and other man-made structures and forages over the forest canopy (DECC 2005a). It can to disperse up to disperse 300 kilometres of maternity caves during non-breeding periods (DECC 2005a).

Large-eared Pied Bat occurs in most vegetation types provided there are caves or tunnels available for roosting. The species frequents low to mid-elevation dry open forest and woodland and well-timbered areas containing gullies (DECC 2005a), but has also been recorded in *Callitris* dominated forest, tall open eucalypt forest with a rainforest sub-canopy, sub-alpine woodland and sandstone outcrop country (EA 1999). Daytime roosts include caves, abandoned mine tunnels and disused Fairy Martin nests (Ayers *et al*. 1996).

The Large-footed Myotis roosts close to water in caves, mine shafts, hollow-bearing trees, storm water channels, buildings, under bridges and in dense foliage (DECC 2005a). It forages over nearby lakes, rivers, large streams (DECC 2005a).

Potential sheltering habitat for these species within the Application Area includes caves, rocky overhangs and rocky crevices.

a) *In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*

The Eastern Bentwing-bat, Large-eared Pied Bat and Large-footed Myotis are cave-roosting bat species. The proposed activities will not result in tensile cracking in solid rock, or the removal of forest or woodland communities within the Application Area, and impacts to bat foraging habitat are anticipated to be minor. In addition, each bat species is highly mobile with the ability to use a diverse range of habitats for foraging and roosting.

The Large-footed Myotis is a fishing bat, and as creeks may be affected by the proposal, the foraging habitat for this species may be impacted. However, the potential impacts to creeks and drainage lines within the Application Area if they occur will be localised, and there are large areas of foraging habitat within the Application Area and within the larger locality. It is unlikely that foraging activities of the other bats would be affected by the proposal, given that they feed ion insects over areas of vegetation.

It is considered that the life cycle of the cave dwelling microbats will not be affected by the proposal.

b) *In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*

Not applicable to a species.

c) *In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*

   (i) *Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*

Not applicable to a species.

   (ii) *Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,*

Not applicable to a species.

d) *In relation to the habitat of a threatened species, population or ecological community:*

(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The location and extent of modification to cave dwelling microbat roosting habitat within the Application Area is unknown. However, it is anticipated that any impacts to potential roosting habitat would represent a small proportion of available habitat within the Application Area. In addition, Eastern Bentwing-bat, Large-eared Pied Bat and Large-footed Myotis are highly mobile species, and it is anticipated that individuals could readily relocate to unmodified areas of habitat if required.

(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposal is considered unlikely to result in fragmentation or isolation of caves and rocky habitats for these mobile species.

Given that the proposal will not involve the direct removal of Eastern Bentwing-bat, Large-eared Pied Bat and Large-footed Myotis roosting or foraging habitat, habitat connectivity will be retained within the Application Area and locality.

(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

The Application Area contains intact vegetation and watercourses for foraging and caves and rocky overhangs for roosting as required by Eastern Bentwing-bat, Large-eared Pied Bat and Large-footed Myotis. These resources are also available in the wider locality. As such, it is considered unlikely that each species would be entirely dependent on the habitat resources within the Application Area given the mobility of each species. Similarly, the Application Area is not known to contain any large maternity caves.

The Application Area is consequently considered to be moderately important to the species.

e) *Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),*

Critical habitat has not been declared for the species.)

f) *Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,*

There is currently no recovery plan or threat abatement plan for the Eastern Bentwing-bat, Large-eared Pied Bat and Large-footed Myotis.

g) *Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*

'*Alteration of habitat following subsidence due to longwall mining*' is listed as Key Threatening Processes (KTP) under the TSC Act. Eastern Bentwing-bat, Large-eared Pied Bat and Large-footed Myotis roosting habitat may be impacted by rock movement due to subsidence. However, it is anticipated that any impact to caves and overhangs (and therefore current or potential roosting habitat) would only represent a small proportion of available habitat within the Application Area.

It is considered unlikely that the proposal would have a significant impact on Eastern Bentwing-bat, Large-eared Pied Bat and Large-footed Myotis populations within the Application Area.

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Annex M

Green and Golden Bell Frog Assessment

i. Targeted Green and Golden Bell Frog (Litoria aurea) Surveys: NRE No. 1 Colliery

ii. Additional Green and Golden Bell Frog (Litoria aurea) Surveys: NRE No. 1 Colliery

Annex M.1

Targeted Green and Golden Bell Frog (Litoria aurea) Surveys: NRE No. 1 Colliery

BIOSIS
RESEARCH

Targeted Green and Golden Bell Frog (*Litoria aurea*) Surveys: NRE No. 1 Colliery

FINAL REPORT

May 2010

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PROJECT	Targeted Green and Golden Bell Frog (*Litoria aurea*) Surveys at the Gujarat NRE Coking Coal Limited NRE No.1 Colliery, Russell Vale

BIOSIS PROJECT NO	S11659

REPORT FOR	Gujarat NRE Coking Coal Limited

REPORT TITLE:	Targeted Green and Golden Bell Frog (*Litoria aurea*) Surveys: NRE No.1 Colliery

AUTHOR(S):	Michael Roberts

REVISION	*PREPARED*	*INTERNAL REVIEW*	*EXTERNAL REVIEW*	*AMENDED*
Draft V1	Michael Roberts	Brendan Ryan	Danyil Skora/Chris Harvey (NRE)	13/05/2010
Final	Michael Roberts	Melanie Thomson		

REVISION	*ISSUED*	*NAME*	*SIGNED*
Draft	7/05/2010	Michael Roberts	
Final Draft	12/05/2010	Melanie Thomson	

ACKNOWLEDGMENTS

Biosis Research acknowledges the contribution of the following people and organisations in preparing this report:

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ABBREVIATIONS AND COMMON TERMS

Biodiversity	The variety of biological life (plants and animals)
DECCW	NSW Department of Environment, Climate Change and Water (formerly NSW Department of Environment and Climate Change)
DEWHA	Department of the Environment, Water, Heritage and the Arts (formerly Department of Environment and Water Resources)
EEC	Endangered Ecological Community
EP&A Act	*Environmental Planning and Assessment Act* 1979
EPBC Act	*Environment Protection and Biodiversity Conservation Act* 1999
EPI	Environmental Planning Instrument
KTP	Key Threatening Process
LEP	Local Environmental Plan
LGA	Local Government Area
Locality	10 km radius of Subject Site
NPWS	NSW National Parks and Wildlife Service (now part of the DECCW)
Study Area	Area where survey occurred (in this case Gujarat NRE Coking Coal Limited Russell Vale Pit Top, Russell Vale)
TSC Act	*Threatened Species Conservation Act* 1995
sp.	species (singular)
spp.	species (plural)
ssp.	subspecies
var.	variety

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1.0 INTRODUCTION

Biosis Research has been engaged by Gujarat NRE Coking Coal Limited to undertake targeted Green and Golden Bell Frog (*Litoria aurea*) surveys at Dam 6 located at their NRE No.1 Colliery, Russell Vale, in the Wollongong Local Government Area (LGA), herein referred to as the Study Area (Figure 1). Dam 6 has been used previously to supplement water usage at NRE No.1 Colliery, however for quite some time (i.e. since early 80's), the dam level has been fed only by rainfall.

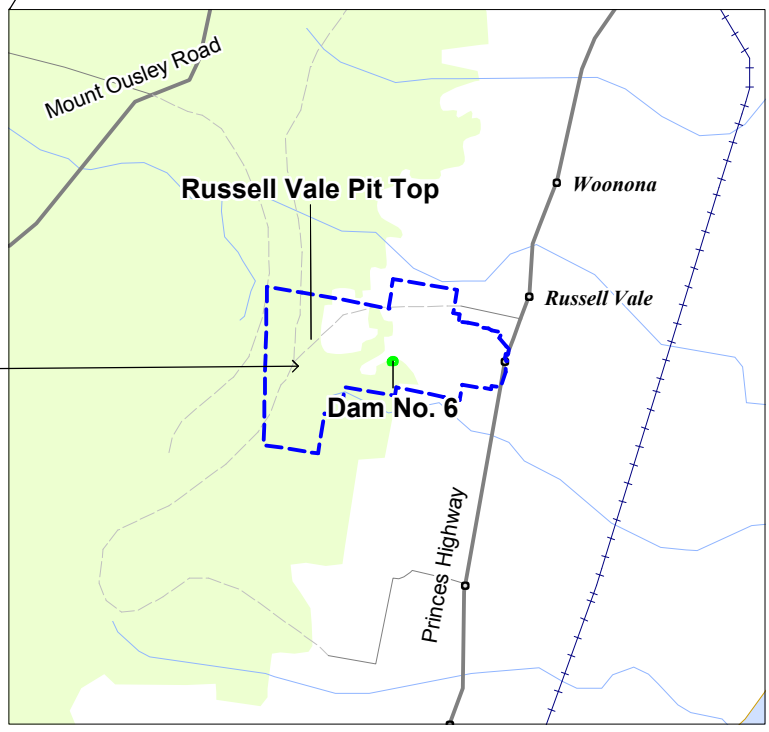
Gujarat NRE Coking Coal Limited (hereafter referred to as NRE) is currently seeking approval for the upgrade of surface facilities at the NRE Colliery and to facilitate part of this upgrade, it has been identified that Dam 6 will require de-commissioning. The removal of this dam will allow for an appropriately battered slope to be constructed above NRE's proposed re-alignment of Bellambi Gully via an open channel. This project requires approval under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act). Environmental Resources Management Australia Pty Ltd (ERM) has been commissioned by NRE to undertake an Environmental Assessment and prepare the associated report. As a component of the Environmental Assessment, ERM identified potential habitat for the Green and Golden Bell Frog (hereafter referred to as GGBF) at Dam 6. This species is listed as Endangered under the *Threatened Species Conservation Act 1995* (TSC Act) and Vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). As such, a significance assessment in accordance with section 5A of the EP&A Act and the *EPBC Act - Principal Significant Impact Guidelines 1.1. Matters of National Environmental Significance* for assessment under the EPBC Act is required for the proposal.

This report provides the results of targeted GGBF surveys at Dam 6 and aims to inform the aforementioned assessments that will undertaken by ERM.

1.1 Green and Golden Bell Frog

Most existing locations for the species occur as small, coastal, or near coastal populations, with records occurring between south of Grafton and northern VIC (NSW Government 2009). The species is found in marshes, dams and stream sides, particularly those containing bullrushes or spikerushes. Preferred habitat contains water bodies that are unshaded, are free of predatory fish, have a grassy area nearby and have diurnal sheltering sites nearby such as vegetation or rocks (NPWS 1999; White and Pyke 1996), although the species has also been recorded from highly disturbed areas including disused industrial sites, brick pits, landfill areas and cleared land. Breeding usually occurs in summer. Tadpoles, which take approximately 6 weeks to develop, feed on algae and other vegetative matter. Adults eat insects as well as other frogs, including juveniles of their own species (DEC 2005).

Previous records of GGBF within the locality are presented in Figure 2. The nearest record is approximately 650 m to the west of Dam 6 (recorded 19 November 1997 – Central CRA Survey Dataset) within the Study Area. This is suggestive that suitable dams located on the Colliery site could form part of a corridor for the GGBF in the locality.



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Wollongong
NEW SOUTH WALES 2500

Figure 1: Location of the Study Area in a regional context

Date: 6 May 2010	Drawn by: ANP
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Scale: 0 0.5 1.0 1.5 2.0 kilometres

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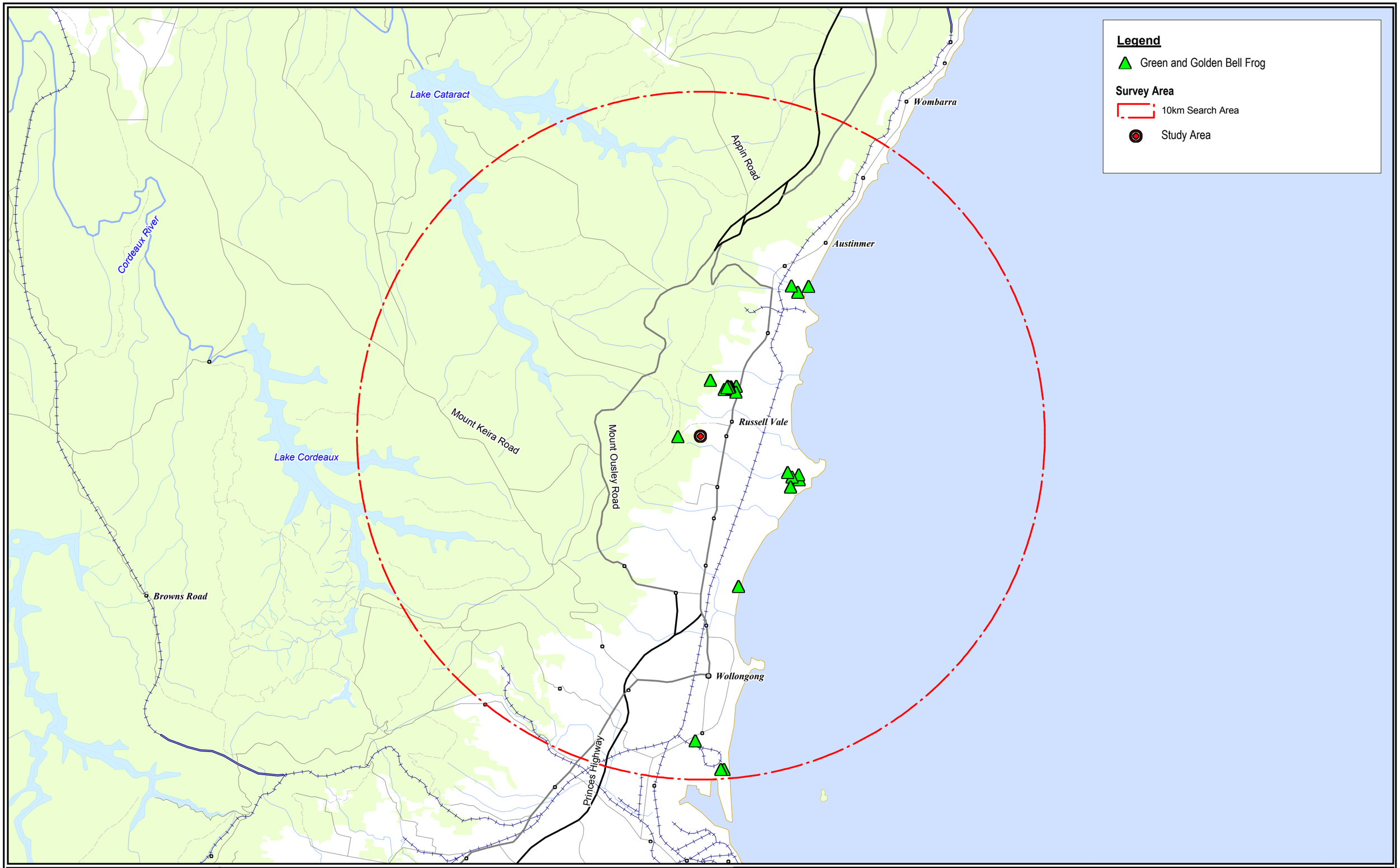

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NEW SOUTH WALES 2500

Figure 2 - Location of previous Green and Golden Bell Frog records in the locality

Date: 6 May 2010	Drawn by: ANP
File number: 11659	Checked by: MWR
Location:-...P:\11600s\11659\Mapping\11659 F2_Green and Golden Bell Frog.WOR	

Acknowledgements:
Species data from DECCW/NPWS and Biosis Research Pty Ltd
This product incorporates Data which is copyright to the Commonwealth of Australia (c.2003-)

0 1 2 3 4 5
kilometres

Scale: 1:100,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N
W E
S

Figure 2

2.0 METHODS

The targeted GGBF survey included searches of databases and historical records in addition to a field survey of the Study Area. This section outlines the specific methods used during the survey.

2.1 Contributors, qualifications and licences

The contributors to the preparation of this report, their qualifications and roles are outlined in Table 1.

Table 1: Contributors, qualifications and their roles

Name	Qualification	Role
Michael Roberts	B. Env Sc (Hons)	Consultant Zoologist – field surveys, report preparation
Brendan Ryan	BSc MSc	Sydney Resource Group Manager and Senior Zoologist – report review

2.2 Field Surveys

Targeted GGBF surveys were carried out at Dam 6 and immediate surrounds between 4th and 6th of May 2010. The level of survey effort used during the survey was based on that described for GGBF in *Threatened Species Survey and Assessment Guidelines: Field Survey Methods for Fauna (Amphibians)* (DECC 2009). Dam 6 was defined as small areas of habitat as it was less than 0.3 ha in size (DECC 2009). It should be noted that the most suitable time of year to survey this species is between August and February, when this species is known to be most active (DECC 2009). Thus, a precautionary approach has been utilised and the species was assumed to be present if suitable habitat was identified.

A combination of diurnal and nocturnal field techniques were utilised during the survey and these are described in Table 2.

Table 2: Survey techniques and survey effort

Survey technique	Time of day	Survey effort
Active searches of dam and surrounding vegetation	Diurnal	3 person hours over three (3) separate days
Active searches (spotlighting) of dam and surrounding vegetation	Nocturnal	3 person hours over three (3) separate nights
Call playback, listening and follow-up searches	Diurnal	1.5 person hours over three (3) separate days

Call playback, listening and follow-up spotlighting	Nocturnal	1.5 person hours over three (3) separate nights
Tadpole surveys	Opportunistic	Not applicable

Temperature, relative humidity and rainfall immediately before and during the survey are presented in Table 3.

Table 3: Weather conditions immediately before and during the survey

Date	**Temperature (°C)**		**Relative Humidity at 3 pm**	**Rainfall (mm)**
	Min	Max		
1/5/2010	15.5	21.6	77	0
2/5/2010	14.9	25.1	61	0
3/5/2010	15.9	21.4	79	0
4/5/2010	**17**	**24.1**	**64**	**0**
5/5/2010	**16.7**	**21.3**	**36**	**0**
6/5/2010	**11.4**	**20.8**	**34**	**0.2**

Notes_source: Bureau of Meteorology (2010) – temperature, humidity and rainfall data collected from Bellambi Weather Station. Survey dates are in bold.

3.0 RESULTS

3.1 Description of habitat

The aquatic habitat within Dam 6 consisted of approximately 60% vegetation cover and was moderately disturbed by surrounding landuses, including coal wash stockpiles, road ways and associated runoff. Dam 6 was dominated by *Typha domingensis* Narrow-leaved Cumbungi, *Schoenoplectus validus* and *Triglochin striata* Streaked Arrowgrass (Plate 1). The vegetation surrounding the dam comprised *Paspalum distichum* Water Couch, *Pennisetum clandestinum* Kikuyu, *Paspalum dilatatum* Paspalum, *Ageratina adenophora* Crofton Weed, *Bothriochloa macra* Red-leg Grass, *Setaria parviflora* Pigeon Grass, *Conyza* spp. Tall Fleabane and *Verbena bonariensis* Purpletop. Scattered shrubs surrounding the dam predominantly consisted of *Acacia longifolia* subsp. *longifolia* Sydney Golden Wattle.

Dam 6 would provide good quality habitat for GGBF.

Plate 1: Aquatic vegetation within Dam 6

3.2 Animal Species

There were no GGBF recorded during the field surveys. Incidental observations of other amphibian species utilising the Study Area during the field survey are listed in Table 4. The most abundant amphibian species recorded was the Eastern Common Froglet (*Crinia signifera*), followed by the Southern Brown Tree Frog (*Litoria ewingi*) and the Emerald

Spotted Tree Frog (*Litoria peroni*). Tadpoles of the Southern Brown Tree Frog were also recorded.

Table 4: Amphibian species recorded during the field surveys

Common Name	**Scientific Name**	**Observation Type**
Emerald Spotted Tree Frog	*Litoria peroni*	Observed, heard
Eastern Common Froglet	*Crinia signifera*	Heard
Striped Marsh Frog	*Limnodynastes peroni*	Heard
Verreaux's Tree Frog	*Litoria verreauxi*	Observed, heard
Spotted Marsh Frog	*Limnodynastes tasmaniensis*	Heard
Southern Brown Tree Frog	*Litoria ewingi*	Observed (adults and tadpoles), heard
Eastern Dwarf Tree Frog	*Litoria fallax*	Heard

4.0 CONCLUSIONS AND RECOMMENDATIONS

This report provides the results of targeted GGBF surveys conducted at NRE. These results will be used to formulate assessments of significance for this species as required under the EP&A Act and the EPBC Act for the Part 3A application being sought by NRE.

Dam 6 was found to provide good quality habitat for GGBF due to the presence of healthy stands of Cumbungi, lack of any predatory fish and the availability of other key fauna habitat elements (NPWS 1999; White and Pyke 1996).

GGBF was not recorded during field surveys. However, Dam 6 was found to be occupied by six other species of amphibians, including Eastern Common Froglet, Emerald Spotted Tree Frog and Southern Brown Tree Frog. Tadpoles of the Southern Brown Tree Frog were also recorded during field surveys.

As a result of this survey occurring outside the most suitable time to investigate this species, the presence of good quality potential habitat provided by Dam 6 and nearby previous records within the Study Area, it could be assumed that GGBF may periodically, utilise the Study Area for the purposes of the assessments. Consequently, the following recommendations are made to inform the assessments of significance and the future operations of NRE:

- Targeted surveys should be conducted using the same techniques described in this report between August and February across the NRE Colliery to accurately determine the presence of the species and to determine the extent of their utilisation (e.g. breeding, foraging, over-winter sites) of the Study Area before any proposal might modify these environments;

- If present, determine whether GGBF move between the NRE Colliery and other surrounding properties (e.g. Russell Vale Golf Course) to establish the potential access/egress corridors that are utilised; and

- Assess the threats to the survival of GGBF across the Study Area.

Finally, should the GGBF be identified, a plan of management be developed to identify and outline the long term goals and objectives for the conservation of the species within the Study Area. This will be imperative as the GGBF is currently rare in the Illawarra region and any location where it occurs is of critical conservation significance.

Further to this, investigations for the utilisation of adjacent dams eg. Dam No.5, should be undertaken to determine their suitability for potential habit for future translocation of the GGBF species.

REFERENCES

DEC (2005). Green and Golden Bell Frog: Threatened Species Profile, http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10483, Department of Environment and Conservation

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NPWS (1999). Green and Golden Bell Frog: Threatened Species Information, http://www.nationalparks.nsw.gov.au/PDFs/tsprofile_green_golden_bell_frog.pdf, National Parks and Wildlife Service

NSW Government (2009). BioNet, http://www.bionet.nsw.gov.au/Area.cfm , NSW Government

White AW and Pyke GH (1996) Distribution and conservation status of the Green and Golden Bell Frog *Litoria aurea* in New South Wales. *Australian Zoologist* 30**,** 177-189.

Annex M.2

Additional Green and Golden Bell Frog (Litoria aurea) Surveys: NRE No. 1 Colliery

Annex N

Seven Part Tests

309 Panel Seven Part Tests

N.1 THREATENED SPECIES IMPACT ASSESSMENT 309 PANEL AREA

An assessment pursuant to Section 5A of the NSW EP&A Act was conducted for the following species:

- *Leucopogon exolasisus*;
- *Epacris purpurascens* var. *purpurascens*;
- *Putenaea aristata*;
- Giant Burrowing Frog;
- Red-crowned Toadlet;
- Large-eared Pied Bat;
- Eastern Bentwing-bat; and
- Large-footed Myotis.

Section 5A of the NSW EP&A Act sets out seven factors that need to be considered in determining whether a proposed action will or is likely to have a significant impact on a threatened species, endangered population or endangered ecological community listed under the TSC Act and the FM Act.

An impact assessment using the EPBC impact assessment guidelines was also undertaken for the Giant Burrowing Frog.

N.1.1 Leucopogon Exolasisus (Woronora Beard-Heath) (V Tsc Act, V Epbc Act), Epacris Purpurascens Var. Purpurascens (V Tsc Act), Putenaea Aristata (Prickly Bush Pea) (V Tsc Act, V Epbc Act)

Leucopogon exolasisus (Woronora Beard-heath) is an erect shrub that grows to a metre tall and has hairy branchlets. Its sharp-pointed leaves grow to about 15 mm long by 2.5 mm wide and have a convex upper surface and striated lower surface. Up to three drooping, white, tubular flowers grow in the angles where the leaves meet the stems, on stalks to 5 mm long. Like most beard-heaths they have furry throats, but also have tiny hairs on the outside of the tube. The common and similar *Leucopogon setiger* has longer flower stalks, a smooth outer surface to the flower tube and shorter, wider leaves. The species occurs in woodland on sandstone and is predicted to occur within the Exposed Sandstone Woodland community, and the Sandstone Gully Peppermint Forest, both of which occur within the 309 Panel. The species was not recorded in surveys undertaken by Umwelt (2004).

Epacris purpurascens var. *purpurascens* is an erect shrub, 50 to 180 cm high. Older stems have prominent short, broad leaf scars. Leaves are spreading and recurved above, ovate to heart-shaped, 7-21 mm long, 4.4-9 mm wide, with sharply pointed tips. Flowers are showy, 7-10 mm diameter, covering much of the branchlets, white or sometimes pinkish. Fruit is approximately 2 mm long. The species occurs on sandstone or shale and is predicted to occur in the Exposed Sandstone Scribbly Gum Woodland community. The species was not recorded in surveys undertaken by Umwelt (2004).

Pultenaea aristata (Prickly Bush Pea) is a small shrub, usually less than 40 cm tall. Its unmistakable, sharp-tipped leaves are narrow and concave, to 22 mm long and 2 mm wide. There is a pair of stipules (leafy bracts) at the base of each leaf. The yellow pea-shaped flowers have red markings and a red keel (the pair of petals beneath the flower) and area clustered at the ends of the branches. Each flower is attached to a pair of enlarged stipules, and is covered with long white hairs. Prickly Bush Pea occurs in wet heath or dry sclerophyll woodland on sandstone. It is predicted to occur in the Exposed Sandstone Scribbly Gum Woodland community. This species was not recorded in surveys undertaken by Umwelt (2004).

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,

Potential direct impacts to terrestrial environments from subsidence include tree tilt, tree fall, depression formation and pooling/ponding (*Section 16.5*). Although unlikely, if they occur, these impacts would be highly localised and would not be expected to impact on the life cycle of a local population of any of the three shrub species.

Leucopogon exolasius produces a fruit (drupe) which is most likely distributed by ants. Pollination is most likely by bees or other small insects. The potential impacts of the proposal would not be expected to adversely affect these processes or the ability of this species to reproduce, germinate, or disperse its seed.

Epacris purpurascens var. *purpurascens* produces a capsule and is dispersed as a seed. Pollination is most likely by bees or other small insects. The potential impacts of the proposal would not be expected to adversely affect these processes or the ability of this species to reproduce, germinate, or disperse its seed.

Pultenaea aristata produces a hard coated seed, with recruitment of individuals occurring after fire. The potential impacts of the proposal would not be expected to adversely affect these processes or the ability of this species to reproduce, germinate, or disperse its seed.

Given the above points, the proposal is not expected to affect the life-cycle requirements of these three flora species, nor place any at risk of extinction.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

Not applicable to a species.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable to a species.

d) In relation to the habitat of a threatened species, population or ecological community:

(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and

All three species are predicted to occur within the Exposed Sandstone Scribbly Gum Community, with *L. exolasius* also predicted to occur in the Peppermint Forest. The proposed action will not involve any surface works within the study area. Therefore, the removal of habitat will not occur due to the proposed action. The extent of potential impacts associated with subsidence (include tree tilt, tree fall or ponding formations) are not known, however if impacts from subsidence do occur, they are expected to be localised and are not expected to occur across a wide area.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

Potential direct impacts within the 309 Panel area, if they occur, would not fragment or isolate habitats for these terrestrial flora species. In addition the proposal is not expected to affect pollinators or dispersers, such that a population of any of the three species would become fragmented or isolated.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the Locality.

Given the extensive areas of Exposed Sandstone Scribbly Gum habitat available for these three species within the immediate environs and the locality, the small area within the 309 Panel that may be affected by subsidence is not expected to be important to the long-term survival of any of the species within the locality.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

Critical habitats have not been declared for these species.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

There is currently no recovery plan or threat abatement plan for any of the flora species.

DECCW has identified nine priority actions for *L. exolasius,* six priority actions for *E. purpurascens* var. *purpurascens* and four priority actions for *P. aristata.*

As the proposal is not expected to impact directly on these species, the proposal is not inconsistent with the identified priority actions.

g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The proposal constitutes or is part of the key threatening process '*Alteration of habitat following subsidence due to longwall mining*'. However, it is noted that the maximum subsidence of 400 mm is not anticipated to cause observable adverse impacts on habitats (GeoTerra 2010). This conclusion was based on the results of monitoring conducted since 2006 (GeoTerra 2010). Accordingly the proposal is not expected to have any significant impacts to the terrestrial environments that these species are predicted to occur in.

N.1.2 Red-crowned Toadlet (Pseudophryne australis) (V TSC Act)

The Red-crowned Toadlet prefers periodically wet drainage lines below sandstone ridges on which the predominant vegetation is dry open forests. Breeding occurs in dense vegetation and debris beside ephemeral creeks and gutters, where eggs are laid in moist leaf litter. The Red-crowned Toadlet disperses outside the breeding season to shelter under rocks and logs on sandstone ridges and to forage amongst thick piles of leaf litter (DECC 2005). The species utilisation of the ground litter layer may result in them being significantly affected by fire and other activities that cause the destruction of the leaf litter layer (NPWS 2001a).

Red-crowned Toadlets are sensitive to changes in pH outside of the range 5.5 to 6.5 and have not been recorded breeding in sites that are even mildly polluted nor in permanently flowing watercourses. Most of this species' life is spent under some form of cover, such as rocks, deep leaf-litter, or in rock crevices (NPWS 2001a).

It is known that sandstone exfoliations are particularly important to this species, so activities that impact on this habitat have the potential to affect the species (NPWS 2001a).

The Red-crowned Toadlet requires specific breeding conditions: small nests are formed within moist leaf litter, then rain flushes the embryos from the nest and tadpoles complete development within transient pools (NPWS 2001a). The timing of follow up rain events and duration of temporary pools is critical to reproductive success (NPWS 2001a). Recruitment is usually low.

The species was recorded in previous studies along Lizard Creek and within a Lizard Creek second order tributary (see *Figure 16.3*). The nearest record of the species to the 309 Panel is approximately 500 m to the east, across an area of woodland and within another first order tributary of Lizard Creek. Additional records of the species are within Lizard Creek, approximately 1.5 km downstream of the 309 Panel (see *Figure 16.3*).

The first order tributary and the Scribbly Gum woodland within the 309 Panel area provide potential breeding, foraging, and sheltering habitat for the Red-crowned Toadlet.

a) *In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*

The Red-crowned Toadlet has a specialised terrestrial reproductive strategy and a reliance on ephemeral water flow means that it may be vulnerable to a range of activities that impact on hydrology or water quality. This includes impacts of runoff, pollution and changes in pH (NPWS 2001a).

Red-crowned Toadlets do not usually live along permanent flowing water courses, instead preferring permanently moist soaks or areas of dense ground vegetation or litter along or near non-perennial first or second order drainage systems that are adjacent to ridges, are ephemeral in nature, and commonly called 'feeder-creeks'. These feeder creeks channel water from ridges, benches, cliffs and slopes to perennial streams in the gullies below. Such watercourses are dry or reduced to scattered shallow pools or ponds for much of the year, and have sustained flow for only a few weeks following thunderstorms. Under natural conditions these feeder creeks have high water quality and low nutrient loads (NPWS 2001a).

Given these preferences, the area of potential habitat for the Red-crowned Toadlet within the 309 Panel area would include the tributary (and adjacent vegetation) that leads into the second order watercourse, and then into Lizard Creek. These habitats provide potential foraging, sheltering and breeding resources for the Red-crowned Toadlet.

No significant impacts to the terrestrial environments that provide foraging or overwintering habitat for the species are expected as a result of the proposal. Geoterrra (2010) states that there have been no significant trends in pH, electrical conductivity, sulfate or filterable iron, manganese, nickel and zinc observed over the monitoring period within the T & W Mains area that would indicate any effects from subsidence and that impacts to the aquatic environments of the 309 Panel area are not expected. Therefore, the proposal is considered unlikely to alter the breeding environment or life cycle of the Red-crowned Toadlet such that a local population would be placed at risk of extinction.

b) *In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*

Not applicable to a species.

c) *In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*

   (i) *Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*

   (ii) *Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,*

Not applicable to a species.

d) *In relation to the habitat of a threatened species, population or ecological community:*

   (i) *The extent to which habitat is likely to be removed or modified as a result of the action proposed, and*

Potential habitat for the Red-crowned Toadlet occurs along the first order tributary and the adjacent vegetation within the 309 Panel area (see *Figure 16.3*). The proposed action will not involve any surface works and therefore removal of habitat is not expected to occur. Subsidence related impacts as a result of the proposed action are considered likely to result in modification of

Red-crowned Toadlet breeding habitat to an extent that it would reduce breeding success.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

If the 309 Panel area was impacted by subsidence it would result in a loss of area of habitat, but would not result in fragmentation, as the habitat occurs at the upper extremity of the tributary. Therefore Red-crowned Toadlet habitat is not considered likely to become fragmented or isolated from other areas of habitat.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the Locality.

The catchment of the Woronora Plateau has been identified by the DECC (2005) as being of extreme importance to the overall survival of the Red-crowned Toadlet and it is considered that "any future declines from this stronghold will jeopardise the survival of the species as a whole" (DECC 2005).

Given the restricted distribution of the species and the habitat type within the greater region, the habitat within the 309 Panel area would be considered important. However, the proposal is unlikely to directly or indirectly remove, modify or fragment habitat of the species such that the long-term survival of the species will be affected.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

Critical habitat has not been declared for the species.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

There is currently no recovery plan or threat abatement plan for the Red-crowned Toadlet. However, the DECC has prepared 14 Priority Actions to help recover this species. The proposal is not inconsistent with the priority actions for the species.

g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Although impacts to the Red-crowned Toadlet habitat within the 309 Panel area are not expected to occur, the proposal has the potential to constitute the following Key Threatening Process:

'Alteration of habitat following subsidence due to longwall mining'

N.1.3 Giant Burrowing Frog (Heleioporous australiacus) (V TSC Act)

The Giant Burrowing Frog is found in hanging swamps on sandstone shelves and beside perennial non-flooding creeks (Daly 1996 and Webb 1993) in the northern part of its range. The species is also associated with sandy soil on sandstone ridges that support heath vegetation (Mahony 1993). Giant Burrowing Frog is found in sand or rock based streams and less frequently in constructed dams. Giant Burrowing Frog has been reported to occur in a wide range of forest communities in the southern part of its range. The species often spends significant periods of time underground during unfavourable conditions and to avoid detection during the day (NPWS 2001b).

The species was recorded in previous studies along Lizard Creek and within a Lizard Creek second order tributary. The Lizard Creek first order tributary within the 309 Panel area and adjacent terrestrial environments provide potential breeding, foraging, and sheltering habitat for the Giant Burrowing Frog.

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,

The Giant Burrowing Frog breeds throughout the year, generally following heavy rain (Penman *et al.* 2004). Mating occurs in ephemeral pools and slow or standing water such as small soaks formed in eroded sandstone drainage lines (Mahony 1993; Watson & Martin 1973).

No significant impacts to the foraging or breeding habitat for the species are expected as a result of the proposal. GeoTerrra (2010) states that there have been no significant trends in pH, EC, sulfate or filterable iron, manganese, nickel and zinc observed over the monitoring period within the T & W Mains area that would indicate any effects from subsidence and that impacts to the aquatic environments of the 309 Panel area are not expected. Therefore, the proposal is considered unlikely to alter the breeding environment or life cycle of the Giant Burrowing Frog such that a local population would be placed at risk of extinction.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

Not applicable to a species.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable to a species.

d) In relation to the habitat of a threatened species, population or ecological community:

(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and

Potential habitat for the Giant Burrowing Frog occurs along the first order tributary within the 309 Panel area and adjacent terrestrial environments. Based on the subsidence predictions as described previously, it is unlikely that breeding habitat within the tributary could be affected.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Giant Burrowing Frog can travel several hundred metres from non-breeding areas to creeks to breed (NPWS 2001). In addition the 309 Panel Area occurs at the extremity of the tributary. Therefore, an area of Giant Burrowing Frog habitat will not become fragmented or isolated from other areas of habitat if subsidence impacts do occur.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the Locality.

The Giant Burrowing Frog is considered an uncommon resident within the Greater Southern Sydney region (DECC 2005). In addition, DECC (2005) states that the protection of Upland Swamps and associated creeks is paramount to the survival of the Giant Burrowing Frog on the Woronora Plateau. Given the above, Giant Burrowing Frog habitat would be considered to be of high importance to the long-term survival of the species within the locality. However, the proposal is unlikely to directly or indirectly remove, modify or fragment habitat of the species such that the long-term survival of the species will be affected.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

Critical habitat has not been declared for the species.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

There is currently no recovery plan or threat abatement plan for the Giant Burrowing Frog. However, the DECC has prepared 19 Priority Actions to help recover this species. The proposal is not inconsistent with the priority actions for the Giant Burrowing Frog.

g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Although impacts to the Giant Burrowing Frog within the 309 Panel area are not expected to occur, the proposal has the potential to constitute the following Key Threatening Process:

'Alteration of habitat following subsidence due to longwall mining'

N.1.4 Large-footed Myotis (Myotis macropus) (V TSC Act)

The Large-footed Myotis generally roost in groups of 10 to 15 individuals close to water in caves, mine shafts, hollow-bearing trees, storm water channels, buildings, under bridges and in dense foliage and forages over nearby lakes, rivers, large streams (DECC 2005). The 309 Panel Area provides potential foraging resources for the species, in the form of the tributary on the western extent of the area.

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,

Cave roost dependent bats such as the Large-footed Myotis are susceptible to loss of roost sites, changes in micro-climate of roost sites and reduction in foraging habitat. There will be no caves or overhangs affected by potential subsidence within the 309 Panel area and consequently breeding and sheltering habitat for the Large-footed Myotis will not be impacted. In addition the proposal is not expected to impact the quantity or quality of water within the 309 Panel area and therefore no foraging habitat will be impacted. In addition, there are large areas of alternative foraging habitat within the local area and within the larger locality. It is therefore considered that the proposal will not affect the life cycle of the Large-footed Myotis such that a local population would be placed at risk of extinction.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

Not applicable to a species.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Not applicable to a species.

(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable to a species.

d) In relation to the habitat of a threatened species, population or ecological community:

(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and

There are no impacts predicted to the breeding or foraging habitat of the Large-footed Myotis and as it is a highly mobile species, if impacts did occur, individuals could readily relocate to nearby unmodified areas of habitat if required.

(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

Given the mobility of the species, the proposal will not result in fragmentation or isolation of foraging habitat for the Large-footed Myotis.

(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

The foraging resources available within the 309 Panel area are also abundant in the wider locality. Given the mobility of the species it is considered unlikely that the species would be dependent on the habitat resources within the area. The area is consequently considered to be of relatively low importance to the species within the locality and the greater region.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

Critical habitat has not been declared for the species.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

There is currently no recovery plan or threat abatement plan for the Large-footed Myotis. The DECCW has identified 15 priority actions for this species. The proposal is not inconsistent with the identified actions.

g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Although impacts to the Large-footed Myotis within the 309 Panel area are not expected to occur, the proposal has the potential to constitute the following Key Threatening Process:

'Alteration Of Habitat Following Subsidence Due To Longwall Mining'

N.1.5 Cave Dwelling Microbats: Eastern Bentwing-Bat (Miniopterus Schreibersii Oceanensis) And Large-Eared Pied Bat (Chalinolobus Dweryi)

The Eastern Bentwing-bat and Large-eared Pied Bat are cave-roosting bat species, raising young in specialised maternity roosts. These species have been grouped together due to their similar habitat requirements. The Eastern Bentwing-bat roosts in caves, derelict mines, storm-water tunnels, buildings and other man-made structures and forages over the forest canopy (DECC 2005). It can disperse up to 300 kilometres from maternity caves during non-breeding periods (DECC 2005).

Large-eared Pied Bat occurs in most vegetation types provided there are caves or tunnels available for roosting. The species frequents low to mid-elevation dry open forest and woodland and well-timbered areas containing gullies (DECC 2005), but has also been recorded in Callitris-dominated forest, tall open eucalypt forest with a rainforest sub-canopy, sub-alpine woodland and sandstone outcrop country (Environment Australia 1999). Daytime roosts include caves, abandoned mine tunnels and disused Fairy Martin nests.

There is no potential sheltering habitat in the form of rocky cliffs, caves or overhangs within the 309 Panel area. The area provides potential foraging habitat only.

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,

Cave roost dependent bats are susceptible to loss of roost sites, changes in micro-climate of roost sites and reduction in foraging habitat. The proposed activities are not expected to impact forest or woodland communities within the 309 Panel area, and impacts to bat foraging habitat, if they did occur, would be minor. In addition, these bat species are highly mobile with the ability to use a diverse range of habitats for foraging and roosting.

Given that no breeding or sheltering habitat will be affected by subsidence within the 309 Panel area, the life cycle of the cave dwelling microbats will not be affected by the proposal.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

Not applicable to a species.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Not applicable to a species.

(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable to a species.

d) In relation to the habitat of a threatened species, population or ecological community:

(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and

There are no known caves or other roosting habitat available within the Panel 309 area for these species. There may be minor and localised impacts to some terrestrial foraging habitat within the area. However given that the Eastern Bentwing-bat and Large-eared Pied Bat are highly mobile species and that there is extensive foraging habitat within the greater locality for these species,

any potential reduction in foraging resource is likely to be relatively negligible.

> *(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and*

The proposal will not result in fragmentation of habitat for these two species.

> *(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,*

The 309 Panel area contains intact vegetation for foraging for the Eastern Bentwing-bat and the Large-eared Pied Bat. These resources are also extensive across the local area and the wider region. Therefore the habitat within the area is considered to be of low importance to these highly mobile species.

> *e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),*

Critical habitat has not been declared for these species.)

> *f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,*

There is currently no recovery plan or threat abatement plan for the Eastern Bentwing-bat or Large-eared Pied Bat.

The DECCW has identified 25 Priority Actions for the Eastern Bentwing Bat. As the proposal will not impact habitat for this species, the proposal is not inconsistent with any of the identified actions.

The DECCW has identified 17 Priority Actions for the Large –eared Pied bat. As the proposal will not impact habitat for this species, the proposal is not inconsistent with any of the identified actions.

> *g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*

The proposal has the potential to constitute the following Key Threatening Process relevant to these two species:

'*Alteration of habitat following subsidence due to longwall mining*'. However, any impacts of the proposal will be minor and will be to foraging habitat only.

N.1.6 Significant Impact Assessment Under The EPBC Act - Vulnerable Species – Giant Burrowing Frog

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

- lead to a long-term decrease in the size of an important population* of a species;
- reduce the area of occupancy of an important population;
- fragment an existing important population into two or more populations;
- adversely affect habitat critical to the survival of a species;
- disrupt the breeding cycle of an important population;
- modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;
- result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;
- introduce disease that may cause the species to decline; or
- interfere substantially with the recovery of the species

**What is an important population of a species?*

An 'important population' is a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:

- *key source populations either for breeding or dispersal;*
- *populations that are necessary for maintaining genetic diversity; and/or*
- *populations that are near the limit of the species range.*

There are no available population estimates for the Giant Burrowing Frog (DEWHA 2010). However, information indicates that the species is now rare and populations appear to have declined. The IUCN listed this species as Vulnerable based on an inferred population decline, estimated to be more than 30% over the last ten years. This decline was inferred from an observed decline in numbers, and from habitat destruction and degradation (DEWHA 2010). The Giant Burrowing Frog may exist as two distinct subpopulations: a northern population largely confined to the sandstone geology of the Sydney

Basin and south to Jervis Bay, and a southern population occurring in disjunct regions from around Narooma southwards to eastern Victoria (DEWHA 2010). Smaller breeding populations appear to be scattered within these two broad areas and the connectivity of these smaller populations is not known.

Given the above points, the precautionary approach will be taken and the population within the site will be considered to be an important population.

Will the proposed action lead to a long-term decrease in the size of an important population of a species?

A long-term decrease in the size of the population could be expected if the proposed action resulted in impacts to surface water availability and quality within the 309 Panel area and downstream environments. These impacts are not expected as a result of this proposal. This assumption is based on monitoring results and subsidence predictions (Geoterra 2010).

Will the proposed action reduce the area of occupancy of an important population?

A reduction in area of occupancy could occur if there were impacts to the first order tributary and associated soaks within the area. These impacts are not expected as a result of this proposal. This assumption is based on monitoring results and subsidence predictions (Geoterra 2010).

Will the proposed action fragment an existing important population into two or more populations?

If impacts did occur, the proposed action is considered unlikely to fragment an existing population, as the species has been recorded moving hundreds of metres between breeding and non breeding sites (Penman *et al.* 2004).

Will the proposed action adversely affect habitat critical to the survival of a species?

There has been no critical habitat declared for the species. However, the first order tributary could be considered critical to the breeding success of the population.

Will the proposed action disrupt the breeding cycle of an important population?

Disruption to breeding cycle of the population could occur if impacts resulted in loss of breeding habitat, loss of breeding individuals, or loss of extensive areas of over-wintering habitats. These impacts are not expected as a result of this proposal. This assumption is based on monitoring results and subsidence predictions (Geoterra 2010).

Will the proposed action modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The proposed action is not expected to impact availability or quality of habitat for the species within the 309Panel area. Therefore, the action is unlikely to lead to species decline in the local area. This assumption is based on monitoring results and subsidence predictions (Geoterra 2010).

Will the proposed action result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat?

The proposed action is unlikely to result in invasive species becoming established in the habitat of the 309 Panel area.

Will the proposed action introduce disease that may cause the species to decline?

The proposed action is unlikely to result in introduction of disease that could cause the species to decline.

Will the proposed action interfere substantially with the recovery of the species?

There is no recovery plan for the Giant Burrowing Frog. However, the proposed action is considered unlikely to interfere with the priority actions for recovery of the species identified by the NSW DECCW.

REFERENCES

Daly G (1996). **Observations on the Eastern Owl Frog (Heleioporous australiacus) in Southern New South Wales** Herpetofauna.

DECC (2005) **Threatened Species Profiles** Online Resource: http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/index.aspx

DEWHA (2010) **Threatened Species Profile Giant Burrowing Frog** *(Heleioporous australiacus)* Online Resource: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1973

Environment Australia (1999) **Recovery outline Large-eared Pied Bat (*Chalinolobus Dweryi*)** Online Resource: http://www.environment.gov.au/biodiversity/threatened/publications/action/bats/15.html

GeoTerra Pty Ltd (31 May 2010) **RE: Extraction of V Mains, Panel 309, P and R Drifts as well as Longwalls 4 and 5 Gateroads Hydrological and Hydrogeological Assessment.** Email to Chris Harvey (Gujarate NRE Coking Coal Limited).

Mahony, M. (1993). **The status of frogs in the Watagan mountains area the central coast of New South Wales** Herpetology in Australia.

NSW National Parks and Wildlife Service (NPWS) (2001a) *Threatened Species Information Red-crowned Toadlet (Pseudophryne australis)* Hurstville NSW.

NSW National Parks and Wildlife Service (NPWS) (2001b). **Threatened Species Information Sheet: Giant Burrowing Frog** Online Resource: http://www.environment.nsw.gov.au/resources/nature/tsprofileGiantBurrowingFrog.pdfWebb G (1993) **Significance of the Giant Burrowing Frog (Heleioporous australiacus) in the Bomaderry Creek Reserve** Submission to Land & Environment Court.

Penman T.,F Lemckert & Mahony M (2004) **Two Hundred and Ten Years of Looking for Giant Burrowing Frog** Australian Zoologist.

Umwelt Pty Ltd (2004) **Flora and Fauna Assessment for Section 138 Application**. Report prepared for Bellpac Pty Ltd.

Watson G.F & Martin A.A (1973) **Life History, Larval Morphology and Relationships of Australian Leptodactylid Frogs** Transactions of the Royal Society of South Australia.

Annex O

Aboriginal Heritage Consultation

Table O.1 Stage 1 – Aboriginal Group Registration; Advisory Requests Sent

Orgainsation	Contact	Date Sent	Comment	Reference
Illawarra Mercury Newspaper	Michelle McCormack	03 October 08	Add to run on 10 October 2008 requesting response by 20 October 2008	Annex Q2
DECCW	Laurel Alexander	03 October 08	Emailed; response 15 October 2 groups	Annex Q3
Illawarra LALC		16 October 08	Response to Advertisement: 9 groups	Annex Q3
Registrar Aboriginal Owners	Kylie McLeod	03 October 08	Emailed	Annex Q3
Native Title Services		03 October 08	2 active claims Sada Services and Cubbitch Barta Clan (not in our area)	Annex Q3
Local Council	Joel Thompson	03 October 08	Emailed	Annex Q3

Table O.2 Aboriginal Group Registrations

Organisation	Contact person	Date Registered	Comments
Illawarra LALC	Sharralyn Robinson	16 October 08	Registered Interest
D'harawal Knowledge Holders	Peter Faulk	21 October 08	Registered Interest
Northern Illawarra Aboriginal Collective (NIAC)	Daniela Reverberi	27 October 08	Fax to Register Interest
Wodi Wodi Elders Corporation		30 October 08	Phone call registering interest
Kullila Welfare and Housing Aboringal Corporation	Maria Mah	14 October 08	Phone call registering interest

Table O.3 Stage 2 - Briefing & Methodology Advice Sent

Organisation	Date Sent	Reference
NIAC (representing 3 groups)	06 November 08	Annex Q5
Illawarra LALC	06 November 08	Annex Q5
Wodi Wodi Elders Corporation	06 November 08	Annex Q5
D'harawal Knowledge Holders	11 November 08	Annex Q5
Kullila Welfare and Housing Aboringal Corporation	14 November 08	Annex Q5

Table O.4 Stage 3 - Aboriginal Group Comments Received

Organisation	Date Received	Comment
D'harawal Knowledge Holders	24 November 08	Letter Registering for fieldwork
Illawarra LALC	27 November 08	Email Registering for fieldwork
NIAC (representing 3 groups)	01 November 08	Letter Registering for fieldwork

Table O.5 Stage 4 – Field Survey

Organisation	Field Representative(s)	Date(s) of fieldwork
D'harawal Knowledge Holders	Virginia Faulk	09 and 10 February 09
Illawarra LALC	Steve Henry	09 and 10 February 09
D'harawal Knowledge Holders	Peter Falk	9-19 November 2009
Illawarra LALC	Michael Pixton, Allan Walker, Craig Tungai and Richard Campbell	9-19 November 2009
D'harawal Knowledge Holders	Peter Falk	20 April 10
Illawarra LALC	Richard Campbell	20 April 10

Table O.6 Stage 5 – Draft Report Sent

Organisation	Contact person	Date Sent
Illawarra LALC		
D'harawal Knowledge Holders		
Northern Illawarra Aboriginal Collective (NIAC)		
Wodi Wodi Elders Corporation		
Kullila Welfare and Housing Aboringal Corporation		

Table O.7 Stage 6 – Aboriginal Community Comments Received

Organisation	Contact person	Date Received	Comment

NRE NO. 1 COLLIERY, RUSSELL VALE

An Aboriginal heritage assessment is proposed for planned extensions to underground mining operations at NRE No. 1 Colliery, Russell Vale. Local Aboriginal parties wishing to be consulted for this assessment are invited to register a written expression of their interest by 20 October 2008

Please respond in writing to:

Attn: Diana Neuweger
Environmental Resources Management Australia
Locked Bag 24
Broadway NSW 2007

Or by fax on 02 8584 8800.

Environmental Resources Management Australia

Building C,
33 Saunders Street
Pyrmont NSW 2009

Locked Bag 24,
Broadway NSW 2007

Telephone +61 2 8584 8888
Facsimile +61 2 8584 8800

www.erm.com

Friday, 28 May 2010

Illawarra Local Aboriginal Land Council
3 Ellen Street
Wollongong NSW 2500

Our Reference: 0079383 Heritage L01

Dear Sir/Madam,

RE: ABORIGINAL HERITAGE ASSESSMENT – NRE NO. 1 COLLIERY, RUSSELL VALE

In accordance with the Department of Environment and Climate Change Interim Community Consultation Requirements, Environmental Resources Management Australia Pty Ltd (ERM) wishes to inform you that that we are undertaking an Aboriginal heritage assessment of an area proposed for expansion of underground mining operations by NRE No. 1 Colliery, at Russell Vale NSW (please find enclosed a map of the study area). The study is being undertaken on behalf of Gujurat NRE Minerals Ltd as part of environmental assessments of the area.

We would be grateful if you could indicate within ten working days whether your organisation is interested in being consulted regarding this project. In addition could you please supply us with a list of all known Aboriginal groups or individuals who would be interested in being consulted on this project. If you have any specific information concerning the cultural values of the study area, it would be much appreciated if you could let us know. Our contact details are provided at the top right hand side of this letter.

If you have any queries concerning the project, please feel free to contact me by email (Diana.neuweger@erm.com) or on the numbers listed above.

Many thanks,

Diana Neuweger
Heritage Consultant

Environmental Resources Management Australia Pty Ltd
A.C.N. 002 773 248
A.B.N. 12 002 773 248

Offices worldwide

Illawarra Local Aboriginal Land Council

3 Ellen Street WOLLONGONG NSW 2500 Ph: 42263338 Fax: 42263360

31 October 2007

To whom it may concern

As the Acting CEO of the Illawarra Local Aboriginal Land Council I write to inform your organisation of the following Motion endorsed at an Illawarra Local Aboriginal Land Council (ILALC) Ordinary Meeting dated 16 October 2007.

Could you please inform all relevant Divisions within your organisation of the following Motion:

The Motion stated that the Northern Illawarra Aboriginal Collective **(NIAC)** does not represent and is not accepted by the Illawarra Local Aboriginal Community. (All Members present agreed with this Motion)

It needs to be acknowledged that NIAC cannot speak on Country within the Illawarra region as determined by the ILALC members.

If you require any further information regarding this matter, please don't hesitate to contact me on the number listed below.

_____

Yours in UNITY

Sharralyn Robinson
Illawarra Local Aboriginal Land Council
Acting CEO
Ph: 42 26 3338
Fax: 42 26 3360
M: 0410 125463

Environmental Resources Management Australia

Building C,
33 Saunders Street
Pyrmont NSW 2009
Telephone (02) 8584 8888
Facsimile (02) 8584 8800
Locked Bag 24,
Broadway NSW 2007
www.erm.com

Friday, 28 May 2010

Kullila Welfare and Housing Aboriginal Corporation
14 Werrang Rd
Primbee 2502

Our Reference: 0079383 Methodology L02.doc

Dear Maria,

RE: ABORIGINAL HERITAGE ASSESSMENT FOR NRE NO.1 COLLIERY

As we indicated in our letter of 21 November 2008, Environmental Resources Management Australia (ERM) is undertaking an Aboriginal heritage assessment of an area of NRE No. 1 Colliery proposed for underground mining, at Russell Vale NSW (please find attached a map of the area). The study is being undertaken on behalf of Gujurat NRE Minerals Ltd as part of environmental assessments.

This fax provides Kullila Welfare and Housing Aboriginal Corporationwith a proposed methodology for this heritage assessment. We would appreciate it if you could provide us with any written feedback on this methodology by **1 December 2008** (our fax number is 8584 8800, or you can email diana.neuweger@erm.com). Please provide all correspondence on letter-headed paper addressed to Diana Neuweger.

We welcome your feedback on the method of assessing the Aboriginal heritage significance of the study area, and we understand that there are a number of methods that could be used in such an assessment. We would also welcome any information that you could provide us with concerning the cultural heritage values of the study area.

Environmental Resources Management Australia Pty Ltd
A.C.N. 002 773 248
A.B.N. 12 002 773 248

Offices worldwide

We propose to assess Aboriginal heritage of the study area through a week long archaeological survey on a date to be advised in December. This survey will aim to locate any previously unidentified Aboriginal heritage sites that occur within the study area, and to assess their significance. The survey will be undertaken on foot and will cover all archaeologically sensitive landforms in the study area, focusing particularly on any soil exposures. Landform elements where we think sites may occur include:

- within 50 m of the 2nd order and above water courses within the study area, including Wallandoola Creek, Lizard Creek, Bellambi Creek and Cataract Creek; and
- ridgelines and elevated areas suitable for camping or travelling through the country.

During the heritage assessment, we propose to:

- identify and record any Aboriginal heritage sites located during the survey;
- take GPS readings and mark site locations on a map;
- estimate the effective survey coverage of the study area;
- assess the impact of the proposed development on known Aboriginal heritage values;
- assess the scientific and Aboriginal significance of sites; and
- provide recommendations on how to manage and mitigate proposed development impacts on known Aboriginal heritage values.

When these tasks have been completed, ERM will provide a copy of the draft Aboriginal heritage assessment report to Kullila Welfare and Housing Aboriginal Corporation for comment.

Following current NSW DECC Aboriginal heritage consultation guidelines, if Kullila Welfare and Housing Aboriginal Corporationwould like to participate in the survey, we invite you to provide (by **December 1 2008**) an offer of your services which describes the skills or experience of a Kullila Welfare and Housing Aboriginal Corporation representative in one or more of the following:

- field identification or survey techniques (including confirmation of physical ability to undertake fieldwork);
- cultural knowledge of the study area and surrounds; and
- ability to assist in communicating the results of the survey back to the stakeholder community for the assessment of cultural values and significance, and returning advice on their response to ERM (DECC Interim Community Consultation Requirements, January 2005, page 8).

A decision to employ any Aboriginal field survey representatives will be based upon the information supplied in these offers. Any employment will be offered by the client and not by ERM. Client decisions are independent of ERM and may not reflect our opinions and/or advice.

In order to participate in the survey, Aboriginal representatives must be adequately insured. Could you please provide your insurance status and copies of your certificate of currency for details concerning your public liability and workers compensation insurance. We would greatly appreciate it if you could respond to us in writing by Monday 1 December 2008 (to diana.neuweger@erm.com or by fax on 8584 8800) with this information in addition to any offer of services. Our contact details are listed at the top right hand side of this fax.

In summary, we request, by **Monday 1 December 2008**:

1. any feedback with regard to the proposed methodology;
2. any further knowledge with regard to Aboriginal heritage within the study area;
3. an offer of your services on the survey if you wish to participate, and any associated rates;
4. details of the skills and experience of the representative proposing to undertake the survey; and
5. certificates of currency for workers compensation and public liability insurance.

If you have any queries concerning the project, please feel free to contact me by email (Diana.neuweger@erm.com) or on the numbers listed above.

Many thanks,

for Environmental Resources Management Australia Pty Ltd

Dr Diana Neuweger

Illawarra Local Aboriginal Land Council

3 Ellen Street WOLLONGONG NSW 2500 Ph: 42263338 Fax: 42263360

ENVIRONMENTAL RESOURCES MANAGEMENT

ARCHAEOLOGIST-DIANNA NEUWEGER

REPORT

ABORIGINAL ARCHAEOLOGICAL AND CULTURAL HERITAGE IMPACT ASSESSMENT NRE 1 COLLIERY RUSSELL VALE

ABORIGINAL SITE OFFICERS

STEVEN HENRY
9-10 FEBRUARY 2009 23-24-25 MARCH 2009

RICHARD CAMPBELL
20 APRIL 2010

Illawarra Local Aboriginal Land Council

3 Ellen Street WOLLONGONG NSW 2500 Ph: 42263338 Fax: 42263360

SURVEY AIM

To identify impacts to all identified Aboriginal and Historical cultural heritage sites and places based on potential changes as a result of underground mining and to make recommendations to protect and preserve identified sites for future generations.

SURVEY EXAMINATION

Steven Henry

A visual inspection on foot was conducted of the study area proposed for underground mining at the NRE No.1 Colliery at Russell Vale. Ground visibility was poor due to the thick undergrowth; no new or existing registered sites were identified.

Richard Campbell

Today I participated in the induction and then Archaeologist, Dianna Neuweger and I participated in a field survey on foot of the proposed area. Ground visibility was poor due to the thick undergrowth and coalwash everywhere.
No new or existing registered sites were identified.

OUTCOME

Due to the thick undergrowth and coalwash everywhere it made it impossible to identify new or existing registered sites.

RECOMMENDATIONS

- The Illawarra local Aboriginal Land Council objects to all longwall mining projects that impact on Aboriginal Heritage and culture. It has clearly been identified that longwall mining causes subsidence and movement; it is therefore imperative that all Aboriginal sites be preserved for future generations.

- Gujarat NRE enters into discussion with the ILALC to address employment opportunities for local Aboriginal people.

If you require any further information regarding this report, please don't hesitate to contact me on the number listed below.

Yours in UNITY

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Annex P

Aboriginal Heritage Risk Assessment Matrix

Risk Impact Matrix

		Significance			
		Low (4)	Moderate (3)	High/ Moderate (2)	High (1)
Risk Rating	Negliable (5)	9	8	7	6
	Very Low (4)	8	7	6	5
	Low (3)	7	6	5	4
	Moderate (2)	6	5	4	3
	High (1)	5	4	3	1

Annex Q

Historic Heritage Statement Of Significance

The Power House Precinct – Moderate Significance

The Power House (now demolished) provided electric power to the shire of Bulli for the period 1913-1957 and to the South Bulli Colliery until 1959. This dual function indicates that the Power House precinct potentially has historic value to the Russell Vale township, as well as the Colliery, as it was the town's initial supplier of electricity. In addition, the Power House represents, in part, the important shift towards mechanisation of mining operations that could utilise the power source available at site.

The two Original Reservoirs are located near the site of the power house and they provided a ready supply of water for use in boilers and condensers. As elements associated with the Power House they are relics of electricity operations at the site, however, as the Power House precinct no longer retains its primary elements, the reservoirs exist in relative isolation. This reduces their significance because their primary function cannot be demonstrated or interpreted.

As the Power House and the elements that made up the Power House Precinct are not intact, however, their form and function cannot be demonstrated or interpreted through its existing elements, spatial configuration or material remains. In its current state, the Power House Precinct only makes a minor contribution to the history and significance of the site. (GML 2004, p87)

Workshops – Upper Bench – Moderate Significance

The workshops located on the Upper Bench relate to the late-twentieth century phase of coal mining at the South Bulli Colliery. They consist of a number of corrugated-iron clad sheds that have clearly been extended and modified progressively over the years. The sheds are located over and adjacent to the 1887 portal, demonstrating the value of terraced ladn on the escarpment and the parsimony characteristics of coal mining, in the reutilisation of the land and infrastructure after the closure of this portal.

Individually, the sheds have low heritage value but they are illustrative of the continual expansion and development of the Colliery as a whole. (GML 2004, p89)

Workshop Offices - Moderate Significance

The Workshop Offices are located at the rear of the 1887 Portal and Carpenters Workshop and consist of two small rooms linked by an verandah. These offices are relics of the daily administration activities that occur in association with the workshops. Their historic value relates to their contextual relationship to the workshop and the evidence they provide of on-going operations and development at the Colliery. (GML 2004, p89)

1887 Portal - Exceptional Significance

The 1887 Portal and Adits are extant and identifiable key element s of the early mine workings. They are part of the earliest mining episodes on the site and, in association with the rail track immediately to their east, clearly illustrate the relationship between the underground workings and the early rail system that transported coal to the jetty. They are an integral part of the site's history.

Their formal design is aesthetically imposing and evidences a level of long-term investment and pride in the establishment of mining activities. The Adits demonstrate the construction of the entrances to undergrounds workings.

They are in good external condition, although they may require some stabilisation, and are rare examples of the industrial culture of the nineteenth century which frequently expressed the virtues of investment and stability with decorative industrial elements. (GML 2004, p89-90)

Brick retaining wall – High Significance

The curved Brick Retaining Wall adjacent to the 1887 portal for its association with the Adits and stabilisation of the surrounding earth to prevent land-slippage onto the rail tracks and workshop area. The retaining wall has also been used to support roofing attachments for the Carpenters Shops.

While the wall may have no strong significance in its own right, it forms, with the rail track and the Portals, an easily recognisable and interpreted ensemble that clearly illustrates the physical process necessary to gain access to the coal deposits and to transport the output to market. (GML 2004, p90)

Crib Room and First Aid Station – High Significance

The Crib Room and First Aid Station (formerly the Lamp Room, for replenishment, service and storage of the portable lamps used by miners underground) is an relic of early mining operations at South Bulli. Whilst the associated equipment has been removed and no lamps are located within the building, it nevertheless represents an evocative relic of mining practices. The Crib Room and First Aid Station is one of the few surviving buildings at the colliery that date to the early phases of mining operation and it has value in providing visual evidence of the long period of operations at the site.

The heritage significance of the building is in its association with a replaced lighting technology, its location immediately adjacent to the Main Portal, with which it forms an interpretable ensemble, and its ability for its form to reflect the era in which it was constructed. (GML 2004, p91)

Storeroom - High Significance

The Storeroom is a small building immediately adjacent to the Crib Room and First Aid Station and is of similar form and materials. The Storeroom is one of the few surviving buildings at the colliery that date to the early phases of mining operations and its has value in providing visual evidence of the long period of operations at the site.

The heritage significance of the building is in its close physical association with the Crib Room and First Aid Station, its location immediately adjacent to the Main Portal, with which it forms an interpretable ensemble, and its ability for its form to reflect the era in which it was constructed. (GML 2004, p91)

Closed Adits - Moderate Significance

The remnant landforms indicating the location of closed Adits are evidence of the intensity and extent of mining activities in this vicinity. The existing signage associated with these Adits is important to the interpretation of the history of its use and are historical relics which authenticate and reference documentary records. They are significant for their existing and potential contribution to knowledge concerning the site as a whole. (GML 2004, p92)

Gibson's Portal - High Significance

Gibson's Portal began its use as a pair of entrance and coal extraction Adits and was an important main entrance in its own right. It was later adapted to be a ventilation portal with associated infrastructure (fan house). The Ventilation was an integral aspect of the viability of mining operation and worker safety in the underground workings.

Gibson's portal is a relic of early-twentieth century mining operations and illustrates the early development of independent pits which eventually amalgamated both underground and in their pit top processing works. The close association with the Main and 1887 Portals at South Bulli illustrates the growth and change inherent in long-term mining and its history of use demonstrates the expansion of underground ventilation requirements as both safety standards were raised and the extent of underground working increased. (GML 2004, p92-93)

Sandstone Retaining Wall- Moderate Significance

The Sandstone Retaining Wall associated with Gibson's Portal has an ongoing role in the stabilisation of the escarpment surrounding the adit. The wall is similar in function to the curved Retaining Wall at the 1887 Portal and demonstrates, through its different materials a different phase of mining operation to the other Portals across the site.

While the wall may have no strong significance in its own right, it forms, with the portal, an easily recognisable ensemble that illustrates the physical processes necessary to gain access to the coal deposits and to transport the output to market. (GML 2004, p93)

Rail Tracks and System - High Significance

The rail track system, with its associated points and switches and supporting elements (while modified) is a relic of the coal transport system that was an aspect of the Colliery for most of its operating life. They are remnants of a transport system that moved coal from the mine underground to the portals on the escarpment, through the various processing stages, then through the township to the loading jetty at Bellambi Point.

The rail system influenced the spatial and working arrangements of the site throughtout the major part of its history, with buildings and other services located to service its requirements or to avoid interference in its operations. It utilised, for the most part, two separate interconnected systems, that operating to bring coal to the surface and that operating from the mine to the jetty.

The rail system however, is now fragmentary, with the only relatively intact sections of track surviving immediately outside the 1887 Portal at the Upper Bench. Owing to the incomplete nature of the track system and associated infrastructure, the system does not demonstrate the technical configuration and details of the rail system. Those remaining areas of relatively intact track on the Upper Bench, however, remain as significant features that illustrate the coal transport system associated with the mining activities from 1887 onwards to the 1970s, when rail was replaced by road transport. (GML 2004, p96)

Signal Box - High Significance

The Signal Box is the most evocative remnant of the rail transport system at the South Bulli Colliery. It is positioned adjacent to the Pacific Highway at the entrance to the sites and it once controlled the level crossing of the Colliery railway line across the Pacific Highway. The Signal Box retains its basic lever frame and it remains am interesting technical feature of rail operations at the site.

The Signal Box is significant as one of the very few surviving features in the district of the once numerous Colliery railways and tramways that crossed the Pacific Highway on their way between mine and jetty. It is also an important element of the South Bulli Colliery, providing evidence of the original transportation system to Bellambi Jetty. (GML 2004, p97)

Coal Wagon - High Significance

The timber Coal Wagon is significant as an example of the wagons utilised by the South Bulli Colliery for approximately eighty years and is representative of the wagons used throughout the Illawarra district for coal transportation. Although numerous examples of similar coal wagons exist in various situations, this wagon displays signage which identifies it as a South Bulli Coal wagon (its actual provenance is unknown) and this provides a strong association with this location. (GML 2004, p97)

Coal Cutter Head - Moderate Significance

The Coal Cutter Head is a remnant item of underground coal mining machinery which is believed to have been utilised at South Bulli. Althought relatively complete, it is detached from the assemblage of machines with which it would normally operate and missing power and transport mechanisms. It is an interesting example of coal machinery which is relevant to South Bulli. (GML 2004, p97-98)

Remnant Incline Haulage Alignments - High Significance

The incline Haulage alignments are … the only tangible remaining aspect of the haulage system, and embody both the historical and technical aspects of the coal haulage systems that were so important in the history, growth and success of the South Bulli mine. The incline haulage alignments are evocative of the process of transportation of coal from the mine mouth to the market and important indicators of the operations of the mine, where extraction from underground was a mere preliminary stage. In their conversion to lines of conveyors and vehicular roads, the operational associations of the alignments have been maintained through the technological evolution of transport technologies and the alignments are representative of most of the phases of mining that has occurred at South Bulli. (GML 2004, p98)

Original Haulage line Vistas - High Significance

The converse aspect of the sight of the haulage lines in the vegetation of the escarpment are the vistas from the mine Portals and terraces down the alignment of the inclines and across the coastal flats to the ocean in the east. The vista extends towards Bellambi Point, where the loading jetty for the Colliery was located and access to the view is an important visual link between the Colliery and the townships of Russell Vale and Bellambi. While haulage systems no longer exist, the view lines from the Old and Gibsons Portals are important vistas for the interpretation and understanding of the site. (GML 2004, p99)

Annex R

Visual Assessment Photo Montage

REFER TO JBK DRAWING 282803.
FOR DETAILED DESCRIPTION OF SITE WORKS

PHOTO LOCATION TABLE				
LOCATION	EASTING/NORTHING	RL	DISTANCE TO RILL TOWER	PHOTO ID
POSITION 1	34° 21′ 49.70″ S 150° 53′ 30.11″ E	80.116	400m	JH035718.JPG
POSITION 2	34° 21′ 50.36″ S 150° 53′ 36.24″ E	68.751	482m	JH035719.JPG
POSITION 3	34° 21′ 48.06″ S 150° 53′ 51.32″ E	55.124	733m	JH035720.JPG
POSITION 4	34° 21′ 47.09″ S 150° 53′ 46.58″ E	55.032	612m	JH035721.JPG
POSITION 5	34° 21′ 34.27″ S 150° 53′ 56.38″ E	54.100	792m	JH035722.JPG
POSITION 6	34° 21′ 31.73″ S 150° 53′ 44.76″ E	61.093	521m	JH035723.JPG
POSITION 7	34° 21′ 31.73″ S 150° 53′ 44.76″ E	61.093	521m	JH035724.JPG
POSITION 8	34° 21′ 39.59″ S 150° 53′ 59.98″ E	49.606	878m	JH035725.JPG

Position 6

Position 7

Position 5

Position 8

Position 1

Position 2

Position 4

Position 3

REV	DATE	REVISIONS	DRN	APP	REV	DATE	REVISIONS	DRN	APP
A	04/05/10	PRELIMINARY	JAH	-	-	-	-	-	-

AS 1100
ALL DIMENSIONS IN MILLIMETRES UNLESS STATED OTHERWISE

	NAME	DATE
DESIGN	JAH	MAY 10
DRAWN	JAH	MAY 10
CHECKED	XXX	XXX
APPROVED	XXX	XXX
SCALE	1 : 10	

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GUJARAT NRE COKING COAL Ltd
No. 1 COLLIERY RUSSELL VALE
PRELIMINARY WORKS
PHOTOMONTAGE

ISSUE	DWG. SIZE
PROPOSAL	A1
JBK DWG No.	REVISION
282805	A

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