Section 4B

Environmental Features, Management Measures and Impacts

PREAMBLE

This section describes the environmental features within and surrounding the Project Site that would or may be affected by the proposed Yarraboldy Extension. Information is presented on the existing conditions, proposed design and operational safeguards, and predicted impacts.

Where appropriate, the Proponent's proposed monitoring programs are also described.

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4B.1 GROUNDWATER

The groundwater assessment for the Project was undertaken by Aquaterra Consulting Pty Ltd (Aquaterra, 2010). The full assessment is presented as Part 1 of the *Specialist Consultant Studies Compendium*. Relevant information from the assessment is summarised in the following subsections.

4B.1.1 Introduction

Based on the risk analysis undertaken by R.W. Corkery & Co Pty Limited for the Project (Section 3.3 and **Table 3.7**) the potential impacts relating to groundwater requiring assessment and their unmitigated risk rating are as follows.

- Reduced groundwater availability for existing uses (medium).
- Reduced groundwater quality and degradation of groundwater dependent ecosystems (medium - low).
- Reduced groundwater levels and availability to local land owners (medium - low).
- Degradation of aquatic communities (medium-low).

In addition, the Director-General's Requirements issued by the DoP identified "Groundwater" as one of the key issues that requires assessment at the Project Site. The assessment of impacts on groundwater is required to include the following.

- Provide a description of the existing groundwater environment.
- A detailed assessment of the potential impacts on groundwater.
- A detailed description of the measures that would be implemented to avoid or mitigate impacts on groundwater.

The groundwater assessment was undertaken in accordance with the relevant guideline documents and planning policies.

The potential direct impacts to groundwater that may occur as a result of the proposed Yarraboldy Extension have been assessed. The groundwater assessment addresses the potential groundwater related effects on existing surface water resources, any groundwater dependent ecosystems (GDE's) and existing groundwater users.

In summary, the following relating to groundwater was assessed for the proposed Yarraboldy Extension.

- The potential groundwater inflows into the proposed Yarraboldy Extension area.
- The potential effects of dewatering from the Project on groundwater systems.
- The potential groundwater-related effects of the Project on local stream and groundwater systems.
- The potential groundwater-related effects of the Project on local receptors.

4B.1.2 The Existing Environment

4B.1.2.1 Hydrogeological Setting

The main hydrogeological units identified within and surrounding the Project Site are as follows.

- Quaternary alluvium.
- Triassic overburden sediments (sandstone) of the Narrabeen Group.
- Coal seams within the Permian Illawarra Coal Measures –Irondale Seam, Lidsdale Seam and Lithgow Seam.
- Permian interburden sediments (claystone, mudstone, siltstone, and sandstone bands present between coal seams).
- Basal unit comprising the Early Permian Marrangaroo Formation.

Relatively higher permeability occurs in the coal seams, with lower permeability in the interburden and overburden. Minor zones of relatively higher permeability also occur in parts of the Triassic sequence, although the Triassic is only partially saturated to the north of the Yarraboldy Extension area. Minor zones of permeability can also occur in the underlying Marrangaroo Formation. All other units have low permeability.

The geological setting relating to the above units has previously been described in Section 2.2. Further information on the regional geological setting is also presented in Aquaterra (2010).

4B.1.2.2 Groundwater Occurrences and Uses

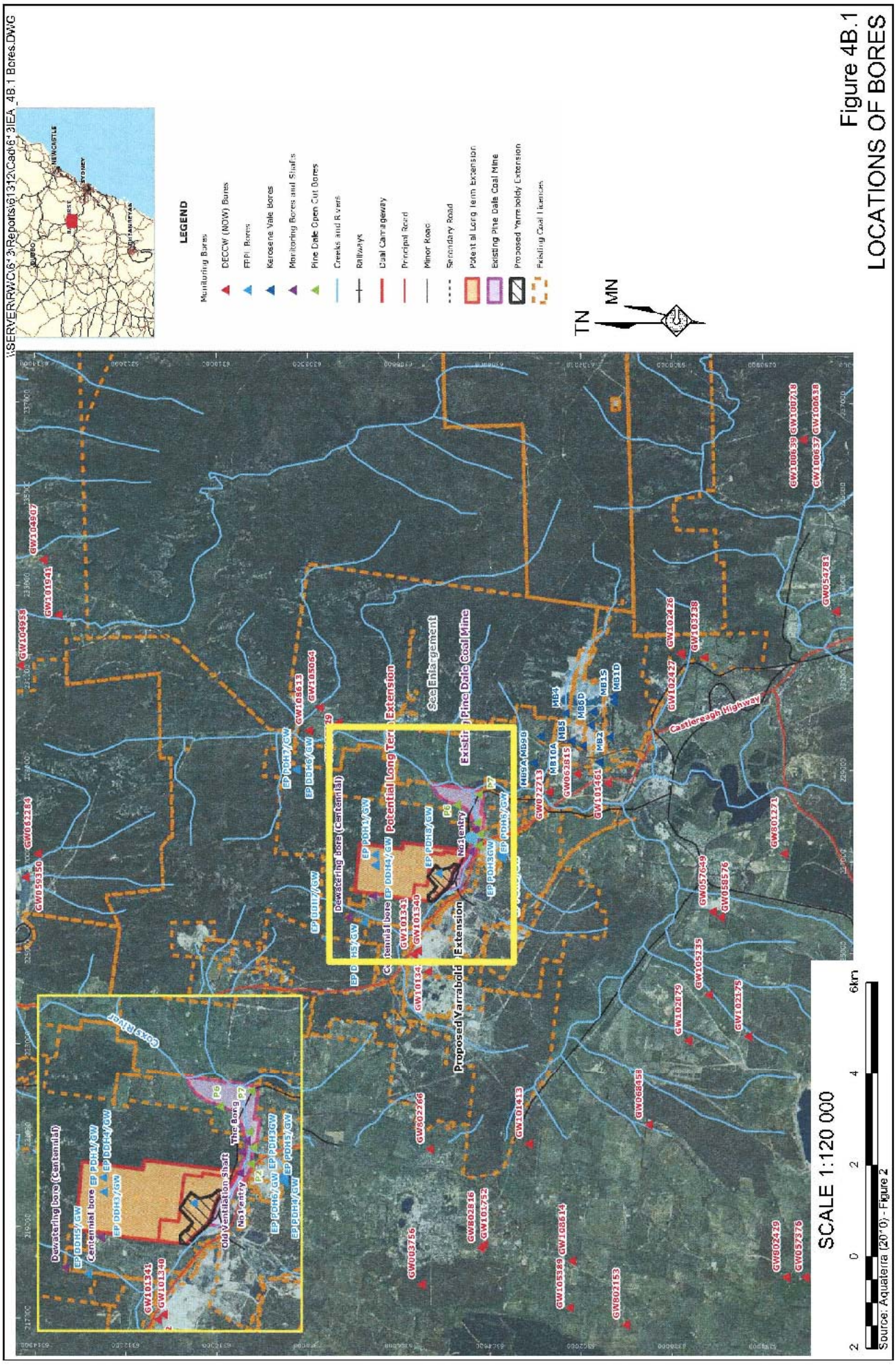
Groundwater occurs across the proposed Yarraboldy Extension area both as naturally occurring aquifers and within abandoned underground mine workings (Wallerawang Colliery).

The primary water-bearing zones are associated with the coal seams, specifically within mined out voids and areas of goaf within the former Wallerawang Colliery underground. Previous hydrogeological investigations have identified the groundwater level in the old workings to be between 883.6 m AHD and 880 m AHD, which represents the high water mark and the base of coal seam respectively. Craven, Elliston & Hayes Surveyors reported that around 8 800ML of water is present in the old Wallerawang Colliery underground workings. Further assessment of the volumes of water stored in the workings indicates around 13 000ML of water may be present.

Minor water-bearing zones also occur within the interburden formations (such as sandstones and siltstones). However, these commonly act as aquitards due to their reduced vertical permeability in comparison to the coal seams and goaf.

No groundwater dependent ecosystems have been identified in the proposed Yarraboldy Extension area.

170 registered groundwater bores are located within a 15 km radius of the Project Site (**Figure 4B.1**). Of these bores, 75 bores are registered as private bores, two for local government purposes, one for mining purposes and for the others, the purpose is unknown.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LEGEND
Monitoring Bores
DECCW (NOW) Bores
EPPL Bores
Kerosene Vale Bores
Monitoring Bores and Shafts
Pine Dale Open Cut Bores
Creeks and Rivers
Railways
Dual Carriageway
Principal Road
Minor Road
Secondary Road
Potential Long Term Extension
Existing Pine Dale Coal Mine
Proposed Yarraboldy Extension
Existing Coal Licences
TN
MN
Figure 4B.1
LOCATIONS OF BORES
Pine Dale Coal Mine
Potential Long Term Extension
Proposed Yarraboldy Extension
Dewatering Bore (Centennial)
Centennial Bore
Castlereagh Highway
Cox's River
SCALE 1:120 000
2 0 2 4 6km
Source: Aquaterra (2010) - Figure 2

4B.1.2.3 Hydraulic Conductivity of Groundwater

Table 4B.1 details the range and mean values of hydraulic conductivity values for the main hydrogeological units within the proposed Yarraboldy Extension area.

Table 4B.1
Hydraulic Testing Results for Main Aquifers within the Project Site

Aquifer	Hydraulic Conductivity (m/d)	
	Range	Mean
Lithgow Seam	0.002 - 8.6	0.09
Old Wallerawang Colliery Underground Goafed area	408	NA
Workings (Lithgow Seam)	33	NA
Source: Aquaterra (2010) – Table 12 NA – insufficient number of tests for meaningful result		

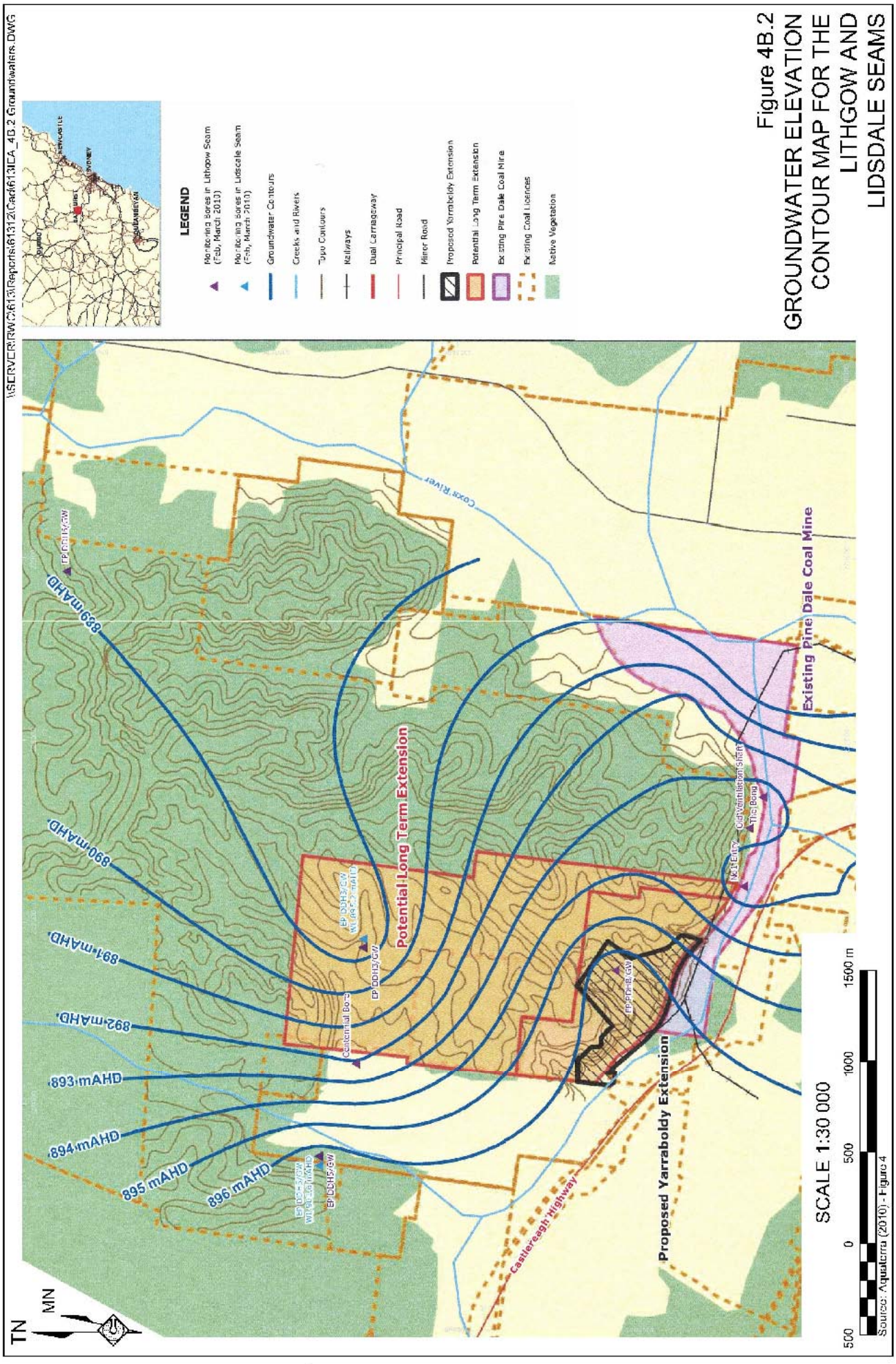
4B.1.2.4 Water Table and Groundwater Flow Direction

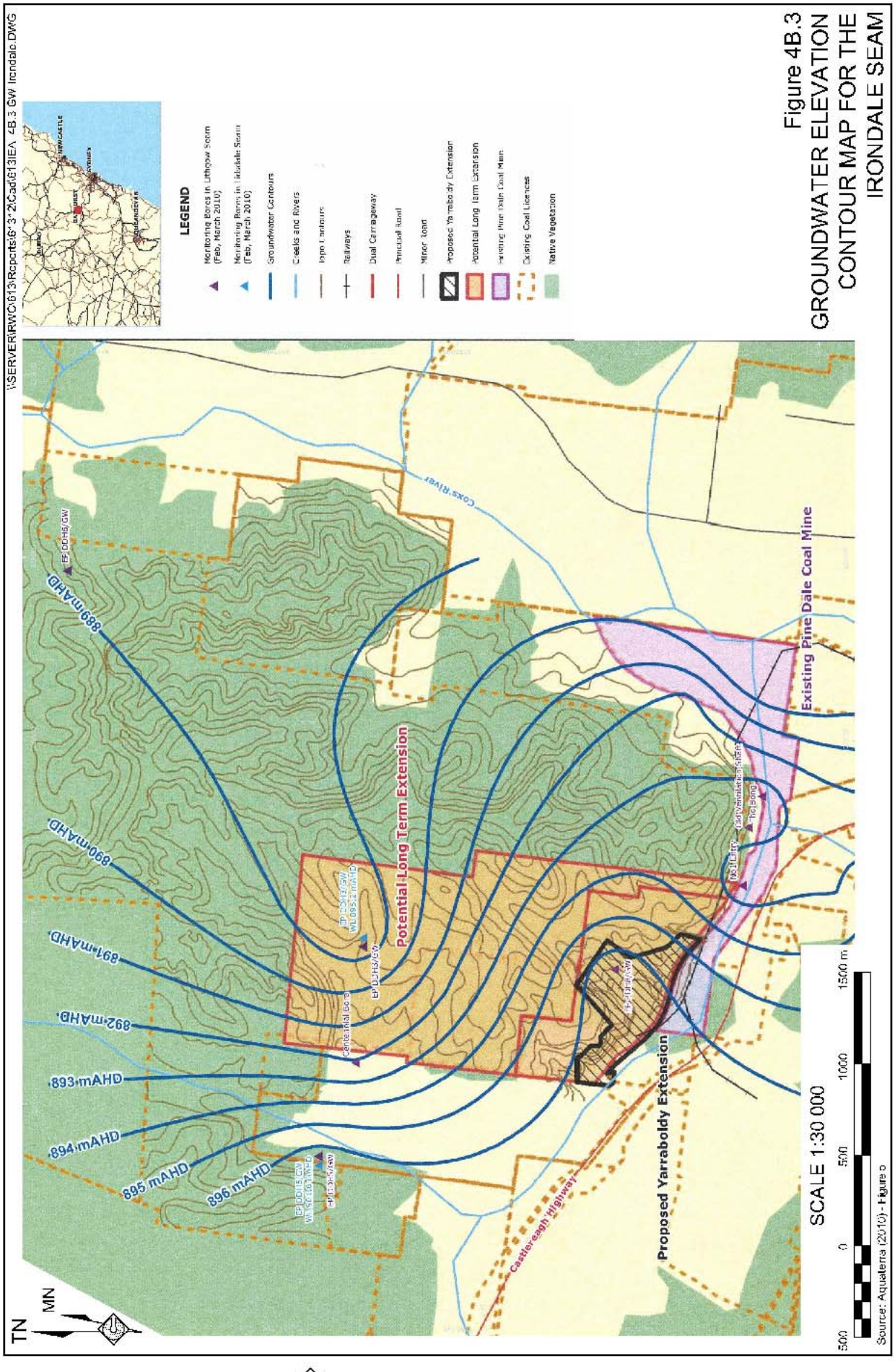
The regional groundwater flow direction within the Illawarra Coal Measures in the Blackmans Flat area is from the west towards the northeast and generally flows occur horizontally through the coal measures in the direction of the dip of the coal seams (Bish, 1999). Local groundwater flow in the old underground mine workings north of the Private Coal Haul Road is inferred to be in an easterly and northeasterly direction.

Groundwater levels for the Lithgow Seam were contoured using data from the Proponent's monitoring bore network in the vicinity of the current Pine Dale Coal Mine open cut area, the bores installed during the 2010 drilling program and other available data from Kerosene Vale and Ivanhoe Collieries. The groundwater flow in the Lithgow Seam within and surrounding the Project Site is in a north and northeasterly direction, generally following the dip of the seam (**Figure 4B.2**). The groundwater levels vary from 896m AHD at the northern boundary of the Proposed Yarraboldy Extension to 889m AHD at the northern boundary of the Potential Long Term Extension area. This represents a drop of 7m over a distance of approximately 5km. The Lithgow Seam is only partially saturated to the south of the existing Pine Dale Coal Mine, with groundwater levels just above the seam floor. The Lithgow Seam outcrops at the southern boundary of the proposed Yarraboldy Extension, where the aquifer is unconfined, and in general dry. As the seam dips to the northeast it becomes saturated and confined.

A local groundwater mounding effect (elevated groundwater levels) occurs to the southeast of the Yarraboldy Extension area. Groundwater mounding in this area is attributed to mine water being discharged back underground into an area referred locally as "The Bong" as part of dewatering operations for the current Pine Dale Coal Mine. As a result, this mounding has the potential to promote a small amount of groundwater seepage into nearby Neubecks Creek.

The Lidsdale Seam outcrops to the north of the Lithgow Seam outcrop within the Yarraboldy Extension area. Here, the aquifer is unconfined and dry and only becomes saturated with depth down dip to the northeast. The water levels within this seam vary from 896 m AHD in the west to 889 m AHD in the east at the Potential Long Term Extension boundary. North of the convergence line, the seams are assumed to form one unit. Groundwater flow direction in the Lidsdale Seam also follows the dip of the seam and is interpreted from bore records to be in an easterly or northeasterly direction (**Figure 4B.3**).


\\SERVER\RW\C\613\Reports\613\2\Cad\613ECA_4B.2 Groundwaters.DWG
Figure 4B.2
GROUNDWATER ELEVATION CONTOUR MAP FOR THE LITHGOW AND LIDSDALE SEAMS
LEGEND
Monitoring Bores in Lithgow Seam (Feb, March 2010)
Monitoring Bores in Lidsdale Seam (Feb, March 2010)
Groundwater Contours
Creeks and Rivers
Tips Contours
Railways
Dual Carriageway
Principal Road
Minor Road
Proposed Yarraboldy Extension
Potential Long Term Extension
Existing Pine Dale Coal Mine
Existing Coal Licences
Native Vegetation
Coxs River
Potential Long Term Extension
Existing Pine Dale Coal Mine
Proposed Yarraboldy Extension
Castlereagh Highway
889 mAHD
890 mAHD
891 mAHD
892 mAHD
893 mAHD
894 mAHD
895 mAHD
896 mAHD
EP DDH3/GW
EP DDH4/GW
EP DDH5/GW
EP DDH6/GW
EP DDH7/GW
Centennial Bore
The Bong
Old Ventilation Shaft
TN
MN
SCALE 1:30 000
500
0
500
1000
1500 m
Source: Aquaterra (2010) - Figure 4


\\SERVER\RW\C\613\Rpcrts\6'3+2\Cad\613IEA_4B.3 GW Irondale.DWG
Figure 4B.3
GROUNDWATER ELEVATION
CONTOUR MAP FOR THE
IRONDALE SEAM
LEGEND
Monitoring Bores in Lithgow Seam (Feb, March 2010)
Monitoring Bores in Irondale Seam (Feb, March 2010)
Groundwater Contours
Creeks and Rivers
Open Cut Mine
Railways
Dual Carriageway
Principal Road
Minor Road
Proposed Yarraboldy Extension
Potential Long Term Extension
Existing Pine Dale Coal Mine
Existing Pine Dale Coal Main
Existing Coal Licences
Native Vegetation
Coxs River
Potential Long Term Extension
Existing Pine Dale Coal Mine
Proposed Yarraboldy Extension
Castlereagh Highway
889 mAHD
890 mAHD
891 mAHD
892 mAHD
893 mAHD
894 mAHD
895 mAHD
896 mAHD
TN
MN
SCALE 1:30 000
500 0 500 1000 1500 m
Source: Aquaterra (2010) - Figure 5

The water levels in the Irondale Seam indicate clear separation from the Lidsdale and Lithgow Seams with water levels between 910 m AHD and 892 m AHD to the northeast of the Potential Long Term Extension boundary. The flow in this aquifer is in an east to northeasterly direction (**Figure 4B.3**).

4B.1.2.5 Groundwater Recharge and Discharge Processes

The Permian and Triassic aquifers of the Yarraboldy Extension area are primarily recharged at their outcrop areas. The primary recharge to the coal seams occurs via direct rainfall recharge through the coal seam outcrop, where the aquifer is unconfined.

Where the Permian aquifers are overlain by alluvium, colluvium and fill material such as within Neubecks Creek, recharge may also occur to the permeable parts of the hard rocks that sub-crop beneath the unconsolidated material.

Groundwater levels within the Permian and Triassic aquifers generally show that a downward hydraulic gradient exists within the coal seam and sandstone aquifers. This is most likely the result of stratigraphically higher layers outcropping at higher topographic elevations.

Natural groundwater discharge occurs through evapotranspiration, seepage through the barriers, lateral flow to the northeast and through baseflow contributions to Neubecks Creek. Local discharge from the Permian aquifers may take place where an aquifer unit within the Permian sediments outcrops, such as on hillsides or the flanks of creeks and gullies to the northeast and over to the Wolgan Valley.

4B.1.2.6 Groundwater Quality

Groundwater quality surrounding the Yarraboldy Extension area is variable, both in terms of field parameters such as salinity and pH, but also relating to major and minor hydrochemical constituents.

Table 4B.2 presents the results of field measurements of groundwater quality (temperature, EC, DO, pH and redox potential). **Figure 4B.4** illustrates the locations of the groundwater monitoring locations.

The groundwater within the Project Site is slightly brackish. Electrical conductivity (EC) measured in different aquifers ranges from 179 to 1240µS/cm. Within the Lithgow Seam, the salinity varies from 179 to 980µS/cm, while salinity in the old Wallerawang Colliery underground void it is generally higher (895 to 1240 µS/cm). Monitored groundwater EC values within the Project Site are generally above the ANZECC (2000) guideline values (300 - 350 µS/cm).

The groundwater pH is slightly acidic to slightly alkaline, with pH values ranging between 5.68 and 9.00. Water from within the Lithgow Seam has the widest pH range of between 6.21 and 9.00, while the water from the old Wallerawang Colliery underground void is generally neutral, with a pH in the range of 6.63 to 7.21. The pH values are slightly below the ANZECC (2000) guidelines in two bores (EP PDH1/GW and P7) and above the guidelines in one bore (EP PDH6/GW).

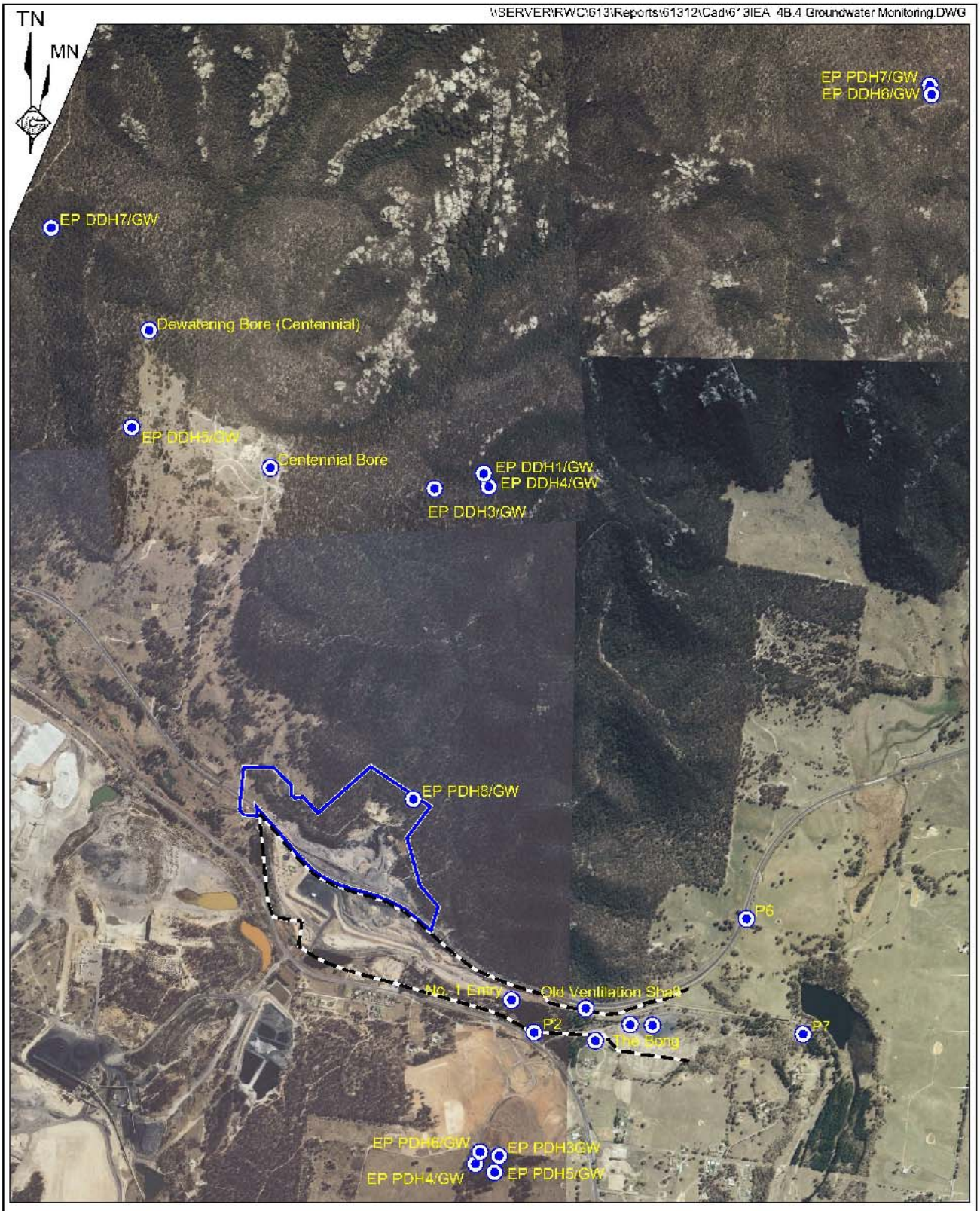


Figure 4B.4
GROUNDWATER MONITORING LOCATIONS

Table 4B.2
Summary of Field Measurements of Groundwater Quality – Yarraboldy Extension Area

Bore	Date Sampled	Aquifer	Standing Water Level (m TOC)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%)	EC (µS/cm)	TDS (mg/L)	pH	Redox Potential (mV)	Temp (°C)	Turbidity (NTU)	Comments
ANZECC Trigger value (95% protection*)					90-110	30-350		6.5-7.5				
EP PDH4/GW	Mar-10	Goaf	23.86	2.49	29	1240		7.31	104	16.5	NM	Clear, no odour or sheen
EP PDH5/GW	Mar-10	Void	24.38	3.43	41	1079		6.79	184	16.4	NM	Clear, no odour or sheen
P6	Dec-09	Void	26.60	NM	NM	895	792	6.63	NM	20.8	12	
EP PDH1/GW	Feb-10	Lithgow Seam	74.46	1.62	13	980	546	6.24	41	21.2	75.1	
EP PDH2/GW	Mar-10	Lithgow Seam	23.32	1.41	17	341		7.14	132	16.0	NM	Clear, slight sediment. No odour or sheen
EP PDH3/GW	Mar-10	Lithgow Seam	23.70	2.59	30	292	NM	6.91	85.7	16.1	NM	Slightly turbid / grey sediment. No odour or sheen
EP PDH6/GW	Mar-10	Lithgow Seam	24.32	1.91	21	179	NM	9.00	149	16.1	NM	Turbid with high sediment content. Insufficient water for sampling
Dewatering bore (Centennial)	Feb-10	Lithgow Seam	-0.70	2.04	23	531	292	7.06	129	15.1	23	
P7	Dec-09	Lithgow Seam	9.02	NM	NM	586	415	6.21		16.9	NM	
EP PDH7/GW	Mar-10	Middle River Seam	14.68	9.22	98	419	225	5.68	103	17.1	841	High sediment content
EP DDH4/GW	Feb-10	Middle River Seam	26.88	2.13	25	991	576	6.57	85	18.2	1030	

Source: Aquaterra (2010) – Table 13
NM – not measured
*ANZECC Water Quality Guidelines for Fresh and Marine Waters- Default Trigger values for south-east Australia (upland rivers)

Monitored levels of dissolved oxygen (DO) are typical of deep groundwater with up to 30% saturation in the Lithgow Seam and up to 40% for the old Wallerawang Colliery underground void groundwater. Groundwater DO concentrations are generally below the ANZECC (2000) guidelines (90 -110%).

The groundwater surrounding the Yarraboldy Extension area has an overall positive redox potential, therefore aerobic conditions prevail. The monitored values overall vary from 41 to 184 mV, across different aquifers, and correlate well with DO saturation.

Moderately elevated dissolved metals concentrations have been reported in groundwater surrounding the Project Site. Dissolved metal concentrations in bores which exceed ANZECC (2000) guideline values for freshwater ecosystem protection are detailed in **Table 4B.3**. While most exceedances are not excessive, several bores reported a number of dissolved metal concentrations in orders of magnitude higher than the ANZECC guideline values. These are mainly cadmium, copper, nickel and zinc. Arsenic is elevated in the old Centennial dewatering bore only, however, anecdotal evidence suggests that arsenic may have been elevated during historical dewatering from this bore.

Ammonia and nitrate concentrations are below the 0.9 mg/L and 0.7 mg/L ANZECC (2000) guideline values for freshwater ecosystem protection, respectively.

Table 4B.3
Dissolved Metals – Exceedances of ANZECC (2000) Freshwater Ecosystem Protection Guideline Values

	ANZECC (2000) Guideline Limits	**P7** ***Lithgow Seam***	**EP PDH1/GW** ***Lithgow Seam***	**Centennial Dewatering Bore** ***Lithgow Seam***	**EP PDH5/GW** ***Lithgow Seam***
Aluminium	0.055	<0.01	<0.01	<0.01	0.21
Arsenic	0.013	<0.001	0.068	0.032	0.002
Cadmium	0.0002	0.0044	0.014	<0.001	0.0003
Copper	0.0014	0.001	0.671	0.002	0.011
Nickel	0.011	0.008	<0.001	<0.001	0.064
Zinc	0.008c	0.028	<0.01	<0.01	0.36
		P6 ***Goaf***	**SHAFT** ***Wallerawang Void***	**EP DDH4/GW** ***Middle River Seam***	**EP PDH7/GW** ***Middle River Seam***
Aluminium	0.055	<0.01	<0.01	0.02	0.16
Arsenic	0.013	<0.001	<0.001	<0.001	<0.001
Cadmium	0.0002	0.0022	0.0003	0.0002	0.0005
Copper	0.0014	0.001	0.002	<0.001	<0.001
Nickel	0.011	0.17	0.14	0.007	0.007
Zinc	0.008[c]	0.454	0.138	0.036	0.026

Source: Modified after Aquaterra (2010) – Table 14

c = Figure may not protect key test species from chronic toxicity (this refers to experimental chronic figures or geometric mean for species

Highlighted cells indicate the exceedance above the ANZECC (2000) guidelines.

BTEX has not been detected in any of the bores on site, however medium fraction TPH has been recorded in one bore above the level of detection. The highest recorded concentration was 0.7 mg/L for the C_{15}-C_{28} fraction. The elevated TPH fraction is most likely due to hydrocarbons being introduced during drilling, but may also be the result of bore flushing with mine water which may have contained low levels of hydrocarbons.

The major ion chemistry classifications indicates that monitored groundwater surrounding the Project Site appears to have mixed cation and anion composition (**Figure 4B.5**). Water from the Lithgow Seam is typically hard to very hard and Cl+SO_4 and Ca+Mg dominated. The major hydrochemical process occurring in this aquifer is the reverse ion exchange $CaCl_2$ type.

4B.1.2.7 Groundwater – Surface Water Interaction

Existing literature suggests that there is limited evidence that water in the Coxs River and Neubecks Creek (a perennial tributary to the Coxs River and south of the existing Pine Dale Coal Mine) is connected to the groundwater.

In the upper reaches of Neubecks Creek (adjacent to the proposed Yarraboldy Extension), the baseline groundwater elevations appear to be lower than the creek elevation (and seam elevation) and thus the creek is likely to be a losing stream across this reach.

In the lower reaches of Neubecks Creek, baseline groundwater elevations (889 – 893m AHD) are somewhat higher than the elevation of the outcrop (874 to 888m AHD) and the base of creek (888 to 891m AHD). Under these conditions there is potential for groundwater seepage from the Lithgow Seam into the creek. The estimated seepage into Neubecks Creek from the Lithgow Seam using a formula from Dupuit (1863) is 0.22 L/s (19.5 m^3/day).

There appears to be no groundwater baseflow contribution to upper Coxs River from aquifers within the Project Site, however, the Coxs River downstream is characterised as a gaining stream.

4B.1.3 Potential Hydrogeological Impacts

The potential hydrogeological impacts associated with the proposed Yarraboldy Extension include the following.

- The potential effects of groundwater inflow into the Yarraboldy Extension area including the management of its volume, treatment and potential discharge and what impact these factors may have on the availability of groundwater as well as the quality of surrounding aquifers and surface waters.
- The potential effects of dewatering from the Project on groundwater systems and the availability of groundwater to other users.
- The potential groundwater-related effects of the Project on local stream systems including the removal of baseflow due to dewatering from the Project and a reduction in surface water quality due to discharge of groundwater into the local creek system.

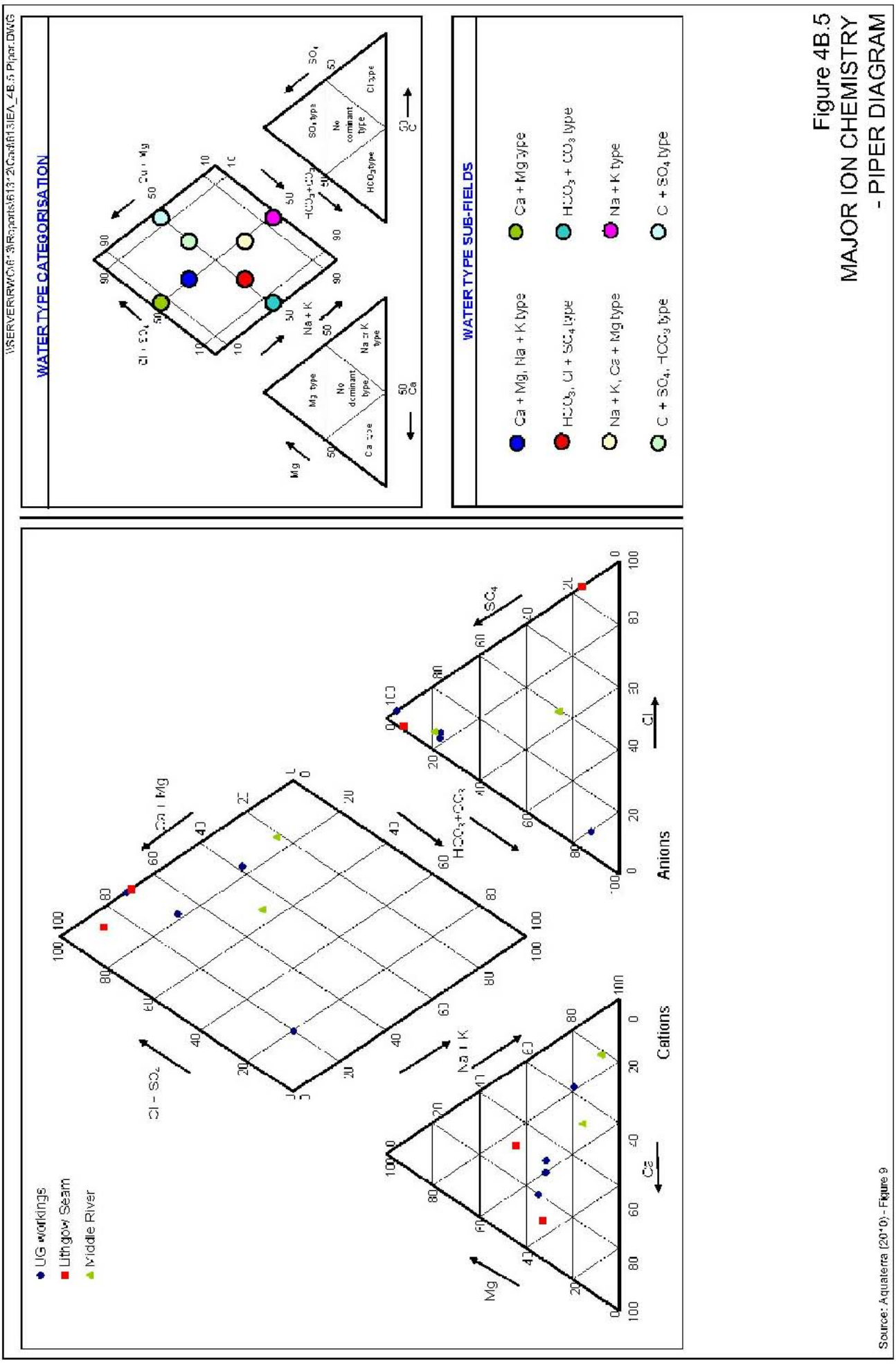


Figure 4B.5
MAJOR ION CHEMISTRY
- PIPER DIAGRAM

Source: Aqualerra (2010) - Figure 9

- The potential contamination of groundwater due to hydrocarbon or chemical spills associated with the Project.
- Potential impacts on groundwater dependent ecosystems.
- The potential sterilisation of future water supply.
- The development of acidic water as the result of exposing acid prone coal materials within the old Wallerawang Colliery underground workings during dewatering activities.

4B.1.4 Management Measures and Mitigation Measures

The mitigation measures and management procedures to be adopted for the Yarraboldy Extension to manage impacts to groundwater quality and availability include the following.

- The mine plan has been designed to minimise the interception of groundwater within the old Wallerawang Colliery underground workings. This reduces the amount of drawdown on local groundwater.
- The small amount of groundwater intercepted would be managed on site and used for dust suppression, therefore the need to discharge raw groundwater into the surrounding surface water environment is negated, thus avoiding the potential change in surface water quality.
- A strategically located sump pump in the open cut pit would be installed and maintained to ensure efficient dewatering of the pit.
- The existing groundwater monitoring regime would continue. The monitoring program would continue to assist in determining if there are any impacts to groundwater associated with the Project. It will also be used to identify potential impacts in a timely manner and allow appropriate mitigation.
- The appropriate management of chemicals and hydrocarbons to ensure that groundwater is not contaminated by spills of these substances and the preparation of an emergency response procedure detailing appropriate spill response measures.
- Any potential acid generation would be managed on site by selective placement of cover material.

4B.1.5 Groundwater Modelling

4B.1.5.1 Pit Inflow

Groundwater data for the old Wallerawang Colliery underground void/goaf and Lithgow Seam were prepared in Surfer software to produce groundwater contours. The GIS assessment involved the preparation of maps to assess the saturation of the Lithgow Seam by comparing its elevation with the groundwater levels.

4B.1.5.2 Analytical Model

The conceptual groundwater model for the proposed Yarraboldy Extension was developed based on geological and topographical data of the area, geological information from coal exploration bores, results from hydrogeological investigations conducted within the area, as well as from other nearby mines and relevant data from the DECCW-NOW groundwater database.

The conceptual model of the region encompasses the area between the outcrop of the base of the Lithgow Seam to the south and the presumed discharge boundary to the north and east where lateral outflows are believed occur. Recharge to the Yarraboldy Extension area is assumed to occur to the Lithgow Seam outcrop along the southern boundary of the Project Site.

The analytical model takes into consideration the presence of the partially saturated old Wallerawang Colliery underground void/goaf and provides a current groundwater table in the Lithgow Seam within the Yarraboldy Extension area. The scenario assumes goaf conditions in old Wallerawang Colliery underground workings.

4B.1.6 Assessment of Impacts

4B.1.6.1 Introduction

The impact assessment has indicated that the existing and future operation of the proposed Yarraboldy Extension poses a very low risk to groundwater systems.

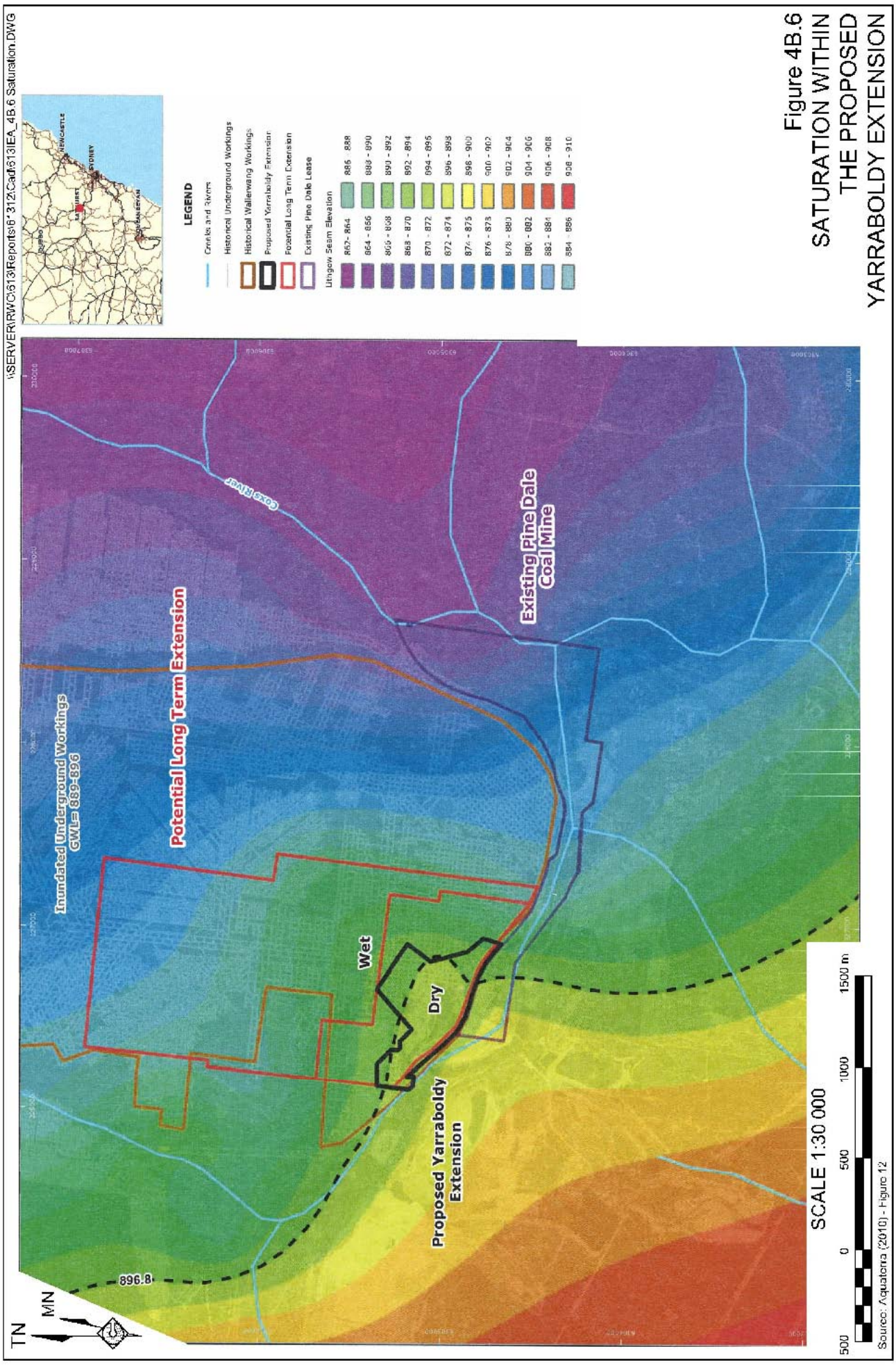
4B.1.6.2 Impacts Related to Groundwater Inflow into the Yarraboldy Extension Area

Predictive analytical modelling has indicated that groundwater inflow to the open cut pit of the Yarraboldy Extension would reduce from $45m^3$/day after the first 6 months of operation to $15m^3$/day at the end of initial 18 months of mining (**Figure 4B.6**). After this time, mining would intercept groundwater stored in the old Wallerawang Colliery underground void and the total inflow would reach $35m^3$/day by the end of the second year of mining.

No advanced dewatering of the old Wallerawang Colliery underground workings would be required and no groundwater treatment and disposal would be required into the old Wallerawang Colliery underground workings as a result of this Project.

4B.1.6.3 Impacts on Existing Groundwater Users

Extraction of groundwater by dewatering would lower the water levels of the Lithgow Seam aquifer within and close to the Yarraboldy Extension area. The maximum lowering of the water levels within the Lithgow Seam is predicted to be approximately 0.7m to the Lithgow Seam floor at the northern boundary of the Yarraboldy Extension. There would be negligible drawdown in the Lithgow Seam (goaf) downgradient of the Yarraboldy Extension area as the seam dips away and the water table is increasingly lower than predicted in the open cut pit of the Yarraboldy Extension.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LEGEND
Creeks and Rivers
Historical Underground Workings
Historical Wallerawang Workings
Proposed Yarraboldy Extension
Potential Long Term Extension
Existing Pine Dale Lease
Lithgow Seam Elevation
862 - 864
864 - 866
866 - 868
868 - 870
870 - 872
872 - 874
874 - 876
876 - 878
878 - 880
880 - 882
882 - 884
884 - 886
886 - 888
888 - 890
890 - 892
892 - 894
894 - 896
896 - 898
898 - 900
900 - 902
902 - 904
904 - 906
906 - 908
908 - 910
Figure 4B.6
SATURATION WITHIN
THE PROPOSED
YARRABOLDY EXTENSION
COX'S RIVER
Existing Pine Dale
Coal Mine
Potential Long Term Extension
Inundated Underground Workings
GWL= 889-896
Wet
Dry
Proposed Yarraboldy
Extension
896.8
TN
MN
SCALE 1:30 000
500
0
500
1000
1500 m
Source: Aquatera (2010) - Figure 12

Therefore, only those bores that are either directly to the north or to the east of the Yarraboldy Extension could be impacted by mine dewatering. As shown in **Figure 4B.1**, privately owned bores within a 15km radius are beyond the extent of the mine dewatering. It is therefore assessed that the Project would not impact on any groundwater users in the area.

4B.1.6.4 Impact on Baseflow Contributions to Neubecks Creek

Neubecks Creek is a losing stream in the upper reaches and a gaining stream in the lower reaches (downstream of the former mining Area A of the Pine Dale Coal Mine). To the south of the proposed Yarraboldy Extension boundary, the creek would remain a losing stream, as the levels in the creek would remain higher than the water levels in the Yarraboldy Extension area. Downstream of the Yarraboldy Extension area, the creek elevations are lower than the Lithgow Seam floor, however since the Yarraboldy Extension area is downgradient of the creek, no change in the hydraulic regime would be occurring.

It is therefore concluded that the proposed Yarraboldy Extension would have no impact on Neubecks Creek groundwater baseflows and the water quality within the creek. There would be no groundwater level depressurisation impact from the Project on local wetlands as Neubecks Creek, which ultimately discharges into the closest wetland system – the Blue Lake, would not be impacted by the Project.

4B.1.6.5 Potential Impacts during Construction

During the construction period for the Project there would be no interception of groundwater and therefore no impacts due to dewatering and water transfer on Neubecks Creek and the Coxs River are predicted. There would be a neutral impact on surface water quality and quantity.

In terms of impacts on groundwater chemistry, care needs to be taken in relation to site management practices. Oils, fuels and lubricants should be stored in an appropriate manner and any spillages/leaks should be managed and reported in line with a suitable environmental management plan and in accordance with Guidelines for the Assessment and Management of Groundwater Contamination (DECC, 2007).

4B.1.6.6 Potential Impacts during Operation

During operation, groundwater volumes collected in the sump within the open cut would range from $15m^3$/day to $45m^3$/day. This water would be effectively managed on site and used mainly for dust suppression. This means that there would be no discharge and therefore no impact on the water levels or water quality of the Neubecks Creek, except in the event of ongoing or significant rainfall events. In that case any groundwater stored would be mixed with surface water and only be discharged through licensed discharge points if water quality met the parameters set out in the Pine Dale Coal Mine's Environmental Protection Licence (Discharge of water is discussed within the Surface Water Assessment for the Project).

There would be no impact of dewatering the old Wallerawang Colliery underground workings and other aquifers on water quantity and quality of the Coxs River.

Once dewatering of the Lithgow Seam/goafed zone ceases, additional minor seepage from the Lidsdale and Irondale Seams is possible. During this period, the open cut would act as a groundwater sink. There would be a neutral effect on receiving groundwater and surface water quality (based on *Drinking Water Catchments Regional Environmental Plan No. 1*, SCA, 2007).

No groundwater users would be affected during the operational stage of the Project, as the decline in the water level is not likely to propagate for more than 100m outside the Yarraboldy Extension boundary.

Regarding the impacts on groundwater chemistry, care needs to be taken in relation to site management practices. Oils, fuels and lubricants should be stored in an appropriate manner and any spillages/leaks should be managed and reported in line with a suitable environmental management plan.

During operations, any surface water from the catchment would be diverted away from disturbed areas thereby preventing any potential mixing with groundwater. Moreover, the clean runoff would be of a superior water quality than the groundwater contained within the coal seams.

4B.1.6.7 Potential Impacts during Decommissioning

During decommissioning, the open pit void would be backfilled and rehabilitated. The final landform would be recreated similar to the existing pre-mining landform. Therefore no impacts are expected on the groundwater regime during this stage. Groundwater levels would in time return to equilibrium (see **Figure 4B.6**). During this stage, there would be no dewatering and therefore no discharge of groundwater.

In terms of groundwater quality, the groundwater recharge would be primarily sourced from rainfall recharge. Therefore, the recharge would have an overall beneficial effect on groundwater quality in the local aquifers. The proposed Yarraboldy Extension would have a neutral effect on surface water flows and water quality.

High concentrations of sulphate ions in the groundwater indicate that the lowering of the water table in the old Wallerawang Colliery underground void may expose acid prone coal seams to air. Following subsequent recovery and rising of the water table within the old Wallerawang Colliery underground void, development of acid water may then result, with a lowering of pH and the precipitation of iron. Based on the analytical modelling results, it is expected that the lowering of water levels in old Wallerawang Colliery underground void/goaf would be negligible. In the short term this may mean that groundwater may become slightly acidic, however, in the long term when the levels reach equilibrium the effect would be neutral. Any potential acid generation would be managed on site by selective placement of cover material. The impact of the potentially acid groundwater would be localised and therefore it would have no impact on groundwater users.

4B.1.6.8 Potential Impacts on Groundwater Dependent Ecosystems (GDEs)

There would be no impact due to subsidence and vibration from the Project and no changes in hydrology and groundwater dependent ecosystems due to subsidence as the proposed Project is an open cut mining development which would not cause ground to subside.

No sensitive groundwater dependent ecosystems have been identified within the Yarraboldy Extension area. Any potential ecosystems associated with the Neubecks Creek would not be impacted by the proposed Yarraboldy Extension both in relation to water quality and quantity. This would be achieved by efficient site management and groundwater use for dust suppression.

4B.1.6.9 Potential Impacts on Future Water Supply

With regards to the potential impact on future water supply, no groundwater sources or aquifers have been identified that would require sterilisation from future water supply use as a consequence of the Project.

4B.1.7 Groundwater Monitoring, Contingency Plans and Reporting

4B.1.7.1 Introduction

Following receipt of Yarraboldy Extension approval, the Proponent would develop a detailed Water Management Plan, including a Groundwater Monitoring and Response Program. The program outlines the proposed monitoring procedures and verifies the impacts of the mine on groundwater over its operational life. The plan would also identify contingency measures to be implemented in the event any trigger criteria are exceeded during the life of the Project.

The program would be developed in consultation with the Department of Environment, Climate Change and Water (DECCW) and the results reported in the Annual Environmental Management Report (AEMR).

4B.1.7.2 Groundwater Monitoring

Groundwater inflows would be monitored closely throughout the life of the Project. This would include recording the volume and quality of water discharged from the mine and pumped from the sump pump.

The monitoring program would include recording of the following.

- Groundwater inflow volumes – monthly totals of water pumped from open cut sump.
- Groundwater quality – monthly measurements on site of the EC and pH of sump pumps.
- Half yearly sampling from the sump pumps for comprehensive hydrochemical analysis as detailed in **Table 4B.4**.

Table 4B.4
Proposed Analytes for Groundwater Monitoring

Class	Parameter
Physical parameters	EC, TDS, TSS, turbidity and pH
Major cations	calcium, magnesium, sodium and potassium
Major anions	carbonate, bicarbonate, sulphate and chloride
Dissolved metals	arsenic, cadmium, chromium, copper, iron, lead, nickel, zinc
Source: Aquaterra (2010) Table 17	

The current baseline groundwater bore monitoring program would be continued, with a modified network of selected monitoring points determined prior to commencement of mining. In addition, it is recommended that a monitoring bore that has been installed within the Yarraboldy Extension footprint (immediately to the south of the northern Yarraboldy Extension boundary) and the old ventilation shaft next to the haul road be included in the monitoring program. Appropriate groundwater assessment criteria would be reassessed for the proposed Yarraboldy Extension based on the completion of baseline sampling.

The following data would be collected from the groundwater monitoring bores.

- Monthly manual and continuous automated monitoring of water levels from the network of monitoring bores (download of vibrating wire data loggers).
- Quarterly sampling of representative monitoring bores for laboratory analysis (as outlined in **Table 4B.4** above).

All bores would be purged prior to sampling until continuous monitoring of the pH and salinity indicates that the quality of water sampled from the bore has stabilised. This would require removal of at least three bore volumes of groundwater before sampling.

All results of the monitoring program would be reviewed as they are received and compared to the groundwater triggers presented in Section 4B1.7.3, with all results and interpretations subsequently reported in the AEMR. The monitoring program would be re-assessed during preparation of the AEMR and may be modified subject to agreement with the relevant government agencies once the variability of the groundwater system is established.

4B.1.7.3 Groundwater Triggers

Standing Water Level

A trigger for investigation of groundwater levels (the effect on groundwater users) would occur if a drop of over 10% within the rolling three month period occurs in saturated aquifer thickness (based on minimum reported baseline value) as monitored in EP DDH7/GW and EP DDH6/GW as a result of activities associated with the proposed Yarraboldy Extension. Modification of this trigger level, in consultation with the DECCW - NOW, may be possible as further data becomes available. Should this trigger level be exceeded or if there is a significant increase outside the normal fluctuation levels in the rate of rise or fall in aquifer water levels compared to the preceding 12 months, an assessment by a suitably qualified specialist would be conducted. The investigation would assess if the observed groundwater level change is exclusively induced by activities associated with the Project or due to other potential factors, such as low rainfall, variation in climate, increased groundwater usage by a private user, or an altered rainfall / recharge relationship. The assessment would consider if potential mitigation measures need to be adopted.

Groundwater Quality

A trigger for investigation of groundwater quality (the effect on receiving body) would be based on baseline data and the potential sensitive receptors. The trigger would occur if a change in water quality occurs from the baseline data. This would be assessed once a full set of baseline data is available.

Where a trigger value is exceeded, the Proponent would initially undertake additional monitoring to determine whether the exceedance relates to an error or interim change in groundwater quality and if it is due to activities associated with the proposed Yarraboldy Extension or some other cause. Additional monitoring after this may involve increasing the frequency of monitoring for laboratory analysis and/or increasing the frequency of field analysis.

Since the area has been disturbed in the past, the threshold for iron has already been determined based on the average longer term monitoring data (two years) as an exceedance of 15% over this value (RWC, 2004).

Long Term Groundwater System Protection

Following cessation of mining within the proposed Yarraboldy Extension area, the protection of the local and regional aquifer systems would be achieved through continued monitoring of the groundwater system for a period of two years after mining has ceased.

If during that time, any adverse effects are observed in relation to groundwater that exceed the triggers outlined in the above sections, the appropriate contingency measures would be implemented.

4B.1.7.4 Groundwater Related Response Measures

The Proponent would implement the following measures if impacts on groundwater users attributed to activities associated with the Project are demonstrated to be greater than anticipated.

- Assess the significance of the impacts.
- Investigate measures to minimise the impacts.
- Describe what measures would be implemented to reduce, minimise, mitigate or remediate these impacts to the satisfaction of the DECCW - NOW.

If a non-conformance with the trigger criteria set out above is determined to be the result of activities associated with the proposed Yarraboldy Extension, then the impacted landholder and DECCW-NOW would be notified and a remediation strategy would be proposed and implemented.

The following indicative response measures may be implemented.

- Remedial action including the deepening of production bores and lowering pump intakes on private bores where a reduction in the standing water level is attributed to the Yarraboldy Extension activity.

- Sealing of surface cracks, if they develop in the vicinity of infrastructure such as roads as a result of dewatering of old Wallerawang Colliery underground void and if they are determined to be adversely impacting safety.

Contingency procedures would be activated following the assessment of groundwater monitoring results in light of the triggers outlined above, including both groundwater levels and groundwater quality.

4B.2 SURFACE WATER

The surface water assessment for the Project was undertaken by GSS Environmental (GSSE, 2010). The full assessment, entitled *Pine Dale Coal Mine Yarraboldy Extension Surface Water assessment*, is presented as Part 2 of the *Specialist Consultant Studies Compendium*. Relevant information from the assessment is summarised in the following subsections.

4B.2.1 Introduction

Based on the risk analysis undertaken by R.W. Corkery & Co Pty Limited for the Project (see Section 3.3 and **Table 3.7**) the potential impacts on surface water requiring assessment and their unmitigated risk rating are as follows.

- Reduced downstream surface water quality and degradation of aquatic ecosystems:
  - Impacts restricted to surface water on Proponent-owned land (medium risk).
  - Localised impacts to surface water (high risk).
  - Regional impacts to surface water (high risk).
- Potential health effects in either humans or livestock (medium risk).
- Changes in stream hydrology and changes due to altered flood regimes (high risk).
- Increased flows and/or flooding in natural drainage lines (high risk).
- Uncontrolled discharge of dirty, saline, contaminated water outside licence conditions (high risk).

In addition, the Director-General's Requirements issued by the DoP identified "Soil and Water" as one of the key issues that requires assessment at the Project Site. The assessment of impacts on surface water is required to include the following.

- Modelling of potential surface (and groundwater) impacts.
- A revised site water balance.
- An assessment of potential impacts on:
  - the quality and quantity of existing surface and groundwater resources; and
  - groundwater dependent ecosystems.
- A description of the mine's water management system, water monitoring program, and other measures to mitigate surface water (and groundwater) impacts.

Documentation used in the preparation of the surface water assessment is listed in GSSE (2010).

The following sub-sections describe and assess the existing drainage and surface water environment, identify the surface water management issues, proposed surface water controls, safeguards and mitigation measures, and presents an assessment of the residual impacts following the implementation of these safeguards and mitigation measures.

4B.2.2 The Existing Environment

4B.2.2.1 Regional Drainage

On a regional scale, the Yarraboldy Extension area (and the Project Site) lies within the Neubecks Creek catchment which is a sub-catchment of the Upper Coxs River catchment. The Upper Coxs River catchment is part of the greater Warragamba Dam Catchment which falls within the catchment for Sydney's water supply.

The Yarraboldy Extension area lies to the west of the upper reaches of the Coxs River (see **Figure 4B.7)**. The runoff from the surrounding area reports to the Coxs River via Neubecks Creek (a perennial tributary) which runs into the Blue Lake, a former open cut void. Neubecks Creek is understood to flow intermittently (noting that many of its tributaries are ephemeral), with flows influenced by water discharges from other upstream industrial land uses in addition to the existing Pine Dale Coal Mine.

The Proponent has rarely discharged surface water to Neubecks Creek since late 2005. Rather, it has been discharging to the old Wallerawang Colliery underground workings (see **Figure 4B.8**). However, a small part of the existing Pine Dale Coal Mine site (undisturbed portions), east of the proposed Yarraboldy Extension area, lies within the Coxs River catchment and ultimately reports to the Coxs River and the Blue Lake.

Approximately 5km downstream of the Blue Lake, the Coxs River flows into Lake Wallace within the township of Wallerawang. The Coxs River continues downstream and eventually reports to Lake Burragorang.

The total catchment area of Neubecks Creek upstream of the Blue Lake is approximately 30km^2. The total catchment area of the Coxs River upstream from its confluence with Neubecks Creek (Upper Coxs River catchment) is approximately 200km^2.

Neubecks Creek and the Coxs River lie within a substantially disturbed catchment in which water quality and quantity are influenced by surrounding historical industrial, mining (Ivanhoe Colliery, Commonwealth Open Cut Coal Mine, Angus Place Coal Mine, Kerosene Vale Mine), power generation (Mt Piper Power Station) and agricultural land uses over a number of decades. However, natural regeneration has occurred in some historically disturbed environments such as the 'Blue Lake'.

Given that Neubecks Creek and Coxs River are 4th order and 5th order streams, respectively, means their conservation significance is high. Similarly, the regenerated Blue Lake contributes to the wetland habitat value in the area.

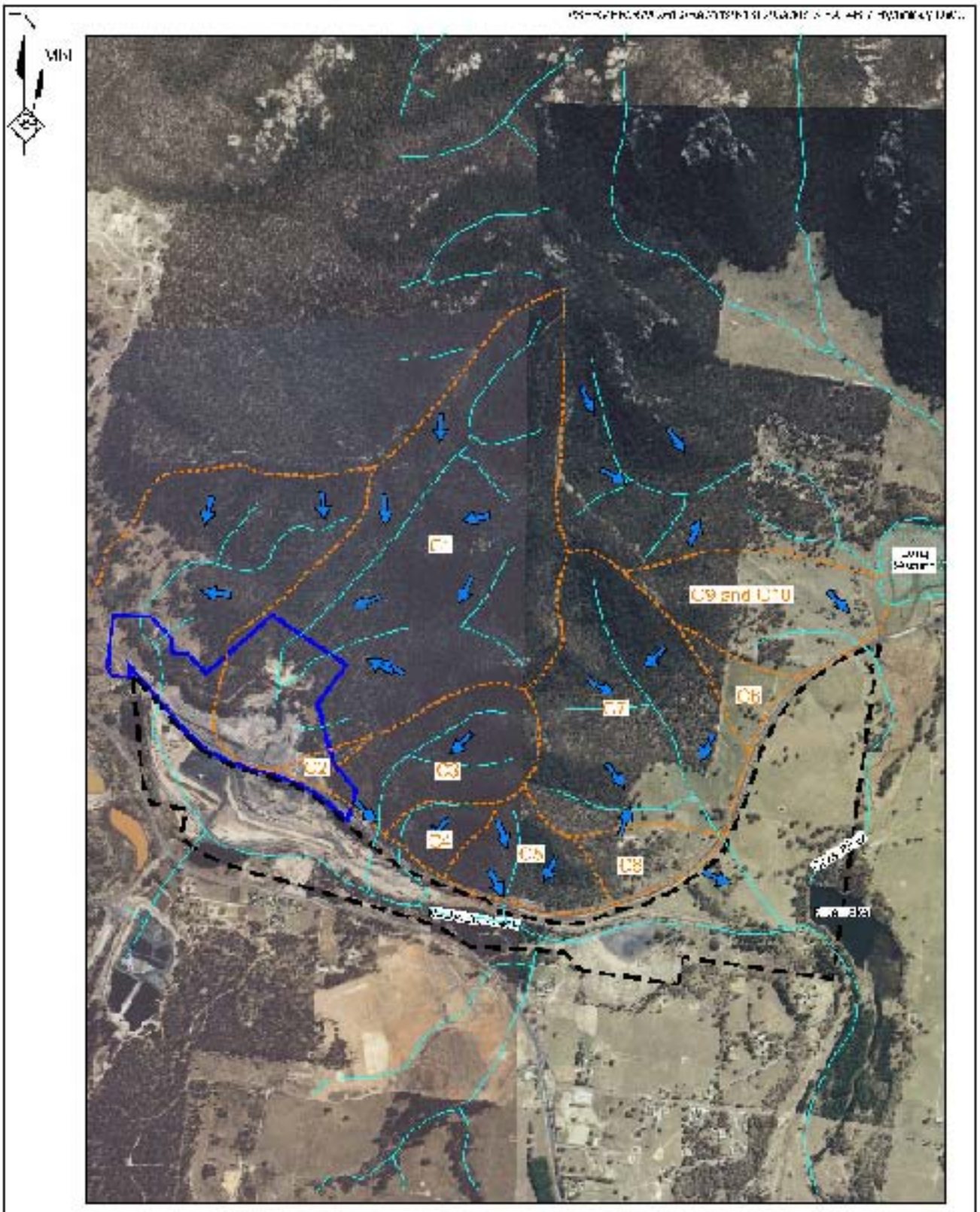


Figure 4B.7
LOCAL HYDROLOGY SHOWING STREAMS AND CATCHMENT AREAS

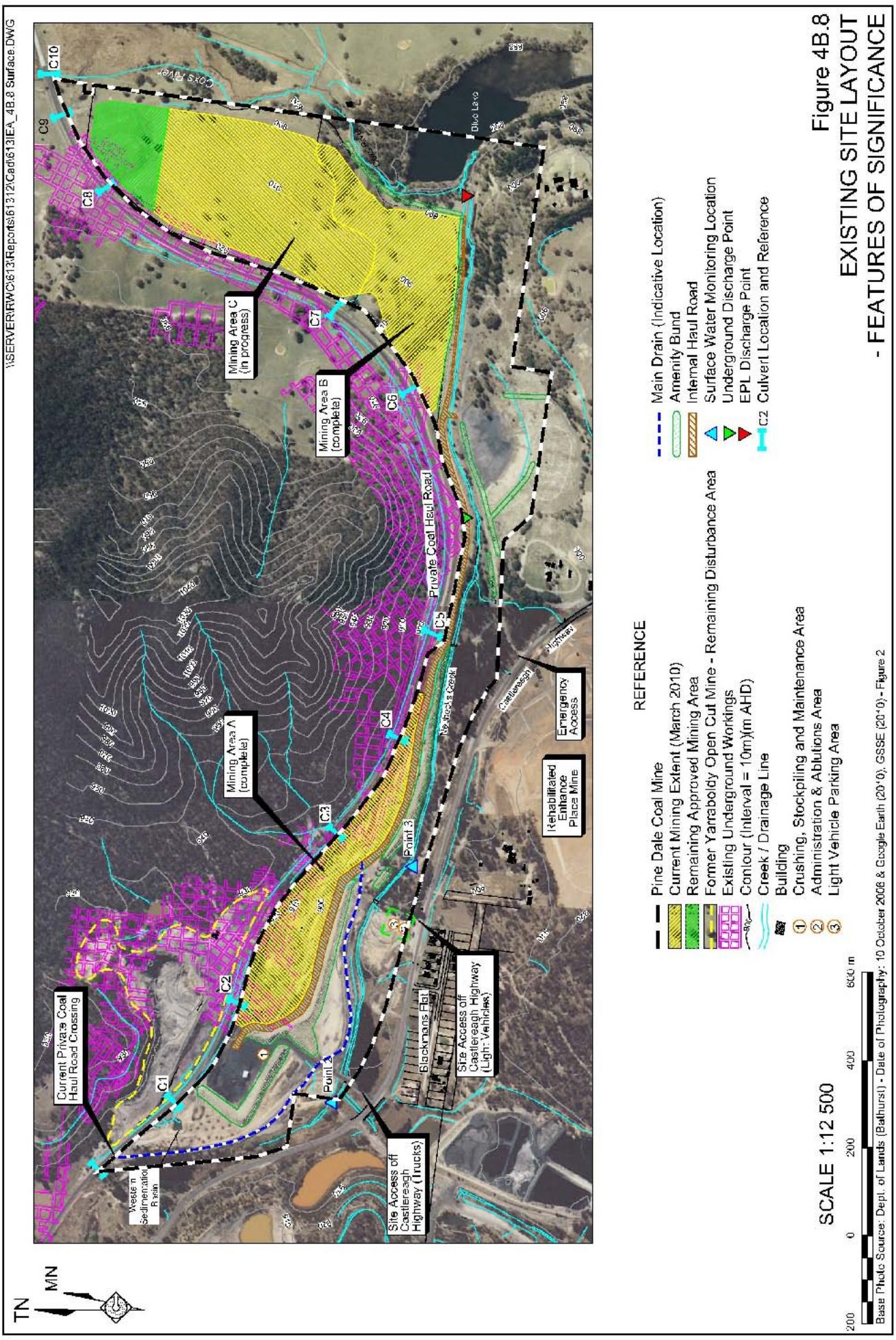


Figure 4B.8
EXISTING SITE LAYOUT
- FEATURES OF SIGNIFICANCE

4B.2.2.2 Mine Site Drainage

Figure 4B.7 depicts the Yarraboldy Extension in relation to the streams in the vicinity of the Project Site and catchment areas. The southern section of the Yarraboldy Extension area has been significantly disturbed through previous mining operations of the former Yarraboldy Open Cut Mine and subsequently, the former natural drainage lines within the area have been substantially altered. The drainage lines that flow into the Yarraboldy Extension area from the Ben Bullen State Forest to the north of the Project Site are all ephemeral. The majority of any water flowing into the former Yarraboldy Open Cut Mine ultimately flows into the old Wallerawang Colliery underground workings via the mine entrances within the mine itself.

Natural drainage within the Yarraboldy Extension area is generally to the south and southeast following the natural topography toward the receiving waters of Neubecks Creek (see **Figure 4B.7**). The old Wallerawang Colliery receives water from Catchment 1 (C1) and Neubecks Creek receives water from the existing Catchment 2 (C2). C1 represents a substantially larger catchment than C2. Both C1 and C2 drainage lines are ephemeral in nature and are predominantly undisturbed. The runoff from the northern catchment area of C1 flows into the existing Yarraboldy Open Cut Mine void and enters the underground workings via an old underground entry (Punch Mine Entry, registered as LDP 5 on the existing Pine Dale Coal Mine's EPL 4911). The majority of the area within the Yarraboldy Extension area is included in Catchment 1.

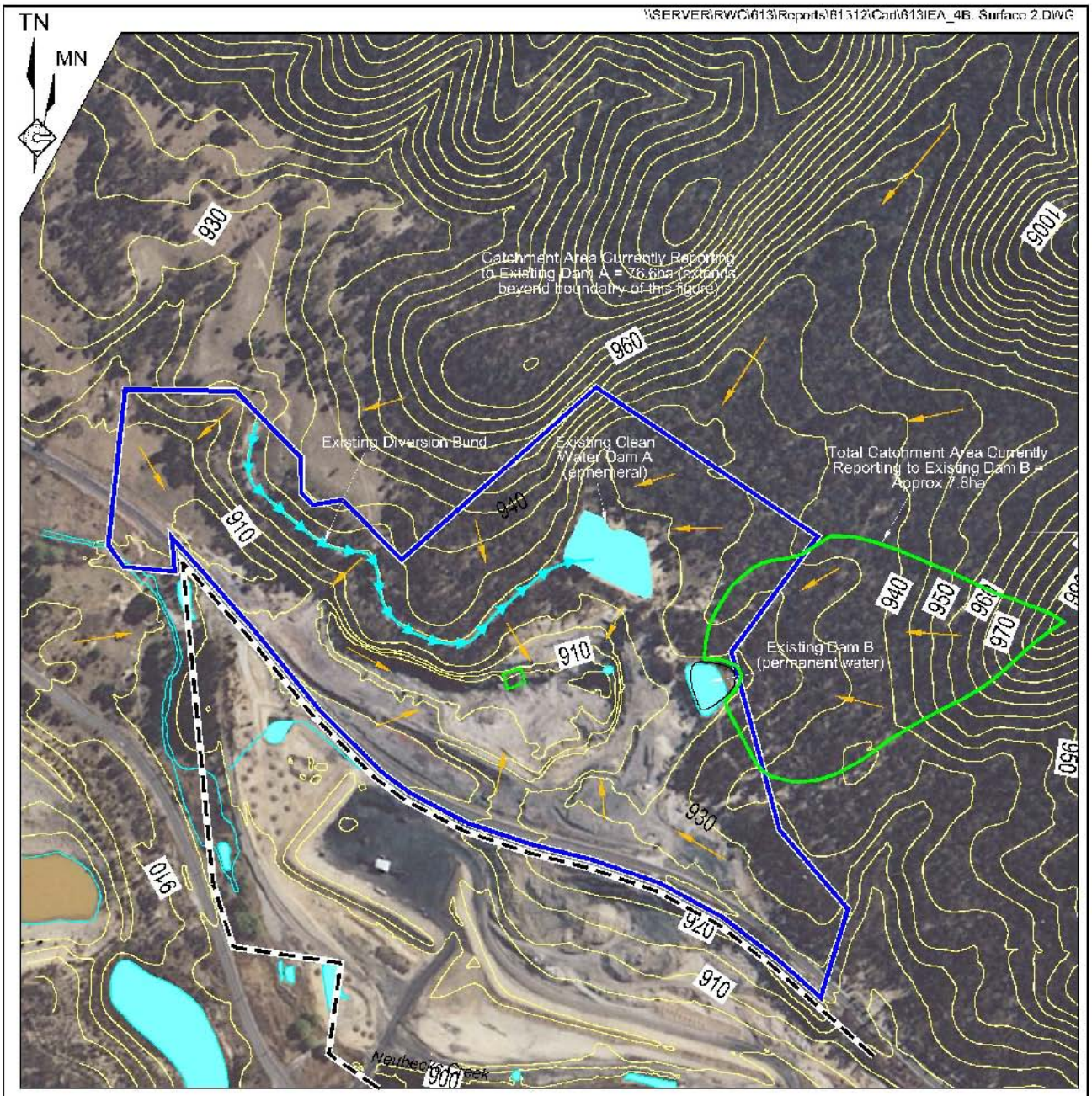
Within C1, two ephemeral second order drainage lines are fed by upper first order drainage lines located beyond the Yarraboldy Extension area. The two second order drainage lines currently feed flows to an Existing Dam A (see **Figure 4B.9**). This dam is also ephemeral. The drainage lines upstream of Existing Dam A lie with the natural bushland of the Ben Bullen State Forest and are essentially undisturbed. It is noted, however, that the drainage lines exhibit no formed bed or banks and are generally shallow depressions where water would concentrate in saturating rainfall events.

A second dam, Existing Dam B, is located east of the ephemeral Existing Dam A described above. It is also within catchment C1 and was holding water at the time of inspection. Water sampled from this location has been used to indicate the quality of water flowing from the upstream ephemeral drainage lines.

4B.2.2.3 Surface Water Quality

Existing surface water quality at the Pine Dale Coal Mine has been determined through on-going surface water monitoring and assessment undertaken in accordance with Environment Protection Licence (EPL) 4911 conditions. Sampling is conducted at locations within and surrounding the Yarraboldy Extension area (see **Figure 4B.10**) and described below.

- Neubecks Creek Upstream (EPL 4911 Point 2) – Upstream of the Project Site, but downstream from the surrounding industrial land use
- Neubecks Creek Downstream (EPL 4911 Point 3) – within/below the Project Site and the existing Pine Dale Coal Mine operations.
- Coxs River Upstream
- Coxs River Downstream (EPL 4911 Point 14).



REFERENCE
- Pine Dale Coal Mine
- Yarraboldy Extension
- Indicative Flow Direction
- 910 Contour (m AHD)(Interval = m)
- Existing Dam / Water Storage
- Existing Diversion bund
- Old Wallerawang Colliery Underground Entry (LDPS)

SCALE 1:7 500

100 0 100 200 300 400m

Source: GSSE (2010) - Figure 6
Base Photo Source: Dept. of Lands (Bathurst) - Date of Photography: 10 October 2006
Contour Source: AAMHatch - August 2009

Figure 4B.9
EXISTING SURFACE WATER MANAGEMENT