BENGALLA Mining Company

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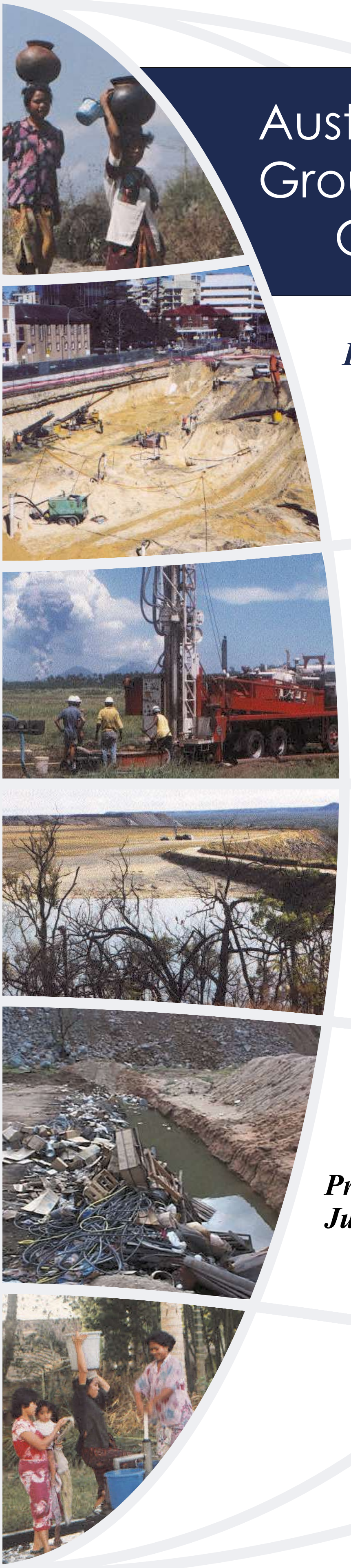
Groundwater Impact Assessment



Australasian Groundwater & Environmental Consultants Pty Ltd

REPORT on

CONTINUATION OF BENGALLA MINE

GROUNDWATER IMPACT ASSESSMENT

prepared for
HANSEN BAILEY PTY LTD

Project No. G1505
June 2013

ABN:64 080 238 642

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Level 2 / 15 Mallon Street
Bowen Hills Qld 4006
Ph (+617) 3257 2055
Fax (+617) 3257 2088
Email: brisbane@ageconsultants.com.au
Web: www.ageconsultants.com.au

A.B.N 64 080 238 642

EXECUTIVE SUMMARY

Hansen Bailey, on behalf of Bengalla Mining Company, commissioned Australasian Groundwater and Environmental Consultants to undertake a Groundwater Impact Assessment for the Continuation of Bengalla Mine Project (the Project). This assessment will form part of the Environmental Impact Statement supporting an application for Development Consent under Part 4, Division 4.1 of the *Environmental Planning and Assessment Act 1979*.

The Project involves the continuation of mining at a rate of up to 15 Mtpa run of mine coal for 24 years. The Project will enable the extraction of an additional 316 Mt of ROM coal from the Permian Whittingham Coal Measures.

Bengalla Mine is located approximately 4 kilometres west of Muswellbrook and 130 km north-west of Newcastle in the Upper Hunter Valley, New South Wales. Bengalla Mine commenced operations in 1999, and has progressed about 1.8 km down the westerly dipping coal measures.

Regionally the stratigraphic sequence comprises two distinct units, namely thin Quaternary alluvial deposits and a low permeability Permian coal seam sequence. The Permian Whittingham Coal Measures contain overburden and interburden consisting of lithic sandstone, interbedded with siltstone, tuffaceous claystone and mudstone. The Permian sediments are unconformably overlain by thin Quaternary alluvial deposits along the alignment of the Hunter River located to the south of the Project.

The Permian Whittingham Coal Measures are not a significant aquifer. While some coal seams may locally show a moderate permeability, the dominant interburden sections are of very low hydraulic conductivity. The very limited volumes of groundwater that have been experienced in the current open cut pits at Bengalla are evidence of this. The groundwater system has only one significant aquifer system, which are the sand and gravel zones within alluvium along the Hunter River. The Quaternary alluvium is connected to the Hunter River, which appears to act as both a recharge and discharge zone depending on the water levels in the river. The alluvium supports groundwater dependent ecosystems in the form of stygofauna species and fragmented occurrences of Red Gum Woodland Red Gums along the Hunter River.

Bengalla Mining Company has been gradually expanding a network of bores for monitoring groundwater levels and quality since 1992. The mine monitors groundwater levels and/or water quality at a total of 45 bore sites installed in either the alluvium or Permian coal measures. The monitoring has recorded cyclic fluctuations in groundwater levels in the alluvial aquifer in response to rainfall, and no significant regional impact is evident due to mining. Mining has depressurised the coal seams in a narrow zone locally around the mining area, and reversed hydraulic gradients with flow of groundwater from the alluvium into the underlying Permian coal measures. Despite the reduced flow of water to the alluvium locally around the mining area the diffuse rainfall recharge over the flood plains appears to be sufficient to maintain groundwater levels, which is why no significant fall in groundwater levels has been observed in the alluvium.

Bengalla Mining Company is currently mining the area referred to as the Wantana extension area, which is in close proximity to the Hunter River alluvium. The distance from the edge of the alluvium to the pit crest is 150 m or more. The Project will result in mining away from the Wantana extension and progressively further away from the edge of the Hunter River alluvium. At the Year 21 mine plan, the highwall will be approximately 1.5km from the alluvial aquifer. There are considerable resources present beyond the 21 year mining limit and in the future, BMC may (depending upon market factors) seek the relevant approvals for the extraction of further coal resources.

A numerical groundwater flow model simulated the impact of the continuation of mining Project on the groundwater regime. The model was based on a previous FEFLOW model constructed for the existing Bengalla Mine to incorporate the Wantana extension. The previous model was found to be over-predicting the extent of depressurisation compared to observations, so the hydraulic conductivity was reduced in the recalibrated model. The model was recalibrated using extensive groundwater monitoring data to obtain the best match to steady state and transient water level measurements collected in bores and wells. After calibration, the modelling assessed the impact of the Project on groundwater levels and the transfer of groundwater between the Permian and the alluvial groundwater systems.

The modelling indicated groundwater seepage from basement Permian coal measures into the open cut mine will peak early in the Project life at about 1 ML/day, and then slowly reduce over the Project life as the mine moves further away from the alluvial aquifer, and up into more elevated land where the unsaturated zone thickens. Evaporation of groundwater that seeps from the coal seams at the pit face will be significant, and is likely to mean that there will be no visible seepage into the pit in the latter years of the Project life, i.e. the pit will be dry. The rate of seepage to the mine is slightly higher than predicted by earlier models due to the changes to the water bearing strata hydraulic properties adopted during the recalibration.

BMC currently have a 125 ML water licence (20BL169798) under the *Water Act 1912* to account for groundwater seepage into the pit from the basement rocks (excluded from the Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009 NSW). This license is sufficient to authorise the average seepage take to the open cut pits which is 110 ML/year, but does not cover the peak period when seepage reaches 365 ML/year. BMC will change the conditions of the licence to authorise extraction of a maximum of 365 ML/year.

The model predicts mining will continue to depressurise and lower groundwater levels in the Permian basement sequence, but this will not result in drawdown extending a significant distance into the alluvial aquifer with drawdown being less than 1m. The depressurisation of the Permian sequence will reduce the groundwater discharge rates into the Hunter River alluvium by a peak of 0.63 ML/day at the beginning of the Project, reducing to 0.25 ML/day as the project moves away from the flood plain. The maximum annual reduction in flow to the alluvium is predicted to be 220 ML/year, which occurs in Year 1 of the Project. The groundwater flow to the alluvium decreases over the Project life with an average reduction of 112 ML/year. This reduction in transfer from the basement to the alluvium will not result in any significant drawdown at any private registered bores.

BMC will transfer additional share component to its existing water access licence for the Hunter River alluvium, which authorises projected take of water from the Hunter River Alluvial Water Source due to mining to increase total share component to 220 units. The additional share component will be transferred from other water access licences which are already held by BMC. These licenses will ensure the Project holds sufficient share component and water allocation to account for the take of water from the adjacent water sources at all times, and complies with the requirements of the Aquifer Interference Policy.

A sensitivity analysis indicated the river and alluvial aquifer acted as a controlling boundary condition, with the 1m drawdown contour remaining along the edge of the alluvium when model parameters were varied. The limited drawdown predicted means only one private groundwater bore is known to be present within the predicted zone of depressurisation. The drawdown at this bore is predicted to be a maximum of 2 m, which is within the minimal impact considerations outlined in the Aquifer Interference Policy. Stygofauna and groundwater dependent vegetation are also not expected to be impacted by the limited drawdown.

Should the mine close after completing the additional proposed mining, dewatering of the pit will cease and a lake will form in the final void. The void lake level will recover relatively rapidly over the first 50 years, followed by a slowing in recovery as the hydraulic gradients to the pit void decrease. A maximum pit lake level in the order of RL 30 m is predicted. The groundwater model and a separate model for the surface water study indicated that the water level in the final void will stabilise well below the crest of the pit, and therefore spillage of water into the environment will not occur. The final void will act as a sink for groundwater, and this will prevent any poor quality water that develops within the pit from migrating into the surrounding groundwater system.

Post mining the evaporative losses from the pit lake will result in a constant flux of groundwater into the final void. This will result in a permanent zone of depressurisation around the pit final void in the Permian, which will reduce the rate of groundwater flow from the Permian to the Hunter River alluvium. The flux to the alluvium was calculated to be reduced by a maximum of 0.6 ML/day (220 ML/year) at 1000 years. This loss is equivalent to the rate estimated for the mining phase, and will be accounted for by Water Access Licenses being surrendered at closure of the mine.

A geochemical study found that all overburden material, apart from the Archerfield Sandstone located above the Wynn seam, has negligible sulfur content, excess acid neutralising capacity, and is classified as non-acid forming. The Project will continue to bury potentially acid forming overburden and coal reject materials in the overburden in the backfilled open cut. The Permian groundwater quality is typically brackish and in the range of 4,000 μS/cm to 8,000 μS/cm. This is similar to the salinity generated by the oxidised coal rejects. Post mining a lake will form in the final void that will act as a sink in the groundwater system and will prevent flow of brackish to saline water in the final void lake from entering the Hunter River alluvium.

A peer review of the study was undertaken by Dr Frans Kalf from Kalf and Associates Pty Ltd in accordance with the Australian Groundwater Modelling Guidelines. Several stages of review were undertaken over the course of the Project including development of the conceptual model, modelling and reporting. The peer review concluded that the groundwater model was fit for assessing the impacts of the Project on the groundwater regime. The model calibration and the impacts predicted by the model were considered to be reasonable.

Bengalla Mining Company will update the existing Water Management Plan including appropriate management and mitigation measures identified for the Project in consultation with relevant regulators.

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JST/DMc:tl/ae(Bengalla)
Project No. G1505
June 2013

REPORT ON

CONTINUATION OF BENGALLA MINE

GROUNDWATER IMPACT ASSESSMENT

1.0 INTRODUCTION

Bengalla Mine (Bengalla) is located approximately 4 kilometres (km) west of Muswellbrook and 130 km north-west of Newcastle in the Upper Hunter Valley, New South Wales (NSW). Figure 2.1 shows the location of the Project.

Bengalla was originally approved to operate for a 21-year period from 1996 and to produce up to 8.7 Mtpa of ROM coal. Bengalla was officially opened in 1999. Strip mining is employed using dragline, truck and shovel mining methods. Mining targets the Permian Whittingham Coal Measures of the Hunter Coalfield with the Warkworth and Edderton Seams currently being mined.

The 1996 EIS acknowledged that significant coal reserves continued west beyond the 21 year mining extent and stated *'the coal reserves continue to the west of the limit of excavation, and beyond the edge of the Authorisation area. It is anticipated that these reserves will be mined by open cut methods in the future, subject to appropriate approvals'.*

Since 1996, there have been four approved modifications for ongoing operations at Bengalla. The current Project will largely rely upon constructed mine site infrastructure including (but not limited to) the Coal Handling and Preparation Plant (CHPP), rail loop/load out facility and workshop / administrative buildings.

BMC is now seeking a new Development Consent under Division 4.1 of Part 4 of the *Environmental Planning & Assessment Act 1979* (EP&A Act) to continue mining west of its current operations for a 24 year period at a rate of up to 15 Million tonnes per annum (Mtpa) of Run of Mine (ROM) coal (the Project).

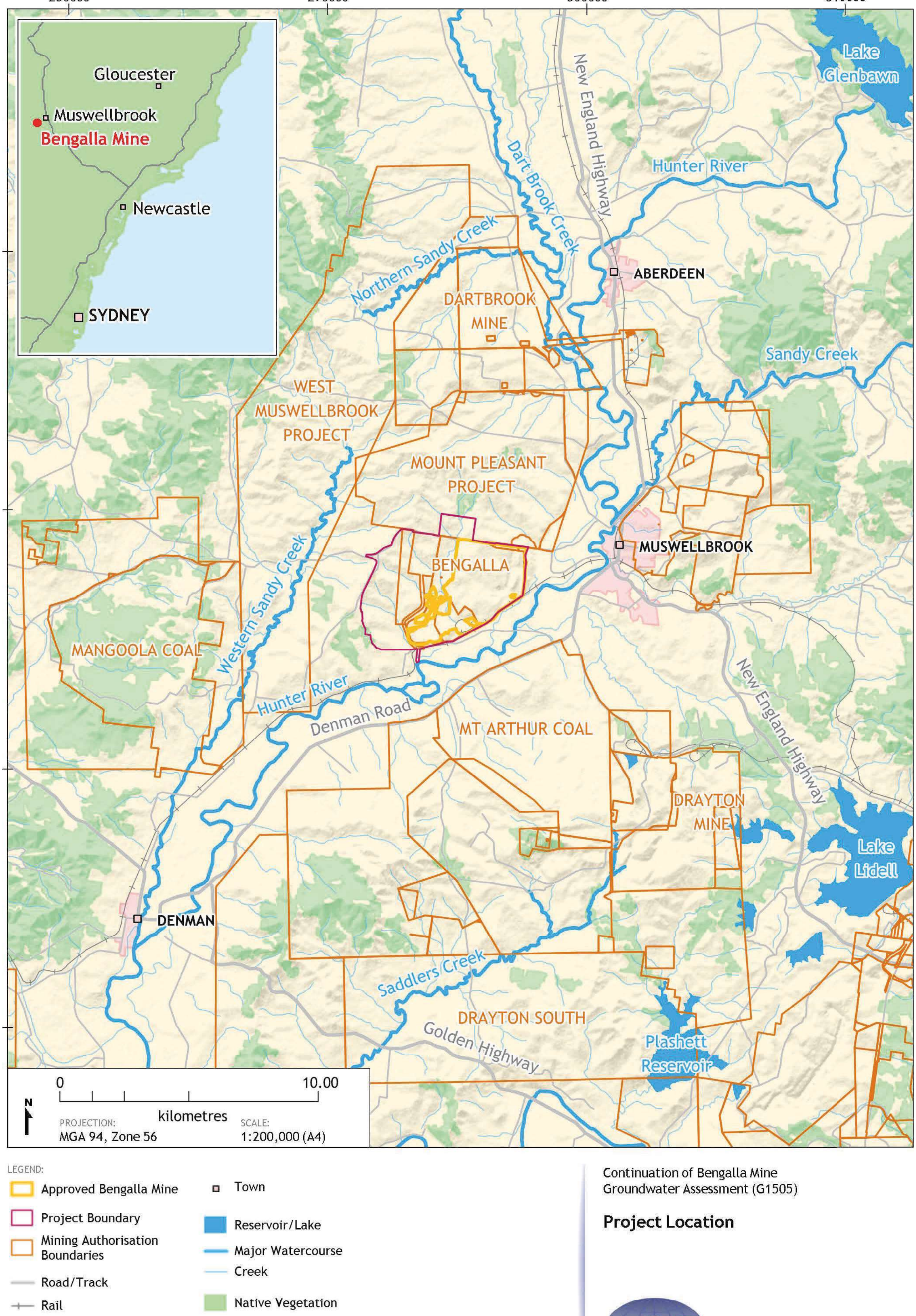
BMC has commissioned Hansen Bailey Environmental Consultants Pty Ltd (Hansen Bailey) to prepare an Environmental Impact Statement (EIS) for the Project. Hansen Bailey engaged Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) to assess the impact of the proposed mining on the groundwater regime on behalf of their client, BMC. This report presents the results of the groundwater impact assessment and forms part of the EIS.

2.0 PROJECT DESCRIPTION

The Project involves the continuation of mining at a rate of up to 15 Mtpa ROM coal for 24 years. The Project will enable the extraction of an additional 316 Mt of ROM coal from the Whittingham Coal Measures. The Project generally consists of the following characteristics:

- Open cut mining at a rate of up to 15 Mtpa ROM coal for 24 years continuing to utilise a dragline and truck and excavator fleet;
- Extending mining to the west of current operations - an out of pit Overburden Emplacement Area (OEA) to the west of Dry Creek which may be utilised for excess spoil material until it is intercepted by mining;
- Processing, handling and transportation of coal via the CHPP to be upgraded, and rail loop for export and domestic sale;
- An additional CHPP stockpile and ROM coal stockpile;
- Continued use, extension and upgrades to existing infrastructure;
- The construction of a radio tower;
- Relocation of the Explosives Magazine and Reload Facility;
- Relocation of a section of Bengalla Link Road near the existing mine access road to enable coal extraction;
- The diversion of Dry Creek via dams and pipe work with a later permanent re-alignment of Dry Creek through rehabilitation areas when emplacement areas are suitably advanced;
- Relocation of water storage infrastructure as mining progresses through existing dams (including the Staged Discharge Dam);
- The construction of raw water dams and a clean water dam;
- A workforce of approximately 900 full time equivalent personnel at peak production; and
- Supporting power and water reticulation infrastructure, other ancillary facilities, infrastructure including roads, co-disposal and temporary in pit coal reject emplacement along with earth handling facilities, which enable construction activities.

Figure 2.2 shows the conceptual Project layout.



Continuation of Bengalla Mine
Groundwater Assessment (G1505)

Project Location

DATE: 6/12/2012

FIGURE No: 2.1

LEGEND:

- Approved Bengalla Mine
- Project Boundary
- Wantana Extension
- Town
- Road
- Rail
- Alluvium
- Major Watercourse
- Creek

Air Photo courtesy of Bengalla Mine - photo date 08/2012; For wider area background aerial from Google Maps - ©2012 Google

Continuation of Bengalla Mine
Groundwater Assessment (G1505)

Conceptual Project Layout

DATE:
6/12/2012

FIGURE No:
2.2

3.0 SCOPE OF WORK

The following sections outline the requirements of both the New South Wales and Federal Governments for inclusion in the water assessments for the Project.

3.1 New South Wales Government Requirements

The Director-General of the Department of Planning and Infrastructure (DPI) issued Director-General's Requirements (DGRs) for the Project under Part 2 of Schedule 2 of the *Environmental Planning and Assessment Regulation 2000*. Table 1 presents the DGRs relating to water resources and the sections that address these requirements.

Table 1: DEPARTMENT OF PLANNING AND INFRASTRUCTURE REQUIREMENTS

Water Resources	Addressed in Section
• detailed assessment of potential impacts on the quality and quantity of existing surface and groundwater resources, including:	
o detailed modelling of potential groundwater impacts including any potential impacts on the alluvial aquifers of the Hunter River and confirmation of the physical extent of the river's alluvium;	7.3.1, 11.0
o impacts on affected licensed water users and basic landholder rights;	11.5
o impacts on riparian, ecological, geo-morphological and hydrological values of watercourses, including environmental flows;	Surface Water Impact Assessment
o details and staging for the proposed Dry Creek re-diversion; and;	Surface Water Impact Assessment
o a flood assessment including identification of any necessary flood impact mitigation measures;	Surface Water Impact Assessment
• a detailed site water balance, including a description of site water demands, water disposal methods (inclusive of volume and frequency of any water discharges), water supply infrastructure and water storage structures;	Surface Water Impact Assessment
• an assessment of proposed water discharge quantities and quality/ies against receiving water quality and flow objectives;	Surface Water Impact Assessment
• assessment of impacts of salinity from mining operations on groundwater and surface water resources, including disposal and management of coal rejects and modified hydrogeology, a salinity budget and the evaluation of salt migration to surface, near surface and groundwater sources;	11.8 and Surface Water Impact Assessment
• identification of any licensing requirements or other approvals under the *Water Act 1912* and/or *Water Management Act 2000*;	4.1, 0, 11.3
• demonstration that water for the construction and operation of the development can be obtained from an appropriately authorised and reliable supply in accordance with the operating rules of any relevant Water Sharing Plan (WSP);	surface water report

Table 1: DEPARTMENT OF PLANNING AND INFRASTRUCTURE REQUIREMENTS	
Water Resources	**Addressed in Section**
• a description of the measures proposed to ensure the development can operate in accordance with the requirements of any relevant WSP or water source embargo;	Surface Water Impact Assessment
• a detailed description of the proposed water management system (including sewage), water monitoring program and other measures to mitigate surface and groundwater impacts; and	Surface Water Impact Assessment and 14.0
• compliance with the Hunter River Salinity Trading Scheme;	Surface Water Impact Assessment

Table 2 presents the New South Wales Office of Water (NOW) requirements for the groundwater assessment and the sections that address these requirements.

Table 2: NSW OFFICE OF WATER REQUIREMENTS	
Requirement	**Addressed in Section**
<u>Water licenses to take groundwater</u> The EIS must identify all current and proposed groundwater extraction including details of the purpose and expected annual extraction volumes of all proposed groundwater extraction.	11.0
<u>Water supply works to take groundwater</u> For all water supply works which are proposed to be used for the purpose of taking water from a groundwater source (such as water bores for the purposes of investigation, testing, extraction, dewatering and monitoring), the EIS must provide details regarding purpose, location, construction and expected annual extraction volumes of all such works. The EIS must detail the extent to which the proposed development is consistent with the approval requirements for water supply works prescribed in section 97 of the WMA.	Not applicable – dewatering bores not required
<u>Aquifer interference activities which intercept groundwater</u> For all proposed aquifer interference activities which may intercept groundwater (including activities which involve the penetration of an aquifer (such as excavation), the interference with water in an aquifer, and the taking of water from an aquifer in the course of carrying out mining), the EA must provide details regarding purpose, location, construction and expected annual extraction volumes.	11.0
The EA must also detail the extent to which the proposed project is consistent with the water management principles of the aquifer interference activities prescribed in section 5(8) of the *Water Management Act 2000*.	13.2
<u>Groundwater source protection</u> The EIS must include an assessment of the impact of the proposed development on groundwater sources and provide the following:	
• identification of all groundwater sources which will be intersected or connected;	7.3, 7.4 & 7.5

Table 2: NSW OFFICE OF WATER REQUIREMENTS

Requirement	**Addressed in Section**
• Baseline monitoring of groundwater quality and quantity for all aquifers within and adjacent to the proposed development site (minimum monthly data collected over a minimum time period of two years);	7.2, 7.3.2, 7.3.6, 7.5.2, 7.5.6
• Description of flow directions and rates, physical and chemical characteristics, and highest predicted groundwater table for all aquifers within and adjacent to the proposed development site);	7.3, 7.4, 7.5
• Extent of alluvium within the proposed development site and details on the connectivity of the aquifers to the water courses within the proposed project area and adjacent catchments;	7.3.1, 7.3.2
• Details of any potential works likely to result in pollutants infiltrating into the groundwater;	8.0
• Details of proposed methods of waste water disposal and approval from the relevant authority;	Surface Water Impact Assessment
• Assessment of salinity in catchments downstream of the proposed development;	Surface Water Impact Assessment
• Potential for salt water intrusion;	n/a
• Identification of any groundwater source or aquifer that may be sterilised as a consequence of the proposed development;	n/a
• Detailed description of existing groundwater users within the area, and detailed assessment of any potential impacts on existing users;	7.3.3, 7.5.3
• Details of critical thresholds for negligible impacts to groundwater sources;	11.4, 11.5, 11.6
• Detailed description of any measures to be incorporated into the proposal to avoid or minimise long-term actual and potential environmental impacts, particularly in respect of groundwater pollution;	14.0
• Details of ongoing monitoring programs for groundwater quality and quantity (minimum monthly data);	14.0
• Contingency strategies to remediate, reduce or manage potential impacts, in particular:	
o reporting procedures for ongoing monitoring programs, including mechanism for transfer of information to Office of Water;	14.1
o identification of any nominal thresholds as to the level of impact beyond which remedial measures or contingency strategies would be initiated;	14.0
o detailed description of the remedial measures or contingency strategies proposed; and	14.1
o any funding assurances covering the anticipated post development maintenance cost, for example, ongoing groundwater monitoring.	
• Details of the predicted impacts of the final landform on the groundwater regime, and	11.7
• Details of the extent to which the proposed development is consistent with The NSW State Groundwater Policy Framework Document (1997), The NSW Groundwater Quality Protection Policy (1998), and the Guidelines for Groundwater Protection in Australia (1995).	13.2

Table 2: NSW OFFICE OF WATER REQUIREMENTS	
Requirement	**Addressed in Section**
<u>Groundwater dependent ecosystems</u> GDEs rely on groundwater for their species composition and their natural ecological processes. Examples of ecosystems, which depend on groundwater, are wetlands, terrestrial vegetation such as red gum forests, ecosystems in streams fed by groundwater (gaining streams), limestone cave systems, springs, and hanging valleys and swamps. The EIS should provide the following:	Ecological Impact Assessment and Stygofauna Impact Assessment
• Identification of the potential GDEs within and adjacent to the proposed development site;	as above
• Details of current GDEs condition based on minimum monthly data collected over a minimum time period of two years;	as above
• Details of groundwater quality and quantity requirements for all GDEs based on minimum fortnightly data collected over a minimum time period of two years;	as above
• Details of flora and fauna assessment for all GDEs, including both terrestrial and aquatic (stygofauna, macroinvertebrate and macrophyte) diversity and abundance assessments;	as above
• Detailed assessment of any potential impacts on GDEs;	as above
• Critical thresholds for negligible impacts;	as above
• Detailed description of any measures to be incorporated into the proposal to avoid or minimise adverse impacts on GDEs, including measures to:	as above
o maintain natural patterns of groundwater flow;	as above
o avoid disrupting groundwater levels that are critical for ecosystems;	as above
o avoid pollution or causing adverse changes to groundwater quality; and	as above
o rehabilitate degraded groundwater systems where practical.	as above
• Details of ongoing monitoring and protection programs for potential offset areas	as above
• Contingency strategies to remediate, reduce or manage potential impacts, in particular:	as above
o reporting procedures for ongoing monitoring programs, including mechanism for transfer of information to Office of Water;	as above
o identification of any nominal thresholds as to the level of impact beyond which remedial measures or contingency strategies would be initiated;	as above
o detailed description of the remedial measures or contingency strategies proposed; and;	as above
o any funding assurances covering the anticipated post development maintenance cost, for example, ongoing groundwater monitoring.	as above
o Details to the extent to which the proposal is consistent with the *NSW State Groundwater Dependent Ecosystems Policy (2002)*	as above

Notes – n/a - not applicable

3.2 Project Scope

The objective of the groundwater study was to assess the impact of continuing mining on the hydrogeological regime in terms of the relevant environmental assessment requirements of the Director-General of the Department of Infrastructure and Planning and to meet the applicable government requirements. To achieve this objective, the scope of work included:

- Review of previous hydrogeological studies in the Project area and surrounds;
- Review of groundwater monitoring data before mining commenced and impacts over the mining period;
- Assessment of groundwater behaviour resulting from the Project, including modelling;
    - the cumulative changes in groundwater conditions due to the Project and existing and proposed mining projects;
    - behaviour of groundwater at each identified privately owned licensed bore surrounding the Project area;
    - the level of impact at GDEs;
    - post-mine groundwater conditions;
- Develop groundwater management strategies;
- Identify any groundwater impact mitigation measures necessary for the Project; and
- Identify revisions to the existing groundwater management program.

4.0 LEGISLATION, POLICY AND GUIDELINES

The following section outlines NSW State Government legislation, policy and guidelines with respect to groundwater that must be addressed in the assessment and operation of mining proposals.

4.1 Water Act 1912

The unrepealed parts of the *Water Act 1912* (Water Act), (essentially Parts 2 and 5) govern the issue of water licences for water sources including rivers, lakes and groundwater aquifers in NSW.

The unrepealed parts of the Water Act are progressively being replaced by the *Water Management Act 2000,* but some provisions of the Water Act are still in force where water sharing plans are not in place. This is the case in the bedrock outcrop area where the Project is located.

4.2 Water Management Act 2000

The objectives of the *Water Management Act 2000* include the sustainable and integrated management of the State's water for the benefit of both present and future generations. The *Water Management Act 2000* provides clear arrangements for controlling land based activities that affect the quality and quantity of the State's water resources. It provides relevantly for three types of approvals:

- *Management works approvals:*
  - *water supply work approval;*
  - *drainable work approval; and*
  - *flood work approval (Section 90 Water Management Act 2000)*
- *Water use approval – which authorises the use of water at a specified location for a particular purpose, for up to 10 years (Section 89 Water Management Act 2000);*
- *Activity approvals comprising:*
  - controlled activity approval; and
  - aquifer interference activity approval – which authorises the holder to conduct *activities that affect an aquifer such as approval for activities that intersect groundwater, other than water supply bores and may be issued for up to 10 years (Section 91 Water Management Act 2000).*

The provisions relating to aquifer interface activity approvals have not yet been commenced under the *Water Management Act 2000*. However relevantly to the Project, the Aquifer Inference Policy has been released and the principles within that policy are being assessed against the Project.

The *Water Management Act 2000* requires that the activities avoid or minimise their impact on the water resource and land degradation, and where possible the land must be rehabilitated (see the "Water Management Principles" set out in Section 5 of the *Water Management Act 2000*).

Section 5(8) of the *Water Management Act 2000* outlines the principles in relation to the aquifer interference activities and states *"in relation to aquifer interference activities:*

a) *the carrying out of aquifer interference activities must avoid or minimise land degradation, including soil erosion, compaction, geomorphic instability, contamination, acidity, waterlogging, decline of native vegetation or, where appropriate, salinity and, where possible, land must be rehabilitated, and*

b) *the impacts of the carrying out of aquifer interference activities on other water users must be avoided or minimised."*

The *Water Management Act 2000* also imposes licensing requirements for water sources that are subject to a water sharing plan. Two water sharing plans have commenced for the Hunter River and groundwater sources that surround the Project. Water access licences and approvals to take and use water are granted according to the *Water Management Act 2000*.

4.3 Water Sharing Plans

4.3.1 Hunter Regulated River Water Sharing Plan

The Hunter Regulated River Water Sharing Plan 2003 (HRRWSP) commenced on 1st July 2004 and applies for a period of 10 years to 30 June 2014. It is a legal document made under the WM Act.

The HRRWSP contains rules for how water is shared between the environment and water users and different categories of licences.

The Hunter River water source is located in the central eastern area of NSW and drains an area of some 17,500 km^2. The Hunter River originates in the Mount Royal Range north-east of Scone and travels approximately 450 km to where it enters the ocean at Newcastle. The river is regulated from Glenbawn Dam to Maitland, a distance of about 250 km. Glennies Creek is regulated by Glennies Creek Dam, which also provides water to the lower reaches of the Hunter River. The area to which the WSP applies is shown on Figure 4.1.

The HRRWSP applies to rivers (and associated alluvial sediments) regulated by Glenbawn and Glennies Creek Dams. The water source is divided into three management zones. These are:

- The Hunter River from Glenbawn Dam to its junction with Glennies Creek;
- The Hunter River downstream of its junction with Glennies Creek; and
- Glennies Creek downstream of Glennies Creek Dam.

The Project is located within the first Hunter River management zone listed above; this being the Hunter River from Glenbawn Dam to its junction with Glennies Creek.

The vision for the HRRWSP is to achieve a healthy diverse and productive water source and sustainable management for the community, environment, towns, agriculture and industry. The HRRWSP also recognises the significance of water to the Aboriginal community.

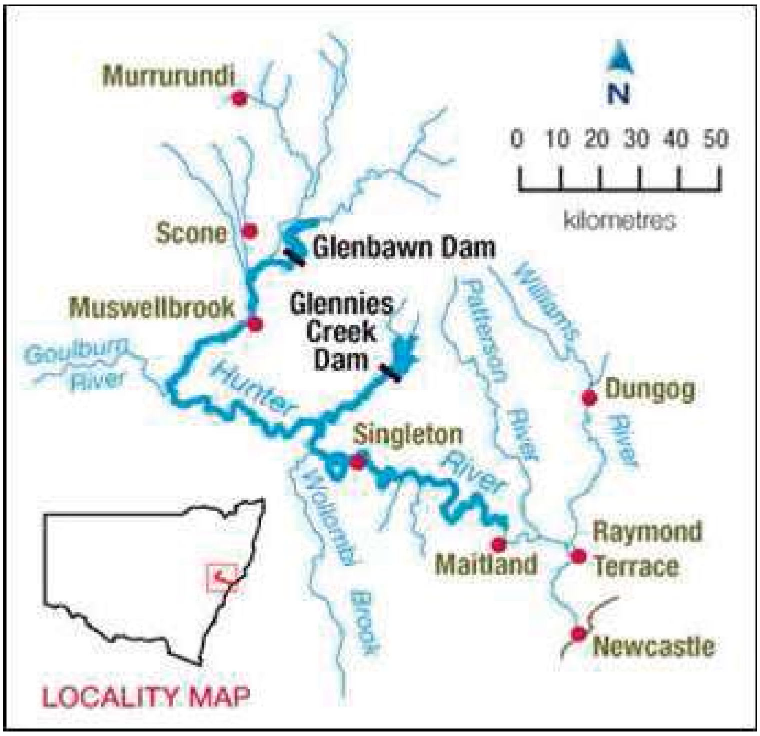


Figure 4.1: Locality Map for the Hunter Regulated River Water Sharing Plan (Source NOW, 2011)

The WM Act requires that the sharing of water must protect the water source and its dependent ecosystems and that water sharing plans establish specific environmental water rules. The environmental water rules are designed to:

- *Reserve all water volume above a specified limit for the environment;*
- *Ensure that flows in the river do not drop below a prescribed minimum flow rate;*
- *Provide water in Glenbawn and Glennies Creek Dams that can be used for water quality and other environmental management purposes; and*
- *Preserve a portion of natural flows during periods when supplementary water access licences are permitted to extract water.*

The HRRWSP provides for domestic and stock rights and native title rights – both forms of basic landholder rights, which allow some extraction of water from the river without an access licence. All water extraction, other than basic landholder rights extractions, must be authorised by an access licence.

4.3.2 Hunter Unregulated and Alluvial Water Sources Water Sharing Plan

The Hunter Unregulated and Alluvial Water Sources Water Sharing Plan (HURAWSP) commenced on 1 August 2009 and applies for a period of 10 years to 31 July 2019. It is a legal document made under the WM Act. Figure 4.2 displays the area to which the HURAWSP applies.

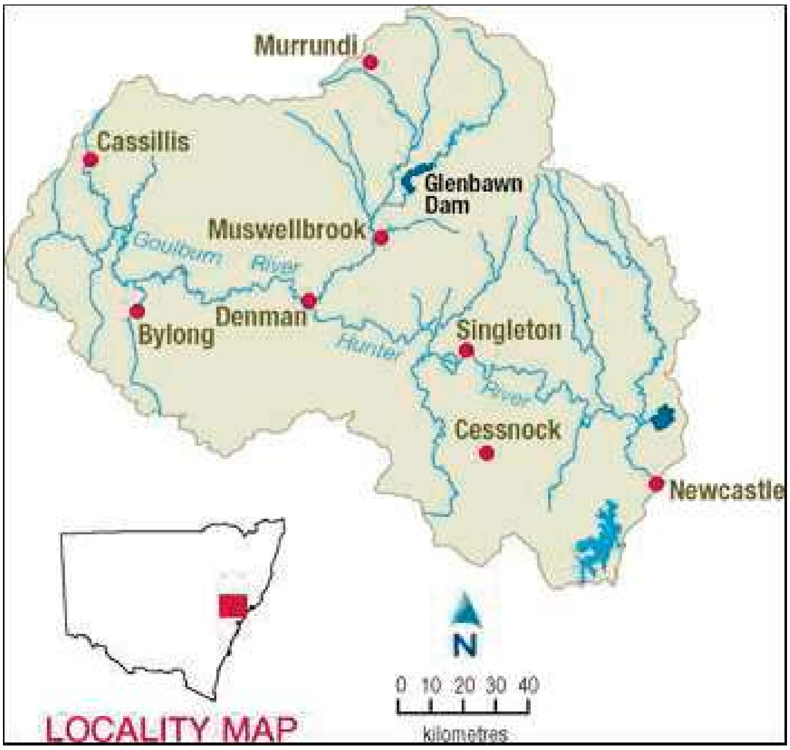


Figure 4.2: Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources (Source NOW, 2011)

Water sharing plans for unregulated rivers and groundwater systems (such as the HURAWSP) have been completed using a "macro" or broader scale river catchment or aquifer system approach. Unregulated rivers are those which rely only on natural flow and are not regulated by releases from upstream dams.

Dry Creek is the closest unregulated stream to the immediate west of the active mining area. Dry creek is a small ephemeral drainage line incised in the Permian hill area that does not have associated mapped alluvium, due to the slope of the creek bed which is well above the water table. Dry Creek forms a 'loosing system" and is not considered to have any significant interaction with the groundwater system. Sandy Creek is a more significant drainage line located about 7 km west of the current mining area.

The HURAWSP set rules for sharing water between the environment and water users and clearly defines shares in available water for licence holders, enabling better water trading opportunities. Water sharing plans support the long-term health of rivers and aquifers by making water available specifically for the environment.

With respect to groundwater, macro water sharing plans for unregulated rivers may include rules that recognise that some alluvial aquifers are highly connected to their parent streams and in these circumstances, the goal of water sharing rules is to manage the surface water and highly connected groundwater as one resource.

A long-term average annual extraction limit referred to as the Extraction Management Unit (EMU) applies across an entire catchment area. The limit is a longer-term management tool against which total extraction will be monitored and managed over the 10-year life of the plan. The rules in the plan that determine when licence holders can and cannot pump on a daily basis are more specific. Basic landholder rights (i.e. extraction of a "reasonable use" volume of surface or groundwater for stock or domestic supply) do not require a water access licence. However, water access licences are required for mining activities where these activities intercept an unregulated river or connected aquifer water.

The HURAWSP includes alluvial sediments not covered by the Hunter Regulated River Water Sharing Plan.

4.4 State Groundwater Policy

The NSW State Government Groundwater Policy Framework Document (1997) was adopted in 1997 for the purpose of providing a framework for the management of the State's groundwater resources to sustain their environmental, social and economic uses. The policy has three parts, namely the:

- NSW Government (1998a) Groundwater Quality Protection Policy, adopted in December 1998;
- NSW Government (2002) State Groundwater Dependent Ecosystems Policy, adopted in 2002; and
- NSW Government (undated) Groundwater Quantity Management Policy advice.

4.4.1 Groundwater Quality Protection Policy

The NSW Groundwater Quality Protection Policy (1998), states that the objectives of the policy will be achieved by applying the management principles listed below.

- *All groundwater systems should be managed such that their most sensitive identified beneficial use (or environmental value) is maintained.*
- *Town water supplies should be afforded special protection against contamination.*
- *Groundwater pollution should be prevented so that future remediation is not required.*
- *For new developments, the scale and scope of work required to demonstrate adequate groundwater protection shall be commensurate with the risk the development poses to a groundwater system and the value of the groundwater resource.*
- *A groundwater pumper shall bear the responsibility for environmental damage or degradation caused by using groundwaters that are incompatible with soil, vegetation and receiving waters.*
- *Groundwater dependent ecosystems will be afforded protection.*
- *Groundwater quality protection should be integrated with the management of groundwater quality.*
- *The cumulative impacts of developments on groundwater quality should be recognised by all those who manage, use, or impact on the resource.*
- *Where possible and practical, environmentally degraded areas should be rehabilitated and their ecosystem support functions restored.*

4.4.2 Groundwater Dependent Ecosystems Policy

The NSW Groundwater Dependent Ecosystems Policy is specifically designed to protect valuable ecosystems which rely on groundwater for survival so that, wherever possible, the ecological processes and biodiversity of these dependent ecosystems are maintained or restored for the benefit of present and future generations. The policy defines GDEs as *"communities of plants, animals and other organisms whose extent and life processes are dependent on groundwater".*

Five management principles establish a framework by which groundwater is managed in ways that ensure, whenever possible, that ecological processes in dependent ecosystems are maintained or restored. The principles are:

- *GDEs can have important values. Threats should be identified and action taken to protect them;*
- *Groundwater extractions should be managed within the sustainable yield of aquifers;*
- *Priority should be given to GDEs, such that sufficient groundwater is available at all times to meet their needs;*
- *Where scientific knowledge is lacking, the precautionary principle should be applied to protect GDEs; and*
- *Planning, approval and management of developments should aim to minimise adverse effects on groundwater by maintaining natural patterns, not polluting or causing changes to groundwater quality and rehabilitating degraded groundwater ecosystems where necessary.*

4.4.3 Groundwater Quantity Protection Policy

The objectives of managing groundwater quantity in NSW are:

- *To achieve the efficient, equitable and sustainable use of the State's groundwater;*
- *To prevent, halt and reverse degradation of the State's groundwater and their dependent ecosystems;*
- *To provide opportunities for development which generate the most cultural, social and economic benefits to the community, region, state and nation, within the context of environmental sustainability; and*
- *To involve the community in the management of groundwater resources.*

4.4.4 NSW Aquifer Interference Policy

The Aquifer Interference Policy forms the basis for assessment of aquifer interference activities under the EPA Act. It clarifies the need to hold water access licences or Water licences (as the case may be) under the WM Act and Water Act and establishes consideration in assessing whether 'minimal impact' occurs.

The assessment criteria in the AI Policy are required to be addressed in the EIS because the DGRs require assessment of the Strategic Regional Land Use Policy which assessment criteria include assessment of the criteria in the AI Policy.

The WM Act defines an aquifer interference activity as that which involves any of the following:

- penetration of an aquifer;
- interference with water in an aquifer;
- obstruction of the flow of water in an aquifer;
- taking of water from an aquifer in the course of carrying out mining or any other activity prescribed by the regulations; and
- disposal of water taken from an aquifer in the course of carrying out mining or any other activity prescribed by the regulations.

Examples of aquifer interference activities (NOW 2012b) include mining, coal seam gas extraction, injection of water, and commercial, industrial, agricultural and residential activities that intercept the water table or interfere with aquifers.

According to the WM Act, an aquifer is defined as a geological structure or formation, or an artificial landfill, that is permeated with water or is capable of being permeated with water. This is at odds with the commonly used definition, which refers to an aquifer as a groundwater system that is sufficiently permeable to yield productive volumes of groundwater. The definition of aquifer provided by the WM Act is more consistent with the term groundwater system, which refers to any type of saturated geological formation that can yield low to high volumes of water.

The Policy states that "*all water taken by aquifer interference activities, regardless of quality, needs to be accounted for within the extraction limits defined by the water sharing plans. A water licence is required under the WM Act (unless an exemption applies or water is being taken under a basic landholder right) where any act by a person carrying out an aquifer interference activity causes:*

- *the removal of water from a water source; or*
- *the movement of water from one part of an aquifer to another part of an aquifer; or*
- *the movement of water from one water source to another water source, such as:*
    - *from an aquifer to an adjacent aquifer; or*
    - *from an aquifer to a river/lake; or*
    - *from a river/lake to an aquifer."*

The Aquifer Interference Policy requires assessment of the likely volume of water taken from a water source(s) as a result of an aquifer interference activity. These predictions need to occur prior to project approval. After project approval and during operations these volumes need to be measured and reported in annual environmental management reports (AEMR). The water access licence must hold sufficient share component and water allocation to account for the take of water from the relevant water source at all times.

The AI Policy states that a water licence is required for the aquifer interference activity regardless of whether water is taken directly for consumptive use or incidentally. Activities may induce flow from adjacent groundwater sources or connected surface water. Flows induced from other water sources also constitute take of water. In all cases, separate access licences are required to account for the take from all individual water sources.

In water sources where water sharing plans do not yet apply, an aquifer interference activity that takes groundwater is required to hold a water licence under the Water Act 1912. It is possible for the *Water Act 1912* to apply in a groundwater source and the WM Act to apply in a connected surface water source or vice versa. Where this occurs and the aquifer interference activity is taking water from both water sources then licences will be required under each Act.

In addition to the volumetric water licensing considerations, the following information needs to be considered to enable assessment and approval of the activity:

- establishment of baseline groundwater conditions including groundwater depth, quality and flow based on sampling of all existing bores in the area;
- a strategy for complying with any water access rules applying to relevant categories of water access licences, as specified in relevant water sharing plans;
- details of potential water level, quality or pressure drawdown impacts on nearby water users who are exercising their right to take water under a basic landholder right;
- details of potential water level, quality or pressure drawdown impacts on nearby licensed water users in connected groundwater and surface water sources;
- details of potential water level, quality or pressure drawdown impacts on groundwater dependent ecosystems;
- details of potential for increased saline or contaminated water inflows to aquifers and highly connected river systems;
- details of the potential to cause or enhance hydraulic connection between aquifers;
- details of the potential for river bank instability, or highwall instability or failure to occur.

In particular, the Policy describes minimal impact considerations for aquifer interference activities based upon whether the water source is highly productive or less productive and whether the water source is alluvial or porous / fractured rock in nature. In general, the policy applies a predicted 2 m drawdown maximum limit at existing groundwater users.

The NOWs assessment of impacts and subsequent advice and proposed conditions of approval for a project is based on an "*account for, mitigate, avoid/ prevent, and remediate*" approach. NOWs methodology is based on "*a risk management approach to assessing the potential impacts of aquifer interference activities, where the level of detail required to be provided by the proponent is proportional to a combination of the likelihood of impacts occurring on water sources, users and dependent ecosystems and the potential consequences of these impacts*."

The AI Policy divides groundwater sources into "highly productive" and "less productive". Highly productive groundwater is defined by the AI Policy as a groundwater source that is declared in the Regulations and will be based on the following criteria:

a) has total dissolved solids of less than 1,500 mg/L, and
b) contains water supply works that can yield water at a rate greater than 5 L/sec. Highly productive groundwater sources are further grouped by geology into alluvial, coastal sands, porous rock, and fractured rock. "Less productive" groundwater includes aquifers that cannot be defined as "highly productive" according the yield and water quality criteria.

The Hunter River alluvium adjacent to the Project has been assessed and determined to satisfy the “highly productive” criteria, while the Permian coal measures are “less productive” porous rock. The aquifer interference policy defines the following Minimal Impact Considerations for “highly productive” and less productive groundwater. Table 3 summaries the Minimal Impact Considerations for the “highly productive” Hunter River alluvium, and the “less productive” Permian coal measures. If these considerations are not met the Project needs to demonstrate to the Minister’s satisfaction that the impact will be sustainable, or that “make good agreements” are in place.

The following sections outline the Project’s compliance with the “Minimal Impact Considerations”:

- Water Table - Sections 11.2, 11.4, 11.5, 11.6 and 11.8;
- Water Pressure - Sections 11.2, 11.5, 11.6 and 11.8; and
- Water Quality - Section 11.8.

4.5 Aquifer Risk Categories

In mid-1997, the NSW Government announced a series of water reforms which included an assessment of the State’s groundwater systems in terms of risk of over extraction and/or contamination. Water bearing formations at high risk were to have priority management attention with groundwater management plans started immediately. Those at medium risk were to have plans prepared over a five-year period. Those in the low risk category were to be regularly reviewed and steps taken to prevent them from becoming stressed.

The ultimate aim of the reforms was to achieve clean and healthy groundwater systems (and rivers) and productive use of water by providing:

- Better balance in sharing water between the environment and water users;
- Better clarity of access and use rights for water; and
- A water transfer market that will facilitate reallocation of water to its highest valued use.

The NSW Government Aquifer Risk Assessment Report (1998b) used a number of criteria to classify risks to various significant groundwater resources across the State. It classified the regulated reaches of the Hunter Valley Alluvium as a ‘High Risk Aquifer’, the Hunter Miscellaneous Tributaries Alluvium as ‘Medium Risk Aquifers’, and the Hunter Coal-Associated Fractured Rocks as ‘Low Risk Aquifers’.

The classification process was designed as a rapid desktop assessment of the (then) current and potential future stress of groundwater systems. The reported findings were designed to aid resource planning and prioritisation of action for aquifers across NSW.

4.6 Buffer Zone Guidelines

Guidelines were prepared for the Hunter Region in April 2005, by the Department of Infrastructure, Planning and Natural Resources (DIPNR 2005) (now the Department of Planning and Infrastructure) to assist the coal mining industry in managing risks when mining close to streams using either longwall or open cut mining methods. The guidelines relate to the classification of the stream that may be impacted by mining.

Table 3: SUMMARY MINIMAL IMPACT CONSIDERATIONS – AQUIFER INTERFERENCE POLICY

Category	1. Water Table	Water Pressure	Water Quality
Highly productive alluvium – Hunter River Alluvium	1. Less than or equal to a 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" variations, 40 m from any: (a) high priority groundwater dependent ecosystem; or (b) high priority culturally significant site; listed in the schedule of the relevant water sharing plan; or A maximum of a 2 m decline cumulatively at any water supply work.	1. A cumulative pressure head decline of not more than 40% of the "post-water sharing plan" pressure head above the base of the water source to a maximum of a 2 m decline, at any water supply work.	1. (a) Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity; and (b) No increase of more than 1% per activity in long-term average salinity in a highly connected surface water source at the nearest point to the activity. Redesign of a highly connected(3) surface water source that is defined as a "reliable water supply"(4) is not an appropriate mitigation measure to meet considerations 1.(a) and 1.(b) above. (c) No mining activity to be below the natural ground surface within 200 m laterally from the top of high bank or 100 m vertically beneath (or the three dimensional extent of the alluvial water source - whichever is the lesser distance) of a highly connected surface water source that is defined as a "reliable water supply". (d) Not more than 10% cumulatively of the three dimensional extent of the alluvial material in this water source to be excavated by mining activities beyond 200 m laterally from the top of high bank and 100 m vertically beneath a highly connected surface water source that is defined as a "reliable water supply"
Less productive porous rock – Permian Coal Measures		A cumulative pressure head decline of not more than a 2m decline, at any water supply work.	Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity.

The guidelines provide a range of assessment and management criteria for each stream classification. This range is developed on the basis of:

- *A checklist for minor stream systems (Schedule 1) with monitoring and remediation procedures to minimise the extent of damage which occurs to them;*
- *A notification system for significant stream systems (Schedule 2) to the department, so that an agreed monitoring and management regime can be developed for the stream system involved; and*
- *A precautionary stance for primary rivers (Schedule 3), subject to environmental assessment which can demonstrate that the impact on those rivers and associated alluvial groundwaters can be minimised.*

Based on the management guidelines, the Hunter River system is classified as a Schedule 3 stream/river. The guideline document indicates that the NOW is adopting a precautionary approach to mining in the vicinity of Schedule 3 streams and associated alluvial groundwater, involving a buffer between the mining area and the stream. The guideline states that "*the buffer provides a front line protection for surface and groundwater quality and managing connectivity*".

The management guideline requires a buffer of 150 m between an open cut mining area and the stream and its related alluvium, as shown on Figure 4.3. The guideline states that "*this buffer should be used except where detailed assessment, developed to the department standard, indicates minimal likely impact on stream flow, stability or water quality in surface or groundwaters will occur*".

The management guidelines indicate that mining would not be allowed to impact the groundwater or surface waters of the Hunter River and that a buffer would be required between open cut mines and the alluvium.

Based on the April 2005 guideline and Schedule 3 stream classification for the Hunter River, it is assessed that open cut mining will not be permitted within the Hunter River alluvial plain. Figure 2.2 illustrates that the Project will not encroach within 150 m of the Hunter River alluvial plain.

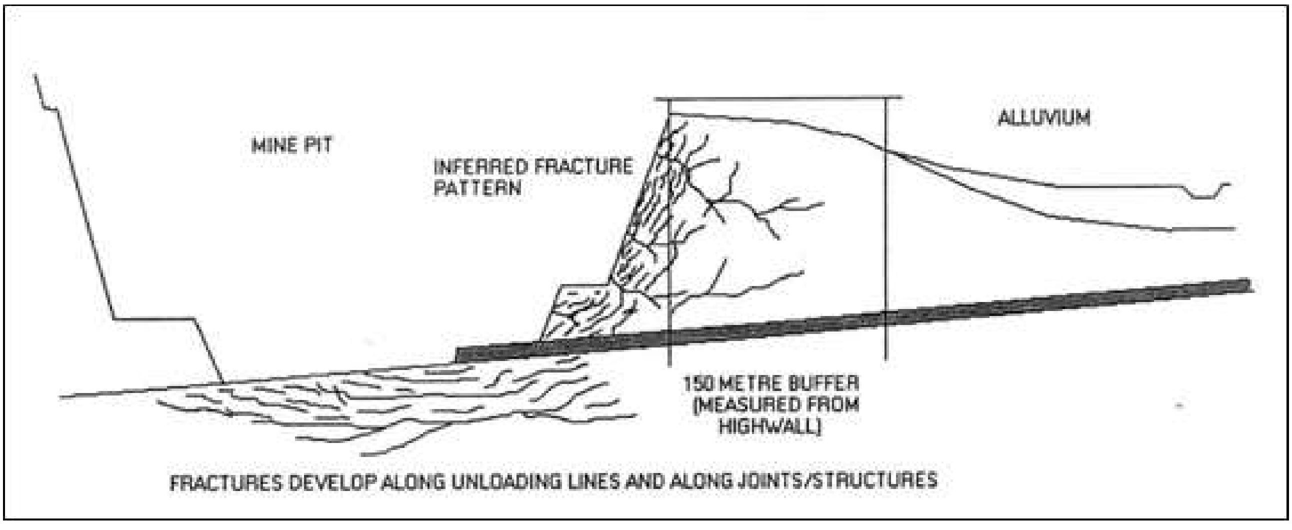


Figure 4.3: Buffer Zone Requirement for Open Cut Mining Operations Next to Rivers / Alluvium

Source: DIPNR Hunter Region, 2005

5.0 REGIONAL SETTING

5.1 Project Location

Bengalla is located south of Wybong Road, east of Roxburgh Road, north of the Hunter River and west of Muswellbrook. The Project Boundary covers an area of approximately 2,340 ha.

Bengalla is in close proximity to a number of existing and proposed coal mines as shown on Figure 5.1. The existing Mt Arthur Coal Mine (MAC) is located on the southern side of the Hunter River. Currently approval is being sought for an Extension to the MAC open pit.

Drayton Mine is located adjacent to the MAC operations to the east. Currently approval is being sought for the Drayton South mine located to the south of the MAC operations.

The Dartbrook Underground Mine is located to the far north of Bengalla however is currently in a care and maintenance.

Located immediately north of Bengalla is Coal & Allied's approved Mount Pleasant Project. The Mount Pleasant Project physically commenced in 2004 with the construction of Environmental Dam 1; however, no additional construction or coal mining has occurred.

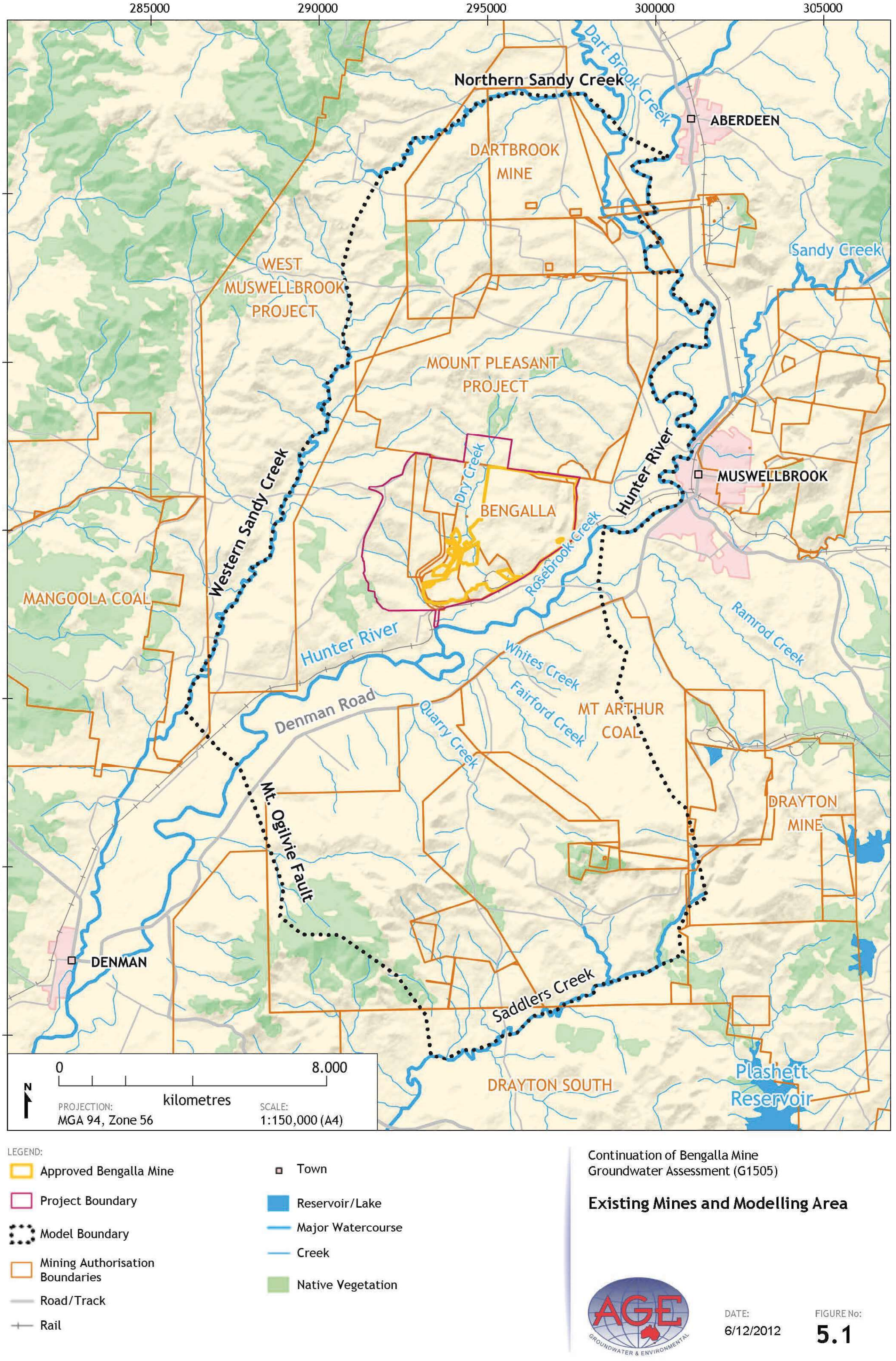
The Xstrata Mangoola Coal Mine to the west of Bengalla commenced mining operations in late 2010.

5.2 Climate

The climate of the region is temperate and characterised by hot summers and mild dry winters. Climate monitoring data collected by the Bureau of Meteorology (BoM)[1] is available for Jerrys Plains (Station No. 061086) located about 9 km to the south-east of Project, and Scone (Station No. 061089) which is about 40 km north of the Project. Mean monthly temperatures and rainfall are available from the Jerrys Plains Station for the period 1884 to 2011. The closest weather station to the Project recording evaporation is located at the township of Scone.

The mean maximum temperatures at Jerrys Plains range from 31.7°C in January to 17.4°C in July. Mean minimum temperatures range from 17.1°C in January and February to 3.8°C in July. Heat waves can occur between October and March and frosts between May and August. The average annual rainfall at Jerrys Plains is 644.7 millimetres (mm), of which the majority falls in the warmer months of the year (November to February), with January being the wettest month (77 mm). Mean daily pan evaporation in the summer season reaches 7.1 mm in December and January, and 1.6 mm in June. Average daily evaporation of 4.4 mm/day (1606 mm/year) exceeds mean rainfall throughout the year, the highest moisture deficit occurring during summer.

[1] http://www.bom.gov.au/climate/data/weather-data.shtml


285000
290000
295000
300000
305000
6437000
6432000
6427000
6422000
6417000
6412000
Northern Sandy Creek
Dart Brook Creek
ABERDEEN
DARTBROOK MINE
Sandy Creek
WEST MUSWELLBROOK PROJECT
MOUNT PLEASANT PROJECT
Dry Creek
BENGALLA
Hunter River
MUSWELLBROOK
Western Sandy Creek
Rosebrook Creek
MANGOOLA COAL
Ramrod Creek
Hunter River
Whites Creek
Fairford Creek
MT ARTHUR COAL
Denman Road
Quarry Creek
DRAYTON MINE
Mt. Ogilvie Fault
DENMAN
Saddlers Creek
DRAYTON SOUTH
Plashett Reservoir
0
8.000
kilometres
N
PROJECTION:
MGA 94, Zone 56
SCALE:
1:150,000 (A4)
LEGEND:
Approved Bengalla Mine
Project Boundary
Model Boundary
Mining Authorisation Boundaries
Road/Track
Rail
Town
Reservoir/Lake
Major Watercourse
Creek
Native Vegetation
Continuation of Bengalla Mine
Groundwater Assessment (G1505)
Existing Mines and Modelling Area
AGE
GROUNDWATER & ENVIRONMENTAL
DATE:
6/12/2012
FIGURE No:
5.1

In order to place recent rainfall years into a historical context the Cumulative Rainfall Departure (CRD), which is a summation of the monthly departures of rainfall from the long-term average monthly rainfall, was calculated as follows:

$$CRDn = CRDn\text{-}1 + (Rn - Rav)$$

Where:	*CRDn*	=	CRD for a given month
	CRDn-1	=	CRD for a preceding month
	Rav	=	long-term average rainfall for a given month
	Rn	=	actual rainfall for given month

The average monthly rainfall used to produce the CRD graph shown on Figure 5.2 was obtained from the BoM, Jerrys Plains Station.

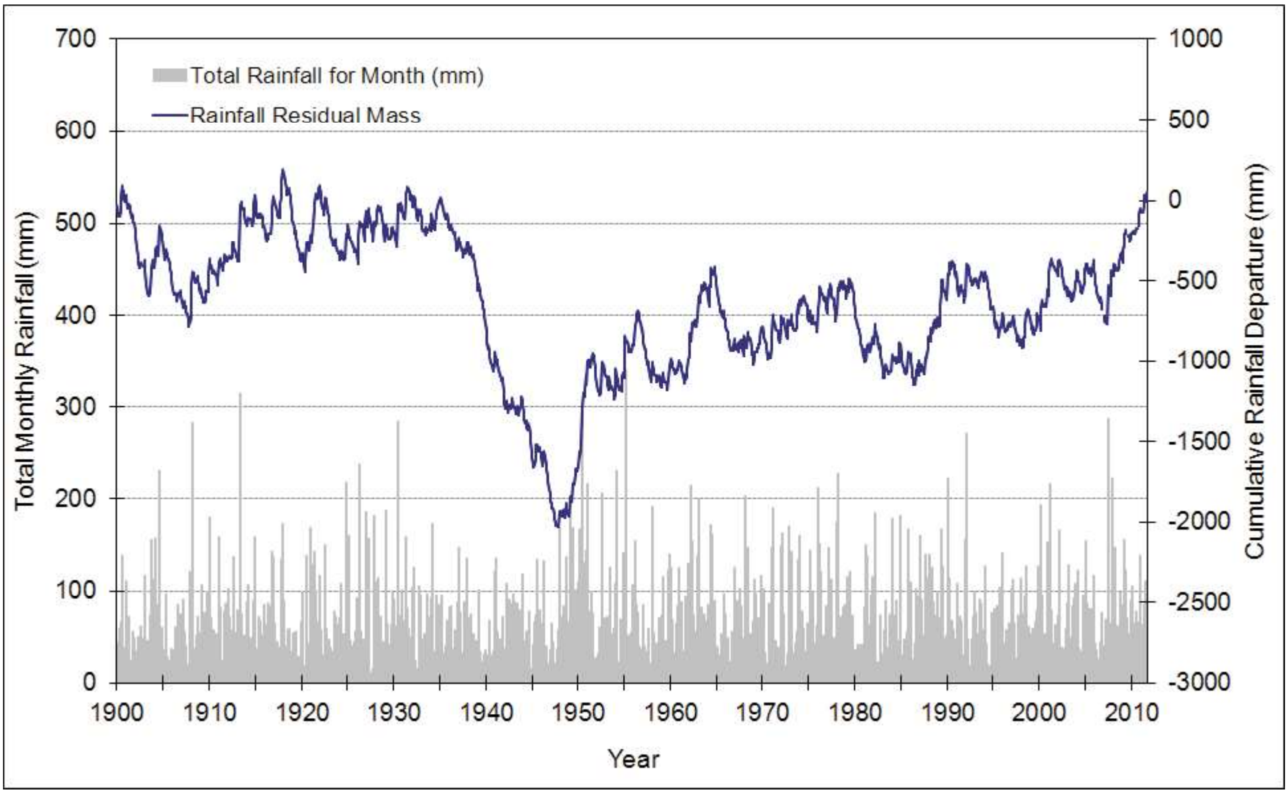


Figure 5.2: Cumulative Rainfall Departure – Jerrys Plains (Station No. 061086)

A positive slope in the CRD plot indicates periods of above average rainfall, whilst a negative slope indicates periods when rainfall is below average. The CRD indicates that the area has been generally experiencing above average rainfall since 2007.

5.3 Topography and Drainage

The topography within the Project Boundary consists generally of low and undulating hills that decline towards the Hunter River floodplain in the south. The topographic elevation varies from about RL 135 m at the Hunter River flood plain, to about RL 225m at the highest areas at the northern part of Bengalla. The mining area for the Project is split into two areas of high ground by an ephemeral gully known as Dry Creek that runs in a general north–south orientation through the central part of the Project Boundary.

Figure 5.1 shows the locations of water courses surrounding the Project which are:

- Hunter River which is located adjacent to of the Project Boundary and flows in a north-east to south-westerly direction;
- Dry creek, an ephemeral tributary of the Hunter River running through the Project area that will be diverted and reinstated as part of the Project;
- Rosebrook Creek located about 1 km to 2 km to the east of the Project Boundary;
- Dartbrook Creek to the north which flows in a north-south direction parallel to the Hunter River;
- Sandy Creek (northern Sandy Creek) also located to the north and flows west-east; and
- Sandy Creek (western Sandy Creek) located 4 km west of the Project area and flows in north-south direction towards the Hunter River.

South of the Hunter River, the main tributaries are Ramrod Creek, Whites Creek, and Quarry Creek. Saddlers Creek is located 8 km south of the Hunter River. All the creeks are ephemeral except the Hunter River that has the flow maintained by releases from the upstream Glenbawn Dam.

Several water storage dams have also been constructed within the Project area to manage both clean and mine water at Bengalla. Figure 5.3 below provides an overview of the regional setting.

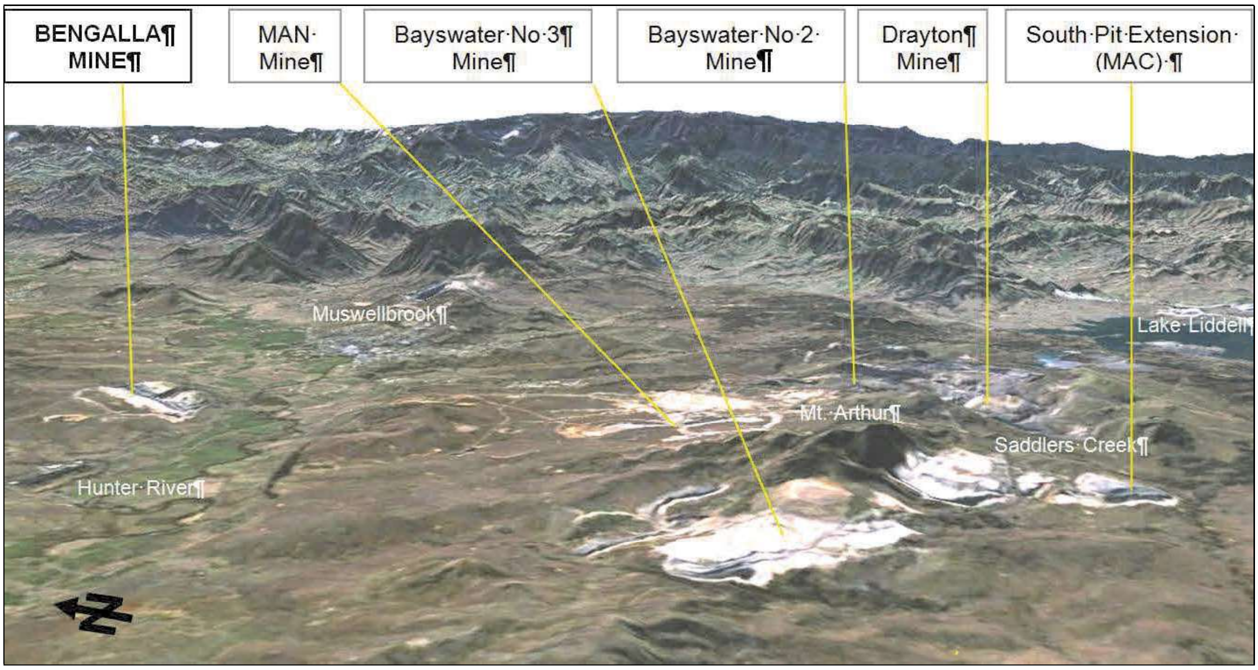


Figure 5.3: Overview of the Vicinity of the Project Area (Landsat 7 satellite imagery)

5.4 Land Uses

The hilly areas surrounding Bengalla are mainly used for cattle grazing while the rich alluvial floodplain of the Hunter River to the south and east of the Project Boundary, support a variety of agricultural land uses including dairy and beef cattle grazing on improved pastures, fodder cropping, horse breeding and training and viticulture. Coal mining is also an important land-use, being the largest land owner in the vicinity of the Project.

6.0 GEOLOGY

6.1 Stratigraphy

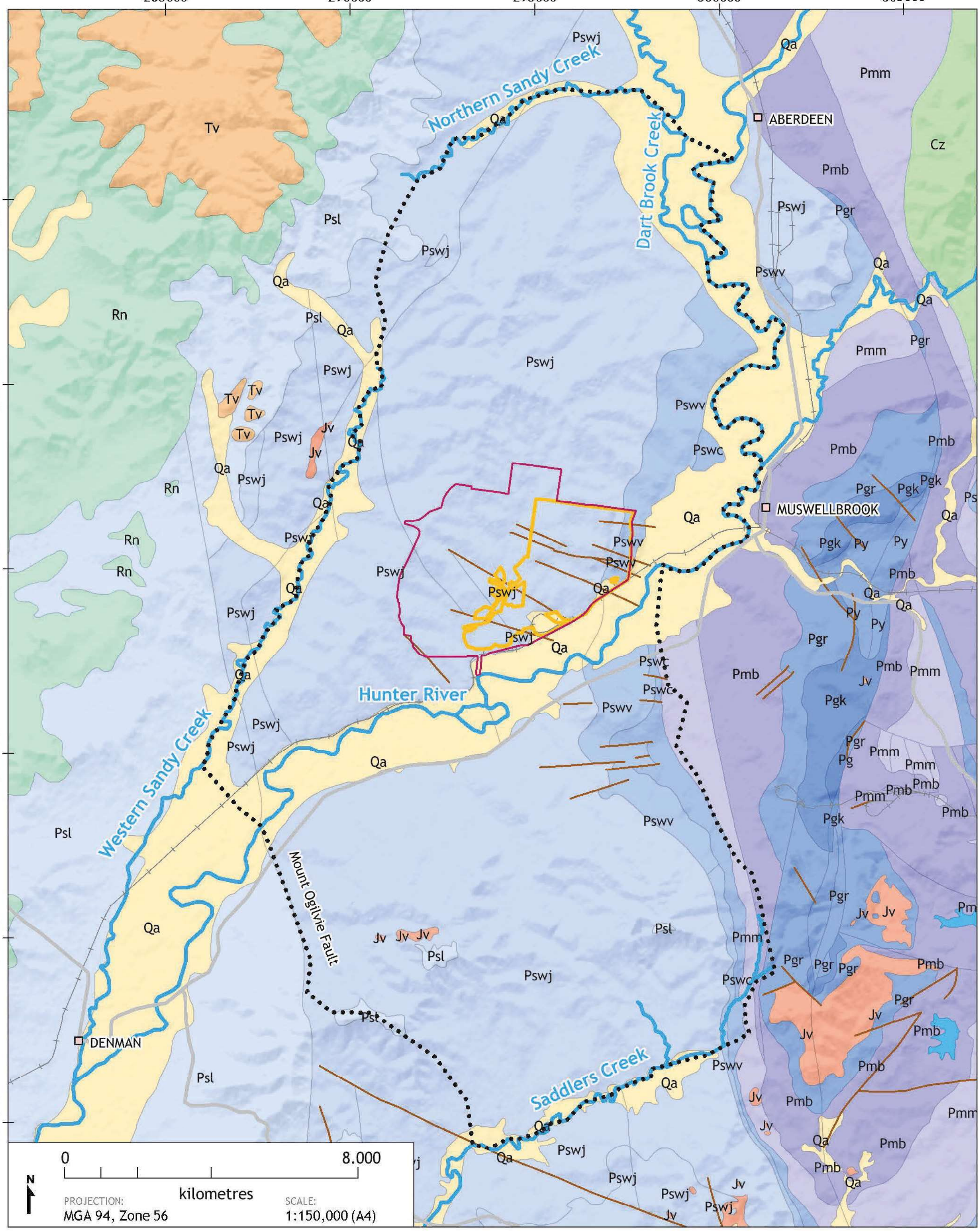
The stratigraphic sequence across the site comprises three distinct units, namely a Permian coal seam sequence, overburden and interburden consisting of lithic sandstone, interbedded with siltstone, tuffaceous claystone and mudstone and thin alluvial cover. The Permian sediments are unconformably overlain by thin Quaternary alluvial deposits. The Quaternary alluvial deposits consist of sand and gravel along the creek valleys within the Project Boundary, and in the alluvial floodplain of the Hunter River to the south and east. Figure 6.1 shows the surface geology in the vicinity of the Project.

The Permian rocks form a regular layered sedimentary sequence consisting of the Whittingham Coal Measures that contain the economic coal seams and underlie the whole of the Project Boundary to a depth of about 500 m. Figure 6.2 shows the indicative stratigraphy of the Project Boundary.

The Project will mine coal seams within the Jerrys Plains and Vane Subgroups, which are part of the Whittingham Coal Measures. The Warkworth Seam to the Edderton Seam are currently mined by the approved operations at Bengalla and will continue to be mined as part of the Project. Table 4 summarises the average seams and interburden thicknesses occurring in the Project area. The thickness of the seams and interburden is based on information received from BMC while the information for the lower seams is taken from AGE (2006). The total thickness of the coal measures and interburden is approximately 150 m.

Table 4: COAL SEAMS WITHIN THE PROJECT BOUNDARY

	Seam Name	Average Thickness (m)	Average Thickness of Interburden to Underlying Seam (m)
Project Coal Seams	Warkworth Upper	0.5	<0.1
	Warkworth Lower	1.0	35
	Mount Arthur	4.5	5
	Unnamed	< 1.0	10
	Piercefield	2.3	26
	Vaux	4.0	20
	Broonie	1.3	13
	Bayswater	2.5	10
	Wynn	<1.0	5
	Unnamed	1.0	5
	Edderton	2.0	10
	Clanricard	1.8	10
	Bengalla	2.5	10
	Edinglassie	3.9	30
	Ramrod Creek	6.5	-



LEGEND:

100K Geology

- Qa - Quaternary Alluvium
- Tv - Tertiary Basalt
- Rn - Hawkesbury Sandstone, Narrabeen G.
- Jv - Jurassic Volcanics
- Psl - Wollombi Coal Measures
- Pswj - Denman F., Jerrys Plains Subgroup
- Pswv - Archerfield Ss., Vane Subgroup
- Pswc - Saltwater Creek Formation
- Pmm - Mulbring Siltstone
- Pms - Muree Sandstone
- Pmb - Branxton Formation
- Pgr - Greta Coal Measures
- Pgk - Greta Coal Measures
- Cz - Tuff and Ignimbrite
- Water

Approved Bengalla Mine

Project Boundary

Model Boundary

Fault

Town

Road

Rail

Major Water-course

Geology based on 1:100,000 Hunter Coalfield Regional Geology

Continuation of Bengalla Mine Groundwater Assessment (G1505)

Geology

DATE: 6/12/2012

FIGURE No: **6.1**

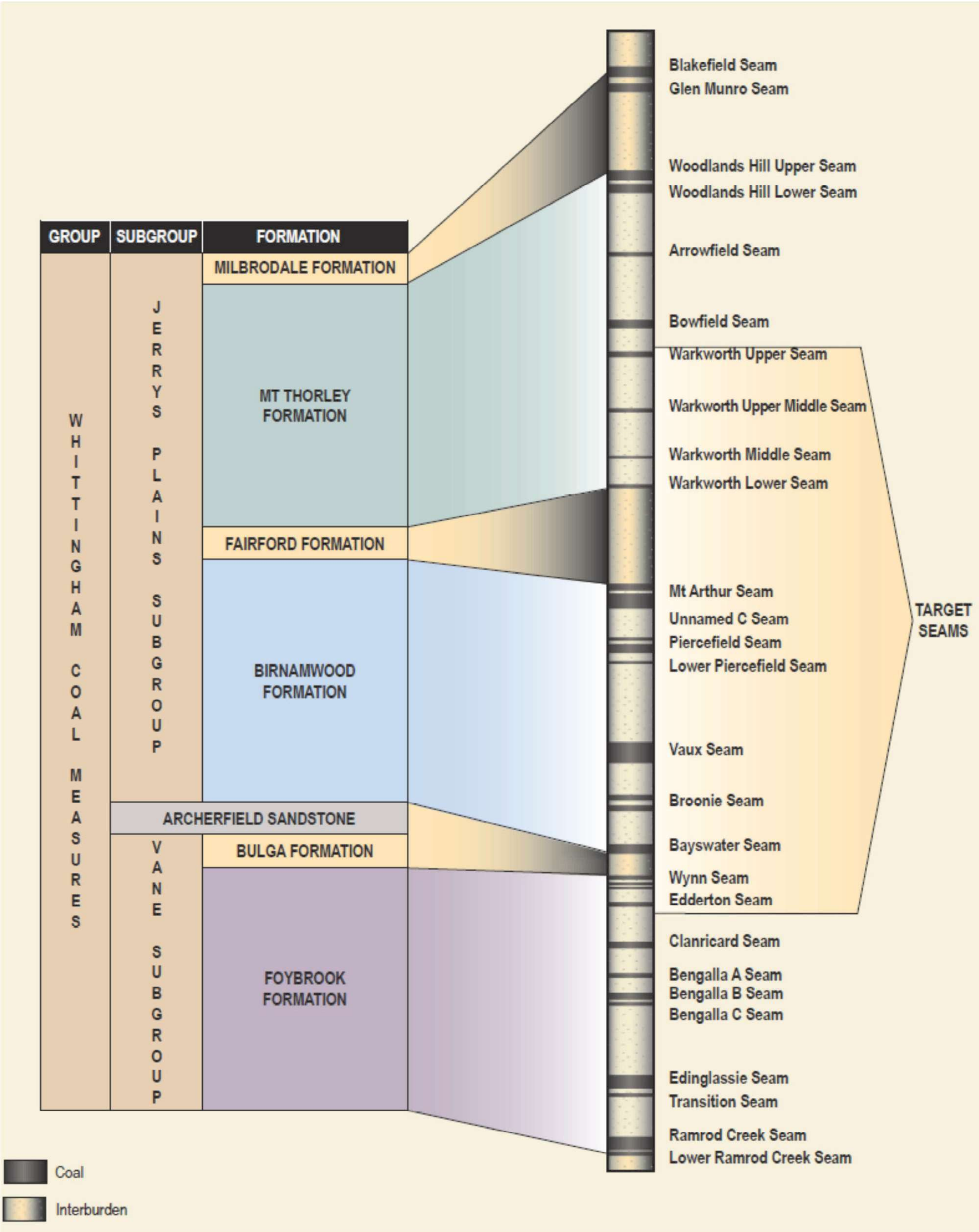


Figure 6.2: Indicative Stratigraphic Column (seams mined at Bengalla highlighted)

6.2 Structures

The Project is located to the west of the Muswellbrook Anticline where the mined seams outcrop. The Whittingham Coal Measures are generally gently dipping at about 5° to the west. All coal seams subcrop beneath the Quaternary deposits of the Hunter River south of the Project Boundary.

The north-south striking Mount Ogilvie Fault forms a structural boundary of the Project to the west. Minor faults with an approximate east-west strike and dykes running in a north-south direction are present in the Project Boundary. Figure 6.3 shows a dyke within a coal seam in the Bengalla pit wall while Figure 6.1 shows the orientation of the main structural features in the Project area.

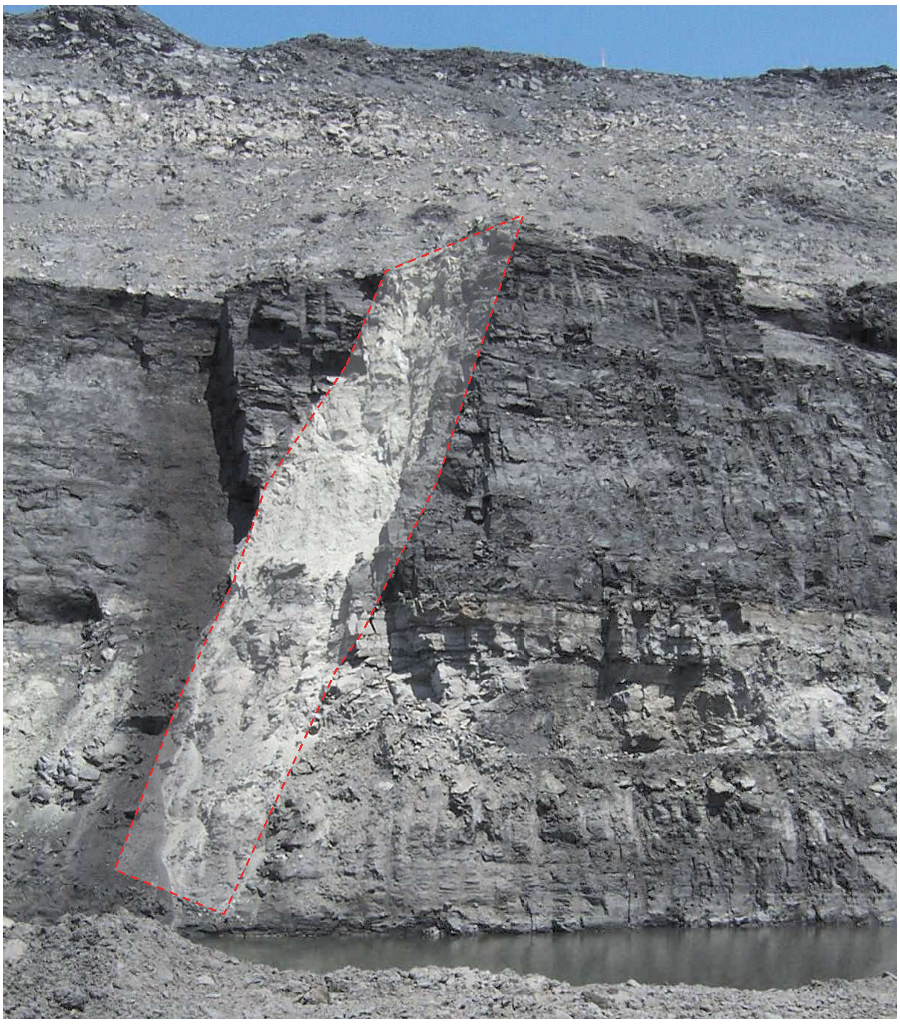


Figure 6.3: Dyke Intruding Coal Seam at Bengalla

7.0 HYDROGEOLOGICAL REGIME

7.1 Previous Hydrogeological Studies

Groundwater studies in the region commenced in the late 1970s primarily for development of the adjacent MAC. Australian Groundwater Consultants Pty Ltd (AGC,1979) investigated the area for the Electricity Commission of NSW. The investigation included undertaking:

- Packer testing at 10.5 m intervals up to 216 m deep;
- Three falling head tests to obtain comparative hydraulic conductivity data; and
- Two airlift/recovery type hydraulic tests.

The objective of the investigation was to obtain data on the hydraulic characteristics of the stratigraphic profile to assess groundwater inflow to a 2 km long, shallow, strip mining operation at the neighbouring MAC. The seams of interest were the Vaux, Bayswater, Edinglassie and Ramrod Creek coal seams, of which the upper two are mined at Bengalla.

In August 1980, AGC investigated the Whittingham Coal Measures and the Hunter River alluvium for the MAC Coal Project, south of Hunter River and Bengalla. Laurie Montgomerie and Pettit Pty Ltd (LM&P) undertook a groundwater investigation for the same project in 1982 publishing long term pumping test data.

Mackie Martin & Associates (MMA) undertook a groundwater study for Bengalla in January 1993 as part of an EIS prepared by HLA-Envirosciences Pty Limited (1993). The study included a review of existing information, field investigations, groundwater monitoring, sampling and analysis, and the development of a groundwater model, to assess the impact of open cut strip mining on the groundwater regime.

In 2000, Mackie Environmental Research (MER) conducted water management studies for the Dartbrook and MAC Mines and assessed the impact of the mines on the groundwater system.

Additionally AGE completed a hydrogeological impact assessment on the South Pit Extension Project for MAC in 2006, which included the cumulative impact with MAC and an analysis of the potential impacts on the Saddlers Creek colluvium. MAC operates within the Whittingham Coal Measures as does Bengalla, thus useful data can be obtained from this study regarding issues such as groundwater recharge estimates, interburden and coal seam permeability and regional structural settings.

AGE (2007) undertook a groundwater study to assess the impact of extending mining into the Wantana area as part of an application to modify the Bengalla development consent. The assessment included a FEFLOW three-dimensional, transient, groundwater flow model of the study area to simulate the impact of the Project on the groundwater regime. The calibrated model simulated Bengalla/Wantana Pit inflows rates, drawdown effects in both the Permian groundwater system and Hunter River alluvial aquifer, changes in flows from the Hunter River alluvium and recovery of water levels in the final void level. Predicted pit inflows ranged from 0.43 ML/day in 2007 to 0.32 ML/day in 2017, with a peak of 0.58 ML/day in 2012. Additional inflows to the Wantana Extension did not exceed 0.13 ML/day. The study noted that groundwater flow to the Hunter River alluvium are reduced by 0.5 ML/day during 2012 and increased to a 0.6 ML/day reduction in 2017. Final pit lake recovery modelling simulated a final steady pit lake level about 62m AHD, with this final steady level reached after more than 200 years. The final void was noted to act in the long term as a sink from the local groundwater environment.

AGE (2010) included a groundwater impact assessment as part of the Bengalla Development Consent Modification to assess the effects from accelerated mining operations in the Wantana Extension area, extension of the existing OEA and relocation of the already approved OEA. This scope of works included stratigraphic drilling, monitoring bore construction and 2D modelling using SEEPW and water quality analysis.

7.2 Groundwater Monitoring Program

7.2.1 Monitoring Bore Network

BMC began establishing a network of bores for monitoring groundwater levels and quality in 1992, and has slowly expanded the network over time. Table 5 summarises the monitoring bore network. Figure 7.1 shows the monitoring bores and private bores on a regional scale. Figure 7.2 and Figure 7.3 show the registered water bores and monitoring bores in proximity to the Project.

Table 5: SUMMARY OF MONITORING BORE INSTALLATIONS

Bore ID	Easting[1]	Northing[1]	Ground Level (RL m)	Top of Casing (RL m)	Stick-up (m)	Screen (mbGL)	Geology
18298*	294375	6423521	132.86	133.47	0.61		Alluvium
BG1	296656	6426003	138.2	138.8	0.58		Alluvium
BG3	294731	6424413	133.6	133.8	0.16		Alluvium
BG5	298609	6427874	142.2	142.6	0.31		Alluvium
19116*	296078	6425589	135.60	136.43	0.82		Alluvium
42927*	298843	6428570	144.26	145.36	1.10		Alluvium
47277*	299145	6428643	143.54	144.59	1.06		Alluvium
SMB1	296955.1	6426391.9	141.20	142.47	1.27	13-19	Alluvium
SMB2	297124.5	6426549.5	141.69	142.61	0.92	15-21	Alluvium
B18	295711	6426003					Shallow Permian
A10*	295445	6428834	199.33	199.33	0		Shallow Permian
A5*	296681	64286725	201.46	201.67	0.21		Shallow Permian
BG45*	291570	6424648	166.04	166.36	0.31		Shallow Permian
E12*	294808	6427576	197.06	197.17	0.11		Shallow Permian
46737*	291862	6427143	227.69	227.9	0.21		Shallow Permian
64092*	297762	6428813	151.27	151.35	0.09		Shallow Permian
Rep I7[2]	295575	6425832	135.47	136.38	0.91	49-52	Vaux Seam
53007*	298720	6428857	143.97	144.01	0.04		Deep Permian
11953	298192	6428693	148.0	148.0	0.97		Deep Permian
42701	298586	6428632	145.0	145.0	0.97		Deep Permian
37774	298488	6428998	146.0	146.0	0.4		Deep Permian
28510	298649	6429105	144.0	144.0	1.3		Deep Permian
BE1*	293469	6429033	241.48	242.67	1.19	69-75	Permian Sandstone
BE2*	293374.7	6425866	204.22	205.38	1.16	45-48	Permian Sandstone
BE3*	292977.4	6427587	175.21	176.39	1.18	48-54	Permian Sandstone
Nested Monitoring Bores							
WAN1A	296519	6426099	140.6		0.75	16-20	Wynn Seam
WAN1B					0.75	29-33	Edderton Seam
WAN2A	296217	6425824	137.7		0.70	13-16	Vaux Seam
WAN2B					0.74	36-39	Wynn Seam
WAN2C					0.73	51-54	Edderton Seam

Table 5: SUMMARY OF MONITORING BORE INSTALLATIONS							
Bore ID	Easting[1]	Northing[1]	Ground Level (RL m)	Top of Casing (RL m)	Stick-up (m)	Screen (mbGL)	Geology
WAN3	295772	6425713	136.4		0.30	87	Deep Permian
WAN4A	295442	6425690	135.1		0.83	11.5-14.5	Alluvium
WAN4B					0.79	21-24	Deep Permian
WAN5A	296019	6425360	135.9		0.84	10.5-13.5	Alluvium
WAN5B					0.88	26-29	Deep Permian
WAN6A	296553	6425634	136.9		0.77	7.5-10.5	Alluvium
WAN6B					0.76	30-33	Edderton Seam
WAN7A	296856	6426254	138.1		0.76	12-15	Alluvium
WAN7B					0.79	80-83	Edinglassie Seam
WAN8A	296457	6425854	136.4	137.47	1.07	11-14	Alluvium
WAN8B	296450	6425855	136.33	137.42	1.09	15-18	Wynn Seam
WAN9A	296326	6425582	136.88	137.98	1.10	8.5-10.5	Alluvium
WAN9B	296328	6425576	136.93	137.88	0.95	21-24	Wynn Seam
WAN10A	295828	6425571	135.07	136.13	1.06	10-13	Alluvium
WAN10B	295825	6425578	135.04	136.10	1.06	44-47	Vaux Seam

Notes: 1. co-ordinates: MGA 1994, Zone 56
2. REP I7 replacement for I7 which will be mined out
3. mbGL – metres below ground level
* new survey coordinates as part of this study.

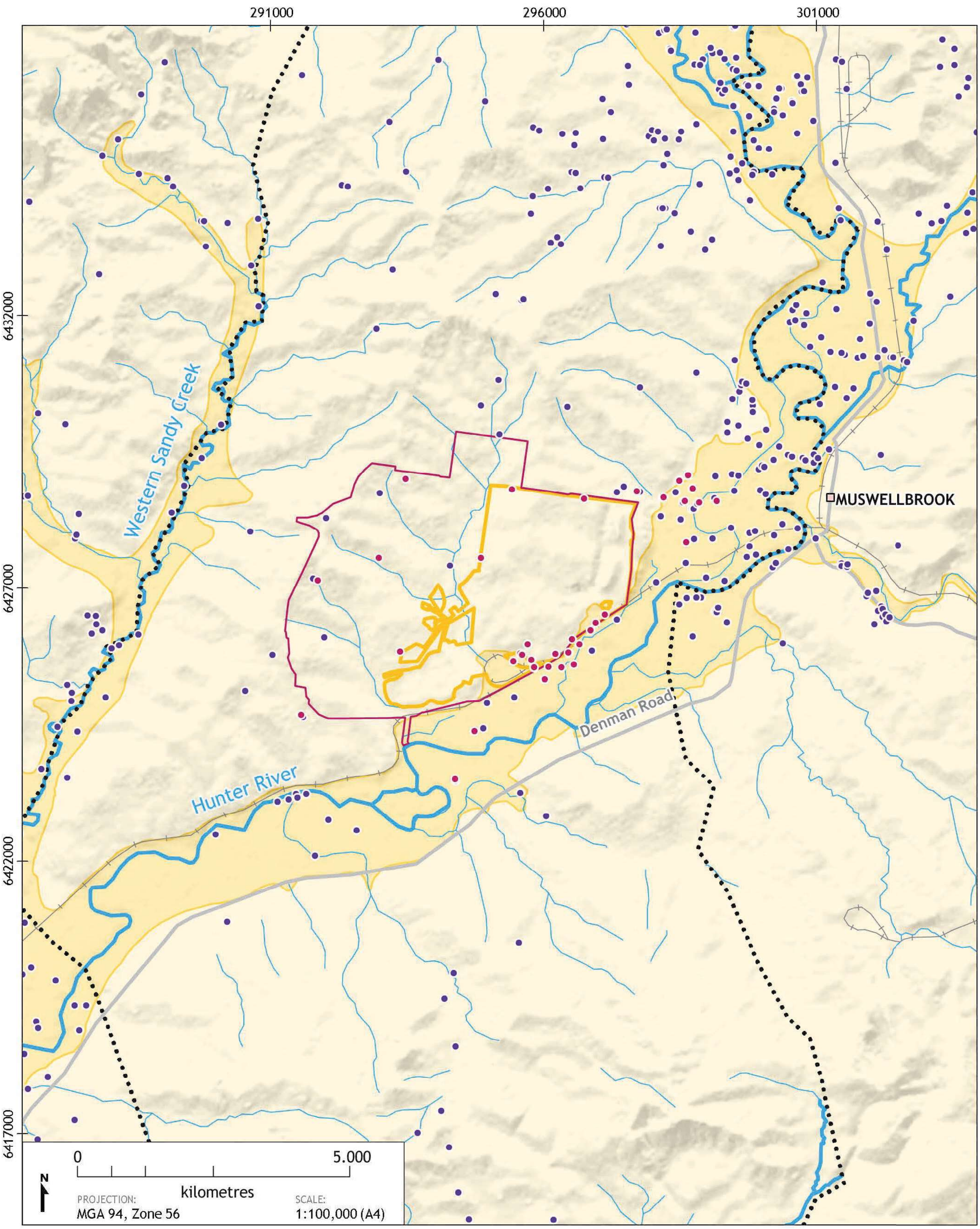
Open cut mining during the Project will progress over time in a westerly direction away from the alluvial sediments of the Hunter River floodplain. The expected impact will be depressurisation of the coal seams primarily to the west but also to the north and south. During the early stages of the EIS development, AGE identified the existing monitoring network as lacking bores in the western area of the Project Boundary, and recommended sites for three vibrating wire piezometers (VWP) to be installed. ACE[2] drilling installed three monitoring bores at sites BE1, BE2 and BE3 shown on Figure 7.3 in December 2011. The objective of the new bores was to provide sites that will monitor the rate and extent of depressurization of the coal seams; and the overlying weathered and fractured rock.

Table 6 summarises the construction details for the VWPs.

Table 6: VWP DETAILS					
Bore ID	Licence Number	Easting	Northing	Target Seam	Sensor Depth (mbGL)
BE1	20BL172815	293475	6429036	Warkworth/Mt Arthur	120
				Edderton Seam	264.5
BE2	20BL172816	293374	6425866	Warkworth/Mt Arthur	97.8
				Edderton Seam	212.5
BE3	20BL172817	292977	6427587	Warkworth/Mt Arthur	80.6
				Edderton Seam	154.6

Note: co-ordinate projection: MGA 1994 Zone 56, mbGL – metres below ground level

[2] ACE drilling stands for Aqua Coal Exploration Drilling.



LEGEND:

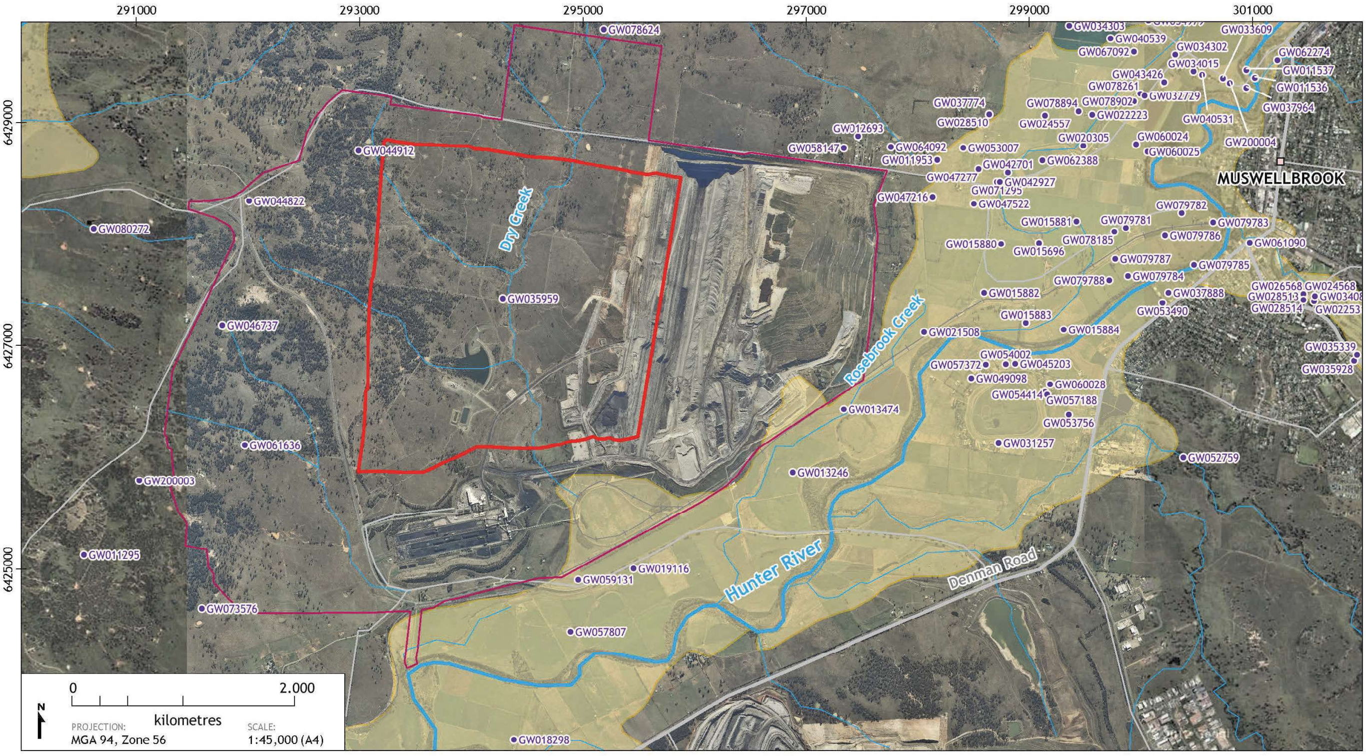
- Approved Bengalla Mine
- Project Boundary
- Model Boundary
- Alluvium
- Major Watercourse
- Creek
- Registered Bore Source Pinneena 3.2, September 2010
- Monitoring Bore BMC
- Town
- Road
- Rail

Continuation of Bengalla Mine
Groundwater Assessment (G1505)

Registered and Monitoring Bores

DATE: 6/12/2012

FIGURE No: **7.1**



LEGEND:

- Project Mining Area
- Project Boundary
- Registered Bore Source Pinneena 3.2, September 2010
- Town
- Road
- Rail
- Alluvium
- Major Watercourse
- Creek

Air Photo courtesy of Bengalla Mine - photo date 08/2012; For wider area background aerial from Google Maps - ©2012 Google

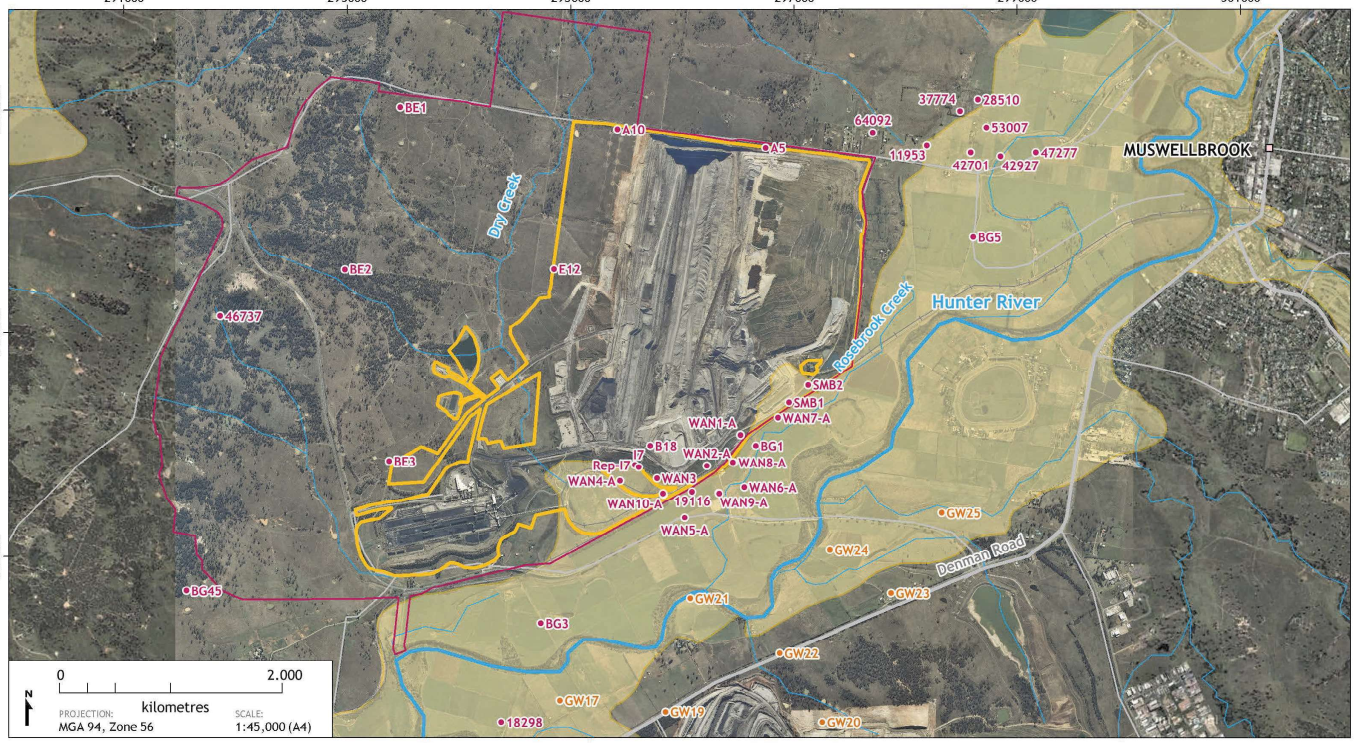
AGE GROUNDWATER & ENVIRONMENTAL

Continuation of Bengalla Mine
Groundwater Assessment (G1505)

Registered Bores

DATE:
6/12/2012

FIGURE No:
7.2



LEGEND:

- Approved Bengalla Mine
- Project Boundary
- Monitoring Bore BMC
- Monitoring Bore MAN
- Town
- Road
- Rail
- Alluvium
- Major Watercourse
- Creek

Air Photo courtesy of Bengalla Mine - photo date 08/2012; For wider area background aerial from Google Maps - ©2012 Google

AGE GROUNDWATER & ENVIRONMENTAL

Continuation of Bengalla Mine
Groundwater Assessment (G1505)

Monitoring Bores

DATE:
6/12/2012

FIGURE No:
7.3

7.2.2 Groundwater Quality

BMC collects routine groundwater samples at Bengalla and conducts analyses for:

- Electrical Conductivity (EC);
- Total Dissolved Solids (TDS);
- pH;
- Sulphate; and
- trace elements (Al, As, Be, B, Cd, Cr, Co, Cu, F, Fe, Pb, Li, Hg, Mo, Ni, Se, V, Zn).

EC, TDS and pH have been monitored in the Wantana Extension bores WAN1, 2, 3, 4, 5, 6 and 7 to the south of the mine since September 2005, and in the more regional bores since 1999. Monitoring of EC, TDS and pH in bores SMB1 and SMB2 commenced in June 2010, immediately after construction of the bores.

Sulphate and trace elements have been monitored in Wantana Extension bores WAN8, 9 and 10 since May 2009, immediately after construction of the bores, and in all Wantana Extension bores from August 2009. Monitoring of sulphate and metals commenced in 11 of the regional monitoring bores in 2003, and in the remaining eight regional monitoring bores in August 2009. Monitoring of the new monitoring bores BE1, BE2 and BE3 commenced in June 2012.

Concentrations of major cations and anions have not been analysed in the samples with the exception of sulphate.

7.3 Quaternary Alluvium

7.3.1 Distribution

Deposits of unconsolidated silts, sand and minor fine gravels of mixed colluvial-alluvial origin occur within the vicinity of the project in the valleys of the creeks and gullies including Dry Creek. These deposits are quite thin and of limited aerial extent, and hence do not have significant groundwater storage capacity and therefore cannot be considered to be classed as an aquifer. They may contain temporary perched groundwater systems infiltrated from slope runoff following heavy rainfall. Discharge of this groundwater from the alluvium maintains a baseflow in the creeks and gullies following rainfall. The alluvium drains quite quickly and discharge/baseflow to the creeks is short lived.

In contrast, the alluvial deposits of the Hunter River to the south of the Project Boundary are a significant source of groundwater. The typical stratigraphic profile is comprised of a silty/clayey upper unit overlying clean sands and gravel aquifer at the base. Numerous monitoring bores have been installed in the alluvium in the area of the Wantana Extension including four stratigraphic boreholes drilled by AGE (2010). These bores intersected 5 m of silty clay overlying gravel and sand. The gravels and sand vary from clean to silty and clayey and extend to a maximum depth of about 20 m below the floodplain where they unconformably rest on Permian mudstone. The sand and gravel layer has a maximum thickness of about 15 m.

The borehole logs indicate that that within and near the Project Boundary, the alluvium is up to 14 m thick and the basal gravel varies between about 2.5 m and 4 m in thickness. The material overlying the basal sand consists predominantly of silt with minor clay. Water bearing sand lenses occur within the silt. The saturated thickness of the alluvium ranges from about 2 m to 10 m.

On the southern side of the Hunter River, MAC have also found a similar stratigraphic sequence of low permeability silts/clays overlying sands and gravels that form the main a productive aquifer.

Monitoring bores and mapping for the Wantana Extension and Water Management Plan were used to define the edge of the alluvium. The alluvial deposits thin to the north towards the margin of the alluvium as the surface of the Permian basement rises and outcrops. The limit of the alluvium is well defined by the 1:100,000 scale geological map for Singleton, and as the proposed mine will continue to the west and move away from the alluvial aquifer no further mapping of the limit of the alluvium was undertaken for the current EIS.

7.3.2 Groundwater Levels and Water Table Surface

Figure 7.4 shows the section of the CRD graph from 1995 to 2012, which is the period of monitoring at Bengalla.

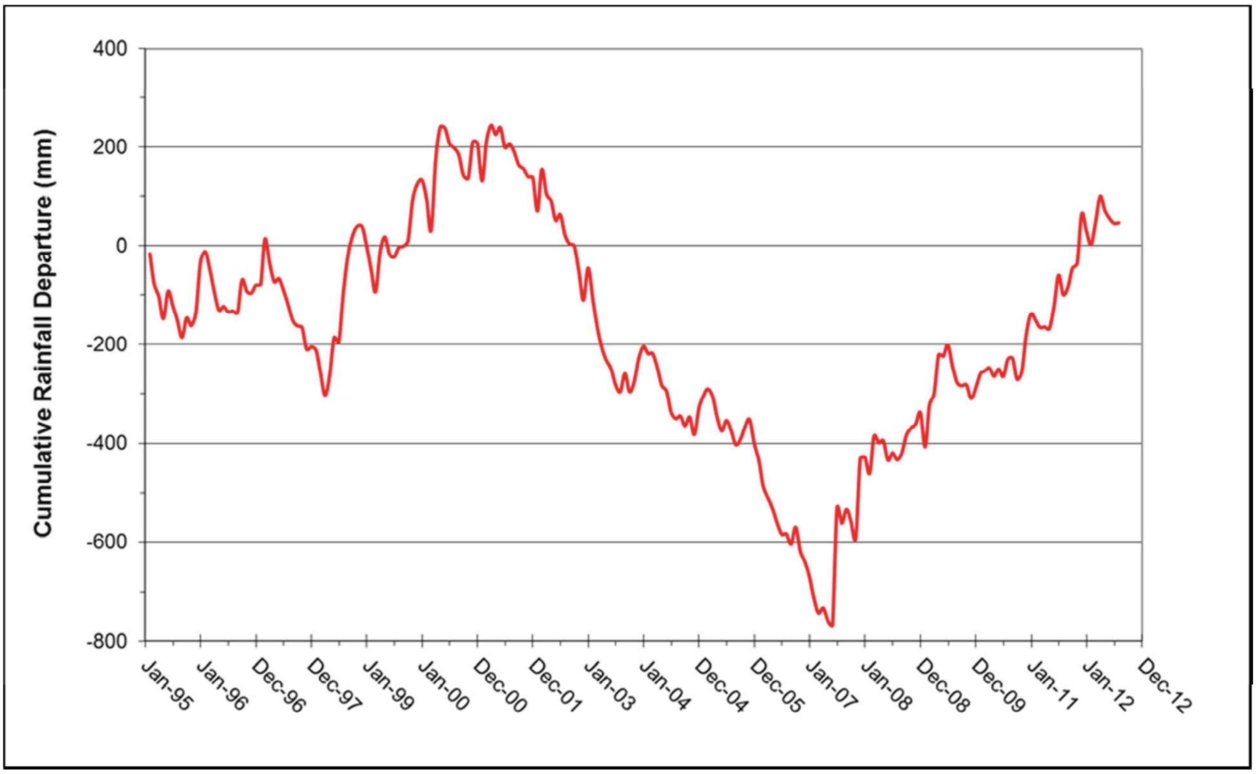


Figure 7.4: Cumulative Rainfall Departure, 1995 to 2012 – Jerrys Plains (Station 061086)

Figure 7.4 indicates that there was an extended dry period from July 2001 until July 2007 and that since then, rainfall has generally been above average. Groundwater levels respond to rainfall and the fluctuations recorded in the monitoring bores would be expected to have some correlation with the CRD. Poor correlation between groundwater levels and the CRD may indicate water being extracted, or added to the groundwater system from sources other than rainfall, or a poor response to rainfall recharge.

Figure 7.5 to Figure 7.8 present hydrographs for the bores monitoring the Hunter River alluvium. Figure 7.1 shows the locations of the bores. The bores were grouped as follows:

- Those to the immediate south of the southern end-wall of the current mine, referred to here-in-after as the Wantana Extension bores (prefixed with WAN); and
- Those bores located in the alluvium at a greater distance from the mine and which are unlikely to be impacted by mining, referred to as the regional Hunter River alluvial bores.

The data is considered to be of a high quality as all the bores have been surveyed and the water bearing zones in which the bores are constructed are known.

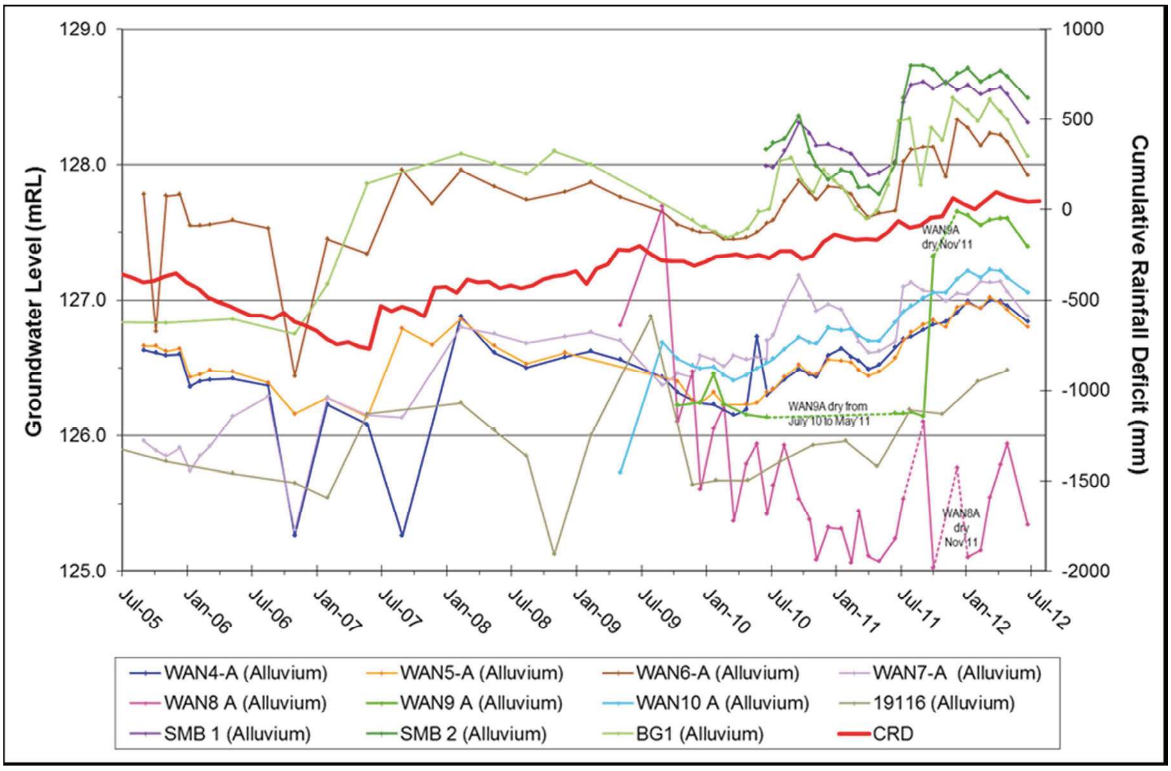


Figure 7.5: Hydrographs of Alluvial Bores – Wantana Extension Area

<u>Wantana Extension Bores</u>

Bores in the alluvium typically have recorded a general trend of rising groundwater levels since 2007. Alluvial groundwater levels are correlated with the CRD.

The exception has been WAN8A that has recorded water levels with significant fluctuations and an overall declining trend since 2009. The reason for the fluctuating water levels in WAN8A could potentially be that it is close to the pit area and / or related to pumping from irrigation bores in area.

The hydrographs also include the water level in the Hunter River recorded at Muswellbrook Bridge where the zero gauge elevation is RL 136.25 m. The Hunter River level was calculated as a three-month moving average and then reduced by 10m to enable comparison of river levels with groundwater levels. The data suggests that during periods of low rainfall, surface water flows in the Hunter River recharge the adjacent alluvium. There is strong correlation between river levels and water levels in the alluvium. River flow is maintained during the dry season by consistent releases from Glenbawn Dam and flow from the river back into the alluvium appears to be influencing groundwater levels in the alluvium.

Figure 7.6 to Figure 7.8 below present hydrographs for the bores located in the alluvium at a greater distance from Bengalla.

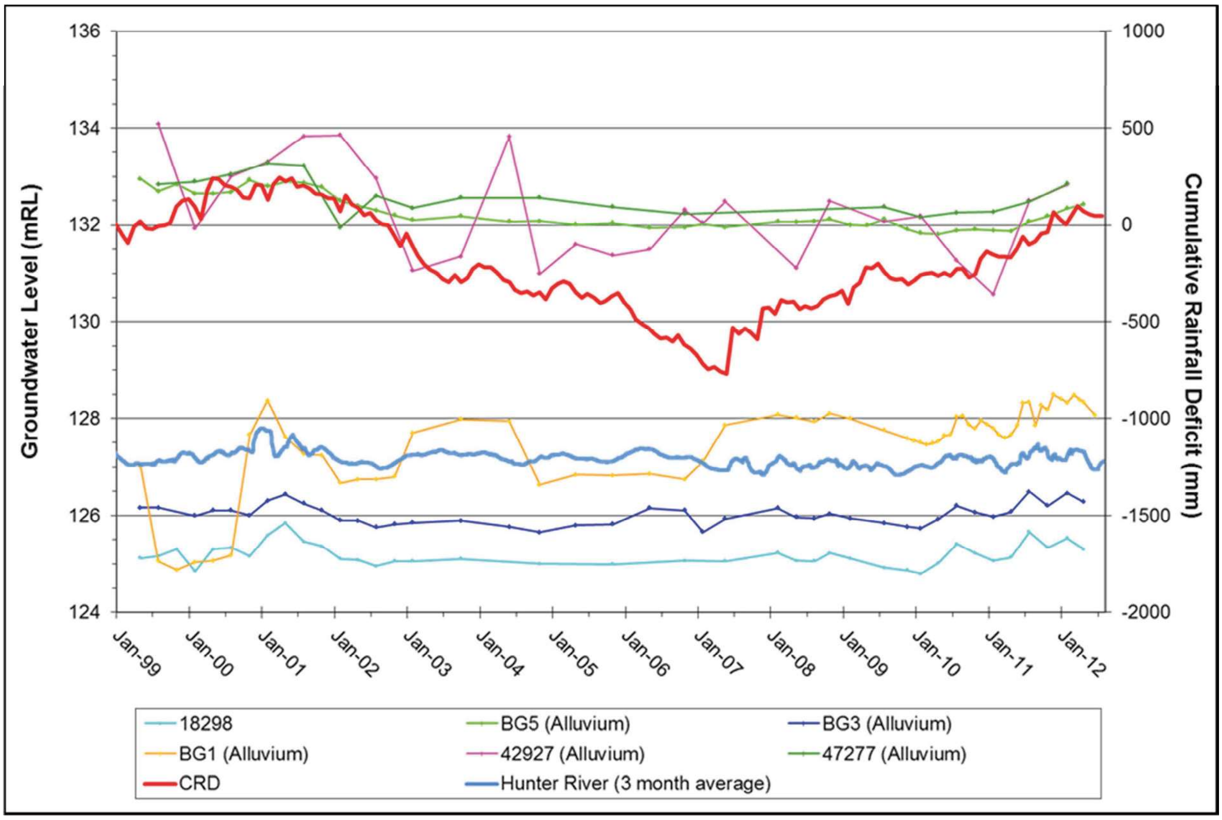


Figure 7.6: Hydrographs of Regional Hunter River Alluvial Bores

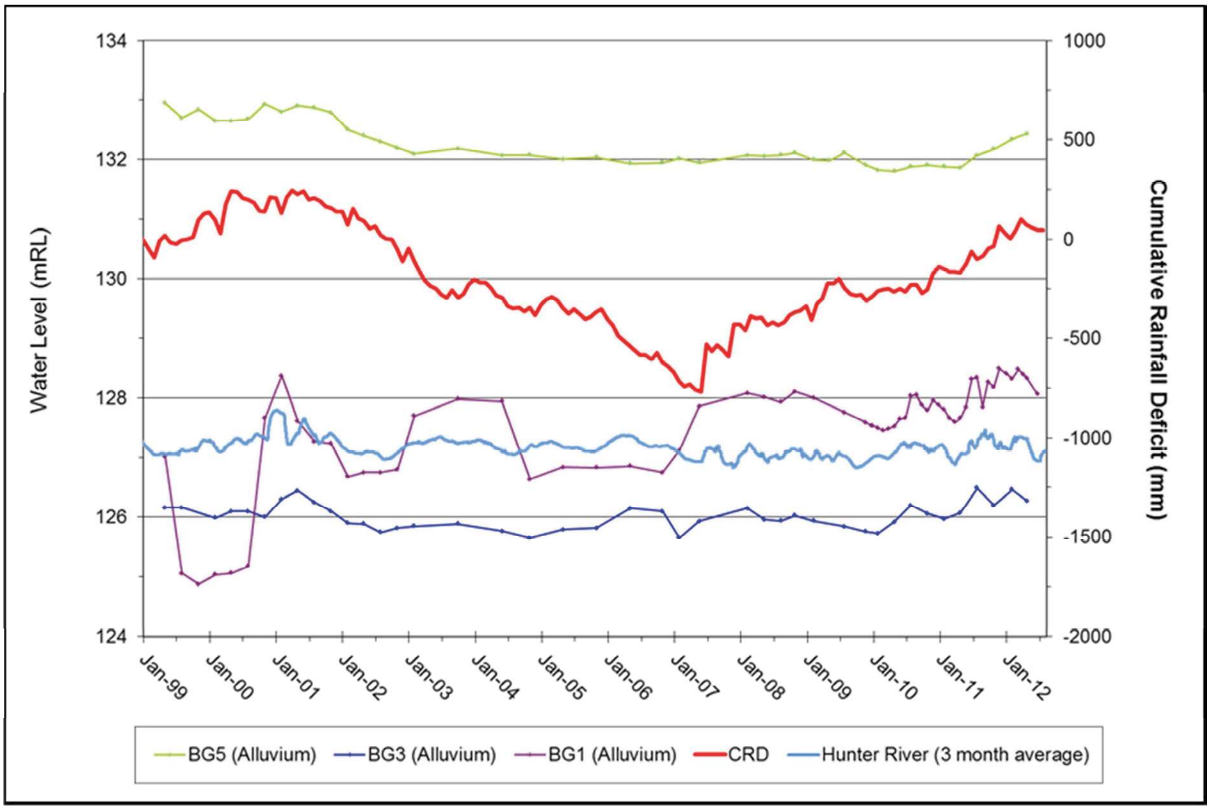


Figure 7.7: Hydrographs of Regional Alluvial Bores from North (BG5) to South (BG3)

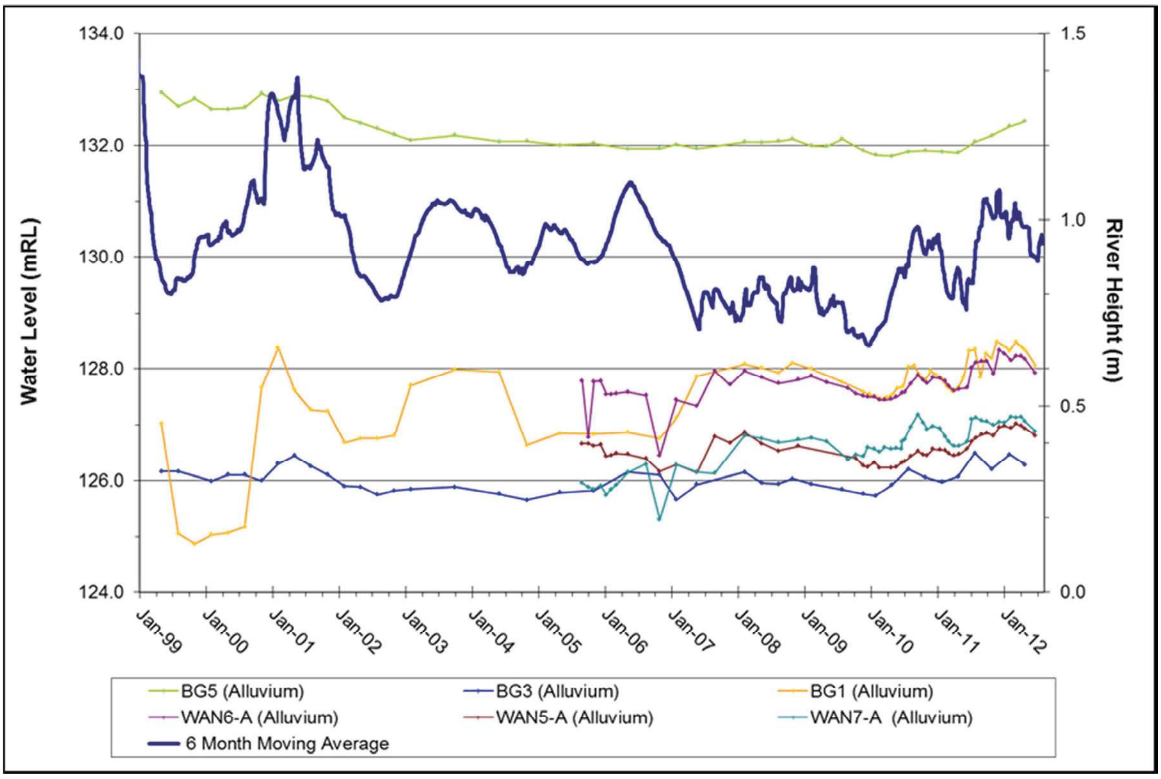


Figure 7.8: Hydrographs of Regional Alluvial Bores (BG1, 3, 5)

Regional Hunter River Alluvial Bores

Figure 7.7 shows alluvial groundwater levels in bores upstream of Bengalla (BG5), in the central area close to the southern end-wall of Bengalla (BG1), and downstream of Bengalla (BG3), compared to the CRD. The water levels show little fluctuation from January 1999 to December 2011, with the exception of BG1 which fluctuates by up to 2.5 m. The hydrographs indicate an alluvial water table gradient of 0.001, from RL132.2 m (BG5) to RL126.2 m (BG3), that is, 6.0 m over a distance of about 5.5 km.

The hydrographs show limited fluctuation and correlation with the CRD. Figure 7.8 shows the six month moving average of the Hunter River level, and exhibits a broad correlation with river level, particularly for monitoring bore BG1 which is in the Wantana Extension area. Of interest is the decline in alluvial groundwater levels from about November 2008 until March 2010 which correlates well with a declining river level, thus providing strong evidence that recharge of the alluvium is dependent to a significant extent on the level of the Hunter River. It appears the Hunter River alluvium is recharged by both direct rainfall and by the Hunter River, and that the Hunter River water level has a stabilising effect on groundwater levels. Figure 7.9 shows the water table surface within the Hunter River alluvium interpolated from water level measurements in June and July 2012. Figure 7.9 also indicates a groundwater flow is similar to the Hunter River, downstream and to the south-west with a hydraulic gradient of 0.001, or about 1.1m per km. Groundwater levels closer to the Wantana Extension do not follow this regional trend, but show a gradient towards the mine, suggesting that alluvial groundwater levels within a narrow zone adjacent to the Wantana Extension are impacted by depressurisation of the underlying Permian due to mining. However, it should be noted this conclusion has been reached based on water level measurements from a range of bores, including WAN8A and WAN9A, where the reasons for their water level response is not clear. Drilling of new bores at these sites has been recommended to confirm the observed trend adjacent to the mine. Despite the limitations in the data, it is evident that downstream flow through the alluvial aquifer is being maintained, despite the close proximity of the mining to the alluvial aquifer. The modelling also indicated downstream flow would be maintained during mining.

LEGEND:

Groundwater Contour (1m Interval)

Groundwater Monitoring Bore / Hunter River Survey Point Used for Contouring

Monitoring Bore (BMC, MAN) / Irrigation Bore

Continuation of Bengalla Mine
Groundwater Assessment (G1505)

Alluvium Water Table - June/July 2012

DATE: 6/12/2012

FIGURE No: 7.9

7.3.3 *Yield and Usage*

Figure 7.1 shows the location of all water bores registered with NOW. Table 7 summarises the details of all bores located within the Hunter River alluvial plain within 5 km of Bengalla.

Table 7: REGISTERED BORES ON NOW DATABASE WITHIN ALLUVIUM 5 KM FROM BENGALLA

Work No	Easting	Northing	Date	Type	Work Status	Land Owner	Depth (m)	Salinity
GW079731	289,989	6,422,513		Bore	(Unknown)	MAC	10	
GW053299	291,127	6,423,123	1981	Well	Supply Obtained	Private	10.1	1001-3000 ppm
GW053233	291,336	6,423,158	1981	Well	(Unknown)	Private	11.2	Good
GW053700	291,465	6,423,253	1981	Well	Supply Obtained	Private	8	(Unknown)
GW053701	291,492	6,423,192	1981	Well	(Unknown)	Private	8.4	1001-3000 ppm
GW053572	291,651	6,423,266	1981	Well	Supply Obtained	MAC	10.5	501-1000 ppm
GW270001	291,815	6,422,117		Bore	SWL Man obs - 6 to 12 mths	MAC	13.8	
GW027311	292,056	6,422,787	1967	Well	Supply Obtained	MAC	11.6	(Unknown)
GW060282	292,578	6,422,598		Well	Abandoned - Backfilled	Private	14.9	(Unknown)
GW018298	294,391	6,423,498	1960	Well	Supply Obtained	MAC	9.1	(Unknown)
GW057807	294,895	6,424,463	1981	Well	(Unknown)	BMC	10	(Unknown)
GW059131	294,964	6,424,927	1981	Well	(Unknown)	BMC	11.6	1001-3000 ppm
GW019116	295,459	6,425,029	1951	Well	(Unknown)	BMC	11.9	Good
GW024700	295,573	6,423,275	1979	Well	Abandoned - Collapsed	MAC		(Unknown)
GW013246	296,881	6,425,890	1956	Well	Supply Obtained	BMC	9.8	(Unknown)
GW013474	297,341	6,426,454	1958	Well	(Unknown)	BMC	11.3	(Unknown)
GW021508	298,060	6,427,146	1960	Well	(Unknown)	BMC	12.5	Fresh
GW047216	298,141	6,428,349	1978	Well	(Unknown)	BMC	11.3	(Unknown)
GW011953	298,186	6,428,689	1956	Well	(Unknown)	BMC	9.1	(Unknown)
GW053007	298,420	6,428,786	1965	Well	(Unknown)	MTP	12.5	(Unknown)
GW049098	298,487	6,426,723	1978	Well	Supply Obtained	BMC	10.7	(Unknown)
GW047522	298,508	6,428,295	1980	Well	Supply Obtained	BMC	13.4	(Unknown)
GW047277	298,554	6,428,604	1976	Well	(Unknown)	MTP	12.2	(Unknown)
GW015882	298,603	6,427,496	1930	Well	Supply Obtained	MTP	9.1	Good Stock
GW057372	298,616	6,426,849	1982	Well	(Unknown)	BMC	11	(Unknown)
GW028510	298,649	6,429,099	1965	Well	Supply Obtained	MTP	12	501-1000 ppm
GW037774	298,649	6,429,099	1974	Well	(Unknown)	MTP	13.5	(Unknown)
GW031257	298,734	6,426,143		Well	(Unknown)	MTP		(Unknown)
GW071295	298,714	6,428,484	1992	Well	(Unknown)	Private	12.7	
GW037481	298,740	6,428,485		Well	Collapsed Bore	MTP	15.2	Good
GW042927	298,740	6,428,485	1976	Well	Supply Obtained	MTP	14.3	(Unknown)

Table 7: REGISTERED BORES ON NOW DATABASE WITHIN ALLUVIUM 5 KM FROM BENGALLA								
Work No	**Easting**	**Northing**	**Date**	**Type**	**Work Status**	**Land Owner**	**Depth (m)**	**Salinity**
GW015880	298,751	6,427,930	1954	Well	(Unknown)	MTP	11	Good
GW054002	298,799	6,426,853	1981	Well	(Unknown)	Private	6.5	(Unknown)
GW042701	298,817	6,428,579	1976	Well	Supply Obtained	BMC	14	(Unknown)
GW045203	298,877	6,426,854	1976	Well	(Unknown)	Private	5	(Unknown)
GW015883	298,974	6,427,226	1948	Well	Supply Obtained	Private	9.1	Good
GW015696	299,091	6,427,937	1946	Well	(Unknown)	MTP	11.6	Good
GW057188	299,144	6,426,613		Well	Abandoned - Backfilled	BMC	3.7	(Unknown)
GW062388	299,129	6,428,677	1987	Well	(Unknown)	Private	10.7	(Unknown)
GW054414	299,171	6,426,583		Bore	(Unknown)	MTP	6	(Unknown)
GW024557	299,147	6,429,078	1965	Well	(Unknown)	Private	14.1	(Unknown)
GW060028	299,195	6,426,676		Well	(Unknown)	Private	3	(Unknown)
GW015884	299,316	6,427,171	1956	Well	(Unknown)	Private	11	Good
GW053756	299,357	6,426,402	1982	Well	(Unknown)	Private	9.8	(Unknown)
GW015881	299,428	6,428,129	1957	Well	(Unknown)	MTP	11	Good
GW078894	299,448	6,429,119		Bore	(Unknown)	MTP	9.5	Excellent
GW020305	299,493	6,428,808	1962	Well	(Unknown)	MTP	13.4	(Unknown)
GW022223	299,566	6,429,087	1964	Well	(Unknown)	MTP	11.9	(Unknown)
GW079788	299,726	6,427,611	1992	Bore	Needs Reconditioning	BMC	14	
GW078185	299,770	6,428,043	1995	Bore	Supply Obtained	BMC	15.6	Fair
GW079787	299,778	6,427,792	1992	Bore	SWL Man obs - 6 to 12 mths	BMC	12.5	
GW079781	299,874	6,428,076	1992	Bore	Needs Reconditioning	BMC	12	
GW079784	299,894	6,427,648	1992	Bore	Supply Obtained	BMC	13.8	
GW078902	299,940	6,429,213	1953	Bore	(Unknown)	Private	12.12	
GW067092	299,947	6,429,649		Bore	Supply Obtained	MTP	53.2	
GW060024	299,964	6,428,817	1983	Well	(Unknown)	MTP	13	0-500 ppm
GW078261	300,003	6,429,273	1992	Bore	(Unknown)	Private	23.8	
GW032729	300,034	6,429,250	1970	Bore	(Unknown)	Private	12.2	(Unknown)
GW060025	300,070	6,428,758	1983	Well	Abandoned - Backfilled	MTP	7	(Unknown)
GW053490	300,201	6,427,404	1981	Well	(Unknown)	Private	6.7	(Unknown)
GW079786	300,222	6,428,000	1992	Bore	Abandoned Bore	Private	12	
GW043426	300,215	6,429,377	1974	Bore	(Unknown)	BMC	12.1	(Unknown)
GW037888	300,252	6,427,498	1971	Well	(Unknown)	Private	11.5	(Unknown)
GW034302	300,314	6,429,625		Well	(Unknown)	MTP	12	(Unknown)
GW079782	300,369	6,428,209	1992	Bore	Needs Reconditioning	BMC	13	
GW079785	300,482	6,427,749	1992	Bore	(Unknown)	MTP	13.2	
GW034015	300,475	6,429,474		Well	(Unknown)	BMC	14	(Unknown)

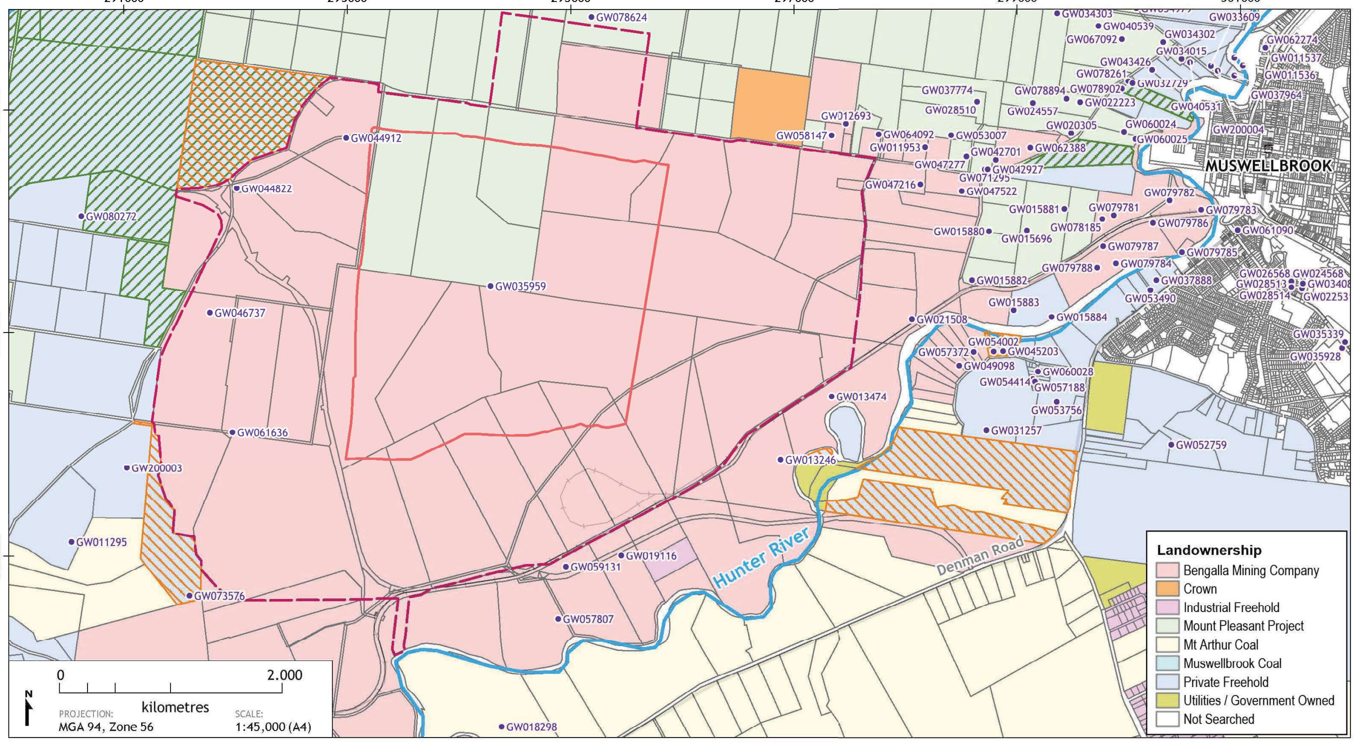
Table 7: REGISTERED BORES ON NOW DATABASE WITHIN ALLUVIUM 5 KM FROM BENGALLA								
Work No	**Easting**	**Northing**	**Date**	**Type**	**Work Status**	**Land Owner**	**Depth (m)**	**Salinity**
GW040531	300,554	6,429,445	1961	Well	Collapsed Bore	Private		(Unknown)
GW079783	300,652	6,428,122	1992	Bore	(Unknown)	BMC	11.2	
GW033609	300,737	6,429,418	1971	Well	Supply Obtained	Private	12.2	(Unknown)
GW200004	300,800	6,429,367	1991	Bore	(Unknown)	Private	19	Good
GW011537	300,946	6,429,484	1955	Bore	(Unknown)	Unknown	12.8	Hard
GW037964	300,949	6,429,330		Well	(Unknown)	Private	12.4	(Unknown)
GW061090	300,976	6,427,944	1985	Bore	(Unknown)	Unknown	18.3	1001-3000 ppm
GW011536	301,025	6,429,424	1955	Bore	(Unknown)	Unknown	12.5	Hard
GW062274	301,232	6,429,582	1960	Well	Supply Obtained	Unknown	15.2	(Unknown)

Notes: coordindates – MGA94 Zone 56

There are a total of 76 bores on the NOW database within the Hunter River alluvial plain that are located within 5 km of Bengalla. The majority are shallow wells (54) with a smaller number of bores (22). Most of the bores/wells (71) are less than 20 m deep, with an average depth of 11.5 m. This highlights the thin nature of the alluvium. The status of most of the bores is unknown, but at least ten are not in use. BMC land ownership extends from the proposed mining area, about 2 km to the south and east, 3 km to the west and generally less than 0.5 km to the north. To the south, the land ownership extends to the edge of the Hunter River. Figure 7.10 shows the landownership and registered water bores. Figure 7.10 indicates that the majority of the registered water bores are located on land owned by BMC, or by the adjacent MTP[3] or MAC Projects. Only a small number of bores are located on private land and these are relatively distant from the proposed mining area.

Yields of bores in the Hunter River alluvium are generally relatively low due to the thin saturated thickness of the alluvium, with the higher yielding bores being those with the greatest saturated thickness. MER (2000) undertook test pumping on the five monitoring bores at rates of around 0.25 L/s, the drawdown in individual bores varied between 0.01 m and 0.97 m. Yield data on the NOW database is limited to seven bores which recorded yields between 0.1 L/s and 7 L/s.

[3] Mount Pleasant Project



LEGEND:

- Registered Bore Source Pinneena 3.2, September 2010
- Project Mining Area
- Project Boundary
- Property Entitled to Acquisition by Mt Arthur Coal
- Property Entitled to Acquisition by Mt Pleasant Project
- Road
- Rail
- Major Watercourse

Continuation of Bengalla Mine
Groundwater Assessment (G1505)

Groundwater Users, Landownership and Drawdown

DATE:
6/12/2012

FIGURE No:
7.10

7.3.4 Hydraulic Parameters

Pumping tests carried out during the EIS by MMA (1993) indicated a transmissivity in the range of 100 m^2/day to 700 m^2/day. Assuming a saturated thickness of 10m, this equates to a hydraulic conductivity ranging from 10 m/day to 70 m/day.

Pumping tests on bores GW16, 17, 21, 24 and 25 by MER (2000) indicate that the basal gravel has a moderate to high hydraulic conductivity in the range 5-40 m/day with a median value of 8.2 m/day. Values determined at other locations in the area range from 2 m/day to more than 60 m/day.

The available data indicates a generally high but spatially variable distribution of hydraulic conductivity in the alluvium.

7.3.5 Recharge and Groundwater Flow

Recharge to the alluvium occurs by direct infiltration of rainfall, and runoff from elevated bedrock subcrop areas. The groundwater that occurs in the thin, locally limited alluvial deposits within the Project Boundary is probably perched above the main water table, and is short lived, draining relatively rapidly into the creeks and gullies.

Apart from infiltration of rainfall and runoff from higher areas, the alluvium along the Hunter River is likely recharged during very dry periods from flow in the Hunter River, which is maintained by release of water from Glenbawn Dam. Upward leakage from the underlying coal measures also adds to recharge of the Hunter River alluvium and to the base flow of the creeks. Section 7.5.2 also discusses vertical gradients in the Permian geological units.

MER (2000) states that measurements of groundwater levels in the alluvium indicate a shallow hydraulic gradient towards the Hunter River, contiguous with the regional hydraulic gradient. That is, the hydraulic gradient in the alluvium appears to be similar with that of the coal seams and the overall gradient in the study area.

7.3.6 Groundwater Quality and Beneficial Use

BMC regularly monitors groundwater quality in a subset of bores installed in the Hunter River alluvium. Bores BG1, BG3, BG5, 18298, 19116, 42927 and 47277 have been monitored since the late 1990s. The Wantana extension bores have been monitored since 2005. Figure 7.11 and Figure 7.12 present the electrical conductivity (EC) data over time, which is an indicator of the trends in salinity.

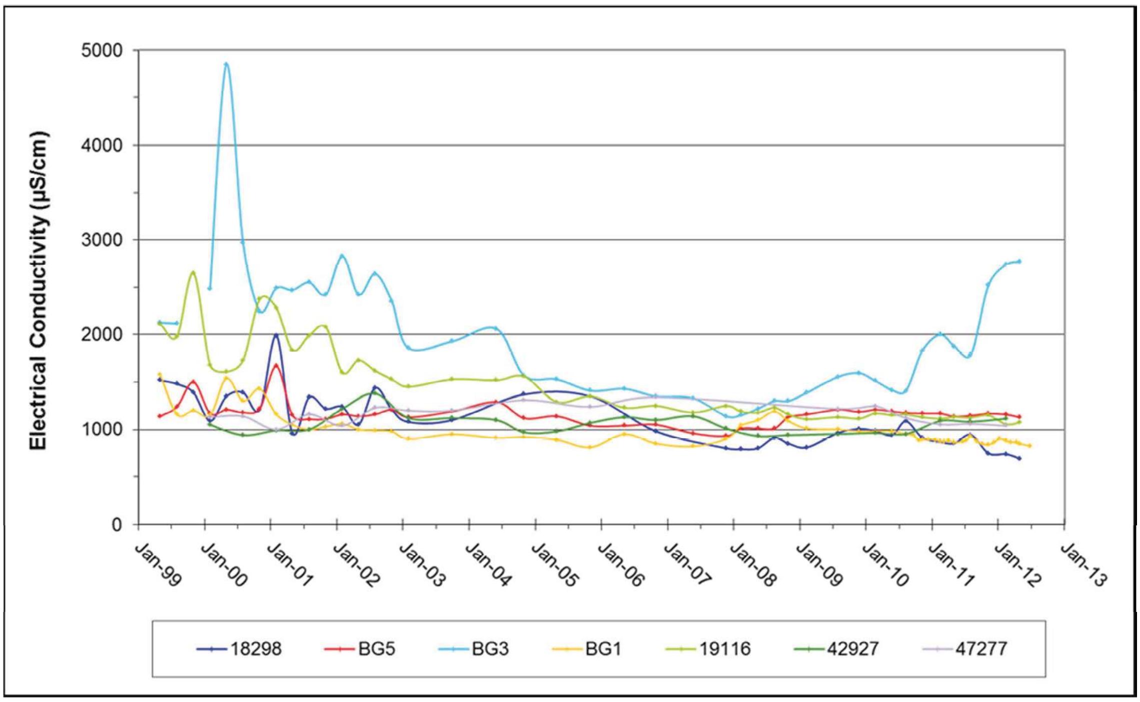


Figure 7.11: Electrical Conductivity vs Time – Hunter River Alluvium

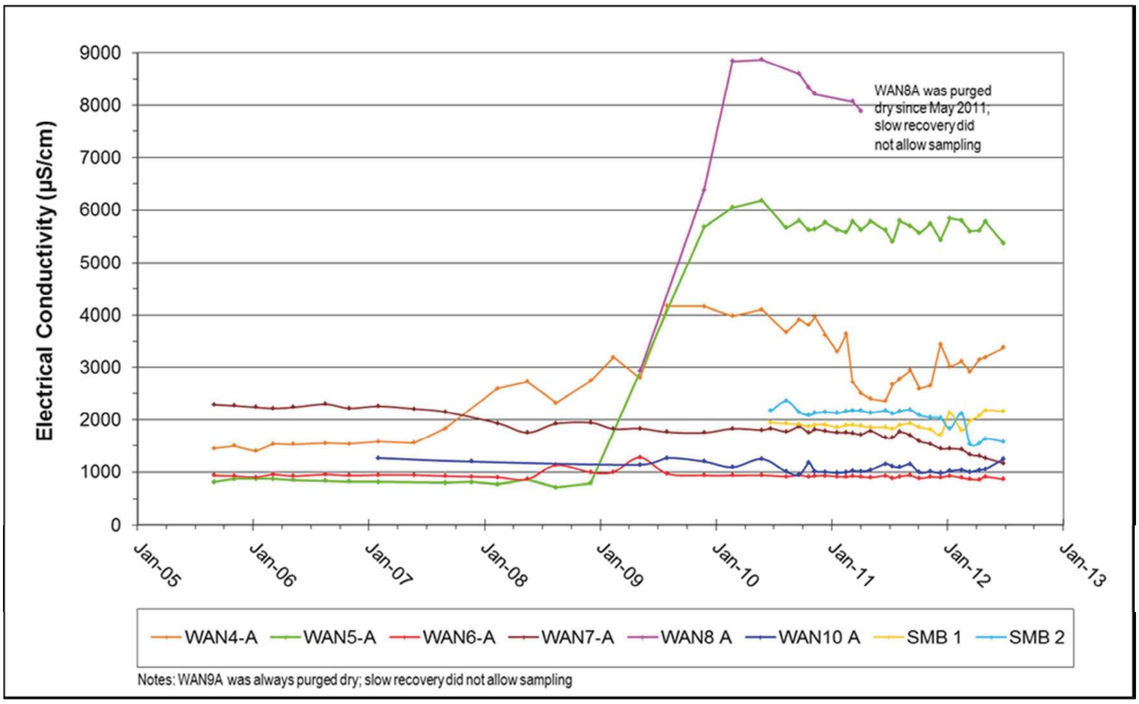


Figure 7.12: Electrical Conductivity vs Time – Hunter River Alluvium (Wantana Extension)

Figure 7.11 indicates the groundwater within the Hunter River alluvium typically has an EC less than 1,500 μS/cm and is therefore fresh to slightly brackish in quality.

A general reduction in salinity since the commencement of monitoring in 1999 is evident in the dataset. This may relate to increased rainfall since 2007 and recharge from the Glenbawn Dam. This trend is not evident in the bores installed for the Wantana extension which recorded large increases in EC in three bores from 2007. Bores WAN4A, 5A and 8A show a gradual increasing EC from 2007 until 2009 with a steep increase in June-August 2009, and in August 2009 a peak level of 4,170 µS/cm, at which time values started to stabilise or decrease. WAN5A appears to have stabilised on an elevated EC of about 5,600 µS/cm, whereas EC concentrations in WAN4A and WAN8A are generally declining since having reached peak levels.

The reason for the significant increases in EC in WAN4A, 5A and 8A is not clear, particularly given that both WAN10A and bore 19116, which lie within the triangle containing these three bores, have a low EC of 977 µS/cm and 1,150 µS/cm respectively in December 2011. There is no evidence of a trend in water quality from the mine towards the Hunter River. However, it should be noted that WAN8A has very slow groundwater level recovery rate, and after purging sampling was sometimes not possible. This bore may be installed in low permeability sediments not representative of surrounding material, and could explain the very high EC readings. It is also possible that salt in the profile above the screen that accumulated during drought evapotranspiration was remobilised by improved rainfall and flushed into the screen zone.

The salinity of the alluvial groundwater varies spatially and can be too brackish for irrigation, but is consistently suitable for stockwatering. The main beneficial use category is therefore considered to be for stockwatering.

7.3.7 Groundwater Dependent Ecosystems

EcoLogical Australia (2013) sampled thirteen bores for the presence of stygofauna in July 2012 and then again in September 2012. Eight samples were collected from the Hunter River alluvium, and five were collected from the Permian strata. Seven of the sampled bores contained stygofauna, with the only non-alluvial bore being BG45.

Six stygofauna taxa were collected with *Cyclopoid crustaceans* being the most numerous and frequently encountered taxa. Other taxa were *Notobathynella sp*. 1, *Bathynella sp*. 1, *Chillagoe sp*. 1, *Ostracoda*, and *Oligochaeta*, although not all taxa were identified to species. Based on existing knowledge of Hunter Valley stygofauna, it is unlikely that there are any species endemic to the area impacted by drawdown and depressurisation.

Cumberland Ecology (2013) determined that the floodplain and creek-line communities dominated by such canopy species as *Eucalyptus tereticornis* (Forest Red Gum) or *Angophora floribunda* (Rough-barked Apple) are likely to have some root access to deep water tables and may have some dependence on groundwater. Thus, the riparian community Hunter Floodplain Red Gum Woodland is considered to be a GDE that may rely on groundwater resources during periods of drought or low rainfall. The floodplain areas to the south of the Study Area would have historically supported GDEs, namely floodplain vegetation such as Hunter Floodplain Red Gum Woodland. This floodplain area is now largely dominated by exotic pasture maintained for dairy farming, except along the Hunter River, where fragmented occurrences of Hunter Floodplain Red Gum Woodland have been retained. Section 11.6 discusses the predicted impacts of the Project on GDEs.

7.4 Shallow Permian Bedrock

The shallow bedrock water bearing zone comprises surficial soils and weathered bedrock. The depth of the water bearing zone is likely to be variable and depends on the depth of weathering; and the extent and frequency of permeable fracture systems. The transition of the mixed colluvial-alluvial type deposits to underlying weathered coal measures is often difficult to define in areas where coarse clastics occur and the depth of weathering is significant. It is possible that there are zones of perched water at the interface between soils and bedrock, and zones of locally increased permeability caused by weathering or structures.

7.5 Permian Coal Measures

The Permian strata may be categorised into the following hydrogeological units:

- hydrogeologically "tight" and hence very low yielding to essentially dry sandstone and lesser siltstone that comprise the majority of the Permian interburden/overburden; and
- low to moderately permeable coal seams which are the prime water bearing strata within the Permian sequence.

7.5.1 Distribution

As discussed the Permian deposits occur across the whole of the Project area as a regular layered sedimentary sequence. The coal measures are generally gently dipping at about 5 degrees to the west. All coal seams subcrop in the western area of the mine and strike roughly north-south.

7.5.2 Groundwater Levels

BMC has installed a network of monitoring bores within the Permian sequence, primarily targeting the coal seams. Figure 7.13 shows hydrographs for Permian bores in the Wantana extension area. Figure 7.1 shows the locations of the bores.

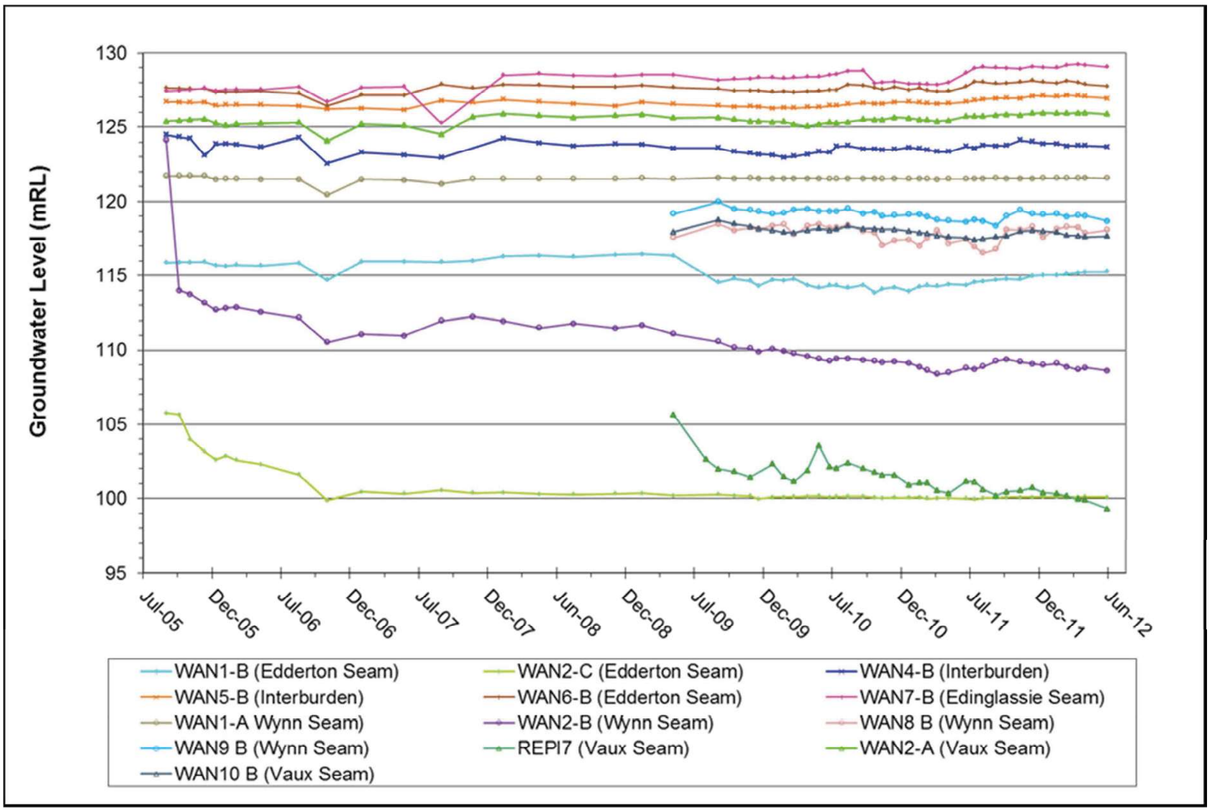


Figure 7.13: Hydrographs of Coal Seam / Interburden Bores – Wantana Extension Area

The hydrographs indicate that the deepest coal seam monitored, the Edinglassie seam (bore WAN7B), generally has a potentiometric level of RL 128-128.5m. The Edinglassie seam is not being mined at Bengalla. The potentiometric level of the Edinglassie seam was at RL 129.1m in December 2011. This is considered representative of the pre-mining potentiometric surface of the coal seams in the area of the Bengalla. The seams that are mined, with the Edderton Seam being the deepest, have been depressurized to a varying extent, depending on their stratigraphic position and the proximity of the monitoring bore to the end-wall of the pit. As would be expected, the greatest depressurization from an assumed pre-mining water level of RL 129.1 m has been recorded in those bores closest to the mine. Examples are:

- Bore REPI7 Vaux Seam RL 100.7 m
- Bore WAN2 Wynn Seam RL 109.1 m, Edderton Seam RL 100.1 m
- Bore WAN1 Wynn Seam RL 121.6 m, Edderton Seam RL 115.0 m

The hydrographs indicate that following initial depressurization the potentiometric levels have remained relatively stable, that is depressurization of the seams has reached a quasi-steady state.

Figure 7.14 shows the hydrographs of interburden and overburden (bedrock) monitoring bores to the north-east (up-dip) of Bengalla, between it and the Hunter River alluvium.

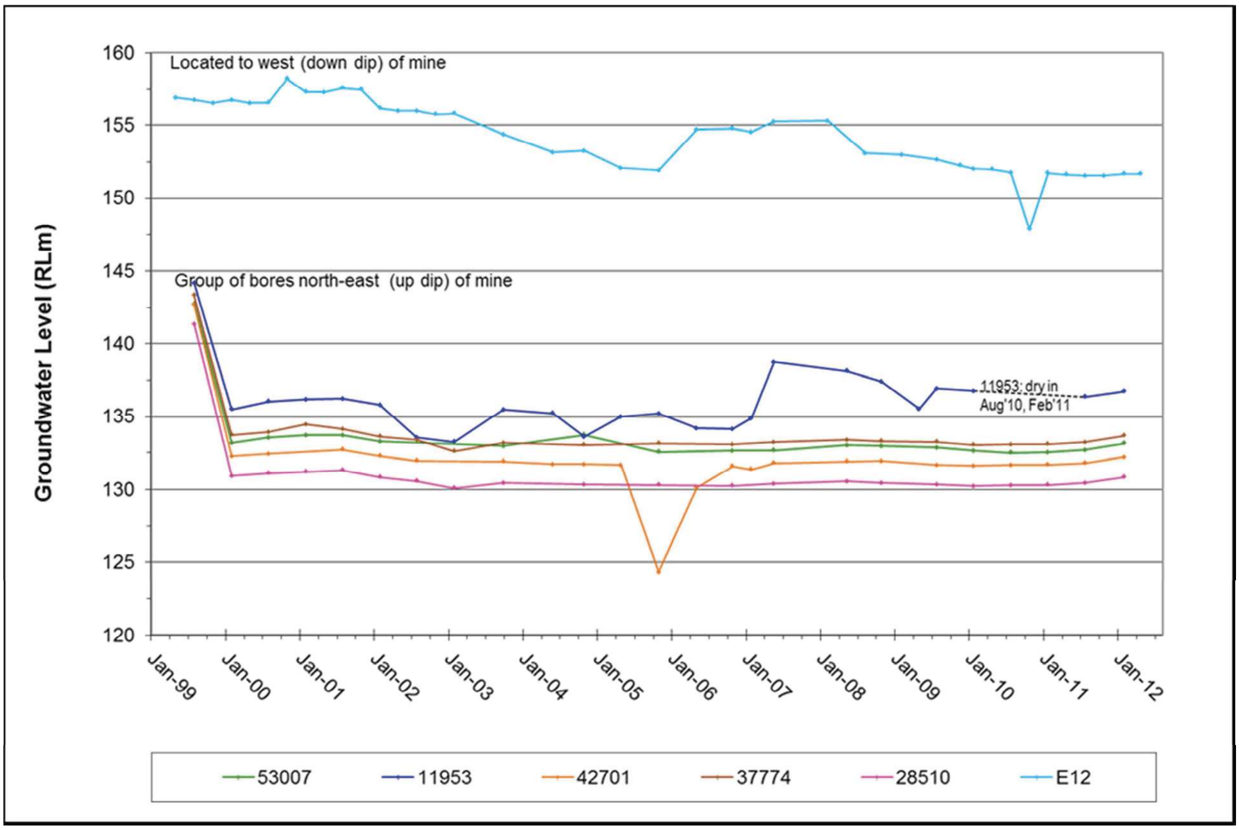


Figure 7.14: Hydrographs of Regional Overburden / Interburden Monitoring Bores

The bores in this area are unlikely to have been impacted by mining and the hydrographs indicate a potentiometric level of between RL 130.4 m and RL 133.2 m, which compares to an alluvial water level in the same area of RL 132.2 m (BG5). This confirms that in general under pre-mining conditions, there is a potential for discharge from the Permian coal seams to the base of alluvium where they subcrop beneath the alluvium.

To the west (down-dip) of Bengalla and away from the river, the potentiometric level of the coal seam and interburden is at RL 151.5 m (bore E12). This also indicates a gradient from the hilly areas north of the Hunter River towards the alluvium. A declining trend is evident in bore EL12, and given the proximity to the highwall, drainage of groundwater to the Bengalla is the likely cause.

Nested monitoring bores, generally one in the alluvium and the second in a coal seam below the base of the alluvium, have been installed in the Wantana Extension area to the south of Bengalla, where it is expected that the greatest impact from coal seam depressurisation will occur. Groundwater levels in the interburden and coal seams and the overlying alluvium have been monitored in WAN4, 5, 6 and 7 since June 2005. Monitoring at WAN 8, 9 and 10 commenced in 2005. Figure 7.15 to Figure 7.18 show the hydrographs.

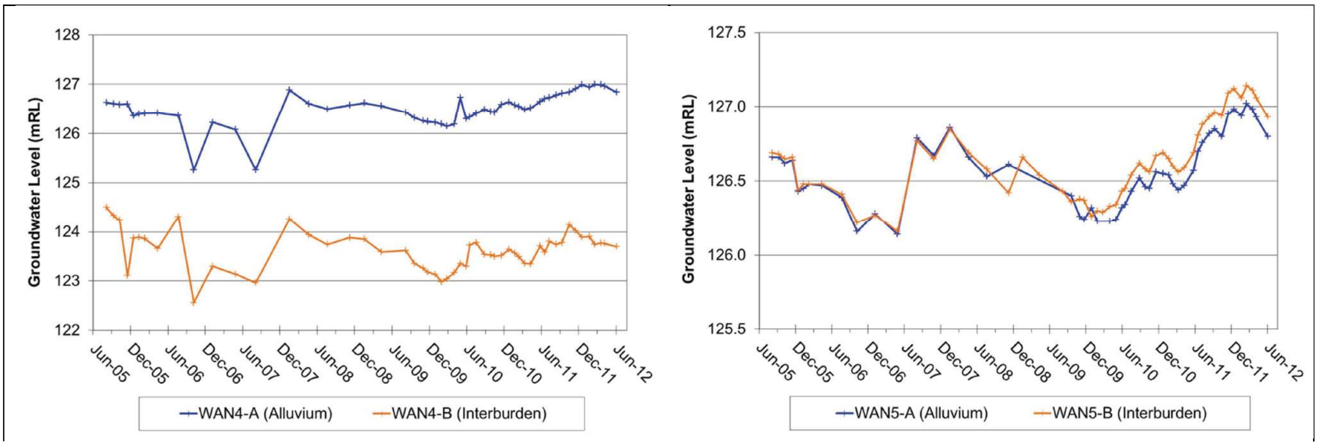


Figure 7.15: Hydrographs of Alluvium and Interburden – WAN4 (left) and WAN5 (right)

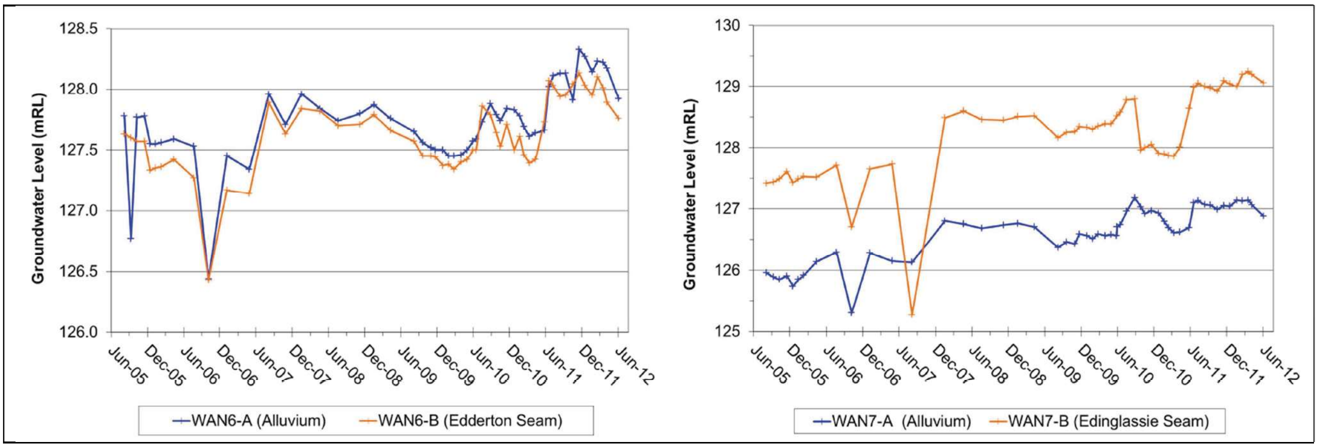


Figure 7.16: Hydrographs of Alluvium and Coal Seam – WAN6 (left) and WAN7 (right)

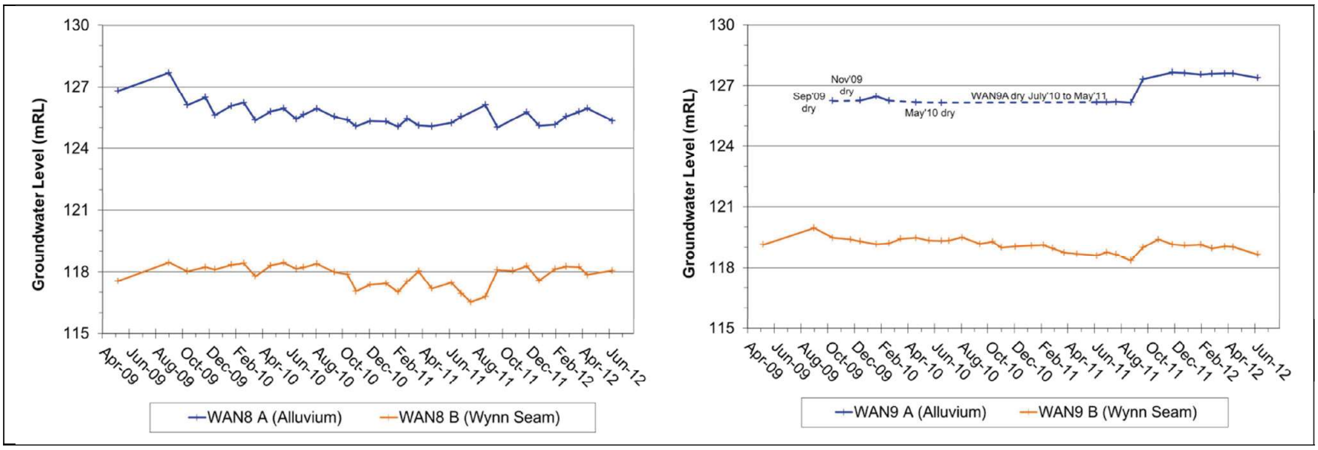


Figure 7.17: Hydrographs of Alluvium and Coal Seam – WAN8 (left) and WAN9 (right)

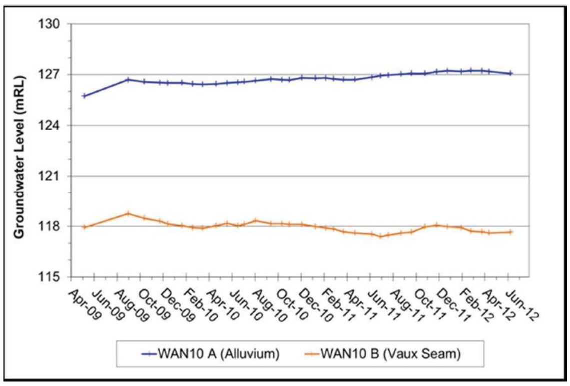


Figure 7.18: Hydrographs of Alluvium and Coal Seam – WAN10

The hydrographs indicate that the potentiometric level of the interburden at WAN4 is about 2 m below the alluvial water table level. This is probably indicative of WAN4 being closer to the Bengalla pit and the interburden being depressurised. The hydrographs of the nested bores at WAN7 indicate that the potentiometric level of the deep Edinglassie Seam, which is not mined at Bengalla and hence has not been impacted, is about 2 m higher than that of the alluvial water table.

Figure 7.17 and Figure 7.18 show hydrographs of the nested monitoring bores (WAN8, 9 and 10) installed in March 2009. They have recorded a water level of between RL 125.0 m and RL 126.8 m in the alluvium, and a potentiometric level in the underlying coal seams of between RL 117.5 m and RL 118.6 m. This is a head differential of up to 9.3 m as a result of mining induced depressurization of the coal seams, indicating potential for alluvial groundwater to leak to the coal seams and eventually towards Bengalla. It should be noted that WAN9 has been dry for most of the period of record indicating that no leakage of alluvial groundwater has actually occurred at this point.

Similarly, Figure 7.19 shows the hydrographs of three coal seams monitored at WAN2. They indicate an increasing level of depressurisation with the depth of the coal seam as would be expected. The shallowest (Vaux Seam) is depressurised the least, whereas the deepest (Edderton

Seam) shows the highest level of depressurisation to about RL100m from the estimated pre-mining level of about RL128 m.

Figure 7.20 to Figure 7.22 present the pore pressure records for the new VWPs installed in the coal seams in the western area of the Project Boundary. The VWPs have measured a significant difference in the pore pressure between the coal seams. The pore pressure in the shallow Mt Arthur Seam (MA2) is about 10 m to 20 m higher than the deeper Edderton Seam (ED1). The potential for this difference to be related to depressurisation is uncertain as the monitoring record is relatively short. The Mt Arthur Seam in BE2 appears to respond slowly to recharge over the summer wet season period.

Figure 7.23 and Figure 7.24 show the interpolated potentiometric surface for the shallow Permian (Wynn and Vaux seams and interburden) and deeper Permian (Edderton and Edinglassie seams and interburden) respectively. The depressurisation of the coal seams and the hydraulic gradient towards the mine is clearly evident in the water level measurements. It is interesting to note that the recorded depressurisation does not appear to be resulting in significant drawdown in the alluvial aquifer, except in close proximity to the edge of the Wantana Extension.

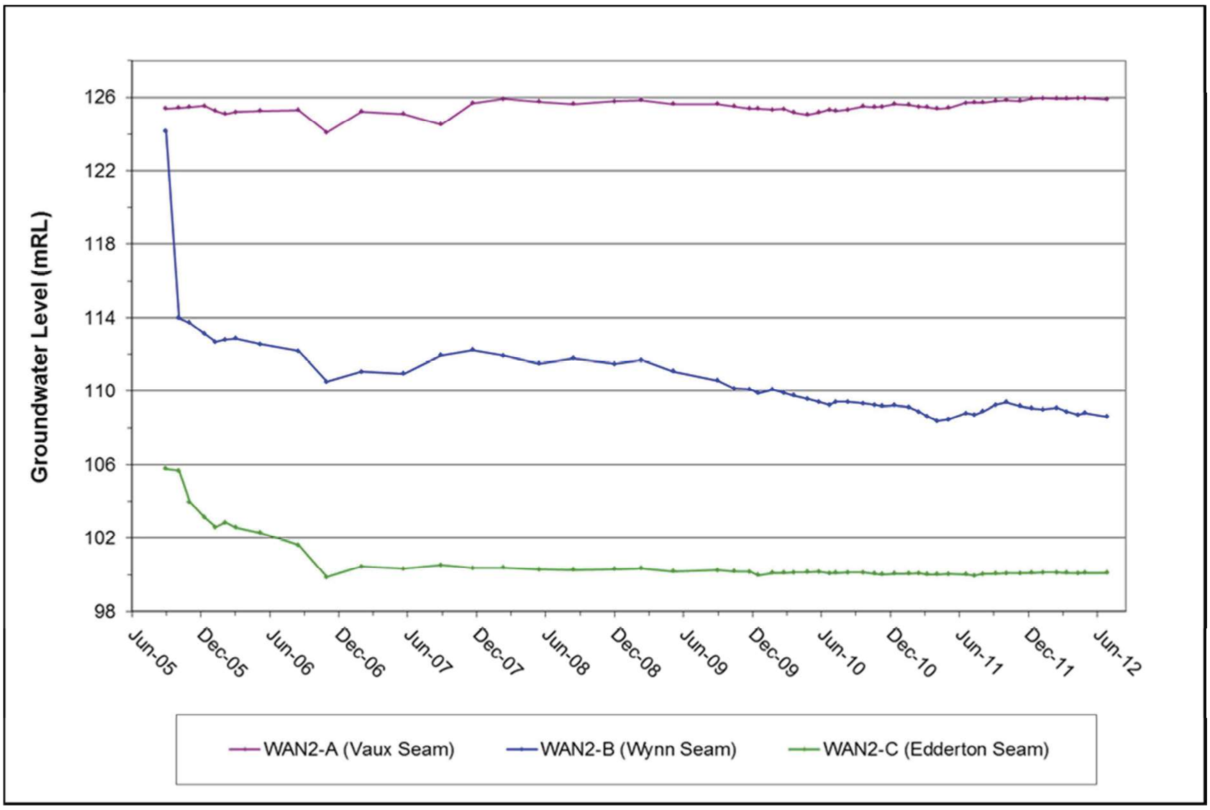


Figure 7.19: Hydrographs of coal seams – WAN2

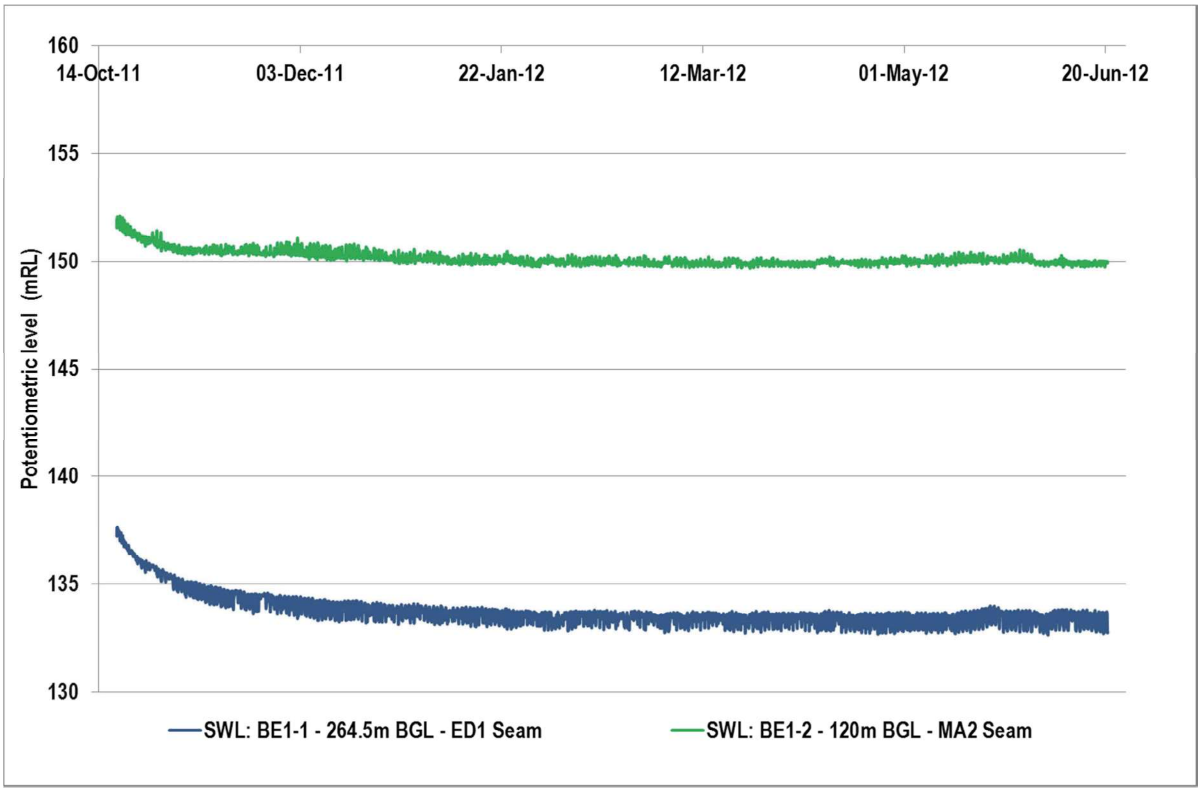


Figure 7.20: Hydrographs of pore pressures heads as potentiometric levels– BE1

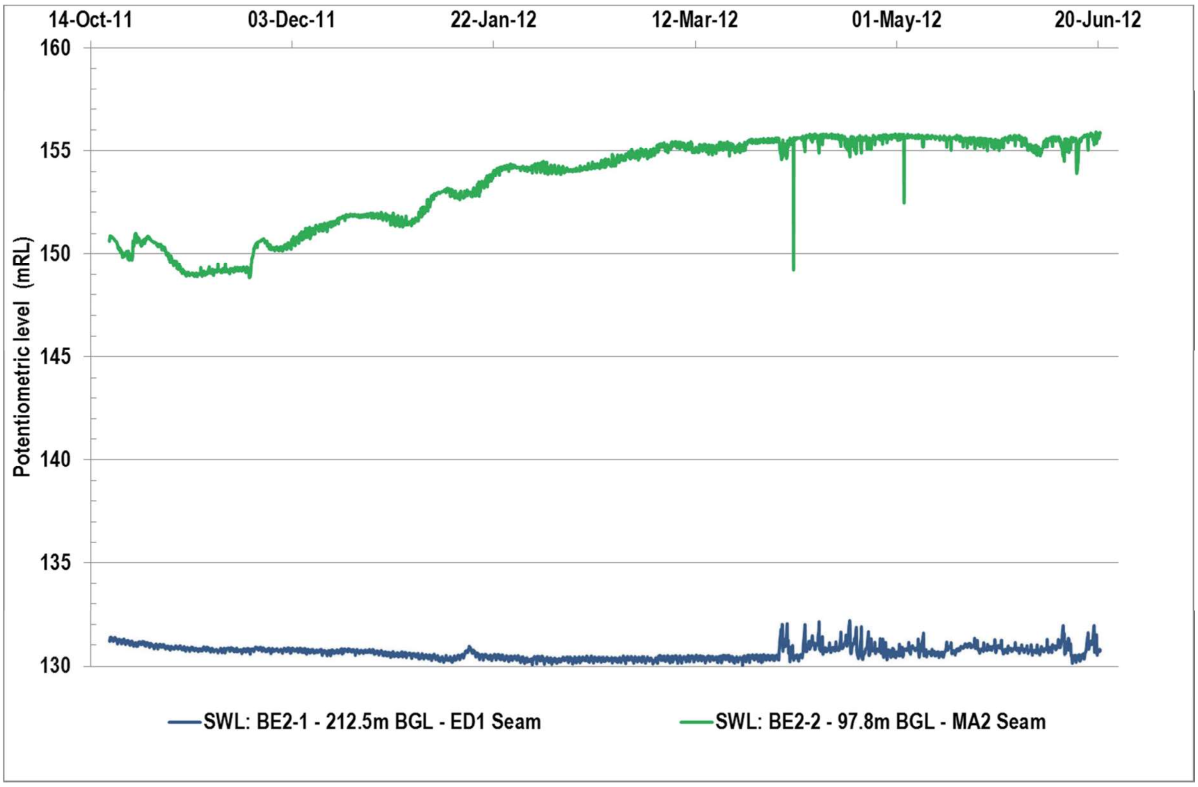


Figure 7.21: Hydrographs of pore pressures heads as potentiometric levels – BE2

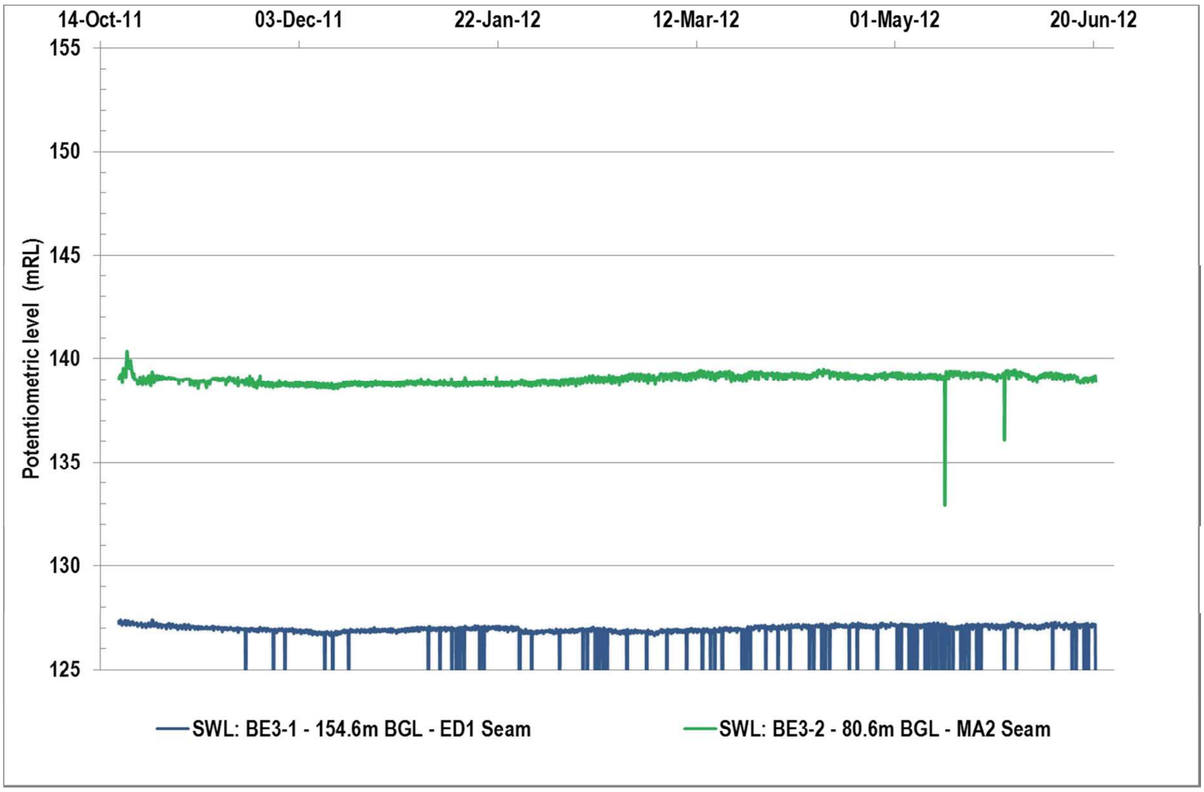


Figure 7.22: Hydrographs of pore pressures heads as potentiometric levels – BE3

LEGEND:

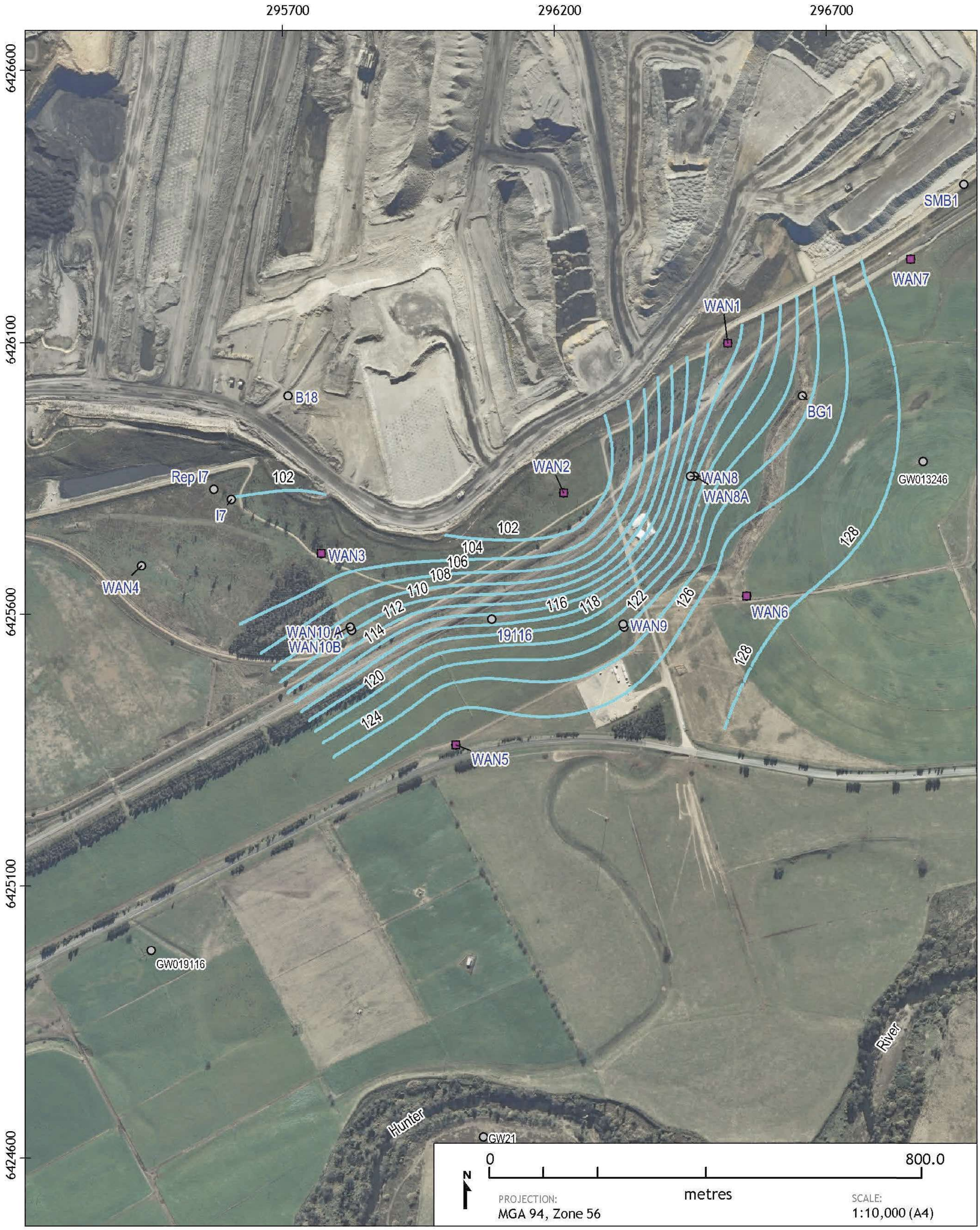
- Groundwater Contour (2m Interval)
- Groundwater Monitoring Bore Used for Contouring
- Monitoring Bore (BMC, MAN) / Irrigation Bore

Continuation of Bengalla Mine
Groundwater Assessment (G1505)

Shallow Permian Groundwater Levels June 2012

DATE: 6/12/2012

FIGURE No: **7.23**



LEGEND:

- Groundwater Contour (2m Interval)
- Groundwater Monitoring Bore Used for Contouring
- Monitoring Bore (BMC, MAN) / Irrigation Bore

Continuation of Bengalla Mine
Groundwater Assessment (G1505)

Deep Permian Groundwater Levels June 2012

DATE: 6/12/2012

FIGURE No: **7.24**

7.5.3 Yield and Usage

Figure 7.1 shows the location of groundwater bores registered with NOW. Table 8 summarises details held by NOW for bores within the Permian units surrounding Bengalla.

Table 8: REGISTERED BORES ON NOW DATABASE WITHIN PERMIAN SURROUNDING BENGALLA

Work No	Easting	Northing	Date	Type	Work Status	Owner	Depth (m)	Salinity
GW011295	290536	6425144	1955	Bore	(Unknown)	Private	29	(Unknown)
GW080272	290627	6428067	2002	Bore	(Unknown)	Private		
GW200003	291033	6425814		Bore	(Unknown)	Private	21	
GW073576	291596	6424675	1995	Bore	(Unknown)	Private	20	
GW046737	291776	6427203	1975	Bore	Supply Obtained	BMC	74.7	(Unknown)
GW061636	291981	6426129	1986	Bore	Abandoned Bore	BMC	42.7	1001-3000 ppm
GW044822	292015	6428318	1976	Bore	(Unknown)	BMC	30.5	(Unknown)
GW044912	293000	6428769	1975	Bore	(Unknown)	BMC	15.5	(Unknown)
GW035959	294284	6427440		Bore	(Unknown)	MTP	21.3	(Unknown)
GW016280	294853	6430379	1960	Bore	(Unknown)	MTP	21.6	501-1000 ppm
GW078624	295194	6429840	1994	Bore	(Unknown)	MTP	21.9	
GW078625	295175	6430840	1994	Bore	(Unknown)	MTP	175.1	
GW078627	295175	6430840	1994	Bore	(Unknown)	MTP	120	
GW078631	296435	6430363	1994	Bore	(Unknown)	MTP		
GW058147	297346	6428796	1983	Bore	Abandoned - Backfilled	BMC	26	(Unknown)
GW012693	297475	6428891	1956	Bore	Supply Obtained	unknown	54.9	(Unknown)
GW064092	297765	6428804	1984	Bore	(Unknown)	BMC	31.2	(Unknown)
GW080732	297768	6430712	2003	Bore	(Unknown)	MTP		
GW053159	298795	6430982	1981	Well	Supply Obtained	MTP	14.6	1001-3000 ppm
GW053487	299363	6430069	1981	Well	(Unknown)	MTP	15.2	(Unknown)
GW034303	299367	6429884		Well	(Unknown)	MTP	14.1	(Unknown)
GW048754	299459	6430502		Well	Supply Obtained	MTP	12.4	(Unknown)
GW056514	299497	6431211	1982	Well	(Unknown)	MTP	14	(Unknown)
GW033610	299574	6430011	1971	Well	Supply Obtained	MTP	14	(Unknown)
GW053534	299588	6430628	1981	Well	Supply Obtained	MTP	15	501-1000 ppm
GW032709	299826	6430478	1970	Bore	(Unknown)	MTP	12	Good
GW037832	299828	6430386	1975	Well	(Unknown)	MTP	13.7	(Unknown)
GW040536	299831	6430263	1934	Well	Equipped - bore used for obs	MTP	16.6	501-1000 ppm

There are a total of 28 registered bores immediately surrounding Bengalla. The majority are bores installed between the 1950s and 1990s, prior to the commencement of mining in the locality. These bores were therefore likely to be for agricultural use. The land surrounding Bengalla is now largely owned by BMC and other mining companies and there are no private bores within 2 km of the Project.

7.5.4 Hydraulic Parameters

Various tests including 84 airlift and 4 packer tests were undertaken for the 1993 EIS (HLA-Envirosciences Pty Limited 1993). According to this study, 90% of the airlift data indicates a transmissivity range of 0.2 m^2/day to 10 m^2/day, where the higher values may indicate a high secondary permeability due to fracture zones. An average range of 1 m^2/day to 2 m^2/day is estimated for the coal seams.

AGC (1979) and LM&P (1982) undertook hydraulic testing in the MAC area to the south of the Project Boundary. These results are considered to be representative of conditions for the Project Boundary since Mt Arthur Coal targets the same coal measures and is in close proximity to Bengalla. The tests indicate a relatively large variation in the hydraulic conductivities of the coal seams in the subcrop area.

Table 9: SUMMARY OF COAL SEAM HYDRAULIC PARAMETERS

Bore	Seam	Depth Tested (m)	T (m^2/day)	K (m/day)	S	Test Method	Reference
WT1	Vaux	25-35	1	0.12	-	Packer	AGC (1979)
	Bayswater	50-60	1	0.11	-		
	Wynn	65-75	0.1	0.04	-		
	Clanricard	85-95	0.01	0.01	-		
	Bengalla	98-108	0.05	0.02	-		
	Edinglassie	130-140	0.5	0.05	-		
	U. Ramrod Ck	156-166	0.6	0.12	-		
	L. Ramrod Ck	168-178	0.3	0.15	-		
	Interburden	various	<0.01	<0.01	-		
T13 (BH403)	Piercefield	-	-	0.69	-	Packer	LM&P(1982)
	Vaux	-	-	0.52	-		
	Bayswater	-	-	0.35	-		
	Wynn	-	-	0.35	-		
	Clanricard	-	-	0.26	-		
	Bengalla	-	-	0.15	-		
	Edinglassie	-	-	0.16	-		
	Ramrod Ck	-	-	0.06	-		
T16 (BH401)	Piercefield	-	-	0.60	-	Packer	LM&P(1982)
	Vaux	-	-	0.52	-		
	Bayswater	-	-	0.26	-		
	Wynn	-	-	0.17	-		
	Clanricard	-	-	0.35	-		
	Bengalla	-	-	0.60	-		
	Edinglassie	-	-	0.26	-		
	Ramrod Ck			0.1			
	Interburden	-	-	5.2×10^{-3} to 8.6×10^{-5}	-		

Notes: T = transmissivity
K = hydraulic conductivity
S = storage coefficient

A reduction in the hydraulic conductivity of the coal seam water bearing zones with depth is observed in many coal mines. AGC (1984)[4] developed an equation based on the interpretation of depth-dependent hydraulic conductivities of 17 seams in the Upper Hunter Valley as shown below:

$$K = K_o * e^{(-cz)} \qquad \text{(Equation 1)}$$

where:

K	=	Hydraulic conductivity (m/day)
K_o	=	Reference hydraulic conductivity = 5 (m/day)
c	=	Slope of trendline (0.046 for Hunter Valley coal seams)
z	=	Depth (m)

Thus even if very high hydraulic conductivities are indicated by the pumping tests within the subcrop area, much lower values can be expected at greater depths. Mackie (2009) further developed this relationship and determined that the level of brightness affects coal permeability. Figure 7.25 shows the permeability versus depth and coal brightness relationship developed by Mackie (2009).

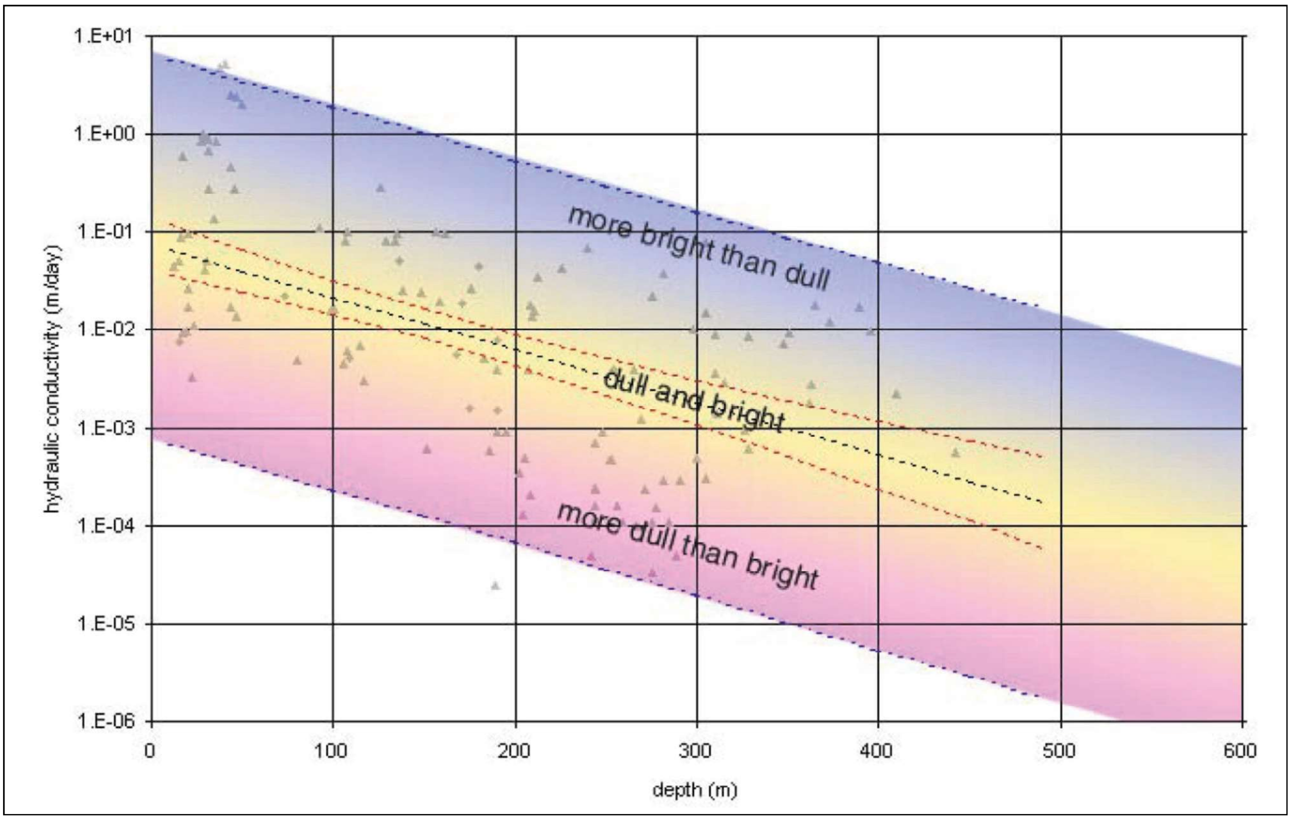


Figure 7.25: Coal Seam Hydraulic Conductivity vs Depth (Mackie 2009)

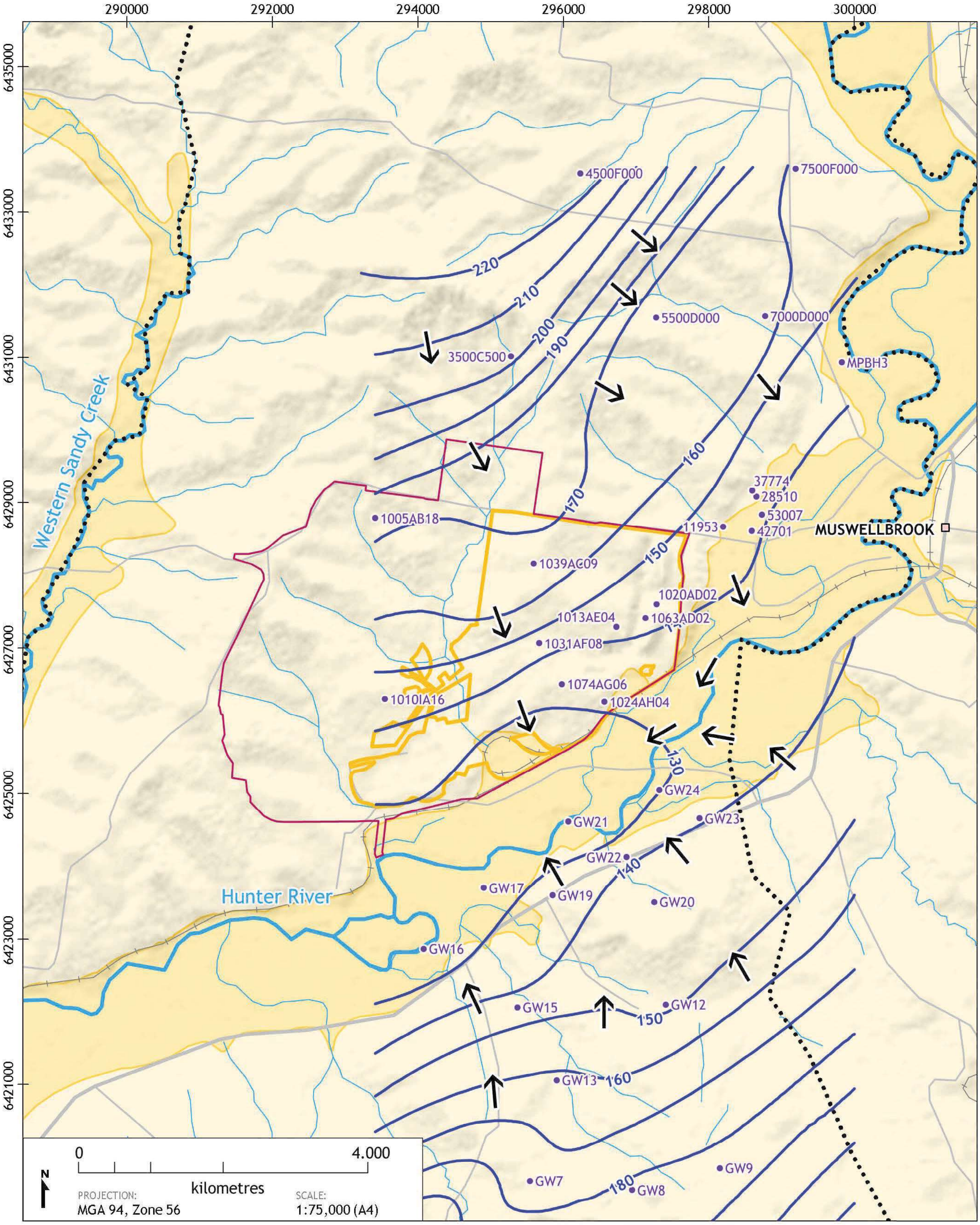
The packer tests indicate a lower range of hydraulic conductivity values between 5×10^{-3} m/day and 8.6×10^{-5} m/day for the interburden material, which is typical.

[4] Australian Groundwater Consultants Pty Ltd, (June 1984), *"Effects of Coal Mining on Groundwater Resources in the Upper Hunter Valley",* Volume 1.

7.5.5 Recharge and Groundwater Flow

Figure 7.26 presents the potentiometric surface developed using water levels measured by BMC in open exploration holes and in dedicated monitoring bores prior to mining. The pre-mining potentiometric surface is a subdued reflection of topography, and shows a groundwater mound beneath the topographically elevated areas of the ridgeline between Sandy Creek and Bengalla and a hydraulic gradient towards the Hunter River valley to the south and south-east. Hydraulic gradient pre-mining at Bengalla is in the order of 0.015.

Groundwater recharge occurs through rainfall infiltration, and groundwater flow is towards the lower lying areas where discharge occurs into the alluvial valleys and creeks/rivers.



LEGEND:

- Approved Bengalla Mine
- Project Boundary
- Model Boundary
- Groundwater Monitoring Bore for Contouring
- Potentiometric Level Contour (RLm)
- Major Watercourse
- Creek
- Alluvium
- Town
- Road/Track
- Rail

Continuation of Bengalla Mine
Groundwater Assessment (G1505)

Interpolated Potentiometric Levels Pre-mining

DATE: 6/12/2012

FIGURE No: **7.26**

7.5.6 Groundwater Quality and Beneficial Use

BMC monitors groundwater quality in a network of bores installed in the Permian coal measures on a routine basis. Figure 7.27 shows the EC of the coal seams in the Wantana Extension area, which have been monitored since September 2005.

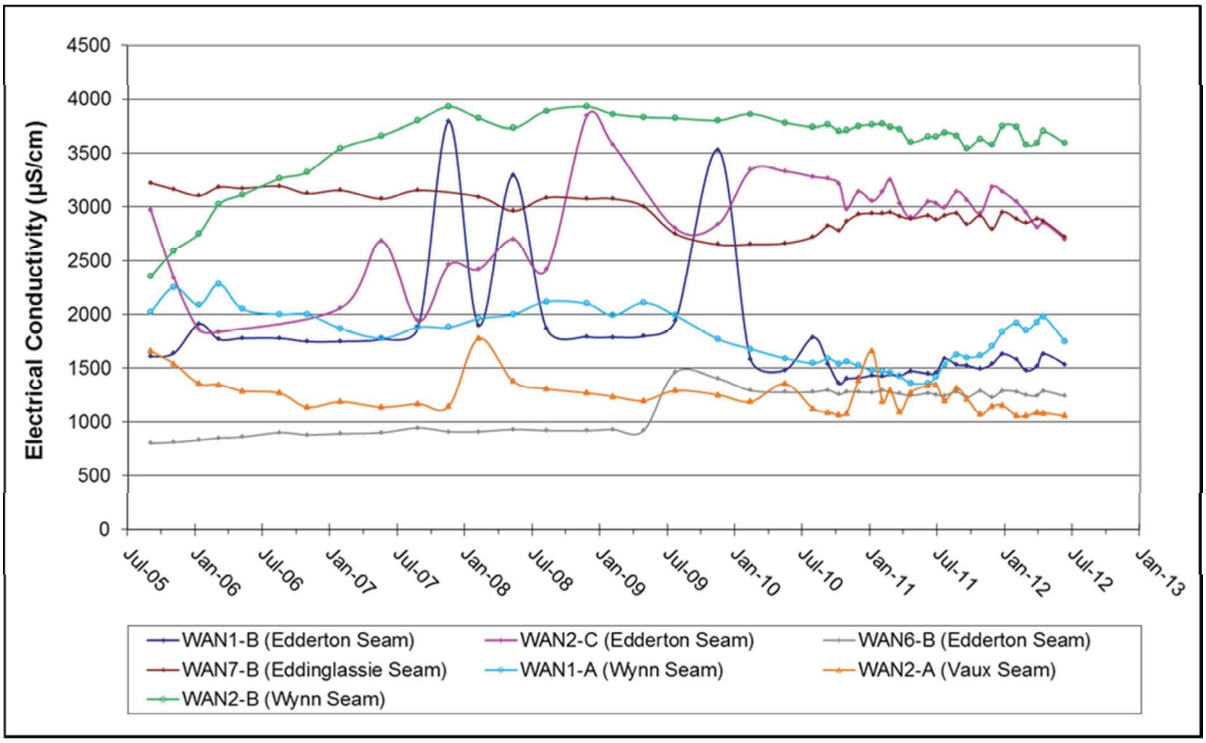


Figure 7.27: Electrical Conductivity Trends – Coal Seam Aquifers (Wantana Area)

The graph indicates that the EC ranges from fresh (less than 1,000 μS/cm for the Edderton Seam) to brackish (up to 4,000 μS/cm for the Wynn Seam). In comparison, the EC graphs for the interburden and coal seams from regional monitoring (Figure 7.28) indicates an EC generally in the range of 4,000 μS/cm to 8,000 μS/cm. This is considered a normal background range for coal measure water bearing zones in the region. The lower EC for the coal seams and interburden in the Wantana Extension area suggest that the EC of the coal measures may be decreasing due to depressurisation from mining and the resultant leakage from the alluvium.

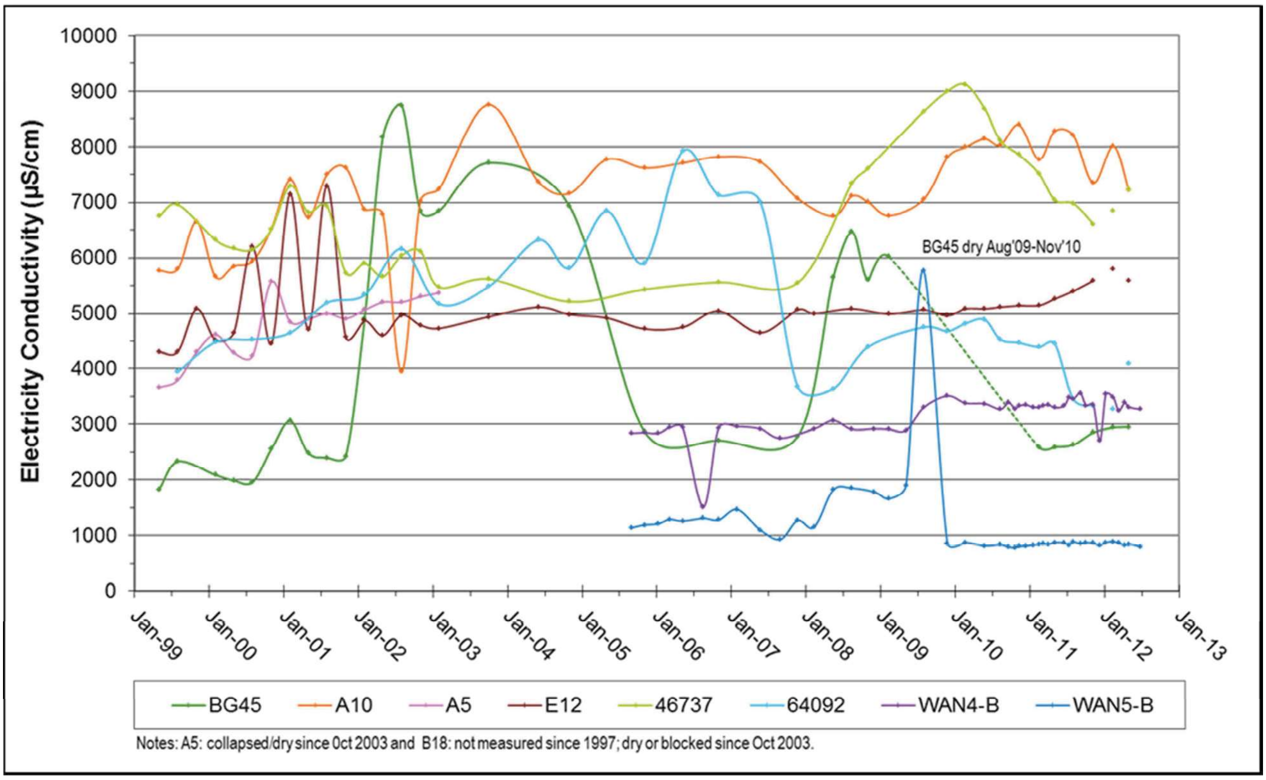


Figure 7.28: Electrical Conductivity Trends – Coal Measures (Regional)

The beneficial use of the Permian groundwater is dependent on the salinity which varies spatially. The groundwater is largely suitable for stock watering, but too brackish to be potable, or to be used for irrigation or by industry.

7.5.7 Mining Operations

The available data shows that to date, mining at Bengalla has depressurised the coal seams in the surrounding area and shallow groundwater only in the immediate area around the mine open cut. There is some groundwater inflow into the open pit. However, the currently observed inflows enter the pit mostly from the spoil area, suggesting that groundwater inflow through the pit walls and floor is minor and mostly evaporated. The inflow from the spoil likely consists of direct rainfall recharge and seepage from wet reject material buried within the overburden emplacement area.

The monitoring of groundwater levels in the Permian coal measures does indicate localised depressurisation adjacent to the Wantana extension, but this is not reflected in a regional impact on the alluvium. Groundwater levels within the alluvium have generally continued to fluctuate in response to rainfall and water levels within the Hunter River.

The impacts of other existing mines surrounding Bengalla are outlined below.

Figure 5.1 shows the Bengalla and surrounding mines.

- <u>Mount Pleasant Mine</u> (MTP) - The NSW Government granted development consent for the MTP project in 1999, and a subsequent modification in 2011. The mine is approved to extract up to 10.5 Mtpa for a period of 21 years (until 2020) using open cut mining methods. The Mount Pleasant Project physically commenced in 2004 with the construction of Environmental Dam 1, however no additional construction or coal mining has occurred. The MTP proposes to target the same coal seams mined at Bengalla and there is the potential for cumulative groundwater impacts.

- Mangoola Coal Mine - The Mangoola Coal Mine, formerly known as the Anvil Hill Project is located about 10 km west of Bengalla. The NSW Government approved the Mangoola Coal Project in June 2007, and the mine commenced operations in late 2010. The approval authorises the extraction of 150 Mtpa of ROM of coal over 21 years (until 2029), at a rate of up to 10.5 million tonnes of ROM coal a year. The groundwater system around the Mangoola Mine, to the west of Bengalla, is separated from the study area by the structural feature of the Mt. Ogilvie Fault. Therefore, no cumulative impact is expected.
- Mt Arthur Coal Mine - The Mt Arthur Coal Mine (MAC) is located to the south of the Hunter River. Given that MAC also extracts coal from the Whittingham Coal Measures, there is the potential for cumulative impacts on the Hunter River alluvium. The MAC operation extracts coal to the deeper Ramrod Coal seam than the Bengalla operation.
- Drayton Mine - Drayton Mine is located to the south-east of Bengalla. Since Drayton Mine targets coal seams within the Greta Coal Measures, it is unlikely that Drayton Mine will contribute to cumulative groundwater impacts. The Greta Coal Measures are hydraulically separated from the Whittingham Coal Measures by the low permeability Saltwater Creek Formation.
- Dartbrook Underground Mine - The Dartbrook Underground Mine to the north of Bengalla had been operating several years before being put into care and maintenance at the beginning of 2007. MER (2000) predicted only a marginal cumulative impact between the Dartbrook Mine operations and neighbouring MTP which lies between Bengalla and Dartbrook Mines.
- Drayton South Coal Project - Approval is currently being sought for development of the Drayton South Mine located to the south of MAC. Limited information is available for this application at this time, therefore has not been included in this study. Although the relative distance and the fact the MAC lies between Drayton South and Bengalla suggest limited cumulative effects with the Project Boundary.

7.6 Conceptualisation of Groundwater Regime

This section of the report discusses the conceptualisation of the groundwater regime, which is the basis of the numerical groundwater model.

Figure 7.29 shows graphically the conceptual groundwater regime of the of the study area, which is based on the available geological and hydrogeological data.

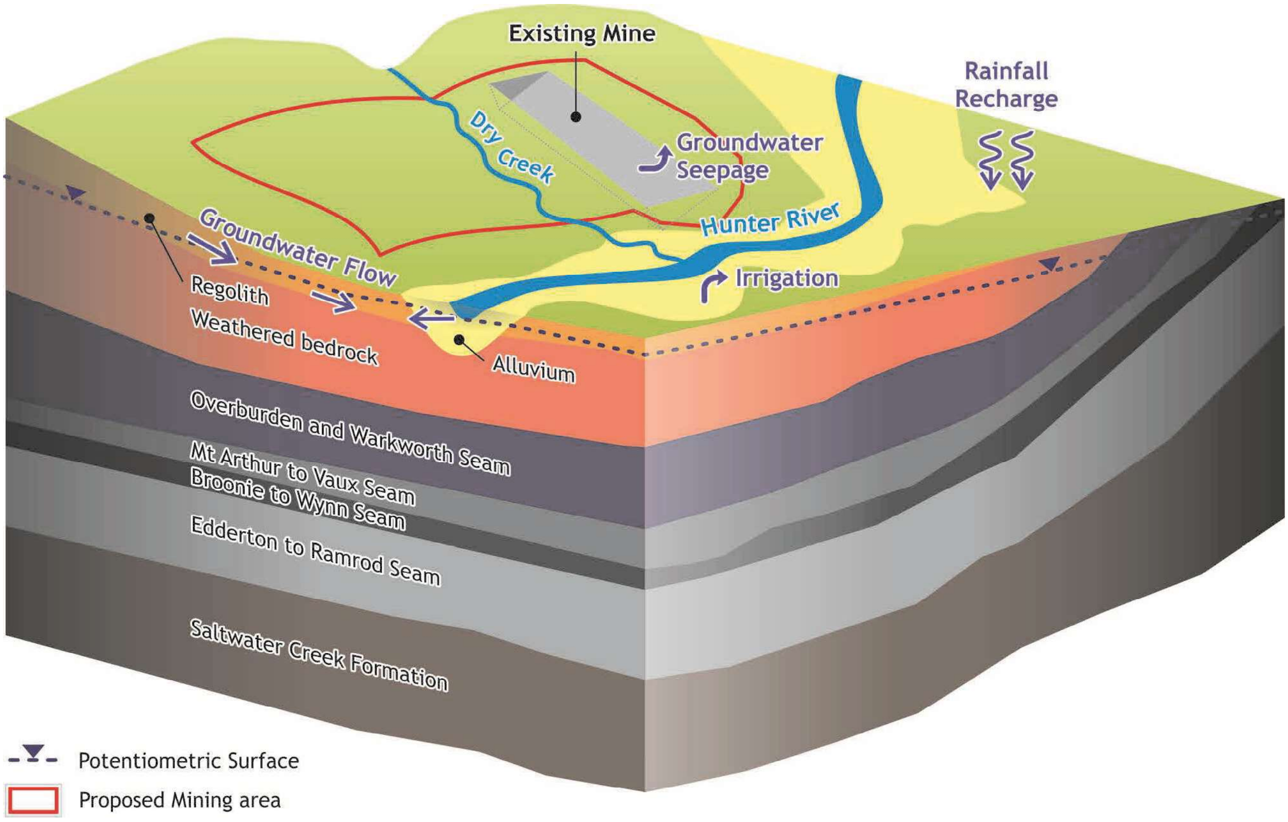


Figure 7.29: Conceptual Model - Vicinity of the Project

The Permian Whittingham Coal Measures are not a significant aquifer. While some coal seams may locally show a moderate permeability, the dominant interburden sections are of very low hydraulic conductivity. This is evident by the very limited volumes of groundwater that have been experienced in the current open cut pits at Bengalla. Only the weathered bedrock (regolith) directly below the ground surface may have somewhat higher hydraulic conductivity locally due to weathering, but this can have a limited saturated thickness, or be unsaturated.

Therefore, from a conceptual groundwater model perspective, the groundwater system has only one significant aquifer system, which are the sand and gravel zones within alluvium along the Hunter River. The sands and gravels are considered an unconfined aquifer, but can be confined where clays and silts overly the sand and gravel zones. The Permian coal seams form a form a confined water bearing strata system with lower permeability interburden units separating the coal seams.

The Hunter River and associated alluvium is the main feature that influences the groundwater flow system. Recharge occurs in the hills where the Permian bedrock outcrops and flows down gradient to discharge into the Hunter River alluvium. The recharge rate, hydraulic properties of the geological strata and topography determine potentiometric levels in the Permian strata and alluvium. This results in mounding of groundwater under the hill areas and a water table surface that is a subdued reflection of the overlying topography. The rate of recharge over the alluvial deposits is significantly higher than over Permian bedrock areas. The lower rates of recharge through the Permian, more evaporative concentration of salts in rainwater and less flushing due to lower permeability resulting in higher groundwater salinity in the Permian strata. Fresh rainfall recharge dominates inputs to the alluvial aquifer system and dilutes brackish to moderately saline Permian groundwater discharging into the alluvial aquifers.

The Hunter River, which is controlled by releases from the Glenbawn Dam, has a flow rate at the Muswellbrook Bridge gauge of between 285 and 427 ML/day. The low flow water level is about 0.5m to 1m above the bed level. The construction of the Glenbawn Dam has altered the flow regime in the Hunter River, and releases of water into the river since this control appear to be recharging the alluvial aquifer during dry periods.

In summary, the area is considered to consist of the following geological units that control flow of groundwater:

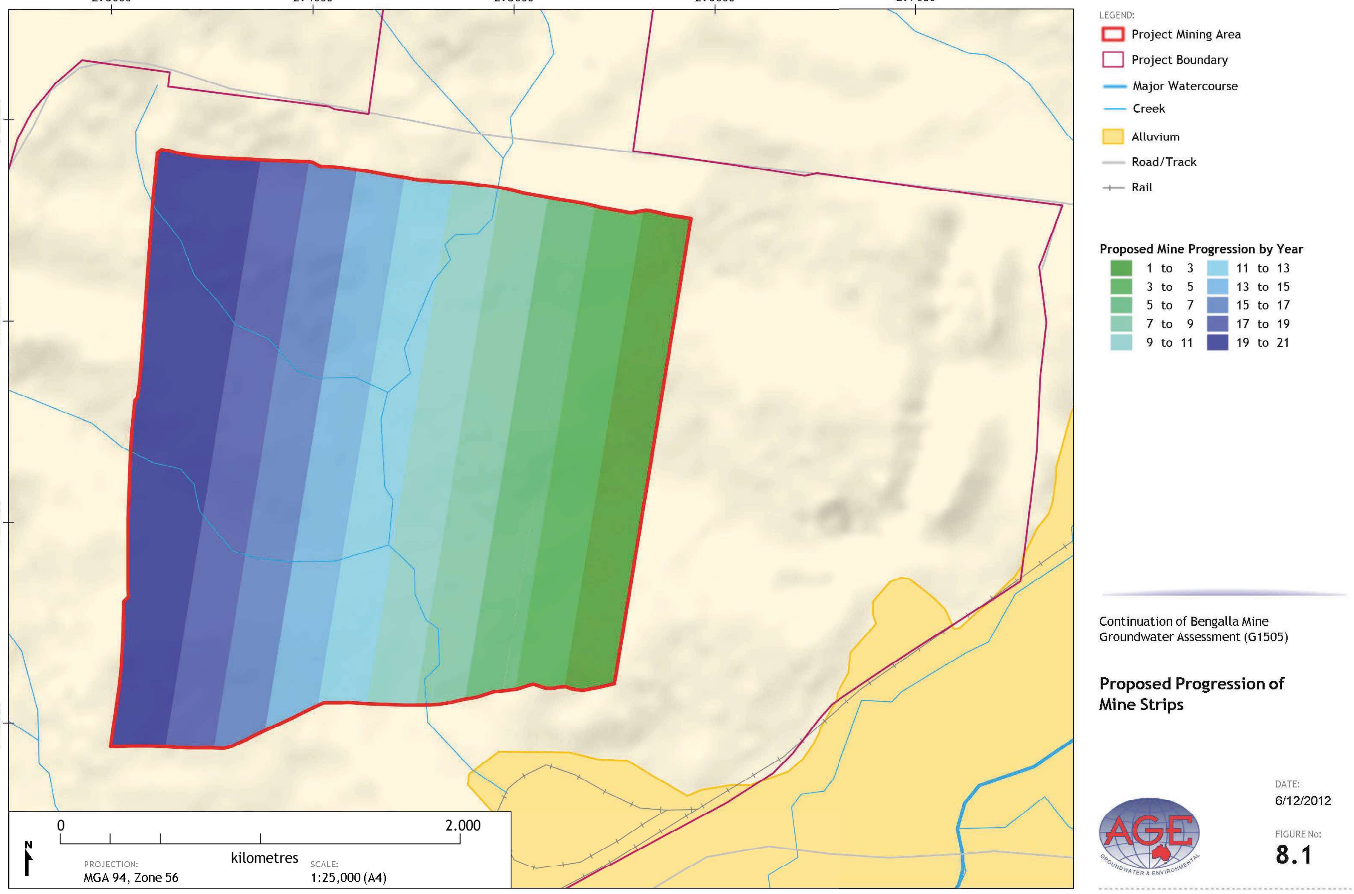
- Alluvium along Hunter River (and minor tributaries);
- Permian regolith;
- Permian coals seams and interburden; and
- Underlying low permeability Saltwater Creek Formation.

8.0 PROPOSED PROJECT DEVELOPMENT

Bengalla commenced coal production in 1999. As discussed previously the project is west of the Muswellbrook Anticline and all coal seams subcrop towards the east and dip towards the west. Mining will advance further down-dip in a westerly direction with the dragline removing strips of approximately 60 m in width. Figure 8.1 shows the planned dragline strips at the pit floor over the life of the Project.

The establishment of a satellite pit (i.e. individual mining area in advance of the main Bengalla pit) may be required during up to Year 4 of the Project to assist with coal quality management. If required, this pit would be within the footprint of the proposed dragline strip area and will be mined through with the westerly progression of the mine plan.

Spoil will be placed within the existing Overburden Emplacement Area (OEA) located east of active mining operations at up to RL 270 m and will descend towards the west. Overburden may also be placed within an additional OEA to the west of Dry Creek until this area is mined. Reject material from the Coal Handling and Preparation Plant (CHPP) will be dried in cells, placed within the spoil and capped with a minimum of 5 m of inert material.



Continuation of Bengalla Mine
Groundwater Assessment (G1505)

Proposed Progression of Mine Strips

DATE:
6/12/2012

FIGURE No:
8.1