APPENDIX

M

Groundwater Impact Assessment

Australasian Groundwater & Environmental Consultants Pty Ltd

REPORT on

MAULES CREEK COAL PROJECT

GROUNDWATER IMPACT ASSESSMENT

Prepared for
ASTON RESOURCES LIMITED

Project No. G1508
June 2011

ABN:64 080 238 642

Australasian Groundwater & Environmental Consultants Pty Ltd

REPORT on

MAULES CREEK COAL PROJECT

GROUNDWATER IMPACT ASSESSMENT

prepared for
ASTON RESOURCES LIMITED

Project No. G1508
June 2011

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

The Maules Creek Coal Project (the Project) is located approximately 18km to the north-east of the township of Boggabri in the north-west region of New South Wales.

Mining tenements across the Project were originally granted in the 1970s. Following this, extensive exploration activities were undertaken with the ultimate aim of defining the local geology and developing a viable mine plan.

The Project was approved and commenced in 1995 with the construction of the Development Dam; however, no open cut mining has been undertaken at the site to date.

Aston Resources Limited (Aston) is seeking a contemporary Project Approval to facilitate the construction and operation of an open cut mining operation extracting up to 13 Million tonnes per annum (Mtpa) of Run of Mine (ROM) coal for a period of 21 years.

The Project targets the Maules Creek coal measures which are early Permian in age and are underlain by the Boggabri Volcanics which form the basement to the Maules Creek sub-basin. The Maules Creek coal measures outcrop as a large hilly area in the Leard State Forest. Outside this area, the coal measures are covered with an extensive blanket of unconsolidated Cainozoic sediments. The Cainozoic sediments are subdivided into two distinct aquifers being the basal Gunnedah Formation and the overlying surficial Narrabri Formation. A total of 15 coal seams have been identified within the Project Boundary, with the average thickness of the seams being between 0.5m and up to 5.0m.

The Maules Creek Coal Measures forms a regular layered easterly dipping sedimentary sequence that gradually thickens to the east to over 800m at the Mooki thrust fault. The Maules Creek Formation consists predominantly of conglomerate and sandstone, with minor siltstone, claystone and intercalated coal seams.

The upper seams in the sequence are incomplete having been eroded by drainage systems and are therefore limited in extent and controlled by topography. This means that some of the shallow seams in the sequence do not extend under, or have a direct hydraulic connection to the alluvial aquifer as they do not form continuous layers on a regional scale. The fact that the deeper seams subcrop against the basement, the Boggabri Volcanics, means that a direct hydraulic connection between these seams and the overlying alluvial sediments is also not present.

A number of hydrogeological studies were undertaken within the Project Boundary in the 1980s as part of the original EIS and project feasibility studies. Information from these studies was supplemented with a field investigation program that included construction of groundwater monitoring bores, vibrating wire pressure sensors, measurement of the hydraulic conductivity of key stratigraphic units, water quality analysis and a census of private bores surrounding the proposed mining operation.

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

- hydrogeologically “tight” and hence very low yielding to essentially dry sandstone, and conglomerate that comprise the majority of the Maules Creek Formation strata;
- low to moderately permeable coal seams which are the prime water bearing strata within the Maules Creek Formation; and
- the underlying Boggabri Volcanics that act as a low permeability basement to the sedimentary units.

The Project proposes an open cut coal mining operation with mining undertaken in strips progressing across dip along the limit of oxidisation of the coal reserve. The mining then continues to move across and down-dip in a series of south-westerly moving strips. The proposed open cut mining area will remain at least 3km from the alluvial aquifers throughout the 21-year mine life.

Numerical simulation of groundwater flow in the aquifers was undertaken using the MODFLOW SURFACT code. The model extent was 29.9km x 39.8km covering an area of approximately 1,190km^2 and centred over the Project Boundary. The model comprised 12 layers representing the major stratigraphic units within the sequence. The model was designed to encompass other coal mines that surround the Project to assess the cumulative impacts of simultaneous mining operations.

The model was calibrated using water level observations from the New South Wales Office of Water (NOW) bores, and monitoring bores constructed for the Project and from surrounding mining operations in steady state conditions.

The transient model was then set up with quarterly stress periods, representing the period from 2006 to 2032 which the historical mining that commenced at adjacent operations and the 21-year period of the Project (2012 to 2032). Cumulative impacts were addressed by including the proposed extension to the adjacent Boggabri Mine and the approved operations at Tarrawonga Mine in the modelling.

The modelling indicates the depressurised zone, as indicated by the 1m drawdown contour at the end of mining in Year 21, extends between 5km and 7km from the proposed open cut pit. The zone of influence largely remains within the Permian outcrop zone, but does extend slightly into the alluvial aquifer in the south-west where a thin zone of alluvium is present in a small valley extending into the outcropping hill. A total of 27 registered bores are encompassed within the zone of influence of the Project, all constructed within the Permian aquifers. Only three of the 27 bores are considered likely to have the potential for a complete failure of water supply. None are privately owned and the three bores are located on land owned by Aston.

The numerical modelling predicts an average groundwater seepage rate to the open cut pit of 550ML/year with a peak of up to 1064ML/year. The groundwater seepage to the proposed open cut pit is largely sourced from storage in the fractured rock overburden/interburden and the coal seams. The seepage will also result in a reduction in the volume of groundwater flow from the Permian bedrock into the alluvial aquifer. The model predicts an average loss of recharge to the alluvial aquifer of 50ML/year. The modelling indicates this 50ML/year water is sourced from Groundwater Management Zone 4 (17ML/year), Zone 5 (5ML/year) and Zone 11 (28ML/year). This loss is very low at less than 1% of both the rainfall recharge simulated by the steady state model, and also the recharge to Zone 4, Zone 5 and Zone 11 reported in the Water Sharing Plan at 43,900ML/year.

The model made a number of conservative assumptions in the setup including the use of a uniform permeability to represent the heterogeneous fractured rock and alluvial systems. The model did also not represent faults that can act as barriers to groundwater flow and therefore the predictions of the model are considered to be conservative, and seepage volumes would potentially be lower than simulated.

The Ecological studies undertaken for the EA have identified *Melaleuca sp* riparian woodland along the alignment of Back Creek and that these species are expected to have a root zone extending some 2m to 3m below the land surface. The modelling indicates some areas along Back Creek may record groundwater levels less than 2m below topography and additional monitoring bores will be constructed in these areas to confirm any effects of groundwater depressurisation by the Project. This will be backed up by other management measures which are discussed in the EA Ecology Impact Assessment Report.

Should mining operations cease after 21 years, dewatering of the open void would not be required and a slow recovery in groundwater levels in the area will occur. The impact of two alternative final landform scenarios on the groundwater regime was simulated as part of the post closure options for the Project. The first, Option 1, was the final void remaining open, with the second option being backfilling of the spoil to a level that is above pre-mining groundwater levels.

In Option 1 where the final void is left open, the groundwater levels reach equilibrium conditions of approximately RL 220m after about 1000 years of pit lake recovery, indicating the final void lake will remain a sink to local groundwater flow. This is due to the high evaporation rates in the region which slow the rate of recovery.

Under Option 2 where the spoil is backfilled, recovery of groundwater levels will reach equilibrium conditions of between RL 307mRL and 309mRL. The recovery period will be between about 400 and 1000 years, depending on the recharge rate to the spoil. Option 2 will result in mounding of groundwater above the pre-mining levels.

The model was subject to a third party review by Associate Professor, Dr Noel Merrick in accordance with the Murray Darling Basin Commission guidelines. Several stages of review were undertaken over the course of the Project, including during conceptualisation of the system, development of the model and reporting. The review classified the model as “moderate complexity” and concluded it was “fit for purpose”.

The potential for the Project to impact on groundwater quality was not considered significant as geochemical testing by others has indicated most overburden materials will generate slightly alkaline and relatively low-salinity run-off and seepage following surface exposure.

Enhancement of the existing groundwater monitoring program has been recommended to provide both an on-going assessment of the impact of the Project and a proactive indicator of any adverse impacts on the groundwater regime.

TABLE OF CONTENTS

Page No.

(G1508)

TABLE OF CONTENTS
(Continued)

Page No.

TABLE OF CONTENTS
(Continued)

Page No.

Project No. G1508.V8
June 2011

REPORT ON

MAULES CREEK COAL PROJECT GROUNDWATER IMPACT ASSESSMENT

1.0 INTRODUCTION

The Maules Creek Coal Project (the Project) is located approximately 18km to the north-east of the township of Boggabri in the north-west region of NSW within the Narrabri Local Government Area. The Project largely falls within Coal Lease 375 (CL 375) and Authorisation 346 (A 346). The Project is owned by Aston Coal 2 Pty Limited (Aston), a wholly owned subsidiary of Aston Resources Limited (Aston Resources).

Mining tenements across the Project were originally granted in the 1970s. Following this, extensive exploration activities were undertaken with the ultimate aim of defining the local geology and developing a viable mine plan. To this end, the document entitled *Maules Creek Coal Project Environmental Impact Statement* (Maules Creek EIS) (KCC 1989) was prepared and submitted to the Narrabri Shire Council (NSC) in October 1989. Development Consent approval (DA 85/1819) was granted on 12 June 1990 for the Maules Creek Coal Mine pursuant to the Maules Creek EIS. DA 85/1819 was physically commenced in 1995 when the Development Dam was constructed; however no open cut mining has been undertaken at the site to date. DA 85/1819 has no sunset clause and remains valid.

Aston seeks a contemporary Project Approval under Part 3A of the *Environmental Planning & Assessment Act 1979* (EP&A Act) to facilitate the development of surface infrastructure and open cut mining activities for the Project generally within its current mining tenements for a period of 21 years. The Project is also generally consistent with activities approved in DA 85/1819. The Project Application Boundary (Project Boundary) is shown on Drawing No. 1.

Aston Resources commissioned Hansen Bailey Pty Ltd (Hansen Bailey) to prepare an Environmental Assessment (EA) in support of the Part 3A Project Application. This groundwater impact assessment has been completed by Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) at the request of Hansen Bailey, on behalf of their client Aston Resources and forms part of the EA.

2.0 PROJECT OVERVIEW

Aston is seeking a contemporary Project Approval to facilitate the development of surface infrastructure and open cut mining activities for the Project generally within its current mining tenements for a period of 21 years. The Project generally comprises:

- The construction and operation of an open cut mining operation extracting up to 13 Million tonnes per annum (Mtpa) Run of Mine (ROM) coal to the Templemore Seam;
- Open cut mining fleet including excavator / shovels and fleet of haul trucks, dozers, graders and water carts utilising approximately 470 permanent employees;
- The construction and operation of a Coal Handling and Preparation Plant with a throughput capacity of 13 Mtpa ROM coal;
- The construction and operation of a Tailings Drying Area;
- The construction and operation of a rail spur, rail loop, associated load out facility and connection to the Werris Creek to Mungindi Railway Line;
- The construction and operation of a Mine Access Road;
- The construction and operation of administration, workshop and related facilities;
- The construction and operation of water management infrastructure including a water pipeline, pumping station and associated infrastructure for access to water from the Namoi River;
- The installation of supporting power and communications infrastructure; and
- The construction and operation of explosive magazine and explosives storage areas.

The Project as proposed is generally consistent with that approved in DA 85/1819.

3.0 SCOPE OF WORK

The Director General's Environmental Assessment Requirements (EARs) for the soil and water assessments provided by NSW Department of Planning (DoP) on 6 December 2010 are as follows:

- a detailed modelling of the potential surface and groundwater impacts of the project;
- a detailed site water balance, including a description of the measures to be implemented to minimise water use on site;
- a detailed assessment of the potential impacts of the project on:
    - the quality and quantity of both surface water and ground water resources;
    - water users, both in the vicinity of and downstream of the project;
    - the riparian and ecological values of the watercourses both on site and downstream of the project; and
    - environmental flows; and
- a detailed description of the proposed water management system for the project and water monitoring program.

(G1508)

The objective of the groundwater study was to assess the impact of the Project on the hydrogeological regime and to meet the applicable EARs. To achieve this objective a scope of work was developed that included:

- identification of groundwater resources in the vicinity of the site which could be impacted by the Project;
- a site visit to discuss the Project with staff at the mine;
- assessment of the potential for any groundwater impacts resulting from the Project, including modelling the cumulative groundwater impacts of the Project with existing and proposed mining projects (including groundwater impacts on each identified privately owned bore);
- assessment of post-mine groundwater impacts and recovery of groundwater levels;
- the development of groundwater management strategies;
- identification of any groundwater impact mitigation measures necessary for the Project; and
- a recommended groundwater management program.

The area investigated as part of the groundwater study had an approximate radius of 15km surrounding the Project Boundary and encompassed the alluvial aquifers surrounding the mine.

4.0 LEGISLATION, POLICY AND GUIDELINES

The following section outlines New South Wales State Government legislation, policy and guidelines with respect to groundwater that must be addressed in assessing a mining proposal.

4.1 Water Act 1912

The *Water Act 1912* (Water Act) governs the issue of water licences from water sources including rivers, lakes and groundwater aquifers in NSW. It also manages the trade of water licences and allocations.

The Water Act is progressively being replaced by the *Water Management Act 2000* (WM Act), 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. A draft Water Sharing Plan for this area known as the *Murray-Darling Basin Porous Rock Groundwater Sources Water Sharing Plan* was released for public comment between 6 December 2010 and 31 January 2011, but has not been adopted at the time of writing.

Aston Resources currently has a single 6ML/year groundwater licence under Part 5 of the Water Act to extract groundwater from the Permian coal seam aquifer for mining and industrial purposes (90BL255704). This licence replaces licence 90BL121059 which was surrendered when bore GW053825 was replaced during 2010.

A water sharing plan is in place for the Namoi Valley alluvial aquifer that surrounds the Project Boundary and water access licences and approvals to take and use water are granted according to the WM Act.

4.2 Water Management Act 2000

The objective of the WM Act is the sustainable and integrated management of the State's water for the benefit of both present and future generations. The WM Act provides clear arrangements for controlling land based activities that affect the quality and quantity of the State's water resources. It provides for four types of approval:

- water use approval – which authorise the use of water at a specified location for a particular purpose, for up to 10 years;
- water management work approval;
- 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.

For controlled activities and aquifer interference activities, the WM Act requires that the activities avoid or minimise their impact on the water resource and land degradation, and where possible the land must be rehabilitated.

The Water Sharing Plan for the Upper and Lower Namoi Groundwater Sources commenced in November 2006. The water sharing plan sets the framework for managing groundwater in the Upper and Lower Namoi alluvial aquifers until the end of the 2015/16 water year.

The Water Sharing Plan for the Upper and Lower Namoi Groundwater Sources includes all water contained in the unconsolidated alluvial sediment aquifers associated with the Namoi River and its tributaries and is subdivided into 13 zones. The Project is located in an area of outcropping bedrock surrounded by Zone 4 to the south, Zone 5 to the west, and Zone 11 to the north. The location of the zones is shown in Figure 1.

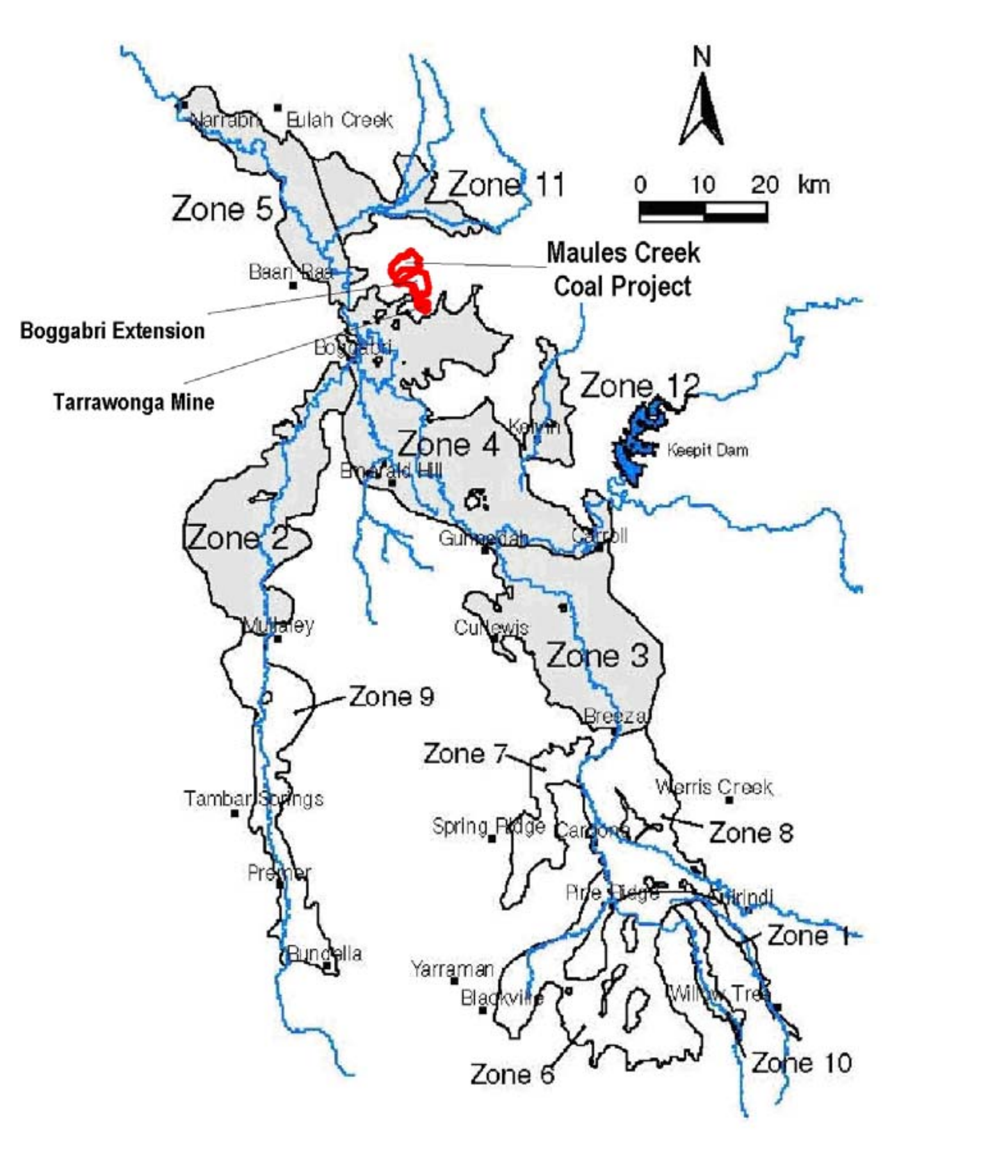


Figure 1: Upper Namoi Alluvial Aquifer Zones (after NOW 2006)

The objectives of the Water Sharing Plan are to:

> *"(a) protect, maintain and, where practicable, enhance ecosystems dependent on groundwater, and the cultural and spiritual values of groundwater, by minimising the impacts on these of groundwater extraction,*
>
> *(b) protect the structural integrity of the aquifers and groundwater quality, by ensuring groundwater extraction does not result in any aquifer compaction, aquitard compaction, land subsidence or change in the beneficial use of the aquifer,*
>
> *(c) manage access to the extraction limits to ensure there are no long-term declines in water levels,*
>
> *(d) preserve basic landholder rights access to these groundwater sources and ensure the fair, equitable and reliable access to groundwater through the management of local impacts or interference effects,*

(e) contribute to the protection, maintenance and enhancement of the economic viability of groundwater users and their communities in the Namoi Valley,

(f) ensure opportunities for market based trading of groundwater access licence rights within sustainability and interference constraints, and

(g) ensure sufficient flexibility in account management to encourage efficient use of these groundwater sources and to manage these groundwater sources to account for climatic variations."

A summary of the aquifer access licences presented in the Water Sharing Plan for zones surrounding the Project Boundary are summarised in Table 1.

Table 1: SUMMARY OF AQUIFER ACCESS LICENCES

Category	Aquifer Volumetric Licence (ML/yr)			
	Zone 4	Zone 5	Zone 11	TOTAL
Domestic and Stock	667	262	210	1,139
Native Title	0	0	0	0
Local Water Utility	4,660 3,900 Gunnedah 760 Boggabri	None	None	4,660
Share Components	21,040	16,000	2,200	39,240
Recharge	25,700	16,000	2,200	43,900

Aston Resources currently holds Water Access Licence WAL 2811 in Zone 5 for 135 unit shares which can be extracted from a bore on the Olivedene property.

Under the draft *Murray-Darling Basin Porous Rock Groundwater Sources Water Sharing Plan* the area is subdivided in zones, with the Project being located in the Gunnedah-Oxley Basin Murray Darling Zone I.

4.3 State Groundwater Policy

The NSW State Groundwater Policy (Framework Document) was adopted in 1997 and aims to manage the State's groundwater resources to sustain their environmental, social and economic uses. The policy has three components parts, namely:

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

4.3.1 Groundwater Quality Protection

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

1. *"All groundwater systems should be managed such that their most sensitive identified beneficial use (or environmental value) is maintained.*
2. *Town water supplies should be afforded special protection against contamination.*
3. *Groundwater pollution should be prevented so that future remediation is not required.*
4. *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.*
5. *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.*
6. *Groundwater dependent ecosystems will be afforded protection.*
7. *Groundwater quality protection should be integrated with the management of groundwater quality.*
8. *The cumulative impacts of developments on groundwater quality should be recognised by all those who manage, use, or impact on the resource.*
9. *Where possible and practical, environmentally degraded areas should be rehabilitated and their ecosystem support functions restored."*

4.3.2 Groundwater Dependent Ecosystems

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 Groundwater Dependent Ecosystems 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. A summary of the principles follows:

- groundwater dependent ecosystems (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 affects on groundwater by maintaining natural patterns, not polluting or causing changes to groundwater quality and rehabilitating degraded groundwater ecosystems where necessary.

4.3.3 Groundwater Quantity Protection

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 (sic) 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 Aquifer Risk

The "Aquifer Risk Assessment Report" of 1998 used a number of criteria to classify risks to various significant groundwater resources across the State. It classified the Upper Namoi Valley Alluvium as a "highest risk aquifer".

4.5 Federal Government Legislation

The Federal Water Act 2007 applies to the Murray Darling Basin in which the Project Boundary lies. There is no direct requirement for the licensing of water under this Act; however Basin Plans and Water Resource Plans for this area are currently being prepared. These plans may impact on how water can be extracted, stored, used and the rules for trading or transferring water rights.

5.0 REGIONAL SETTING

5.1 Location

The Project is located approximately 18km north-east of the township of Boggabri which is situated approximately 40km and 60km from the larger centres of Gunnedah and Narrabri respectively. The Project is located within the Leard State Forest and largely on mining lease CL375 which covers an area of approximately 4,154ha (Drawing No. 1).

The Leard State Forest covers an area of 8,134ha and incorporates the Willow Tree Range that borders the southern boundary of the Project Boundary. The Boggabri Coal Mine and Tarrawonga Mine adjoin the Project Boundary to the south.

Drawing No. 2 shows where the key facilities are located along with the adjacent mining operations.

5.2 Surrounding Mining Operations

The adjacent Boggabri Coal Mine is an open cut mine with approval to produce up to 5 Mtpa of thermal coal. In 2009 the Boggabri Coal Mine produced 1.5 Million tonnes (Mt) of thermal coal for the export market.

Construction of the Boggabri Coal Mine commenced in 2005 with the first coal delivered to the ROM coal pad in October 2006 and the construction activities were largely completed by November 2006. The current method of open cut mining allows coal extraction to occur in the uppermost seams in the sequence including the Braymont, Bollol Creek, Jeralong and Merriown Coal Seams to a depth of approximately 110m below the existing surface.

A Coal Preparation Plant (CPP), tailings dam, rail spur and mine site rail loop are approved but have not yet been constructed nor has a dragline been introduced to the operations.

The current mining approval for the Boggabri Coal Project expires in 2012 and the company is currently seeking approval for a further 21 years of mining at rates of up to 7 Mtpa ROM coal.

The approved Tarrawonga Mine, located immediately to the south of the Boggabri Coal Mine is managed by Whitehaven Coal Mining Limited (Whitehaven) on behalf of Tarrawonga Coal Pty Ltd, which is a joint venture between Whitehaven (70%) and Boggabri Coal (30%). The Tarrawonga Mine commenced coal production within ML 1579 during 2006, using truck and excavator methods and produces up to 1.5 Mtpa product coal (Resource Strategies 2010). DoP approved Whitehaven's proposal to extract additional coal reserves within the existing ML 1579, with no planned increase in annual coal production or mine life.

Goonbri Coal Mine currently holds Exploration Lease (EL) 7435 located approximately 6km south-east of the Project Boundary. Tarrawonga Mine also holds EL 5967 to the south of its existing operations. No information is currently available on the plans to develop these areas as at the time of writing this EA.

There are a number of other coal mining operations within the Gunnedah Basin that are distant from the Project Boundary and are discussed further within this document.

5.3 Topography and Drainage

The topography of the area is controlled by the underlying geology that is comprised of volcanic basement overlain by sedimentary coal measures, which are inturn overlain by alluvial sediments. The alluvial lands form a relatively flat floodplain adjacent to the Namoi River. Tributaries of the Namoi River including Maules Creek to the north of the Project and Bollol Creek to the south run in a westerly direction and also have large broad but gently sloping flood plains.

The outcrop of the basement geology is evident as upland slopes and hills that rise up to between RL 315m and RL 445m in the area of the Project. Away from the ridgelines, the topography is gently undulating and ground slopes are principally less than 10%. The hills and slopes are drained by a series of generally westerly flowing ephemeral creeks that meander across the floodplain and discharge to the Namoi River. The alluvial land falls gently from about RL 340m in the east to RL 230 at the Namoi River over a distance of about 20km. Back Creek originates within the mining lease and flows in a westerly direction.

The Namoi River is the most significant water body in the Namoi Valley and flows in a north-westerly direction passing through the town of Boggabri. The Namoi River is about 10km west of the Project Boundary.

Photographs of the creeks are included in Appendix 1.

5.4 Land Use

The predominant land uses in the Leard State Forest area are forestry, mining and recreational uses. Land use in the wider region also includes forestry, mining and agriculture. Forestry activities occur predominantly on the steeper slopes and poorer soils. The fertile Namoi River alluvial floodplain, shown on Drawing No. 1, supports an array of agricultural enterprises including cotton, wheat and cattle grazing.

5.5 Climate

The climate in the vicinity of the Project Boundary is temperate and is characterised by hot summers with regular thunderstorms and mild dry winters. Rainfall records collected by the Bureau of Meteorology (BoM) were obtained from the Boggabri Post Office which is located about 19km to the south-west of the Project Boundary, and the Gunnedah Pool BOM Station, located about 41km to the south. A summary of climate data is provided in Table 2.

Table 2: CLIMATE AVERAGES

Month	Mean Daily Temperature (°C)				Mean Monthly Rainfall (mm)		Mean Monthly Rain Days		Mean Monthly Relative Humidity (%)*		Mean Monthly Evaporation (mm)**
	Gunnedah Pool		Boggabri Met Dataset		Gunnedah Pool	Boggabri Met Dataset	Gunnedah Pool	Boggabri Met Dataset			
	Min	Max	Min	Max					9:00 AM	3:00 PM	
January	18.3	34.0	19.6	34.5	71.1	56.0	6.5	6.0	60.0	43.0	238.7
February	18.1	32.9	18.8	32.9	66.5	100.1	6.1	8.7	65.0	45.0	197.2
March	15.8	30.7	15.1	31.1	47.9	19.1	4.6	2.3	64.0	44.0	186.0
April	11.4	26.4	12.3	25.5	37.7	13.0	4.3	2.5	67.0	46.0	132.0
May	7.1	21.3	3.0	22.0	42.5	50.0	5.1	3.0	73.0	51.0	83.7
June	4.3	17.6	6.5	17.9	43.9	57.2	6.3	6.5	78.0	55.0	57.0
July	3.0	16.9	3.9	16.9	42.2	36.1	6.2	4.0	77.0	53.0	58.9
August	4.1	18.9	5.4	22.6	41.3	38.7	6.1	3.3	71.0	48.0	86.8
September	6.9	22.8	8.6	22.4	39.6	37.1	5.8	2.7	65.0	43.0	120.0
October	10.7	26.7	12.3	27.4	55.2	27.6	6.9	4.0	61.0	43.0	164.3
November	14.1	30.3	16.2	26.7	61.2	78.3	6.8	8.0	59.0	40.0	201.0
December	16.8	33.0	17.8	30.0	68.0	80.7	6.9	8.3	58.0	40.0	241.8
Annual Mean / Total	**10.9**	**26.0**	**12.4**	**26.2**	**617.1**	**593.9**	**71.6**	**59.3**	**67.0**	**46.0**	**1767.4**

Source: Hansen Bailey (2010)[1]

The average annual rainfall at Boggabri is 594mm with February being the wettest month (101mm). Evaporation of 1,767mm/year exceeds mean rainfall throughout the year, with the highest moisture deficit occurring during summer.

Monthly rainfall records were used to calculate the Cumulative Rainfall Deficit (CRD - also referred to as the Rainfall Residual Mass) for the Boggabri Post Office (refer Figure 2). The CRD is a summation of the monthly departure of rainfall from the long-term average monthly rainfall and provides a historical record of relatively wet and dry periods. A rising trend in slope in the CRD plot indicates periods of above average rainfall, whilst a declining slope indicates periods when rainfall was below average.

The CRD for Boggabri indicates a long cycle of below average rainfall from about 1910 to 1947. From 1947 to 1980 the pattern was dominated by above average falls indicated by the rising trend in the graph. Since 1980 there have been several cycles of above and below average rainfall each of about 10 years in duration.

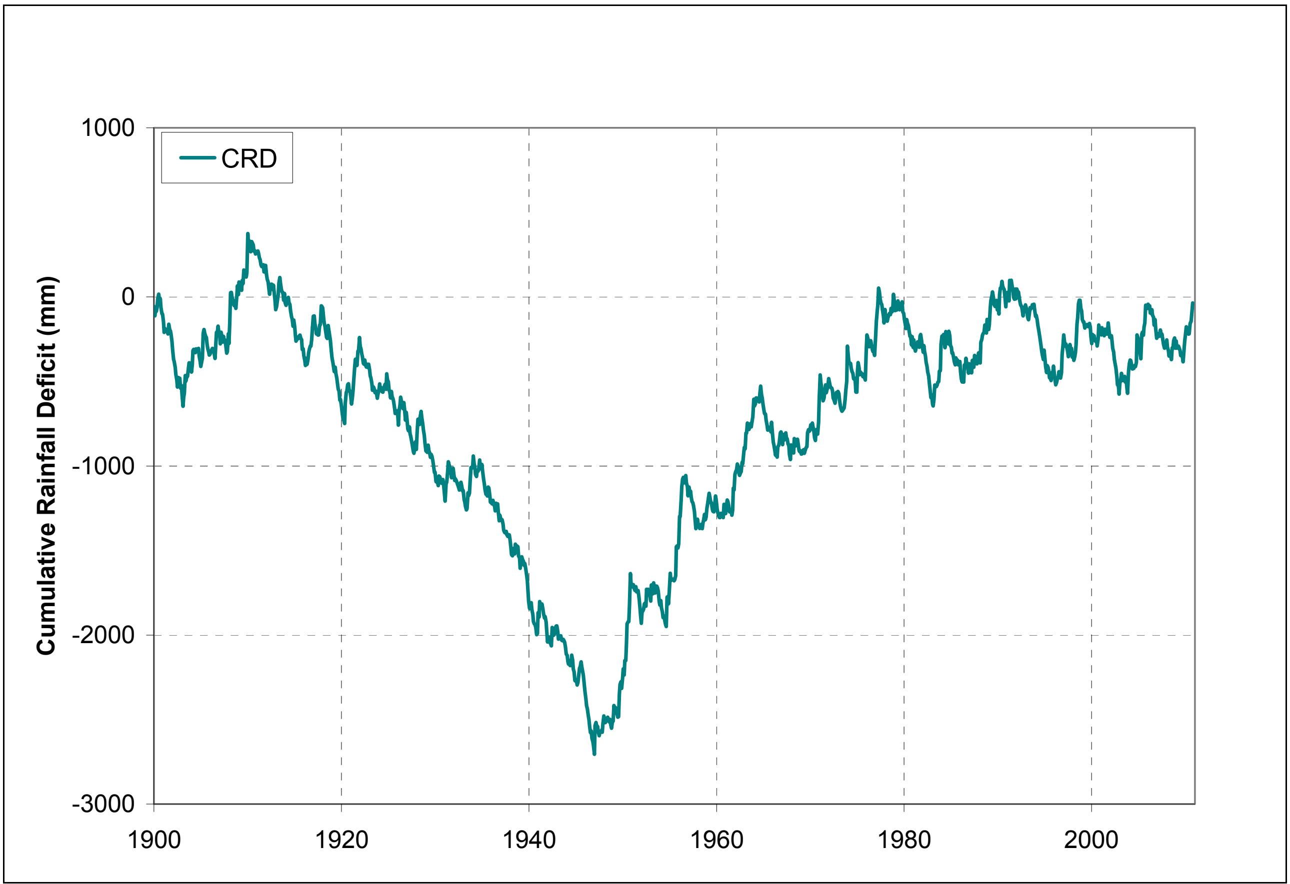


Figure 2: Cumulative Rainfall Deficit - Boggabri Post Office (mm)

5.6 Geology

The Maules Creek coal deposit which is early Permian in age and part of the Bellata Group is located in the Maules Creek sub-basin. The Maules Creek sub-basin is underlain by the Boggabri Volcanics, and is physically separated from the western Mullaley sub-basin by a basement ridge formed by the Boggabri Volcanics, which primarily consists of dacitic to rhyolitic basalt and pyroclastic rocks (refer Figure 3).

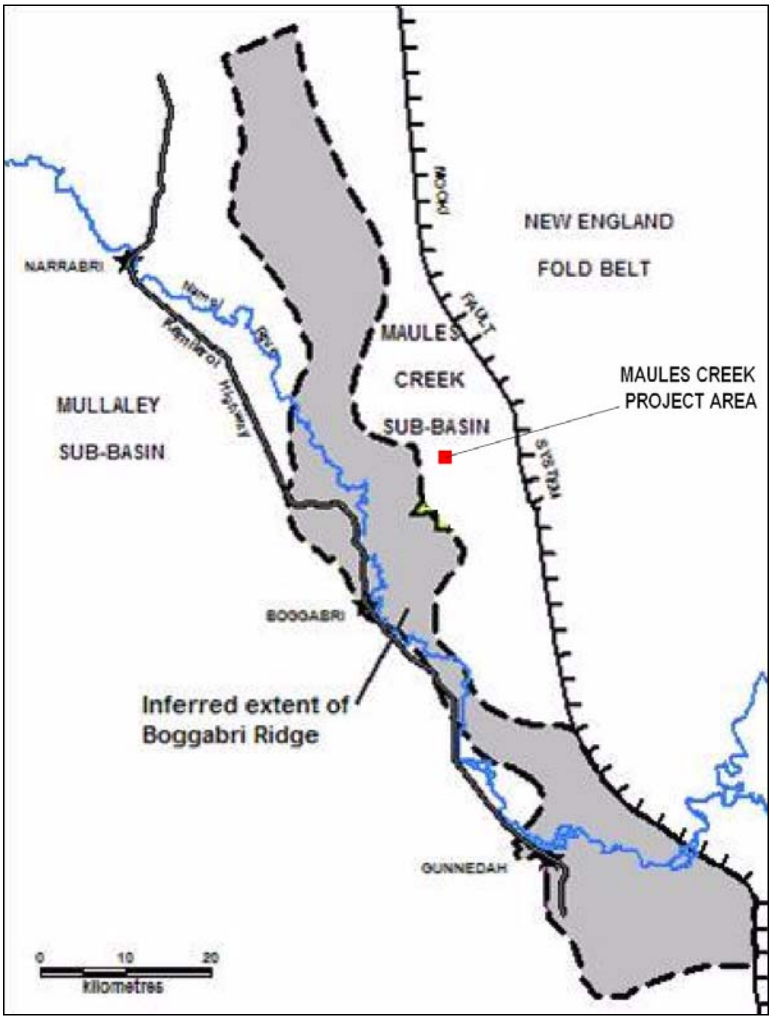


Figure 3: Maules Creek Sub-Basin

The Boggabri Volcanics were subject to extensive erosion and weathering during the very early Permian resulting in the formation of an irregular palaeo-topography onto which the Belatta Group coal deposits were laid. A large area of the Permian bedrock is covered with an extensive blanket of unconsolidated Cainozoic sediments as shown in the regional geology map published by the then Department of Mineral Resources (now Department of Infrastructure and Investment [DII]) (1993) which is reproduced in Drawing No. 3. The Cainozoic sediments can be subdivided into two distinct aquifers being the basal Gunnedah Formation and the overlying surficial Narrabri Formation.

The Maules Creek Formation forms a regular layered easterly dipping sedimentary sequence that gradually thickens to the east to over 800m at the Mooki Thrust Fault. The Maules Creek Formation consists predominantly of conglomerate and sandstone, with minor siltstone, claystone and intercalated coal seams. The Maules Creek Formation underlies the Cainozoic sediments to the north and south of the Project Boundary. To the west the Cainozoic sediments are underlain by the Boggabri Volcanics.

The generalised stratigraphy of the site is shown graphically in Figure 4. A total of 15 coal seams have been formally identified in the area of mining lease CL 375. The average thickness of the seams in the above sequence are between 0.5m and up to 5.0m. The adjacent Boggabri Coal Mine currently recovers coal from the upper Braymont, Bollol Creek, Jeralong and Merriown Seams. The Tarrawonga Mine extracts coal to the floor of the Nagero Seam.

(G1508)

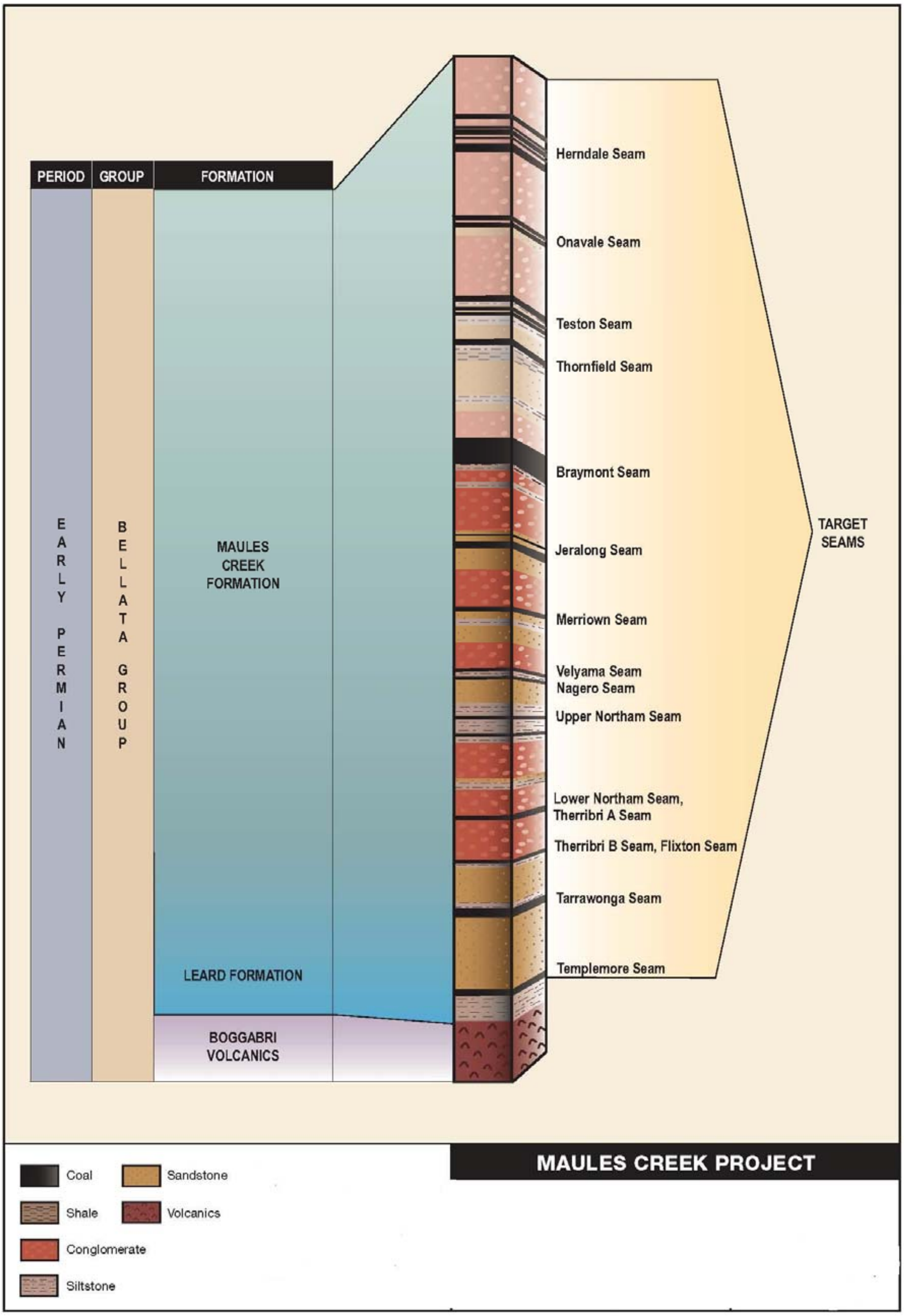


Figure 4: Generalised Stratigraphy after Hansen Bailey (2010)[2].

6.0 FIELD INVESTIGATION PROGRAM

A field investigation was undertaken as part of the coal resource exploration drilling program to gather additional hydrogeological information within CL 375. The hydrogeological investigation program included:

- measurement of the hydraulic conductivity of key stratigraphic units using a wireline packer;
- construction of eight groundwater monitoring bores (piezometers) within different lithological units;
- installation of grouted in vibrating wire piezometers (VWPs) in four exploration drillholes;
- measurement of groundwater levels in the new piezometers, and one off measurements in exploration drill holes prior to grouting;
- collection of groundwater samples for water quality analysis from the new piezometers on a routine basis, and a one-off sampling event from selected exploration drill holes, prior to then being grouted up;
- collection and analysis of rainwater samples; and
- a census of private bores surrounding the proposed mining operation.

The key components of the field investigation program are described in more detail below.

6.1 Groundwater Monitoring Network

Drilling and installation of the groundwater monitoring network was undertaken between 5 June and 10 August 2010. Eight piezometers and four VWPs were constructed in exploration drill holes as part of the hydrogeological investigation program. The sites were selected to provide good spatial coverage over the area to be mined as shown in Drawing No. 4. The nomenclature used to identify each bore was the original number for the exploration drill hole. Key details from the monitoring bore network are summarised in Table 3.

Table 3: MONITORING NETWORK DETAILS

Drill Hole ID	NOW Licence No.	Hole Depth (m)	Construction Method	Screen or VWP Depth	Screen or VWP Zone Geology
MAC252	90BL255780	260	bore	92.5 – 98.5	Braymont Seam
MAC1218	90BL255788	110	bore	107 – 110	Nagero, Upper/Lower Northam, Therribri and Flixton Seams
MAC1219	90BL255789	163	bore	107 – 110	Jeralong and Merriown Seams
MAC1259B	90BL255783	98	Screened bore	94 – 97	Boggabri Volcanics
MAC1261	90BL255781	180	Screened bore	161 – 164	Braymont Seam
MAC1279	90BL255782	144	Screened bore	70 – 73	Jeralong Seam

Table 3: MONITORING NETWORK DETAILS					
Drill Hole ID	**NOW Licence No.**	**Hole Depth (m)**	**Construction Method**	**Screen or VWP Depth**	**Screen or VWP Zone Geology**
MAC1280	90BL255785	146	Screened bore	56 – 59	Conglomerate interburden
MAC1283	90BL255779	91	Screened bore	61 – 64	Velyama Seam
MAC1284	90BL255790	180	VWP	165	Lower Northam Seam
MAC263	90BL255784	234	VWP	105 183	Braymont Seam Velyama, Nagero, Upper Northam
MAC267P	90BL255786	299	VWP	154 260	Braymont Seam Velyama, Nagero, Upper Northam
MAC268P	90BL255787	318	VWP	280	Velyama, Nagero, Upper Northam

RAB – rotary air blast

VWP – vibrating wire piezometer

Vibrating wire sensors were used in the more elevated areas of the Project Boundary where the groundwater levels were relatively deep, that is the depth to the potentiometric surface exceeded 100m.

In the short-term, the monitoring bores were designed to provide water quality information and water level data for numerical modelling. In the long-term, the bores provide locations for monitoring the impact of the operations on groundwater levels and quality during mining. Most of the bores are within the proposed mining footprint and will therefore be removed during mining, however prior to this each bore will provide information on the magnitude of the zone of influence as it propagates out from the highwall.

6.2 Monitoring Bore Construction

The monitoring network was constructed in holes drilled for exploration purposes. Photographs of the drilling program are included in Appendix 1. Fully cored boreholes (96mm OD HQ size), and rotary air blast (RAB) boreholes (114mm OD), were utilised. Each hole was drilled and logged under the supervision of an Aston Resources geologist. The lithological and geophysical logs were then supplied to an AGE hydrogeologist and each monitoring bore designed. The installation of the monitoring bores and VWPs was undertaken by GOS Drilling Contractors under the supervision of an independent New South Wales Class 6 licensed water bore driller. At completion the details of each monitoring bore constructed were provided to NOW. Monitoring bore construction logs are included in Appendix 2.

The boreholes were cased with Class 18, 50mm diameter, lead free, uPVC casing. Machine slotted uPVC screens were placed at the base of the hole with blank PVC casing completing the hole to the surface. A clean, 3-6mm gravel filter was placed by gravity around the screens and a bentonite seal (1/4” bentonite pellets) was placed above the gravel pack. A cement/bentonite grout plug was used to seal the hole to the surface. Lockable steel covers protruding about 0.75m at the surface were placed at each site. Table 4 summarises the construction of the monitoring bores, with more detailed borehole logs included in Appendix 2.

After construction, the monitoring bores were developed using the airlift method, until all drilling foam was removed and clear sediment free water was being produced.

Table 4: MONITORING BORES WATER LEVEL DATA

Bore ID	Target Aquifer	Coordinates		Ground Level (mRL)	TOC (mRL)	Screen Zone (mRL)	Static Water Level		
		Easting (m)	Northing (m)				Date	mbTOC	mRL
MAC252	coal	226231	6614775	340.63	341.19	248.1-242.1	17/09/10	51.24	289.91
MAC1218	coal	224015	6613693	361.40	362.32	254.4-251.4	1/09/10	82.96	279.36
MAC1219	coal	224172	6613678	370.41	371.23	263.4-260.4	1/09/10	91.6	279.63
MAC1259B	volcanics	224959	6615286	316.95	317.1	222.9-219.9	1/09/10	39.26	277.86
MAC1261	coal	226750	6614872	382.28	383.07	221.3-218.3	17/09/1	96.87	286.20
MAC1279	coal	226446	6616312	326.85	327.76	256.8-253.8	17/09/10	47.14	280.62
MAC1280	interburden	226525	6616503	323.50	324.55	267.5-264.5	17/09/10	31.12	293.43
MAC1283	coal	224989	6615291	318.22	318.98	257.2-254.2	1/09/10	41.07	277.91
MAC1284	coal	223745	6612486	434.23	434.33	S1: 269.23	Sensor Failed		
MAC263	coal	226037	6614513	348.26	349.67	S1:143.26	1/11/10	70.67	277.59
						S2:165.26	1/11/10	74.67	273.59
MAC267P	coal	227440	6615472	405.56	405.66	S1: 251.56	1/11/10	119.27	286.29
						S2:148.56	1/11/10	131.27	274.29
MAC268P	coal	227498	6614521	416.77	416.92	S1: 136.77	1/11/10	170.09	246.68

Notes: TOC – top of casing
mRL – metres Australian Height Datum
Screen zone from base of borehole to top of bentonite/cement seal
Coordinate Projection - MGA94, Zone 56

S1 and S2: VMP pressure sensor (1 & 2) install elevation

6.3 Water Sample Collection and Analysis

Groundwater samples were collected after development of the monitoring bores by representatives of ALS Laboratory Group using disposable bailers.

The groundwater samples were analysed for:

- pH, EC and Total Dissolved Solids (TDS); and
- Major Anions (CO_3, HCO_3, Cl, SO_4) and Cations (Ca, Mg, Na, K).

The results of the laboratory testing are presented and discussed in Section 7.4.

The water quality program also included collection of samples from selected open exploration drill holes prior to abandonment, and collection of rainwater samples.

6.4 Permeability Tests

Hydraulic packer testing was carried out in four HQ size core holes; MAC250, MAC257, MAC263 and MAC265. The test intervals within the drill holes were based on a review of the core logs for each hole. The equipment used for the testing was a straddle / double packer arrangement inflated to between 250 – 400 psi within the HQ (97 mm diameter), drill holes at the pre-selected depths. GOS Drilling carried out the packer testing between 10 and 20 September 2010. The raw data was recorded by licenced driller Gordon Monkman and interpreted by AGE using the Thiem equation to derive an effective transmissivity. The results of the testing are presented in Section 7.4.2.

6.5 Bore Census

A census of privately owned bores within the predicted zone of influence was undertaken between 5 and 6 January 2011 by a representative of Aston Resources. The purpose of the bore census was to gather information on bores within the potential zone of depressurisation created by the Project.

Anecdotal information on the construction of each bore, yield and usage was collected. Where possible groundwater levels were measured at each bore and a sample of water collected for laboratory analysis. The results of the bore census are summarised in Appendix 3 and discussed in Section 10.3.

7.0 HYDROGEOLOGICAL REGIME

7.1 Previous Groundwater Investigations

The first major hydrogeological investigation undertaken at the Maules Creek site was carried out in 1982 by Kembla Coal and Coke Pty Ltd. This work was undertaken by Coffey and Partners (1982) and comprised baseline data collection, water supply consideration and a characterisation of the site hydrogeology and hydrology. This Project identified a number of sites to be investigated in the alluvial aquifers for a potential project water supply.

Coffey and Partners (1983) undertook a field investigation program to assess an appropriate and potential water supply in the Maules Creek alluvium. Work was also undertaken in the Permian coal seams within the Leard State Forest. Coffey and Partners (1983[2]) followed this up with further field investigation of the extent and nature of sediments in the Maules Creek alluvium, at sites identified in the 1982 report. Surface resistivity geophysics was undertaken near the Stoney Creek junction. Coffey and Partners (1984) then investigated the Namoi River alluvium “on and near the vicinity of Velyama” to supplement a proposed Maules Creek alluvium wellfield. (Note: a wellfield is not required for the current Project).

Coffey and Partners (1985 and 1986) work followed on from the previous studies looking at a 1,500ML/yr groundwater supply from the Maules Creek alluvium. Work included a numerical model and the likely impacts from pumping.

The information from the hydrogeological studies was used by Kembla Coal and Coke (1989) in the Environmental Impact Statement (EIS) to gain government approval for the proposed development of the coal deposit. The water balance for the project estimated 175ML/yr inflow of groundwater to the open cut, and 10ML/yr to the proposed underground mine. This was based on open cut mining down to the level of the Braymont Seam only.

Hydrogeological investigations were also undertaken at the site of the current Boggabri Coal Mine in the 1970s and 1980s. This project also identified the alluvial aquifer as a potential water supply for mining and included some investigations in this aquifer to the south of the mine. Modelling studies as part of the environmental approvals process were undertaken for the Boggabri Coal Mine by PB (2005) and AGE (2010).

Outside the Permian outcrop area, the Namoi Valley alluvial aquifer has been much more heavily investigated by government water departments and research institutions. The most recent modelling report on the alluvial aquifer relevant to the current study is the groundwater model prepared for Groundwater Management Zones 2, 3, 4, 5, 11 and 12 by the New South Wales Office of Water [NOW] (2006), formerly New South Wales Department of Natural Resources (2006). Also of relevance is groundwater modelling undertaken by CSIRO (2007) that used previously developed models to investigate sustainable yields of surface water and groundwater in the Namoi Valley.

The Cotton CRC has also sponsored a number of groundwater research projects undertaken by the University of New South Wales within the Maules Creek catchment. This has included an assessment of the interaction between surface water streams and groundwater in the Maules Creek catchment using a range of techniques (Andersen and Acworth 2009).

Relevant information from the above reports is provided in the following discussion of the hydrogeological regime of the alluvial and bedrock aquifers.

7.2 Alluvial Aquifers

7.2.1 Distribution

Alluvial plains are present in areas surrounding the Project Boundary, existing to the:

- North - Maules Creek alluvial aquifer,
- South - Bollol, Driggle Draggle and Barneys Spring Creeks, and
- West - Namoi River.

The alluvial aquifers that underlie the alluvial plains are part of the Upper Namoi Alluvial Aquifer Zones shown previously in Figure 1. Maules Creek alluvial aquifer is in Zone 11, Bollol, Driggle Draggle and Barneys Spring Creeks in Zone 4 and the Namoi River alluvial aquifer is located in Zone 5. The boundary between Zones 4 and 5 is at Gins Leap.

The Maules Creek alluvial aquifers are located to the north of the Project Boundary and are divided into two distinct zones by a constriction in the flood plain created by the outcropping Permian basement. Upstream of the constriction the Maules Creek alluvium is some 90km^2 in area and drained by three ephemeral creeks; Horsearm Creek, Middle Creek and Maules Creek. Downstream of the constriction area, Horsearm Creek and Middle Creek discharge into Maules Creek and a zone of permanent water holes known as Elfin Crossing are present. The Maules Creek alluvial plain widens significantly in this area and Maules Creek eventually discharges into the Namoi River about 11km to the west of the Project Boundary. The closest alluvial aquifer system to the Maules Creek mining area is located approximately 3.2 - 3.5km south-west and west of the Project.

The southern alluvial plains, south of the Boggabri Mine, covers some 240km^2 with Bollol Creek running through the northern area and Driggle Draggle / Barneys Spring Creeks to the south. These creeks also discharge to the Namoi River to the west.

The Namoi River to the west meanders through two wide flood plains. The flood plains constrict at the area known as Gin's Leap due to the presence of the outcropping Boggabri Volcanics, which act as a natural barrier, similar to a dam wall in the aquifer. Further to the north, beyond Gins Leap, the flood plain again widens and merges with the Maules Creek alluvial plain. The extent of the alluvial aquifer is shown in Drawing No. 3, where it is symbolised with "Qx".

A deeply incised palaeo-channel is present to the west along the course of the Namoi River in Zones 4 and 5, which forms a high yielding aquifer. The thickness of the alluvial material thins out through the flood plains to the north and south of the Project Boundary. The thickness of the alluvial aquifer was determined from a review of lithologic logs of registered monitoring bores constructed in the floodplains. Stock, domestic and irrigation bores were generally not useful for this task as they rarely penetrated the full thickness of the alluvial aquifer. The locations of the registered monitoring bores used in this assessment are shown in Drawing No. 4.

Logs for thirty bores were examined to determine the thickness of the alluvial aquifer in the study area and a summary of the aquifer thickness is presented as a histogram in Figure 5. The data indicates a maximum thickness of about 125m, along the Namoi River, with the majority of the bores intersecting between 25m and 75m of alluvium.

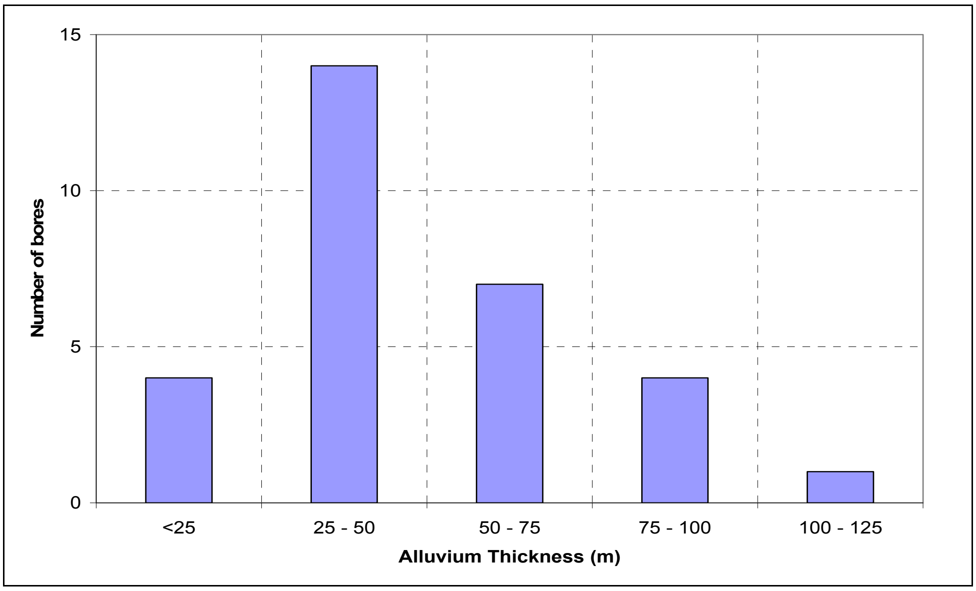


Figure 5: Alluvial Aquifer Thickness Histogram

Modelling undertaken by CSIRO (2007) for the alluvial aquifer *"incorporated two aquifer layers of the basal Gunnedah Formation and the surficial Narrabri Formation. The Gunnedah Formation reaches a maximum thickness of 115 m and consists of sands and gravels with interbedded clays. It is conceptualised as a high-yielding aquifer with good quality, low salinity water. The overlying Narrabri Formation reaches a maximum thickness of 70 m and is conceptualised as a lower-yielding aquifer composed generally of clays with some sand and gravel."*

Coffey and Partners (1986) found the Maules Creek alluvium aquifer has three types of sediments:

- Sand and gravel of the stream channel alluvium (centre of the valley);
- Clayey sand/gravel beds on valley plains and slopes; and
- Weathered/fractured rock under alluvium / colluvium.

Coffey and Partners (1986) also found in the northern region of the Maules Creek flood plain traversed by Horsearm and Middle Creeks the alluvium is shallower and water storage is within weathered and fractured rocks.

7.2.2 Yields

Bore yields in the alluvial aquifers are highly variable and dependent on the nature and thickness of the sediment intersected when drilling. Approximately 1,800 registered bores are present within the study area; however information on yields was only available for about 28 of these bores. The bores show a very wide range in yields, from less than 1L/s up to a maximum of 175L/s, (refer Drawing No. 5).

The locations of registered bores with information on yields are shown on Drawing No. 5 which indicates that all of the bores with very high yields are located along the Namoi River. This has been noted by CSIRO (2007) indicating that *"a palaeochannel in the central valley area represents the deepest parts of the aquifer. Good quality groundwater is found in high-yielding aquifers across wide areas of the alluvial plain. The most productive aquifer is the main palaeochannel. The coarseness of the palaeochannel sediments supports high groundwater extraction rates."*

The various studies by Coffey and Partners also made this conclusion and found that the highest extraction rates are restricted to alluvium of Namoi River area with yields of up to 200L/s from the deep alluvium.

Coffey and Partners (1986) investigated the Maules Creek aquifer as a potential water supply for the proposed Maules Creek Mine. The Maules Creek alluvial aquifer east of the bedrock constriction was subdivided into two zones being the higher yielding Central Valley aquifers associated with stream channels of Maules Creek, Horsearm Creek and Middle Creek, and the lower yielding Valley Plain aquifers located more distant from the centre of the creek channels. Bores yields from the Central Valley aquifers were reported to be between 12L/s and 33L/s with the Valley Plains aquifer yields much lower at between 0.1L/s and 1L/s range.

7.2.3 Water Quality

CSIRO (2007) summarises the groundwater quality of the alluvial deposits and indicated that "*salt storage in the finer-grained units of these systems is high and groundwater salinity is variable from fresh to saline. Lower salinity levels characterise the coarser sediments. These systems respond rapidly to a change in the water balance."*

The most comprehensive investigation of groundwater quality in the Maules Creek alluvial aquifer was undertaken by Anderson and Achworth (2009). The key findings of the study are reproduced below.

Groundwater quality measurements recorded in August 2006 suggests that low EC levels (~300 uS/cm) are discharging into Horsearm Creek, whereas higher EC levels (~800 uS/cm) are detected discharging into the upper Maules Creek. This reflects the different sources of *groundwater from the north and south, respectively. Measurements recorded in the north of the creek range from 290 to 497 uS/cm and 542 to 1,613 uS/cm south of the creek. Surface water EC levels follow a similar pattern, ranging from 330 uS/cm near the confluence of the Horsearm creek, increasing to 457 uS/cm at the Maules creek downstream termination. Groundwater temperatures reflect the discharge of relatively warm groundwater, displaying a drop in temperatures to the south reflecting the absence of groundwater discharge. Measured surface and groundwater temperatures indicate that groundwater is actively discharging in the upper part of Maules Creek and its tributary Horsearm Creek.*

7.2.4 Groundwater Levels and Hydraulic Gradients

Coffey and Partners (1986) undertook measurements of groundwater levels in the Maules Creek alluvial aquifer which indicated water levels were between 2.5m to 8m below ground in the central area of the Maules Creek alluvium, becoming deeper to the north-east at 15m–35m below ground level. Groundwater levels were observed to decline slowly during periods without flow in creeks.

A network of groundwater bores monitored by the NSW government has been installed in the alluvial aquifers that surround the Project Boundary. The locations of the monitoring bores are shown in Drawing No. 4. Many of the bores have been monitored routinely since the mid 1970s providing a long record of groundwater fluctuations.

The closest monitoring site within the Maules Creek aquifer to the open cut pit footprint is monitoring bore GW967138, which is located about 6km to the north. This site has two bores constructed, one in the shallow zone of the alluvium (pipe 1) and the second in the deeper basal section (pipe 2). The hydrograph for GW967138 is presented in Figure 6, with the location of the bore shown in Drawing No. 6. The hydrograph indicates a hydraulic gradient of about 0.012 (1m in 83m) from the shallow alluvium to the deeper basal section of the alluvium. The shallow bore shows rapid rises in rainfall associated with recharge events, with a slightly delayed gradual rise in water levels in the deeper zone of the aquifer. The water levels in both pipes for this bore show a good correlation with rainfall as represented by the CRD.

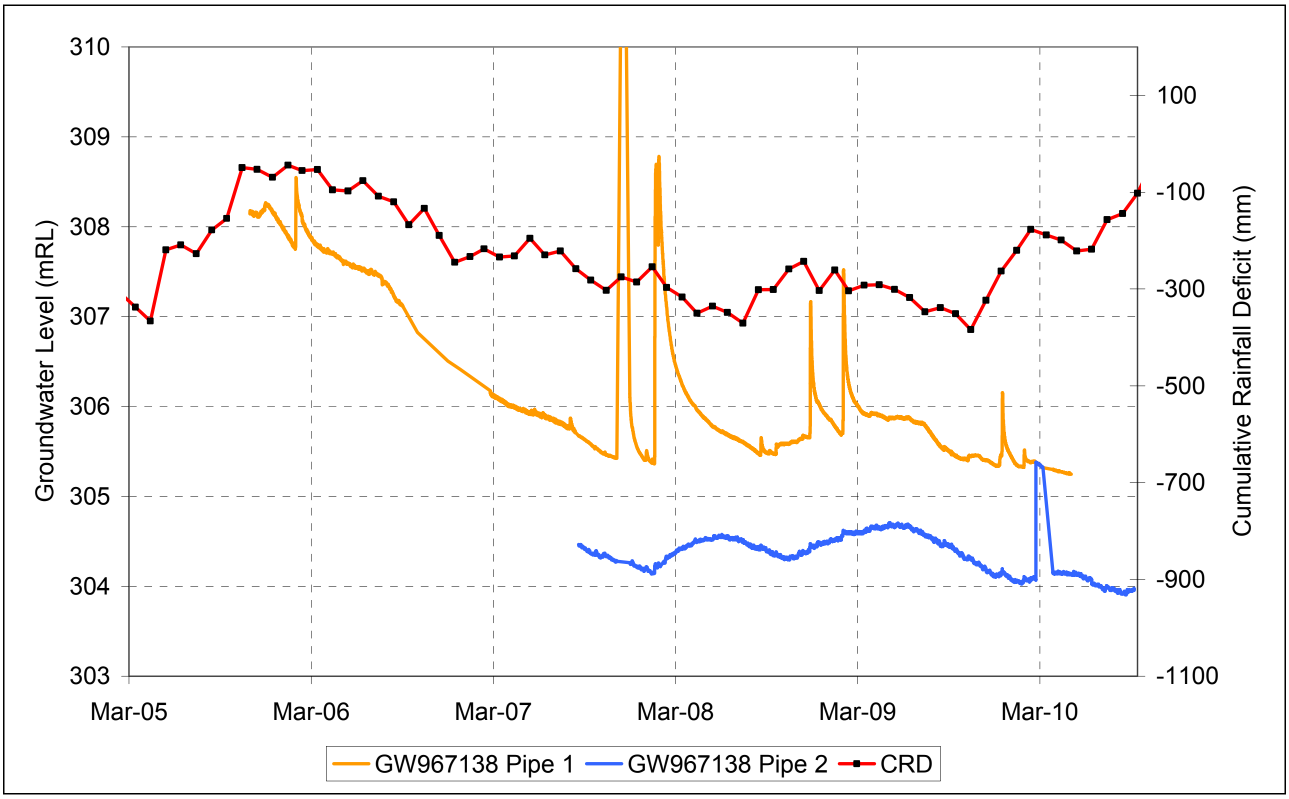


Figure 6: Hydrographs – Monitoring Bore GW967138

A network of NOW monitoring bores into the lower area of the Maules Creek alluvial aquifer have been equipped with electronic water level loggers. Hydrographs from these monitoring bores which are presented in Figure 7 also show a strong correlation between rainfall and recharge as represented by the CRD.

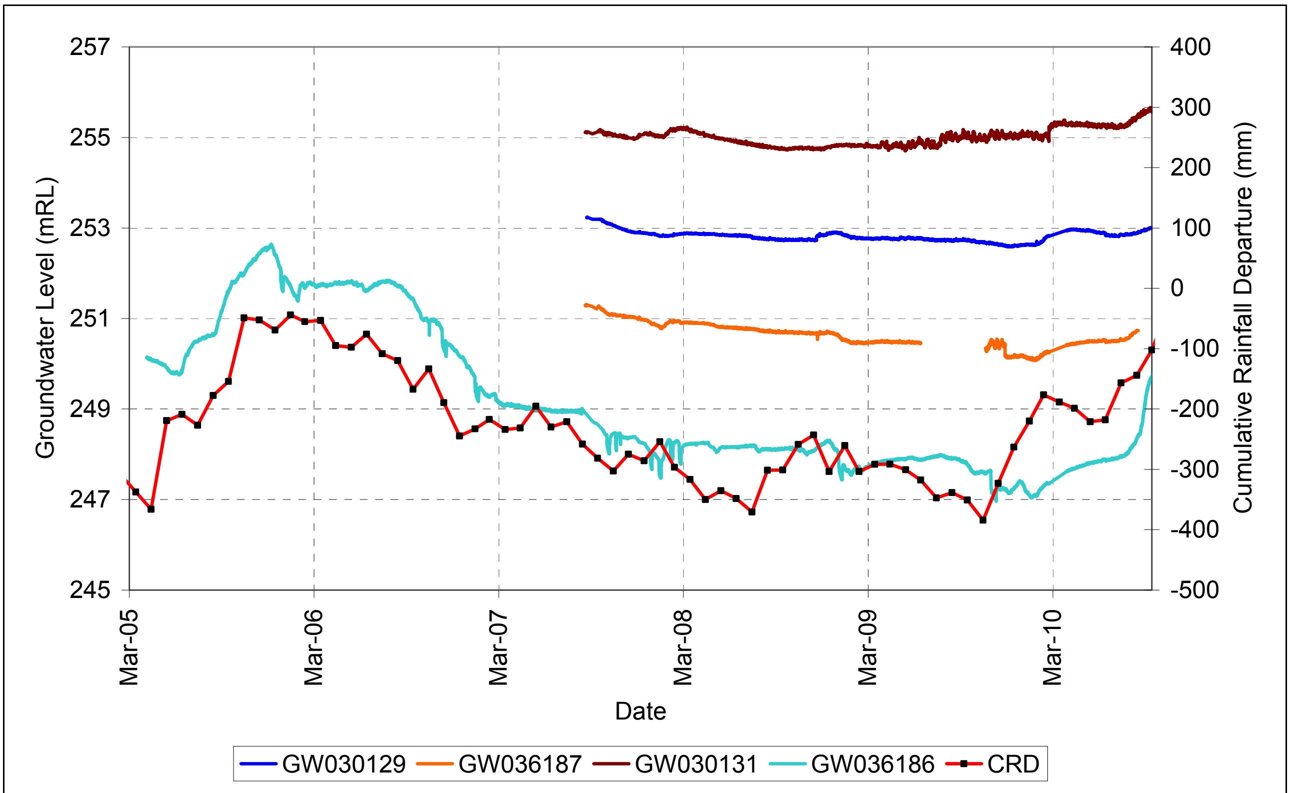


Figure 7: Hydrographs – NOW Monitoring Bores – Maules Creek

7.2.5 Hydraulic Parameters

As discussed previously Coffey and Partners (1986) sub-divided the Maules Creek aquifer into two different hydrogeological zones being the higher yielding Central Valley aquifers associated with stream channels of Maules Creek, Horsearm Creek and Middle Creek, and the lower yielding Valley Plain aquifers located more distant from the centre of the creek channels.

The Central Valley Alluvium was found to have higher yielding bores in sand and gravel deposits with transmissivity measured at 1,100m^2/day to over 2,000m^2/day. The yields from bores more distant from the creeks were lower at 0.1L/sec to 1L/sec. Transmissivity measured from pumping tests was as follows (refer to Figure 8):

- northern arm of valley - T - 5m^2/day;
- south of Scrubby Hill which is a bedrock outcrop that divides the Middle Creek/Horsearm Creek from Stoney Creek/Maules Creek - T - 20m^2/day; and
- south of Maules Creek - T - 400m^2/day.

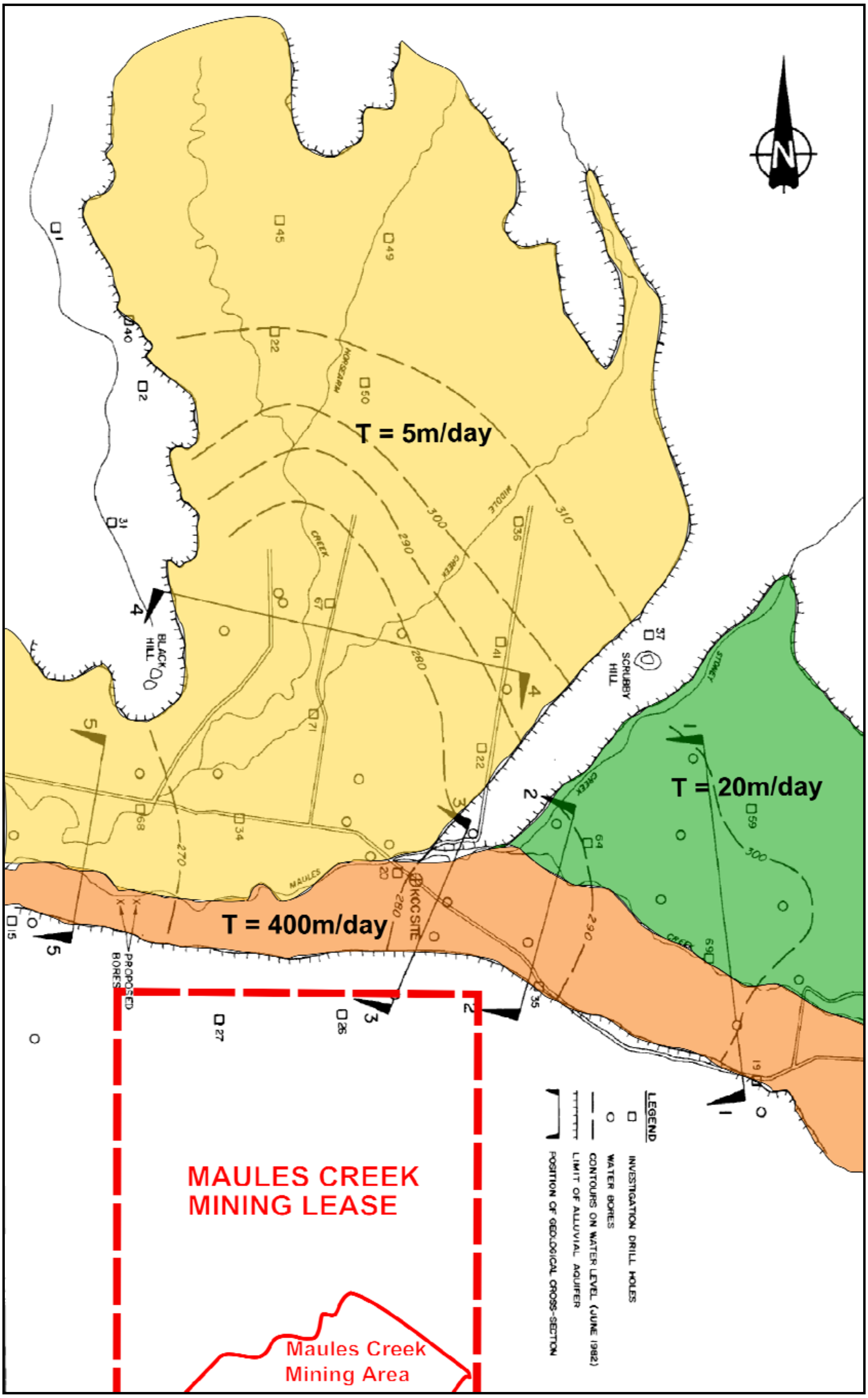


Figure 8: Maules Creek Alluvial Aquifer Hydraulic Parameters (Modified from Coffey, 1986)

(G1508)

7.2.6 Recharge, Discharge and Groundwater Flow

Recharge and discharge from the alluvial aquifer is most recently summarised by CSIRO (2007) as follows:

"Recharge to the aquifers occurs via six mechanisms: direct rainfall recharge, irrigation, river leakage, flood inundation, inflow from surrounding aquifers, and hillslope 'run-on' from outcropping bedrock at the aquifer margins. Direct rainfall recharge is modelled at 3 percent of rainfall with an adjustment for evapotranspiration. The Upper Namoi valley experienced average annual rainfall of 660 mm/year over the period 1985 to 2001; higher than the long-term average. Pan evaporation over the same period was approximately 1700 mm/year. Stream–aquifer interaction is an important part of the hydrological cycle in the Upper Namoi valley and the Namoi River has good hydraulic connection to the shallow aquifer. Traditionally the Namoi River was a losing stream upstream and a gaining stream downstream of Boggabri. Lower groundwater levels in recent times (post-2000) have produced increasing losses to groundwater. Groundwater discharges are largely restricted to pumping, river interaction and lateral groundwater flow to the Lower Namoi. Groundwater pumping has increased significantly since the 1980s and now approximately 70 GL/year is extracted. Watertables in the Namoi Valley are typically deeper than 2 m and consequently direct groundwater evapotranspiration is not a significant part of the water balance."

The groundwater flow model developed by NOW (2006) included area recharge via rainfall, side-slope runoff and floods, point source recharge from ephemeral streams and irrigation leakage.

Coffey and Partners (1986) investigated the area of the Maules Creek alluvial aquifer upstream of the bedrock constriction and concluded that in the Central Valley area recharge to the aquifer occurred by creek flow infiltration, underflow from upstream aquifer and lateral inflow from aquifers underlying valley plains. Discharge occurs via central aquifer and flows to the west.

In the Valley Plain Area recharge was considered to occur via percolation through stream bed leakage, run-off from hills onto the outcropping edge of the aquifer, direct rainfall and westerly groundwater flow. Discharge was into the central aquifer or directly to streams.

Giambastiani (2010) estimated recharge using a 1D soil water balance for directed land uses in the Maules Creek catchment. Recharge to cleared pasture was estimated at 6% of average annual rainfall with recharge to timber areas lower at 3%. Recharge to areas where cotton is flood irrigated was 3% of annual rainfall plus irrigation returns which was estimated at 3% of the groundwater extraction rate.

7.2.7 Groundwater Dependent Ecosystems

The Water Sharing Plan notes that *"there are no high priority groundwater dependent ecosystems identified and scheduled at the commencement of this Plan."* Significant stands of groundwater dependent vegetation in the area is unlikely given that CSIRO (2007) noted that *"watertables in the Namoi Valley are typically deeper than 2m and consequently direct groundwater evapotranspiration is not a significant part of the water balance."* The creeks in the vicinity of the Project Boundary are also ephemeral and therefore are not expected to support groundwater dependent ecosystems (GDEs).

Studies undertaken by Cumberland Ecology (2011) have identified that *Melaleuca sp* riparian woodland have been identified along the alignment of Back Creek and that these species are expected to have a root zone extending some 2m to 3m below the land surface. A thin and shallow zone of alluvial/colluvial sediments have been identified long the alignment of Back Creek by GSS (2011).

Groundwater bores along the Back Creek alignment are limited to a number of bores installed in the 1980s hydrogeological investigations. These bores indicate that groundwater levels were at the time around 10m below ground level. It is therefore considered unlikely that the root zone of these species extends into the saturated zone of the underlying Permian aquifer.

Cumberland Ecology (2011) have identified the presence of River Redgum and River Oaks along sections of the Maules Creek and the lower lying areas of Back Creek, and these species are known to rely upon groundwaters from underlying aquifers.

7.3 Shallow Bedrock (Regolith) Aquifer

The regolith or shallow bedrock aquifer comprises surficial soils and weathered bedrock. The depth of weathering is variable and depends on factors such as the extent and frequency of fracturing. Deep weathering profiles averaging about 25m, and in some cases down to 60m are present within the Project Boundary. Sandstones and conglomerates are most affected by the weathering process. Finer grained sediments, where present, form an effective barrier to the weathering process and can locally reduce the weathering depth. Deeper weathering profiles are found along fracture and potential fault zones.

The regolith is largely dry in the more elevated areas of the Leard State Forest, but acts as a temporary water store during sustained wet periods and provides a source for recharge to the underlying fresh rock.

7.4 Permian Aquifers

Early investigations by Coffey and Partners (1982) within the Permian Formations at the Maules Creek lease concluded that:

- the sandstones and conglomerates are tightly consolidated with little primary porosity;
- secondary porosity is greater from weathering, faulting, jointing;
- The coal seams are the main aquifers in the Permian sequence; and
- the weathered profile is largely unsaturated.

These conclusions have been confirmed with subsequent investigations and the Permian strata can be categorised into the following hydrogeological units:

- hydrogeologically “tight” and hence very low yielding to essentially dry sandstone, and conglomerate that comprise the majority of the Maules Creek Formation strata;
- low to moderately permeable coal seams which are the prime water bearing strata within the Maules Creek Formation; and
- the underlying Boggabri Volcanics, which that act as a low permeability basement to the sedimentary units.

These units are discussed below.

7.4.1 Distribution

The Permian sedimentary deposits occur as a regular layered easterly to north-easterly dipping sedimentary sequence and are underlain by the Boggabri Volcanics. The basal Boggabri Volcanics outcrop in the western area of the Project Boundary and form the basement to the alluvial aquifer to the west. In the eastern zone of the study area the Maules Creek Formation forms the basement to the alluvial aquifer (refer Drawing No. 3). The Boggabri Volcanics have been intersected by a number of resource exploration drill holes in the Project area and have been observed to be a rhyolite with a macro-crystalline structure suggesting emplacement as a near surface intrusion, not as an extrusive lava flow (pers com R. Brims, Aston General Manager Technical).

To assist the groundwater modelling (described in Section 9.0), the regional coal seam surfaces were mapped by J.B Mining Services. This process involved utilisation of coal seam data from the following sources:

- 1980s resource exploration program within the Maules Creek lease;
- Recent exploration data from the Maules Creek 2010 drilling program; and
- Drilling data provided by the adjacent Boggabri Coal Mine on a 1km grid.

The drilling data was used to interpolate the coal seam surfaces on a regional scale using the VULCAN software package. Fifteen individual coal seams have been named within the Maules Creek lease, with each seam splitting into a number of individual plys as shown in Figure 9. The location of the cross section is shown in Drawing No. 7.

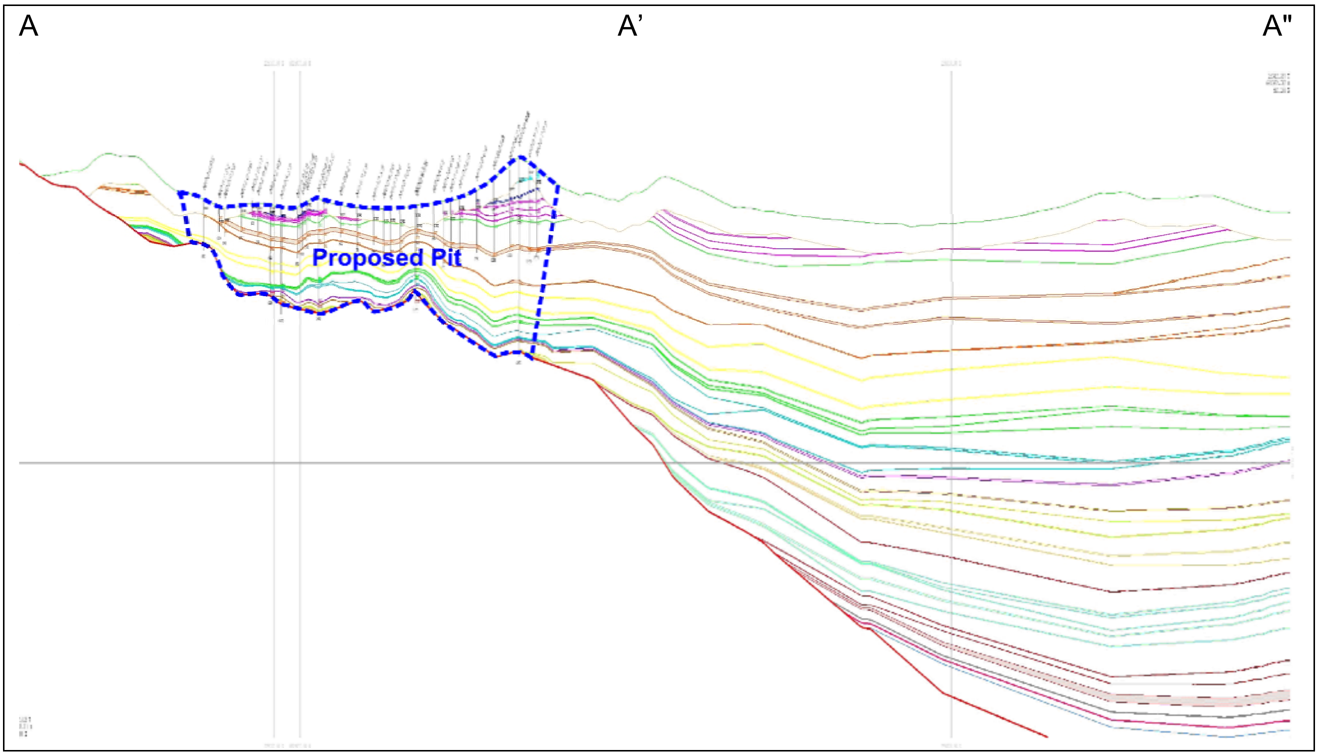


Figure 9: North-east to South-west Cross Section through CL 375 (source: JB Mining 2010)

Due to the large number of coal seam surfaces, and the need to represent this data in the groundwater model, it was decided to merge the coal seams into four logical groups or "super seams" with the seam thickness combined for each. The four seam groups were as follows:

- Herndale Seam to Braymont Seam;
- Jeralong Seam to Velyama Seam;
- Nagaro Seam to Flixton Seam; and
- Tarrawonga Seam to Templemore Seam

The interpolated seam surface contours for the floor of each of the above seam groups are shown in Drawing Nos. 7 to 10. On a regional scale the coal seams surfaces dip gently to the east and north-east at about 1 degree. Towards the subcrop/outcrop area to the west, the seams are more steeply dipping at about 2 to 3 degrees. The coal seam surfaces are a reflection of the underlying Boggabri Volcanics basement topography, with topographic features in the basement being reflected through the overlying coal seams surfaces as shown in Figure 10 below (refer Drawing Nos. 7 to 10).

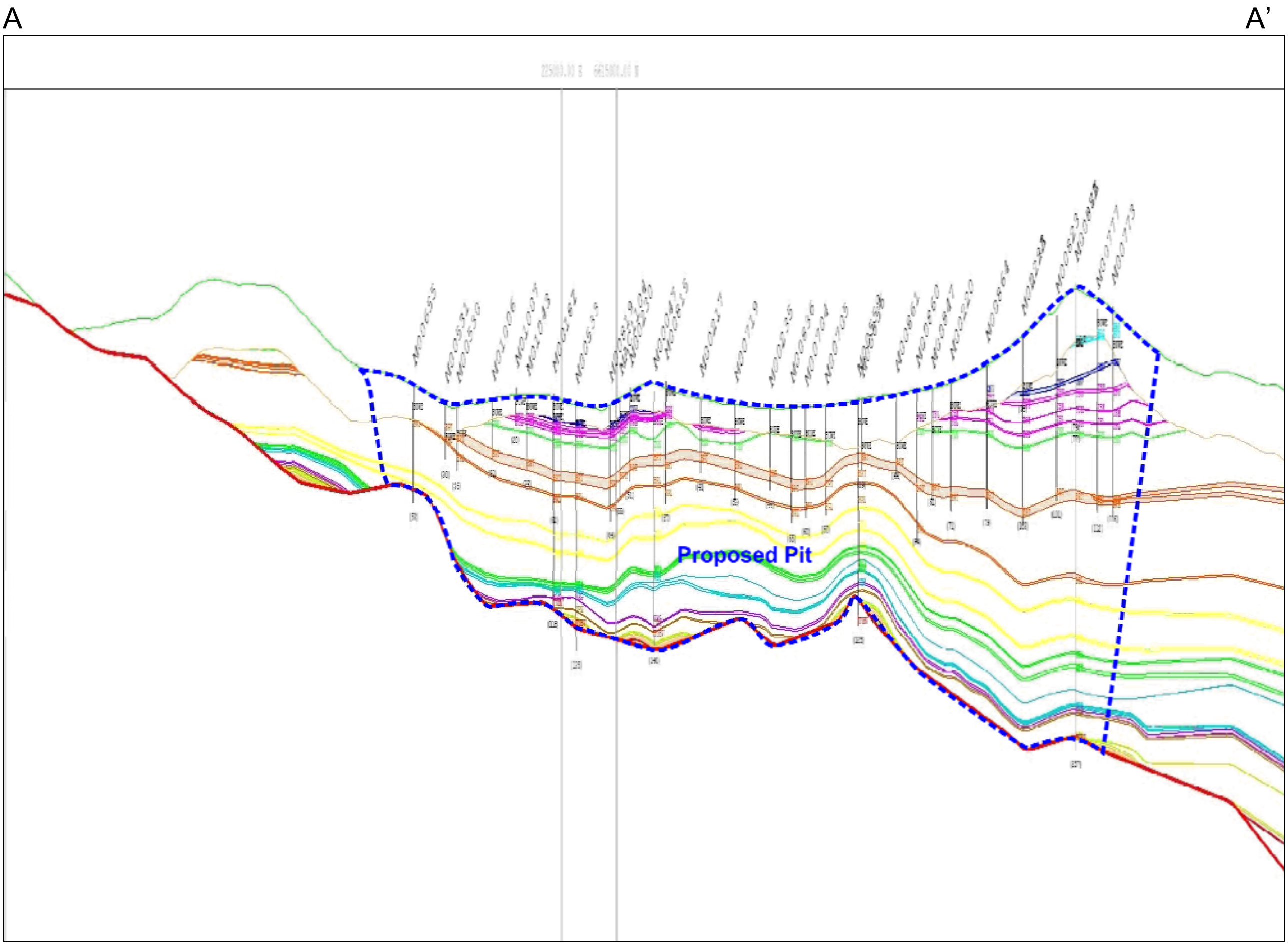


Figure 10: North-east to South-west Cross Section through Proposed Mining Area (source: JB Mining 2010)

A ridge in the Boggabri Volcanics basement is present within the northern area of the proposed mining footprint, around which the deeper coal seams subcrop and is evident in the subcrop of the Flixton and Templemore Seams as shown in Drawing Nos. 7 to 10.

It can be seen from Figure 10 that the upper seams in the sequence are incomplete having been eroded by peat drainage systems and are therefore limited in extent and controlled by topography. This means that some of the shallow seams in the sequence do not extend under, or have a direct hydraulic connection to the alluvial aquifer as they do not form continuous layers on a regional scale. The fact that the deeper seams subcrop against the basement Boggabri Volcanics means that a direct hydraulic connection between these seams and the overlying alluvial sediments is also not present.

7.4.2 Hydraulic Parameters

The first measurements of hydraulic conductivity were undertaken by Coffey Partners (1982 and 1986) as part of the 1980s exploration program. The testing program focused on the coal seams and reported a hydraulic conductivity range between 0.001m/day to 0.1m/day. The work indicated the Braymont Seam was the most permeable seam in the sequence.

The investigations also indicated it was considered possible that the hydraulic conductivity of the coal seams decreased with depth down dip to the east. A general observation made during the most recent resource exploration drilling program has been that calcite cementing of fractures and cleats generally appears to increase with depth, supporting this conclusion (pers com R. Brims, Aston General Manager Technical).

Hydraulic packer testing was carried out in four core holes (MAC250, MAC257, MAC263 and MAC265) within the Project Boundary during September 2010. The testing program included testing of 3m to 5m zones of interburden, coal seam and Boggabri Volcanics. The results of the testing are summarised as follows:

- MAC 263 - The testing indicated that the Braymont Coal Seam in MAC263 has the highest average hydraulic conductivity of the coal seams tested of about 0.2m/day, which is in agreement with the early work by Coffey Partners (1982 and 1986). The remainder of the coal seams within MAC263 recorded an average hydraulic conductivity in the range of 1.5 – 6.2 x 10^{-2}m/day. An interburden unit (conglomerate) within drill hole MAC263 was also tested giving an average hydraulic conductivity of 1.7 x 10^{-3}m/day, an order of magnitude lower than the coal seam permeability and 2 orders lower than the Braymont Seam value.
- MAC265 - The entire bottom hole section below 55m was tested (TD at 152.66m) providing a very low average bulk hydraulic conductivity value of 2.5 x 10^{-4}m/day for the 97.66m thick section. Several smaller packer intervals (5m) were attempted in drill hole MAC265, including the underlying Boggabri Volcanics; however, given the very low permeability, no significant water flow was recorded and the tests were unable to be analysed, but are expected to be <10^{-4}m/day.
- MAC257 - Within drill hole MAC257, the Merriown Coal Seam (between 93 – 98m below the surface) was able to be tested using the inflatable packer assembly. The results of hydraulic conductivity values from this coal seam (average of 6.5 x 10^{-2}m/day) are very similar to the hydraulic conductivity value interpreted from the same coal seam in drill hole MAC263 (average of 6.15 x 10^{-2} m/day). Due to a very low permeability within drill hole MAC257, which precluded the use of the inflatable packer, the remainder of the tests were undertaken using a conventional falling head test method. The intervals from 59 - 64m, 70 - 73m, 77 - 80m, 81 - 84m, 87 - 90m, 100 - 105m and 105 - 111m did not record any reduction in the starting head during each test period (generally between 20 and 50 minutes duration), indicating a very low hydraulic conductivity. The remainder of the coal seams, the interburden, overburden and underlying Boggabri Volcanics at MAC257 are considered to have very low hydraulic conductivity and values less than 1 x 10^{-4}m/day are expected.
- MAC250 - Packer testing was also undertaken on MAC250; however, due to a very low permeability the tests were unable to be analysed. Similar to MAC265, the expected

hydraulic conductivity range over the intervals tested is expected to be less than 1 x 10^{-4}m/day.

The average transmissivity and hydraulic conductivity values for each interval successfully tested are summarised in Table 5. Measurements of hydraulic conductivity from the adjacent Boggabri Coal Mine are also included for comparison (AGE 2010). Figure 11 shows the data presented as histogram and suggests the median hydraulic conductivity for the coal seams lies between 0.01 and 0.1m/day.

Table 5: SUMMARY OF AVERAGE HYDRAULIC TESTING VALUES

Source	Hole ID	Geology	Test Interval (mbGL)	Average Transmissivity (m^2/d)	Average Hydraulic Conductivity (m/d)
Maules Creek Exploration Program	MAC257	MN	93 – 98	3.3 x 10^{-1}	6.5 x 10^{-2}
	MAC263	BR	99 - 104	8.5 x 10^{-1}	1.7 x 10^{-1}
		JE	133 - 138	7.65 x 10^{-2}	1.53 x 10^{-2}
		MN	150 - 155	3.07 x 10^{-1}	6.15 x 10^{-2}
		Conglomerate	161 - 166	8.64 x 10^{-3}	1.73 x 10^{-3}
		VE	176 - 181	1.88 x 10^{-1}	3.77 x 10^{-2}
		NAG, UPN	181 - 186	1.4 x 10^{-1}	2.8 x 10^{-2}
		LR, TE	220 - 225	2.31 x 10^{-1}	4.61 x 10^{-2}
	MAC265	Entire Hole	55 - 152.66	2.45 x 10^{-2}	2.5 x 10^{-4}
Boggabri Mine	AB1060	BR,BC,JE, MN	-	5.04 x 10^{0}	4.8 x 10^{-1}
	AB040	BC, JE, MN	-	3.81 x 10^{0}	6.8 x 10^{-1}
	AB030	JE	-	1.25 x 10^{0}	5.0 x 10^{-1}
	AB043	BR,BC,JE, MN	-	1.25 x 10^{0}	1.2 x 10^{-1}
	IBC2102	JE	-	2.5 x 10^{-2} – 7.5 x 10^{-2}	1 x 10^{-2} - 3 x 10^{-2}
	IBC2102	MN	-	2.2 x 10^{-2} – 2.2 x 10^{-1}	1 x 10^{-2} - 1 x 10^{-1}
	IBC2104	BR	-	4.9 x 10^{-2}	1 x 10^{-2}
	IBC2105	JE	-	2.5 x 10^{-2}	1 x 10^{-2}
	IBC2115	MN	-	1.1 x 10^{-2}	5 x 10^{-3}

BR – Braymont Seam, BC – Bollol Creek Seam, JE – Jeralong Seam, MN – Merriown Seam, VE – Velyama, NAG – Nagero, UPN – Upper Northam, LR – Lower Northam, TE - Therribri

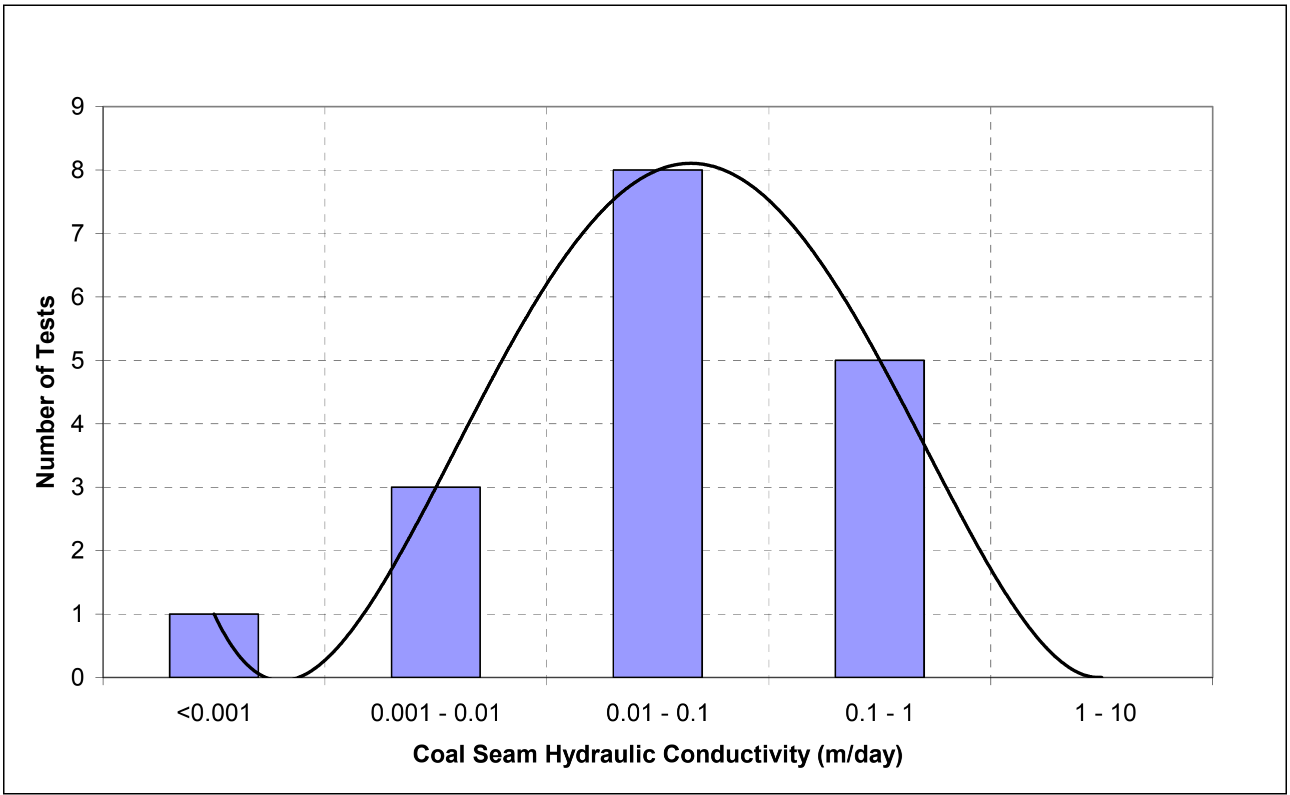


Figure 11: Histogram Permian Hydraulic Conductivity

7.4.3 Yield and Usage

Usage of groundwater from the Permian strata via bores is limited, due to poor yields and the better prospects obtainable in the alluvial aquifer. The early investigations by Coffey and Partners (1982) noted that very few bores for water supply had been drilled in the Permian formations. Airlift flows during the 2010 resource drilling campaign on the Maules Creek mining lease were generally low (<0.5L/s), and typically water injection was required to remove cuttings from the holes as the groundwater flow was insufficient. A general increase in flow was noted with depth as the thickness of coal seam exposed in the borehole increased.

A total of thirteen registered water bores were identified within the outcrop of the Maules Creek Formation. A summary of the available information for these bores is provided in Table 6 below. The locations of the bores are shown in Drawing No. 6.

Information on yields is limited with only two bores reporting relatively low yields of 0.42L/s and 0.76L/s. Bore GW053825 was constructed as part of the 1980s coal exploration program on the Maules Creek mining lease. This bore was replaced with a new bore as part of the 2010 resource exploration program which was used to supply water for the drilling campaign in accordance with Licence No. 90BL255704. The yield from the bore was relatively low and reportedly reduced markedly over the course of the 2010 drilling program, suggesting poor lateral continuity in the coal seam aquifers.

The other bores within the Maules Creek Formation were drilled between the 1920s and 1980s and given the age of the bores, it is unlikely all remain in use. Water quality is variable from fresh to brackish.

Table 6: SUMMARY OF REGISTERED BORES IN MAULES CREEK FORMATION							
Work No.	**Date**	**Work Status**	**Drilling Method**	**Completed Depth (mbgl)**	**Standing Water Level (mbgl)**	**Salinity**	**Yield (L/s)**
GW000583	1920	Reconditioned	Unknown	98.7	31.1	Fresh	0.76
GW001799	1926	Unknown	Cable Tool	78.3		Fresh	
GW001852	1926	Unknown	Cable Tool	88.7		3,001-7,000 ppm	
GW002506	1928	Unknown	Cable Tool	33.5		Fresh	
GW002523	1928	Unknown	Cable Tool	38.4		Good	
GW002748	1929	Unknown	Cable Tool	72.2		Good Stock	
GW003466	1937	Unknown	Cable Tool	50		Fresh	
GW003496	1937	Supply Obtained	Cable Tool	172.8	61.6	Salty	0.42
GW008255	1951	Abandoned Bore	Cable Tool	91.4			
GW001869	1962	Unknown	Cable Tool	63.1		Good	
GW029832	1968	Unknown	Cable Tool	66.8			
GW048934	1976	Reconditioned Bore	Rotary Air	49.4		1,001-3,000 ppm	
GW053825	1981	Unknown	Rotary	257		1,001-3,000 ppm	

mbgl – metres below ground level

ppm – parts per million

L/s – Litres per second

Fourteen registered water bores were identified within the outcrop zone of the Boggabri Volcanics. A summary of the available information for these bores is provided in Table 7 below. The locations of the bores are shown in Drawing No. 6.

Yields are not available for bores within the Boggabri Volcanics, probably because the majority of the bores are relatively old, being drilled prior to 1965 using the cable tool method and given the age of the bores, it is unlikely all remain in use. Water quality is variable from fresh to brackish.

Table 7: SUMMARY OF REGISTERED BORES IN BOGGABRI VOLCANICS FORMATION							
Work No	**Date**	**Work Status**	**Drilling Method**	**Completed Depth (mbgl)**	**Standing Water Level (mbgl)**	**Salinity Description**	**Yield (L/s)**
GW020434	1927	unknown	Cable Tool	85.3	-	Salty	-
GW002799	1929	unknown	Cable Tool	21	-	Good Stock	-
GW002831	1930	unknown	Cable Tool	33.2	-	Unknown	-
GW003115	1932	unknown	Cable Tool	82.9	-	Good	-
GW003478	1937	unknown	Cable Tool	33.8	-	Fresh	-
GW003483	1937	unknown	Cable Tool	32.9	-	Fresh	-
GW003489	1937	unknown	Cable Tool	45.4	-	Fresh	-
GW006529	1939	unknown	Cable Tool	34.7	-	Good	-
GW006567	1940	unknown	Cable Tool	59.1	-	Fresh	-
GW008221	1951	unknown	Cable Tool	108.2	-	Unknown	-
GW019267	1962	unknown	Cable Tool	20.7	-	1001-3000 ppm	-
GW020607	1963	unknown	(Unknown)	29.9	-	Brackish	-

(G1508)

Table 7: SUMMARY OF REGISTERED BORES IN BOGGABRI VOLCANICS FORMATION							
Work No	**Date**	**Work Status**	**Drilling Method**	**Completed Depth (mbgl)**	**Standing Water Level (mbgl)**	**Salinity Description**	**Yield (L/s)**
GW025637	1965	unknown	Cable Tool	36.6	-	Unknown	-
GW900043	1995	unknown	Cable Tool	32.9	-		-

mbgl – metres below ground level

ppm – parts per million

L/s – Litres per second

The prime users of groundwater within the region from the Permian Maules Creek Formation are the Boggabri Coal Mine and Tarrawonga Mine that use in-pit seepage from the coal seams for dust suppression purposes.

7.4.4 Water Quality

The 1980s exploration program and Maules Creek EIS included collection of water samples and analysis from a number of drill holes as reproduced in Table 8. The location of these bores or the strata from which the samples were collected is not certain; however the data indicates a fresh to slightly brackish water quality with electrical conductivity (also known as specific conductance) between 403µS/cm and 1,980µS/cm.

Table 8: SUMMARY OF 1980s PERMIAN WATER QUALITY DATA				
Quality Parameters	MAC 182	MAC 179	MAC 181	MAC18
Depth of Sample (m)	52	58	18	-
pH	6.4	6.6	6.0	6.6
Alkalinity due to HCO_3 (mg/L)	370	335	580	
Specific Conductance (µS/cm)	878	736	403	1,980
Filtrable Residue (mg/L)	554	462	256	1,230
Non-filtrable Residue (mg/L)	282	304	1,812	
HCO_3 (mg/L)				771
Ca (mg/L)	34	27	18	78
Mg (mg/L)	15	17	10	70
Na (mg/L)	41	34	7	300
K (mg/L)	15	7	4	15.2
Cl (mg/L)	56	34	40	240
SO_4 (mg/L)	32	17	6	126
Fe (mg/L)	5	23	41	5.9

Groundwater samples were collected after development of the new monitoring bores installed as part of the 2010 drilling campaign and a selection of open drill holes. The results of the laboratory analyses are summarised in Table 9.

Table 9: SUMMARY OF 2010 PERMIAN WATER QUALITY DATA (mg/L)												
Sample ID	**Date**	**pH Value**	**EC**	**TDS**	**Ca**	**Mg**	**Na**	**K**	**Cl^-**	**SO_4^{2-}**	**CO_3**	**HCO_3**
MAC1218	26/07/2010	6.75	960	552	120	24	43	26	21	19	<1	469
MAC1219	26/07/2010	6.65	545	308	60	13	18	26	12	12	<1	250
MAC1219	19/09/2010	7.08	893	730	98	23	46	118	24	43	<1	494
MAC1219	24/10/2010	7.59	885	494	82	28	36	41	23	30	<1	383
MAC1219	17/11/2010	8.01	805	400	67	31	39	30	26	22	<1	355
MAC1227	1/08/2010	6.74	787	544	87	20	24	28	26	15	<1	337
MAC1246	2/08/2010	6.54	700	446	48	19	49	25	31	49	<1	241
MAC1249	2/08/2010	6.46	904	604	51	20	98	26	64	38	<1	324
MAC1251	1/08/2010	6.60	1,480	1,300	81	26	209	31	81	50	<1	608
MAC1252	1/08/2010	6.61	2,240	1,620	103	48	360	41	259	147	<1	693
MAC1255	1/08/2010	6.75	1,910	1,410	80	45	298	30	190	121	<1	614
MAC1256	1/08/2010	6.67	2,300	6,400[1]	99	60	359	35	293	185	<1	633
MAC1258	1/08/2010	6.69	1,910	1,210	82	53	300	30	207	118	<1	605
MAC1259	26/07/2010	6.72	1,590	920	92	46	216	26	98	60	<1	707
MAC1259A	26/07/2010	6.80	1,640	1,040	82	40	265	26	97	62	<1	732
MAC1259A	19/09/2010	7.09	1,400	1,040	99	40	249	29	94	63	<1	711
MAC1259A	24/10/2010	6.99	1,690	958	82	38	247	28	92	71	<1	749
MAC1261	26/07/2010	6.71	1,130	726	77	51	113	5	24	86	<1	512
MAC1263	16/08/2010	6.28	1,680	1,080	77	58	232	18	194	160	<1	490
MAC1270	16/08/2010	6.86	1,400	1,320	58	32	265	12	48	47	<1	669
MAC1271	16/08/2010	6.78	1,660	1,090	73	56	270	18	182	109	<1	568
MAC1272	16/08/2010	6.89	1,710	948	58	56	306	9	166	100	<1	614
MAC1279	26/07/2010	6.72	2,760	1,780	104	93	431	9	456	140	<1	755
MAC1279	24/10/2010	8.57	2,160	1,290	20	11	516	19	305	282	42	426
MAC1279	16/11/2010	8.86	1,940	1,320	14	11	478	10	276	188	6	452
MAC1280	26/07/2010	7.31	2,150	1,310	43	28	492	9	336	52	<1	654
MAC1281	26/07/2010	6.80	1,960	1,250	52	57	370	10	192	101	<1	760
MAC1283	26/07/2010	6.77	1,510	1,070	82	41	213	25	68	51	<1	701
MAC1284	16/08/2010	6.05	629	348	74	15	17	19	24	11	<1	255
MAC252	24/10/2010	9.20	1,290	650	25	5	144	107	276	46	15	128
MAC252	16/11/2010	9.42	816	554	19	1	133	53	179	32	15	95
MAC 257	19/09/2010	7.45	749	476	36	21	75	18	46	26	<1	278
MAC267P	2/08/2010	7.31	1,040	654	30	19	188	2	38	60	<1	401
MAC268P	2/08/2010	7.92	709	6,750[1]	20	12	113	11	71	25	<1	221
MAC268P	2/08/2010	7.98	818	1,000[1]	36	18	98	14	94	29	<1	236
MAC268P	3/08/2010	7.87	1,080	700	24	18	186	13	86	24	<1	364
Lawlers Well	26/07/2010	6.65	814	442	81	33	28	12	51	22	<1	324

Note: 1 - ALS noted that TDS may bias high, or overestimate the true TDS value in samples "1256" and "MAC268P"due to the presence of fine particulate matter, which may pass through the prescribed GF/C paper.

The salinity data for the Permian geological units can be categorised as generally fresh to brackish, according to the following system, which is presented as a histogram in Figure 12.

Fresh water	<500 mg/L
Slightly Brackish	500 to 1,000 mg/L
Brackish water	1,000 to 3,000 mg/L
Moderately saline	3,000 to 7,000 mg/L

(G1508)

Saline	7,000 to 14,000 mg/L
Highly saline	14,000 to 35,000 mg/L
Brine	>35,000 mg/L

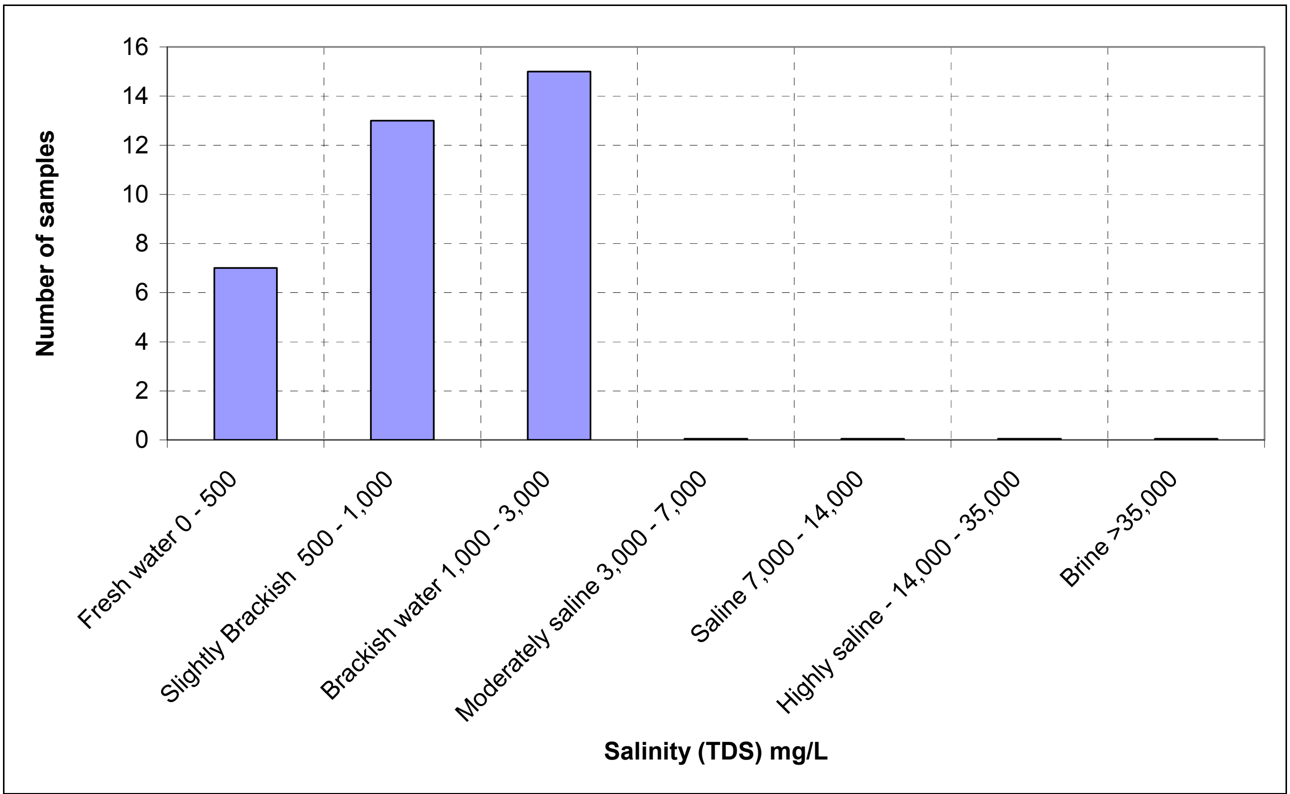


Figure 12: Histogram Permian Groundwater Salinity

The groundwater samples collected from the Permian aquifers on the Maules Creek CL 375 recorded a fresh to brackish water quality with an average Total Dissolved Solids (TDS) of about 900mg/L. The major anion / cation data is presented as a Piper Diagram in Figure 13.

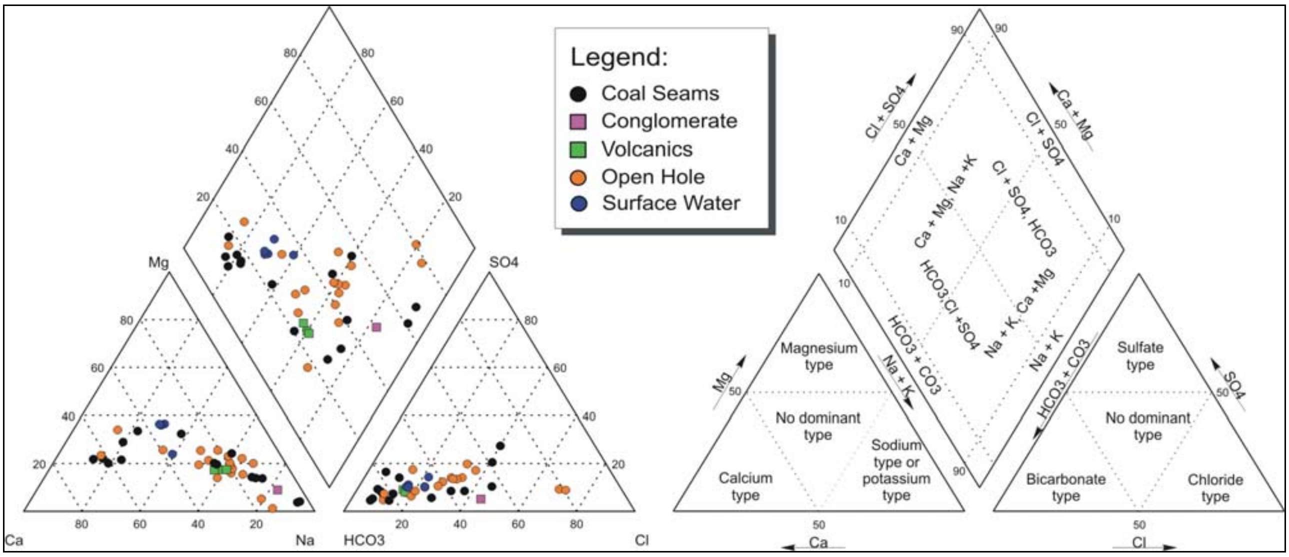


Figure 13: Piper Diagram of Permian Groundwater

The Piper Diagram shows a significant scatter in the data with the most common ionic composition being Ca-HCO_3, Na-HCO_3 and Na-Cl dominant water types. There does not appear to be any trends in the water types associated with geology, which was similarly concluded from an examination of water quality data from the adjacent Boggabri Coal Mine monitoring bores (AGE 2010).

7.4.5 Groundwater Levels

Graphs of pressure heads measured in the VWPs installed within the Project Boundary are shown in Figure 14 to Figure 16 below. The twin VWPs at each location show steep downward gradients between the coal seams of 0.05 (1m in 20m) for MAC263P and 0.1 (1m in 10m) for MAC267P.

The pressure head recorded in MAC268P was anomalously low at between RL 246m and RL 247m, and well below the groundwater levels in surrounding bores. The source of this anomaly is uncertain but it is unlikely to be related to dewatering of the Boggabri Coal Mine as the VWP is installed in the underlying seams that are not targeted at that operation.

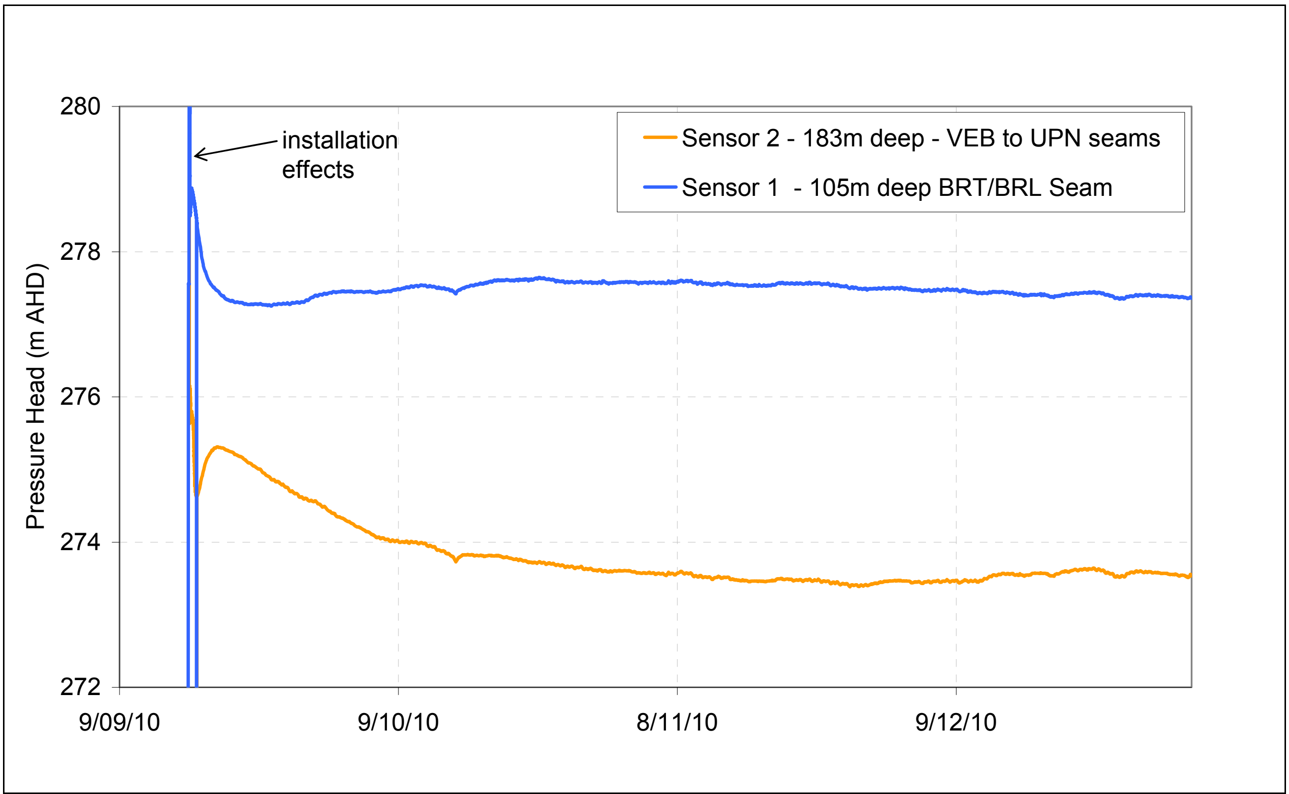


Figure 14: VWP Hydrographs – MAC 263P

(G1508)

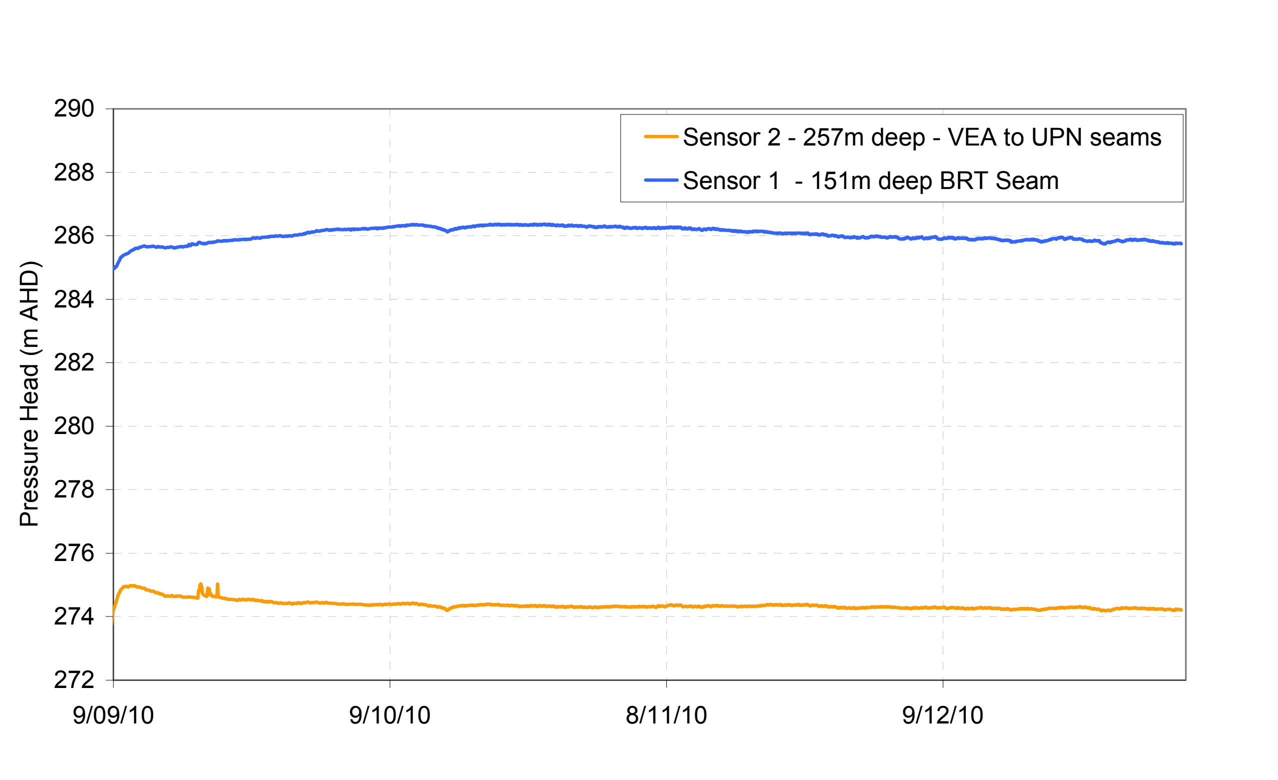


Figure 15: VWP Hydrographs – MAC 267P

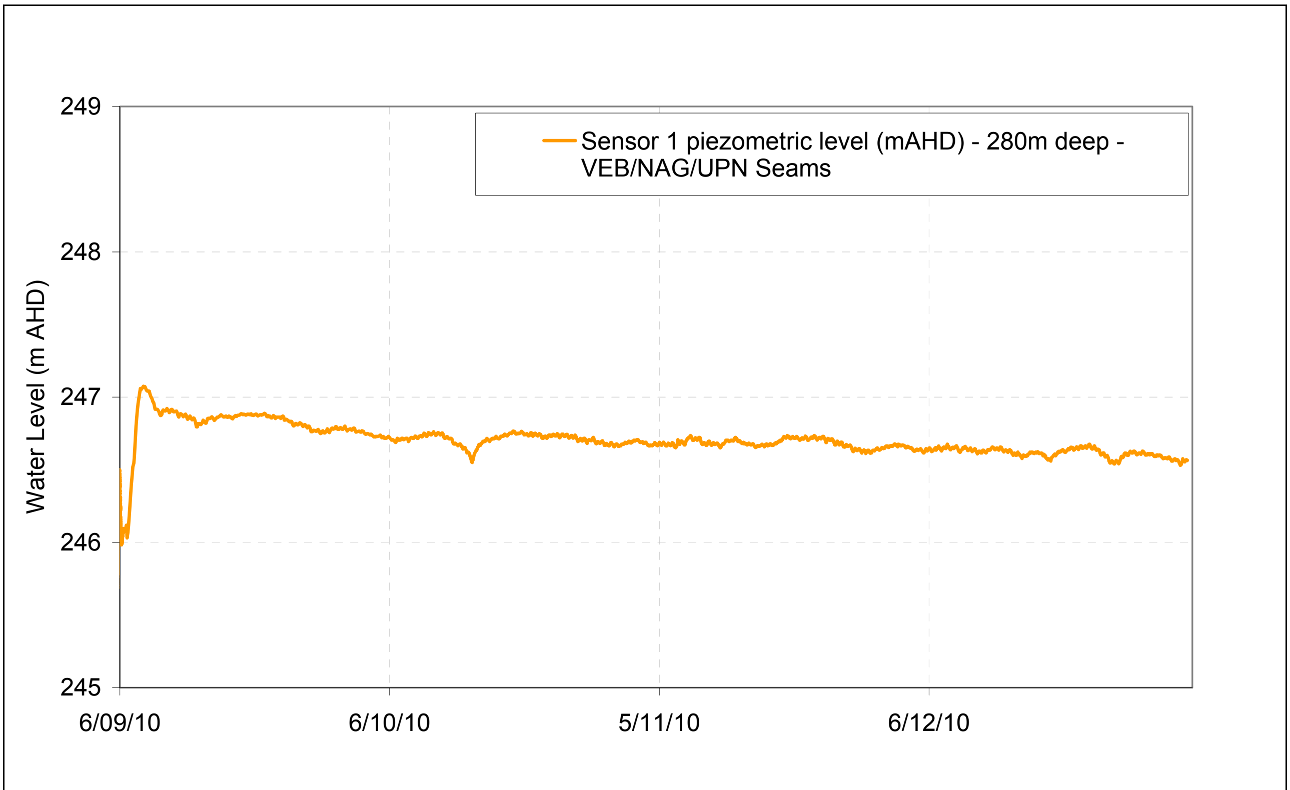


Figure 16: VWP Hydrographs – MAC 268P

7.4.6 Recharge, Discharge and Groundwater Flow

Early measurements of groundwater levels within the Maules Creek mining lease are reported by Coffey and Partners (1982). The water levels were determined by examination of geophysical logs from 75 exploration holes. The map of the potentiometric surface is reproduced in Figure 17.

Coffey and Partners (1982) concluded that the groundwater flow direction is similar to surface water flow directions and a reflection of the topography. The map of the potentiometric surface indicated a groundwater divide along the catchment divide between Back Creek and Maules Creek. It was indicated that faults may have an effect on water levels but insufficient data was available to confirm this.

Coffey and Partners (1982) considered rainfall recharge to occur in the high country in the Leard State Forest with groundwater then flowing along the alignment of Maules Creek and Back Creek. The creeks in the outcrop area including Back Creek do not have any permanent baseflow and therefore discharge from the Permian aquifer is expected to occur via direct discharge to the alluvial aquifer. The Maules Creek EIS indicated some groundwater discharge occurs via permanent springs along Maules Creek at the Elfin Crossing area, which has been confirmed by subsequent studies undertaken by Andersen and Acworth (2009).

Groundwater levels generally appear to be a subdued reflection of topography with a hydraulic gradient to the north, north-west in the Project Boundary within the footprint of the proposed open cut mine. The potentiometric surface for the Permian bedrock and the Quaternary sediments is presented in Drawing No. 11.

The potentiometric surface is based on average water levels in the NOW monitoring bores constructed within the alluvial aquifer, and on water levels in the Permian aquifer that were considered not to be impacted by mining. The Permian potentiometric surface should be considered as indicative only, as it combines groundwater levels across a range of coal seams, and does not account for differences in hydraulic head with depth. It does however provide a regional indication of groundwater flow directions and hydraulic gradients.

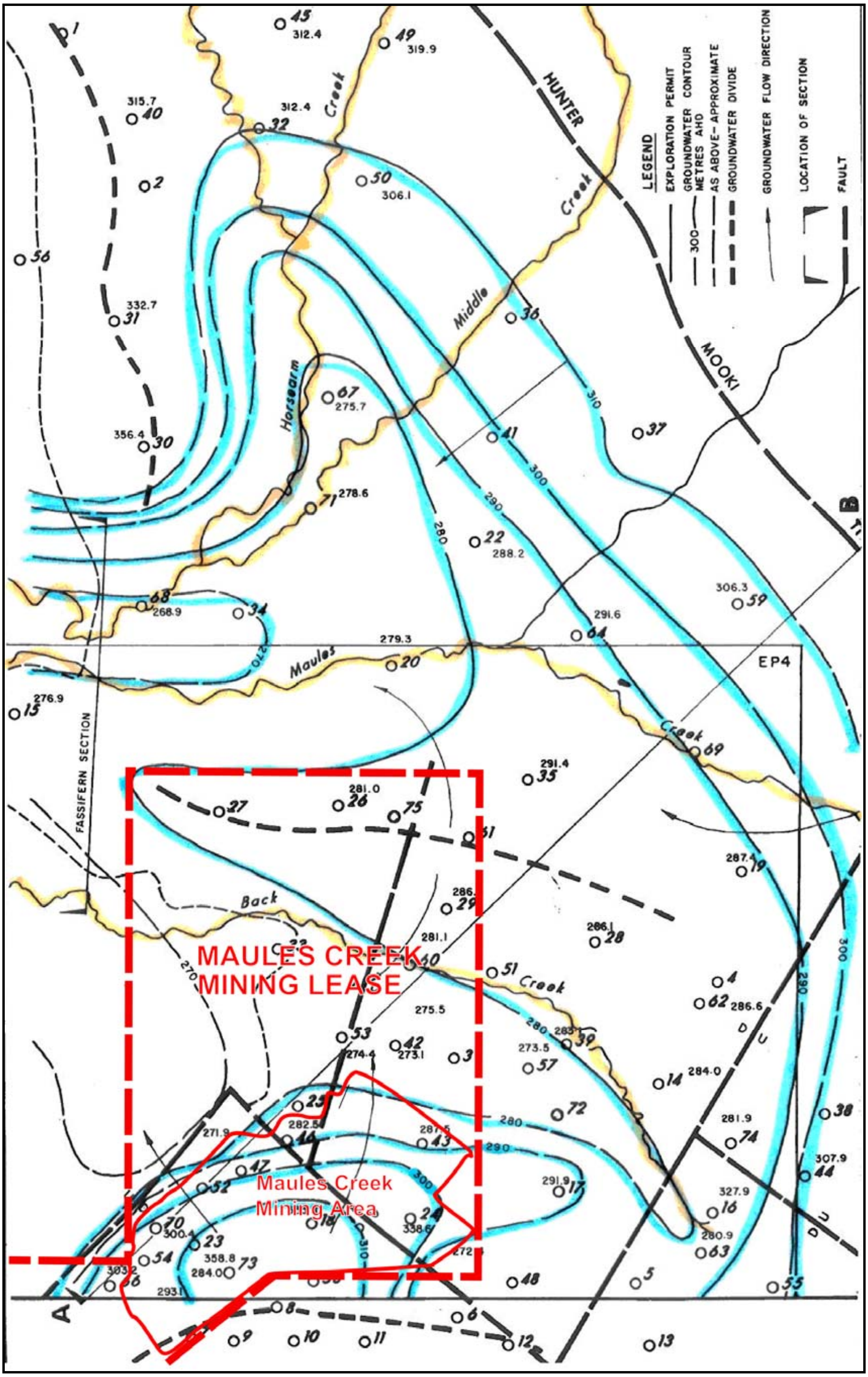


Figure 17: Groundwater Levels - Coffey and Partners 1982

(G1508)

AGE (2010) concluded that *"groundwater recharge to the Permian formations is expected to be relatively low due to the steep slopes in the outcrop areas that shed runoff, in addition to the tree cover that intercepts rainfall."* Estimates of diffuse recharge to the Permian formations from modelling studies for the adjacent Boggabri Coal Project varied from 1mm/year by AGE (2010) to 3mm/year by PB (2008).

A preliminary attempt to quantify the groundwater recharge rate was undertaken using the chloride mass balance method. This method involves determining the ratio of the chloride concentrations in rainfall and dry deposition to the concentration present in pore water in the unsaturated zone.

Rainwater samples were collected in a polyethylene bucket on 1 December 2010 and submitted to an ALS laboratory for chloride analysis. The sample reported a chloride concentration <1mg/L.

The concentration of chloride in the groundwater samples from the Permian varies from 12mg/L to 456mg/L with an average value of 128mg/L. Assuming a concentration of 0.5mg/L chloride in rainfall and no significant dry deposition, an average recharge rate of about 0.3% (ranging from 0.1% to 4.2%) or about 2mm/year can be approximated. It should be noted this is an extremely crude estimate and does not use pore water from the unsaturated zone but it does suggest recharge rates to the Permian are low.

7.4.7 Faulting

The Mooki Thrust Fault is the major structural fault in the area which marks the boundary of the Gunnedah Basin and the New England Fold Belt (refer Drawing No. 3).

The 1980s exploration work tentatively identified sub-parallel and perpendicular faulting to the Hunter-Mooki Thrust within the exploration permit, with vertical movements in the range of 20m to 50m. This finding appears to be repeated in Whitehouse (1993) who noted that *"faulting, both sub-parallel and perpendicular to the Hunter-Mooki Fault system, has displaced a block in the south-east, with respect to the remainder of the area. Several of the other blocks have been displaced some 40m to 50m, by prominent faults."*

This finding appears to be in contrast to more recent geological interpretations associated with the 2010 resource exploration program that could not identify any significant faults in the proposed mining area through geological modelling. It should be noted that the 1980s exploration permit covered an area of 105km^2, extending north of Maules Creek and as far south as the current Tarrawonga Mine, covering a large area relative to the current lease area, which does not incorporate the major structures observed east of the Project Boundary (refer to Figure 17).

Faulting has been exposed in the open cut pits at the adjacent Boggabri Coal Mine. AGE (2010) noted *"reverse faults are orientated in a north-west – south-east direction and are typically low angle. The maximum throw recorded on a reverse fault is horizontally 30m in the Merriown Seam. …... There is also evidence of bedding plane shear both within each coal seam and at the coal floor interface."*

A number of north-south trending faults have also been identified in the Permian sequence at the adjacent Tarrawonga Mine with displacements in the order of 30m. Several north-south trending faults have also been mapped in the area of the Vickery Mine to the south of the Project Boundary (refer Drawing No. 3).

8.0 MINE PLAN

The proposed mining operations commence in the central west of the mining area, progressing across dip to the south-west along the limit of oxidisation of the coal reserve. The mining then continues to move across and down-dip in a series of south-westerly moving strips. In the latter years of the Project, a series of short strips are advanced in the northern area of the footprint. The annual mining blocks are shown in Figure 18.

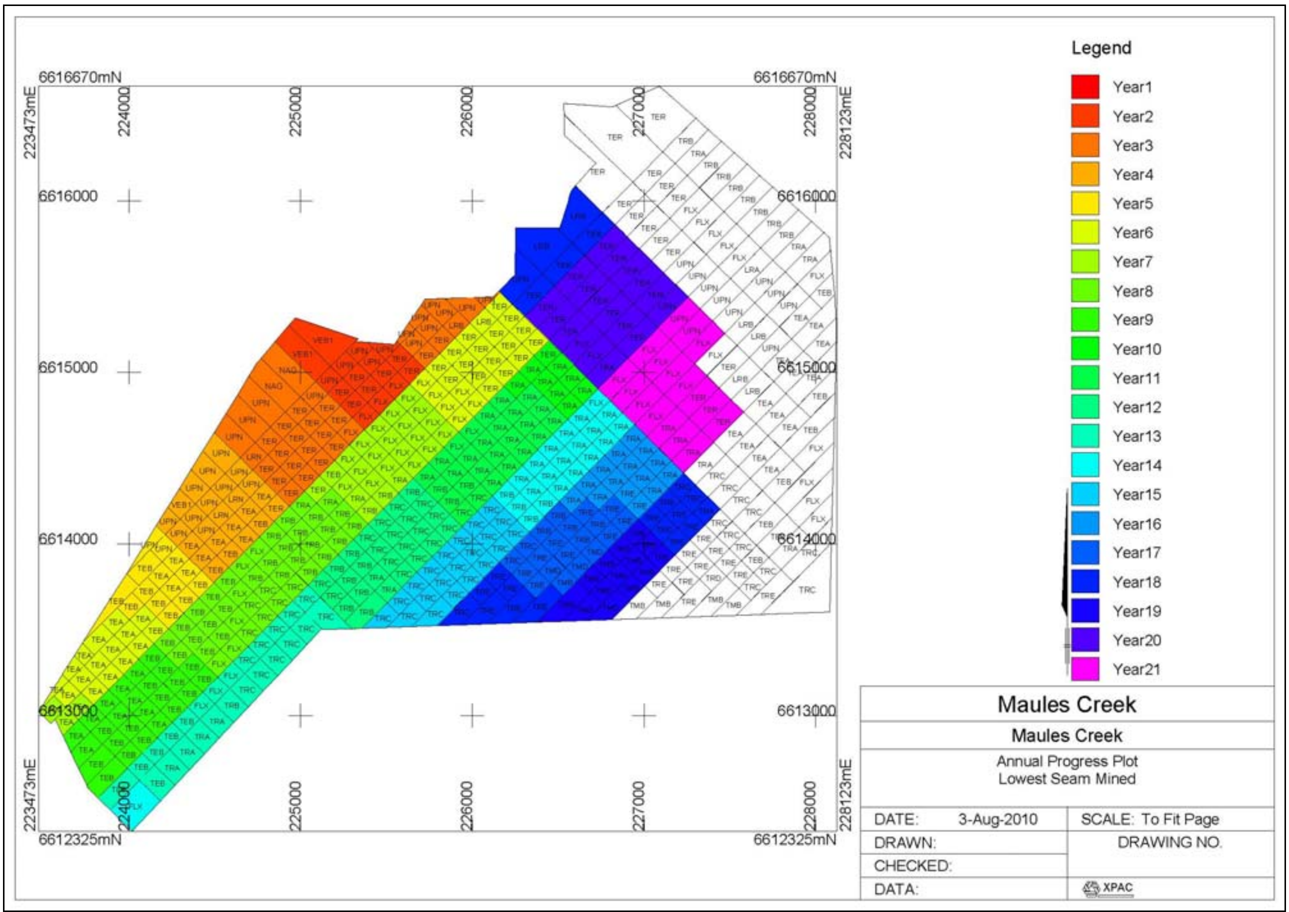


Figure 18: Project Mine Plan

During the early years of operation, the Northern Overburden Emplacement Area (OEA) is proposed to be developed in the northern part of the Project Boundary to the east of and north of the proposed infrastructure area. The Northern OEA is proposed to be fully developed by the end of Year 10 and largely rehabilitated by Year 15 (refer Drawing No. 2).

Due to the shallow nature of the coal reserves during the early years of mining, the Project will commence production at approximately 4 Mtpa ROM coal from Year 1. Production rates are then scheduled to increase to peak production by Year 9.

The proposed open cut mining area will remain at least 3km from the alluvial aquifers to the south and at least 5.6km from the Maules Creek alluvial aquifer to the north as shown in Figure 19.

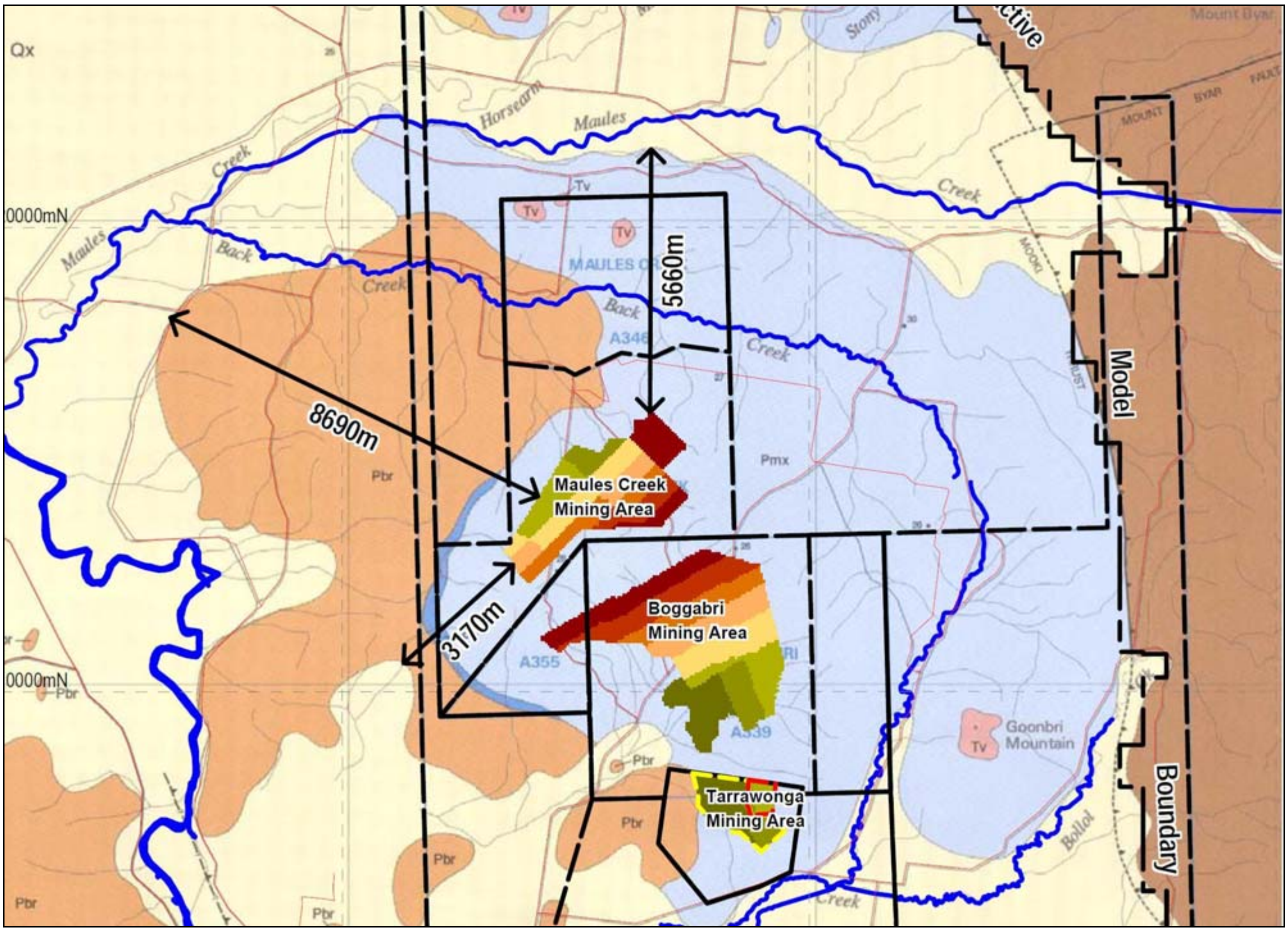


Figure 19: Distance of Proposed Mine from Alluvial Aquifer

Additional coal resources are known to exist beyond the proposed 21-year mining limit for the Project and the mine plan has allowed for further mining should a future approval be granted.

Should a future approval not be granted for the continuation of mining, the remaining open void is likely to be shaped down and rehabilitated leaving a final void. A further option that has been investigated is the backfilling of this void to a level above the regional groundwater levels and reshaped as indicatively shown in Figure 20. However the preferred option is to leave a final void in place should a future approval not be granted.

(G1508)

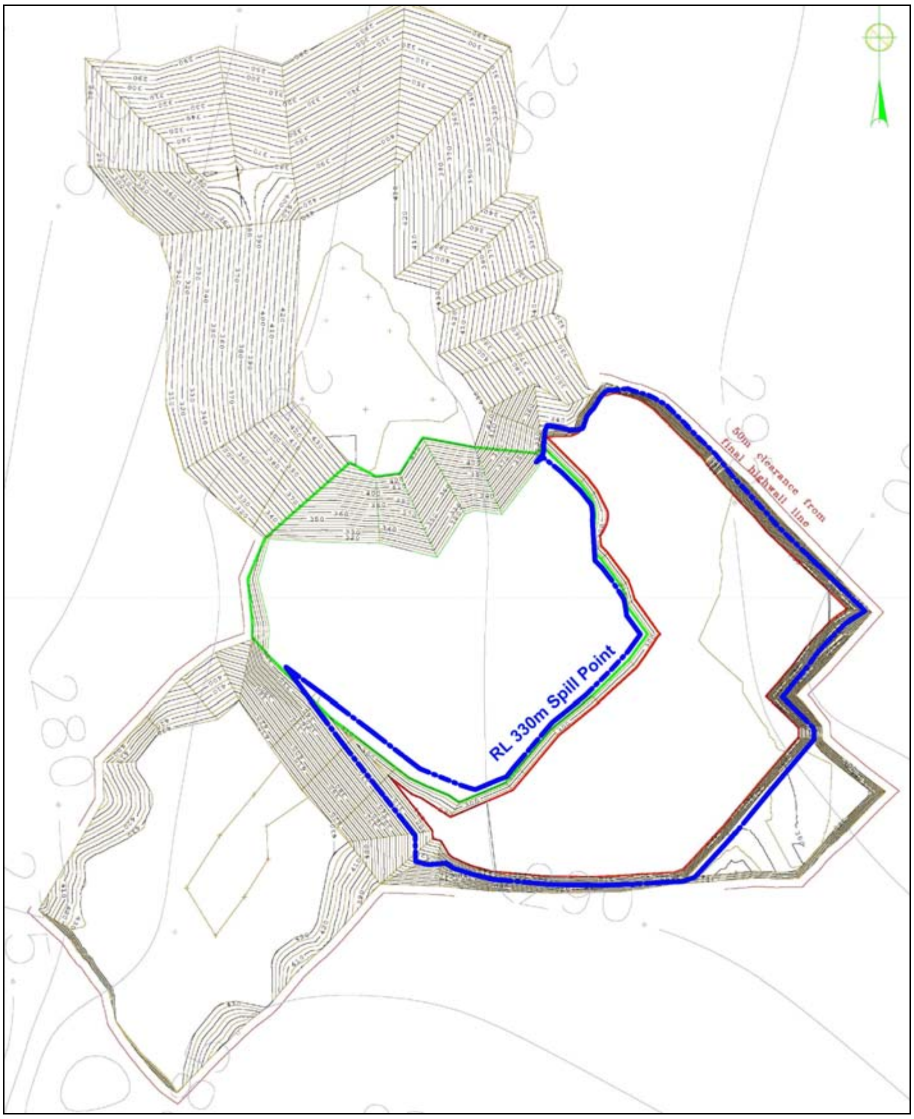


Figure 20: Indicative Post Closure Landform

9.0 NUMERICAL GROUNDWATER MODEL

9.1 Modelling Objectives

Predictive numerical modelling was undertaken to assess the impact of the Project on the groundwater regime. The objectives of the predictive modelling were to:

- estimate groundwater inflows to the open cut void over the 21-year mine life;
- predict the zone of influence of dewatering and the level and rate of drawdown at specific locations;
- predict the magnitude of any drainage from the alluvial aquifer into the underlying Permian strata;
- predict the impact of mine dewatering on groundwater discharges to surface flows and other groundwater users; and

- identify areas of potential risk where groundwater impact mitigation/control measures may be necessary.

9.2 Conceptual Model

Every numerical groundwater model has as its foundation a conceptual model. The conceptual model is an understanding of how the groundwater system operates and is an idealised and simplified representation of the natural system.

Extensive information on the natural system is typically required to develop an equivalent and simplified conceptual groundwater model representative of the system. Development of the conceptual groundwater model is a crucial step in groundwater modelling. Care has to be taken during the development of such models since errors in the conceptual model cannot be corrected during the model calibration, or at any later stage of the modelling study, without major revisions. Formulation of the conceptual model often highlights gaps in data or deficiencies in the understanding of the groundwater system.

Zheng and Bennett (1995) note that '*a conceptual model contains numerous qualitative and subjective interpretations. The appropriateness of the conceptual model can not be tested until a numerical model is built and comparisons between field observations and model simulation results are made'.*

The following sections present the available information that has been used to develop a model of the hydrogeological regime. This task includes an initial conceptual model and a more detailed numerical model. This conceptual model forms the basis of the assumptions used when developing the more detailed numerical model. MDBC (2000) define a conceptual model as an "*idealised summary of the current understanding of catchment conditions, and the key aspects of how the flow system works…subject to some simplifying assumptions.*

The data indicate the area supports three distinct groundwater systems:

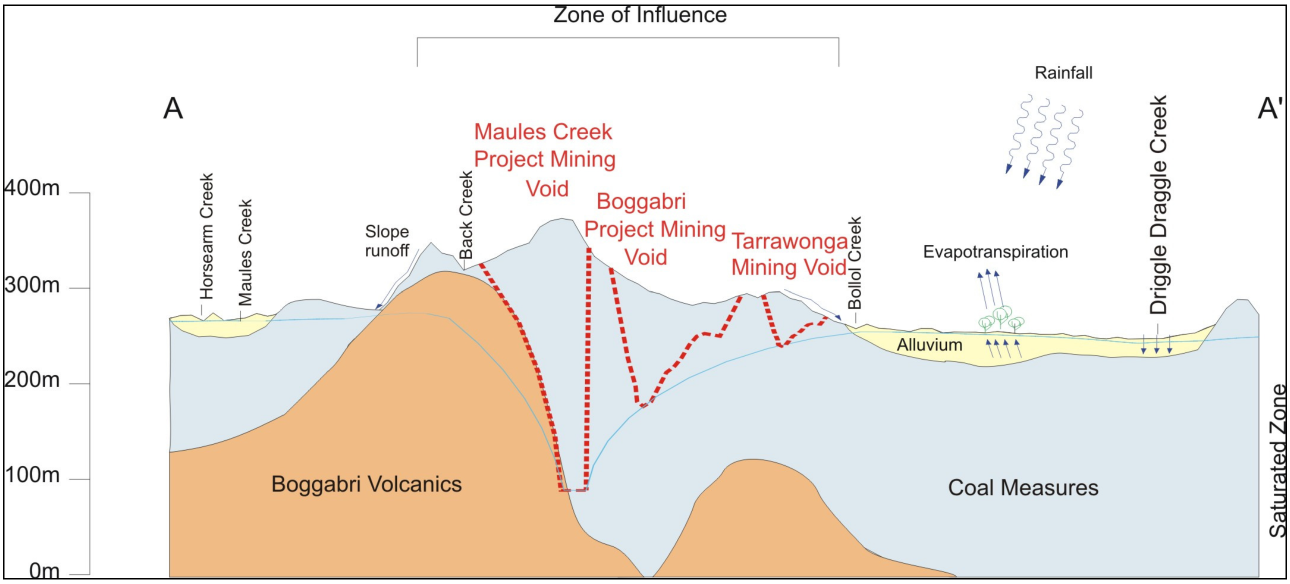
- alluvium associated with the Namoi River and its tributaries;
- weathered bedrock (regolith) near ground surface; and
- low permeability Permian aquifers associated with the Maules Creek Formation and the Boggabri Volcanics.

Recharge to the groundwater system is from rainfall, lateral groundwater flow at the boundaries of the study area, and leakage from the major rivers and tributaries. The water balance is dominated by recharge to the alluvial aquifer that is significantly higher than recharge to the bedrock basement that forms elevated "island" outcrops throughout the study area. Groundwater inflow to the alluvial aquifers from the surrounding bedrock is considered to be low, as evident in previous government studies that have excluded the bedrock aquifers from groundwater models.

Although groundwater levels are sustained by recharge, they are controlled by surface topography, surface water levels and aquifer permeability. Groundwater mounds are present beneath the hill areas, with a hydraulic gradient towards the lower lying alluvial lands. Groundwater flow is from these elevated areas with discharge to the Namoi River in areas where the potentiometric surface is above the bed of the river, and removal by evaporation and/or evapotranspiration through vegetation where the water table is within a few metres of ground surface. Irrigation, stock and domestic bores also remove a significant amount of water from the alluvial aquifer on an often variable basis.

During events of high water flows in the ephemeral creeks, water can discharge or leak into the alluvial aquifers. In places where mining has occurred, groundwater discharge is expected to be via the mined seam and to a lesser extent from the strata above and below at a rate related to the permeability and the hydraulic gradient.

The conceptual model is illustrated in a cross section in Figure 21. The location of the cross section is shown on Drawing No. 3. It should be noted this figure displays the key concepts in the hydrogeological regime but does not represent localised detail in the geological surfaces.



Note i) this figure is conceptual only - ~2.5 x vertical exaggeration
ii) the Maules Creek Coal Project is projected to the cross section and does not intersect the Boggabri Volcanics

Figure 21: Conceptual Cross Section – Section A – A'

9.3 Model Development

9.3.1 Model Code

Numerical simulation of groundwater flow in the aquifers was undertaken using the MODFLOW SURFACT code (referred to as SURFACT for the remainder of the report). A commercial derivative of the standard MODFLOW code, SURFACT is distributed by Hydrogeologic Inc and has some distinct advantages over the standard MODFLOW, that are critical for the simulation of groundwater flow in the vicinity of the Project Boundary.

The MODFLOW code (on which SURFACT is based), is the most widely used code for groundwater modelling and is presently considered an industry standard. Use of the SURFACT modelling package is becoming increasingly widespread, particularly in mining applications where mine dewatering and recovery are simulated.

SURFACT is capable of simulating variably saturated conditions. This is critical for the requirements of the Project where coal seams will be progressively dewatered with time resulting in desaturated model cells within the pit dimensions. Then active dewatering will cease, and groundwater recovery will rewet the spoil within the pit and adjoining dewatered strata. SURFACT is also supplied with robust numerical solution schemes to handle the more complex numerical problem resulting from the unsaturated flow formulation. Added to the robust numerical solution schemes is an adaptive time-stepping function that aides the progression of the solution past difficult and complex numerical situations such as oscillations.

The MODFLOW pre and post processor PMWIN (Chaing and Kinzelbach, 1996) was used to generate some of the input files for the SURFACT model, such is the similarity between it and the standard MODFLOW. Where files differ to allow for the additional capabilities of SURFACT, these changes were undertaken through manual editing of the model files.

9.3.2 Model Geometry and Boundary Conditions

The model grid is overlain on the regional geology in Drawing No. 12. The model domain was discretised into 47,965 rectangular cells comprising 265 rows and 181 columns. The dimensions of the model cell size vary from 50m by 50m within the mining area and up to 500m by 500m outside the Project Boundary, as shown on Drawing No. 12.

The north-west corner of the grid is located at 212,150mE and 6,632,450mN (MGA94, Z56), with the grid oriented directly north-south to align the principal axis direction with the majority of observed groundwater flow directions. The model extent is about 29.9km x 39.8km covering an area of approximately 1,190km^2. The cells located to the east of the Mooki Fault, where the coal seams are not present were excluded from the simulation.

Publicly available digital elevation data with a 250m x 250m grid spacing was used to represent the ground surface in the model. This data was chosen as the existing neighbouring open cut pits were not evident and therefore the dataset was suitable for the pre-mining calibration.

The model comprises 12 layers with the various geologies represented as follows:

- Narrabri Formation in the alluvial parts of Layer 1;
- Gunnedah Formation in the alluvial parts of Layer 2;
- Coal seams are simulated in Layers 4, 6, 8, and 10 and exist between the subcrop for each seam and the Mooki Thrust Fault;
- Permian interburden exists in Layers 3, 5, 7, 9, and 11 where the particular layer is above the top of the basalt basement;
- Basalt forms the basement and can appear in all layers as it also outcrops in the model area;
- Weathered Permian (Regolith) exists in Layers 1 and 2 where there is no alluvium or no outcropping basalt.

The model structure detailing the locations of the geological units can be seen in Figure 22, Figure 23 and Figure 24 which show three-dimensional and cross sectional views through the Project Boundary.

The model domain extent has the following boundary conditions applied:

- a “no flow” boundary along the Mooki Thrust Fault zone marks the eastern boundary of the model;
- a constant head boundary set at RL 234m in model layer 2 was used to represent southern boundary flow into the model in the Gunnedah Formation alluvial aquifer, with a second

constant head boundary in model layer 2 set on the North-West boundary side at RL 224m to represent outflow from the model; and

- “no-flow” boundaries were set along the northern, western and southern boundaries where no fixed heads were applied at an arbitrary distance considered beyond the influence of the mining operations.

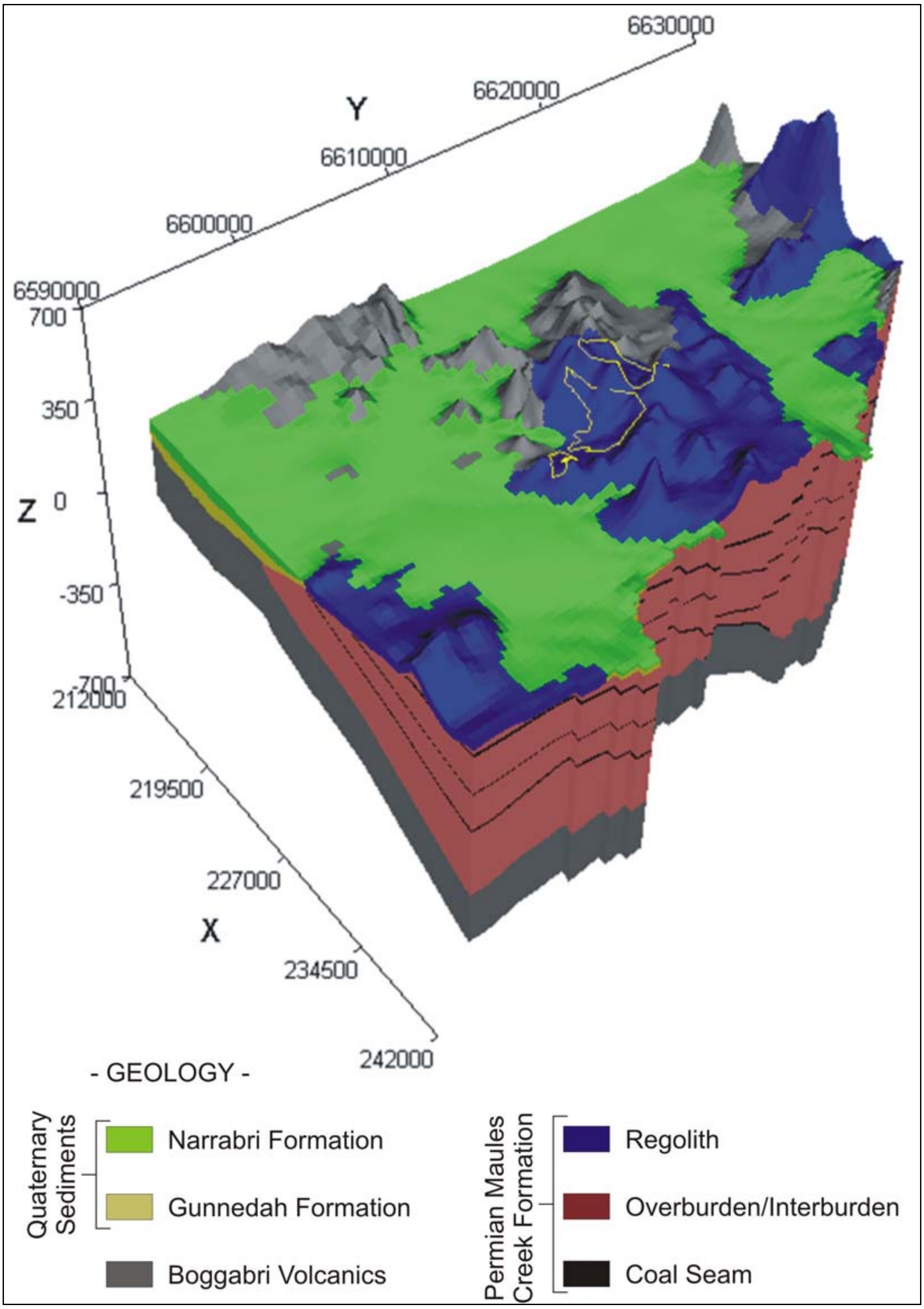


Figure 22: 3D Representation of Model Domain

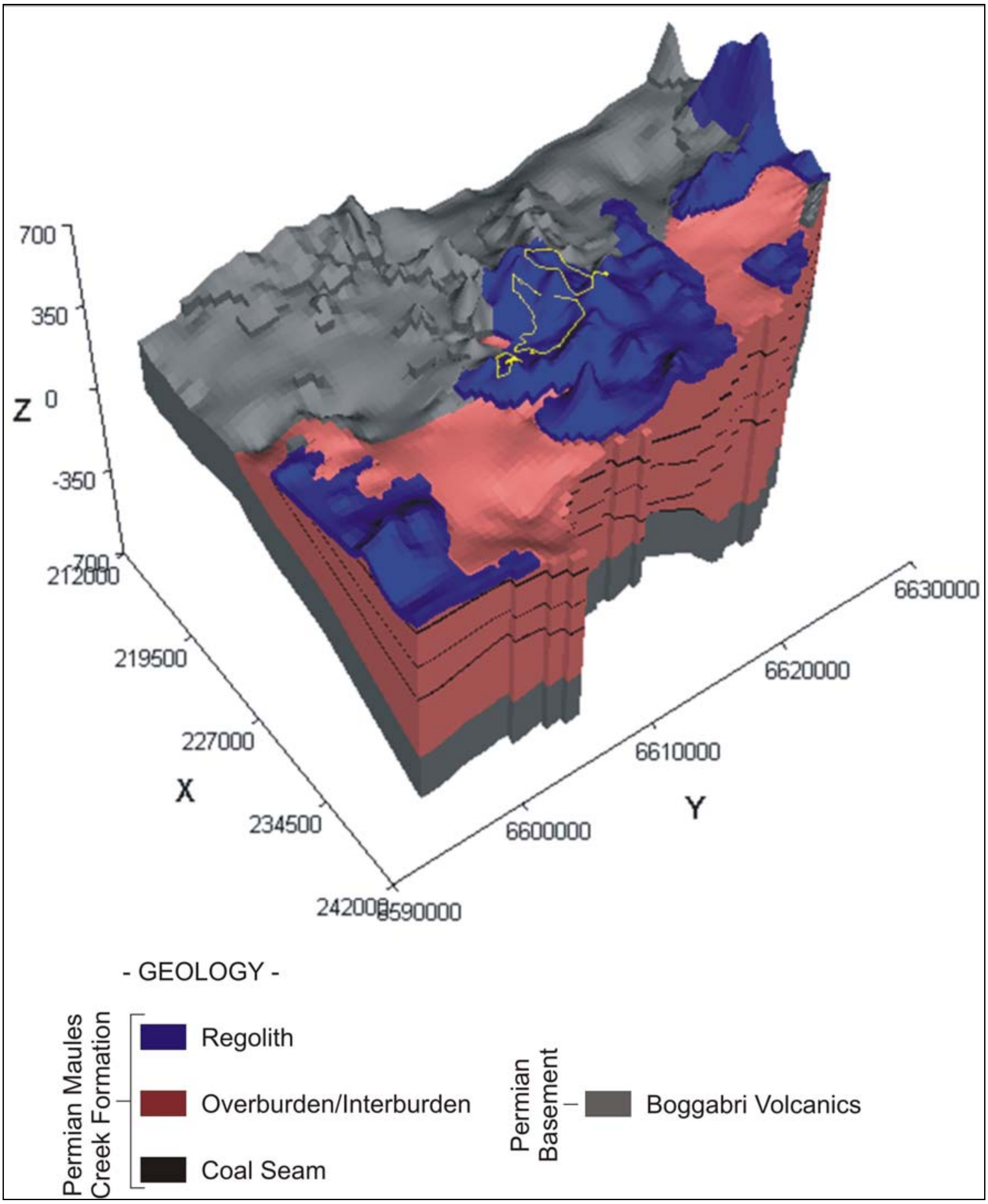


Figure 23: 3D Representation of Model Domain – Alluvium Removed

(G1508)

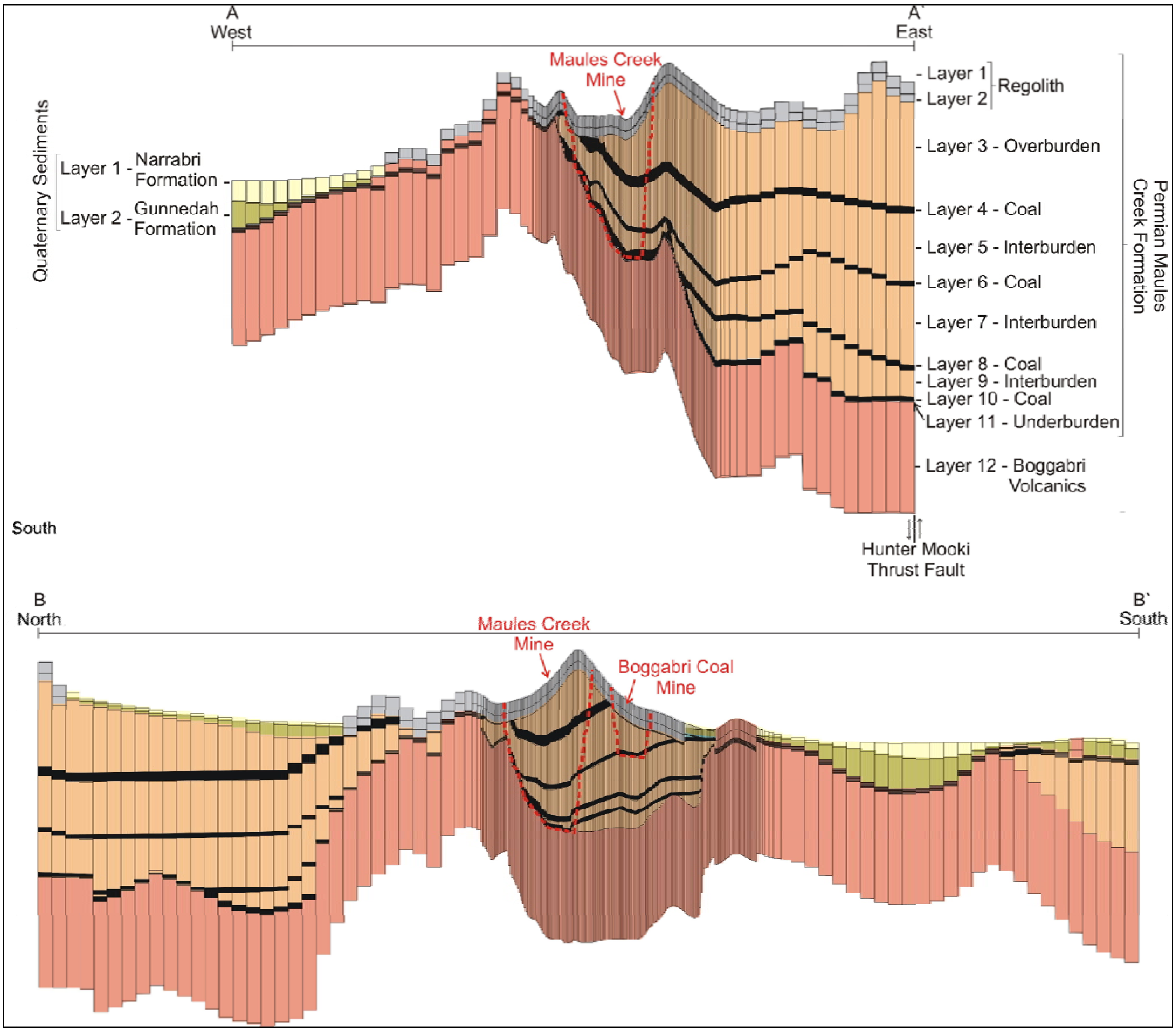


Figure 24: Cross Sections through Numerical Model

9.3.3 Hydraulic Parameters

The hydraulic parameters adopted through a calibration process for the various geological units simulated in the model are as shown in Table 10.

Table 10: HYDRAULIC PARAMETERS		
Geology Type	**Parameter**	**Value**
Narrabri Formation (Alluvial)	Horizontal Hydraulic Conductivity kh	7.02 m/day
	Vertical Hydraulic Conductivity kv	6.25×10^{-2} m/day
	Specific Yield S_y	0.05
	Specific Storage S_s	5×10^{-4} m^{-1}

Table 10: HYDRAULIC PARAMETERS		
Geology Type	**Parameter**	**Value**
Gunnedah Formation (Alluvial)	Horizontal Hydraulic Conductivity kh	8.32 m/day
	Vertical Hydraulic Conductivity kv	2.38 m/day
	Specific Yield Sy	0.05
	Specific Storage Ss	5×10^{-4} m^{-1}
Coal Seams	Horizontal Hydraulic Conductivity kh	5.43×10^{-2} m/day
	Vertical Hydraulic Conductivity kv	5.0×10^{-3} m/day
	Specific Yield Sy	5×10^{-3}
	Specific Storage Ss	1×10^{-5} m^{-1}
Permian Interburden	Horizontal Hydraulic Conductivity kh	1.88×10^{-4} m/day
	Vertical Hydraulic Conductivity kv	5.96×10^{-5} m/day
	Specific Yield Sy	1×10^{-4}
	Specific Storage Ss	1×10^{-6} m^{-1}
Boggabri Volcanics (Basaltic Basement)	Horizontal Hydraulic Conductivity kh	1.01×10^{-2} m/day
	Vertical Hydraulic Conductivity kv	5.93×10^{-4} m/day
	Specific Yield Sy	1×10^{-3}
	Specific Storage Ss	1×10^{-5} m^{-1}
Weathered Permian (cover material)	Horizontal Hydraulic Conductivity kh	0.145 m/day
	Vertical Hydraulic Conductivity kv	9.2×10^{-3} m/day
	Specific Yield Sy	1×10^{-3}
	Specific Storage Ss	1×10^{-5} m^{-1}

The above parameters generally fall within the ranges of aquifer parameters determined in the field investigations and by previous testing and modelling studies.

9.3.4 Recharge and Discharge

Recharge zones and rates were based on previous modelling studies by NOW (2006), CSIRO (2007) and Martin Anderson from UNSW Connected Water Innovative (Cotton CRC). The recharge zones and rates are shown in Drawing No. 13 and were as follows:

- Alluvial aquifer 7.2mm/yr - 1.2% of annual rainfall
- Slope wash zone 116.3mm/yr - 19.6% of annual rainfall
- Volcanic outcrop 2.7mm/yr - 0.5% of annual rainfall
- Permian outcrop 0.66mm/yr - 0.1% of annual rainfall

(G1508)

The recharge was applied to the uppermost layer in the model that represented the topographic surface.

Discharge from the model was via river cells assigned along Namoi River and the major ephemeral creeks. The bed elevations of the river were set by subtracting an inferred river bed depth from the topographic surface elevation. The inferred river bed depth was based on observations and estimations from a site visit carried out on 23 November 2010.

The Namoi River was assigned a bed elevation 5m below ground level. Some other surface drainages were assigned only half a metre of incision into the landscape, such as Bollol Creek. Only the Namoi River, Maules Creek downstream of Elfin Crossing and an upstream section of the Bollol Creek were assigned a positive head of water in the river, that is they were able to recharge the aquifer. The other surface drainage lines in the model were assigned a water level equal to the base elevation, hence they only simulated the "drainage" of water out of the aquifer where and when the groundwater levels were high enough.

Evapotranspiration was applied to the entire model domain at a rate of 0.4mm/day with an extinction depth of 2m below ground surface using the SURFACT evapotranspiration package. While the max evapotranspiration is considered at the lower end of the range of possible values, higher values were found to cause numerical convergence problems in the steady state model.

Extraction of water from irrigation bores in the alluvial aquifer was not included in the model as this data is variable and was not available in the public domain. However the extraction from bores is accounted for in the balance of inputs and outputs adopted during the steady state model calibration. Groundwater discharging from the model via drains, river flow, evapotranspiration and constant head cells accounts for water that would be removed by irrigation from the aquifer.

Discharge and recharge also occur through the fixed head boundary conditions applied to the Gunnedah formation representing the down-gradient flow in the alluvial aquifer.

9.4 Model Calibration

Anderson and Woessner (1992) note that *'calibration of a groundwater flow model refers to a demonstration that the model is capable of producing field measured heads and flows which are the calibration values. Calibration is accomplished by finding a set of parameters, boundary conditions and stresses that produce simulated heads and fluxes that match field measured values within an acceptable range of error'.*

9.4.1 Calibration Targets

Groundwater levels were collated for monitoring bores within the Project Boundary, Boggabri Coal Mine and Tarrawonga Mine and from publicly available levels measured in registered monitoring bores.

A long record of water level measurements was available for the NOW monitoring bores. The median water level was calculated and adopted as the steady state calibration target. Calibration targets adopted for the monitoring bores at the mining operations were selected from pre-mining measurements, or from sites that were relatively distant from the mining operations and hence unaffected by any existing mine dewatering.

The objective of the steady state modelling was to simulate pre-mining conditions and therefore bores which had been potentially affected by mining activities were removed from the calibration process. A total of 97 bores were used to calibrate the model.

During the simulations, the recharge rates to the model domain were fixed and the horizontal and vertical hydraulic conductivity and river bed vertical conductivity were altered to obtain model calibration. The main objective of model calibration was to reproduce groundwater levels at the individual monitoring bores and hence the general pattern of the groundwater contours and the direction of the groundwater flow.

A transient calibration was not attempted because information on extraction rates from individual bores was not readily available in the public domain, which would have been necessary to match the water levels measured in the government monitoring bores with the model predictions. In addition no accurate measurements of groundwater seepage rates to the existing Boggabri Coal Mine and Tarrawonga Mine were available for a transient calibration. The calibrated hydraulic properties in the model for the alluvial aquifers have a good match with the parameters reported by NOW (2006) which were estimated through a transient model calibration. In particular, the calibrated hydraulic conductivities of 7.02 and 8.32m/day compare well with the NOW estimated average parameters of 6.3 and 7.1m/day for the Narrabri and Gunnedah Formations respectively.

9.4.2 Calibration Results

Comparison of observed and simulated groundwater levels in the model area are given in Table 11 and as scattergram in Figure 25. The simulated steady state water levels in Layer 2 are presented in Drawing No. 14.

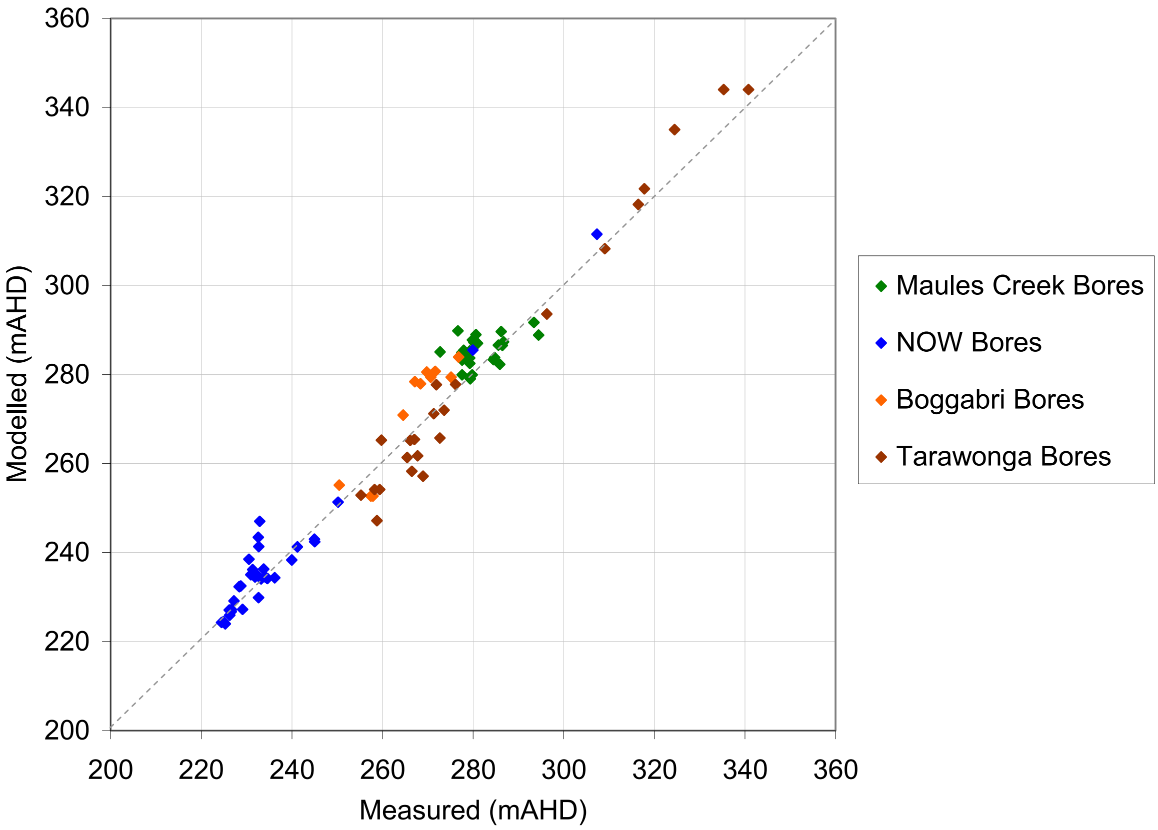


Figure 25: Observed vs Simulated Groundwater Levels – Steady State Model

(G1508)

Table 11: CALIBRATION TARGETS AND SIMULATED WATER LEVELS – STEADY STATE MODEL						
BORE_ID	**Easting**	**Northing**	**Measured Water Level (RL m)**	**Modelled Water Level (RL m)**	**Residual (m)**	**Location**
MAC1218	224015	6613693	279.4	279.0	-0.3	Maules Creek Mine
MAC1219	224172	6613678	279.8	279.9	0.2	Maules Creek Mine
MAC1227	224542	6613991	277.6	279.9	2.3	Maules Creek Mine
MAC1246	224837	6614553	285.9	282.3	-3.6	Maules Creek Mine
MAC1249	224879	6614627	279.3	282.5	3.2	Maules Creek Mine
MAC1251	224722	6614877	277.6	283.4	5.7	Maules Creek Mine
MAC1252	224771	6614868	277.6	283.2	5.6	Maules Creek Mine
MAC1254	224725	6614966	279.2	283.7	4.5	Maules Creek Mine
MAC1255	224928	6615075	277.2	283.8	6.6	Maules Creek Mine
MAC1256	224879	6615085	284.8	283.8	-0.9	Maules Creek Mine
MAC1258	224927	6615148	277.2	283.9	6.8	Maules Creek Mine
MAC1259	224948	6615277	272.7	285.1	12.4	Maules Creek Mine
MAC1259A	224959	6615286	277.9	285.1	7.2	Maules Creek Mine
MAC1261	226750	6614872	286.2	289.7	3.5	Maules Creek Mine
MAC1263	226069	6615258	279.3	285.3	6.0	Maules Creek Mine
MAC1270	225888	6615695	279.9	287.8	7.9	Maules Creek Mine
MAC1271	226144	6615653	285.6	286.6	1.0	Maules Creek Mine
MAC1272	226165	6615852	281.0	287.0	6.1	Maules Creek Mine
MAC1279	226446	6616312	280.6	289.0	8.3	Maules Creek Mine
MAC1280(s)	226525	6616503	293.4	291.7	-1.7	Maules Creek Mine
MAC1280(d)	226525	6616503	276.6	289.8	13.2	Maules Creek Mine
MAC1281	226076	6615969	280.2	287.2	7.1	Maules Creek Mine
MAC1283	224989	6615291	277.9	285.4	7.5	Maules Creek Mine
MAC250	225009	6615230	277.5	284.9	7.4	Maules Creek Mine
MAC252	226240	6614772	294.5	288.9	-5.6	Maules Creek Mine
MAC257	224966	6614950	284.5	283.4	-1.1	Maules Creek Mine
MAC267	227440	6615472	286.7	287.4	0.7	Maules Creek Mine
MAC268P	227498	6614521	286.4	286.5	0.1	Maules Creek Mine
GW030048	220712	6600066	233.8	236.3	2.5	NOW Monitoring Bore
GW030051	224986	6599590	232.7	241.3	8.6	NOW Monitoring Bore
GW030052	226616	6599386	232.9	247.0	14.1	NOW Monitoring Bore
GW030129	217136	6619638	240.0	238.3	-1.6	NOW Monitoring Bore
GW030130	217406	6620539	241.2	241.3	0.0	NOW Monitoring Bore
GW030131	217455	6621711	245.1	242.4	-2.6	NOW Monitoring Bore
GW030132	217321	6623773	245.0	243.0	-2.0	NOW Monitoring Bore
GW030468	217748	6603410	231.0	235.0	4.1	NOW Monitoring Bore
GW030469	218614	6603895	231.9	234.5	2.6	NOW Monitoring Bore
GW030470	218997	6604552	232.1	235.1	3.1	NOW Monitoring Bore
GW030471	219450	6605581	231.4	236.2	4.8	NOW Monitoring Bore
GW030472	225148	6602615	232.6	243.4	10.9	NOW Monitoring Bore
GW030535	222609	6599838	230.5	238.5	8.0	NOW Monitoring Bore
GW036003	212979	6618419	224.9	224.5	-0.4	NOW Monitoring Bore

Table 11: CALIBRATION TARGETS AND SIMULATED WATER LEVELS – STEADY STATE MODEL						
BORE_ID	**Easting**	**Northing**	**Measured Water Level (RL m)**	**Modelled Water Level (RL m)**	**Residual (m)**	**Location**
GW036007	216174	6607530	228.5	232.4	3.9	NOW Monitoring Bore
GW036008	216601	6607510	228.4	232.4	4.0	NOW Monitoring Bore
GW036014	213903	6611723	226.3	225.9	-0.4	NOW Monitoring Bore
GW036015	215136	6611509	226.6	226.7	0.1	NOW Monitoring Bore
GW036016	216205	6611383	226.7	227.2	0.5	NOW Monitoring Bore
GW036056	215028	6609534	227.2	229.1	1.9	NOW Monitoring Bore
GW036057	216488	6607723	228.7	232.5	3.7	NOW Monitoring Bore
GW036092	218434	6603674	231.4	235.1	3.7	NOW Monitoring Bore
GW036093	212642	6617022	225.3	224.0	-1.3	NOW Monitoring Bore
GW036164	213083	6617497	224.5	224.3	-0.2	NOW Monitoring Bore
GW036185	215750	6611464	226.2	227.1	0.9	NOW Monitoring Bore
GW036186	214347	6618116	229.1	227.3	-1.9	NOW Monitoring Bore
GW036187	215355	6618358	232.6	229.8	-2.8	NOW Monitoring Bore
GW036548	222929	6594698	236.2	234.3	-1.9	NOW Monitoring Bore
GW036565	217594	6598104	234.2	234.4	0.2	NOW Monitoring Bore
GW036567	217798	6596445	234.6	234.2	-0.4	NOW Monitoring Bore
GW036568	217621	6595084	234.6	234.2	-0.4	NOW Monitoring Bore
GW036598	217315	6593569	233.2	234.0	0.8	NOW Monitoring Bore
GW041027	232730	6620523	307.3	311.5	4.2	NOW Monitoring Bore
GW967137	219846	6622452	250.2	251.3	1.2	NOW Monitoring Bore
GW967138	227001	6622422	280.0	285.5	5.5	NOW Monitoring Bore
GW3115	225174	6608903	250.4	255.2	4.7	Boggabri Coal Mine
IBC2102	226892	6611771	270.6	279.4	8.7	Boggabri Coal Mine
IBC2103	226898	6611773	275.1	279.4	4.3	Boggabri Coal Mine
IBC2105	228321	6612212	276.8	283.9	7.1	Boggabri Coal Mine
IBC2110	225939	6607684	257.9	252.7	-5.2	Boggabri Coal Mine
IBC2111	225950	6607683	257.4	252.7	-4.7	Boggabri Coal Mine
IBC2113	229720	6608797	268.4	277.9	9.5	Boggabri Coal Mine
IBC2114	229146	6610283	269.8	280.5	10.8	Boggabri Coal Mine
IBC2115	229155	6610279	271.7	280.7	9.1	Boggabri Coal Mine
IBC2138	226725	6610387	264.6	270.9	6.3	Boggabri Coal Mine
IBC2139	229421	6609296	267.2	278.4	11.2	Boggabri Coal Mine
BCS1	237177	6610679	335.3	344.0	8.7	Tarrawonga Mine
BCS2	236682	6609459	324.5	335.0	10.6	Tarrawonga Mine
BCS3	236179	6608490	317.8	321.7	3.9	Tarrawonga Mine
BCS4	236016	6608368	316.5	318.2	1.8	Tarrawonga Mine
BCS5	235314	6607331	309.1	308.3	-0.8	Tarrawonga Mine
BCS6	234563	6606093	296.3	293.6	-2.7	Tarrawonga Mine
BCS7	231656	6605754	271.9	277.7	5.8	Tarrawonga Mine
Greentree A	237537	6610693	340.8	344.0	3.2	Tarrawonga Mine
GW002129	228724	6606271	259.7	265.3	5.5	Tarrawonga Mine
GW002501	228013	6606613	267.1	265.4	-1.7	Tarrawonga Mine

(G1508)

Table 11: CALIBRATION TARGETS AND SIMULATED WATER LEVELS – STEADY STATE MODEL						
BORE_ID	**Easting**	**Northing**	**Measured Water Level (RL m)**	**Modelled Water Level (RL m)**	**Residual (m)**	**Location**
GW031856	229157	6603179	266.5	258.2	-8.2	Tarrawonga Mine
GW044997	230870	6605895	273.6	272.0	-1.6	Tarrawonga Mine
GW052266	227848	6604674	259.4	254.2	-5.2	Tarrawonga Mine
MW1	228743	6605702	265.4	261.4	-4.1	Tarrawonga Mine
MW2	228851	6605704	267.8	261.7	-6.1	Tarrawonga Mine
MW3	226041	6607875	255.3	252.9	-2.3	Tarrawonga Mine
MW4	227848	6604708	258.2	254.2	-4.1	Tarrawonga Mine
MW5	229488	6605985	272.7	265.7	-7.0	Tarrawonga Mine
MW6	225385	6607871	258.7	247.1	-11.6	Tarrawonga Mine
MW7	229823	6607932	276.1	277.8	1.6	Tarrawonga Mine
MW8	226795	6606958	268.9	257.1	-11.8	Tarrawonga Mine
Templemore A	230997	6605537	271.3	271.2	-0.1	Tarrawonga Mine
Templemore B	230544	6604345	266.1	265.2	-0.9	Tarrawonga Mine

The calibrated model provides a good match between the observed and simulated heads within the alluvial aquifer zone.

Within the Project Boundary, the predicted groundwater levels were generally higher than the observed water levels. The average absolute residual between the observed and simulated groundwater levels is 4.88 m. For the information sourced from the NOW bores and representing water level measurements in the alluvium, this average absolute residual is only 3.0m. The Tarrawonga Mine and Boggabri Coal Mine observation bore subsets produced 4.75m and 7.43m as average absolute residuals respectively from the calibration.

The effect of the adopted parameters on the model predictions, particularly the low recharge rate in the Permian outcrop areas (0.1%) allows the zone of influence to expand to a greater extent. Therefore these adopted parameters are considered conservative.

An objective method to evaluate the calibration of the model is to examine the statistical parameters associated with the calibration. One such method is by measurement of the error between the modelled and observed (measured) water levels. The root mean square (RMS) error is expressed as follows:

$$RMS = \left[1/n \sum (h_o - h_m)_i^{\,2} \right]^{0.5}$$

where: n = number of measurements
h_o = observed water level
h_m = simulated water level

The RMS error calculated for the calibrated model was 5.74m. The maximum acceptable value for the calibration criterion depends on the magnitude of the change in heads over the model domain. If the ratio of the RMS error to the total head change is small, known as the Scaled RMS (SRMS), the errors are only a small part of the overall model response (Anderson and Woessner, 1992). The ratio of RMS (5.74m) to the total head change across the calibration points (116.3m) indicated a SRMS of 4.93%. The acceptable target for SRMS varies between models but is typically below 5% (MDBC 2000), which has been achieved. This result is further supported by the following considerations which may have constrained the calibration in achieving a perfect match for all observations and predictions:

- the steady state model used a simplified uniform representation of permeability based on limited data to represent complex heterogeneous fractured rock and alluvial systems;
- the model did not represent faults that can act as barriers to groundwater flow and result in variability in water levels that are not reproducible when a homogenous system is assumed; and
- the water levels recorded at some of the calibration points are assumed to have been representative of pre-mining conditions; however no long term groundwater level records were available for some of the bores to confirm this assumption.

Generally, the polarity observed at bores monitored at various depths shows shallower bores with higher potentiometric heads. This is consistent with the model results, that indicates a deeper model layers have lower potentiometric heads than overlying shallower layers.

The mass balance error, that is, the difference between calculated model inflows and outflows, at the completion of the calibration run expressed as a percentage of discrepancy, was 0.0%, indicating good accuracy of the numerical solution and overall stability of the model. The model water budget is summarised in Table 12 below.

Table 12: WATER BUDGET – STEADY STATE MODEL (ML/DAY)

Parameter	Input	Output
Rainfall recharge	34.2 (41.3%)	0.0
River leakage	41.7 (50.4%)	54.7 (66.0%)
Evapotranspiration	0.0	12.8 (15.5%)
Fixed head	6.9 (8.3%)	15.3 (18.5%)
TOTALS	**82.8**	**82.8**

The water budget indicates a net discharge of approximately 13ML/day to surface drainages across the study area. Of the long term average of 34.2ML/day of recharge entering the groundwater system, approximately 13ML is discharged to surface drainage, 12.8ML is lost to evapotranspiration, and the remainder (8.4ML) is removed as down valley flow in the alluvial aquifers.

10.0 PREDICTIVE SIMULATIONS

After the steady state model was calibrated to the available data, the model was then converted to transient flow conditions to undertake the predictive scenarios. The steady state heads were used as the starting heads in the transient model. To achieve the transient simulation of mine progression, a number of assumptions were made as discussed below.

10.1 Set-up and Assumptions

The transient model was set up with 110 quarterly (91.3125 days) stress periods, representing the period from the second quarter of 2006 to fourth quarter of 2032. This period covers the historical mining that commenced at both Boggabri Coal Mine and Tarrawonga Mine in 2006 and the 21-year period of the Project (2012 to 2032).

Specific yield and specific storage values for the alluvial aquifer were set at values similar to those used by NOW (2006). The other storage parameters (as presented previously in Table 10) were derived from previous studies from the region.

Dewatering of the open cut mines was represented by the introduction of drain cells to the floor of the seam being mined.

To simulate the mining within the Project Boundary, drain cells were set in the model down to Layer 10, which represents the lowest ply in the Templemore Seam). Mining at the Boggabri Coal Mine and Tarrawonga Mine was simulated by specifying drain cells down to model Layer 6. The Merriown Seam, which is the lowest seam targeted at Boggabri Coal Mine, was not modelled separately, therefore the floor of the Boggabri Coal Mine was assigned to the elevation of the Velyama Seam (Layer 6), resulting in up to 50m more depth of dewatering at places within the mine footprint. Publicly available information indicated the Tarrawonga Mine is mining to the floor of the Nagero Seam which is immediately below the Velyama Seam, hence the pit floor was also assigned to the floor elevation of the Velyama Seam in the model. Mining at Tarrawonga Mine was simulated until 2014, the currently approved period of mining, at which time the drain cells were removed from the model to simulate closure of the mine and to allow localised recovery of groundwater levels into the spoil deposited in the pit.

The locations of the mines and the rate of advancement used in the transient simulations are shown in Drawing No. 15.

Canyon Mine is an open cut operation located about 17km to the south of the Project Boundary, at the southern limit of the model boundary domain and is not expected to interact with the three simulated mines due to the presences of structures between the mines and was therefore not included in the predictive modelling.

Mine progression and the placement of spoil within the pit were simulated through a yearly ‘stop-start’ process. Each stop-start period or ‘stage’ was assigned the length of one year and divided into four stress periods of three months duration each, except the last stage that was only 6 months long and consequently divided into two quarterly stress periods. A total of 28 stages are used for the mining period simulation.

Throughout each stage, the number of cells defined as active mining with SURFACT Drain package (DRN) increased with each quarterly stress period. Once a drain boundary condition was applied, it was assumed to be active for the entire year. At the completion of each yearly stage, the drain cells were removed from the area where mining had been completed for that year and are then reapplied to the cells representing the first stress period in the next year. At this point, the aquifer parameters for the previously mined areas were reset to parameters representing spoil, as shown in Table 13. These parameters were based on a Hunter Valley study undertaken by Mackie, (2009). This allowed for the simulation of groundwater level recovery within the spoil as mining progresses, beyond mined out areas, as well as the simulation of potentially increased pit seepage rates from this recharge.

Table 13: HYDRAULIC PARAMETERS OF SPOIL		
Geology Type	**Parameter**	**Value**
Spoil	Horizontal Hydraulic Conductivity kh	1 m/day
	Vertical Hydraulic Conductivity kv	1 m/day
	Specific Yield S_y	0.1
	Specific Storage S_s	$1 \times 10^{-3} m^{-1}$

Higher recharge rates to the spoil are also expected, and therefore when model cells were defined as spoil, the recharge applied to the cell was also modified for the next stage. A recharge rate of 32.87mm/year was adopted for spoil areas also based on work by Mackie (2009) in the Hunter Valley.

It is generally accepted there is a lag between when the spoil is placed in the pit, and when it has sufficiently "wet-up" to allow rainfall recharge to report as seepage to the pit. The groundwater model does not simulate this lag time required for the wetting up of the spoil, but applies it instantaneously to the top surface of the model. This is considered a conservative assumption as it is likely to increase the predicted inflow rates.

As three different mining operations were active in the model with potentially interactive cumulative affects on groundwater levels, the model was run twice, firstly with all three mines operating and, secondly excluding the Project. The results of the two models were then compared to separate the cumulative impact of the mining operations from those attributable to the Project only.

10.2 Piezometric Surface/Water Table Levels

The modelling indicates the depressurised zone, as indicated by the 1m drawdown contour at the end of mining in Year 21, extends between 5km and 7km from the Project open cut pit. The zone of influence largely remains within the Permian outcrop zone, but does extend slightly into the alluvial aquifer in the south-west where a thin zone of alluvium is present in a small valley extending into the outcropping hill. There is a known fault within the Permian to the north of this alluvium which may prevent the depressurisation zone extending this distance. As the alluvium thickens to the south-west, the transmissivity and ability to transmit water increases and the zone of influence does not extend beyond this point.

Drawings Nos. 16 to 19 present potentiometric head changes in response to mine progression for Years 1, 5, 10 and 15. The drawings illustrate the rapid decline in groundwater levels in Layer 2, as the pit progresses from north-east to south-west. Layer 2 represents the Maules Creek Formation regolith, the Boggabri Volcanics outcrop and the Gunnedah Formation aquifer in the alluvial lands.

Drawing No. 20 presents both, the simulated drawdown in Layer 2 that is attributable only to the Project, and the cumulative drawdown at the end of mining in Year 21. The cumulative impact is based on both the Project, and the Boggabri Coal Mine extension (currently pending approval), operating as proposed. It is assumed that the Boggabri Coal Mine is closed at Year 21 in the model.

Drawing No. 21 presents groundwater level contours at Year 21. The zone of depressurisation around the Project and the neighbouring Boggabri Coal Mine are evident.

Appendix 4 presents the simulated heads on a series of cross-sections. Cross sections were developed for a north-south alignment, along column 80 of the model grid, and an east-west direction along row 70. Appendix 4 includes the cross sections, in Figures A4.1 to A4.8, for the north-south alignment, and A4.9 to A4.16 for the east-west alignment. Drawing No. 12 shows the locations of the cross sections.

The cross sections show the predicted water table surface, and the contours for lines of equal hydraulic head, super-imposed on the geological units represented in the model. Above the line that represents the water table surface, the groundwater regime is unsaturated.

The cross sections show the development of the zone of depressurisation as the Project progresses over time for the Years 1, 5, 10, 15 and 21. The sections demonstrate that the potentiometric surface is only appreciably depressed in the ridge areas within the Project Boundary, and demonstrates that the change in water table in the alluvium over time is negligible.

10.3 Impact on Groundwater Users

A total of 27 registered bores are encompassed within the zone of influence as defined by the 1m drawdown contour at the end of mining. The locations of the registered bores within the zone of depressurisation are shown in Drawing No. 22 and details of the registered bores from the NOW groundwater database are summarised in Table 14. Bores within the simulated zone of influence were visited by a representative of Aston Resources to assess groundwater levels, usage and construction of the bores potentially impacted by the Project.

The majority of the bores within the zone of influence are located on land owned by Aston Resources or other neighbouring mining companies. Four of the bores are used for groundwater level monitoring at the adjacent Boggabri Coal Mine and are not used for groundwater extraction. No registered irrigation bores constructed in the alluvial sediments are present within the zone of influence.

Table 14 compares the simulated drawdown in each bore within the zone of depressurisation with the available drawdown. The available drawdown was assumed to be the difference between the groundwater level and depth of the bore, minus 5m to allow for a sump zone that can not be used for pumping. Bores where the simulated drawdown exceeds the available drawdown have the potential to fail during the mining phase of the Project. Water levels in three bores that are licensed for use for stock watering, GW002748, GW003478 and GW003483 have the potential to fall below 5m from the base of the bore. It should be noted that the actual available drawdown for each bore is related to the pump setting, pump capacity, the bore design, and the depth of the water bearing zones. Table 14 highlights the bores where there is the potential for failure; it is recommended all private bores with a simulated drawdown being greater than 20% of the available drawdown be monitored.

It is recommended that Aston Resources develop a mitigation plan to monitor any possible impacts of the Project upon private landholders bores and to ensure there is a mechanism in place for these landholders to be compensated for falling adverse water levels that are directly attributable to the Project.

Table 14 also presents the proportion of the simulated drawdown that is attributable to the Project, with the remainder due to dewatering at the adjacent mining operations.

Table 14: REGISTERED BORES WITHIN ZONE OF INFLUENCE

Work No.	Date	Land Ownership	Usage	Bore Depth (m)	Standing Water Level (mbgl)[1]	Estimated Maximum Available Drawdown in Bore (m)	Simulated Water Level Drawdown (m)		Drawdown in Bore		Outcome
							Maules Creek Mine only	Total Cumulative – all mines	% of Available Drawdown	% Drawdown due to Maules Creek Mine	
GW000583	1920	MJ Brennan	Stock	98.7	20.31	78.39	1.44	4.53	6	32	
GW020434	1927	Boggabri Coal	Monitoring	85.3			13.70	15.45		89	
GW002748	1929	Aston Coal 2 Pty Limited	Stock	72.2	20.9	51.3	50.65	60.33	100	84	Bore failure
GW002789	1929	PF Murphy	Destroyed	22.6			1.38	1.47		94	
GW002799	1929	MJ & MC Nott	Destroyed	21			11.73	12.79		92	
GW002831	1930	PF Murphy	Stock	33.2	18.66	14.54	1.22	1.30	14	94	
GW003115	1932	Boggabri Coal	Monitoring	82.9	23.0	59.9	1.63	16.35	30	10	
GW003466	1937	VA and MA Younger[3]	Stock	50	9.36	40.64	16.78	18.12	51	93	
GW003478	1937	DJC Watson[3]	Stock and domestic	33.8	25.29	8.51	12.88	13.46	100	96	Bore failure
GW003483	1937	DJC Watson[3]	Stock	32.9	22.85	10.05	13.62	14.03	100	97	Bore failure
GW003489	1937	MJ & ML Nott	Stock and domestic	45.4	21.16	24.24	6.49	6.81	35	95	
GW003496	1937	LA & KA & PD Finlay	Destroyed	172.8			1.78	2.86		62	
GW006529	1939	Aston Coal 2 Pty Limited		34.7		34.7	3.12	4.70	16	66	
GW006567	1940	PF Murphy	Stock	59.1	19.13	39.97	4.90	5.30	15	92	
GW008221	1951	Aston Coal 2 Pty Limited	Can not locate	108.2			32.04	36.64		87	

Work No.	Date	Land Ownership	Usage	Bore Depth (m)	Standing Water Level (mbgl)[1]	Estimated Maximum Available Drawdown in Bore (m)	Simulated Water Level Drawdown (m)		Drawdown in Bore		Outcome
							Maules Creek Mine only	Total Cumulative – all mines	% of Available Drawdown	% Drawdown due to Maules Creek Mine	
GW008255	1951	MJ Brennan	None	91.4	7.5	83.9	1.27	3.07	4	41	
GW001869	1962	CM & RRF Morse	No access	63.1			1.45	7.03		21	
GW020607	1963	JM Morris	No access	29.9			1.98	2.19		90	
GW028893	1968	Aston Coal 2 Pty Limited	Stock	54.9			1.15	1.51		76	
GW028894	1968	Aston Coal 2 Pty Limited	Stock	48.8	20.24	28.56	2.56	4.31	18	59	
GW053825	1981	NSW State Forest	None	257	13.21	243.79	142.51	159.57	67	89	
GW900043	1995	JM Morris	No access	32.9			3.63	4.02		90	
GW967856	2006	NSW State Forest	Monitoring	66.5	61.7	4.8	1.55	79.13	100	2	
GW967861	2006	NSW State Forest	Monitoring	59	49.4	47.62	1.78	107.15	100	2	
GW967862	2006	NSW State Forest	Monitoring	85	70.3	68.52	1.78	107.09	100	2	

Table 14: REGISTERED BORES WITHIN ZONE OF INFLUENCE

Notes:

1 - all water levels measured between 5 and 6 January 2011, except Boggabri Coal Mine Monitoring bores measured on 28 October 2010

2 - based on Gunnedah North Coalfields 1:100,000 scale Geology Map

3 - Aston have reached agreement for purchase of these properties

The modelling adopted a conservative approach, and the zone of influence is not expected to develop to the extent predicted by the numerical modelling because the model does not include the faults, igneous intrusions or zones of low permeability in the area. The model therefore simulates a continuous hydraulically interconnected aquifer system, which is not present in reality. Faults offsetting the coal seams and intrusions can act as barriers to groundwater flow, both of which limit the expansion of the zone of depressurisation. Zones of lower hydraulic conductivity have been detected in the coal seams and a reduction in the coal seam permeability with depth would further reduce the potential for the growth of the zone of influence.

10.4 Inflow to Mined Void

Flows into drain cells representing dewatering were extracted for each stress period to assess the rate of groundwater inflow to the mine pits. The model simulated inflow rates to the Project are shown in Figure 26 below.

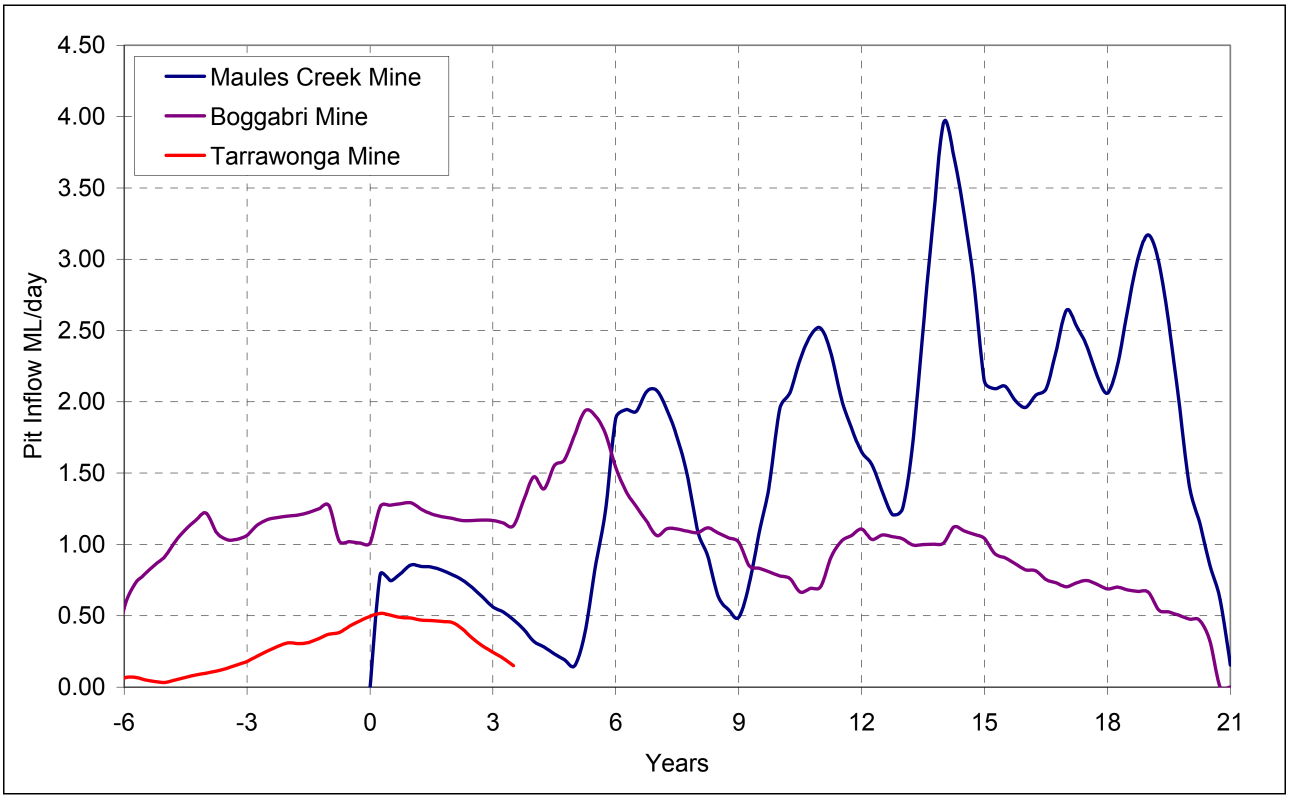


Figure 26: Simulated Seepage into the Maules Creek Mine and Neighbouring Mines

As shown in Figure 26, the simulated pit seepage rates vary throughout the mining period. This variability in inflow is directly related to the proposed mine plan, the depth/thickness of saturated coal being mined and hydraulic gradients induced by the depressurisation of the coal seam. The peaks in the simulated inflows are partially due to the quarterly steps used to represent mining in the model, and in reality the measured seepage rate would not be expected to peak at the extremes predicted by the model simulation. Simulated seepage rates peak at about 4ML/day in Year 14. The simulated seepage rate to the Boggabri Coal Mine is reduced as the Maules Creek Mine deepens, and demonstrates the interaction of the zone of depressurisation created by each mining operation.

Groundwater inflow reaches a peak of 4ML/day during the third quarter of Year 14 due to a combination of factors. Pit floor elevations reach a the lowest level of approximately RL 82m in Year 14 from a pit floor of about RL 230 during the previous year. The cyclic increases in pit inflow (Years 7, 11, 14, and 17), reflect the lower pit floor elevations. Due to the lower pit floor elevations, the hydraulic gradient will be greater at these locations and therefore pit inflows will increase. Variances in the rate of mining progression rates also affect pit inflow estimates.

The annual simulated seepage volumes to the Project's open cut pit are shown in Figure 27 below. The predicted cumulative inflow of groundwater over the life of the mine is approximately 11,540ML, which is an average of 550ML/yr (17L/s) over the 21 years of mining. The peak year is Year 15 where the seepage is simulated at 1,064ML.

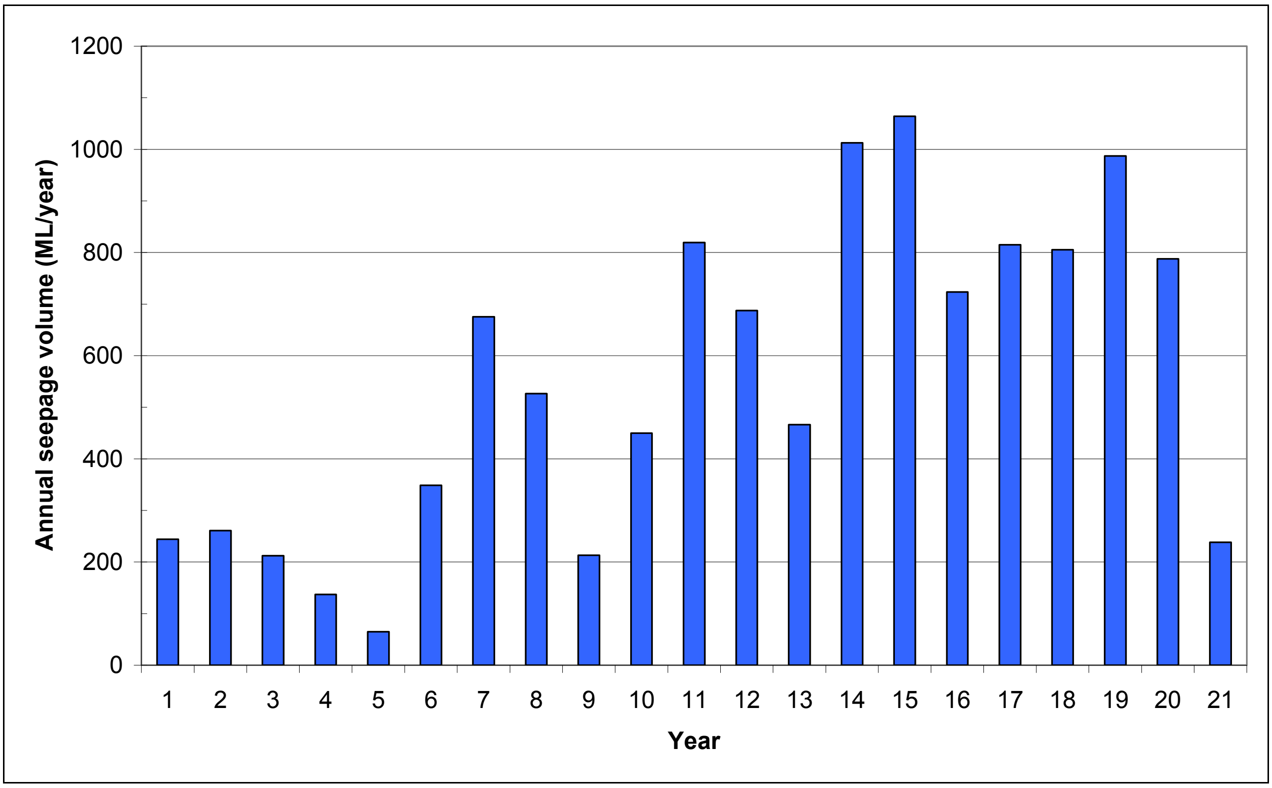


Figure 27: Simulated Annual Seepage Rate - Maules Creek Mine

The representation of pit dewatering through the SURFACT drain package means that some of the processes are accumulated into the predicted inflow. In reality evaporation from the coal face exposed in the highwall and endwall would remove a proportion of the seepage predicted by the modelling and not all of the simulated seepage would flow to sumps for removal by pumping. Similarly, an amount of predicted groundwater inflow is removed as moisture in the coal and overburden.

A simple approximation to the evaporation at the mine face can be achieved by applying the evaporation rate to the surface area of coal seams exposed in the pit. This calculation indicates that this evaporation is comparatively small (~0.1ML/day), and hence would not vary the quoted predicted mine inflows significantly.

It should also be noted that for the reasons mentioned previously, the simulated inflows are considered to be a conservative overestimate for the following reasons:

- the model simulates a continuous aquifer system and does not include the minor faults, igneous intrusions and variability in hydraulic conductivity in the area – the impact of these features would be to lower the simulated seepage rate;
- the starting heads used in the model were higher within the Project Boundary than the observed head and this has the effect of increasing the hydraulic gradients between the aquifer and the pit, increasing inflow rates to the pit;
- the expected lag time required for spoil emplacements to wet up and allow rainfall recharge to migrate through into the pit was not simulated which means seepage from the spoil may be over predicted; and
- the aggregation of the numerous coal seams into four seams at the base of a layer within the groundwater model increased the thickness of coal within the saturated zone, and the hydraulic gradient between the open pit and the aquifers, which is expected to have the effect of increasing the simulated seepage rates.

10.5 Impact on Alluvial Aquifers

The Project, Boggabri Coal Mine and the Tarrawonga Mine are in relatively close proximity to each other which results in interaction between the zones of depressurisation created by each mine. In order to determine the amount of groundwater flow from the hard rock areas to the alluvial areas that is intercepted by the mine drawdown attributable to the Project only, two model scenarios were compared, firstly with all three mines operating, and secondly with the Project removed. The predicted volume intercepted was then calculated by extracting geologically zoned cell by cell flow data for each stress period from the model and subtraction of the two scenarios. The predicted interception of flow to the alluvial aquifer is shown in Figure 28 below.

Figure 28 shows the predicted net inflow to the alluvial aquifers, being both the Narrabri and Gunnedah formations, with and without the Project. Figure 28 excludes rainfall recharge, and therefore represents inflow from the underlying bedrock aquifers into the alluvial aquifers as follows:

- the blue line plots the net simulated inflow to the alluvial aquifers, with all mines operating, and shows the largest decline due to the mining operations depressurising the underlying bedrock;
- the orange line plots the net simulated inflow to the alluvial aquifers, with all mines operating except the Project; and,
- the green line plots the difference between the orange and blue lines, which is the decline in flow to the alluvium attributable only to the Project.

(G1508)

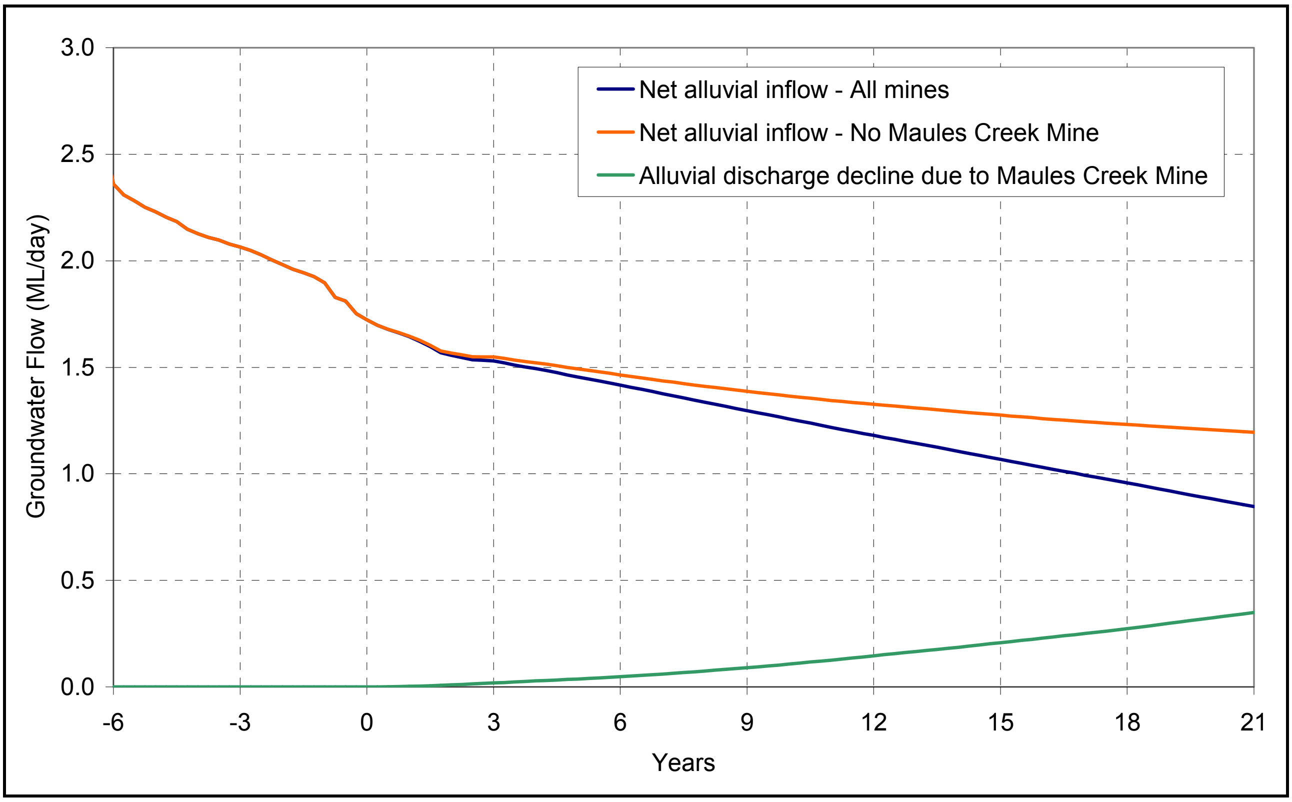


Figure 28: Simulated Net Flow to Alluvial Aquifer (Narrabri and Gunnedah Formations – Layer 1 and Layer 2)

The overall decline in flow to the alluvial aquifer when all three mines are operational, assuming that Tarrawonga Mine is not active beyond Year 2014, is approximately 1.5ML/day. With the Project removed from the simulation the predicted decline in the inflow is 1.15ML/day. The modelling indicates that the interception of flow to the alluvial aquifer due to the Project alone reaches a maximum of about 0.35ML/day (128ML/year) at the end of mining.

The cumulative predicted decline in inflow to the alluvial aquifer directly attributable to the Project over the 21-year mine life is about 1,060ML. This is equivalent to an average annual extraction from the alluvial aquifer of about 50ML/year; this is attributable to the Project directly. This loss is very low at less than 1% of both the rainfall recharge simulated by the steady state model, and also the recharge to Zone 4, Zone 5 and Zone 11 reported in the Water Sharing Plan at 43,900ML/year.

The break down of the 50ML/year decline in alluvial inflow into the adjacent Groundwater Management Zones (4, 5, and 11) is shown below in Figure 29. The highest decline due to the Project is within Zone 11 with a peak of 0.19ML/day and an average of about 0.08ML/day (28ML/year) over the 21 year mining period. Alluvial inflow rates from the Project Boundary south to Zone 4 are also predicted to be impacted by the Project, reaching a peak of 0.11ML/day with an average of 0.05ML/day (17ML/year). Zone 5 to the west of the Project Boundary is predicted to only be impacted by a peak decline in alluvial inflow of 0.04ML/day, which is a 0.01ML/day (5ML/year) average over the 21-year mining period. The result of Zone 5 being impacted the least is expected, due to the outcrop of Boggabri Volcanics that largely separates the Project from this zone.

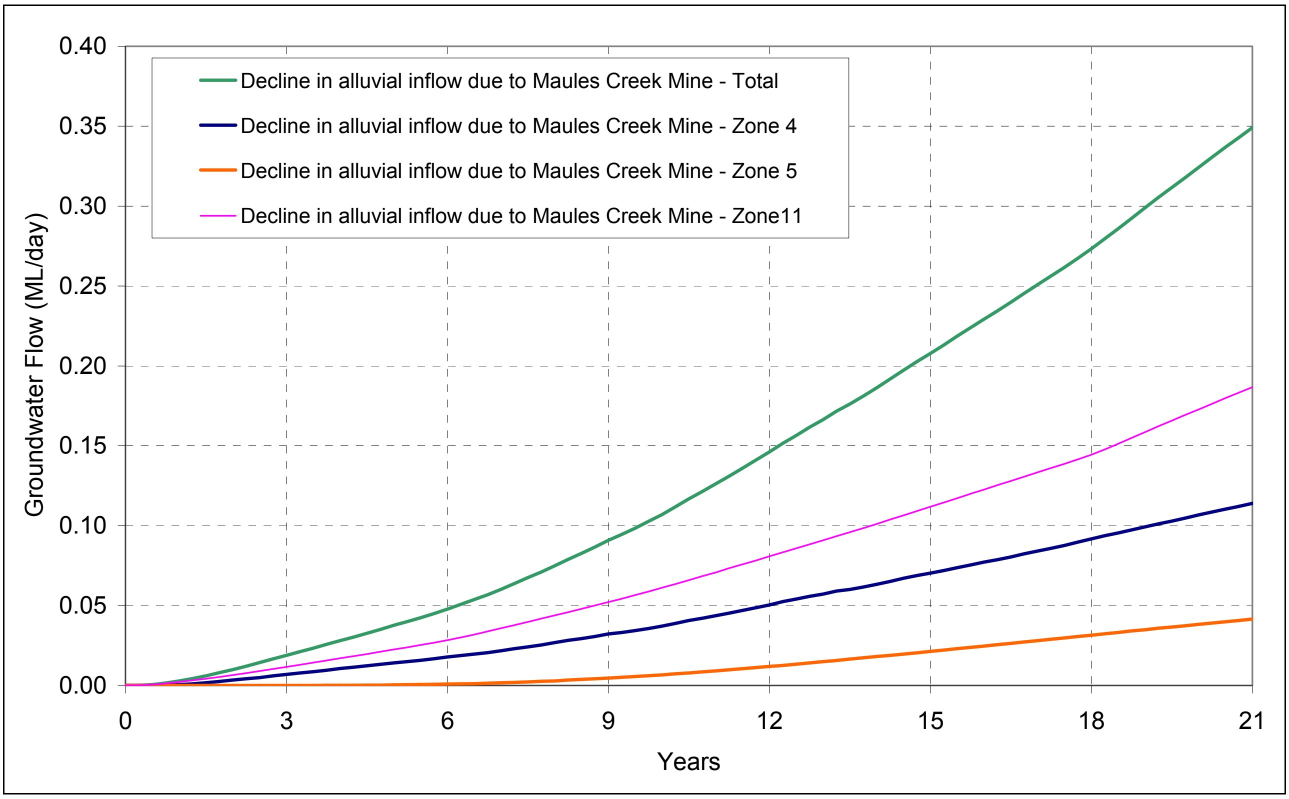


Figure 29: Simulated Net Flow to Alluvial Aquifer Subdivided into Groundwater Management Zones

10.6 Groundwater Dependent Ecosystems

Cumberland Ecology (2011) have identified the presence of River Redgum and River Oaks along sections of Maules Creek and the lower lying areas of Back Creek, and these species are known to rely on groundwaters from underlying aquifers. Modelling indicates that the Project will not result in significant drawdown of groundwater levels in the Maules Creek alluvial aquifer and for this reason the groundwater dependent vegetation identified along the creek alignment will not be impacted by the Project.

Studies undertaken by Cumberland Ecology (2011) have identified *Melaleuca sp* along the alignment of Back Creek and that these species are expected to have a root zone extending some 2m to 3m below the land surface. Groundwater bores along the Back Creek alignment are limited to a number of bores installed in the 1980s hydrogeological investigations. These bores indicate that groundwater levels were at the time around 10m below ground level. The groundwater model simulated slightly higher groundwater levels along Back Creek, in some areas being within 2m of the ground surface. An area where the groundwater level is less than 2m below topography has been presented in Drawing No. 23. Additional monitoring bores will be required along the Back Creek alignment in areas where potentially shallow groundwater levels were simulated by the groundwater model. Proposed bores have been included in Drawing No. 24, which are discussed in Section 13.1.

10.7 Mining Phase Water Budget Summary

Apart from the drain budgets presented above, the other major components of the water balance are summarised in Figure 30 below.

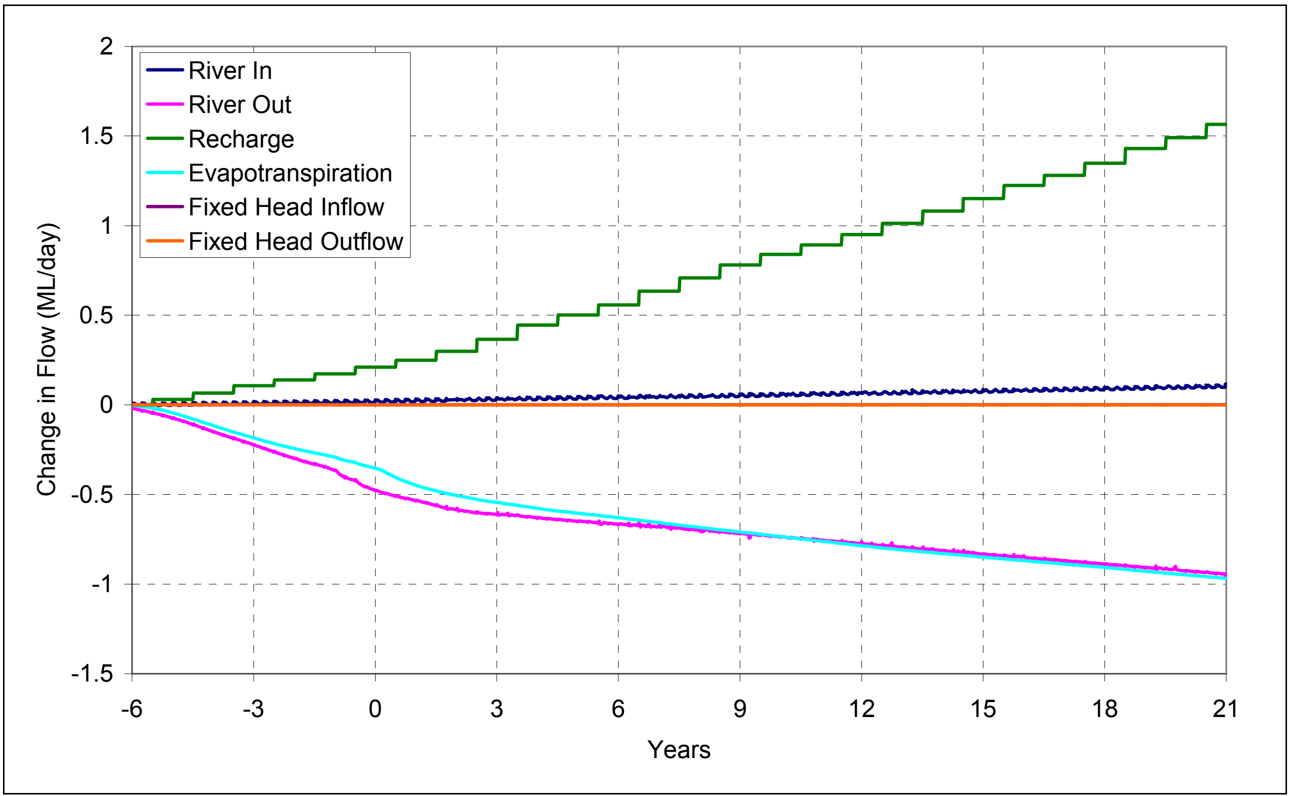


Figure 30: Component Water Budget Variation with Time – Cumulative Impacts Simulation

Figure 30 presents the change in the water budget from the steady state rates presented in Table 12. There is no significant change in the fixed head inflow or outflow through the transient predictive simulation, indicating that these boundaries are set at appropriate distances away from the stresses being varied and predicted. The inflow plots directly below the outflow and therefore cannot be seen on Figure 30.

There is a very slight rise in the predicted inflow from the River package. This is due to an equally minor lowering of adjacent groundwater levels. Water leaving the aquifer due to surface drainage (River Out) shows a decline with time. This is from the river cells that occur over the outcrop areas. Declines in groundwater levels within these outcrop areas due to mining have resulted in this almost 1ML/day decline by the end of mining.

Evapotranspiration is modified by a similar magnitude to the River out, and is also the result of the reduced groundwater levels across the Permian outcrop areas.

Figure 30 indicates that recharge has increased over the transient period, and has done so in a step wise manner. This step feature is an artefact of the 'stop-start' simulation undertaken, and the increase in recharge is due to the heightened recharge rate from the expanding spoil area.

10.8 Groundwater Recovery

Should mining operations cease after 21 years, dewatering of the open void would not be required and a slow recovery in groundwater levels in the area will occur. The impact of two alternative final landform scenarios on the groundwater regime was simulated as part of the post closure options for the mine. The first, Option 1, was the final void remaining open, with the second option being backfilling of the spoil to a level that is above pre-mining groundwater levels. It is understood that the adjacent Boggabri Coal Mine has committed to backfilling the final void with spoil should mining not proceed beyond 21 years as proposed in the Application that is currently pending approval.

Option 1 – Open Final Void Simulation
Under Option 1, once mining operations cease, dewatering will not be required and a slow recovery in groundwater levels in the area will occur. A void will remain at the north-eastern extent of the mine footprint with an area of approximately 350ha and will be up to a maximum of 290m deep.

Groundwater and rainfall inflows will slowly fill the void forming a lake and eventually reaching an average stable water level which will be influenced by the balance of inflows from groundwater, surface runoff and losses from evaporation.

At the cessation of mining, there will be a relatively high groundwater gradient between the open void and the coal seam aquifers which will result in relatively rapid inflows. However as a lake begins to form in the void, the gradient is reduced and the rate of groundwater inflow will slow. Eventually a state of 'quasi' equilibrium will occur where inputs are balanced by outputs.

The rate of recovery of groundwater levels in the aquifers will be dependent on rainfall, with years of below average rainfall extending the recovery period and wet years reducing the time for stabilisation. Due to the absence of spoil within the void, a higher proportion of rainfall would directly recharge the groundwater system at this location. However, due to the exposure of the pit lake surface to the effects of evaporation, groundwater recovery is likely to be impeded and would be expected to reach equilibrium conditions at a lower than pre-mining potentiometric surface elevations.

Modelling of the open void area was achieved by assigning the open area an arbitrary high horizontal and vertical hydraulic conductivity (1000m/day) and storage parameters (specific yield and storage coefficient) of 1.0, in order to simulate free water movement within the void. Rainfall recharge rates of 90%, assuming potential transmission losses within the pit, of average historic rainfall were applied to the final void lake area to simulate a direct input of rainfall to the pit lake surface and surrounding pit walls. The simulation of evapotranspiration was modified to simulate direct evaporation from the pit lake. The maximum evapotranspiration rate adopted across the final void surface was 4.1mm/day to simulate the evaporation from a surface water body.

Option 2 – Backfilled Final Void Simulation
For this option the final void was assumed to be backfilled to a level above the pre-mining levels which was guided by the steady state groundwater modelling. The spoil levels were assumed to be up to RL 310m in the former void. This level is above the pre-mining groundwater level but a local topographic depression will remain within the mining footprint due to the elevation differences between pre-mining topography and backfilled spoil levels. Under this scenario a small catchment would be present where surface water runoff would be trapped and potentially form an ephemeral perched lake that would contribute to additional groundwater recharge in this area.

Modelling of the backfilled spoil option involved converting the final areas of mining into spoil, setting additional recharge across the surface depression and then in an extended groundwater model run, the groundwater levels within the pit footprint were allowed to recover into the spoil zone. The simulation of evapotranspiration was also modified for these depressions where the evaporative surface was lowered to the expected landform elevations.

The uncertainty around the potential additional recharge from the topographic depression that would remain under this scenario was addressed by undertaking an additional simulation where the recharge to the area defined by the depression was increased from the base spoil recharge rate of 32.87mm/yr to 100mm/yr.

Simulation Results

The simulated water level recovery in the final void for both Option 1 and Option 2 are presented in Figure 31 below. The simulated groundwater level recovery is based on a hypothetical bore located within the depression/final void area.

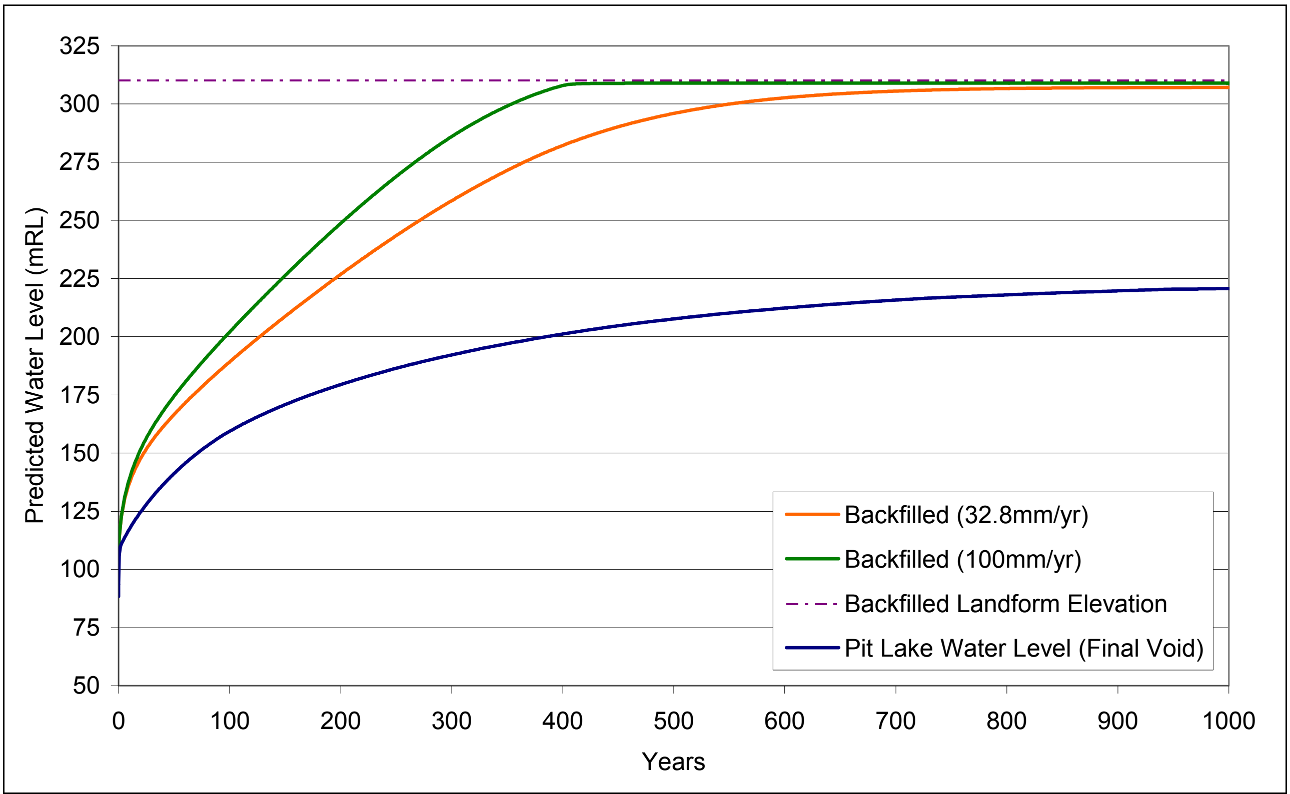


Figure 31: Simulated Water Level in Final Void

Figure 31 shows that the rate and level of water level recovery differs between Option 1 and Option 2. In Option 1 where the final void is left open, the groundwater levels reach equilibrium conditions of approximately RL 220m after about 1000 years of pit lake recovery, indicating the final void lake will remain a sink to local groundwater flow. This is due to the high evaporation rates in the region which slow the rate of recovery.

Under Option 2 where the spoil is backfilled, recovery of groundwater levels reaches equilibrium conditions of between RL 307mRL and 309mRL, depending on the recharge rate. As indicated in Figure 31, the bulk of the water level recovery occurs in the initial 300 years post mining, with Option 1 recovering 80% of its total predicted recovery level, and Option 2 backfilled simulations recovering to 76% and 89% of total predicted recovery for the 32.8mm/yr and 100mm/yr scenarios respectively. The remaining recovery for the various options is predicted to take between 100 and 300 years to slowly stabilise to equilibrium.

The recovery in groundwater levels of the backfilled options to just below the final landform indicates that the level is controlled by evaporation at the surface. The estimate is based on long term average recharge, and if above average rainfall occurs, water levels can be expected to rise above the final landform elevation and pond as surface water, hence adequate surface drainage of the final landform for the backfilling option will be required.

The evaporative pumping from the open void creates a permanent zone of depressurisation in the surrounding aquifers, the extent of which is shown for Option 1 in Drawing No. 25. Drawing No. 25 indicates that the long term zone of depressurisation will be similar to that created during the mining phase extending between about 5km and 7km from the Project open cut pit.

Appendix 4 presents the post mining simulated heads in cross section for Option 1 and Option 2 (Cross sections No. - A4.7, A4.8, A4.15, A4.16). The cross sections show the simulated water table surface at 1000 years, and the pre-mining steady state water levels for comparison purposes. These cross sections highlight the differences between the two options, with the backfilled option resulting in a higher water table than the open void option.

Option 2, of backfilling the final void, produces a higher water table than the pre-mining water table because of the higher recharge rate applied to the spoil dump areas. Option 1, of a leaving an open void is controlled by the ongoing evaporative losses from the final void lake. In Option 1, the higher recharge rate is applied to the spoil, which assists the recovery of the water level in the lake, but as the lake area increases, the evaporative losses increase and prevent further recovery. The water balance data presented below shows this.

Water Balance

Figure 32 presents water balance data for the model cells representing the final void within the model. The predicted net evaporative loss (total evaporation minus long term average rainfall across the pit) from the final void is approximately 1ML/day.

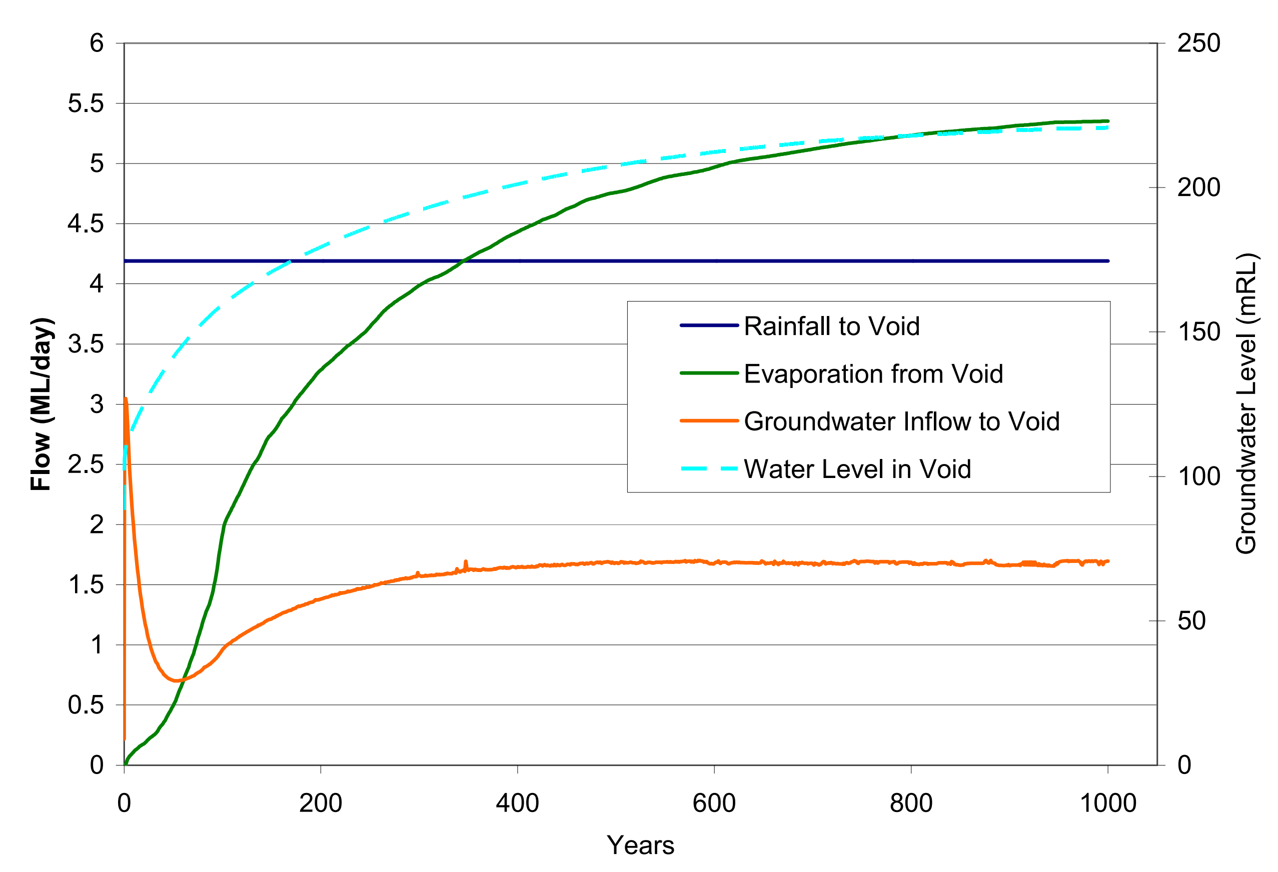


Figure 32: Final Void Model Budget and Predicted Water Level

In contrast, under Option 2 where the final void is backfilled with spoil the groundwater levels rise above the pre-mining groundwater levels due to the enhanced recharge rate. Under this scenario a groundwater mound in the aquifer is created and there is no permanent drawdown. The rise in groundwater levels for Option 2 is shown in Drawing No. 26. Under this scenario where groundwater levels are within 2m of the land surface, which occurs in the backfilled void area, there is the potential for evaporative concentration of salts from groundwater in surface soils.

10.9 Sensitivity Analysis

A sensitivity analysis was undertaken to assess the model responses to variations in uncertain input parameters. The parameters with the highest uncertainty and those most likely to affect the magnitude of the predictions are the un-calibrated storage parameters and the adopted recharge rates. The following perturbations were assessed in the sensitivity analysis:

- a ±50% change in the rainfall recharge rate across the model domain,
- a ±50% change in the specific yield for all model layers,
- a ±50% change in the specific storage for all model layers,
- a ±50% change in the vertical hydraulic conductivity values in alluvial areas of Layer 2 (Gunnedah Formation), and
- a ±50% change in the horizontal hydraulic conductivity values of the coal seams.

Table 15 summarises the variation of key model outputs with changes in the listed model parameters.

As can be seen from Table 15, there was only a very limited change in the steady state model outputs, and in the key transient model outputs. The largest change in the steady state model budget occurred when varying the recharge rate to the model by ±50%. Changes to the recharge volume must be distributed to the other boundary packages in the steady state model, hence the results. However such changes in the steady state model do not flow onto the transient model and in particular the key model predictions of predicted mine inflow and predicted interception of water flowing to the alluvium.

The increase and decrease in the recharge rate was made to the baseline recharge rates across the model domain. If recharge is modified through the simulation process that is increased recharge is applied to areas converted to spoil, then the sensitivity run leaves these modifications unchanged.

Table 15: SENSITIVITY ANALYSIS SUMMARY

Parameter	Units	Baseline	CS Kh -50%	CS Kh +50%	Gdh Kv -50%	Gdh Kv +50%	RCH -50%	RCH +50%	SY -50%	SY +50%	SS -50%	SS +50%
RMS	m	5.79	6.40	6.17	6.29	6.29	5.83	9.14	-	-	-	-
SRMS	m	4.98	5.50	5.30	5.41	5.41	5.02	7.86	-	-	-	-
Steady State Rech	ML/day	34.22	34.22	34.22	34.22	34.22	17.09	51.33	-	-	-	-
Steady State FH IN	ML/day	6.96	6.96	6.96	6.84	7.00	7.08	6.87	-	-	-	-
Steady State FH OUT	ML/day	15.22	15.21	15.22	15.21	15.22	13.40	17.02	-	-	-	-
Steady State EVT	ML/day	12.90	12.93	12.90	12.94	12.90	7.98	17.60	-	-	-	-
Steady State RIV IN	ML/day	41.62	41.64	41.65	41.58	41.66	44.63	38.79	-	-	-	-
Steady State RIV OUT	ML/day	54.69	54.68	54.71	54.50	54.77	47.43	62.38	-	-	-	-
Average Daily Inflow Maules Creek Mine	ML/day	1.57	1.04	1.97	1.57	1.57	1.49	1.62	1.55	1.59	1.46	1.65
Max Inflow Rate Maules Creek Mine	ML/day	3.96	2.48	5.06	3.96	3.96	3.85	4.03	3.93	3.98	3.78	4.09
Max change in Alluvial inflow	ML/day	0.35	0.29	0.40	0.35	0.35	0.36	0.32	0.36	0.34	0.54	0.23
Average change in Alluvial inflow	ML/day	0.14	0.11	0.16	0.14	0.14	0.16	0.12	0.14	0.13	0.25	0.08

Note: CS = Coal Seam hydraulic conductivity, Gdh Kv = Vertical hydraulic conductivity, RCH = Recharge, Sy = Specific Yield, SS = Specific Storage, FH = Constant head, EVT = Evapotranspiration, RIV = River leakage

RMS = Root Mean Square residual – a measure of the difference between modelled and predicted values

SRMS = Scaled RMS - ratio of the RMS error to the total head change

The adopted recharge rate for the spoil was also investigated for its impact on the predicted groundwater inflow rates (Table 16). It was found that there was no significant change to the predicted mine inflow for both an increase and decrease in the recharge rate by 50%.

Table 16: SENSITIVY OF SPOIL RECHARGE RATE TO MINE INFLOW

Component	Baseline	Spoil RCH - 50%	Spoil RCH + 50%
Spoil Recharge Rate (mm/yr)	32.8	16.4	49.2
Peak Predicted Mine Inflow (ML/day)	3.96	3.92	3.99
Average Predicted Mine Inflow (ML/day)	1.57	1.55	1.58

Transient model predictions of inflow to the mine are most sensitive to the coal seam horizontal hydraulic conductivity as this is the source of the majority of the water.

One key model prediction is the amount of water that becomes recharge to the alluvial aquifers from the Permian hard rock aquifers. The predicted changes in this flow due to mining, both with and without the Project, are presented in Figure 33. The sensitivity of the predicted contribution from the Project to the interception of this flow from the Permian to the alluvium to the various parameter changes is shown below in Figure 33.

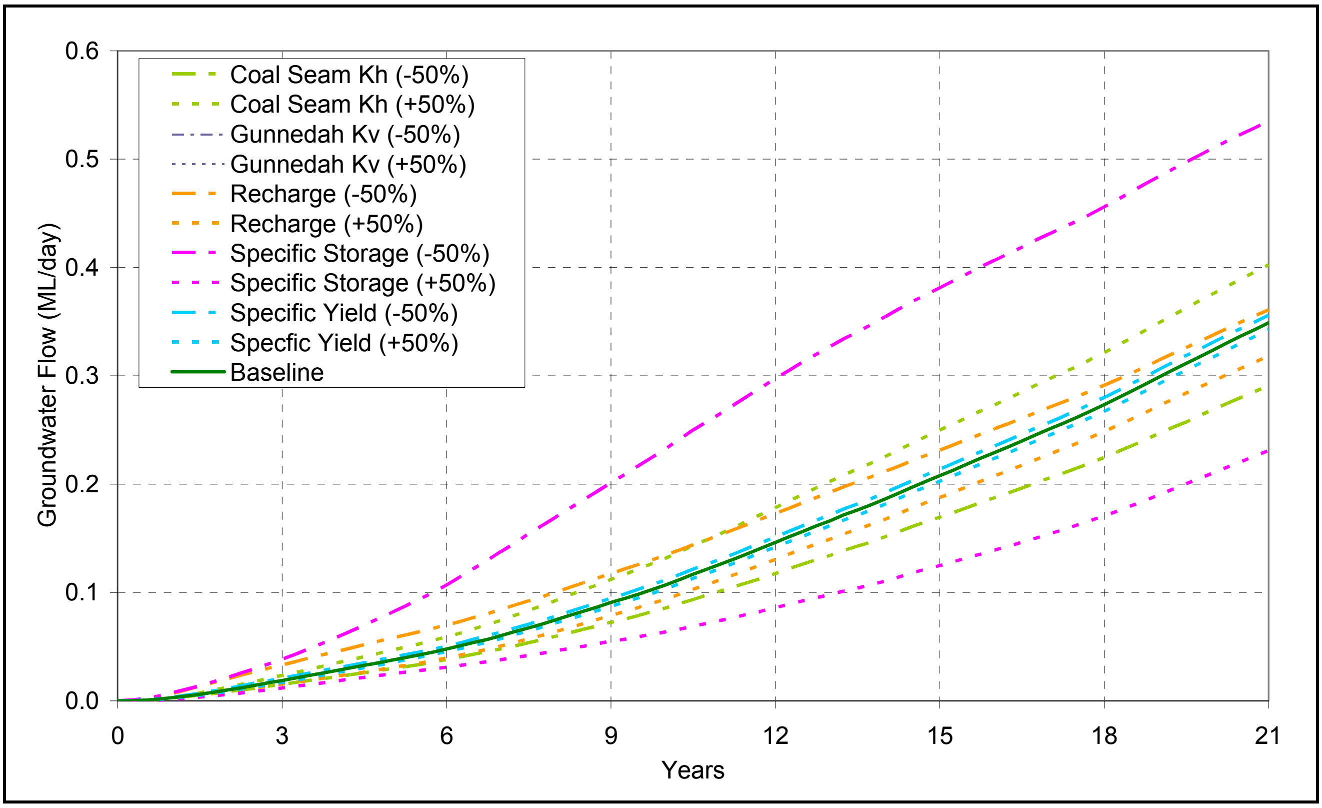


Figure 33: Simulated Interception of Flow from the Alluvial Aquifer due to the Project

The simulation of the interception of flow from the Permian to the alluvial aquifer is most sensitive to the specific storage parameter. The vertical hydraulic conductivity of the Gunnedah Formation had very little impact on the predicted interception. After examining the predicted movement of water from the model water budgets in detail, it was apparent that the majority of the 2.4ML/day flow to the alluvium is through the upper weathered layers of the model (approximately 1.4ML/day from coal measures and 1ML/day from the volcanics). The connection of the subcropping coal seams under the alluvium to the north and south of the mine has little impact on the drawdown as impacts are largely through the outcrop areas.

10.10 Model Uncertainty and Limitations

Development, calibration and the results of predictive simulations from any groundwater model are based on available data characterising the groundwater system under investigation. It is not possible to collect all the data characterising the whole aquifer system in detail and therefore various assumptions have to be made during development of the groundwater model. A number of assumptions were made during development of the groundwater model. These assumptions and their impact on the simulation results are discussed in this report. Where an assumption was necessary, a conservative approach was taken, such as adopting model parameters from plausible ranges, so that the model would likely over predict impacts or be representative of the worst case scenario.

The model assumed that the hydraulic properties of the aquifers were uniform across the entire model domain. In reality, the permeability of the aquifers is variable and this variability can result in a less uniform zone of depressurisation than that predicted by the numerical model.

The 15 coal seams at the site were grouped into four separate layers for the purposes of the groundwater modelling. The floor of each group was set to the level of the lowest seam in the group and the thickness based on the combined thickness of all the coal seams. In the first seam group (Herndale to Braymont Seams), many of the coal seams are above the Braymont Seam. The grouping of these seams increases the thickness of coal within the saturated zone. Many of these shallow seams are also cut into isolated pods where the coal has been removed by erosion along drainage alignments, meaning these seams are not interconnected with the alluvial aquifers on a regional scale. In the groundwater model, these seams are more extensive and are saturated; a conservative assumption that means the predicted seepage to the proposed mines may be greater than that which will occur in reality.

The hydraulic conductivity of coal seams is known to reduce with depth due to the pressure exerted by the overlying strata. The groundwater model assumed a uniform hydraulic conductivity for the coal seams which did not reduce with depth. This is considered to be a further conservative assumption that could result in an overestimation of the potential groundwater seepage rates to the open cut pit and extent of the zone of depressurisation.

10.11 Model Conclusions

The results of the modelling in relation to the stated objectives (refer Section 9.1) is outlined below:

- *Objective 1 - estimate groundwater inflows to the open cut void over the 21 year mine life* - during the 21 year mining period, the modelling indicates the seepage rate to the open cut void will be on average 1.5ML/day inflow. This will vary throughout the mining period with a predicted peak of 4ML/day in Year 14.
- *Objective 2 - predict the zone of influence of dewatering and the level and rate of drawdown at specific locations* - the modelling indicates the zone of depressurisation attributable to the Project will expand to the north and west of the open cut pit but remain

within the hill outcrop area. The predicted drawdown attributable to the Project is shown in Drawing Nos. 16 to 20.

- *Objective 3 - predict the magnitude of any drainage from the alluvial aquifer into the underlying Permian strata* - the modelling indicated that there would be limited direct drainage from groundwater within the alluvium; however, water that is recharged across the outcrop areas and that eventually becomes recharge to the alluvial aquifer will be intercepted by the project. During the mining period this interception grows until it reaches a maximum of 0.35ML/day at the end of mining.
- *Objective 4 - predict the impact of mine dewatering on groundwater discharges to surface flows and other groundwater users* - the impact of the project on creek flows is not significant as the bed level of most surface drainages within the zone of drawdown are largely above the pre-mining groundwater levels, and therefore dry. A total of 27 registered bores are encompassed within the zone of influence of the Project, with the potential for failure of three of these bores. The water bores predicted to be impacted by the Project are listed in Table 14 and are shown in Drawing No. 22.
- *Objective 5 - identify areas of potential risk where groundwater impact mitigation/control measures may be necessary.* – no mitigation measures were considered warranted, however a network designed to monitoring groundwater levels and quality in all key aquifers has been provided (refer Section 13.0).

11.0 WATER QUALITY

The geochemical assessment report prepared by RGS Environmental (2010) was referred to assess the potential for the overburden and reject material from the coal handling and preparation plant (CHPP) to contaminate groundwater,. The assessment provided a geochemical characterisation of the overburden, interburden and potential coal reject material and concluded that:

Overburden

- *Most overburden materials will generate slightly alkaline and relatively low-salinity run-off and seepage following surface exposure. The major ion chemistry of initial surface run-off and seepage from overburden materials is likely to be dominated by sodium, bicarbonate, chloride and sulphate;*
- *The concentration of dissolved metals in initial and ongoing run-off and seepage from overburden materials is unlikely to present any significant environmental issues associated with surface water and groundwater quality as a result of the Project.*

Coal rejects

- *Most non acid forming (NAF) potential coal reject materials will generate slightly alkaline and relatively low salinity run-off and seepage following surface exposure. However, potentially acid forming (PAF) potential coal reject materials may generate acidic and more saline run-off and seepage if exposed to oxidising conditions;*
- *The major ion chemistry of initial surface run-off and seepage from NAF potential coal reject materials is likely to be dominated by sodium, bicarbonate, chloride and sulphate. For PAF materials, calcium, magnesium and sulphate may become more dominant;*
- *For PAF materials, the initial concentration of soluble sulphate in surface run-off and seepage is expected to remain within the applied water quality guideline criterion, although*

further exposure to oxidising conditions could lead to increased sulphate concentrations; and

- *The concentration of dissolved metals in initial surface run-off and seepage from NAF potential coal reject materials is unlikely to present any significant environmental issues associated with surface water and groundwater quality as a result of the Project. For PAF materials, there is some potential for the concentration of dissolved metals in surface run-off and seepage to increase over time.*

Considering the conclusion reached by RGS (2010) following geochemical assessment of the overburden and potential reject materials, it is considered unlikely that leachate generated from these materials will adversely impact regional groundwater quality.

Under the Option 1 mine closure scenario, the quality of the water in the final void will be determined by the quality of the rainfall, which falls directly in the void, groundwater seepage quality, leaching of salts from the spoil piles and CHPP waste disposed of within spoil, and evaporative concentration of these inputs. The final void will act as a sink and groundwater will flow to the void from surrounding aquifers. Therefore the potentially brackish to saline water that accumulates in the void, will not flow back into and contaminate the aquifers.

Under the Option 2 mine closure scenario where the final void is backfilled, the quality of the groundwater recharge is expected to be similar to that determined by RGS (2010), and will have a relatively low salinity.

There is potential for spills and contamination by metals and hydrocarbons from mine workshop, waste disposal and fuel storage areas. However adequate bunding and immediate clean-up of spills which is standard practice or a legislated requirement at mine sites, should prevent contamination of shallow groundwater systems. Any spills from these areas are typically very localised and not regionally significant.

12.0 WATER LICENCING

The numerical modelling predicts an average groundwater seepage rate to the open cut pit of 550ML/year with a peak of up to 1064ML/year. The groundwater seepage to the proposed mine is largely sourced from storage in the fractured rock overburden/interburden and the coal seams and a water licence under the *Water Act 1912* will be required to offset the seepage losses. It is recommended a water licence of 1064ML/year + 25% (1330 ML/year), which will account for the variability in inflows and uncertainty in the seepage estimates, is applied for under the *Water Act 1912*.

It is understood the *Water Act 1912* will be replaced by a *Water Sharing Plan for Fractured and Porous Rocks* at some time in the future, but the water licensing regime proposed under this document is not in the public domain at the time of writing.

The groundwater seepage to the proposed mine will also result in a reduction in the volume of groundwater flow from the Permian bedrock into the alluvial aquifer. The model predicts an average loss of recharge to the alluvial aquifer of 50ML/year with a maximum of 128ML/year at the end of the 21-year mining period. The intercepted seepage to the alluvial aquifer represents about 10% of the total inflow to the open cut pit.

A second water license under the current Water Sharing Plan will be required to account for the water loss from the alluvial aquifer. It is recommended a water licence of 50ML/year is sought under the *Water Management Act 2000* which will offset the loss of recharge to the alluvial aquifer.

The modelling indicates this water is sourced from Groundwater Management Zone 4 (17ML/year), Zone 5 (5ML/year) and Zone 11 (28ML/year) and there is the possibility that each zone will require separate licensing.

Additional groundwater monitoring bores, outlined in Section 13.1 below will also require borehole licences before installation.

13.0 GROUNDWATER MONITORING SYSTEM

This section of the report provides a recommended groundwater monitoring program that will provide both an on-going assessment of the impact of the Project, and a proactive indicator of any adverse impacts on the groundwater regime.

13.1 Installation of Additional Monitoring Bores

The majority of the existing monitoring bores are within the footprint of the proposed mining area and will therefore be removed by mining. It is recommended that the remaining sites be augmented with additional monitoring bores that will not be disturbed during the life of the mine. The sites of the existing and proposed additional monitoring bores are shown in Drawing No. 24 and are focused along lines of bores radiating out from the open cut mining area. The purpose of the additional bores is to monitor for depressurisation in the Permian strata and water level drawdown in the alluvial aquifer on an on-going basis.

A bore licence must be obtained from NOW before installation of any new monitoring bores. All monitoring bores should be constructed according to the Australian guidelines by an appropriately qualified water bore driller. The recommended sites for additional monitoring bores are summarised in Table 17 below. All coal seam monitoring bores should be of a nested construction with separate bores in key seams. This will allow the variability in depressurisation that will occur with depth to be monitored over time.

Vibrating wire pressure sensors are recommended in a number of locations, including adjacent to NOW monitoring bores constructed in the Maules Creek alluvial plain. The purpose of these VWPs is to monitor for depressurisation in the bedrock underlying the alluvial sediments. Multiple VWPs should be installed across key coal seams and overburden units in the boreholes. The monitoring bores proposed along Back Creek should target any shallow groundwater and will likely be less than 15m in depth, and screened in the shallowest water bearing zone.

It should be noted the proposed locations are preliminary and access issues have not been assessed.

Bore ID	Easting	Northing	Location	Type
L1MB1	226366	6617320	Line 1	Monitoring Bore
L1MB2	226395	6619925	Line 1	Monitoring Bore
L1MB3	226480	6621171	Line 1	Monitoring Bore
L2MB1	222622	6616404	Line 2	Monitoring Bore
L2MB2	219990	6618031	Line 2	Monitoring Bore
L3MB1	220971	6612748	Line 3	Monitoring Bore
L1VWP1	226649	6619897	Line 1	VWP
L1VWP2	226536	6622700	Line 1	VWP
L2VWP1	222740	6616673	Line 2	VWP
L2VWP2	217000	6619562	Line 2	VWP
L3VWP1	220876	6613014	Line 3	VWP
L3VWP2	215897	6611153	Line 3	VWP
L4VWP1	223062	6606533	Line 4	VWP
L5VWP1	230174	6614967	Line 5	VWP
BCMB01	223777	6618298	Back Creek	Monitoring Bore
BCMB02	226759	6618248	Back Creek	Monitoring Bore
BCMB03	230121	6617470	Back Creek	Monitoring Bore

Table 17: SUMMARY OF RECOMMENDED ADDITIONAL MONITORING BORES

1. Notes: projection MGA94 Zone 56

13.2 Water Level Monitoring Plan

Groundwater levels are currently measured in the existing monitoring network on a monthly basis. Manual monitoring is suitable for identification of long term trends in groundwater levels but does not provide data on short term events such rainfall recharge that can occur within a three monthly monitoring cycle.

It is therefore recommended that electronic water level loggers are installed in the key monitoring bore sites to the south of the Project Boundary. Automatic water level data loggers should be set to take readings every 15 minutes, and record the readings taken if the water level has changed by more than 30mm. Readings should also be recorded at least once every 24 hours, irrespective of water level change. This will enable water level fluctuations due to rainfall recharge and pumping to be distinguished from potential water level declines due to depressurisation as a result of open cut mining.

Registered bores identified as being within the simulated zone of depressurisation should also be inspected to determine if the bores are still operational and in-use. Monitoring should be undertaken in a subset of registered key bores within the simulated zone of influence.

13.3 Water Quality Monitoring Plan

In order to establish baseline groundwater quality data, water samples should be collected from the monitoring bores on a three monthly basis for the first 12 months of sampling, while on-going sampling should be collected on a six monthly basis. Collected samples should be analysed in the laboratory for:

- major cations and anions;
- nutrients - ammonia, nitrate, nitrite; and
- metals - iron, lead, chromium, cadmium, zinc, arsenic, copper and nickel.

It is recommended the current water quality monitoring regime continue for the life of the mining operation.

13.4 Mine Water Seepage Monitoring

It is recommended that monitoring of mine water seepage be undertaken, particularly to identify seepage rates and quality. Samples should be collected of any pumped seepage with the objective of providing an early indication of any mixing of shallow alluvial groundwaters with the deeper and poorer quality groundwaters of the Permian strata. Analysis should be the same as for the groundwater monitoring bores. The seepage monitoring program should include:

- recording of the time, location and volume of any unexpected increased groundwater outflow from the highwall and endwall;
- measurement of all water pumped from the pits particularly using flow meters or other suitable gauging apparatus;
- monitoring of water pumped from the pits for the same analytical suite outlined in Section 13.3;
- correlation of rainfall records with pit seepage records so groundwater and surface water can be separated; and
- monitoring of coal moisture content.

13.5 Data Management and Reporting

It is recommended data management and reporting include:

- Annual assessment of departures from identified monitoring data trends. If consecutive monitoring data over a period of 6 months exhibit an increasing divergence in an adverse impact sense from the previous data or from the established or predicted trend, then such departures should initiate further actions. These may include a need to conduct more intensive monitoring or to invoke impact re-assessment and/or mitigative measures.
- Formal review of depressurisation of coal measures and alluvial aquifers should be undertaken annually by a suitably qualified hydrogeologist. Every five years the validity of the model predictions should be assessed and if the data indicates significant divergence from

the model predictions an updated or new groundwater model should be constructed for simulation of mining.

- Annual reporting (including all water level and water quality data).

AUSTRALASIAN GROUNDWATER AND ENVIRONMENTAL CONSULTANTS PTY LTD

NEIL MANEWELL
Hydrogeologist/Groundwater Modeller

ANDREW M. DURICK
Principal Hydrologist/Groundwater Modeller

JAMES S. TOMLIN
Principal Hydrogeologist

ERROL H. BRIESE
Principal Hydrologist/Managing Director

14.0 REFERENCES

Australasian Groundwater and Environmental Consultants Pty Ltd, (October 2010), "*Continuation of Boggabri Mine – Groundwater Assessment*", Prepared for Boggabri Coal Pty Ltd, Project No. G1465.

Andersen and Acworth, (2009), *"Stream-aquifer interactions in the Maules Creek catchment, Namoi Valley, New South Wales",* Australia, Hydrogeology Journal, Vol 17, Number 8, December 2009.

Anderson, M. P. and Woessner, W., (1992), *"Applied Groundwater Modeling: Simulation of Flow and Advective Transport"*, (2nd Edition ed.). Academic Press.

Coffey and Partners, (1982), *"Hydrological Review Maules Creek Project",* Report No. HS62/3-AB, May 1982

Coffey and Partners Pty Ltd, (May 1982), *"Hydrological Review Maules Creek Project".* Kembla Coal and Coke Pty Ltd. Report No. HS62/3-AB.

Coffey and Partners Pty Ltd. (April 1983)[1,] *"Maules Creek Groundwater Investigation"*. Kembla Coal and Coke Pty Ltd. Report No. HS62/3-AV.

Coffey and Partners Pty Ltd, (September 1983)[2], *"Further Resistivity Investigations at Maules Creek, Boggabri".* Kembla Coal and Coke Pty Ltd. Report No. HS62/4-AC.

Coffey and Partners Pty Ltd, (November 1984), *"Groundwater Appraisal "Velyama" and Environs".* Kembla Coal and Coke Pty Ltd. Report No. HS62/7-AA.

Coffey and Partners Pty Ltd, (June 1985), *"Maules Creek Proposed Borefield".* Kembla Coal and Coke Pty Ltd. Report No. HS62/B.

Coffey and Partners Pty Ltd, (July 1986), *"Appraisal of Effects of Groundwater Extraction on Maules Creek Aquifer System"*. Kembla Coal and Coke Pty Ltd. Report No. HS62/9-AB.

CSIRO, (2007), *"Water Availability in the Namoi – A Report to the Australian Government from the CSIRO Murray Darling Commission Sustainable Yields Project".*

Cumberland Ecology, (2011), *"Maules Creek Coal Project Ecological Impact Assessment".*

Chaing W.H. and Kinzelbach W., (1996), *"Processing MODFLOW for Windows".*

Department of Mineral Resources, (1993), "*Gunnedah Coalfield (North) Regional Geology",* Geological Series Sheet including parts of 8836, 8837, 8936, 8937 first edition 1998.

Geoscience Australia – *"Geodata 9 Second Digital Elevation Model Version 3",* Gridded Elevation and Drainage Data, 1:250,000.

Giambastiani, Callum, Andersen, Kelly, Ackworth, (2010), *"A groundwater flow model of the Maules Creek Catchment",* University of New South Wales Connected Waters Initiative Sydney Australia.

GSS, (2011), *"Maules Creek Coal Project Soil and Land Capability Assessment".*

Hansen Bailey Pty Ltd, (2010)[1], *"Continuation of Boggabri Coal Mine, Environmental Assessment",* prepared for Boggabri Coal Pty Ltd.

Hansen Bailey Pty Ltd, (July 2010)[2], *"Maules Creek Coal Project, Preliminary Environmental Assessment",* prepared for Aston Resources Pty Ltd

Hydrogeologic Inc., MODFLOW SURFACT Software (Version 3.0), Herdon, VA, USA.

JB Mining, (2010), *"Interpolation of regional coal seam surfaces"* – raw data only, no report.

Kembla Coal and Coke Pty Ltd, (Sept. 1989), *"Maules Creek Coal Project Environmental Impact Statement".*

Land and Water Biodiversity Committee (Sept. 2003) *"Minimum Construction Requirements for Water Bores in Australia"* Ed. 2.

Mackie, (2009), *"Hydrogeological characterisation of coal measures and overview of impacts of coal mining on groundwater systems in the Upper Hunter Valley of NSW",* PhD Thesis, University of Technology, Sydney.

MDBC, (2000), *"Murray Darling Basin Commission Groundwater Modelling Guidelines".* November 2000, Project No. 125, Final guideline issue January 2001.

NSW Department of Land and Water Conservation, (April 1998), *"Aquifer Risk Assessment Report",* HO/16/98.

New South Wales Department of Natural Resources, (2006), *"Upper Namoi groundwater flow model, Groundwater Management Area 004; Zones 2,3,4,5,11 and 12, model development and calibration"*, prepared by Craig McNeilage.

Parsons Brinckerhoff Australia Pty Ltd (Dec. 2005), *"Boggabri Coal Project Groundwater Assessment".*

RGS, (2009), *"Maules Creek Project Geochemical Assessment of Overburden and Potential Reject Materials",* 3 November 2010.

Whitehouse, (1993), *"Coal Resources of the Maules Creek Sub-Basin*, in *The Gunnedah Basin, New South Wales"*, Department of Mineral Resources, Geological Survey of New South Wales, Memoir Geology 12, 1993 ed Tadros, Z.

Zheng C. and Bennett G., (1995), *"Applied Contaminant Transport Modelling"*. Wiley, New York.

15.0 GLOSSARY

Alluvium - Sediment (gravel, sand, silt, clay) transported by water (i.e. deposits in a stream channel or floodplain).

Aquiclude - A low-permeability unit that forms either the upper or lower boundary of a ground-water flow system.

Aquifer - Rock or sediment in a formation, group of formations, or part of a formation which is saturated and sufficiently permeable to transmit economic quantities of water to wells and springs.

Aquifer, Confined - An aquifer that is overlain by a confining bed. The confining bed has a significantly lower hydraulic conductivity than the aquifer.

Aquifer, Perched - A region in the unsaturated zone where the soil may be locally saturated because it overlies a low-permeability unit.

Aquifer, Semi-confined - An aquifer confined by a low-permeability layer that permits water to slowly flow through it. During pumping of the aquifer, recharge to the aquifer can occur across the confining layer. Also known as a leaky artesian or leaky confined aquifer.

Aquifer, Unconfined - An aquifer in which there are no confining beds between the zone of saturation and the surface. There will be a water table in an unconfined aquifer. Water-table aquifer is a synonym.

Aquitard - A low-permeability unit than can store ground water and also transmit it slowly from one aquifer to another.

Barrier Boundary - An aquifer-system boundary represented by a rock mass that is not a source of water.

Baseflow - That part of stream flow that originates from ground water seeping into the stream.

Colluvium - Sediment (gravel, sand, silt, clay) transported by gravity (i.e. deposits at the base of a slope).

Cone of Depression - The depression in the water table around a well or excavation defining the area of influence of the well. Also known as cone of influence.

Discharge - The volume of water flowing in a stream or through an aquifer past a specific point in a given period of time.

Discharge Area - An area in which there are upward components of hydraulic head in the aquifer. Ground water is flowing toward the surface in a discharge area and may escape as a spring, seep, or baseflow or by evaporation and transpiration.

Drawdown - A lowering of the water table of an unconfined aquifer or the potentiometric surface of a confined aquifer caused by pumping of ground water from wells or excavations.

Falling/Rising Head (Slug) Test - A test made by the instantaneous addition, or removal, of a known volume of water to or from a well. The subsequent well recovery is measured and analysed to provide a permeability value.

Groundwater - The water contained in interconnected pores located below the water table in an unconfined aquifer or located in a confined aquifer.

Groundwater Flow - The movement of water through openings in sediment and rock; occurs in the zone of saturation.

Groundwater, Perched - The water in an isolated, saturated zone located in the zone of aeration. It is the result of the presence of a layer of material of low hydraulic conductivity, called a perching bed. Perched ground water will have a perched water table.

Ground water, unconfined - The water in an aquifer where there is a water table.

Heterogeneous - Pertaining to a substance having different characteristics in different locations. A synonym is non-uniform.

Hydraulic Conductivity - A measure of the rate at which water moves through a soil/rock mass. It is the volume of water that moves within a unit of time under a unit hydraulic gradient through a unit cross-sectional area that is perpendicular to the direction of flow.

Hydraulic Gradient - The change in total head with a change in distance in a given direction. The direction is that which yields a maximum rate of decrease in head.

Hydrogeology - The study of the interrelationships of geologic materials and processes with water, especially ground water.

Infiltration - The flow of water downward from the land surface into and through the upper soil layers.

Model Calibration - The process by which the independent variables of a digital computer model are varied in order to calibrate a dependent variable such as a head against a known value such as a water-table map.

Monitoring Bore (Piezometer) - A non-pumping well (bore), generally of small diameter, that is used to measure the elevation of the water table or potentiometric surface. A piezometer generally has a short well screen through which water can enter.

Packer Test - An aquifer test performed in an open borehole to determine rock permeability; the segment of the borehole to be tested is sealed off from the rest of the borehole by inflating seals, called packers, both above and below the segment.

Porosity - The ratio of the volume of void spaces in a rock or sediment to the total volume of the rock or sediment.

Potentiometric Surface - A surface that represents the level to which water will rise in tightly cased wells. If the head varies significantly with depth in the aquifer, then there may be more than one potentiometric surface. The water table is a particular potentiometric surface for an unconfined aquifer.

Pumping Test - A test made by pumping a well for a period of time and observing the response/change in hydraulic head in the aquifer in order to determine aquifer hydraulic characteristics.

Recharge Area - An area in which there are downward components of hydraulic head in the aquifer. Infiltration moves downward into the deeper parts of an aquifer in a recharge area.

Recharge Basin - A basin or pit excavated to provide a means of allowing water to soak into the ground at rates exceeding those that would occur naturally.

Recharge Boundary - An aquifer system boundary that adds water to the aquifer. Streams and lakes are typically recharge boundaries.

Recharge Well - A well specifically designed so that water can be pumped into an aquifer in order to recharge the ground-water reservoir.

Recovery - The rate at which the water level in a well rises after the pump has been shut off. It is the inverse of drawdown.

Rock, Volcanic - An igneous rock formed when molten rock called lava cools on the earth's surface.

Specific Yield - The ratio of the volume of water a rock or soil will yield by gravity drainage to the volume of the rock or soil. Gravity drainage may take many months to occur.

Storativity - The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head. It is equal to the product of specific storage and aquifer thickness. In an unconfined aquifer, the storativity is equivalent to the specific yield. Also called storage coefficient.

Transmissivity - The rate at which water of a prevailing density and viscosity is transmitted through a unit width of an aquifer or confining bed under a unit hydraulic gradient. It is a function of properties of the liquid, the porous media, and the thickness of the porous media.

Unsaturated Zone - The zone between the land surface and the water table. It includes the root zone, intermediate zone, and capillary fringe. The pore spaces contain water at less than atmospheric pressure, as well as air and other gases. Saturated bodies, such as perched ground water, may exist in the unsaturated zone. Also called zone of aeration and vadose zone.

Water Budget - An evaluation of all the sources of supply and the corresponding discharges with respect to an aquifer or a drainage basin.

Watertable Map - A specific type of potentiometric-surface map for an unconfined aquifer; shows lines of equal elevation of the water table.

Well Development - The process whereby a well (bore) is pumped or surged to remove any fine material that may be blocking the well screen or the aquifer outside the well screen.

Well Screen - A tubular device with either slots, holes, gauze, or continuous-wire wrap; used at the end of a well casing to complete a well. The water enters the well through the well screen.

(G1508)

LIMITATIONS OF REPORT

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) has prepared this report for the use of Aston Resources Limited in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 19 December 2009.

The methodology adopted and sources of information used by AGE are outlined in this report. AGE has made no independent verification of this information beyond the agreed scope of works and AGE assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to AGE was false.

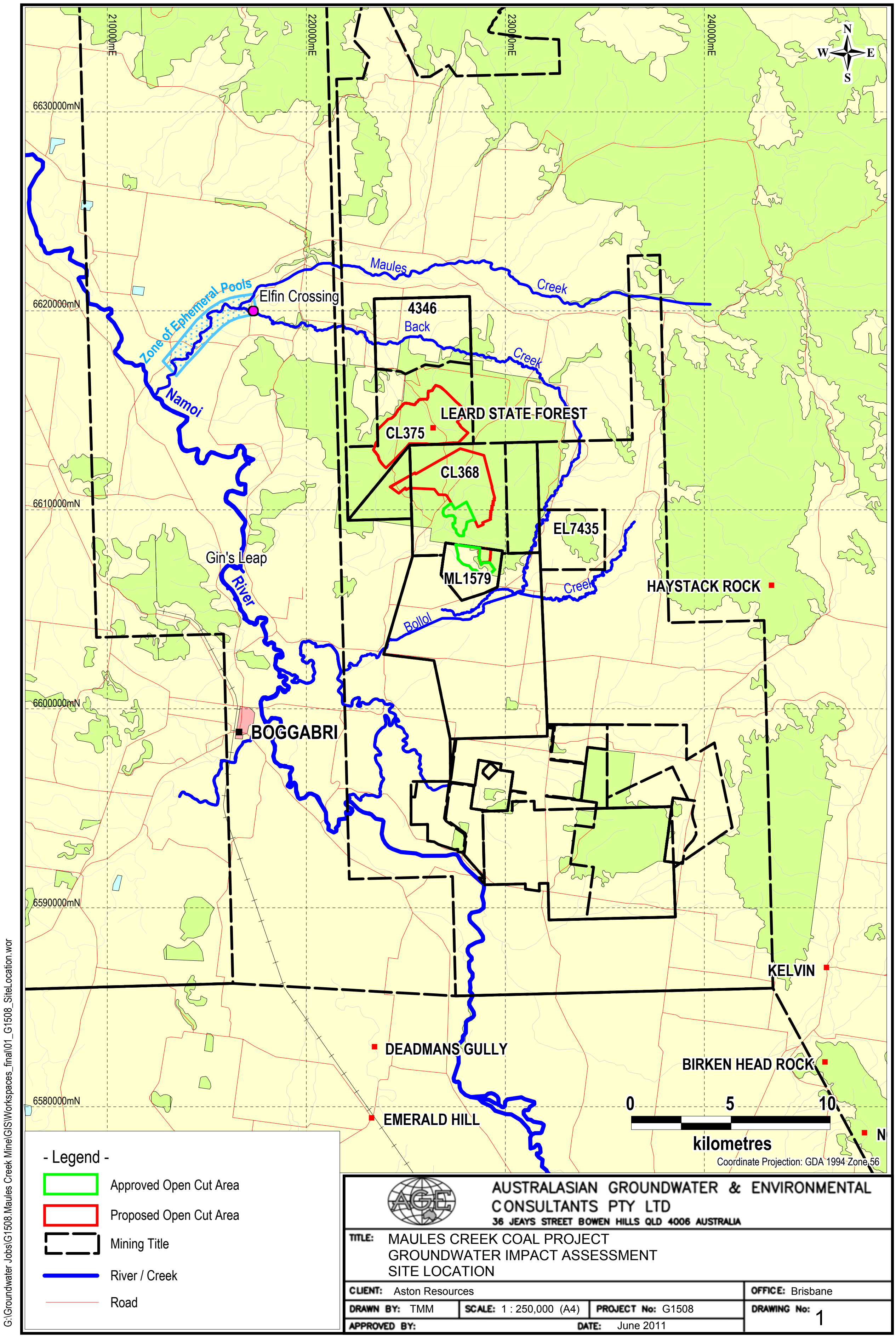
This study was undertaken between 4 May 2010 and 30 June 2011 and is based on the conditions encountered and the information available at the time of preparation of the report. AGE disclaims responsibility for any changes that may occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. It may not contain sufficient information for the purposes of other parties or other users. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

This report contains information obtained by inspection, sampling, testing and other means of investigation. This information is directly relevant only to the points in the ground where they were obtained at the time of the assessment. Where borehole logs are provided they indicate the inferred ground conditions only at the specific locations tested. The precision with which conditions are indicated depends largely on the frequency and method of sampling, and the uniformity of the site, as constrained by the project budget limitations. The behaviour of groundwater is complex. Our conclusions are based upon the analytical data presented in this report and our experience.

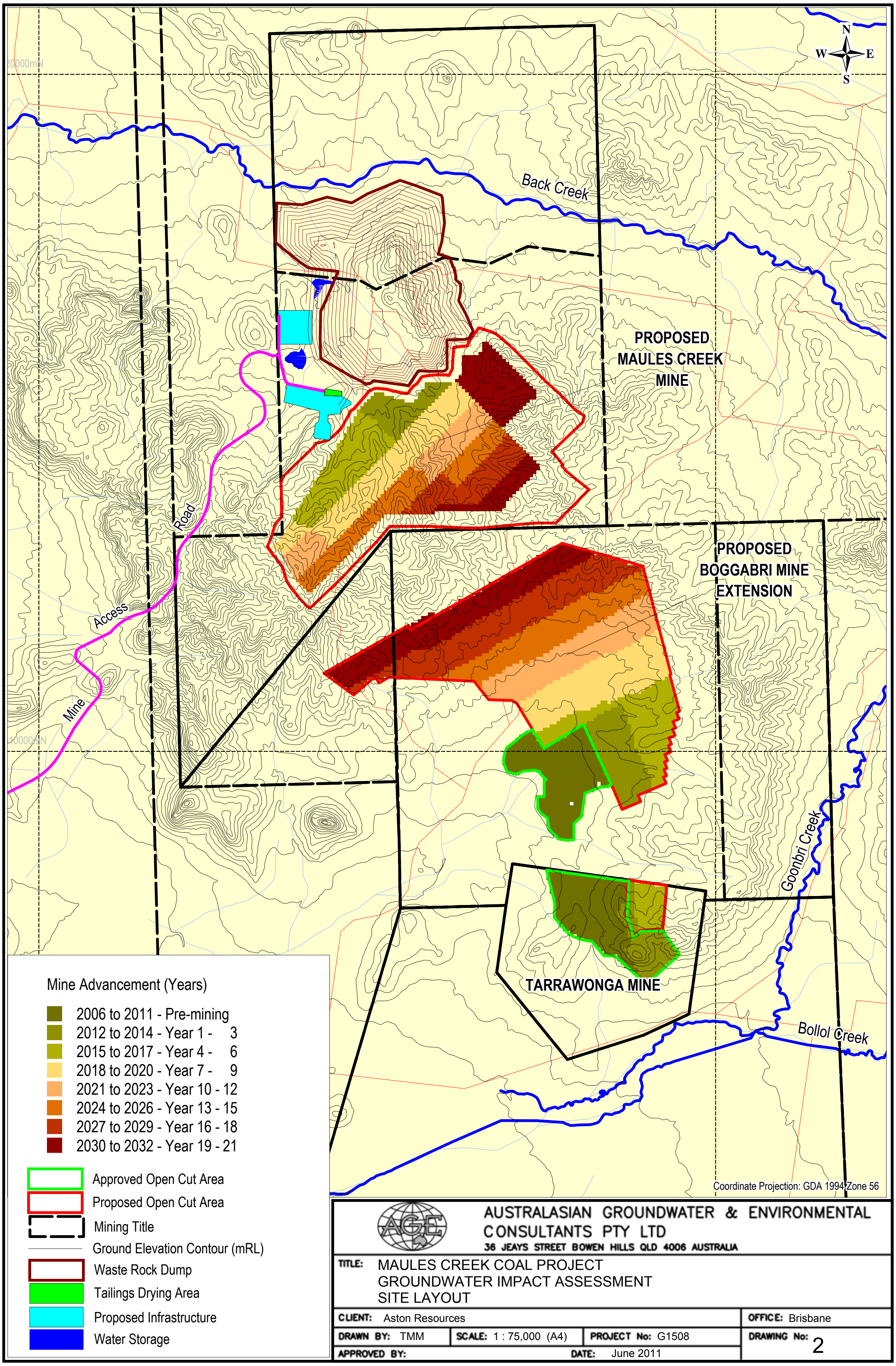
Where conditions encountered at the site are subsequently found to differ significantly from those anticipated in this report, AGE must be notified of any such findings and be provided with an opportunity to review the recommendations of this report.

Whilst to the best of our knowledge, information contained in this report is accurate at the date of issue, subsurface conditions, including groundwater levels can change in a limited time. Therefore this document and the information contained herein should only be regarded as valid at the time of the investigation unless otherwise explicitly stated in this report.



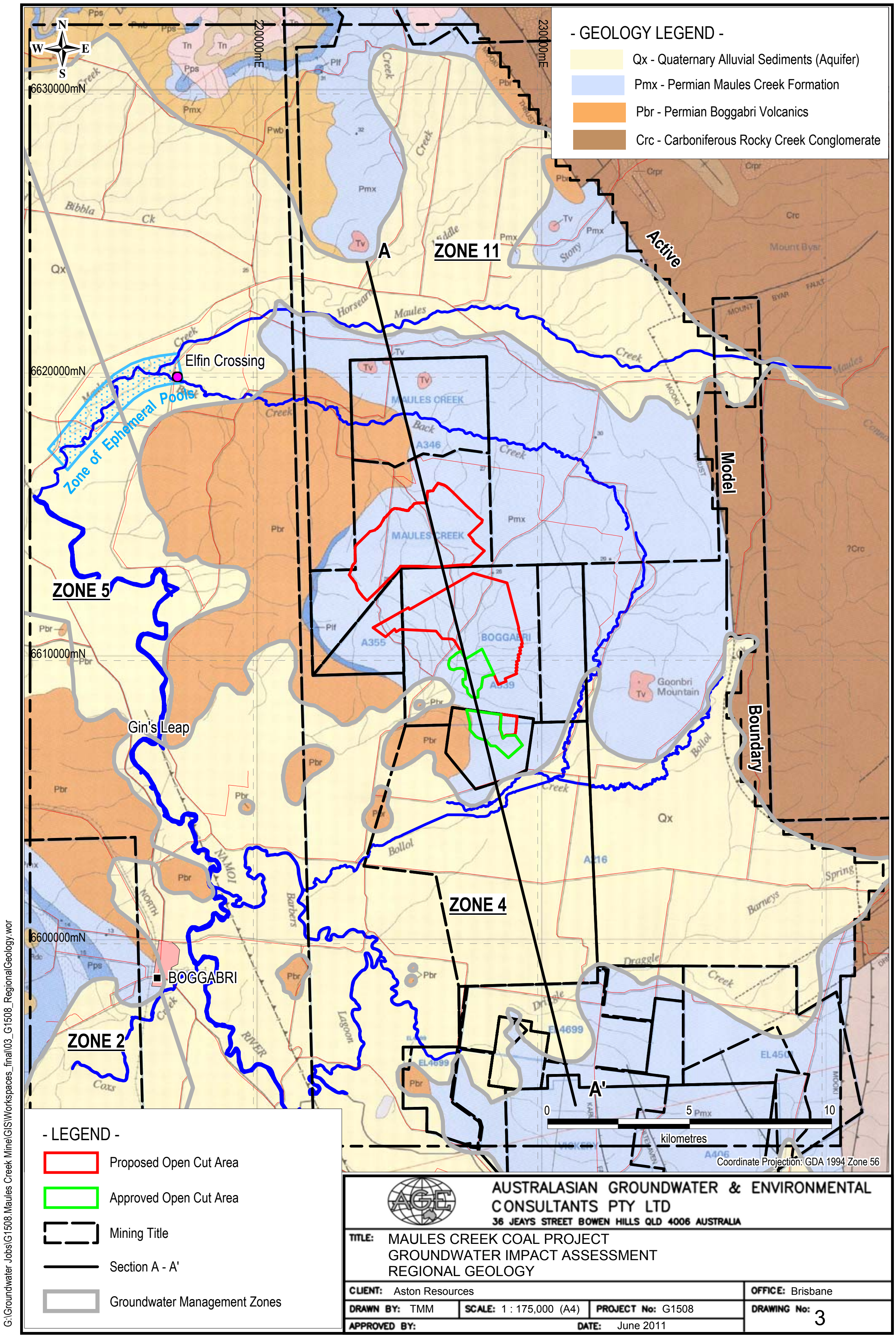
210000mE
220000mE
230000mE
240000mE
6630000mN
6620000mN
6610000mN
6600000mN
6590000mN
6580000mN
Maules
Creek
Elfin Crossing
Zone of Ephemeral Pools
4346
Back
Creek
Namoi
LEARD STATE FOREST
CL375
CL368
EL7435
Gin's Leap
River
ML1579
Creek
HAYSTACK ROCK
Bollol
BOGGABRI
KELVIN
DEADMANS GULLY
BIRKEN HEAD ROCK
EMERALD HILL
0
5
10
kilometres
Coordinate Projection: GDA 1994 Zone 56
N
W
E
S
- Legend -
Approved Open Cut Area
Proposed Open Cut Area
Mining Title
River / Creek
Road
AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA
TITLE: MAULES CREEK COAL PROJECT
GROUNDWATER IMPACT ASSESSMENT
SITE LOCATION
CLIENT: Aston Resources
OFFICE: Brisbane
DRAWN BY: TMM
SCALE: 1 : 250,000 (A4)
PROJECT No: G1508
DRAWING No: 1
APPROVED BY:
DATE: June 2011
G:\Groundwater Jobs\G1508.Maules Creek Mine\GIS\Workspaces_final\01_G1508_SiteLocation.wor

(G1508)



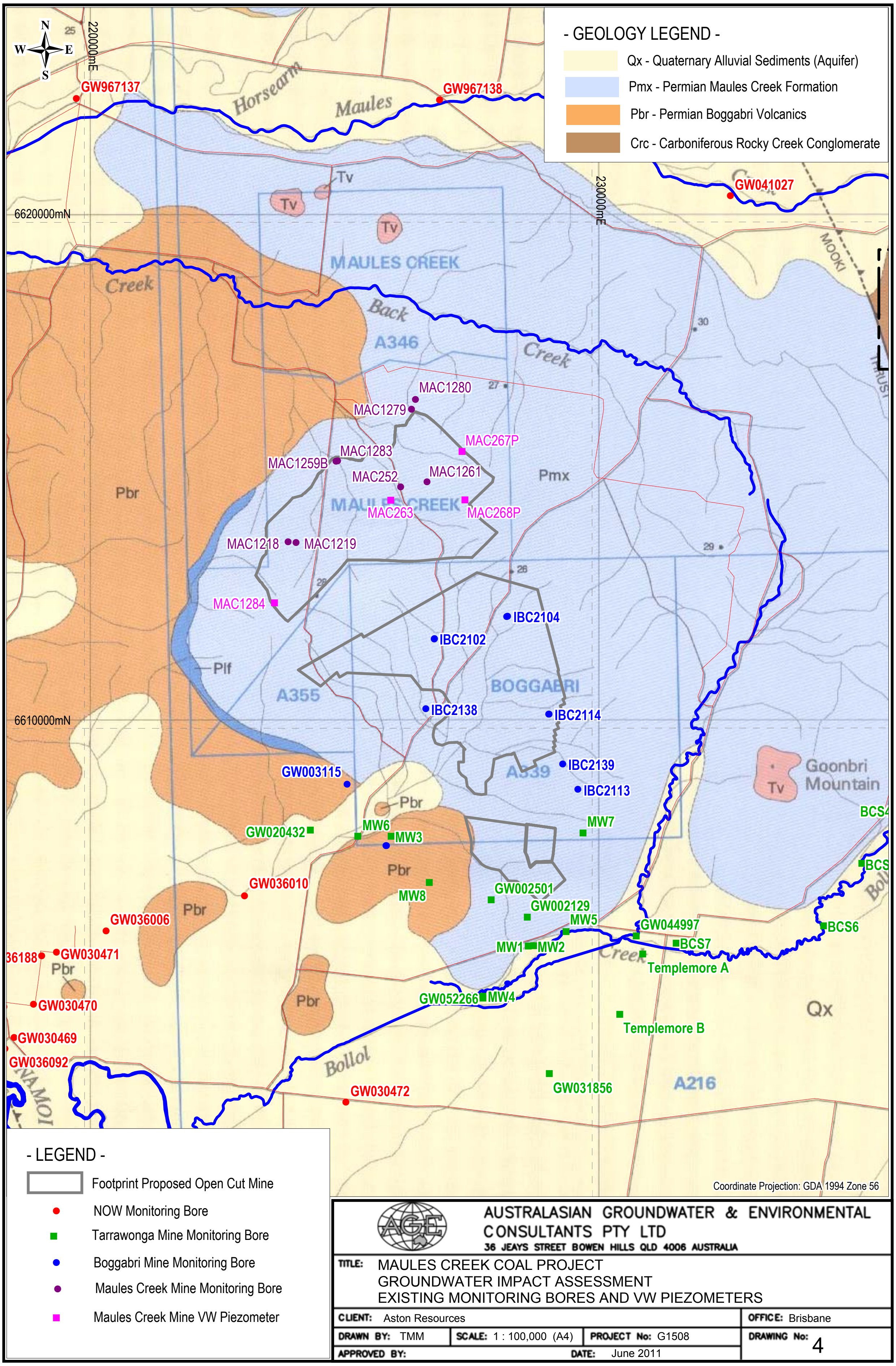
G:\Groundwater Jobs\G1508.Maules Creek Mine\GIS\Workspaces_final\02_G1508_SiteLayout.wor

(G1508)



- GEOLOGY LEGEND -
Qx - Quaternary Alluvial Sediments (Aquifer)
Pmx - Permian Maules Creek Formation
Pbr - Permian Boggabri Volcanics
Crc - Carboniferous Rocky Creek Conglomerate
- LEGEND -
Proposed Open Cut Area
Approved Open Cut Area
Mining Title
Section A - A'
Groundwater Management Zones
ZONE 11
ZONE 5
ZONE 4
ZONE 2
Active Model Boundary
Elfin Crossing
Zone of Ephemeral Pools
Gin's Leap
BOGGABRI
Goonbri Mountain
A
A'
6630000mN
6620000mN
6610000mN
6600000mN
220000mE
230000mE
0 5 10
kilometres
Coordinate Projection: GDA 1994 Zone 56
AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA
TITLE: MAULES CREEK COAL PROJECT
GROUNDWATER IMPACT ASSESSMENT
REGIONAL GEOLOGY
CLIENT: Aston Resources
OFFICE: Brisbane
DRAWN BY: TMM
SCALE: 1 : 175,000 (A4)
PROJECT No: G1508
DRAWING No: 3
APPROVED BY:
DATE: June 2011
G:\Groundwater Jobs\G1508.Maules Creek Mine\GIS\Workspaces_final\03_G1508_RegionalGeology.wor

(G1508)



AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD 36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA	
TITLE: MAULES CREEK COAL PROJECT GROUNDWATER IMPACT ASSESSMENT EXISTING MONITORING BORES AND VW PIEZOMETERS	
CLIENT: Aston Resources	OFFICE: Brisbane
DRAWN BY: TMM SCALE: 1 : 100,000 (A4) PROJECT No: G1508	DRAWING No: 4
APPROVED BY: DATE: June 2011	

(G1508)