Appendix J

Groundwater impact assessment

Moolarben Coal Project Stage 1 Optimisation Modification, Environmental Assessment – May 2013

MOOLARBENCOAL
PART OF THE YANCOAL AUSTRALIA GROUP

EMM
EMGA Mitchell McLennan

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Australasian
Groundwater & Environmental
Consultants Pty Ltd

REPORT on

MOOLARBEN COAL PROJECT

STAGE 1 OPTIMISATION MODIFICATION GROUNDWATER ASSESSMENT

prepared for
MOOLARBEN COAL PTY LIMITED

Project No. G1622
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ABN:64 080 238 642

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EXECUTIVE SUMMARY

The Moolarben Coal Operations (MCO) operates Stage 1 of the Moolarben Coal Project (MCP) located in the Western Coalfields of NSW, approximately 40 km north-east of Mudgee. Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) has been engaged by EMGA Mitchell McLennan Pty Limited (EMM) on behalf of MCO to undertake a groundwater impact assessment for the Moolarben Coal Project – Stage 1 Optimisation Modification (proposed modification).

Stage 1 of MCP has approval to mine three open cut pits, referred to as Open Cuts 1, 2 and 3, and one underground mine referred to as Underground 4. The operations have an approved combined maximum extraction rate of 12 million tonnes per annum (mtpa) of run-of-mine (ROM) coal.

The MCP is bordered by the Goulburn River to the north-west; privately owned grazing land to the north; Goulburn River National Park, Wilpinjong Coal Mine and Munghorn Gap Nature Reserve to the east; privately-owned grazing land to the south; and privately-owned grazing land, Ulan settlement and Ulan Coal Mine to the west. To date, mining has occurred within Open Cut 1 only, commencing in 2010 at the south-western perimeter and progressing in a north-easterly direction.

The approved open cut disturbance boundary limits potential access to additional economically viable recoverable coal resources. Access to these substantial resources represents the most efficient and economic manner to maximise resource recovery. The proposed modification is primarily intended to enable these resources to be mined. It also provides an opportunity to greatly improve the efficiency of mining operations within Open Cuts 1 and 2, by increasing the available strike length and working face, and, consequently reduces extraction costs.

Approval is also being sought from the NSW Minister for Planning and Infrastructure for Stage 2 development at the MCP, including the development of two additional underground areas (Underground 1 and 2) and an open cut pit (Open Cut 4). Stage 2 is in the final phases of the approvals process with determination anticipated in 2013.

Significant historical field investigations, including the drilling and testing of over 100 monitoring bores, has been carried out for the MCP. Conceptualisation and numerical groundwater modelling has also been completed as part of previous studies for the approved Stage 1 and also for the proposed Stage 2. Therefore, the regional and local groundwater systems are well understood, and provide a sound basis upon which to assess the impact of the proposed modification.

The scope of work to assess the proposed modification included review of previous impact assessments and recently collected groundwater monitoring data. The water level and pit seepage data collected to date is within the ranges predicted by previous investigators using numerical models, which verifies the soundness of the previous studies. As the previous models had been gradually refined over time as new data was collected, had been subject to peer review, and were showing good agreement with field data, they were deemed appropriate for use in assessing the impact of the proposed modification, and no further modelling was undertaken.

The existing monitoring points have not detected any significant depressurisation from current mining operations in Open Cut 1. A general increasing trend in groundwater levels is noted in many monitoring bores, with above average rainfall (compared to long term averages) indicating that natural recharge is the source of these increases. Unusually large groundwater level increases are noted in some monitoring bores to the north of Open Cut 1, with a probable cause a response to changes in mining dewatering activities at the Ulan Coal Mine, which is located in close proximity to the north of the MCP. Almost 90 years of underground mining has occurred at the neighbouring Ulan Coal Mine with a resultant long history of antecedent groundwater system dewatering prior to mining at MCP.

The proposed modification seeks to extend open cut mining in two separate areas adjacent to approved mining operations. The first is in an area “high” in the landscape between Open Cut 1 and Open Cut 2, with a second area extending Open Cut 2 to the south-east (near to Moolarben Creek).

Available information and previous numerical model results indicate the proposed modification between Open Cut 1 and Open Cut 2 will result in a negligible increase in seepage rates to the mine and correspondingly “nil” impact on the surrounding groundwater regime. This conclusion has been reached based on the available data that indicates the mined sequence is essentially “dry” in a large area of the proposed modification, either naturally or from historical dewatering at the Ulan Coal Mine.

Mine inflows for the majority of the proposed modification are likely to be within the range predicted for Stage 1 and Stage 2. A large proportion of the proposed extension area is within landscapes that are “dry” or contain limited saturated thickness of groundwater above the base of the Ulan Seam.

Based on Stage 2 model predictions (which includes Stage 1), inflows into the proposed extension areas for the indicative Year 2 mine plan will be 220 m^3/day. As Open Cut 1 advances further down-dip to the north-east, as per the indicative Year 6 open cut mine plan, inflows will increase progressively to 413 m^3/day. Inflows for indicative open cut mine Year 11 to Year 16 as the pit extends to Open Cut 2 are estimated from Stage 2 predictions to be 58 m^3/day to 27 m^3/day. As pits will be progressively backfilled, no increase is expected in pit inflows, rather a continuation of inflows at previously modelled inflow rates.

MCO holds licences under Part 5 Water Act 1912 which entitle MCO to take the following volumes of groundwater from the Permian formations (ie non Water Storage Plan managed water sources):

- up to 150 ML/ year mine dewatering water licence. This licensed amount equates to the maximum predicted inflows from the latest Stage 2 modelling (RPS Aquaterrra 2011). This license currently applies to Open Cut 1 only; and
- 2,850 ML/ year from the southern and northern borefields.

It is noted that maximum pit inflows simulated from Stage 2 modelling include Stage 1.

Minor changes are expected to the piezometric levels in response to the proposed modification, although these are anticipated to be within the margin of error for the current numerical models. A small increase is expected in the area of 2 m drawdown in alluvium associated with Moolarben Creek.

Licence allocations on Water Sharing Plan water sources are being finalised for the Stage 2 application. The purchase of a water license for 218 ML/year from the Wollar Creek water source has recently been finalised. MCO is in the process of purchasing a water licence for 9 ML/year from the Goulburn River water source to account for predicted reductions in baseflow as a result of Stage 1 and Stage 2 operations on this water source. Stage 2 modelling simulated an impact on the water source at a maximum of 7 ML/year with the additional 2 ML/year accounting for security of supply and minor increases in baseflow reduction due to the proposed modification.

Based on the Aquifer Interference Policy (AIP) the groundwater system impacted by the proposed modification can be separated into two systems, as follows:

- porous and/or fractured consolidated sedimentary rock of the Permian Coal Measures and overlying Triassic sequence; and
- groundwater within alluvium associated with Moolarben Creek and Lagoon Creek.

Water quality and yields vary in both groundwater systems, but can be considered less productive aquifers according to the AIP. The AIP requires that aquifer interference activities do not induce a decline of more than 2 m in the water table or water pressure at any water supply work, i.e. a bore or a well in both highly and less productive groundwater sources. No private bores are captured within the zone of drawdown indicating the Project complies with this requirement of the AIP.

To protect surface water the AIP requires "no increase of more than 1% per activity in the long term average salinity in a highly connected surface water source at the nearest point to the activity". Dewatering due to Stage 1 and Stage 2 development is expected to reduce the volumes of baseflow to local streams. This effectively reduces the discharges during mining of more saline groundwaters into the streams and therefore it is considered improbable that the proposed modification would increase the stream salinity.

The current monitoring regime of groundwater levels and water quality are sufficient to monitor the effects of the proposed extension. Any noticeable change in pit inflows over those previously modelled will be recorded by MCO.

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REPORT ON

MOOLARBEN COAL PROJECT

STAGE 1 OPTIMISATION MODIFICATION GROUNDWATER ASSESSMENT

1.0 INTRODUCTION

1.1 Background

The Moolarben Coal Project (MCP) is an approved open cut and underground coal mine in the Western Coalfields of NSW, approximately 40 km north-east of Mudgee (Figure 1). Australasian Groundwater and Environmental Pty Ltd (AGE) was engaged by Moolarben Coal Operations Pty Limited (MCO) to undertake an groundwater impact assessment for the Moolarben Coal Project – Stage 1 Optimisation Modification (proposed modification).

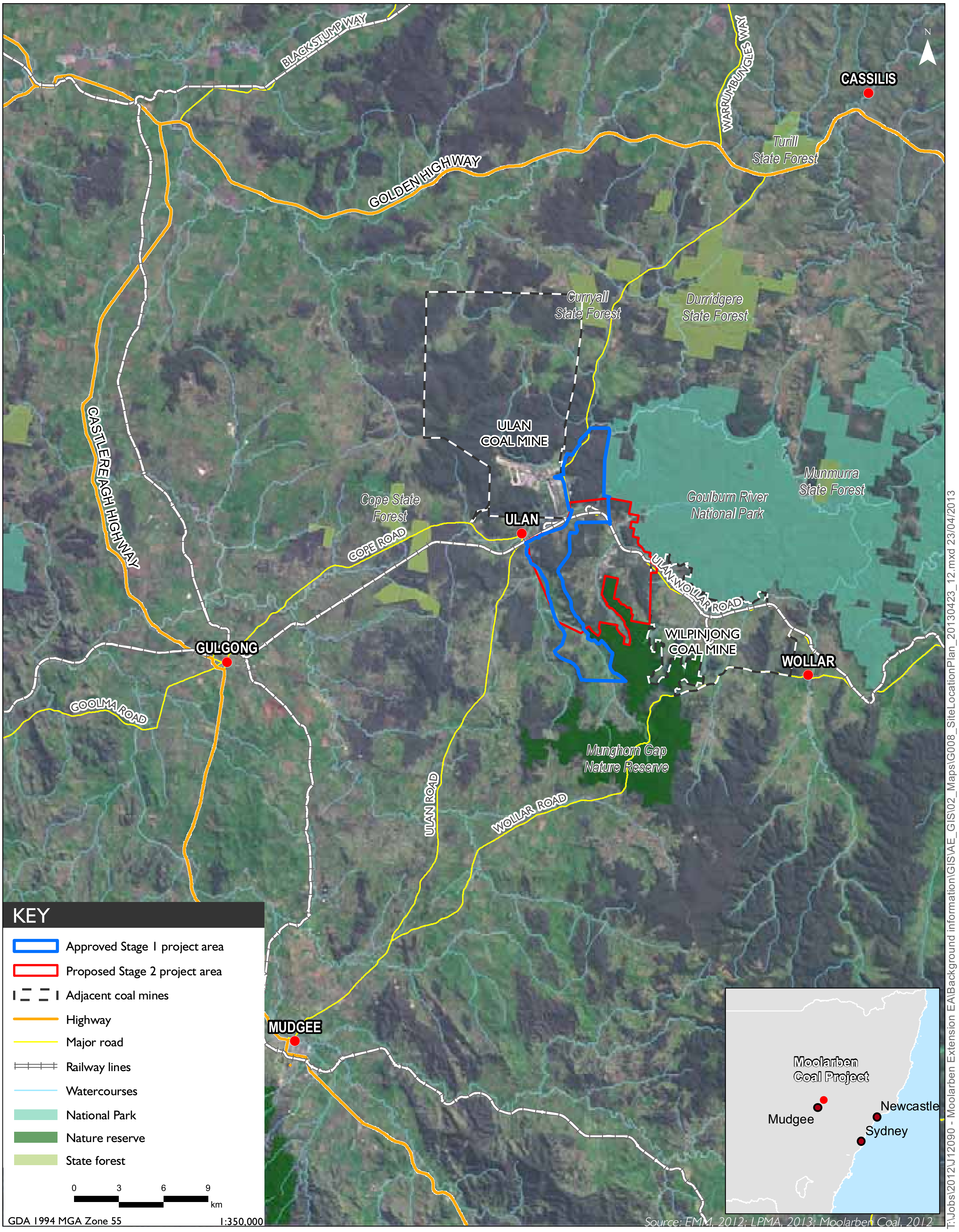
The MCP Stage 1 Major Project approval 05_0117 (MP 05_0117) was approved under Part 3A of the Environmental Planning and Assessment Act 1979 (EP&A Act) in 2007. Since gaining approval, MP 05_0117 has been modified on seven occasions to make administrative changes, minor changes to infrastructure areas and allow the construction of a borefield. The main components of the MCP Stage 1, as modified, comprise:

- three open cut pits, referred to as Open Cuts 1, 2 and 3, which have an approved combined maximum extraction rate of 8 million tonnes per annum (Mtpa) of run of mine (ROM) coal;
- one underground mine, referred to as Underground 4, which has an approved maximum extraction rate of 4 Mtpa of ROM coal;
- coal handling, processing, rail loop, load-out and water management infrastructure; and
- associated facilities including offices, bathhouses, workshops and fuel storages.

To date, mining has occurred within Open Cut 1 only, commencing at the south-western perimeter and progressing in a north-easterly direction.

The current disturbance limit granted under MP 05_0117 is restricting the extraction of large quantities of the deposit which are economically viable in today’s market. The proposed modification will extend the disturbance boundary enabling increased resource utilisation, a longer life for Open Cuts 1 and 2 and promote the continuity of Stage 1 operations. All of the elements of the proposed modification are described in Section 1.2.

The MCP is bordered by the Goulburn River to the north-west; privately owned grazing land to the north; Goulburn River National Park, Wilpinjong Coal Mine and Munghorn Gap Nature Reserve to the east; privately-owned grazing land to the south; and privately-owned grazing land, Ulan settlement and Ulan Coal Mine to the west.



MCP location plan

Moolarben Coal Project Stage 1 Optimisation Modification

Figure 1

1.2 Overview of the Proposed Modification

The elements of the proposed modification to MP05_0117 comprise:

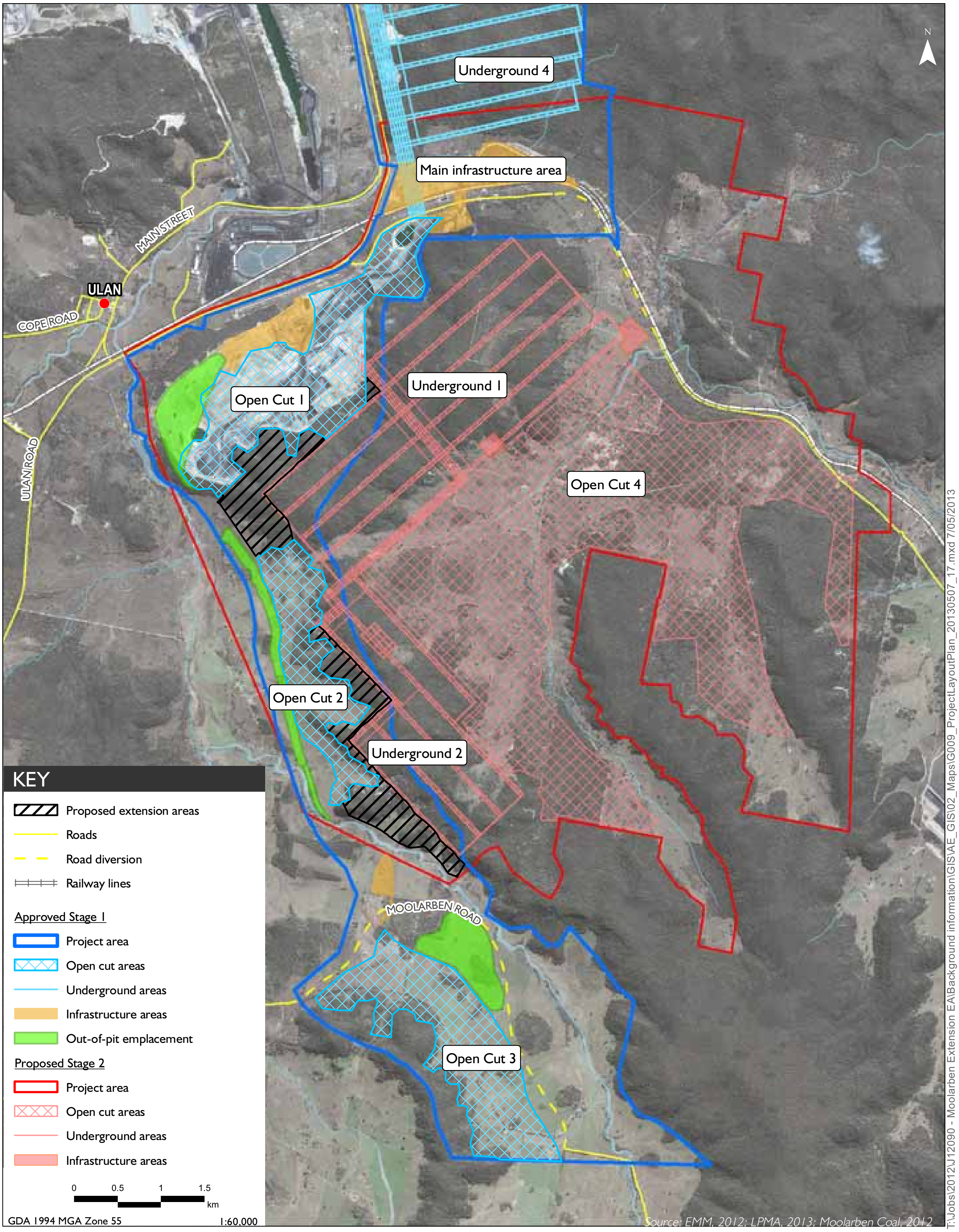
- the extension of mining within Open Cuts 1 and 2;
- the construction and operation of additional water management infrastructure; and
- a minor change to the rehabilitation sequencing and final landform.

No others changes are proposed under the modification.

The proposed modification elements are shown in Figure 2. They are all within the Stage 1 project approval boundary, which forms the 'project area' for the proposed modification. Within the project area, Open Cut 1 and 2 extension areas are referred to collectively as the 'proposed extension areas'. It is noted that proposed extension areas include a disturbance buffer of up to 50 m that will enable the development of a services road and infrastructure if required, such as water pipelines. This ensures that all potential impacts associated with the proposed extension to mining have been assessed. The proposed extension area footprints ensure that a minimum 40 m barrier exists between coal from the proposed and approved open cut and underground mining areas.

1.3 Relationship To Other Projects

A Major Project Application for Stage 2 of the MCP, MP 08_0135, is currently being assessed by the Department of Planning and Infrastructure (DP&I). If approved, Stage 2 will consist of one open cut pit, Open Cut 4, and two underground mines, Undergrounds 1 and 2, and associated additional infrastructure. This groundwater assessment is based on the assumption that Stage 2 of the MCP will be approved, enabling potential worst case impacts to be assessed.



Proposed modification layout plan

Moolarben Coal Project Stage 1 Optimisation Modification

Figure 2

2.0 METHODOLOGY

The methodology to assess the impact of the proposed modification was primarily a desktop study combined with a site visit. The study draws upon previous groundwater investigations and up-to-date monitoring data to make semi-quantitative predictions of the effects of the proposed extension areas on the groundwater regime. The study included:

- review of previous groundwater investigations;
- importing calibration and predictive data sets from previous numerical models into GIS;
- comparing previous conceptual models, numerical models and predictive results against up-to-date groundwater level data;
- confirming that previous numerical models are fit for use in this study; and,
- determining if previous predictions apply to the proposed modification and using hydrogeological principles to infer effects on the wider groundwater environment.

This methodology for the groundwater assessment was chosen following an initial data review, a site visit during November 2012 and discussions with EMM and MCO. The initial data review indicated the proposed modification will be in areas that are either unsaturated, partially saturated and have similar hydraulic characteristics to those already assessed. The initial data review also indicated that the previous numerical models had been gradually refined over time as new data was collected, had been subject to peer review, and were showing good agreement with field data. Further numerical modelling was therefore not considered warranted for the study.

3.0 PREVIOUS GROUNDWATER INVESTIGATIONS

The following sections summarise previous studies and their relevance to the proposed modification.

Extensive groundwater investigations have been undertaken in the project area as part of the Stage 1 and Stage 2 mining applications and have included:

- Field investigation programs including:
    - installing over 100 groundwater monitoring bores (piezometers) and test production bores;
    - monitoring of groundwater levels and water quality;
    - collecting data on privately-owned groundwater bores, natural springs, soaks and seepages;
    - testing aquifer properties permeability including:
        - laboratory permeability testing of core samples;
        - slug testing;
        - short-term pumping tests.
- review of hydrogeological reports in the public domain produced for the Ulan and Wilpinjong coal mines; and
- numerical groundwater modelling.

The following summary of previous field investigations is sourced from RPS Aquaterra (2011).

3.1 Piezometer / Monitoring Bore Installation

During the Stage 1 and Stage 2 investigations, over 100 piezometers and four test production bores were installed. One of the test production bores was commissioned as a production bore, and two additional production bores were drilled and brought into water supply production. The piezometer sites were distributed across the project area with the aim of testing, sampling and monitoring groundwater both in the Ulan Seam (the target seam for coal extraction) and the overlying and underlying lithological units. Additional drilling was undertaken in Stage 2 to further investigate the relationship between groundwater in the shallow regolith and in the deeper coal measures, including the recharge-discharge processes.

Piezometers were installed at locations within the coal deposit and proposed mining areas, as well as up dip (south-west), down dip (north-east) and along strike (north-west and south-east) of the proposed mine areas. Many of the piezometers were installed in existing exploration drill-holes. In areas where coal exploration drill-holes were not available, new bores were drilled specifically for piezometer installation.

The majority of groundwater bores were completed as stand-pipe piezometers, forming an extensive monitoring network from which both groundwater level and groundwater quality data are now collected.

Stage 2 investigation drilling involved a series of shallow monitoring bores drilled along three roughly east-west orientated transects across the Murragamba Valley. At each site, a shallow piezometer was installed, screened across the uppermost (potentially) groundwater bearing zone which was typically either weathered Permian coal measures, colluvium or, at some sites, alluvium. A second slightly deeper bore was then drilled at each site. In the deeper bore, screens were placed at the interpreted highest water intersection in the underlying weathered Permian coal measures.

The primary purpose of installing these monitoring sites was to collect further hydrogeological data on the nature of the regolith, and groundwater in either Quaternary or Tertiary sediments as previously reported by Dundon (2007). Previous coal exploration drilling had also recorded the presence of Tertiary deposits (described as predominantly clayey, quartzose gravels and sands). The drilling of paired bores also provided an ideal set-up for the collection of observation data during subsequent hydraulic testing.

A number of multi-level vibrating wire piezometer bores were installed, mostly around the proposed Underground 1 and 2 mines and approved Underground 4 mine, to provide a number of permanent monitoring sites for monitoring of groundwater levels or pressures at various stratigraphic depths.

3.2 Test Production Bores

Five test production bores were constructed, at four sites. Three of the test bores are to be retained as production bores to facilitate dewatering (predominantly of Underground 4), and/or to provide additional make-up water supply for the MCP. Two are to be retained for monitoring purposes.

At the commencement of site works after approval of Stage 1, two bores were brought into service as water supply bores, and a new production water supply bore was drilled and brought into service. These were used to supply construction water in the early months of Stage 1 construction.

Groundwater Access Licences 20BL171998, 20BL1712000 and 20BL172300 respectively are held for these three production bores.

3.3 Hydraulic Testing

On completion, each piezometer was hydraulically tested, either by a short duration constant rate pumping test with a low capacity sampling pump, or by falling-head slug test, to derive indicative values of aquifer hydraulic conductivity (permeability). Test durations were typically between 1 and 2 hours, which was the practical limitation of the pumps used. The tests provided sufficient data for determination of site-specific aquifer hydraulic properties, but test durations were too short to evaluate aquifer geometry or regional hydraulic continuity.

In addition to this testing completed by Peter Dundon and Associates (PDA), HLA had previously undertaken independent testing of several privately owned bores (Imrie Bore, Elward Bore and Kearins Bore) intersecting the Triassic sediments in the north of the Project Boundary in work undertaken for Ulan Coal Mines Limited (UCML). The results of these tests were presented in Appendix A of the 2002 UCML Annual Environmental Management Report (UCML, 2003).

Laboratory permeability testing on Triassic core samples was also carried out as part of Stage 1 investigations. The results of this testing were reported in Dundon (2007).

3.4 Census of Existing Occurrence and Use

As part of the groundwater investigations for Stage 1 and Stage 2, information on registered groundwater users within and close to the proposed extension area were collated through a search of the NOW groundwater bore database. This was supplemented by a field census to inspect registered sites, and identify and record the presence of unregistered groundwater supply sources such as bores, wells, soaks, dams, and any naturally discharging springs.

The NOW groundwater bore database revealed the presence of 130 registered bores and wells within 10 km of the Project Boundary. The field census involved approaching nearby landholders to determine their current or past use of groundwater, and to collate local first-hand knowledge of other natural expressions of groundwater, such as springs or soaks on their properties.

Each site was visited, sampled and photographed, and construction and other details provided by the landholder were recorded. The location and elevation of each site was determined by GPS. Wherever possible field measurements of groundwater quality (comprising electrical conductivity EC and pH) were also taken and a water sample collected for laboratory analysis.

3.5 Groundwater Monitoring Program

A groundwater level and quality monitoring program encompassing selected installed piezometers and bores, as well as selected registered and unregistered groundwater sites, was established. Monitoring commenced in February 2005, and has been maintained to the present time. Data collected represent a baseline monitoring period of seven years.

Groundwater levels are measured monthly in piezometers and test bores to assess the seasonal fluctuations in groundwater levels, and responses to recharge and natural discharge processes, as well as to detect any impacts from mining which commenced at the MCP in November 2009.

Water samples are collected annually from selected piezometers and test bores with all samples subsequently submitted to a NATA-registered laboratory for comprehensive analysis of major cations and anions, nutrients, and heavy metals. Electrical conductivity and pH are measured in the field at the time of sampling.

3.6 Numerical Modelling Stage 1

Using the data collected from Stage 1 investigations, a numerical model of the groundwater system was set-up in order to assess the potential impacts of Stage 1 of the MCP on the groundwater environment. An integral part of the modelling work was to identify and assess current groundwater conditions, including any existing impacts to groundwater levels as a result of dewatering operations at the adjacent Ulan Coal Mine.

Modelling was undertaken using a three-dimensional finite difference model based on the MODFLOW numerical groundwater flow modelling package (McDonald and Harbaugh, 1988) with the SURFACT Version 3 module (HydroGeoLogic, 2006), operating under the Processing MODFLOW Pro and the Groundwater Vistas Version 5 graphic interface software packages (IES, 2006; ESI, 2006). The model was set up to simulate groundwater conditions over a 1600 km^2 area, to encompass the MCP and the nearby Ulan and Wilpinjong Coal Mines' zone of potential impact.

Results of the Stage 1 groundwater investigations and numerical model were presented in a report prepared by Peter Dundon and Associates (Dundon 2006) that accompanied the Stage 1 application. The model developed for this initial application was termed the MC1.6 model.

During the Stage 1 review and approval process, Dr Colin Mackie was engaged by the Department of Planning (Department) to review the report and MC1.6 model. Additional modelling was carried out to answer queries by Dr Mackie to assess the potential impacts of the MCP Stage 1 proposal in the event that the subsidence failure zone above Underground 4 was to result in direct connection up to at least the predicted maximum height of subsidence fracturing, 122 m above the seam of extraction. The result of this model modification was version MC1.9 and was reported with an attached letter to the Department (Dundon 2007). The amended model resulted in increased mine inflow predictions over the original MC1.6 model.

Both versions of the model subsequently formed the basis for the Stage 1 project approval. Throughout the model development, review was provided by Dr Noel Merrick, former Director of the National Centre for Groundwater Management and now an independent consultant. In addition to this review the Stage 1 model was reviewed by Dr Mackie for the Department.

3.7 Numerical Modelling Stage 2

To support the Environmental Assessment for the Stage 2 MCP proposal, the Stage 1 model was further developed, taking account of data from additional hydrogeological investigations, and additional monitoring data from the nearby Ulan and Wilpinjong coal mines. The model version used for the Stage 2 studies was referred to as MC2.1.

The principal modifications incorporated into the MC2.1 model included (Aquaterra 2008, RPS Aquaterra 2011):

- Extension of the model area a further 15 km to the north and 10 km to the west, to accommodate simulation of future extensions of the Ulan Coal Mine with sufficient distance to the model boundaries;
- Adjustment to the layer configuration in some areas to allow each layer to represent a uniform hydrogeological unit;
- Inclusion of a new Layer 1 to represent the regolith (weathered rock, colluvium, alluvium and Tertiary palaeochannel deposits where present); and
- Modifications to some parameter values, based on additional information obtained since Stage 1.

The Stage 2 modelling (MC2.1) originally allowed for no water sharing between neighbouring mines, and included pumping from bores at both the MCP and Wilpinjong Coal Mine for periods when the model-predicted groundwater inflows at those projects were insufficient to meet their respective water demands, the model was reported in Aquterra 2008.

The model was subsequently used to assess the inflows to each of the three mining operations (the MCP, Ulan Coal Mine and Wilpinjong Coal Mine), but allowing for optimum water sharing between the mines, and with revised mine plans reflecting changes since the initial Stage 2 modelling was carried out. At this stage, the model was recalibrated, with some minor changes in parameters such as specific yield, and horizontal and vertical hydraulic conductivity particularly in the Ulan Coal Mine area. The recalibrated model used for the water sharing simulations was termed MC2.2, and was described in Aquaterra (2009).

The calibration period utilised in the MC2.1 model was maintained but the parameters listed above were changed to improve calibration of groundwater inflows against the most recent estimates of groundwater inflows to the Ulan Coal Mine underground mine. The Ulan Coal Mine inflow rates have been poorly understood in the past.

The modifications made included some reference to parameter values used by MER (2009) in predictive modelling for the Ulan Completion of Mining EA. However, some of the MER parameters are not consistent with the hydraulic testing results from the MCP area, so the parameter changes were mostly limited to the model in the Ulan Coal Mine area, on the western side of the Spring Gully Fault. It is understood that the Ulan Coal Mine model is currently being recalibrated to account for higher than anticipated inflows to the underground workings during 2011.

The MC2.2 model has been used in the impact assessment to support a Stage 2 application as reported in RPS Aquaterra (2011). Model refinement also incorporates modified mine plans for the Ulan and Wilpinjong Coal Mines. Stage 2 model review was provided by Dr Noel Merrick based on the relevant Australian Modelling Guidelines (MDBC 2000) a precursor to the current guideline (Barnet et al 2012). Dr Merrick has approved the Stage 2 model is fit for purpose.

3.8 Modelling Summary – Relevance to the Current Proposed Extension Area

All variants of the Stage 1 (MC1.6 and MC 1.9) and Stage 2 (MC2.1 and MC2.2) models are relevant to the proposed modification. The four models represent an expanding knowledge of the groundwater regime and the impact of mining, with each subsequent model an improvement on the predecessor. The predicted groundwater seepage rates to the mine for all four model variants are included in this report and represent the likely range encountered during mining. Calibrated and predicted heads were all also selected from the MC1.9 and MC2.2 models for discussion in this document.

The proposed modification is located between the approved Stage 1 Open Cuts and Stage 2 proposed operations meaning the results from the previous modelling are applicable to this study. Due to the extensive nature of the previous investigations, the location of the proposed modification within the footprint of previous assessments, and its limited extent it was not deemed necessary to carry out further detailed modelling for this study. Rather the results from both Stage 1 and Stage 2 investigations have been used to assess the potential impacts.

4.0 SITE SETTING

4.1 Climate

The climate in the vicinity of the project area is typical of temperate regions and is characterised by hot dry summers dominated by thunderstorms, and cold winters with frequent frosts. Rainfall data collected by the Bureau of Meteorology (BoM) was obtained for Ulan Post Office which is located immediately west of the project area; and Wollar (Barrigan Street) which is 10 km to the east. The Ulan Post Office (Station No. 062036) has 101 years of rainfall data from 1906 to 2007 and the Wollar Station (Station No. 062032) has 111 years from 1901 to 2012. Table 1 presents the average rainfall from the Ulan Post Office and Wollar.

Table 1: RAINFALL DATA

Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Ulan Post Office (1906-2007)	72.8	61.6	52.6	41.3	45.2	46	47.6	47.4	42	55.3	57.8	65.2	643.3
Wollar Station (1901-2012)	66.5	62.9	51.9	38.9	38.1	43.9	42.9	41.6	40.9	51.9	55.8	59.3	588.9

Note: Source – Bureau of Meteorology

The average total annual rainfall is 643.3 mm at Ulan and 588.9 mm at Wollar. Table 1 shows that rainfall is slightly higher in summer, but relatively uniform throughout the year.

Recent rainfall years have been put into historical context using the Cumulative Rainfall Departure (CRD) method. This method is a summation of the monthly departure of rainfall total from the long-term average monthly rainfall. A rising trend in the CRD plot indicates periods of above average rainfall, whilst a falling slope indicates periods when rainfall is below average. Figure 3 presents the CRD for the period 1906 to 2012.

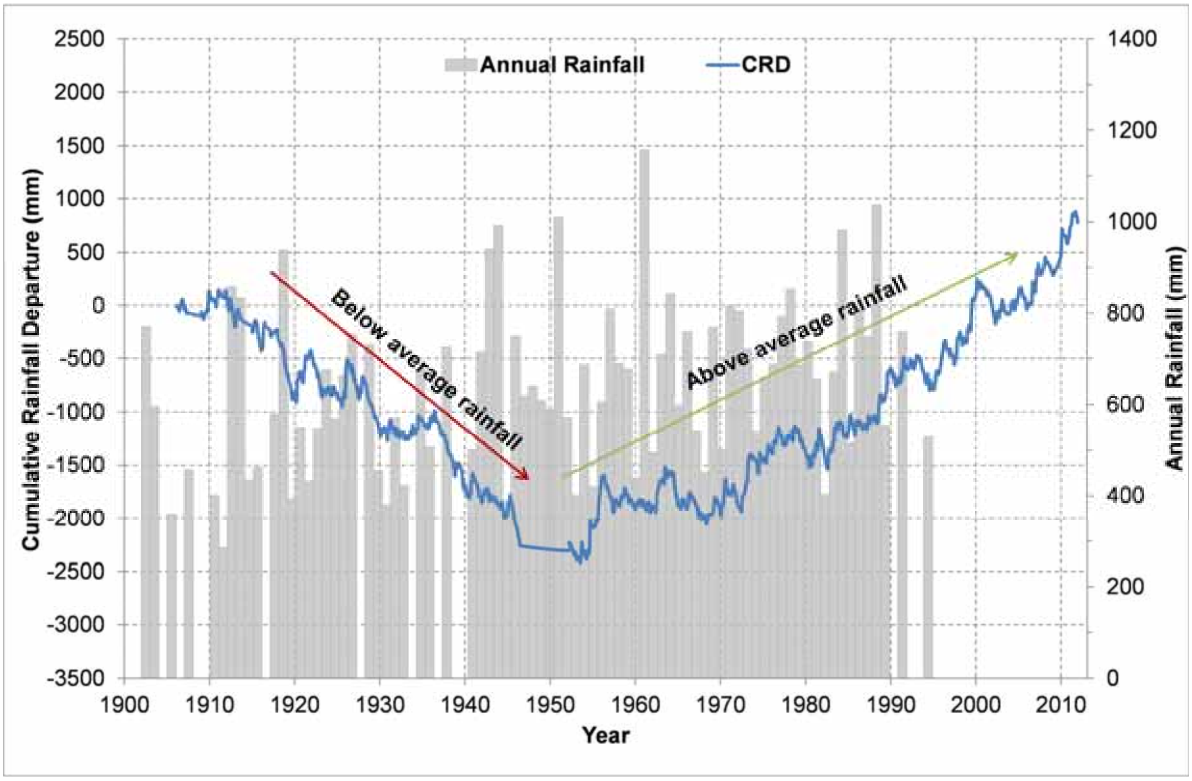


Figure 3: Cumulative rainfall departure

The CRD was calculated from the Ulan Post Office from March 1906 to March 2007 and from Wollar Station between April 2007 and December 2012. Overall, the CRD indicates that the project area has experienced an extended period of above average rainfall from the late 1940s to the present as observed by the overall positive slope during this period. In contrast, the decreasing slope between the 1920s and late 1940s indicates below average rainfall and an extended period of drought.

In the context of a groundwater assessments, above average CRD may represent periods of above average recharge to groundwater systems. This can often correspond to naturally increasing trends in groundwater levels in these systems. This is particularly evident in unconfined aquifer systems, or recharge areas of semi-confined or confined systems. As is discussed in following sections of this report, the project area represents a recharge area, with the groundwater system levels possibly reacting to rainfall events and long term patterns.

4.2 Topography and Drainage

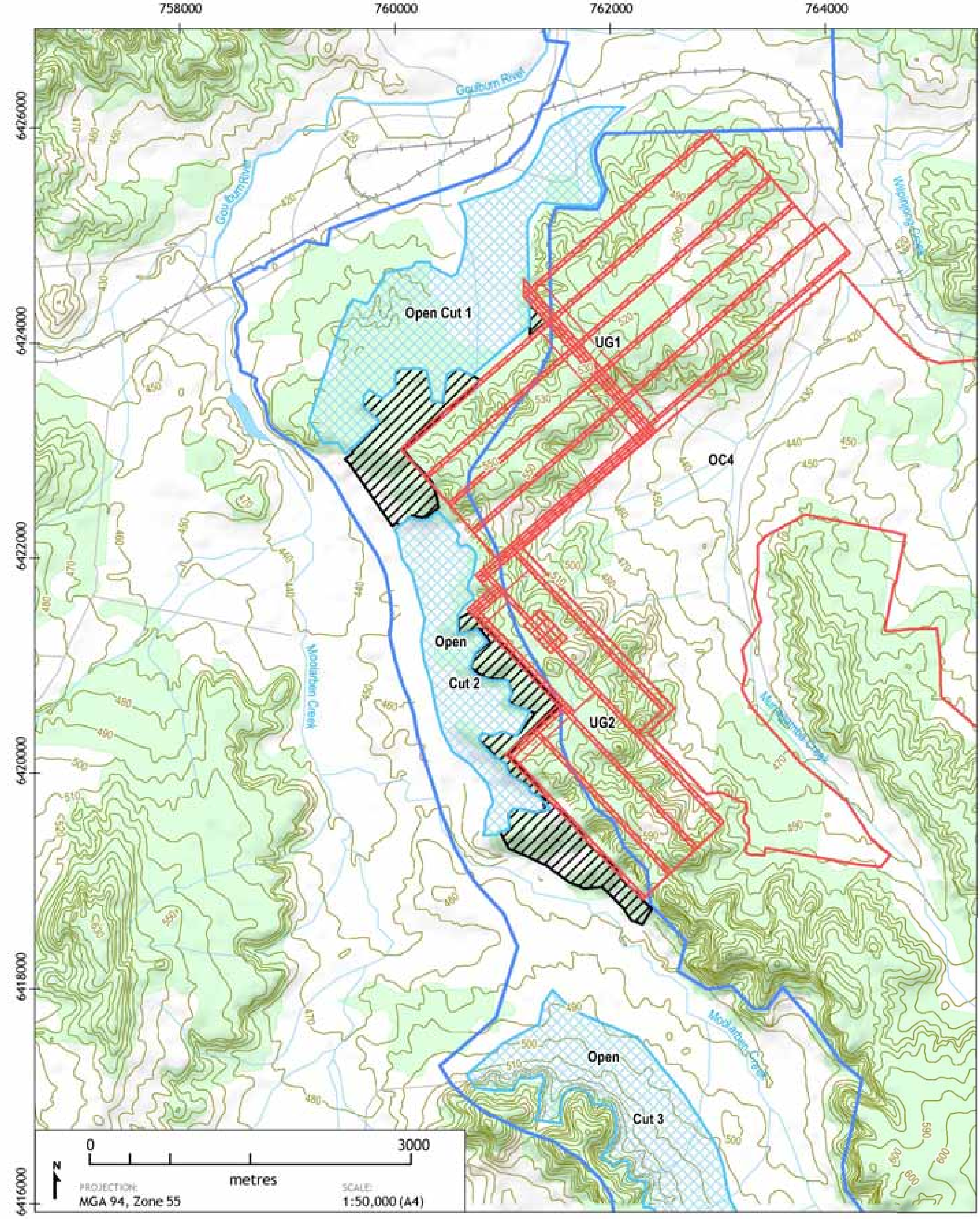
Small ridges and valleys associated with the Goulburn River, Moolarben and Wilpinjong Creeks and their associated minor tributaries characterise the topography of the project area. Land surface elevation varies from about 600 m AHD on the ridges to about 370 m AHD in the Goulburn River Valley. The topography in the project area has been controlled by regional geological structures, including various faults and folds, which have in turn formed a number of erosional sandstone escarpments and plateaus. In the elevated areas groundwater levels are relatively deep and this means there is limited saturated thickness in some of the existing and proposed mining areas. The elevated areas also have steeper gradients along the creek lines that reduce the deposition of sediment, with alluvial areas largely limited to the lower lying landscape adjacent to Wilpinjong Creek and Moolarben Creeks.

On a regional scale, drainage occurs to the east via either the Goulburn River or Wilpinjong Creek. Wilpinjong Creek drains the central part of the project area while the Goulburn River drains the western margins (Figure 4).

The proposed extension area is within the upper Goulburn River catchment. The ephemeral Moolarben Creek is a tributary of the upper Goulburn River catchment. Moolarben Creek flows in a northerly direction along the western project area boundary and joins Sportsman’s Hollow Creek at the settlement of Ulan to form the headwater of the Goulburn River. Moolarben Dam is located on Moolarben Creek, approximately 1.5 km upstream of the Sportsman Hollow Creek confluence. Figure 4 shows the proposed modification extends to the east into the hillside that separates Moolarben Creek from Murragamba Creek.

4.3 Land Use

The predominant land use in the area is farming and coal mining. The valley floors support agricultural activities including sheep and cattle grazing. There is a reliance on groundwater in the area for stock watering.



LEGEND:

- Approved Stage 1 project area
- Approved Stage 1 open cut
- Open cut 1 and 2 proposed extension area
- Proposed Stage 2 Open Cut 4 and Underground 1 & 2
- Elevation contour (m)
- Major watercourse
- Watercourse
- Major road
- Road
- Railway
- Vegetation

Moolarben
Stage 1 Optimisation (G1622)

Project area, topography and drainage

DATE: 29/4/2013

FIGURE No: 4

4.4 Surrounding Mine Operations

MCP is bounded to the west by the Ulan Coal Mine and to the east by the Wilpinjong Coal Mine. Both mines intercept the Ulan Coal Seam (Ulan Seam) which is the target coal seam for the MCP (Figure 1).

Mining of coal at Ulan Coal Mine commenced in the early 1920s and currently utilises both open cut and underground longwall mining methods. Coal seams were first dewatered by the Ulan Coal Mine as early as 1924, however, regular and substantial dewatering did not commence until 1957. Currently, groundwater is abstracted from Ulan Coal Mine at a rate of approximately 15 ML/day (MER, 2010). Wilpinjong Coal Mine commenced open cut mining in 2006 with dewatering occurring as this mine progresses.

The Ulan Seam in the area of the proposed modification is substantially depressurised due to surrounding mining activities, which is discussed further in the following sections of this report.

5.0 GEOLOGICAL SETTING

The MCP is located within the Western Coalfields of the Sydney-Gunnedah Basin. Figure 5 shows the regional geology. The main economic coal seams in the Western Coalfields are within the Permian Illawarra Coal Measures (ICM). The ICM include the Ulan Seam which is the target seam for the MCP. No alluvium is present within or proximal to the proposed extension areas.

Drilling data from the Stage 1 (Dundon 2006) and Stage 2 (RPS Aquaterra 2011) indicate that the weathered profile varies in depth from around 4 m to 18 m, but is generally restricted to depths of less than 10 m. Along valley floors, in the south and central south parts of the project area, the coal measures have been eroded and overlain by Tertiary palaeochannel deposits comprising dominantly alluvium. Palaeochannel deposits have been intersected during Stage 1 pit development and to the west of Moolarben Creek. In places, these palaeochannel deposits have been eroded and superimposed by more recent weathering and Quaternary sedimentation associated with the Moolarben and Lagoon creeks and the Goulburn River.

The Quaternary alluvium occurs in association with, and is connected to, the present day streams and rivers; whereas the Tertiary alluvium occurs in a palaeochannel system that is not coincident with the present drainages, and is generally considered hydraulically disconnected from them. On the western margin of the project area the Carboniferous Ulan Granite basement outcrops. As can be seen in Figure 5 mapped Quaternary alluvium is not present within reaches of the Moolarben Creek. The proposed extension area has greater than 170 m separation from alluvium to the west and greater than 300 m separation from alluvium to the south.

Marine sediments of the Shoalhaven Group (fine-grained silty sandstones), have been intersected in some drill holes in the southern part of the project area. The Ulan Granite outcrops extensively directly to the west of the MCP.

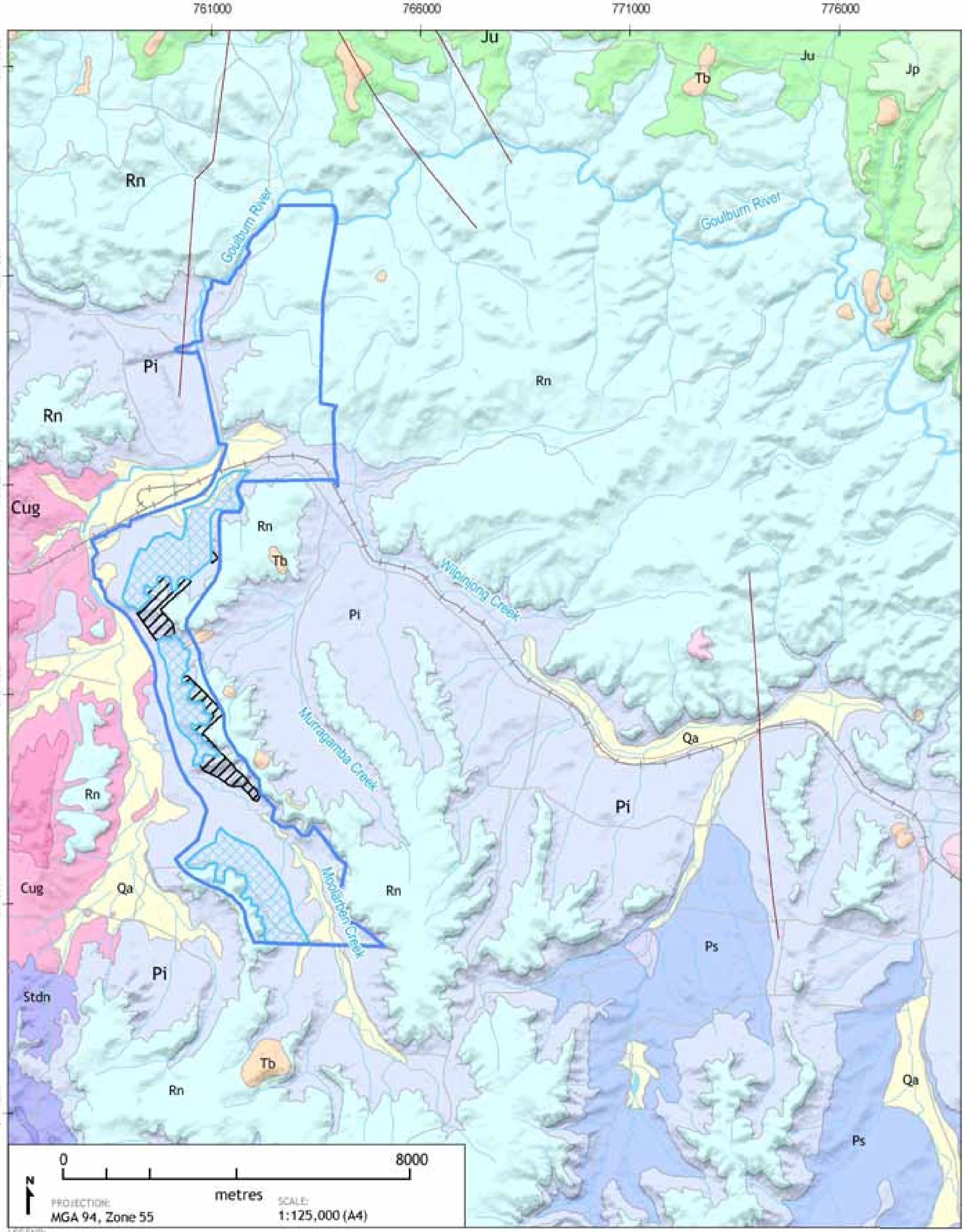
RPS Aquaterra (2011) further describes the geological setting as follows:

“The Permian coal measures within the project area comprise a well-bedded sequence of claystone, mudstone, siltstone, sandstone and coal of Permian age (Johnstone, 2007). These sedimentary units unconformably on-lap the Early Permian or Carboniferous basement and strike in a northwest direction with dips of 1 to 2 degrees to the northeast.

In the northern half of the project area, the Permian coal measures are generally 100 m to 120 m thick, and are overlain by up to 60 m of plateau-forming lower Triassic Wollar Sandstone, part of the Narrabeen Group. The typical lithology of the Wollar Sandstone includes pebbly to medium grained quartz sandstone, red-brown and green mudstone, and lenses of quartz conglomerate (Wilpinjong Coal, 2005). The contact between the Permian and Triassic is marked by an erosional unconformity.

Drilling data indicate that the weathered profile varies in depth from around 4 to 18m, but is generally restricted to depths of less than 10m.

Along the valley floors, in the south and central south parts of EL6288, the coal measures have been eroded by more recent fluvial events. An east-west trending Tertiary palaeochannel has been identified in some areas occupied by the present-day drainage valleys of Murragamba and Wilpinjong Creeks, but not coincident with the present drainage courses. This palaeochannel has been observed to be up to 48m deep. The infill sediments comprise poorly-sorted quartzose sands and gravels semi-consolidated in a clayey matrix. Investigations further to the south and west suggest that this channel may be part of a larger system that originally emanated from the north or west. Exposures of the channel in the Goulburn River diversion, and just north of the Ulan airstrip reveal cross bedding suggestive of a southerly flow direction (Johnstone, 2005).



LEGEND:

- Qa - Quaternary - Alluvium (silt, clay, sand, gravel)
- Tb - Tertiary - Basalt, tholeiite
- Jp - Jurassic - Piliga Sandstone
- Ju - Jurassic - Purlawaugh Formation (sand, mud, clay, coal)
- Rn - Early Triassic - Narrabeen Group (sand, silt, conglomerate)
- Pi - Late Permian - Illawarra Coal Measures
- Ps - Late Permian - Shoalhaven Group (siltstone, sandstone)
- Cug - Carboniferous - Granite, undifferentiated
- Stdn - Palaeozoic - Sandstone

- Approved Stage 1 open cut
- Open Cut 1 & 2 proposed extension area
- Approved Stage 1 project area
- Fault

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Geological setting

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FIGURE No: **5**

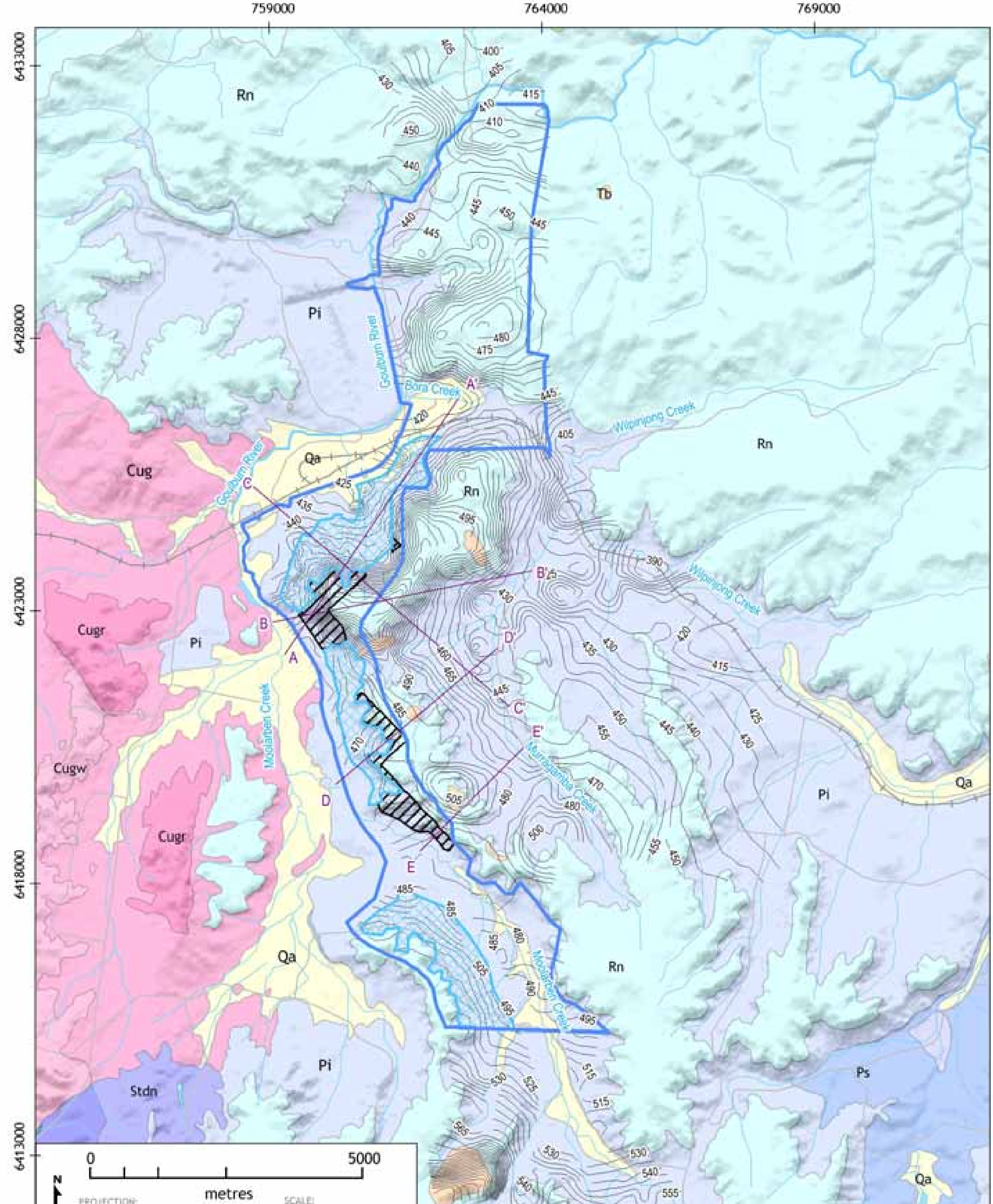
In places, these palaeodeposits have themselves been eroded and superimposed by more recent weathering and sedimentation associated with the Wilpinjong and Murragamba Creek channels. The Quaternary alluvium occurs in association and connected with the present day streams and rivers, whereas the Tertiary alluvium occurs in a palaeochannel system that is not coincident with the present drainages, and is generally hydraulically separate from them. Limited hydraulic connectivity is considered to exist between the alluvium and the coal measures.

Small intrusives and remnant basalt flows of Tertiary, and possibly Jurassic age, have been observed in outcrop in the Murragamba and Wilpinjong valleys and as elevated plateaus mainly to the north of EL6288. Basalt flows of up to 30m have been intersected in some bores. No significant basalt remnants or other igneous intrusives are believed to be present in the areas in which mining is proposed in Stage 1 or Stage 2 of the MCP.

The basement underlying the Illawarra Permian coal measures is the Carboniferous Ulan Granite, with marine sediments of the Shoalhaven Group (fine-grained silty sandstones) having been intersected in some drill holes in the southern part of EL6288. The Ulan Granite outcrops extensively directly to the west of the MCC area."

Structure contours of the base of the Tertiary supplied by MCO are shown in Figure 6, top of the Ulan Seam in Figure 7 and base of the Ulan Seam in Figure 8. The Ulan Seam shows a general dip to the north-north-east with a sub-crop zone close to surface within the project area. The Tertiary paleochannel has been intersected in current mining operations in Open Pit 1 and may pose a limited source or pathway to groundwater flow during initial pit development. As well as the paleochannel, unconsolidated Quaternary alluvium deposits also occur associated with Moolarben Creek and Goulburn River (Figure 5). The alluvium mapped in Moolarben Creek is 300 m from the proposed extension area at its closest point.

A series of five basic geological sections are shown in Figure 9 to Figure 13, with the location of the sections against the proposed modification shown in Figure 6 to Figure 8. These sections show the general north-east dip of the Ulan Seam. It should be noted that the Lower, Middle and Upper Permian surfaces are not shown on these sections. The location of granite basement has been estimated based on geological mapping in underlying Moolarben Creek in the western portion of Section A-A', B-B' and C-C' (Figure 9 to Figure 11). The cross sections will be discussed further in the following sections of this report to illustrate potential groundwater impacts of the proposed modification.



LEGEND:

- Qa - Quaternary - Alluvium (silt, clay, sand, gravel)
- Tb - Tertiary - Basalt, tholeiite
- Rn - Early Triassic - Narrabeen Group (sandstone, conglomerate, siltstone)
- Pi - Late Permian - Illawarra Coal Measures
- Ps - Late Permian - Shoalhaven Group (siltstone, sandstone)
- Cug - Carboniferous - Granite, undifferentiated
- Stdn - Palaeozoic - Sandstone

- Approved Stage 1 open cut
- Open Cut 1 and 2 proposed extension area
- Approved Stage 1 project area
- Base of Tertiary (mAHD)
- A - A' Location of cross section

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Structure contours of the base of the Tertiary

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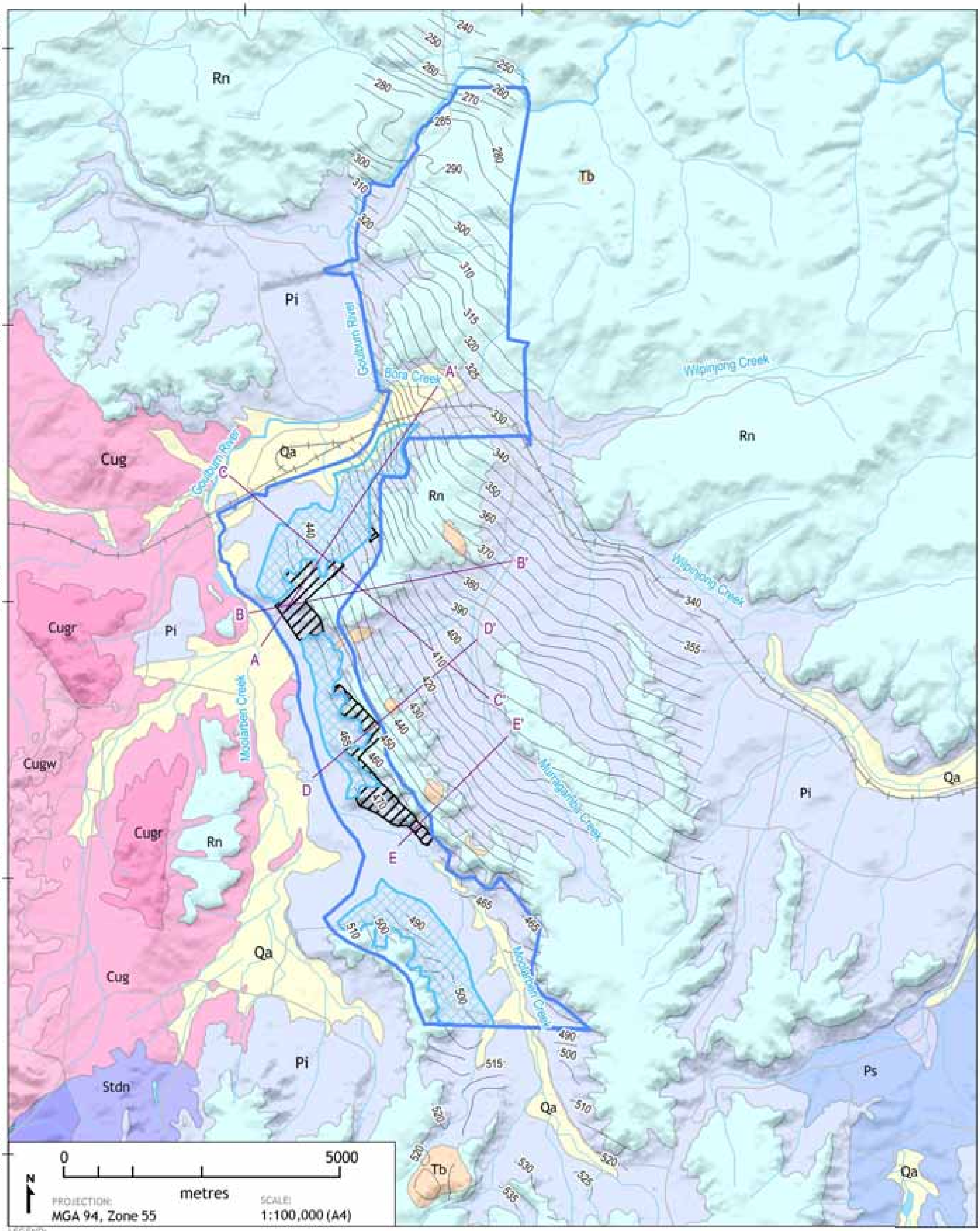
FIGURE No: **6**



LEGEND:

- Qa - Quaternary - Alluvium (silt, clay, sand, gravel)
- Tb - Tertiary - Basalt, tholeiite
- Rn - Early Triassic - Narrabeen Group (sandstone, conglomerate, siltstone)
- Pi - Late Permian - Illawarra Coal Measures
- Ps - Late Permian - Shoalhaven Group (siltstone, sandstone)
- Cug - Carboniferous - Granite, undifferentiated
- Stdn - Palaeozoic - Sandstone

- Approved Stage 1 open cut
- Open Cut 1 and 2 proposed extension area
- Approved Stage 1 project area
- Top of Ulan Seam (mAHD)
- A - A' Location of cross section

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Structure contours of the top of the Ulan Seam

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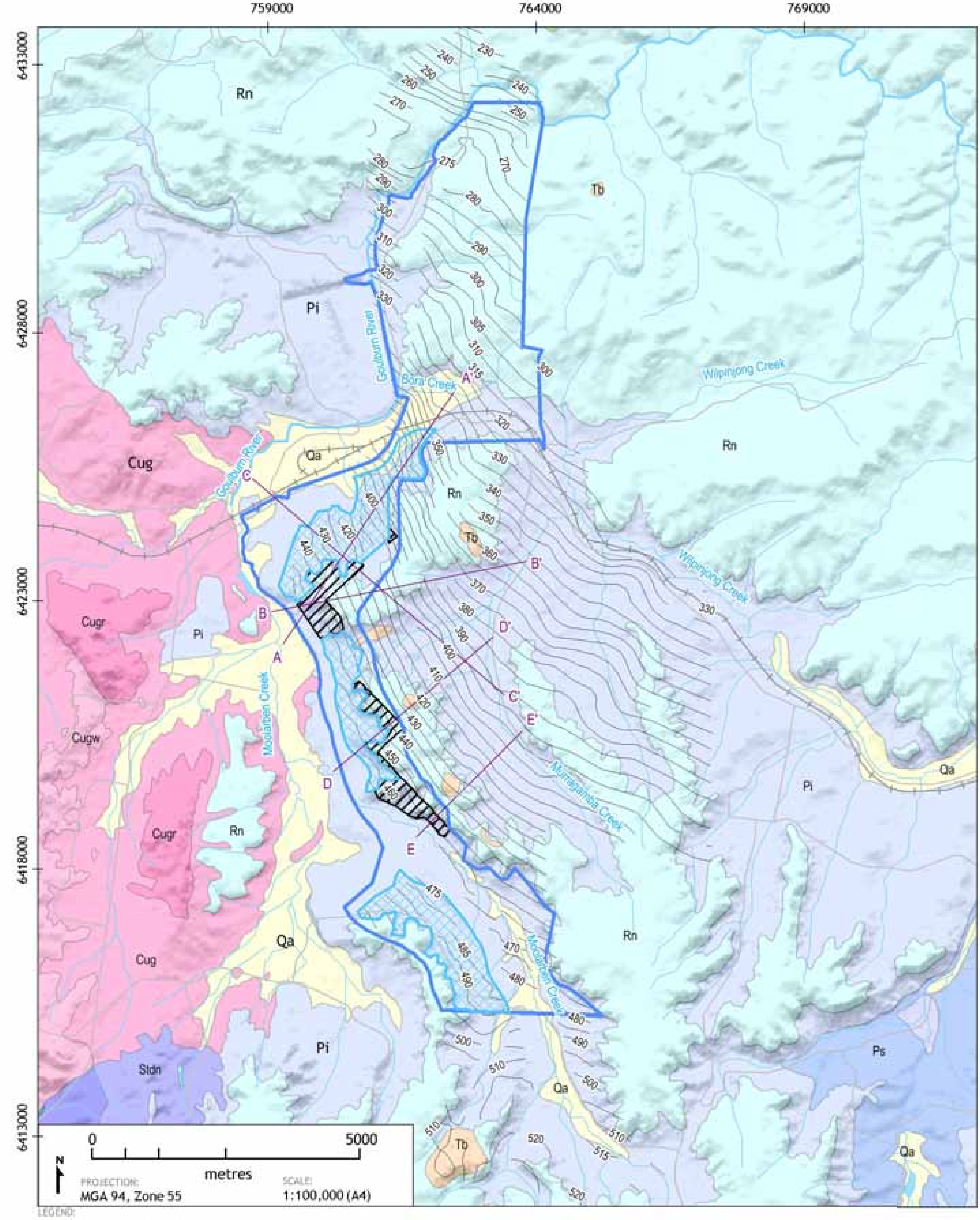
FIGURE No: 7



LEGEND:

- Qa - Quaternary - Alluvium (silt, clay, sand, gravel)
- Tb - Tertiary - Basalt, tholeiite
- Rn - Early Triassic - Narrabeen Group (sandstone, conglomerate, siltstone)
- Pi - Late Permian - Illawarra Coal Measures
- Ps - Late Permian - Shoalhaven Group (siltstone, sandstone)
- Cug - Carboniferous - Granite, undifferentiated
- Stdn - Palaeozoic - Sandstone

- Approved Stage 1 open cut
- Open Cut 1 and 2 proposed extension area
- Approved Stage 1 project area
- Base of Ulan Seam (mAHD)
- A - A' Location of cross section

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Structure contours of the base of the Ulan Seam

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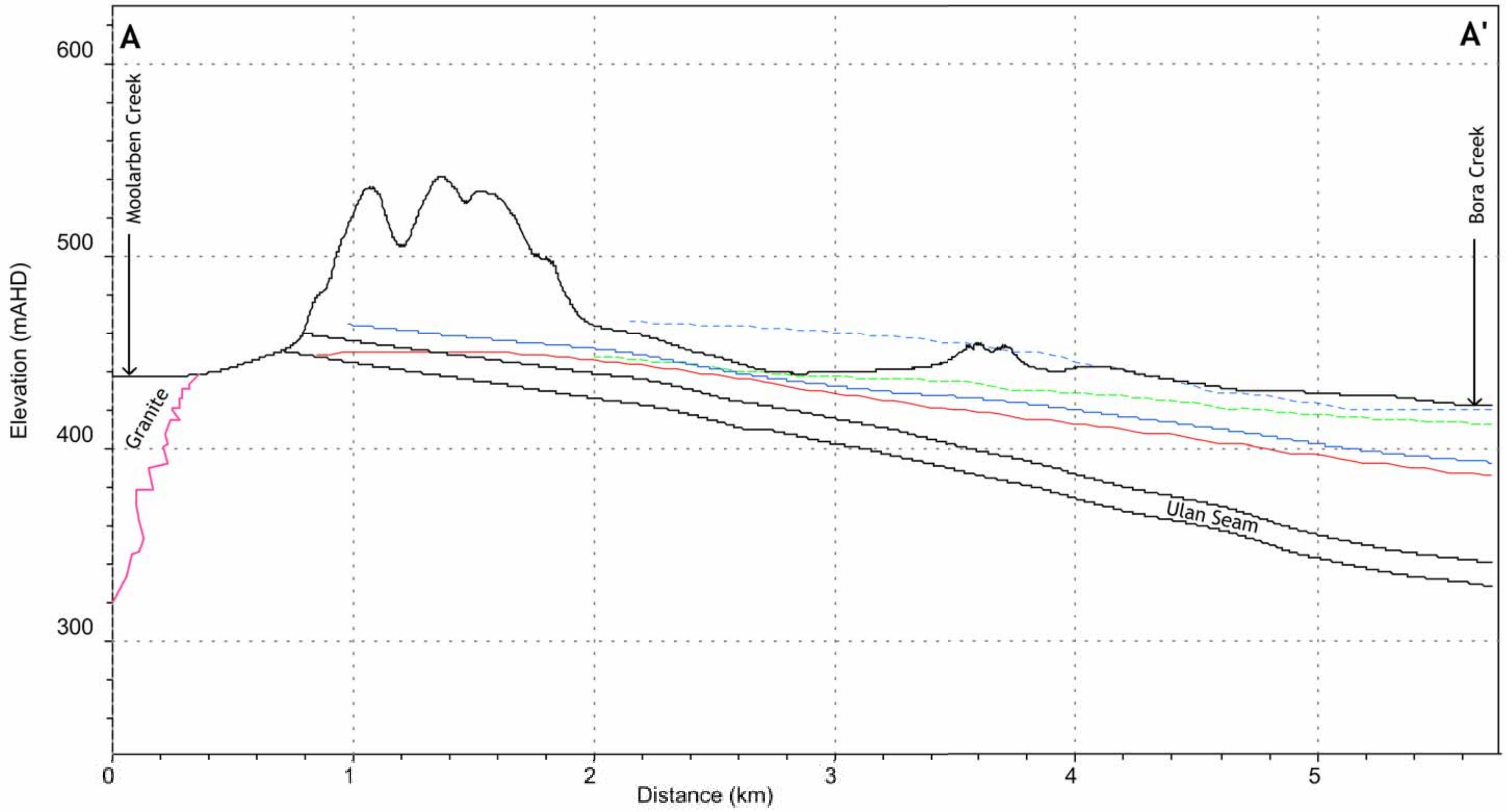
FIGURE No: **8**



LEGEND:

- Piezometric level Upper Permian 2006 *
- Piezometric level Mid Permian 2006 *
- Piezometric level Lower Permian 2006 *
- Piezometric level Ulan Seam 2006 *

* Piezometric levels sourced from Stage 1 modelling (Dundon 2007)

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Cross section A - A'

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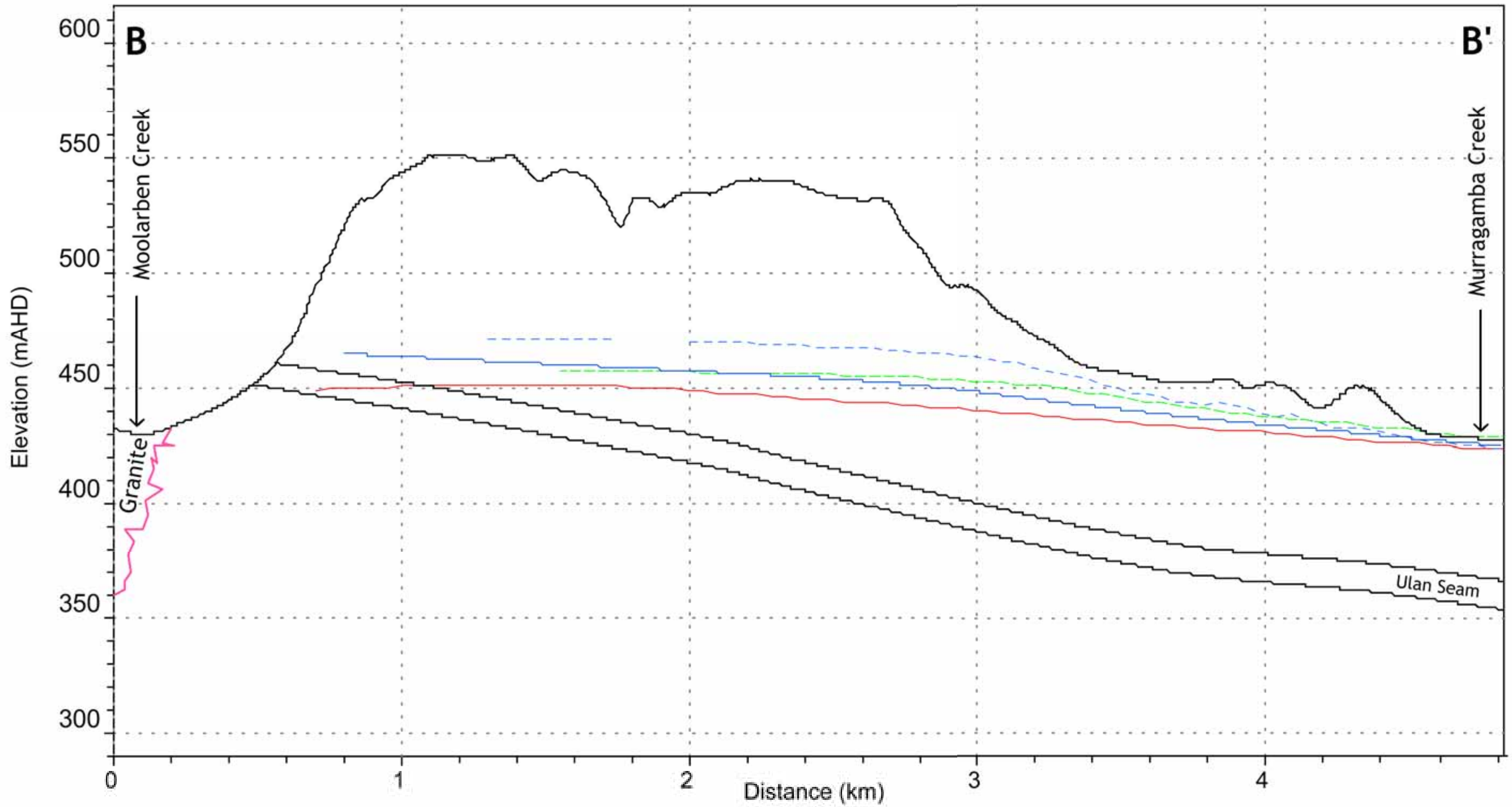
FIGURE No: **9**



LEGEND:

- Piezometric level Upper Permian 2006 *
- Piezometric level Mid Permian 2006 *
- Piezometric level Lower Permian 2006 *
- Piezometric level Ulan Seam 2006 *

* Piezometric levels sourced from Stage 1 modelling (Dundon 2007)

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Cross section B - B'

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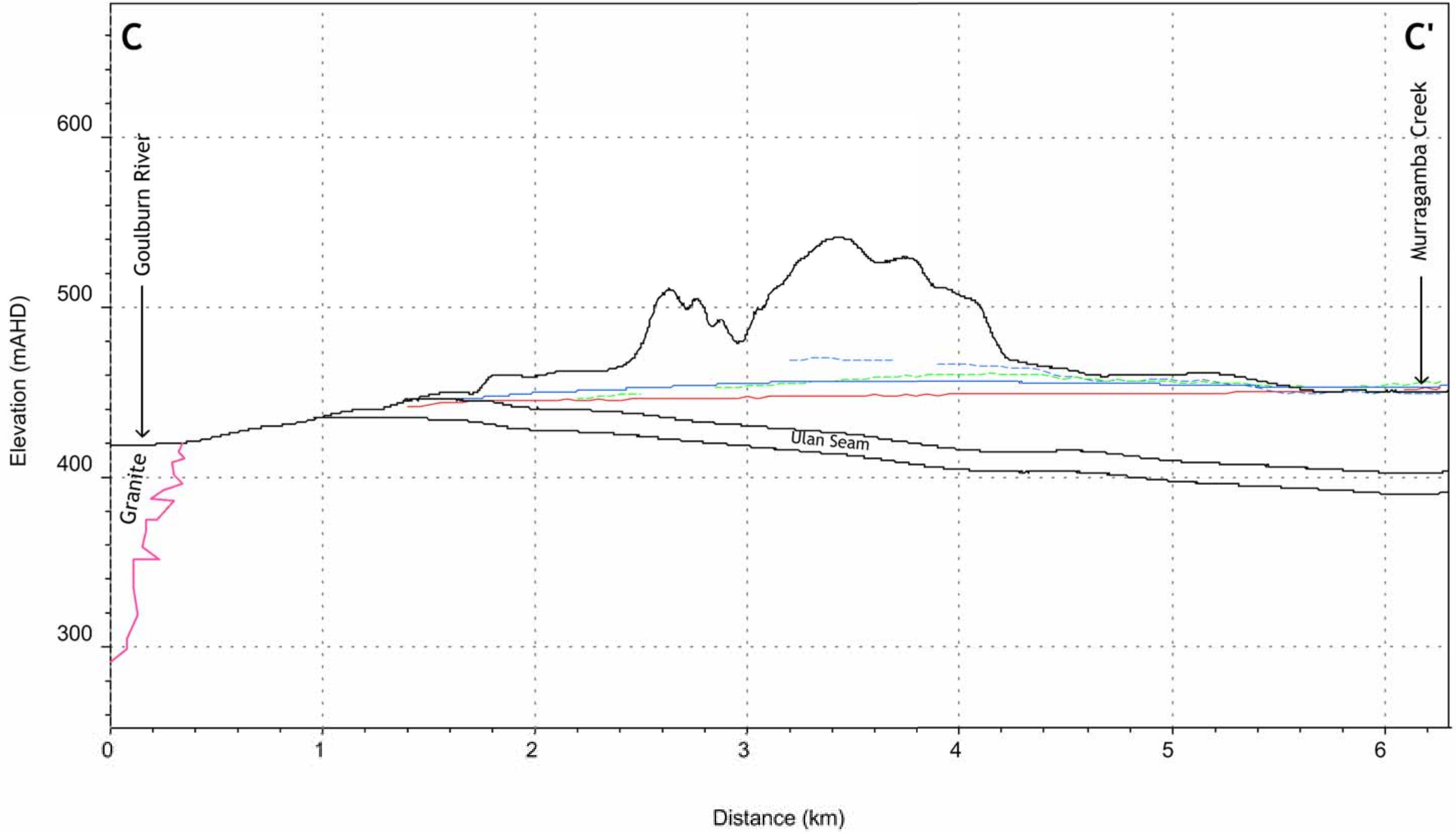
FIGURE No:
10



LEGEND:

- Piezometric level Upper Permian 2006 *
- Piezometric level Mid Permian 2006 *
- Piezometric level Lower Permian 2006 *
- Piezometric level Ulan Seam 2006 *

* Piezometric levels sourced from Stage 1 modelling (Dundon 2007)

Moolarben Stage 1 Optimisation (G1622)

Cross section C - C'

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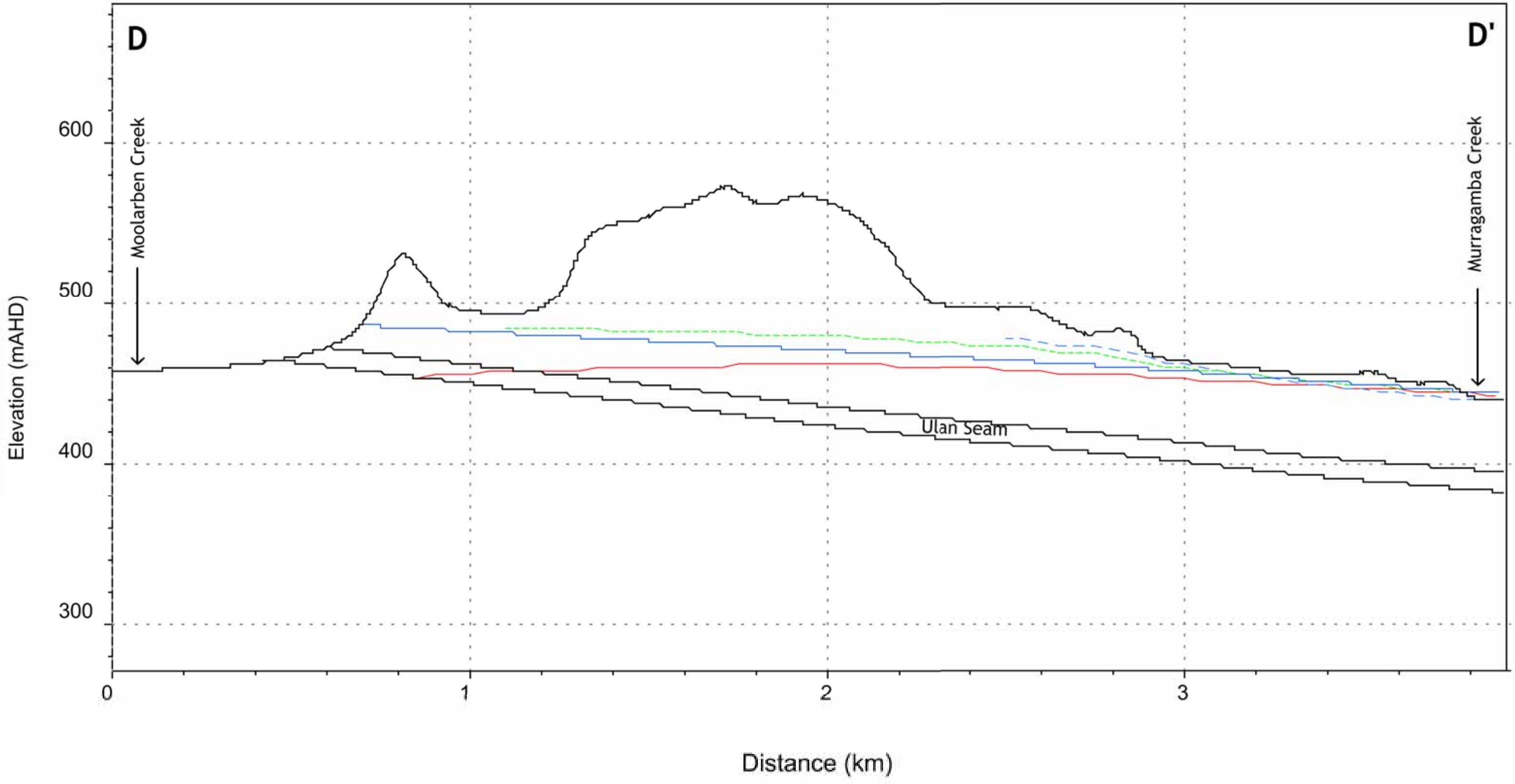
FIGURE No: **11**



LEGEND:

- Piezometric level Upper Permian 2006 *
- Piezometric level Mid Permian 2006 *
- Piezometric level Lower Permian 2006 *
- Piezometric level Ulan Seam 2006 *

* Piezometric levels sourced from Stage 1 modelling (Dundon 2007)

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Cross section D - D'

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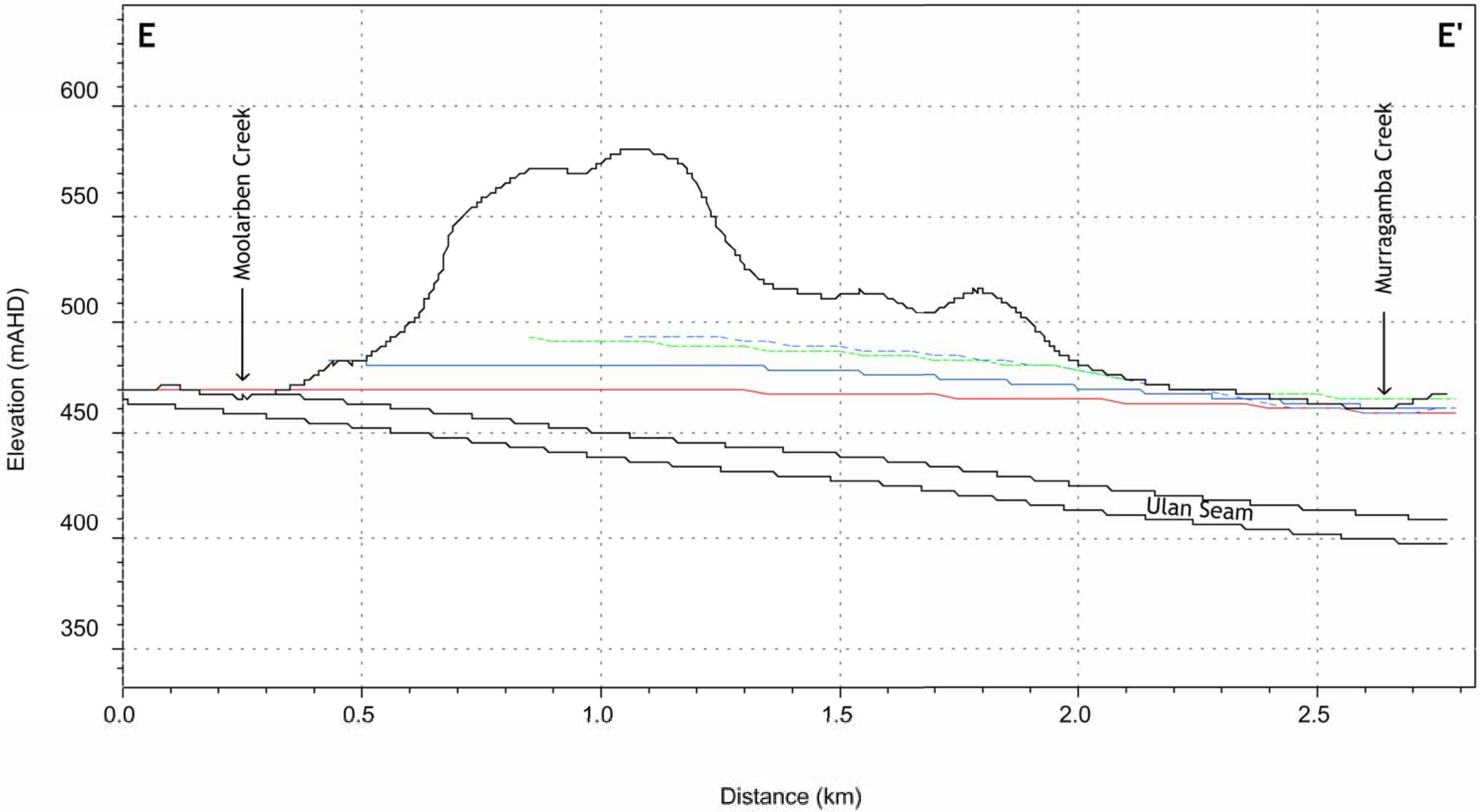
FIGURE No: **12**



LEGEND:

- Piezometric level Upper Permian 2006 *
- Piezometric level Mid Permian 2006 *
- Piezometric level Lower Permian 2006 *
- Piezometric level Ulan Seam 2006 *

* Piezometric levels sourced from Stage 1 modelling (Dundon 2007)

Moolarben Stage 1 Optimisation (G1622)

Cross section E - E'

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FIGURE No: **13**

6.0 HYDROGEOLOGICAL REGIME

6.1 Groundwater Occurrence

Groundwater in the regional area has been recognised as occurring within each of the following regimes (RPS Aquaterra, 2011):

- localised groundwater within the unconsolidated Quaternary alluvium associated with the present drainage system;
- palaeochannel valley-fill deposits within remnants of a Tertiary-age palaeodrainage;
- localised fracture zones within the Triassic Narrabeen Group sediments;
- localised fracture zones within the Permian coal measures, principally the Ulan Seam;
- localised groundwater in jointing and fractures within volcanic intrusive / extrusive structures; and
- limited groundwater potential in the Shoalhaven Group sediments.

The Permian coal measures outcrop along the Moolarben Valley to the west and south-west of the project area. This outcrop area constitutes the primary recharge zone for the Ulan Seam and other permeable horizons within the coal measures. The Permian coal measures within the project area have variable permeability and storage.

(RPS Aquaterra 2011) comment on the hydrogeology of MCP as follows:

"Permeability is generally higher in the coal seams, but there is occasional moderately high permeability in the interburden sediments (generally sandstone, siltstone and mudstone) due to localised fracturing. The Ulan Seam is termed an aquifer by virtue of its relative higher permeability than the interburden sediments. The interburden sandstones, siltstones and mudstones are of significantly lower permeability than the Ulan Seam (by one or more orders of magnitude) and they generally act as aquitards.

The sandstones of the overlying Triassic Narrabeen Group and the underlying Marrangaroo Sandstone and Shoalhaven Group have been shown by the field investigations to have poor aquifer properties, although the Triassic is an important contributor of baseflow to the streams. The basement units (Nile Sub-Group in the eastern parts and granites and volcanics in the western parts) are also relatively impermeable, and constitute a basal aquitard in the groundwater model. Nevertheless, groundwater occurs in all these units, and may form local aquifers where relatively higher permeability exists."

The Ulan Seam is only partially saturated within the project area and is 'dry' (low pore pressure) in places where it outcrops. The Triassic Narrabeen Formation is only saturated to the north of the project area in the vicinity of Underground 4. Groundwater within Quaternary alluvium and palaeochannel valley-fill deposits is typically poor yielding and unsuitable for water supply purposes.

A prominent local seepage feature 'The Drip' is located to the north of the site. 'The Drip' is a spring sourced from seepage from Triassic sediments located to the north of the proposed modification.

6.2 Groundwater Use

A search of the New South Wales Office of Water (NOW) groundwater database for the Stage 2 investigations revealed 130 registered bores and wells within 10 km of the project area. The location of registered bores is shown in Figure 14 with details in Appendix 1. The closest of these bores located to the west and south-west are installed within groundwater bearing strata distant to and hydraulically not connected to the proposed modification. It can be clearly seen that there is a lack of any private water bores in close proximity to the project area that would have the potential to be impacted by the proposed modification.

It should be noted there are a number of registered bores within MCO land and operated by MCO that are not shown on Figure 14. These are not included as impacts on these bores are an operational issue for MCO and are not relevant to this impact assessment.

6.3 Groundwater Dependant Ecosystems

Groundwater Dependant Ecosystems (GDEs) are defined by ARMCANZ/ANZECC (1996) as ecosystems which have their species composition and their natural ecological processes determined by groundwater. A detailed ecological assessment report, which includes discussion of the occurrence and distribution of GDEs within the project area, has been prepared by EMM (2013).

The occurrence of GDEs was assessed by EMM in accordance with relevant NSW policies. 'The Drip' (see Section 6.1), represents the only significant seep/spring GDE within the locality, with vegetation reliant on this surface expression of groundwater clearly evident within the cliff line of 'The Drip'.

6.4 Monitoring Network

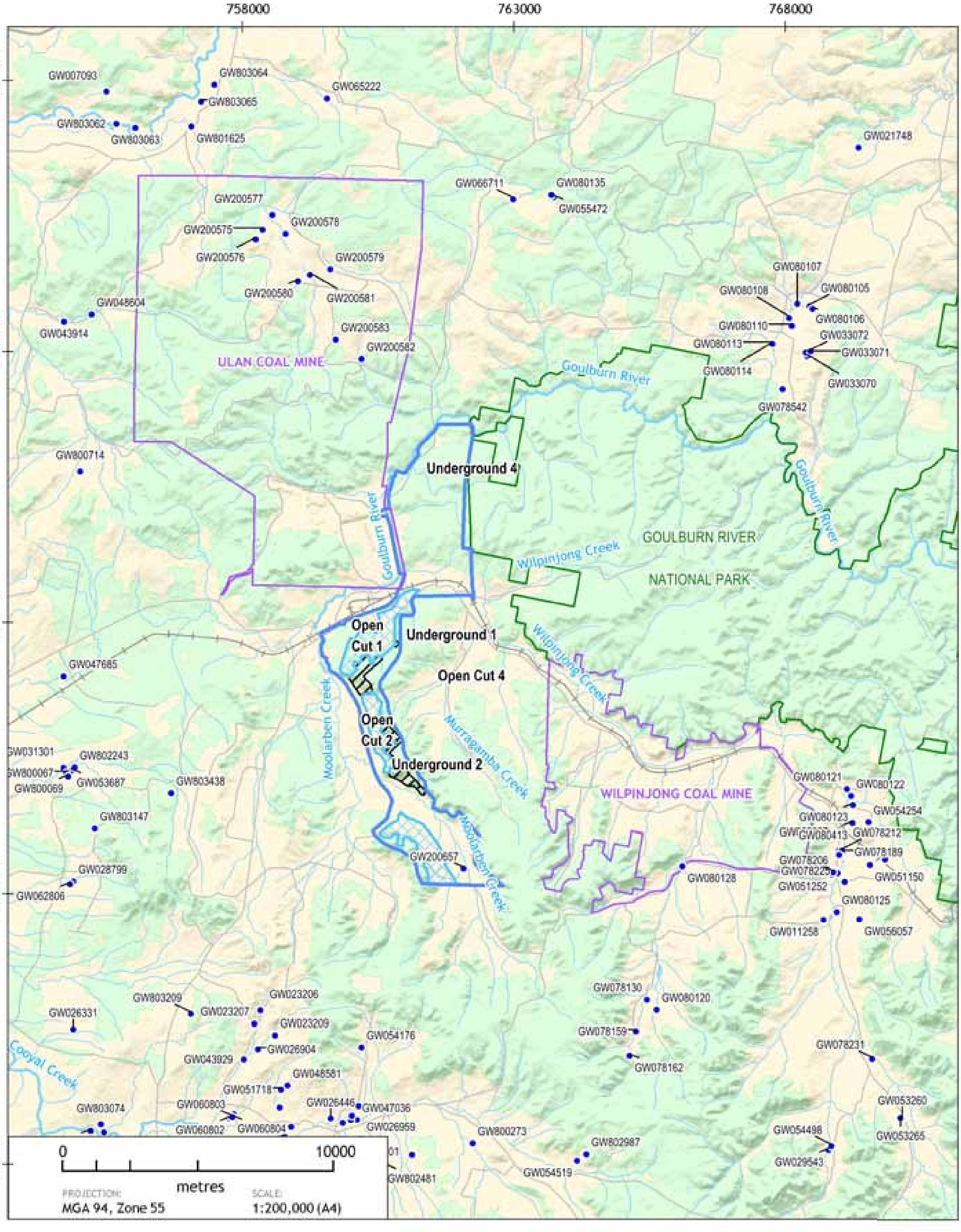
Over 100 groundwater monitoring bores have been drilled and constructed during the Stage 1 and Stage 2 investigations. Groundwater levels and water quality are currently monitored in about 60[1] bores, highlighted in Figure 15. Bore construction logs of monitoring bores installed during the Stage 1 investigations are presented in Dundon (2006). Stage 2 construction logs are presented in Aquaterra (2008) and RPS Aquaterra (2011).

Monitoring commenced in February 2005 from some of the earliest constructed Stage 1 bores. Groundwater levels are measured manually on a monthly basis to assess trends and fluctuations within the different aquifers. Six bores are fitted with vibrating wire pressure transducers (VWP) that monitor groundwater levels at multi levels (Figure 15).

A selection of bores (from the current monitoring network) intersecting all relevant geological formations in close proximity to the proposed extension area is shown and labelled in Figure 15. These are discussed further and with groundwater level data presented as hydrographs. A summary of the monitoring bores, including target geological formation, those currently monitored and whether they are discussed in this study, is tabulated in Appendix 2.

Groundwater samples are collected annually from selected bores for laboratory analysis of major cations, major anions, nutrients and heavy metals.

[1] *It should be noted some of the positions shown in Figure 15 contain nested piezometers monitoring more than one depth (geological formation) at the same location.*



LEGEND:

- NOW registered water bore (2011) - note: excludes monitoring bores in the MCP
- Approved Stage 1 project area
- Approved Stage 1 open cut
- Open Cut 1 and 2 proposed extension area
- Adjacent coal mines
- Major watercourse
- Watercourse
- Major road
- Road
- Railway
- Vegetation

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Registered bores from the NOW database

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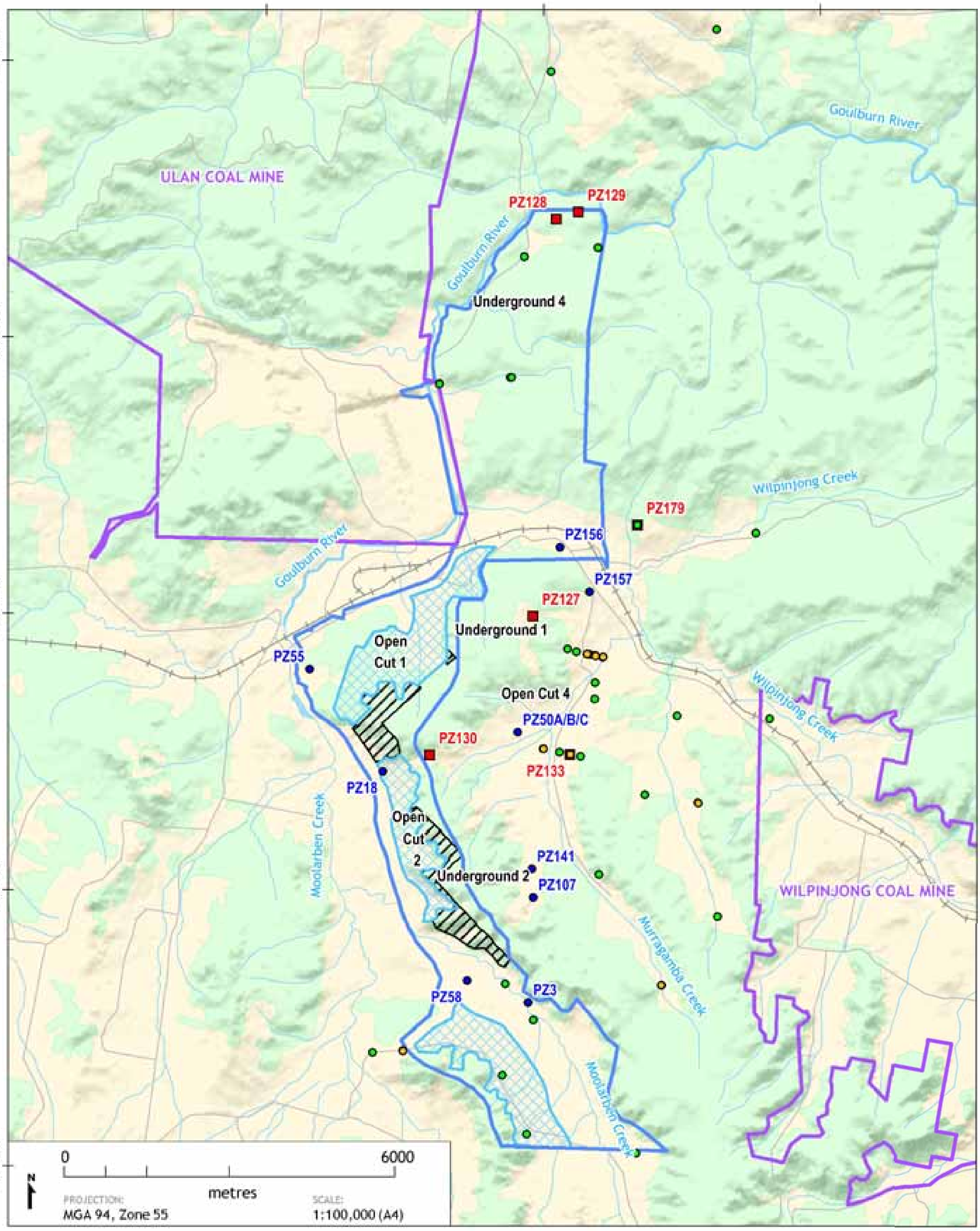
FIGURE No: 14



LEGEND:

- Monitoring bore (used in this study)
- Monitoring bore single, currently monitored
- Monitoring bore nested, currently monitored
- VW piezometer
- Approved Stage 1 project area
- Approved Stage 1 open cut
- Open Cut 1 and 2 proposed extension area
- Major watercourse
- Watercourse
- Major road
- Railway
- Vegetation
- Adjacent coal mines

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Groundwater monitoring network bore locations

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FIGURE No: **15**

6.5 Groundwater Levels and Trends

6.5.1 Hydrographs

Temporal groundwater level trends for the proposed modification area have been shown using a representative series of hydrographs, with the location of the bores labelled and shown in Figure 15. Groundwater levels have been plotted against cumulative rainfall deficit (CRD) (Figure 16 to Figure 21). As discussed in Section 4.1, there is positive CRD for the period of monitoring, which indicates above average rainfall and potentially above average recharge to the groundwater system. Comparison of CRD and groundwater level trends can be used to indicate whether groundwater levels are mimicking the wider climatic pattern, or potentially influenced by other factors such as impacts due to mining.

Bore PZ55 located in shallow surface Quaternary alluvial deposits (or Tertiary Paleochannel deposits) directly west of Open Cut 1, presents an ideal location to track the effects of dewatering associated with mining on geological formations that may interact with alluvium associated with Moolarben Creek (Figure 16). As can be seen in this figure, a gradual increase in groundwater level over the monitoring period, in line with an increase in CRD has occurred, and no impact from adjacent mining is evident.

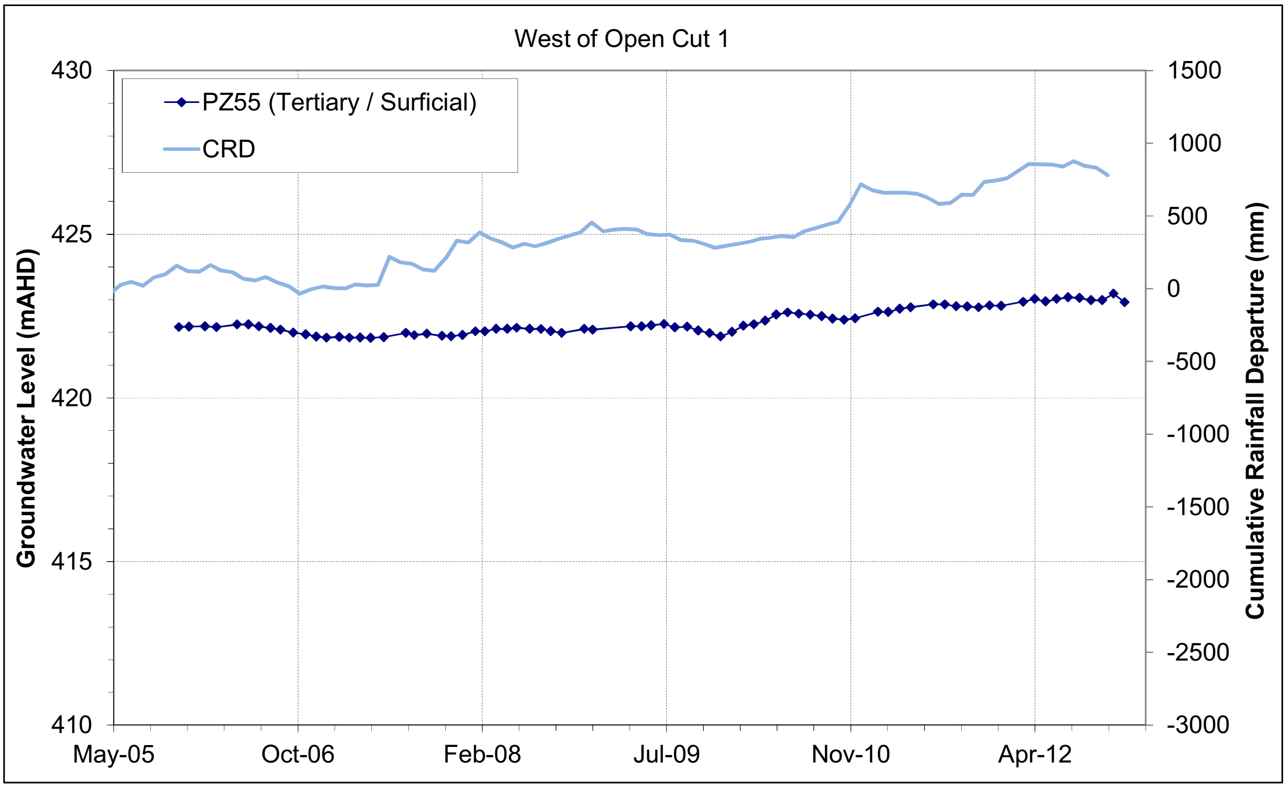


Figure 16: Hydrograph - Quaternary / Tertiary alluvium bore west of Open Cut 1

Bore PZ18 located in the Ulan Seam and underlying formations located directly west of the southern margin of Open Cut 1 and the northern margin of Open Cut 2, indicates a similar increasing trend in water level (Figure 17).

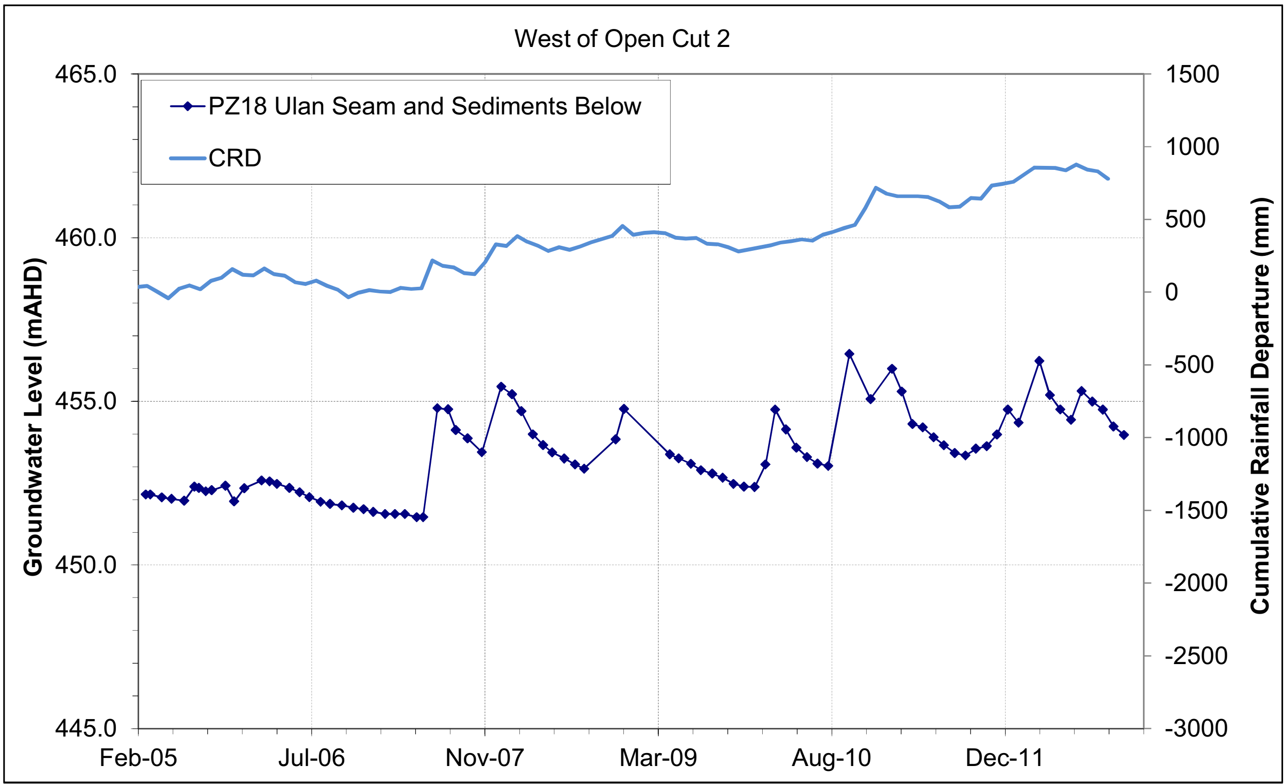


Figure 17: Hydrograph – Ulan Seam west of Open Cut 2

Bore PZ3 (Ulan Seam) and bore PZ58 (Tertiary/ surficial) located to the south of Open Cut 2 show a relatively flat trend, with the record for bore PZ58 extending back to 2005 (Figure 18). Again no impact from Stage 1 mining is evident.

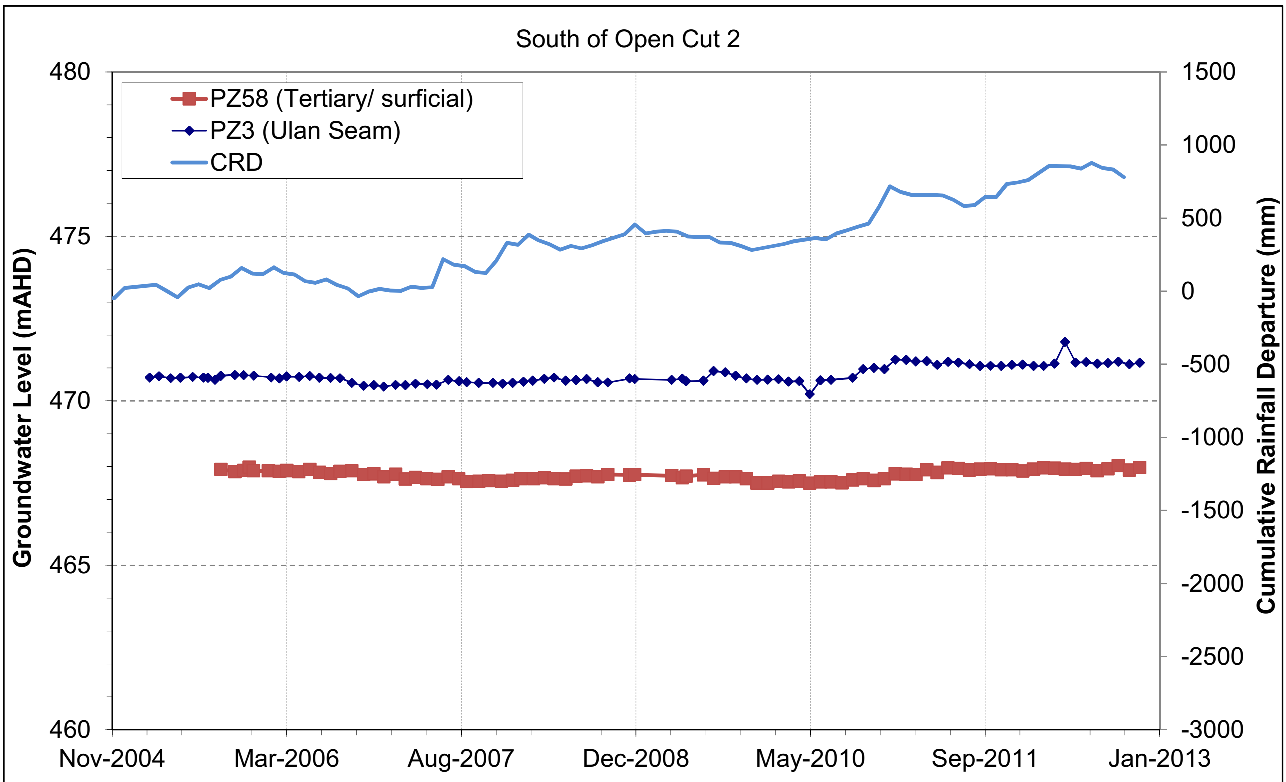


Figure 18: Hydrographs – Ulan Seam and Tertiary south of Open Cut 2

Bores east of the proposed modification are shown in Figure 19 and Figure 20. These plots show relatively flat to slightly increasing trends. A downward hydraulic gradient is evident in the closely spaced bores PZ107 and PZ141 (Figure 19) and the triple nested bores PZ050A, PZ050B and PZ050C (Figure 20). A down-ward hydraulic gradient means water levels (or pressures) reduce with depth. This promotes a downward migration of water, common in elevated recharge areas such as evident within the project area.

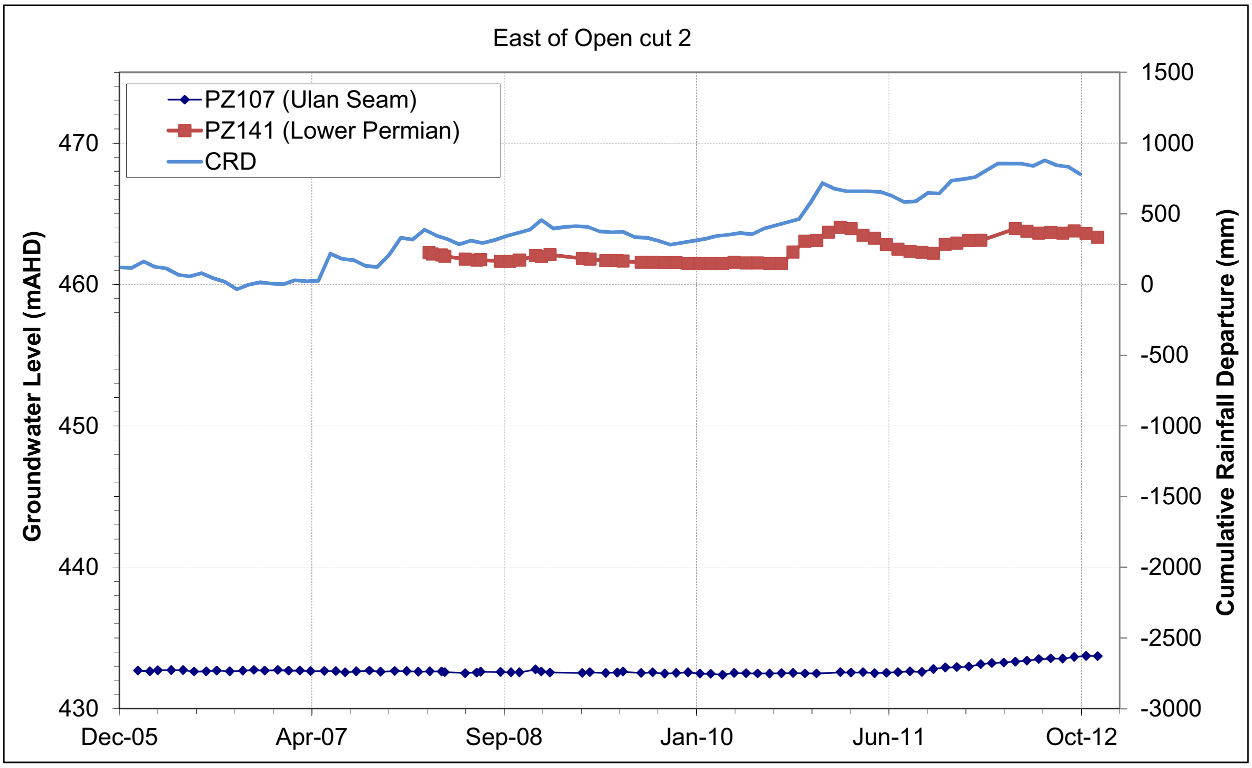


Figure 19: Hydrographs – Ulan Seam and Lower Permian east of Open Cut 2

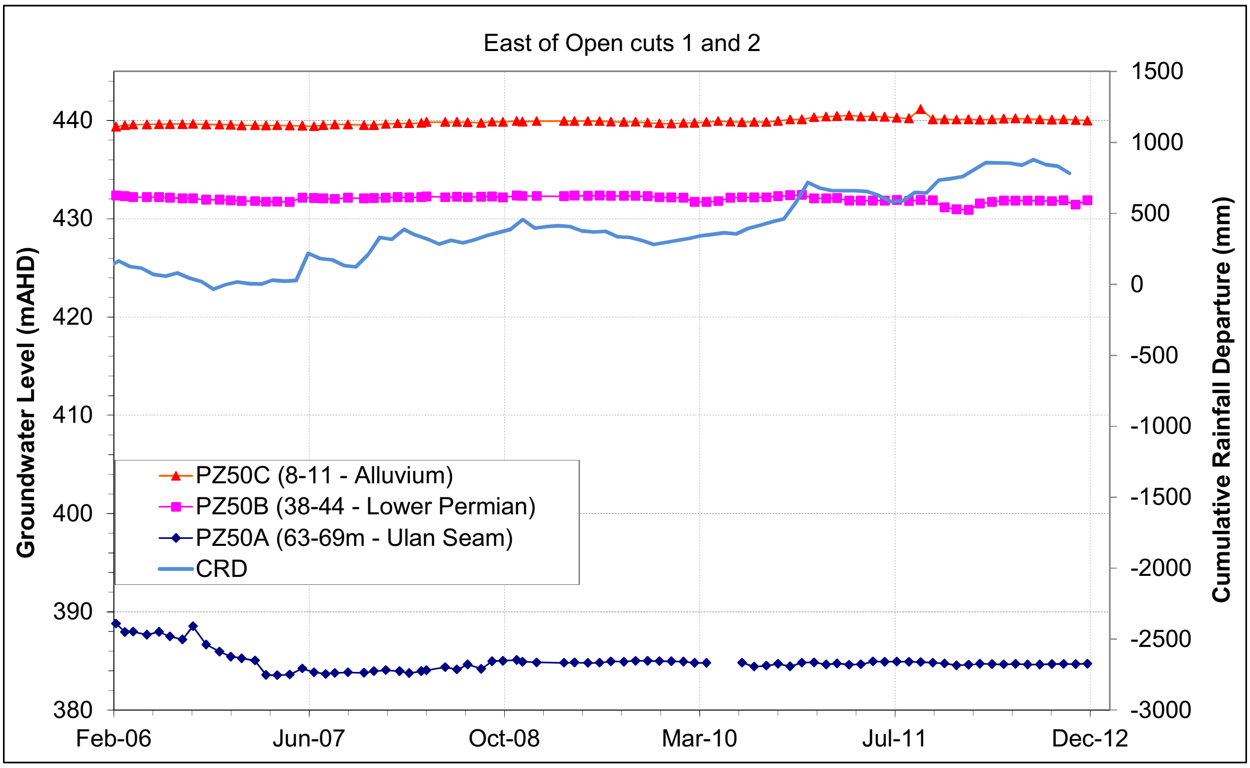


Figure 20: Hydrographs – Alluvium, Lower Permian and Ulan Seam east of Open Cut 1 & 2

Bores PZ156 and PZ157 located in the Ulan Seam both show a substantial increasing trend since monitoring commenced in 2008 (Figure 21). RPS Aquaterra (2011) considered the rising trends a response to an apparent reduction in the net dewatering rate at the Ulan Coal Mine due to the following:

- a northwards shift in the centre of pumping, as the Ulan Coal Mine underground mine has advanced;
- a reduction in the abstraction rate of bores close to the Ulan Coal Mine Open Cut; and
- disposal of surplus water into overburden dumps located inside the former Open Cut voids, leading to localised recharge.

This study concurs with the findings of RPS Aquaterra (2011) that explains this rising trend above increases that would be expected from natural recharge processes.

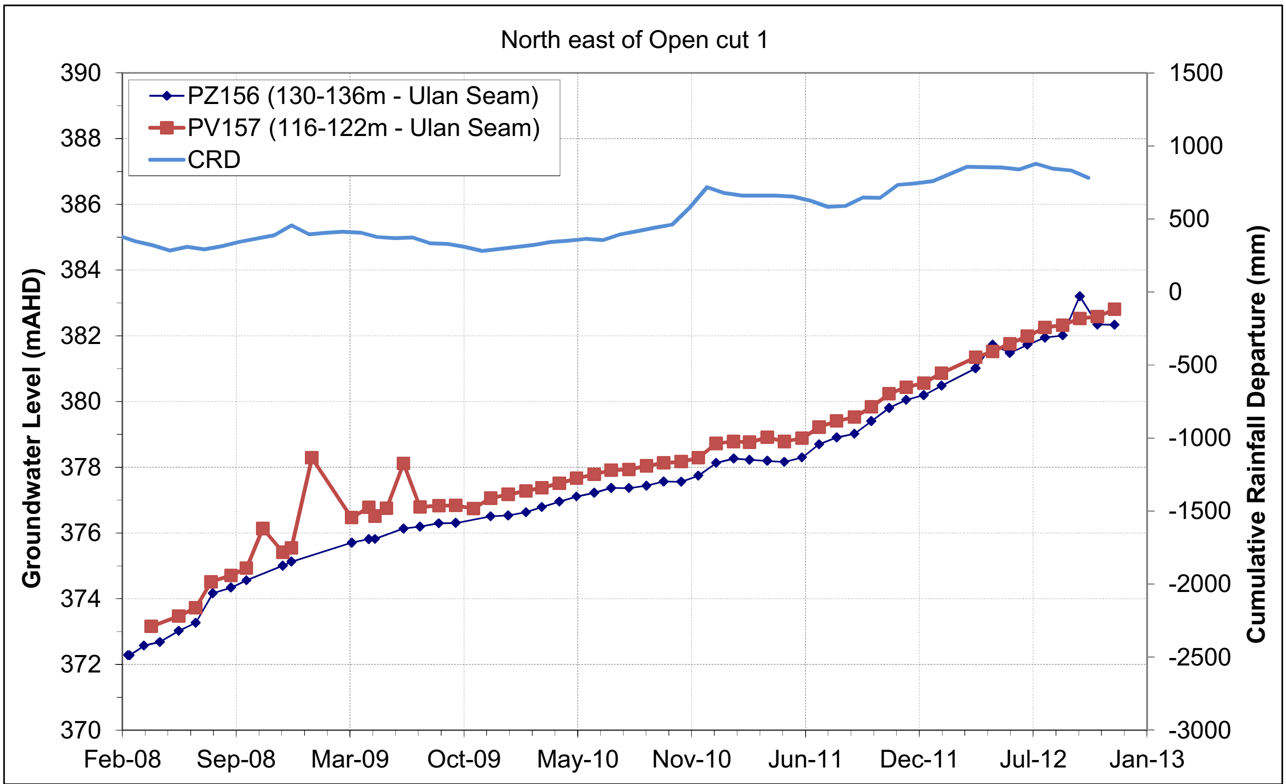


Figure 21: Hydrographs – Ulan Seam east of Open Cut 1

VWP nested piezometers to the east of the proposed modification show similar trends to other bores, with relatively flat or slightly increasing groundwater levels (Figure 22 to Figure 23). The multi-level VWP transducer results also show a downward hydraulic gradient.

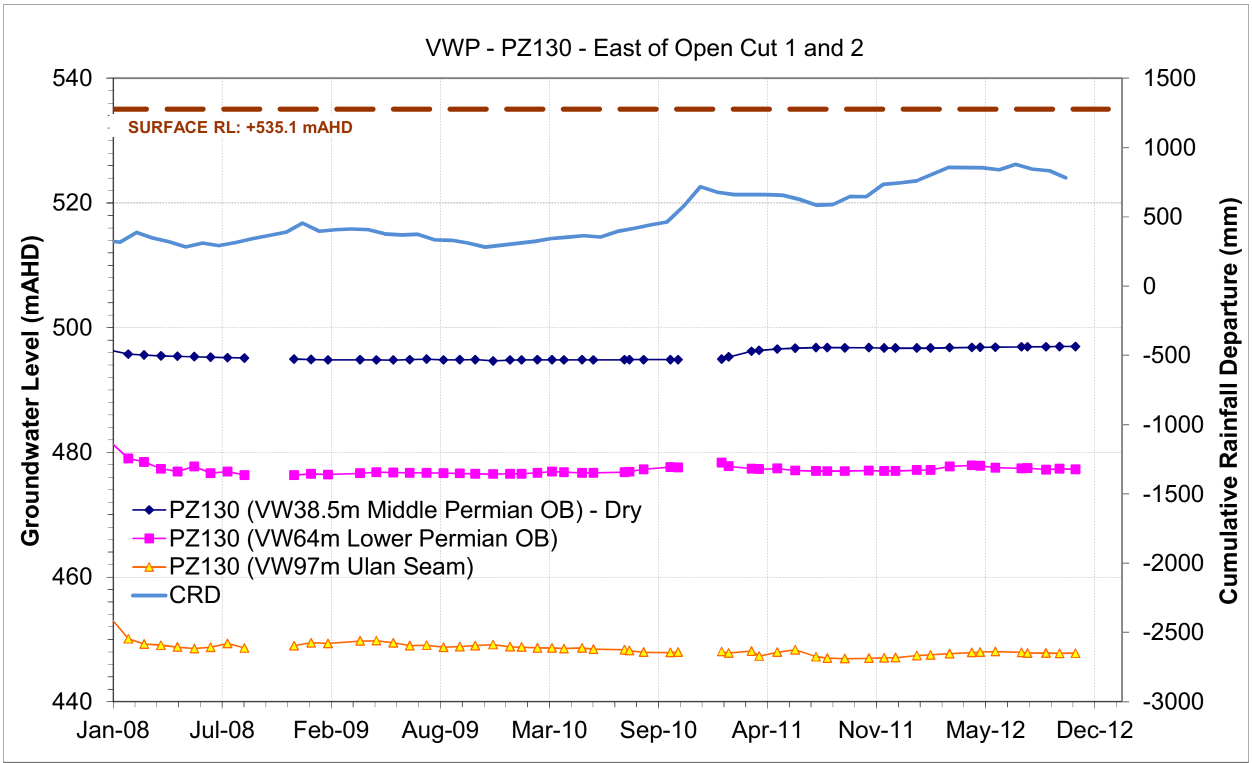


Figure 22: VWP east of Open Cut 1 and 2

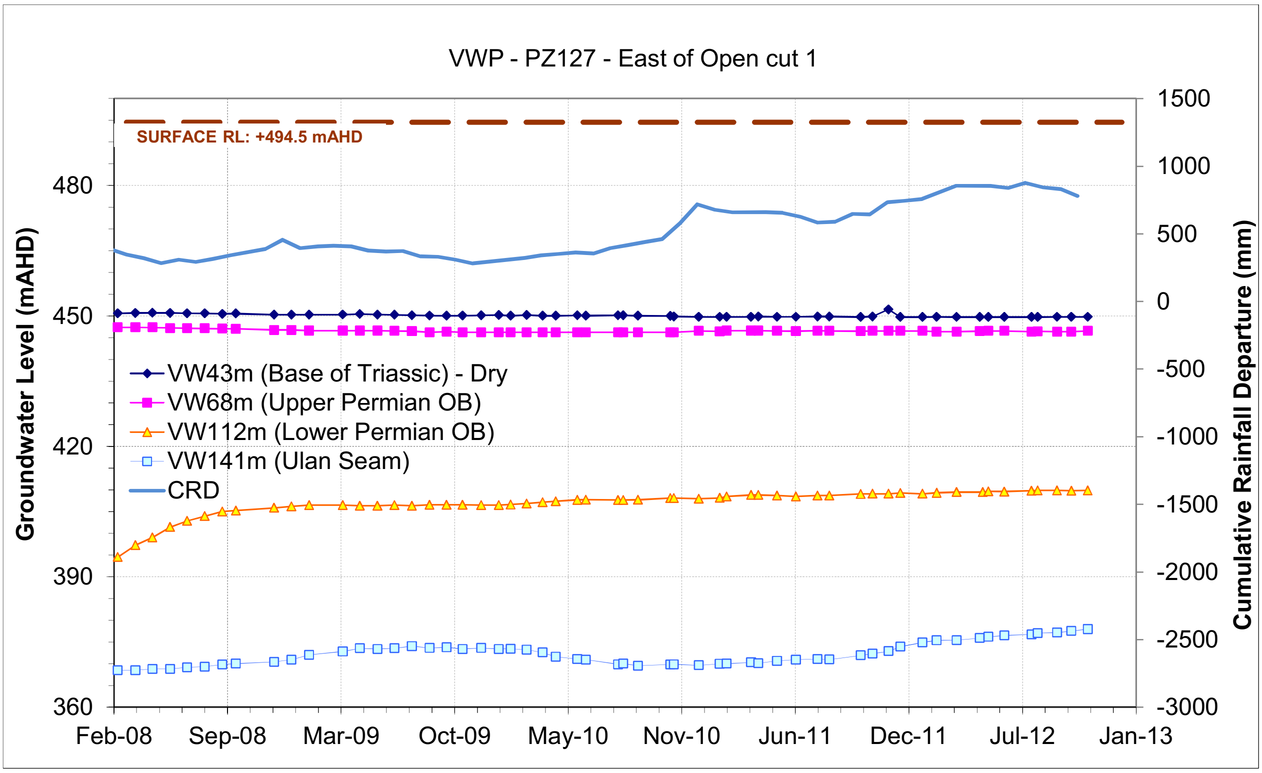


Figure 23: VWP east of Open Cut 1

In summary, groundwater levels generally show little effect from the current mining activities in Open Cut 1, with a gradual increase in water levels through time, due to above average rainfall over the monitoring period. Open Cut 1 mining to date is considered predominantly above the water table, hence little effect to date is noted in groundwater levels.

6.5.2 Groundwater Level Contours

Groundwater level contours for a number of formations were extracted from the numerical models prepared for previous Stage 1 and Stage 2 investigations. Appendix 3 presents a selection of the most relevant contours from Stage 1 (Dundon 2007) and Stage 2 (RPS Aquaterra 2011). The following discussion is based on the water level contours presented in Appendix 3.

Stage 1 modelling in Dundon (2007) presents a series of pre-mining groundwater level contours for 2006 representing the Ulan Seam, Lower, Middle and Upper Permian, Lower and Upper Triassic (Appendix 3 A3.1 to A3.5). The contours represent a groundwater condition prior to mining at MCP and represent antecedent effects from previous mining operations at the Ulan Coal Mine.

Groundwater levels in the Ulan Seam in the proposed extension area around Open Cuts 1 and 2 show a general north-north-easterly flow direction, coincident with dip of bedding and a recharge area in the outcrop areas of the Permian formations (Appendix A3.1). The effects of historical dewatering from the Ulan Coal Mine to the north can be clearly seen in this and contours from other overlying formations.

Groundwater levels are similar in the Lower, Middle and Upper Permian, although it should be noted that a larger proportion of the proposed extension area appears “dry” in these plots, evident from no contours in areas of Open Cuts 1 and 2 (Appendix A3.2 to A3.4). The Upper Permian groundwater contours do seem influenced by local topography as well as regional flow (contours bend around Murragamba Creek). Groundwater level contours for the Lower and Upper Triassic show the limited extent of the Triassic groundwater resources close to the proposed modification (Appendix 1 A3.5 and A3.6).

Groundwater levels for 2006 from Dundon (2007) have been superimposed onto cross-sections (Figure 9 to Figure 13). The downward hydraulic gradient evident in the nested and VWP bore hydrograph data is clearly evident in these sections with piezometric levels higher for shallow geological formations (Permian) and lower for the Ulan Seam. The sections show from model results that the downward hydraulic data is pervasive across the proposed extension area.

Appendix 3 also contains the following sets of groundwater contours:

- Year 2011 from Stage 2 model calibration (RPS Aquaterra 2011);
- Year 2021 from Stage 1 predictive simulation (Dundon 2006); and
- Year 2042 from Stage 2 predictive simulation (RPS Aquaterra 2011).

Subsequent sections of this report reference these contours to discuss impacts of the proposed modification.

Groundwater levels for 2011 from the latest Stage 2 modelling show lower piezometric levels for the Ulan Seam compared to the 2006 results. This suggests that the area of the proposed extension area maybe less saturated than shown in the 2006 data (Figure 27to Figure 31). Both sets of data from 2006 and 2011 are used through the following sections of this report to show a range of possibilities of the degree of saturation in the proposed extension areas.

6.6 Hydraulic Parameters

The permeability and storativity of the Permian coal measures within the project boundary is variable. Permeability is generally higher in the coal seams, but is occasionally enhanced in the interburden sediments (generally sandstone, siltstone and mudstone) due to localised fracturing. The Ulan Seam is termed an aquifer by virtue of its relatively higher permeability when compared to the interburden sediments. The interburden sandstones, siltstones and mudstones are of significantly lower permeability than the Ulan Seam (by one or more orders of magnitude) and they generally act as aquitards (RPS Aquaterra 2011).

The sandstones of the overlying Triassic Narrabeen Group and the underlying Shoalhaven Group have been shown by the field investigations to have poor aquifer properties. However, the Triassic Narrabeen Group is an important contributor of baseflow to the streams where the formation is present, generally to the north-east of Wilpinjong Creek and the proposed extension area. The basement units (Nile Sub-Group in the eastern parts and granites and volcanics in the western parts) are also relatively impermeable and constitute a basal aquitard in the groundwater regime. Nevertheless, groundwater occurs in all these units, and may form local aquifers where relatively higher permeability exists (RPS Aquaterra 2011).

During Stage 1 and Stage 2 investigations, each piezometer was hydraulically tested either by a short duration constant pump test or a falling head slug test to estimate hydraulic conductivity aquifer properties. Table 2 summarises the hydraulic conductivity data for the project area.

Table 2: SUMMARY OF HYDRAULIC CONDUCTIVITY TESTING – STAGE 1 and 2 GROUNDWATER INVESTIGATIONS

Aquifer	Hydraulic Conductivity (m/d)			No. of Tests
	Min.	Max.	Median	
Quaternary Alluvium/Colluvium/Regolith	5×10^{-2}	3	3.8×10^{-1}	10
Tertiary Palaeochannel Alluvium	1×10^{-2}	1.8×10^{-1}	1×10^{-1}	5
Triassic Narrabeen Sediments	4×10^{-2}	7.2	3.2×10^{-1}	6
Upper and Middle Permian Coal Measures Overburden	3×10^{-4}	14	3×10^{-1}	30
Lower Permian Coal Measures Overburden	1.9×10^{-1}	6.8	3.5	18
Permian Coal Measures - Ulan Seam	4×10^{-3}	11	2.9×10^{-1}	18
Shoalhaven Group	6×10^{-2}	1.1	0.22	2
Basement – granite, volcanics	0.3	0.3	0.3	1

Source: RPS Aquaterra (2011)

6.7 Groundwater Quality

As discussed by RPS Aquaterra (2011), groundwater quality across the project area is variable in terms of salinity and pH. The salinity varies considerably, with recorded values of Total Dissolved Solids (TDS) ranging from less than 200 mg/L to more than 11,000 mg/L. Recorded pH values indicate the majority of groundwaters to be mildly acidic with pH values typically around 5 to 6 although the total range is 5.0 to 8.5.

Laboratory analyses indicate moderately elevated concentrations of dissolved metals in groundwater across the MCP. Major ion analysis is of a broadly similar type being typically dominated by sodium and potassium cations, and a combination of carbonate / bicarbonate and chloride anions (RPS Aquaterra 2011).

6.8 Hydrogeology Summary of the Proposed Modification Area

The hydrogeology of the project area and surrounds has been extensively investigated in previous Stage 1 and Stage 2 studies. The proposed modification is in an area between Stage 1 Open Cuts and Stage 2 underground and open cuts, meaning the results from the previous modelling are applicable to this study. Based on recent monitoring results, the predictions of the previous modelling studies are validated. Recent groundwater level data has been studied from relevant monitoring bores in the area of the proposed modification. In the context of the proposed modification the most relevant points to note are:

- the Ulan Seam is the only geological unit that could be termed an aquifer within the sequence that may discharge to, or be impacted by, the proposed modification. Permeabilities within the Ulan Seam are generally one to two orders or more higher than other underlying and overlying formations (for example, other Permian and Tertiary deposits);
- groundwater is present to varying extents of saturation within overlying Permian and Triassic deposits, however, these deposits are generally not considered to contain aquifers due to the low permeability and storage capacity of the material;
- groundwater is present within Tertiary palaeochannel deposits with minor seeps noted when this channel was encountered during Stage 1 pit development. Field observations indicate the limited storage and transmissive capacity of these deposits results in seeps drying up soon after excavation;
- in a large proportion of the proposed extension area between Open Cut 1 and parts of Open Cut 2, the mined formations are elevated in the landscape, with the floor of the Ulan Seam 'dry' before mining commenced;
- dewatering of the Ulan Seam and overlying formations prior to development of the MCP, is evident from historical groundwater level monitoring data and supported by Stage 1 and Stage 2 model calibrations. No impact to date on groundwater levels is evident from current mining operations in Open Cut 1. There have not been any measurable inflows of groundwater to Open Cut 1 during current operations;
- groundwater is present within thin heterogeneous alluvial deposits associated with Moolarben and Lagoon Creeks with moderate salinity and low potential yields. Connection from the alluvium to the proposed extension area is thought to limited due to the low permeability of the sediments and the presence of a granitic basement; and
- the groundwater within the project area is generally brackish and used only for stock watering, the main beneficial use.

7.0 GROUNDWATER IMPACTS

As discussed in section Section 6 it is evident that a large proportion of the Ulan Seam and overlying formations are only partially saturated, or "dry" in the proposed extension area. Mining to date in Open Cut 1 confirms this, with negligible groundwater inflow noted up to November 2012. Due to the low risk nature of the project further groundwater modelling was not considered necessary, and a semi—quantitative[2] methodology was used to predict the effect of the proposed extension on the groundwater regime.

7.1 The Mine Plan

The proposed modification seeks to extend open cut mining in two separate areas adjacent to approved mining operations. The first is in an area "high" in the landscape between Open Cut 1 and Open Cut 2, with a second area extending Open Cut 2 to the south-east (near to Moolarben Creek).

It is proposed to mine further into the hill side directly east of each existing open pit, the final pit high walls being generally aligned with the underground mining proposed in the Stage 2 development (Underground 1 and Underground 2) below this hill side (Figure 4).

Staged mining sequences were supplied for the proposed modification by MCO for the year 2, year 6, year 11 and year 16. Figure 24 and Figure 25 show the mine plans with pit floor and surrounding topographic elevation, together with an outline of the approved Stage 1 Open Cuts 1 and 2.

7.2 Mine Inflows

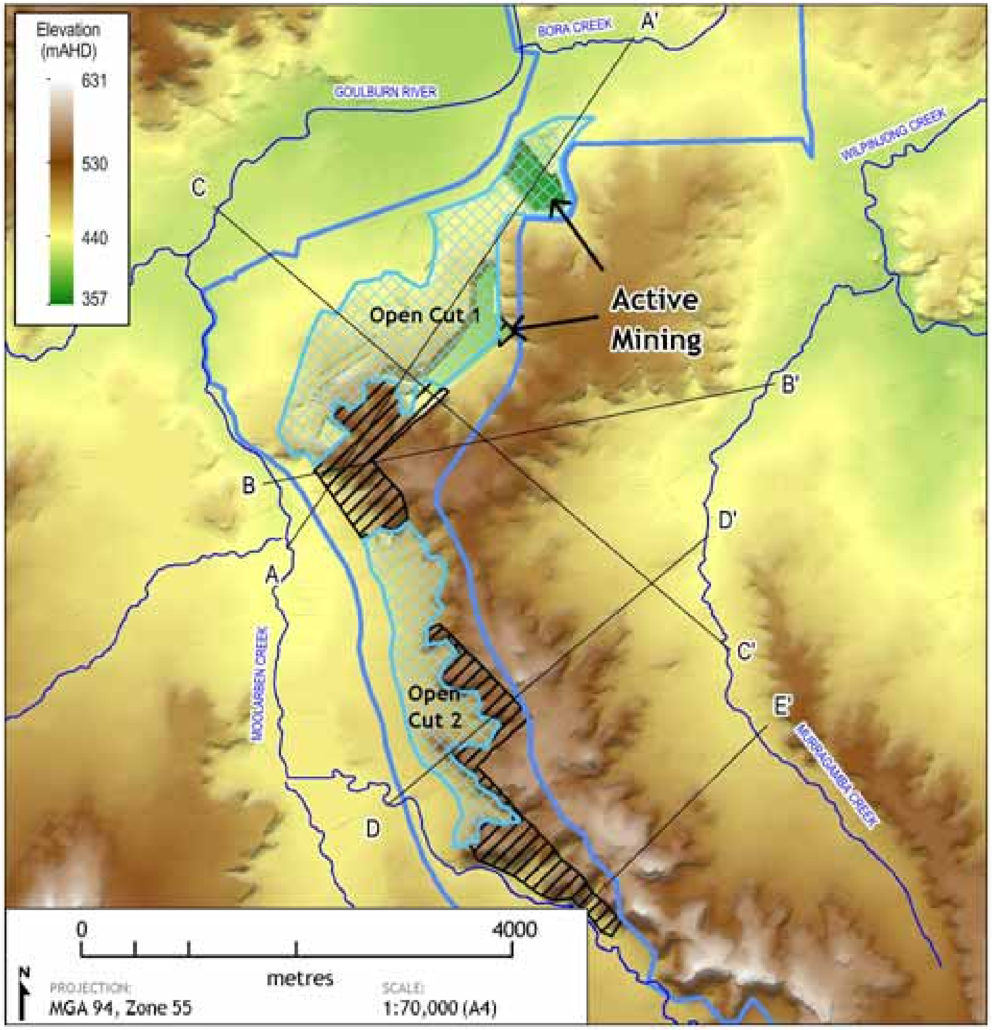
7.2.1 Mine Inflows Predicted from Historical Models

Predicted mine inflows for different variants of the Stage 1 and Stage 2 models have been presented throughout previous historical studies. Section 3.0 discusses the development of the historical models. Table 3 below shows the predicted mine inflow from the four models, being:

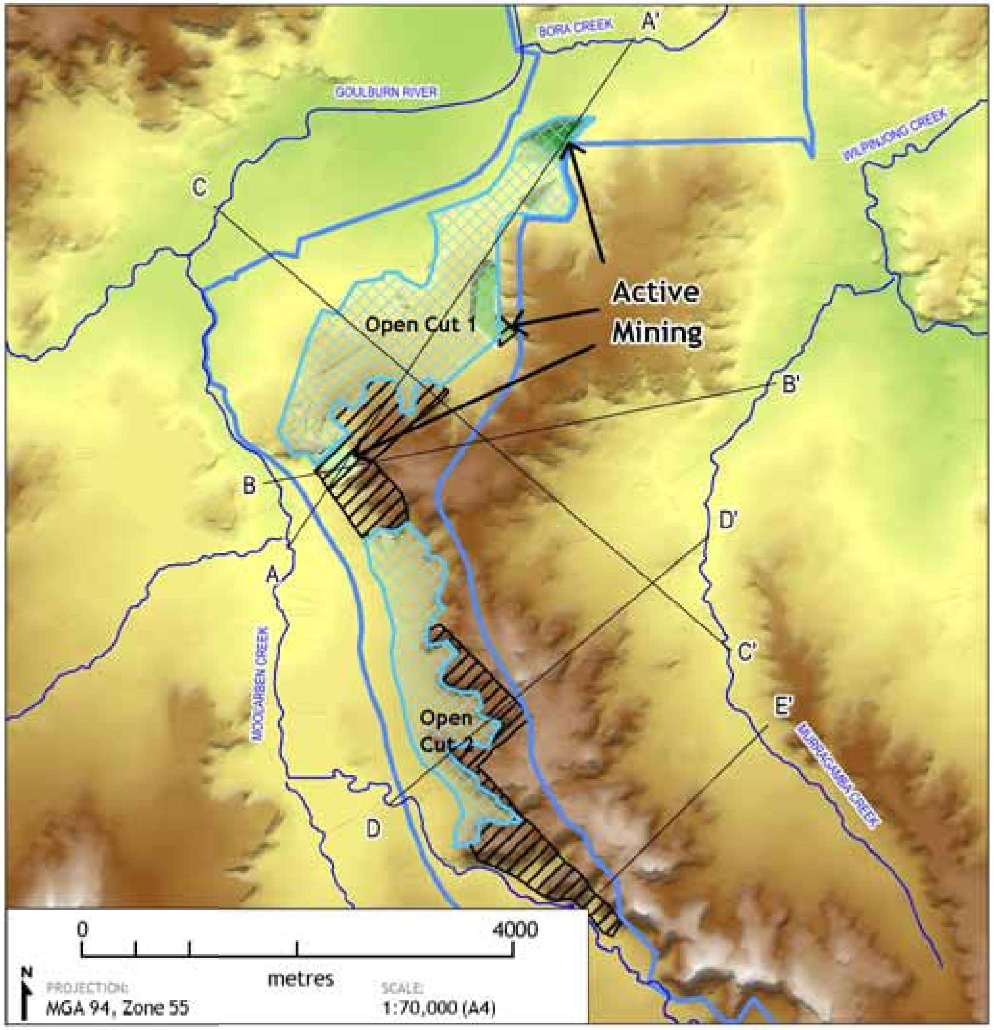
- Stage 1 model MC1.6 (Dundon 2006) – Pre-review amendments (lower fracture zone permeability above underground);
- Stage 1 model MC1.9 (Dundon 2007) – Includes changes recommended by Dr Colin Mackie of MER (increased fracture zone permeability above underground, hence more potential groundwater flow during scenarios);
- Stage 2 model 2008 (Aquaterra 2008) – Prior to review comments; and
- Stage 2 model 2011 (RPS Aquaterra 2011) – Includes changes suggested by Associate Professor Noel Merrick.

[2] Quantitative predictions from previous models have been used in conjunction with mines plans for the proposed extension areas to give a range of inflows and impacts.

Year 2



Year 6



LEGEND:

- Approved Stage 1 project area
- Approved Stage 1 open cut
- Open Cut 1 and 2 proposed extension area
- Location of cross section

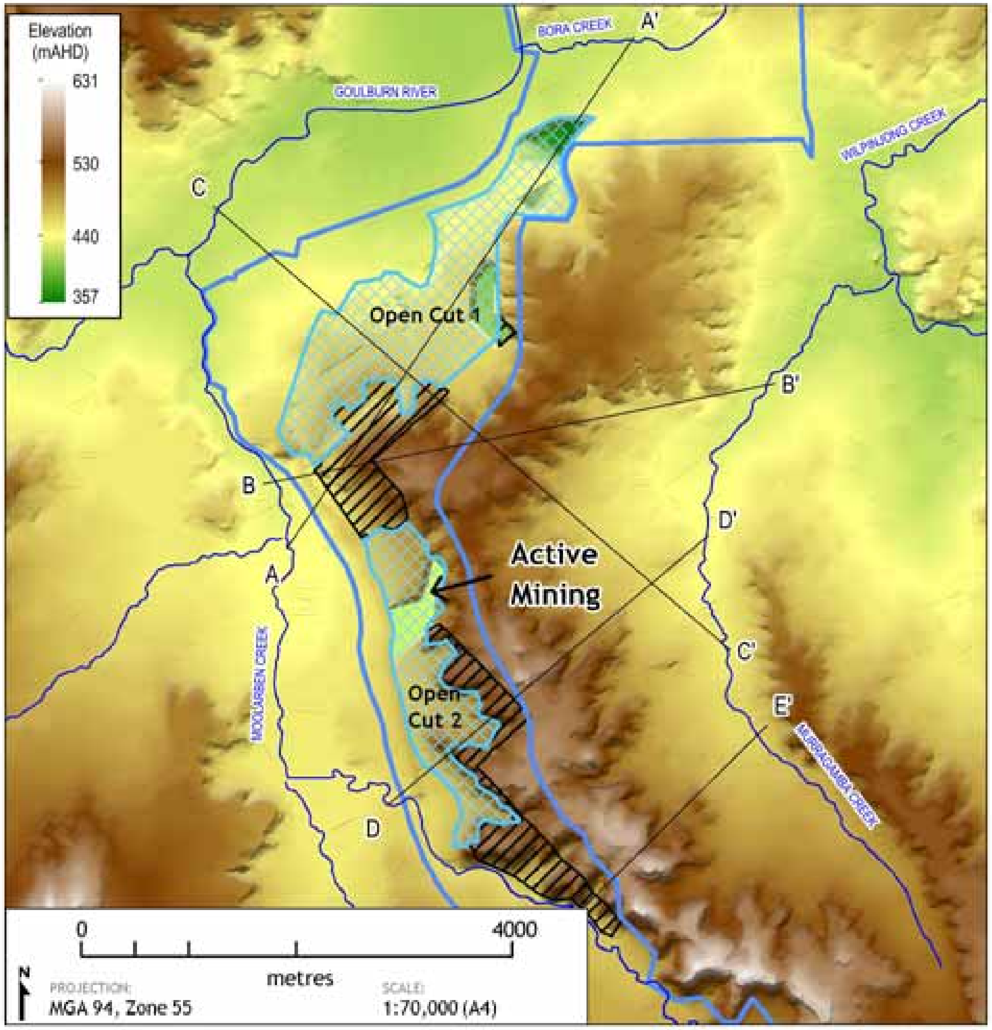
Moolarben Stage 1 Optimisation (G1622)

Mine schedule year 2 - year 6

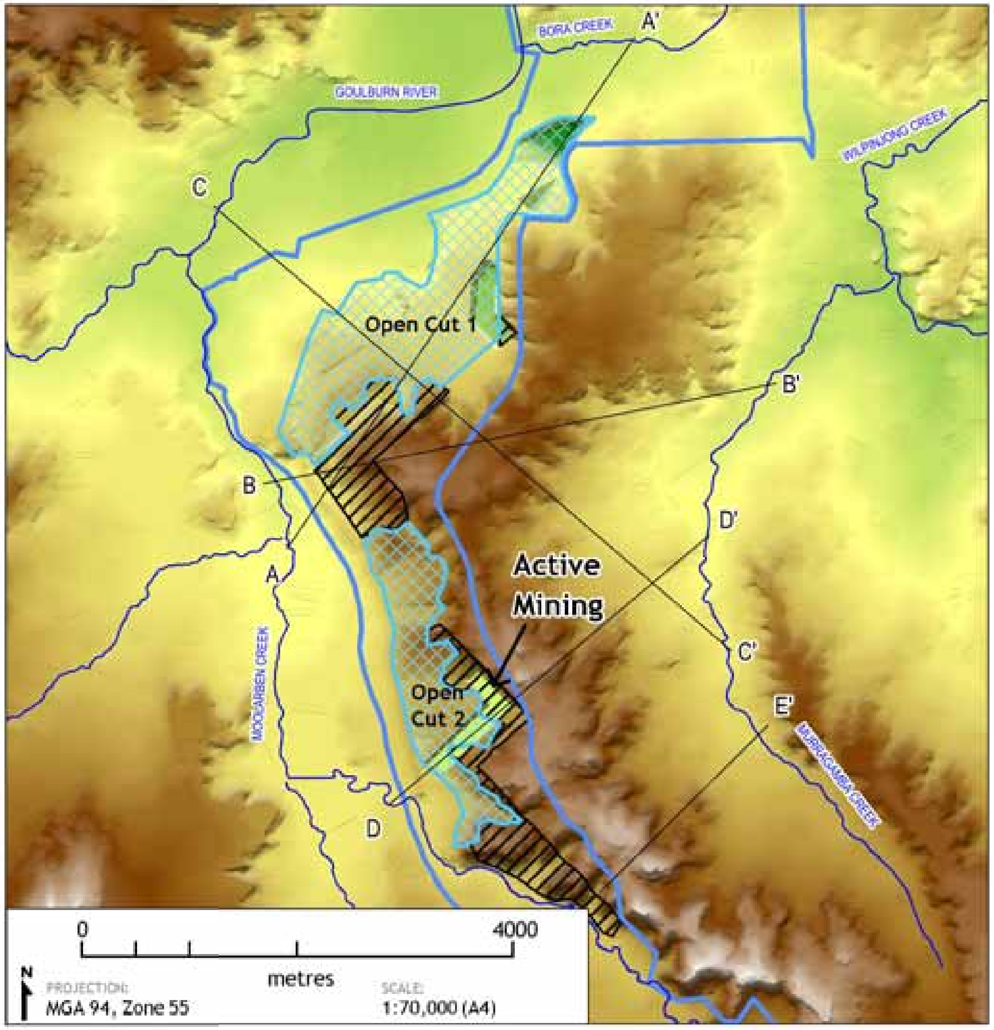
DATE:
29/4/2013

FIGURE No:
24

Year 11



Year 16



LEGEND:

- Approved Stage 1 project area
- Approved Stage 1 open cut
- Open Cut 1 and 2 proposed extension area
- Location of cross section

Moolarben Stage 1 Optimisation (G1622)

Mine Schedule year 11 - year 16

DATE:
29/4/2013

FIGURE No:
25

Table 3: PREDICTED MINE INFLOWS FOR DIFFERENT STAGE 1 AND 2 PREDICTIVE MODELS

		MC1.6 Stage 1 model - Moolarben Mine					MC1.9 Stage 1 model - Moolarben					Stage 2 model (2008) - Moolarben Mine Water Inflows m³/d								Stage 2 model (2011) - Moolarben Mine Water Inflows m³/d							
Mine	**Year**	**UG4**	**OC1**	**OC2**	**OC3**	**Total**	**UG4**	**OC1**	**OC2**	**OC3**	**Tota**	**UG1**	**UG2**	**UG4**	**OC1**	**OC2**	**OC3**	**OC**	**Tota**	**UG1**	**UG2**	**UG4**	**OC1**	**OC2**	**OC3**	**OC4**	**Total**
2	2007-08	227	0			227	3334				3334																
3	2008-09	4033	0			4033	3240				3240																
4	2009-10	3512	11			3512	2678	824			3502				17			445	462								
5	2010-11	2836	318			3153	3350	1235			4585				67			596	663								
6	2011-12	2249	381	0		2630	2565	1268	519		4352				50			424	474				220	58		490	768
7	2012-13	1751		0		1751	2116		441	395	2952				220			320	540				280	17	0	261	558
8	2013-14	1444		0	0	1444	2111		407	635	3153	817			186			214	1217				413	24		275	712
9	2014-15	2008			0	2008	2893			471	3364	924			258	25		142	1349	598				27		253	878
10	2015-16	1016			0	1016	2660				2660	2357				65		100	2522	799						208	1007
11	2016-17	1860				1860	2772				2772	2065				28	43	108	2244	829						151	980
12	2017-18	2471				2471	2570				2570	2169					51	184	2404	772						786	1558
13	2018-19	4052				4052	4214				4214	2080	14				103	219	2416	722						795	1517
14	2019-20	5274				5274	3848				3848	2228	87				67	217	2599	805						1252	2057
15	2020-21	6178				6178	3790				3790	2094	109				54	352	2609	628						1819	2447
16	2021-22	6581				6581						2085	133				117	309	2644	998						1415	2413
17	2022-23											1951	184				136	463	2734	888						1143	2031
18	2023-24											1819	187				89	605	2700	881						1132	2013
19	2024-25											1770	182				75	804	2831	786	5	426				986	2203
20	2025-26											1319	189	1764			92	128	4650	0	24	753				880	1657
21	2026-27													2203			101	107	3383		18	819				802	1639
22	2027-28													3740			144	109	4980		7	988				1357	2352
23	2028-29													3848			155	577	4580			1042				1077	2119
24	2029-30													4485			181	877	5543			1216				847	2063
25	2030-31													4524			235	140	6167			1203			4	1171	2378
26	2031-32													5153			243	160	6997			1397			93		1490
27	2032-33													5119			65		5184			1883			80		1963
28	2033-34													6376					6376			3223			190		3413
29	2034-35													6846					6846			2576			265		2841
30	2035-36													8226					8226			4254					4254
31	2036-37													7971					7971			4244					4244
32	2037-38													8829					8829			4369					4369
33	2038-39													8494					8494			4365					4365
34	2039-40																					4466					4466
35	2040-41																					4465					4465

Figure 26 presents mine inflow results for Open Cuts 1 and 2. Appendix 3 includes:

- modelled hydraulic heads for Stage 1 calibration (pre-mining year 2006) and Stage 2 calibration (pre-mining year 2011); and
- predicted drawdown for Stage 1 (mine year 2021) and Stage 2 predicted drawdown (mine year 2042).

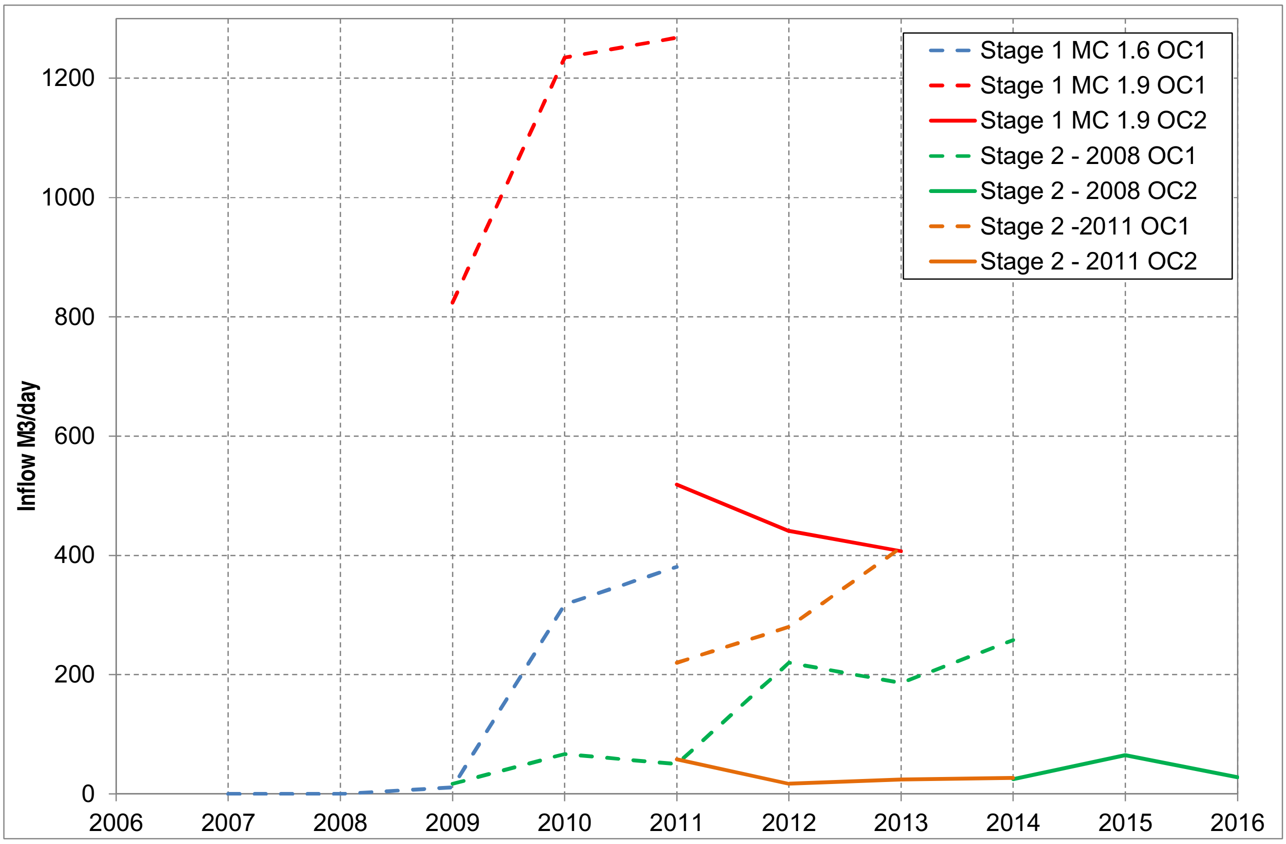


Figure 26: Mine inflow rates for Open Cut 1 and 2 from different Stage 1 and 2 Models

As can be seen in Table 6-1 and Figure 26 the mine inflows vary according to the evolving mine scheduling used in each assessment. Although the sequencing of mining assessed in previous studies has varied, the predicated impacts are considered to be applicable to the proposed modification.

The groundwater inflows to Open Cut 1 are generally less than 400 m^3/day (0.4 ML/day), although the amended Stage 1 MC1.9 model peaks at 1,268 m^3/day (1.3 ML/day). Dundon (2006) suggests that initial inflows to Open Cut 1 will be very low, but will progressively increase as Open Cut 1 advances further down dip to the north reaching 400 m^3/d in Year 6.

The Stage 1 MC 1.6 model predicts Open Cut 2 inflows to be negligible, with the stage Stage 2 models also predicted limited inflow at less than 65 m^3/day (0.07 ML/day). Only the amended MC1.9 model simulates significant inflows to the Open Cut 2 - between 400 m^3/day to 520 m^3/day (0.4 ML/day – 0.6 ML/day). Dundon (2007) suggests that fracture zones above Underground 4 in this model (Stage 1 MC1.9) may be unrealistically permeable and therefore over-estimate inflow to Stage 1 Open Cut Pits 1 and 2. The Stage 1 MC 1.9 model predictions are considered highly conservative and are therefore worst case upper bounds for the proposed modification.

7.2.2 Evaporation Rates from Open Cuts

It should also be noted that inflows predicted by previous modelling do not take evaporative losses into account. Evaporation will occur at the open cut faces and floor when discharge occurs and, therefore, mine inflow amounts that should collect at open cut sumps would be less than modelled inflows. This may explain why no groundwater inflows have currently been observed or required pumping from mining activities within Open Cut 1.

RPS Aquaterra (2011) report the average potential evaporation rate is 1,569 mm/year, based on the closest BoM climate monitoring station (Station No. 062003). A simple calculation of the potential wetted pit face areas (from cross sections) × evaporation rate was performed to estimate potential evaporative loss from the open cuts. This simplistic estimate indicates evaporative losses in the order of 400 m^3/day (0.4 ML/day), similar to the modelled pit inflow. This indicates evaporative losses are the likely reason that no pit seepage has been observed or required pumping.

7.2.3 Water Licenses to Offset Mine Inflows

MCO holds licences under Part 5 Water Act 1912 which entitle MCO to take the following volumes of groundwater from the Permian formations (ie non Water Storage Plan managed water sources):

- up to 150 ML/ year mine dewatering water licence. This licensed amount equates to the maximum predicted inflows from the latest Stage 2 modelling (RPS Aquaterrra 2011). This license currently applies to Open Cut 1 only; and
- 2,850 ML/ year from the southern and northern borefields.

It is noted that maximum pit inflows simulated from Stage 2 modelling include Stage 1.

Licence allocations on Water Sharing Plan water sources are being finalised for the Stage 2 application. The purchase of a water license for 218 ML/year from the Wollar Creek water source has recently been finalised. MCO is in the process of purchasing a water licence for 9 ML/year from the Goulburn River water source to account for predicted reductions in baseflow as a result of Stage 1 and Stage 2 operations on this water source. Stage 2 modelling simulated an impact on the water source at a maximum of 7 ML/year with the additional 2 ML/year accounting for security of supply and minor increases in baseflow reduction due to the proposed modification.

7.2.4 Piezometric Levels Predicted for the Proposed Modification

The five cross sections presented previously in Section 6.0 (Figure 9 to Figure 13) of this report were used to visualise the saturated profile of the proposed extension areas. Figure 27 to Figure 31 present the piezometric levels for the Ulan Seam from various models (as discussed in Section 7.2.1 above) for years 2006, 2011, 2021 and 2042. The Ulan Seam piezometric heads were selected as this unit is the most permeable being mined and the closest surrogate to an aquifer in the area, and hence presents the greatest possibility to yield mine inflows and also transmit impacts to the surrounding groundwater regime.

Section A – A' (Figure 27): This cross section runs down-dip from Moolarben Creek through the proposed extension area pit between the Open Cut 1 and Open Cut 2 and east-north-east through the approved Stage 1 Open Cut 1. The cross-section highlights the relatively high elevation of this part of the proposed modification.

Piezometric levels for the Ulan Seam (red line) from Stage 1 modelling (2006), prior to commencement of Open Cut 1 mine show only a thin veneer of saturated Ulan Seam in the proposed extension area. This is consistent with the high elevation in the landscape, and the Permian formations at outcrop in this area forming a recharge zone. The saturated thickness of the formation increases down-dip. The green line shows the predicted effects on the Ulan Seam piezometric surface at year 2021 without the effects of the proposed modification included. A reduction in the piezometric surface can be seen.

Piezometric levels from Stage 2 modelling (for the Ulan Seam) are also presented in this cross section, with the simulated 2011 levels (orange line) plotting below the base of the Ulan seam for this area of the proposed extension area. The predicted water levels for the proposed Stage 2 application for 2042 show water levels in the area of the proposed modification to be below the base of the Ulan Seam. Stage 2 modelling suggests this sector of the proposed modification is unsaturated at 2011 and hence no impact on the groundwater regime is possible due to the proposed extension.

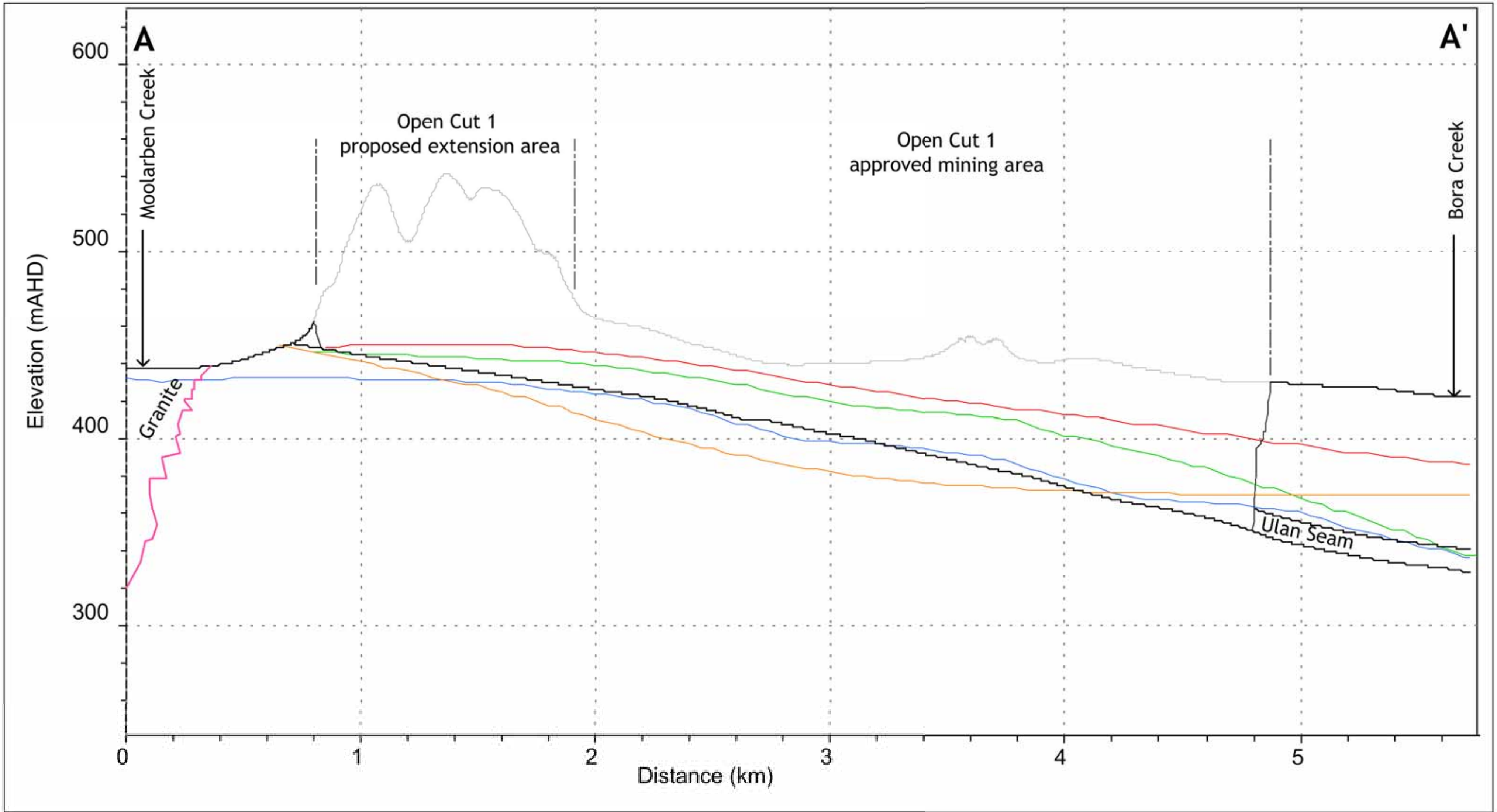
Section B – B' (Figure 28) and Section C – C' (Figure 29): These two sections intersect the same area of the proposed modification as cross section A - A' described above, with cross-section B – B' generated in a west to east orientation and section C – C' in a general north-west to south-east strike. Similar inferences can be drawn from Figure 28 and Figure 29 as those for cross-section A – A' (Figure 27), being that this area of the proposed modification is almost "dry" prior to mining, inferring mine inflows will be negligible with impact on the wider groundwater environment correspondingly negligible.

Section D – D' (Figure 30): This cross-section towards the centre of both the approved Open Cut 2 and the proposed extension area and strikes in a general south-west to north-east direction from Moolarben Creek to Murrangamba Creek. This section clearly shows the concept of the proposed modification with the approved mine area to the west and the proposed modification area directly to the east down-dip further into the hill side.

Slightly more saturated thickness is evident in this section compared to the area shown in previous sections. There is still only a very thin saturated sequence in the area, which is why modelled inflows are so small to this pit (Table 3 and Figure 26).

The piezometric levels shown in this section for the proposed modification Stage 2 show an almost completely dry area for the proposed modification prior to Stage 2 development 2011 and a completely dry pit after Stage 2 Underground mining.

Section E – E' (Figure 31): This cross section has been positioned to the southern extent of the proposed modification area and to the south of the approved Open Cut 2, with a similar strike to Section D – D'. Pre-mining Stage 1 2006 water levels suggest that as the proposed modification extends south groundwater will be encountered. This area (south of the approved Open Cut 2) is expected to be the "wettest" of the proposed modification, if Stage 2 operations are not approved and carried out. Although the piezometric contours for the Ulan Seam from the Stage 2 model for 2011 do show a greatly reduced saturated sequence over Stage 1 simulation. A worst case scenario is in this area to the south-east of approved Open Cut 2 may intercept as much groundwater as indicated from Stage 1 modelling for the later stages of Open Cut 2 development. The effects of the proposed Stage 2 underground mining are clearly evident in this cross section in the piezometric contours for the year 2042, with the Ulan Seam "dry" in the area of the mining.



LEGEND:

- Piezometric level Ulan Seam 2006 *
- Piezometric level Ulan Seam 2011 +
- Piezometric level Ulan Seam 2021 *
- Piezometric level Ulan Seam 2042 +
- Ground surface 2018
- Ground surface pre-mining

* Piezometric levels sourced from Stage 1 modelling (Dundon 2007)

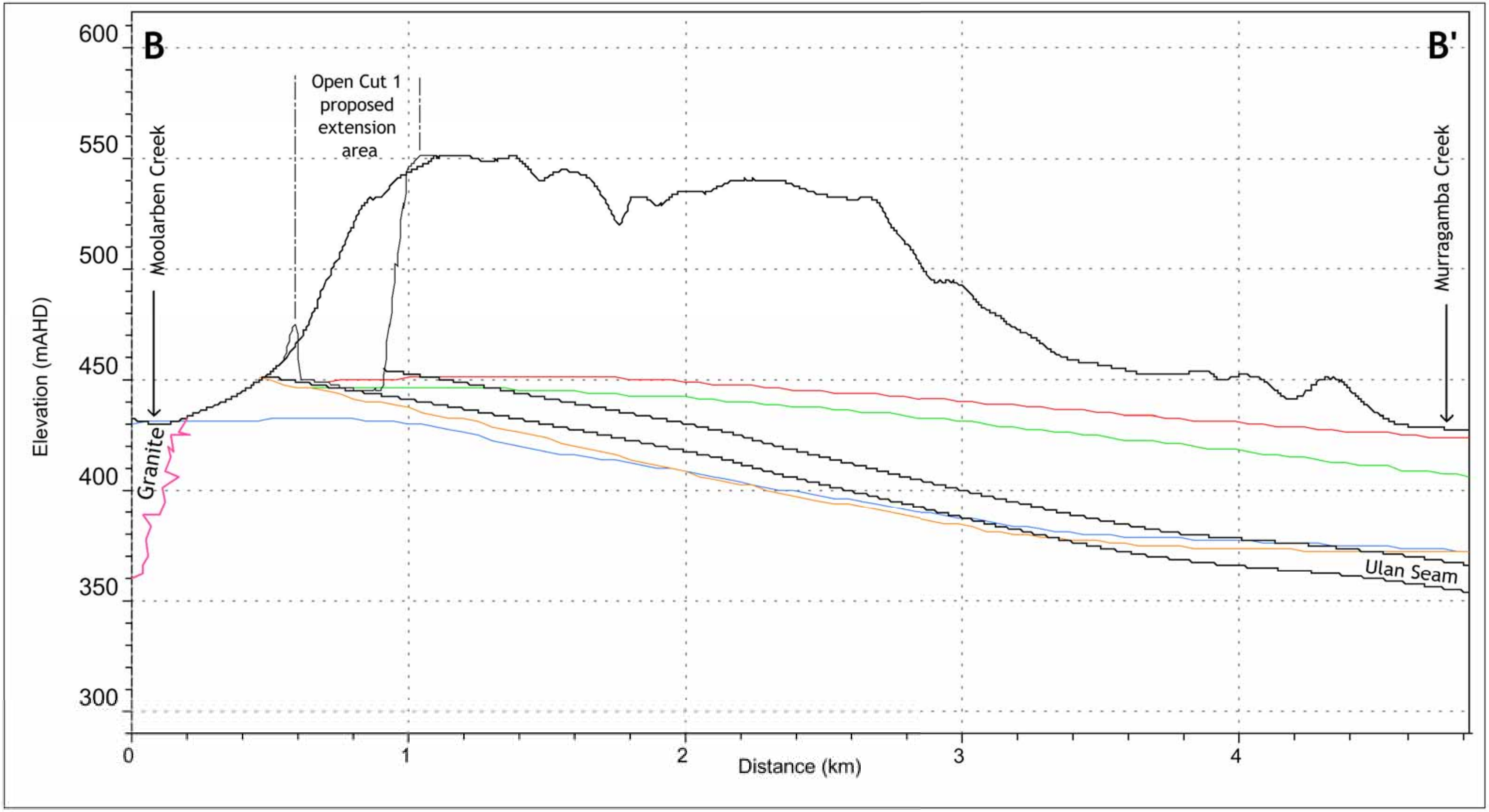
\+ Piezometric levels sourced from Stage 2 modelling (RPS Aquaterra 2011)

Moolarben Stage 1 Optimisation (G1622)

Cross section A - A' of Open Cut 1 proposed extension area

DATE: 29/4/2013

FIGURE No: **27**



LEGEND:

- Piezometric level Ulan Seam 2006 *
- Piezometric level Ulan Seam 2011 +
- Piezometric level Ulan Seam 2021 *
- Piezometric level Ulan Seam 2042 +
- Ground surface 2018
- Ground surface pre-mining

* Piezometric levels sourced from Stage 1 modelling (Dundon 2007)

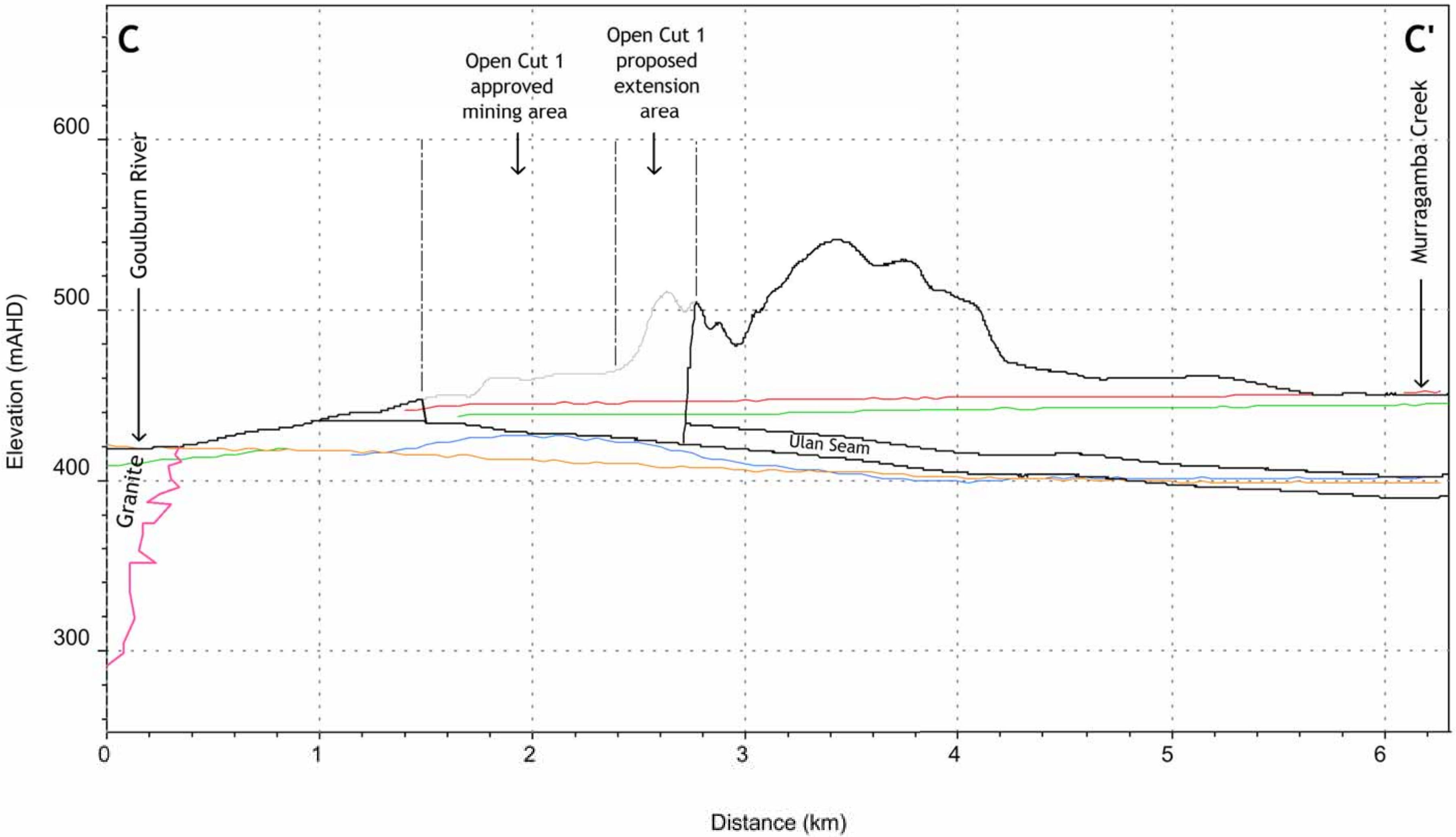
\+ Piezometric levels sourced from Stage 2 modelling (RPS Aquaterra 2011)

Moolarben Stage 1 Optimisation (G1622)

Cross section B - B' of Open Cut 1 proposed extension area

DATE: 29/4/2013

FIGURE No: **28**



LEGEND:

- Piezometric level Ulan Seam 2006 *
- Piezometric level Ulan Seam 2011 +
- Piezometric level Ulan Seam 2021 *
- Piezometric level Ulan Seam 2042 +
- Ground surface 2014
- Ground surface pre-mining

* Piezometric levels sourced from Stage 1 modelling (Dundon 2007)

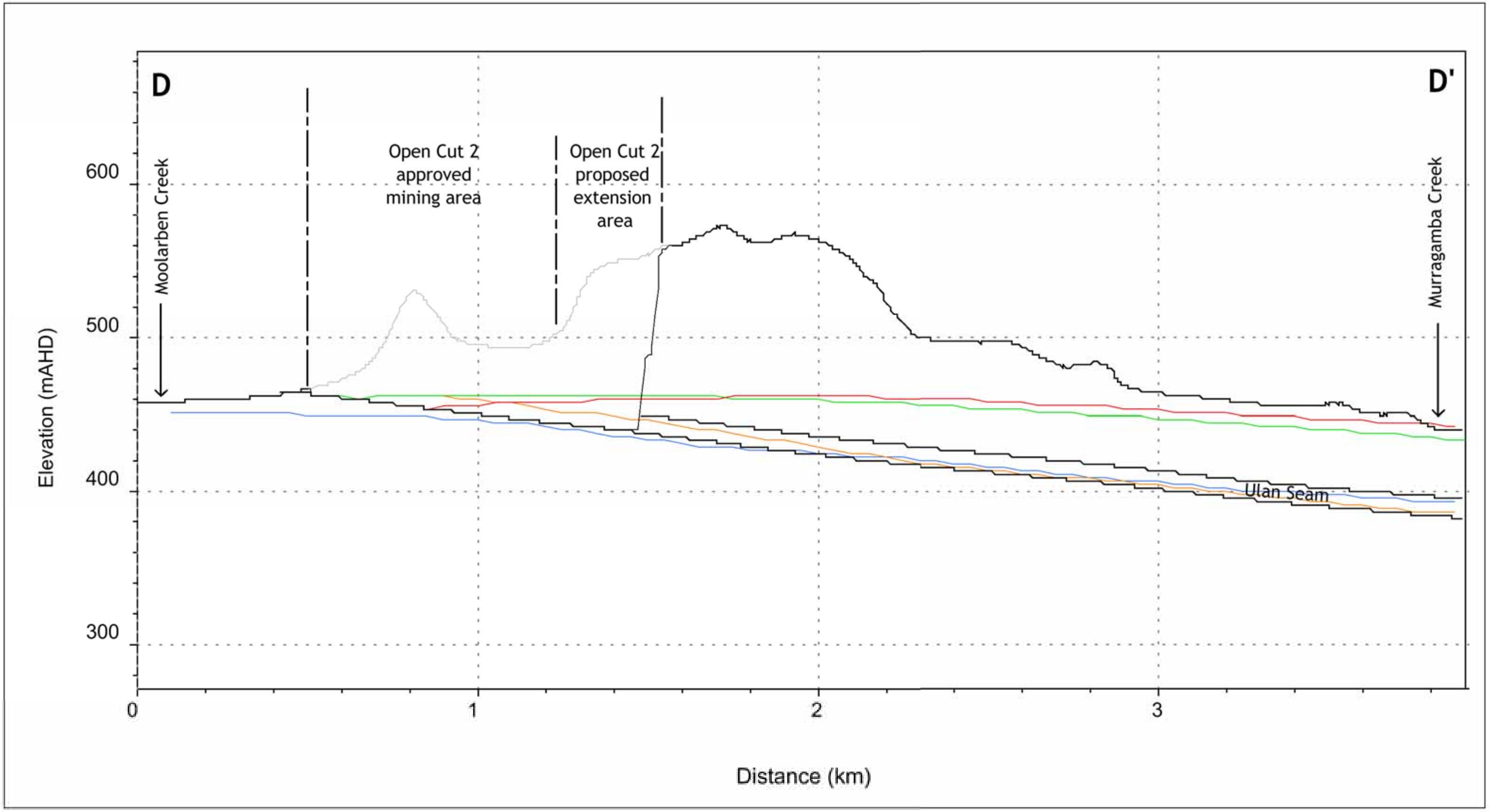
\+ Piezometric levels sourced from Stage 2 modelling (RPS Aquaterra 2011)

Moolarben Stage 1 Optimisation (G1622)

Cross section C - C' of Open Cut 1 proposed extension area

DATE: 29/4/2013

FIGURE No: **29**



LEGEND:

- Piezometric level Ulan Seam 2006 *
- Piezometric level Ulan Seam 2011 +
- Piezometric level Ulan Seam 2021 *
- Piezometric level Ulan Seam 2042 +
- Ground surface 2028
- Ground surface pre-mining

* Piezometric levels sourced from Stage 1 modelling (Dundon 2007)

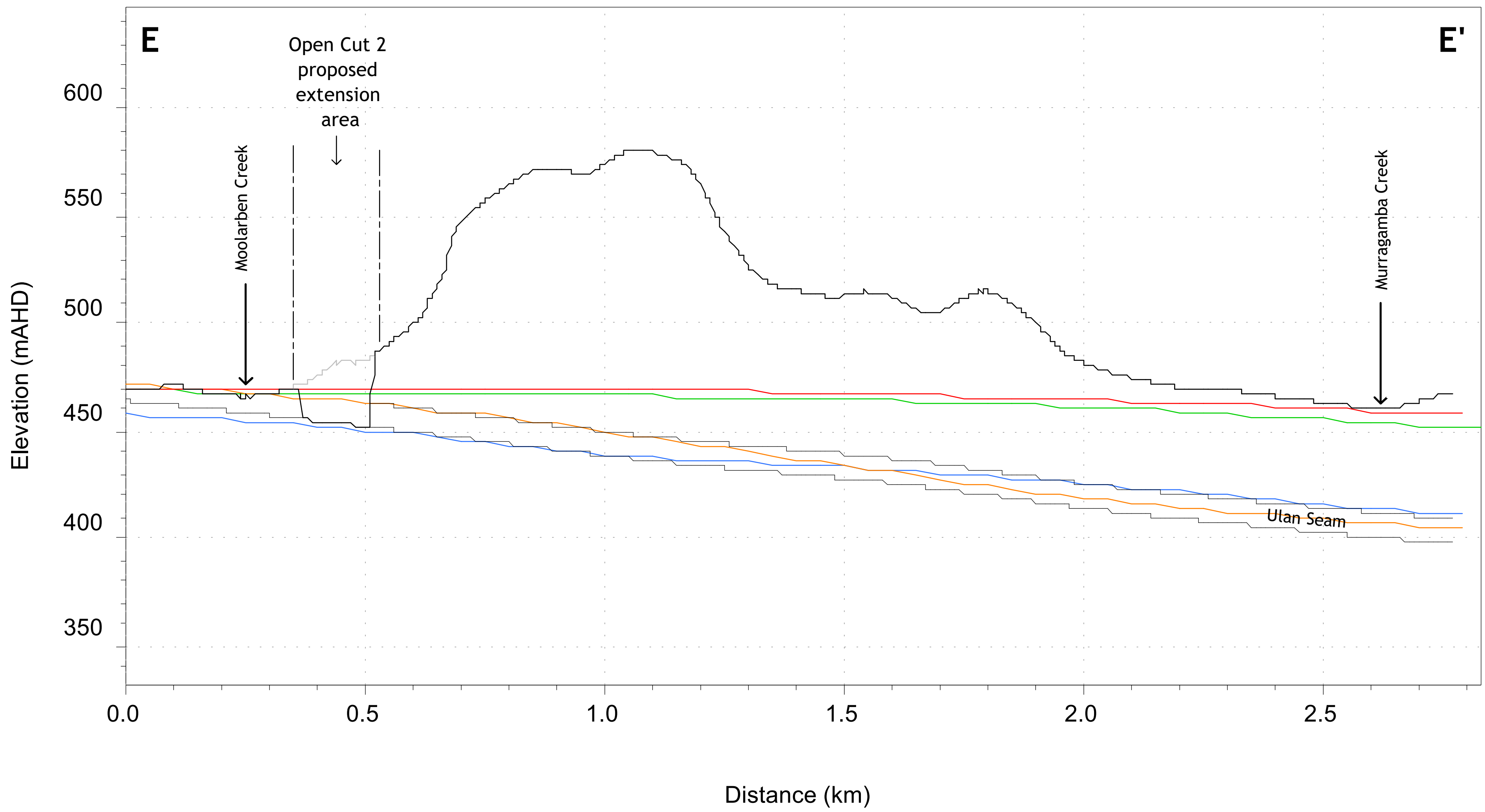
\+ Piezometric levels sourced from Stage 2 modelling (RPS Aquaterra 2011)

Moolarben Stage 1 Optimisation (G1622)

Cross section D - D' of Open Cut 2 proposed extension area

DATE: 29/4/2013

FIGURE No: **30**



LEGEND:

- Piezometric level Ulan Seam 2006 *
- Piezometric level Ulan Seam 2011 +
- Piezometric level Ulan Seam 2021 *
- Piezometric level Ulan Seam 2042 +
- Ground surface 2033
- Ground surface pre-mining

* Piezometric levels sourced from Stage 1 modelling (Dundon 2007)

\+ Piezometric levels sourced from Stage 2 modelling (RPS Aquaterra 2011)

Moolarben Stage 1 Optimisation (G1622)

Cross section E - E' of Open Cut 2 proposed extension area

DATE: 29/4/2013

FIGURE No: **31**

7.3 Impacts on Creeks and Alluvium

RPS Aquaterra (2011) predicted the Stage 2 mining will have minimal impact on the alluvium in the Goulburn River and Wilpinjong Creek, but would extend into the Moolarben Creek Valley. Both the Stage 1 and Stage 2 modelling predicted drawdown exceeding 2 m up to 700 m from Open Cut 1 in the Moolarben Creek Valley. Moolarben Creek is the stream most likely to be affected due to its close proximity to the proposed modification. The proposed modification is likely to slightly increase the extent of drawdown in the Moolarben Creek Valley.

Previous Stage 1 and Stage 2 modelling concluded that mining will have no effect on flows in Moolarben Creek due to:

- a larger proportion of the Ulan Seam being dry in this area;
- a separation distance >200 m between the proposed extension and the alluvium; and
- the presence of granite bedrock between the pit boundary and alluvium.

At its nearest point the proposed extension is 170m to the west and 300 m to the south from the mapped alluvium of Moolarben Creek (see Figure 5). Moolarben Creek is an ephemeral creek located 100 m from the proposed modification area at its closest point. Although no mapped alluvium is located at this closest point, with the creek presumed incised into weathered bedrock.

The Stage 2 modelling predicted the peak worst case loss of baseflow to Moolarben Creek would be 5.5 ML/annum. The magnitude of the impact of the proposed extension over previously simulated effects will depend on the saturated thickness of the Ulan Seam in this area, with previous modelling suggesting the saturated thickness is “thin” indicating there is a low probability of impacts propagating to alluvium and connected streams.

MCO is currently in the process of purchasing a license of 9 ML/annum to off-set impacts on the Goulburn River water source (Moolarben Creek). It is considered this license will cover any minor loss to the Goulburn River water source through reduced baseflow to Moolarben Creek from the proposed modification.

7.4 Impacts on Groundwater Dependent Ecosystems

The proposed modification will have a nil impact on the ‘The Drip’, the only significant seep/spring GDE within the locality. Stage 2 modelling predicted nil impact on the drip due to its relative distance from and limited hydraulic connection. The proposed modification will have nil change in the groundwater drawdown in the vicinity of the drip. Therefore, there will be no impact on vegetation supported by ‘The Drip’.

7.5 Impacts on Water Quality

Previous work has indicated dewatering due to pit development may reduce the volumes of baseflow to local streams. Due to the elevated TDS of groundwaters in the vicinity of the proposed modification a positive effect on the water quality in connected stream is possible. RPS Aquaterra (2011) came to a similar conclusion.

7.6 Assessment Against the Aquifer Interference Policy

7.6.1 Policy Summary

The proposed modification has been assessed against the NSW Aquifer Interference Policy (AIP) [NSW Department of Primary Industries – Office of Water 2012].

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

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

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

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

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

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

Predictions need to be carried out to assess the likely volume of water taken from a water source(s) as a result of an aquifer interference activity. These predictions need to occur prior to project approval. After project approval and during operations these volumes need to be measured and reported in annual reviews of environmental data. The water access licence must hold sufficient share component and water allocation to account for the take of water from the relevant water source at all times.

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

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

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

Highly productive aquifers are classified as TDS less than 1,500 mg/L and water supply works that can yield water at a rate greater than 5 L/sec. Less productive aquifers are classified as TDS more than 1,500 mg/L and water supply works that can yield water at a rate less than 5 L/sec.

7.7 Assessment against Policy

Based on the AIP the groundwater system impacted by the proposed modification can be separated into two systems, as follows:

- Porous and/or fractured consolidated sedimentary rock of the Permian Coal Measures and overlying Triassic sequence; and
- groundwater within alluvium associated with Moolarben Creek and Lagoon Creek.

Water quality and yields vary in both groundwater systems, but can be considered less productive aquifers[3] according to the AIP. The AIP requires that aquifer interference activities do not induce a decline of more than 2 m in the water table or water pressure at any water supply work, i.e. a bore or a well in both highly and less productive groundwater sources. No private bores are captured within the zone of drawdown indicating the Project complies with this requirement of the AIP.

To protect surface water the AIP requires “no increase of more than 1% per activity in the long term average salinity in a highly connected surface water source at the nearest point to the activity”. Dewatering due to pit development is expected to reduce the volumes of baseflow to local streams. This effectively reduces the discharges of more saline groundwaters into the streams and therefore it is considered improbable that the proposed modification would increase the stream salinity.

Water licensing under the AIP has been covered by the following:

- inflows to the proposed modification from the Permian to Triassic formations is not expected to be greater than previously simulated (refer Section 7.2.1). A current water license (20BL172300) for 150 ML/annum is held by MCO to account for groundwater inflows to pits (refer Section 7.2.3). No further water licences are necessary to account for this take according the AIP; and
- the ephemeral Moolarben Creek and the minor associated alluvium is the only water course and alluvial aquifer that requires assessment against the AIP. The Stage 2 modelling predicted the maximum take from the Moolarben Creek baseflow to be 5.5 ML/annum with a total of 7 ML/annum from the Goulburn River water supply. MCO is in the process of purchasing 9 ML/annum from the Upper Goulburn Water supply (refer Section 7.2.3). This license will account for impacts predicted for Stage 1 and Stage 2 and the proposed modification.

A Water Management Plan including a groundwater monitoring regime is implemented at the MCP. This monitoring regime discussed further in Section 8 below will be adequate to access if modelled predictions are adequate.

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[3] *Low yields and TDS on average above 1,500 mg/L.*

8.0 MANAGEMENT AND MONITORING

Groundwater impacts associated with Stage 1 operations are managed under the MCOP's WMP, developed in consultation with NOW, OEH and DP&I. The objectives of the WMP for groundwater comprise:

- a program to monitor and assess groundwater impacts;
- a process to mitigate and respond to potential impacts from mining activities on groundwater; and
- ensuring that groundwater make is stored and treated on-site and re-used as needed.

The WMP includes a Groundwater Response Plan that provides details of management response actions. The WMP and relevant sub-plans will be reviewed and updated as required to accommodate the proposed modification.

As noted, over 100 groundwater monitoring bores have been drilled and constructed during the Stage 1 and Stage 2 investigations. Monitoring commenced in February 2005 from some of the earliest constructed Stage 1 bores. Groundwater levels and water quality are currently monitored in approximately 60 bores, as shown in Figure 15.

Groundwater levels are measured manually on a monthly basis to assess trends and fluctuations within the different aquifers. Six bores are fitted with vibrating wire pressure transducers that monitor groundwater levels at multiple levels (See Figure 15 for the location of these).

The bores in the current monitoring network that are in close proximity to the proposed modification area and which intersect all relevant geological formations are indicated in Figure 15. Groundwater samples are collected quarterly from selected bores for laboratory analysis of major cations, major anions, nutrients and heavy metals.

The current monitoring regime of groundwater levels and water quality is considered sufficient to monitor the effects of the proposed modification.

9.0 CONCLUSIONS

Mine inflows for the majority of the proposed modification are likely to be within the range predicted for Stage 1 and Stage 2. A large proportion of the proposed extension area is within landscapes that are “dry” or contain limited saturated thickness of groundwater above the base of the Ulan Seam.

Based on Stage 2 model predictions (which includes Stage 1), inflows into the proposed extension areas for the indicative Year 2 mine plan will be 220 m^3/day. As Open Cut 1 advances further down-dip to the north-east, as per the indicative Year 6 open cut mine plan, inflows will increase progressively to 413 m^3/day. Inflows for indicative open cut mine Year 11 to Year 16 as the pit extends to Open Cut 2 are estimated from Stage 2 predictions to be 58 m^3/day to 27 m^3/day. As pits will be progressively backfilled, no increase is expected in pit inflows, rather a continuation of inflows at previously modelled inflow rates.

MCO holds licences under Part 5 Water Act 1912 which entitle MCO to take the following volumes of groundwater from the Permian formations (ie non Water Storage Plan managed water sources):

- up to 150 ML/ year mine dewatering water licence. This licensed amount equates to the maximum predicted inflows from the latest Stage 2 modelling (RPS Aquaterrra 2011). This license currently applies to Open Cut 1 only; and
- 2,850 ML/ year from the southern and northern borefields.

It is noted that maximum pit inflows simulated from Stage 2 modelling include Stage 1.

Minor changes are expected to the piezometric levels in response to the proposed modification, although these are anticipated to be within the margin of error for the current numerical models. A small increase is expected in the area of 2 m drawdown in alluvium associated with Moolarben Creek.

Licence allocations on Water Sharing Plan water sources are being finalised for the Stage 2 application. The purchase of a water license for 218 ML/year from the Wollar Creek water source has recently been finalised. MCO is in the process of purchasing a water licence for 9 ML/year from the Goulburn River water source to account for predicted reductions in baseflow as a result of Stage 1 and Stage 2 operations on this water source. Stage 2 modelling simulated an impact on the water source at a maximum of 7 ML/year with the additional 2 ML/year accounting for security of supply and minor increases in baseflow reduction due to the proposed modification.

Based on the Aquifer Interference Policy (AIP) the groundwater system impacted by the proposed modification can be separated into two systems, as follows:

- porous and/or fractured consolidated sedimentary rock of the Permian Coal Measures and overlying Triassic sequence; and
- groundwater within alluvium associated with Moolarben Creek and Lagoon Creek.

Water quality and yields vary in both groundwater systems, but can be considered less productive aquifers[4] according to the AIP. The AIP requires that aquifer interference activities do not induce a decline of more than 2 m in the water table or water pressure at any water supply work, i.e. a bore or a well in both highly and less productive groundwater sources. No private bores are captured within the zone of drawdown indicating the Project complies with this requirement of the AIP.

To protect surface water the AIP requires “no increase of more than 1% per activity in the long term average salinity in a highly connected surface water source at the nearest point to the activity”. Dewatering due to pit development is expected to reduce the volumes of baseflow to local streams.

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[4] *Low yields and TDS on average above 1,500 mg/L.*

This effectively reduces the discharges of more saline groundwaters into the streams and therefore it is considered improbable that the proposed modification would increase the stream salinity.

The current monitoring regime of groundwater levels and water quality are sufficient to monitor the effects of the proposed extension. Any noticeable change in pit inflows over those previously modelled will be recorded by MCO.

10.0 REFERENCES

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AUSTRALASIAN GROUNDWATER AND ENVIRONMENTAL CONSULTANTS PTY LTD

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Principal Hydrogeologist

Appendix 1

BORE SEARCH FROM THE NOW DATABASE

Reg No	Licence	Type	Owner	Completed	Depth	Drilled depth	County	Parish	SWL	Salinity	Comment	Yield	Comment	Easting MGA	Northing MGA	Lat	Long
GW007093	80BL001807	Bore open thru rock	Private	1/07/1945	54.8	54.9	BLIGH	UARBRY			(Unknown)			750611	6444642	32.10676	149.6559
GW011258	20BL004326	Bore	Private	1/09/1955	99.8	99.8	PHILLIP	WOLLAR			Brackish			777037	6414094	32.37556	149.9444
GW021748		Bore	Private		89.9		BLIGH	TOMIMBIL			Fresh			778315	6442564	32.11899	149.9498
GW023206	80BL015694	Well	Private		6		PHILLIP	COOYAL			(Unknown)			756284	6410749	32.41083	149.725
GW023207	80BL015695	Well	Private		10.3	10.7	PHILLIP	COOYAL			(Unknown)			756061	6410269	32.41528	149.7228
GW023209	80BL015696	Well	Private		7.6	7.6	PHILLIP	COOYAL			(Unknown)			756814	6409845	32.41889	149.7308
GW026331	80BL019050	Bore	Private	1/04/1966	42.6	42.7	PHILLIP	WIALDRA			(Unknown)			749388	6410056	32.41871	149.652
GW026446	80BL019402	(Unknown)	Private	1/02/1967	56.3	56.4	PHILLIP	COOYAL			501-1000 ppm			758867	6406770	32.44611	149.7536
GW026904	80BL019895	Bore open thru rock	Private	1/04/1966	39.6	39.6	PHILLIP	COOYAL			Good			756190	6409330	32.42361	149.7244
GW026959	80BL018522	Bore	Private	1/05/1966	48.7	48.8	PHILLIP	BAYLY			(Unknown)			760004	6406006	32.45278	149.7658
GW028799	80BL022787	Well	Private	1/04/1968	2.4	2.4	PHILLIP	WIALDRA			(Unknown)			749393	6415512	32.36954	149.6506
GW029043	80BL022325	Bore	Private		73.1	73.2	PHILLIP	BAYLY			Good			760547	6405400	32.45806	149.7719
GW029543	20BL023549	Bore	Private	1/02/1968	11.8	18	PHILLIP	FITZGERALD						777212	6405589	32.45222	149.9489
GW031201	80BL022177	Bore	Private	1/01/1968	50.2	50.3	PHILLIP	BAYLY			Good			759418	6405093	32.46111	149.76
GW031301	70BL024287	Bore	Private	1/03/1968	24.6	24.7	PHILLIP	WIALDRA			(Unknown)			749025	6419683	32.33204	149.6456
GW033070	80BL025910	Excavation	Private		3.9		BLIGH	MUNMURRA			Stock			776430	6434872	32.18861	149.9319
GW033071	80BL025912	Well	Private		3.6		BLIGH	MUNMURRA			0-500 ppm			776369	6435007	32.1875	149.9314
GW033072	80BL025911	Well	Private		6		BLIGH	MUNMURRA			1001-3000 ppm			776553	6435062	32.18694	149.9333
GW037817	80BL031019	Bore	Private	1/05/1974	34.7	34.7	PHILLIP	BAYLY			Good			758812	6405008	32.46194	149.7536
GW042766	80BL101929	Bore open thru rock	Private	1/05/1976	33.5	33.5	PHILLIP	BAYLY			1001-3000 ppm			758390	6405130	32.46083	149.7489
GW043914	80BL100507	Bore	Private	1/08/1974	25.6	25.6	BLIGH	BUNGABA			(Unknown)			749038	6436142	32.18371	149.6414
GW043929	80BL101945	Bore open thru rock	Private	1/03/1975	45.7	45.7	PHILLIP	COOYAL	8.5		501-1000 ppm			755664	6408960	32.42706	149.7199
GW045626	80BL104997	Bore	Private	1/12/1976	22.5	23	PHILLIP	COOYAL			(Unknown)			759304	6406609	32.4475	149.7583
GW047036	80BL104861	Bore	Private	1/12/1977	40	40	PHILLIP	COOYAL			(Unknown)			759844	6406717	32.44639	149.7639
GW047685	80BL111647	Bore open thru rock	Private	1/07/1980	61	61	BLIGH	COPE			Good			749030	6423073	32.30149	149.6448
GW047685	80BL111647	Bore open thru rock	Private	1/07/1980	61	61	BLIGH	COPE			Good			749030	6423073	32.30149	149.6448

Reg No	Licence	Type	Owner	Completed	Depth	Drilled depth	County	Parish	SWL	Salinity	Comment	Yield	Comment	Easting MGA	Northing MGA	Lat	Long
GW048581	80BL108387	Bore	Private	1/05/1978	61	61	PHILLIP	COOYAL			(Unknown)			757286	6407997	32.43528	149.7364
GW048604	80BL108824	Bore	Private	1/09/1978	18	25	BLIGH	BUNGABA			Good			750067	6436425	32.18093	149.6523
GW051150	20BL113573	Bore open thru rock	Private	1/07/1980	31.3	31.3	PHILLIP	WOLLAR			Fresh			778750	6416130	32.35694	149.9622
GW051252	20BL111924	Bore open thru rock	Private	1/06/1980	33.5	33.5	PHILLIP	WOLLAR			Fresh			777355	6415774	32.36056	149.9475
GW051582	20BL111698	Bore	Private	1/03/1980	38.1	38.1	PHILLIP	WOLLAR			Poor			777481	6415887	32.35944	149.9486
GW051694	80BL113019	Bore open thru rock	Private	1/07/1980	74.7	74.7	PHILLIP	COOYAL			Good			756990	6407180	32.44278	149.7336
GW051718	80BL106359	Bore	Private	1/05/1977	48	48	PHILLIP	COOYAL			(Unknown)			757050	6407850	32.43667	149.7339
GW052150	80BL113300	Bore	Private	1/01/1981	20.9	20.9	PHILLIP	BAYLY			Fresh			758510	6405680	32.45583	149.75
GW052937	20BL112342	Bore open thru rock	Private	1/04/1980	42.7	42.7	PHILLIP	WOLLAR			Fresh			777610	6416668	32.35194	149.9706
GW053260	20BL119252	Well	Private		6.8		PHILLIP	FITZGERALD			(Unknown)			779950	6406780	32.44083	149.9775
GW053265	20BL119251	Well	Private		5.2		PHILLIP	FITZGERALD			(Unknown)			779880	6406800	32.44083	149.9769
GW053687	80BL134207	Bore	Private	1/02/1983	62	62	PHILLIP	WIALDRA			Fresh			749311	6419583	32.33288	149.6487
GW053687	80BL134207	Bore	Private	1/02/1983	62	62	PHILLIP	WIALDRA			Fresh			749311	6419583	32.33288	149.6487
GW054176	80BL113777	Bore	Private		35.7		PHILLIP	COOYAL			(Unknown)			760015	6409400	32.42222	149.765
GW054254	20BL114935	Bore	Private	1/06/1980	35.1	35.1	PHILLIP	WOLLAR			(Unknown)			778690	6417680	32.34306	149.9611
GW054498	20BL116298	Bore	Private	1/09/1981	18.3	18.3	PHILLIP	FITZGERALD			Good			777320	6405740	32.45083	149.95
GW054519	80BL116356	Bore open thru rock	Private	1/03/1981	46.3	46.3	PHILLIP	PRICE			Good			767950	6405200	32.45806	149.8506
GW054759	80BL117670	Bore	Private	1/06/1981	42.7	42.7	PHILLIP	BAYLY			Good			757575	6405460	32.45806	149.7403
GW055472	20BL120585	Bore open thru rock	Private	1/09/1981	91.5	91.5	BLIGH	BOBADEEN			Good			767090	6440738	32.13815	149.8314
GW055515	80BL120656	Bore open thru rock	Private	1/07/1981	61	61	PHILLIP	COOYAL			Fresh			755300	6406950	32.44528	149.7156
GW056057		Bore	Private	1/02/1981	54.6	54.6	PHILLIP	WOLLAR			(Unknown)			778350	6414110	32.37528	149.9583
GW057032	80BL124602	Bore	Private	1/05/1983	18.2	18.2	PHILLIP	COOYAL			(Unknown)			757180	6406100	32.4525	149.7358
GW057528	80BL125783	Bore	Private	1/06/1983	42.6	42.6	PHILLIP	COOYAL			Potable			756310	6406440	32.44972	149.7264
GW059029	80BL116773	Bore	Private	1/01/1981	44	44	PHILLIP	COOYAL			(Unknown)			759615	6406700	32.44639	149.7617
GW059030		Bore	Private	1/01/1981	45.8	45.8	PHILLIP	COOYAL			(Unknown)			759650	6406875	32.445	149.7619
GW059559	20BL131333	Bore	Private	1/07/1984	36.6		PHILLIP	WOLLAR			3001-7000 ppm			777561	6415829	32.36	149.9494

Reg No	Licence	Type	Owner	Completed	Depth	Drilled depth	County	Parish	SWL	Salinity	Comment	Yield	Comment	Easting MGA	Northing MGA	Lat	Long
GW060802		Bore	Private	1/04/1985	45.7		PHILLIP	COOYAL			(Unknown)			755150	6406775	32.44694	149.7142
GW060803		Bore	Private	1/04/1985	53.3		PHILLIP	COOYAL			(Unknown)			755180	6406860	32.44611	149.7144
GW060804	80BL132260	Bore	Private	1/04/1985	45.7	45.7	PHILLIP	COOYAL			(Unknown)			755250	6406820	32.44639	149.715
GW061459	80BL133882	Bore	Private	1/01/1986	23.1	23.1	PHILLIP	BAYLY			Fresh			757500	6405300	32.45972	149.7394
GW061480	80BL133931	Bore	Private	1/02/1986	18.5	18.5	PHILLIP	COOYAL			Fresh			755845	6406325	32.45083	149.7217
GW061514	80BL134032	Bore	Private	1/01/1980	51.8		PHILLIP	BAYLY			(Unknown)			757170	6405070	32.46167	149.7361
GW062319	80BL137662	Bore	Private	1/06/1988	46.2	46.2	PHILLIP	BAYLY		710.4	Fresh			758690	6405440	32.45806	149.7519
GW062319	80BL137662	Bore	Private	1/06/1988	46.2	46.2	PHILLIP	BAYLY		710.4	Fresh			758690	6405440	32.45806	149.7519
GW062806		Bore	Private	1/06/1986	67	67	PHILLIP	WIALDRA			(Unknown)			749260	6415423	32.37038	149.6492
GW065222		Bore	Private	24/08/1989	36.5		BLIGH	UARBRY			Good			758737	6444376	32.10732	149.742
GW066420	20BL143078						PHILLIP	WOLLAR						779320	6416330	32.355	149.9681
GW066711	20BL143246						BLIGH	BOBADEEN						765593	6440654	32.13926	149.8156
GW070892	80BL152297	Bore		12/05/1993	47.2	47.2	PHILLIP	BAYLY			Good			761877	6405412	32.4575	149.7858
GW070937	80BL152298	Bore	Private	16/05/1993	57	57	PHILLIP	BAYLY			Good			761100	6405600	32.45607	149.7786
GW078130		Well	Private		4		PHILLIP	CUMBO						770535	6411152	32.40389	149.8764
GW078159		Well	Private		5		PHILLIP	CUMBO						770125	6409988	32.41444	149.8722
GW078162		Well	Private		6		PHILLIP	CUMBO						769880	6409095	32.4225	149.87
GW078189		Well	Private				PHILLIP	WOLLAR						777764	6416596	32.35306	149.9514
GW078206		Bore	Private				PHILLIP	CUMBO						777385	6415858	32.35972	149.9478
GW078212		Well	Private				PHILLIP	WOLLAR						777707	6416655	32.35245	149.9509
GW078225		Bore	Private				PHILLIP	WOLLAR						777604	6416506	32.35382	149.9498
GW078231		Well	Private				PHILLIP	FITZGERALD						778828	6408978	32.42134	149.965
GW078542	20BL166952	Bore		16/09/1997	72	72	BLIGH	DURRIDGERE						775529	6433668	32.19972	149.9219
GW080105		Bore		1/02/1993	4.5		BLIGH	MUNMURRA	1.1	5875				776530	6436724	32.17194	149.9317
GW080106		Bore		1/02/1993	4.5		BLIGH	MUNMURRA	1	2368				776633	6436629	32.17278	149.9328
GW080107		Bore		1/02/1993	7.5		BLIGH	DURRIDGERE	2.3	12672				776070	6436809	32.17128	149.9276
GW080108		Bore		1/02/1993	4.5		BLIGH	DURRIDGERE	2.5	7462				775758	6436283	32.17611	149.9236
GW080109		Bore		1/02/1993	3		BLIGH	DURRIDGERE	1.4	7840				775758	6436283	32.17611	149.9236
GW080110		Bore		1/02/1993	5.5		BLIGH	DURRIDGERE						775855	6436002	32.17861	149.9247
GW080113		Bore		1/02/1993	4.5		BLIGH	DURRIDGERE	2.3	2560				775155	6435343	32.18472	149.9175
GW080114		Bore		1/02/1993	4		BLIGH	DURRIDGERE	2.4	2675				775155	6435343	32.18472	149.9175
GW080120		Well	Private				PHILLIP	CUMBO						770880	6410781	32.40705	149.8801
GW080121		Bore	Private				PHILLIP	WOLLAR						777903	6418897	32.33221	149.9523

Reg No	Licence	Type	Owner	Completed	Depth	Drilled depth	County	Parish	SWL	Salinity	Comment	Yield	Comment	Easting MGA	Northing MGA	Lat	Long
GW080122		Well	Private				PHILLIP	WOLLAR						778054	6418653	32.33437	149.954
GW080123		Well	Private				PHILLIP	WOLLAR						778115	6418310	32.33744	149.9547
GW080125		Well	Private				PHILLIP	WOLLAR						777521	6414383	32.37297	149.9496
GW080127		Well	Private				PHILLIP	WOLLAR						777810	6415503	32.36281	149.9523
GW080128		Well	Private				Northumberland	ROTHBURY						771830	6416072	32.35926	149.8887
GW080135		Bore	Private		20		BLIGH	BOBADEEN						767004	6440831	32.13734	149.8305
GW080412		Bore	Landcare	9/01/2003	6	6	PHILLIP	CUMBO						778116	6417714	32.34281	149.9549
GW080413		Bore	Landcare	9/01/2003	8.5	8.5	PHILLIP	CUMBO	5.6	1300				778096	6417643	32.34346	149.9547
GW200575	20BL168100	Bore	Mines	4/03/2003	2.5	2.5	BLIGH	BOBADEEN						756363	6439535	32.15149	149.7182
GW200576	20BL168100	Bore	Mines	4/03/2003	4	4	BLIGH	BOBADEEN						756113	6439185	32.1547	149.7156
GW200577	20BL168100	Bore	Mines	4/03/2003	7.3	7.3	BLIGH	BOBADEEN						756713	6440085	32.14646	149.7217
GW200578	20BL168100	Bore	Mines	4/03/2003	2.6	2.6	BLIGH	BOBADEEN						757213	6439385	32.15265	149.7272
GW200579	20BL168100	Bore	Mines	5/03/2003	11.5	11.5	BLIGH	BOBADEEN						758863	6438085	32.16399	149.745
GW200580	20BL168100	Bore	Mines	4/03/2003	7.5	7.5	BLIGH	BOBADEEN	5.8					757663	6437635	32.16832	149.7324
GW200581	20BL168100	Bore	Mines	5/03/2003	3.5	3.5	BLIGH	BOBADEEN						758113	6437885	32.16596	149.7371
GW200582	20BL168100	Bore	Mines	5/03/2003	1	1	BLIGH	BOBADEEN						760013	6434785	32.19346	149.7581
GW200583	20BL168100	Bore	Mines	4/03/2003	2.7	2.7	BLIGH	BOBADEEN						759063	6435485	32.18737	149.7479
GW200657	20BL167090	Bore	Private	31/12/1987	30		PHILLIP	MOOLARBEN				15		763775	6415996	32.36188	149.8032
GW800067	80BL144679	Bore	Private	30/11/1991	90	90	PHILLIP	WIALDRA			Good			749125	6419495	32.33371	149.6467
GW800069	80BL144784	Bore	Private	30/11/1991	43	43	PHILLIP	WIALDRA			Good			749201	6419370	32.33482	149.6476
GW800273	80BL236739	Bore	Private	5/12/1995	48.7	48.7	PHILLIP	PRICE			Good			764100	6405850	32.45306	149.8094
GW800714	80BL236792	Bore	Private	11/09/1995	63	63	BLIGH	BUNGABA						749638	6430634	32.23322	149.6492
GW800759	80BL236221	Bore	Private	21/10/1994	52.5	52.5	PHILLIP	COOYAL			Good			759700	6406800	32.44559	149.7624
GW801199	80BL236002	Bore	Private	1/01/1994			PHILLIP	BAYLY						756846	6405418	32.45861	149.7325
GW801199	80BL236002	Bore	Private	1/01/1994			PHILLIP	BAYLY						756846	6405418	32.45861	149.7325
GW801611	80BL239881	Bore	Private	1/08/2002	24	24	PHILLIP	COOYAL						759905	6407240	32.44157	149.7645
GW801625	80BL237200	Bore	Private	21/09/1996	39	39	BLIGH	BLIGH	6		(Unknown)	3.8	Cumulative	753743	6443344	32.11776	149.6894
GW801903	80BL238245	Bore	Private	24/08/1998	70	70	PHILLIP	BAYLY						758906	6405720	32.45561	149.7543
GW802179	80BL237593	Bore	Private	31/12/1997	61		PHILLIP	COOYAL	9.1		Good	25.2		758875	6406760	32.44614	149.7537
GW802243	80BL242395	Bore	Private	28/09/2004	64		PHILLIP	WIALDRA						749433	6419694	32.33185	149.6499
GW802400	80BL140043	Bore	Private	22/08/1989	46.3	46.3	PHILLIP	BAYLY	21.9		Fresh	6.3		758835	6405005	32.46196	149.7537
GW802481	80BL239880	Bore	Private	2/08/2002	48	48	PHILLIP	BAYLY	15		(Unknown)	0.1		760566	6405206	32.45976	149.7713
GW802987	80BL236858	Bore	Private	30/07/1995	64	64	PHILLIP	PRICE	21.3		S.Brackish	0.2		768298	6405445	32.45587	149.8542

Reg No	Licence	Type	Owner	Completed	Depth	Drilled depth	County	Parish	SWL	Salinity	Comment	Yield	Comment	Easting MGA	Northing MGA	Lat	Long
GW803062	80BL243230	Bore	Private	27/02/2006	21	21	BLIGH	UARBRY	9			1.5	Cumulative	750973	6443455	32.11738	149.66
GW803063	80BL243231	Bore	Private	23/02/2006	15	15	BLIGH	UARBRY	8.5			0.5		751673	6443295	32.11867	149.6675
GW803064	80BL243232	Bore	Private	21/02/2006	25	25	BLIGH	NANDOURA						754593	6444900	32.10355	149.698
GW803065	80BL243233	Bore	Private	22/02/2006	14	14	BLIGH	NANDOURA						754088	6444270	32.10934	149.6928
GW803072	80BL243297	Well	Private	16/06/1961	5		PHILLIP	EURUNDURY	3					750023	6406300	32.45242	149.6597
GW803074	80BL243298	Well	Private	16/03/1837	10		PHILLIP	WIALDRA	4					750403	6406555	32.45004	149.6637
GW803076	80BL243299	Well	Private	30/03/1961	10		PHILLIP	WIALDRA	4					750528	6406250	32.45276	149.6651
GW803147	80BL243472	Bore	Private	9/08/2006	73		PHILLIP	WIALDRA						750189	6417455	32.35186	149.6585
GW803209	80BL243227	Bore	Private	7/06/2006	43	43	PHILLIP	COOYAL	19			0.8		753719	6410619	32.41266	149.6979
GW803230	80BL241941	Bore	Private	10/12/2003	40	40	PHILLIP	WIALDRA	16			0.1	Cumulative	751046	6417957	32.34714	149.6675
GW803350	80BL243672	Bore	Private	23/12/2006	90	90	PHILLIP	COOYAL	7			1	Cumulative	757423	6406455	32.44933	149.7383
GW803438	80BL244260	Bore	Private	30/04/2007	57	57	PHILLIP	WIALDRA	28			0.1		752997	6418758	32.33948	149.688

Appendix 2

MONITORING BORE CONSTRUCTION DETAILS

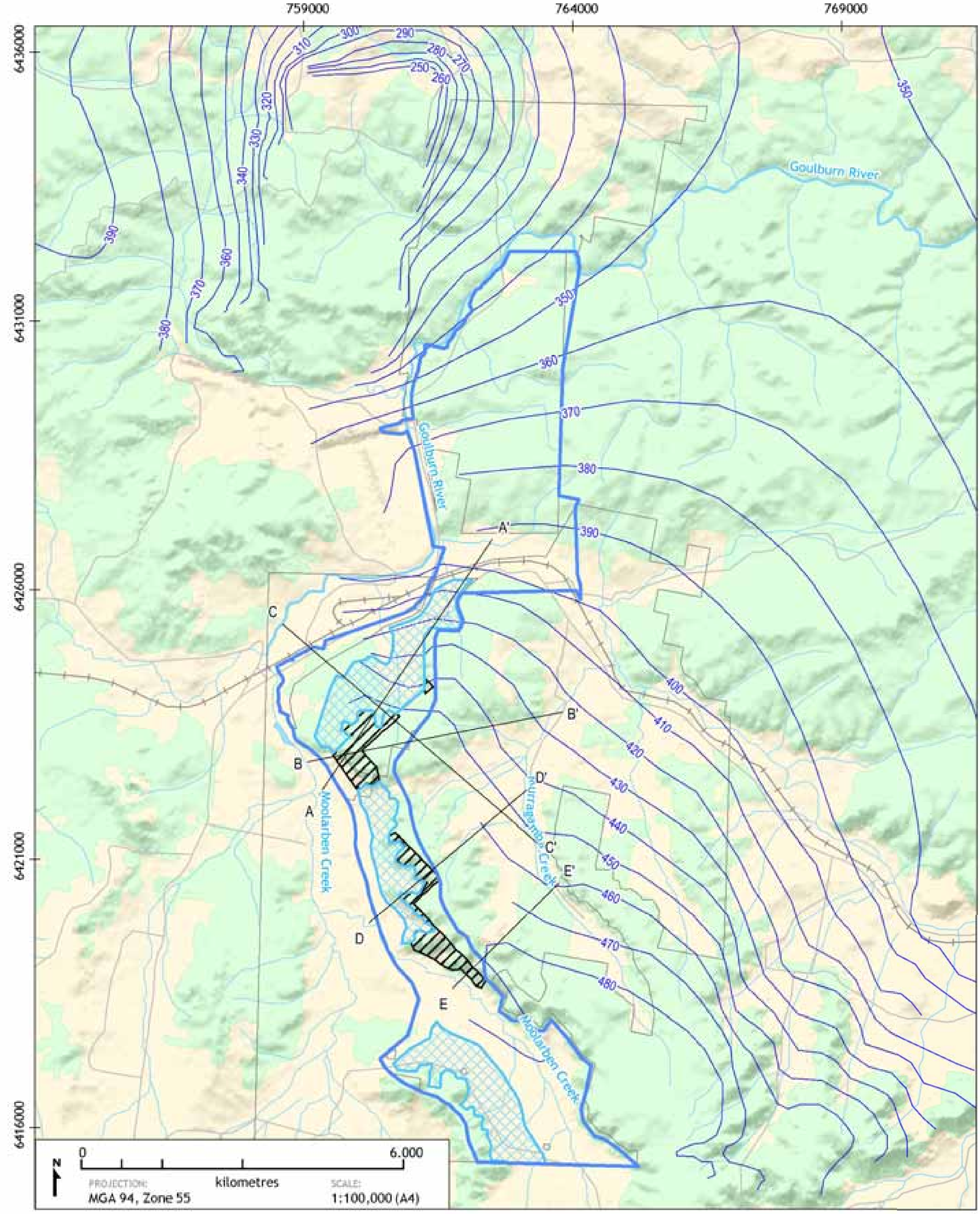
Bore Number	Easting	Northing	Formation Monitored	TOC (mAHD)	GL (mAHD)	Currently Monitored	Bore Type	Use for this Study
OB01	762750	6415400	-	-	-	No	Standpipe	
OB02	763818	6415647	-	495.046	-	No	Standpipe	
OB03	762806	6417649	-	480.082	479.761	Yes	Standpipe	yes
OB04	762300	6418300	-	-	-	Yes	Standpipe	yes
PZ101A	762655	6431452	Bore abandoned due to casing collapse	403.465	402.418	No	Standpipe	
PZ101B	762646	6431445	Lower Permian	403.28	402.59	Yes	Standpipe	
PZ101C	762646	6431446	Lower Triassic	403	402	Yes	Standpipe	
PZ102A	761118	6429150	Marrangaroo Formation	408.54	408.03	Yes	Standpipe	
PZ102B	761117	6429147	Ulan Seam	408.23	407.77	Yes	Standpipe	
PZ103A	762410	6429261	Ulan Seam	425.21	425.12	Yes	Standpipe	
PZ103B	762397	6429264	Lower Permian	425	424.85	Yes	Standpipe	
PZ103C	762397	6429264	Lower Triassic	425	424	Yes	Standpipe	
PZ105A	763988	6431610	Lower Permian	388.93	388.49	Yes	Standpipe	
PZ105B	763987	6431607	Upper / Middle Permian	389.05	388.74	Yes	Standpipe	
PZ105C	763986	6431606		389	388	Yes	Standpipe	
PZ106A	765128	6418275	Lower Permian	510.69	510.49	Yes	Standpipe	
PZ106B	765124	6418279	Upper / Middle Permian	510.91	510.72	Yes	Standpipe	
PZ107	762813	6419869	Ulan Seam	499.36	499	Yes	Standpipe	yes
PZ108R	763134	6434793	Ulan Seam	419.46	419.37	Yes	Standpipe	
PZ109	766123	6435558	Lower Permian	437.12	436.98	Yes	Standpipe	
PZ110	762002	6427216	Ulan/Shoalhaven Group	428.72	728.39	No	Standpipe	
PZ111	767082	6423096	Ulan Seam	404.78	404.55	Yes	Standpipe	
PZ112A	766137	6419519	Ulan Seam	485.64	485.4	No	Standpipe	
PZ112B	766139	6419517	Quaternary / Tertiary Alluvium	485.67	485.29	Yes	Standpipe	
PZ124	763476	6426649	Tertiary Palaeochannel	-	437.51	No	Standpipe	
PZ125	7761864	6426521	Quaternary / Tertiary Alluvium	-	422.488	No	Standpipe	
PZ126	-	-	Bore not completed – collapsing ground	-	-	No	Standpipe	
PZ127	762799	6424948	Completed as multi-level vibrating wire	494.55	494.22	No	VWP	
PZ128	763227	6432120	Completed as multi-level vibrating wire	409.52	409.18	No	VWP	
PZ129	763624	6432251	Completed as multi-level vibrating wire	417.95	417.55	No	VWP	
PZ130	760940	6422438	Completed as multi-level vibrating wire	535.07	534.79	No	VWP	
PZ131	763668	6422406	Upper / Middle Permian	454.71	454.42	Yes	Standpipe	yes
PZ132	763671	6422405	Upper / Middle Permian	454.79	454.53	No	Standpipe	
PZ133	763468	6422445	Completed as multi-level vibrating wire	447.61	447.26	No	VWP	
PZ134	763468	6422445	Upper / Middle Permian	447.56	447.09	Yes	Standpipe	yes
PZ135	763464	6422445	Upper / Middle Permian	439.45	438.99	No	Standpipe	
PZ136	763290	6422480	Upper / Middle Permian	439.25	438.9	No	Standpipe	
PZ137	763286	6422481	Upper / Middle Permian	479.01	478.67	Yes	Standpipe	yes
PZ138	764002	6420285	Upper / Middle Permian	486.17	485.73	No	Standpipe	
PZ139	762604	6420386	Ulan Seam	476.2	475.58	No	Standpipe	
PZ140	762941	6420371	Lower Permian	482.45	482.11	No	Standpipe	

Bore Number	Easting	Northing	Formation Monitored	TOC (mAHD)	GL (mAHD)	Currently Monitored	Bore Type	Use for this Study
PZ141	762783	6420385	Lower Permian	467.52	467.18	Yes	Standpipe	yes
PZ142	-	-	Backfilled	-	-	No	Standpipe	
PZ143	763397	6420306	Lower Permian	464.08	463.75	No	Standpipe	
PZ144	763769	6420209	Lower Permian	467.37	466.99	No	Standpipe	
PZ145	763398	6420314	Lower Permian	463.88	463.54	No	Standpipe	
PZ146	762617	6420387	Upper / Middle Permian	485.85	485.54	No	Standpipe	
PZ147	762792	6420383	Lower Permian	482.25	481.89	No	Standpipe	
PZ148	762941	6420380	Lower Permian	475.68	475.34	No	Standpipe	
PZ149	763994	6420281	Upper / Middle Permian	478.23	477.9	Yes	Standpipe	
PZ150	765785	6421570	Ulan Seam	452.25	451.75	Yes	Standpipe	
PZ151	764825	6421712	Ulan Seam	444.97	444.38	Yes	Standpipe	
PZ152	765789	6421563	Upper / Middle Permian	452.78	452.27	Yes	Standpipe	
PZ153	763776	6420213	Regolith / Surficial	467.47	466.76	No	Standpipe	
PZ154	762612	6420380	Upper / Middle Permian	486.23	485.87	No	Standpipe	
PZ155	763474	6422443	Upper / Middle Permian	447.87	447.56	Yes	Standpipe	yes
PZ156	763289	6426194	Ulan Seam	456.22	455.73	Yes	Standpipe	yes
PZ157	763825	6425391	Ulan Seam	446.55	446.05	Yes	Standpipe	yes
PZ158	763671	6422405	Regolith / Surficial	454.74	454.41	No	Standpipe	
PZ159	763668	6422406	Upper / Middle Permian	454.68	454.39	No	Standpipe	
PZ160	763474	6422443	Upper / Middle Permian	447.88	447.59	No	Standpipe	
PZ161	763468	6422445	Regolith / Surficial	447.59	447.25	No	Standpipe	
PZ162	763291	6422480	Upper / Middle Permian	439.39	439.02	No	Standpipe	
PZ163	763286	6422481	Regolith / Surficial	439.25	438.8	No	Standpipe	
PZ164	762990	6422548	Upper / Middle Permian	441.64	441.21	Yes	Standpipe	yes
PZ165	762993	6422547	Regolith / Surficial	441.68	441.23	Yes	Standpipe	yes
PZ166	762865	6422751	Regolith / Surficial (Palaeochannel)	439.74	439.32	No	Standpipe	
PZ167	762862	6422752	Regolith / Surficial (Palaeochannel)	439.72	439.41	No	Standpipe	
PZ168	763431	6424356	Upper / Middle Permian	451.63	451.17	Yes	Standpipe	yes
PZ169	763432	6424360	Regolith / Surficial	451.36	450.94	No	Standpipe	
PZ17	760774	6419352	Blackmans Flat Fm (below Ulan Seam)	472.154	15	No	Standpipe	
PZ170	763591	6424306	Upper / Middle Permian	437.49	437.08	Yes	Standpipe	yes
PZ171	763595	6424306	Upper / Middle Permian	437.24	436.86	No	Standpipe	
PZ172	763779	6424266	Upper / Middle Permian	429.57	429.1	Yes	Standpipe	yes
PZ173	763782	6424266	Regolith / Surficial	429.38	428.99	Yes	Standpipe	yes
PZ174	763927	6424235	Upper / Middle Permian	425.3	424.89	Yes	Standpipe	yes
PZ175	763932	6424234	Regolith / Surficial	425.03	424.61	Yes	Standpipe	yes
PZ176	764065	6424208	Upper / Middle Permian	419.79	419.47	Yes	Standpipe	yes
PZ177	764067	6424212	Regolith / Surficial	419.66	419.39	Yes	Standpipe	yes
PZ178	-	-	Bore not completed (Backfilled)	-	-	No	Standpipe	
PZ179	764688	6426591	Completed as multi-level vibrating wire	443.09	442.4	Yes	VWP	
PZ18	760088	6422136	Ulan Seam and sediments below	456.843	15	Yes	Standpipe	yes
PZ180	764361	6423759	Tertiary palaeochannel (backfilled to 15m)	433.74	433.15	No	Standpipe	

Bore Number	Easting	Northing	Formation Monitored	TOC (mAHD)	GL (mAHD)	Currently Monitored	Bore Type	Use for this Study
PZ181	763915	6423447	Quaternary / Tertiary alluvium (backfilled to 25m)	435.06	434.55	Yes	Standpipe	yes
PZ182	763834	6423174	Tertiary palaeochannel (backfilled to 15m)	439.33	438.77	No	Standpipe	
PZ183	764972	6422157	Upper Permian (backfilled to 10.5m)	433.05	432.33	No	Standpipe	
PZ184	765411	6423142	Quaternary / Tertiary alluvium /Palaeochannel (backfilled to 10m)	419.4	418.85	Yes	Standpipe	
PZ185	765945	6423452	Quaternary / Tertiary alluvium /Palaeochannel (backfilled to 15m)	421.99	421.36	No	Standpipe	
PZ3	762714	6417964	Ulan Seam	474.918	474.592	Yes	Standpipe	yes
PZ30	760008	6424853	Marrangaroo Conglomerate (below Ulan Seam)	432.928	432.928	No	Standpipe	
PZ31A	759547	6423723	Marrangaroo Conglomerate (below Ulan Seam)	456.794	456.794	No	Standpipe	
PZ39	763832	6424259	Lower Permian	428.385	428.101	Yes	Standpipe	yes
PZ4	762251	6416655	Ulan Seam	517.398	517.087	Yes	Standpipe	
PZ40A	763929	6423745	Lower Permian	-	428.27	No	Standpipe	
PZ40B	763928	6423743	Lower Permian	-	428.404	Yes	Standpipe	yes
PZ41A	763518	6423254	Marrangaroo Conglomerate and Sandstone (below Ulan Seam)	-	432.595	No	Standpipe	
PZ41B	763523	6423258	Ulan Seam	-	432.773	No	Standpipe	
PZ43A	760458	6417102	Marrangaroo Conglomerate (below Ulan Seam)	-	510.408	Yes	Standpipe	
PZ43B	760456	6417102	Shoalhaven Group	-	510.385	Yes	Standpipe	
PZ44	759906	6417069	Ulan Granite	-	491.3	Yes	Standpipe	
PZ50A	762532	6422848	Ulan Seam	449.758	449.468	Yes	Standpipe	yes
PZ50B	762531	6422848	Lower Permian	449.871	449.544	Yes	Standpipe	yes
PZ50C	762530	6422848	Alluvium	449.632	449.492	Yes	Standpipe	yes
PZ52	764832	6425912	Tertiary palaeochannel	419.56	419.43	No	Standpipe	
PZ53	761717	6425481	Lower Permian	-	446.915	No	Standpipe	
PZ55	758773	6423995	Quaternary / Tertiary alluvium	-	429.464	Yes	Standpipe	yes
PZ58	761616	6418360	Tertiary palaeochannel	478.083	477.847	Yes	Standpipe	yes
PZ72A	764661	6415236	Upper / Middle Permian	-	509.982	Yes	Standpipe	
PZ72C	764664	6415235	Quaternary / Tertiary alluvium	-	510.108	Yes	Standpipe	
PZ74	762689	6415586	Upper / Middle Permian	-	531.221	Yes	Standpipe	
PZI04	766832	6426451	Ulan Seam	438.92	438.58	Yes	Standpipe	
Spriggs Bore	756050	6416200	-	-	-	No	Standpipe	
TB103	762415	6429261	Lower Permian	425.2	424.93	Yes	Production	
TB105	763981	6431611	Lower Permian / Ulan Seam	388.78	388.6	Yes	Production	
TB179	764703	6426598	Lower Permian	444.75	444.4	No	Production	
TB52A	764823	6425908	Lower Permian / Ulan Seam	419.28	419.23	No	Production	
TB52B	764825	6425911	Tertiary palaeochannel	419.46	419.23	No	Production	

Appendix 3

MODELLED PIEZOMETRIC CONTOURS



LEGEND:

- Piezometric contour (mAHD) *
- EL6288
- Approved Stage 1 project area
- Approved Stage 1 open cut
- Open Cut 1 & 2 proposed extension area
- Vegetation
- Major watercourse
- Watercourse
- Major road
- Road
- Railway
- A - A' Location of cross section

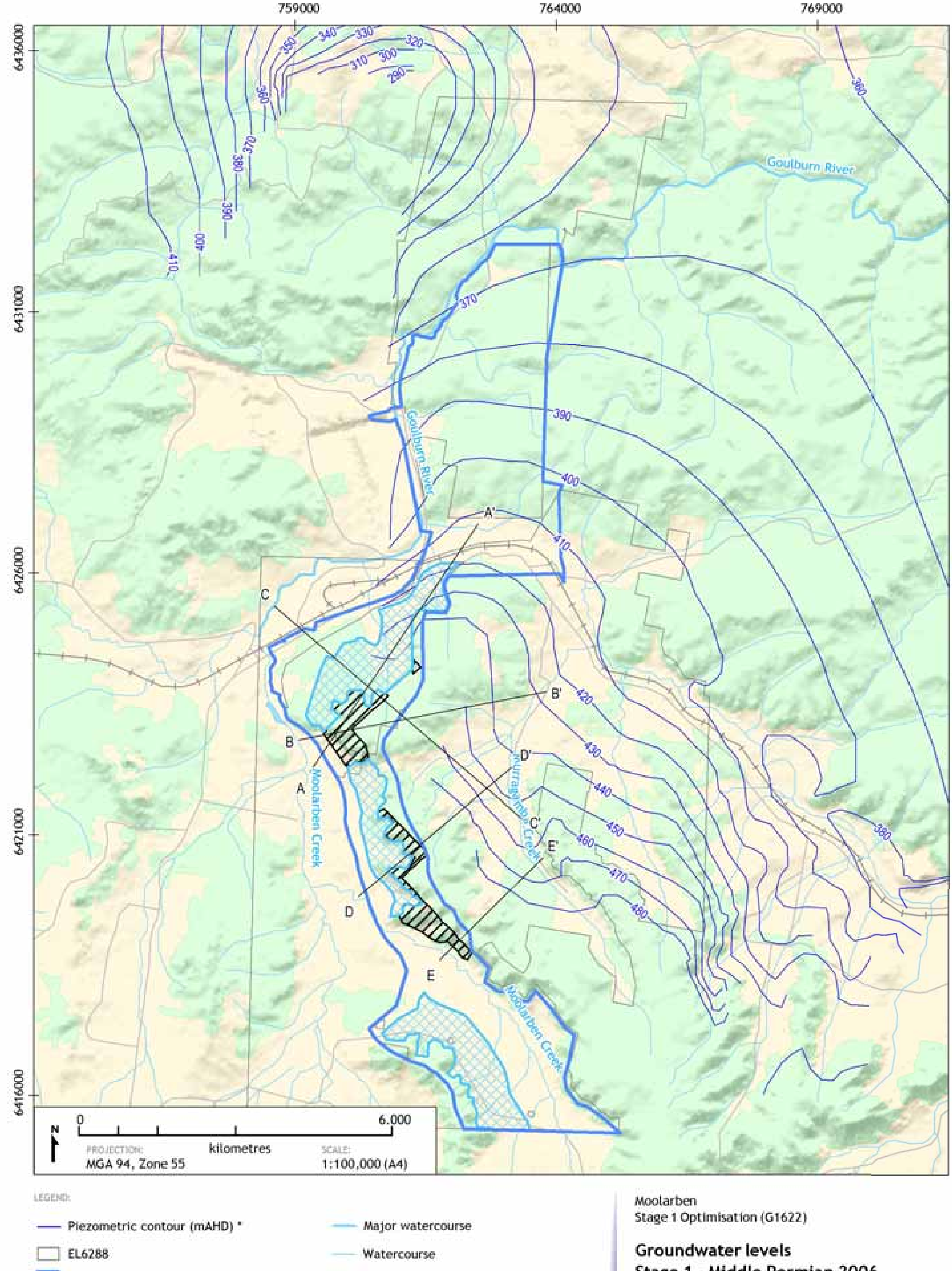
* Contours reproduced from DUNDON (2006)

Moolarben
Stage 1 Optimisation (G1622)

Groundwater levels
Stage 1 - Lower Permian 2006

DATE: 29/4/2013

FIGURE No: **A3.2**



LEGEND:

- Piezometric contour (mAHD) *
- EL6288
- Approved Stage 1 project area
- Approved Stage 1 open cut
- Open Cut 1 & 2 proposed extension area
- Vegetation
- Major watercourse
- Watercourse
- Major road
- Road
- Railway
- A - A' Location of cross section

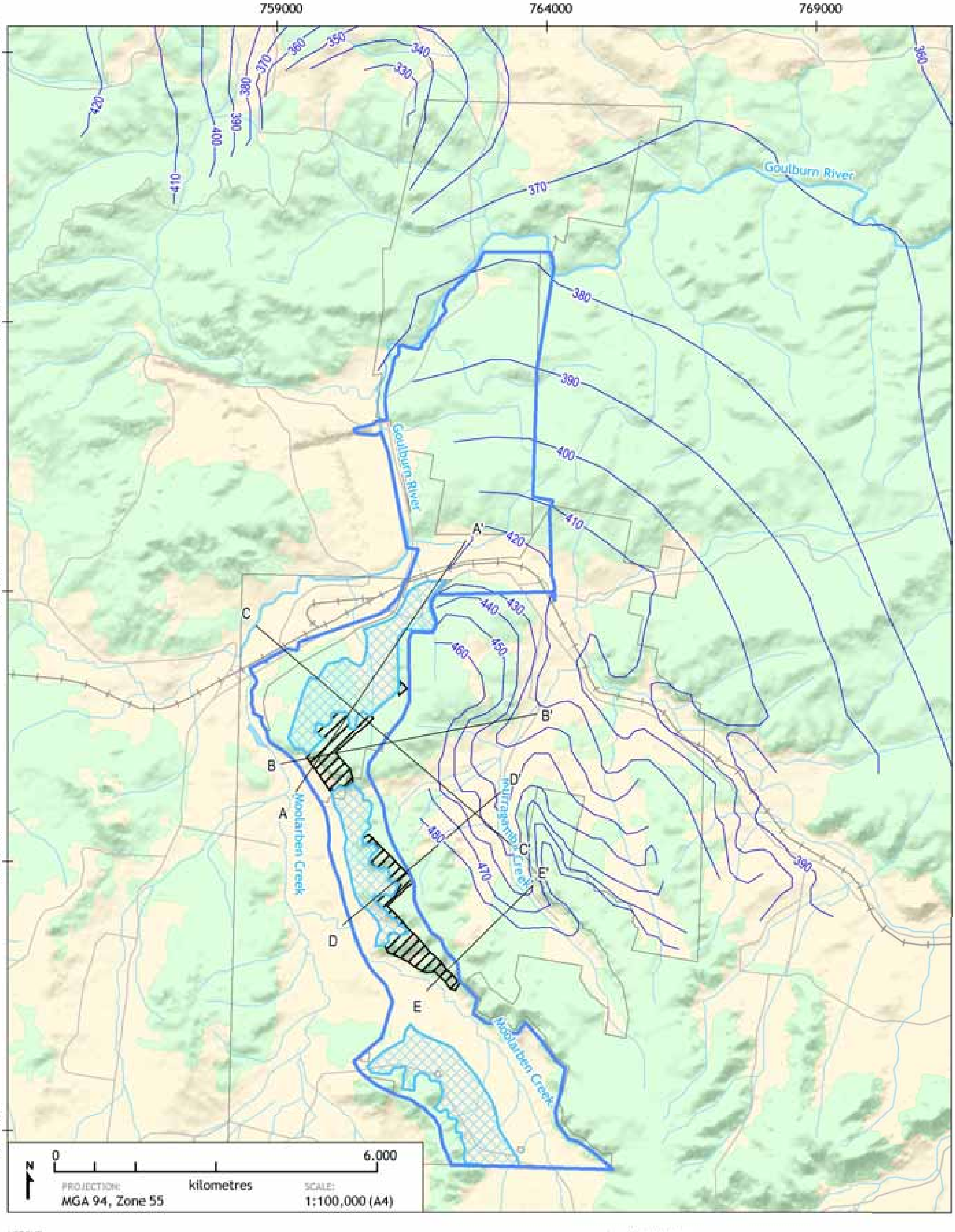
* Contours reproduced from DUNDON (2006)

Moolarben
Stage 1 Optimisation (G1622)

Groundwater levels
Stage 1 - Middle Permian 2006

DATE: 29/4/2013

FIGURE No: **A3.3**



LEGEND:

- Piezometric contour (mAHD) *
- EL6288
- Approved Stage 1 project area
- Approved Stage 1 open cut
- Open Cut 1 & 2 proposed extension area
- Vegetation
- Major watercourse
- Watercourse
- Major road
- Road
- Railway
- A - A' Location of cross section

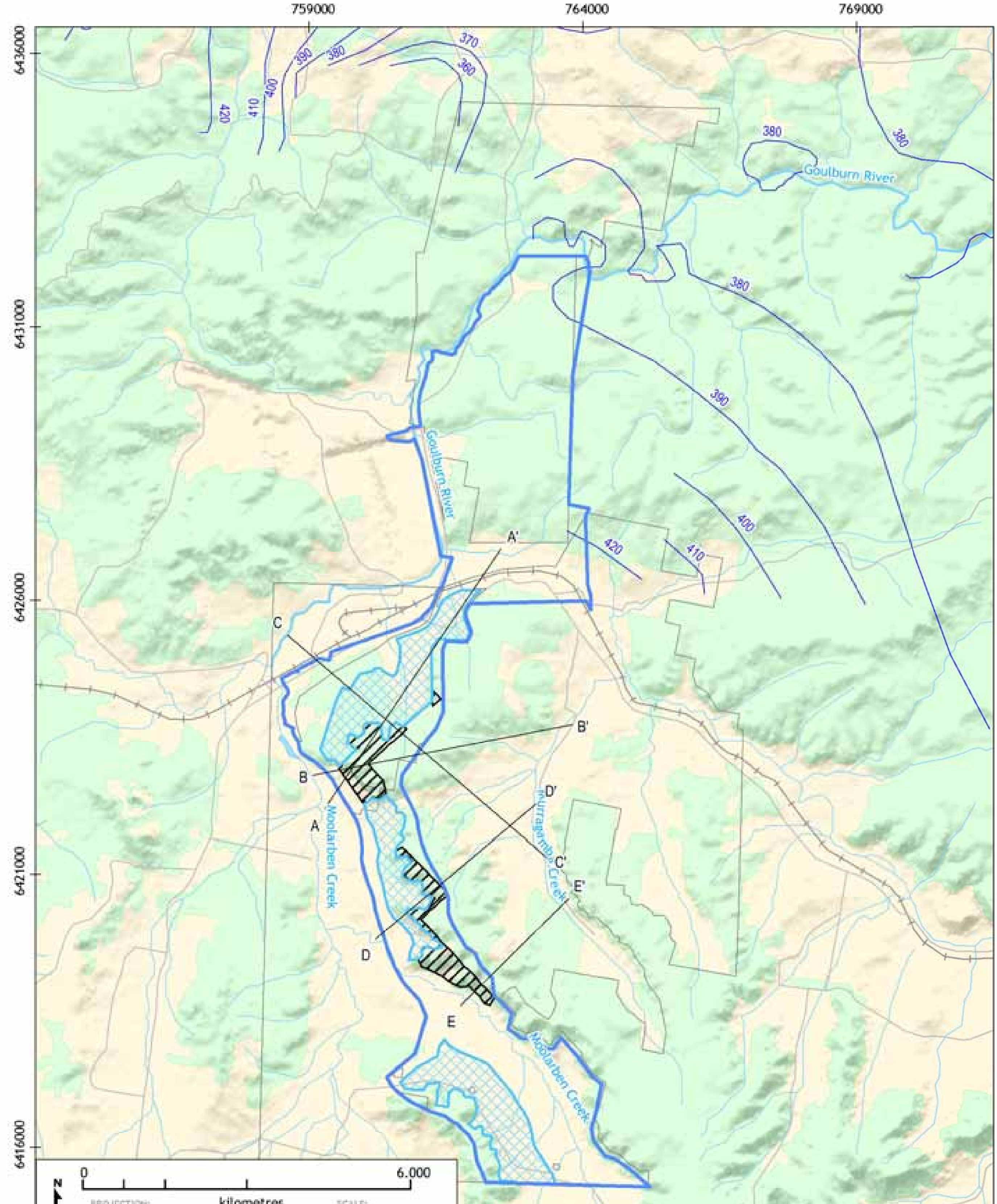
* Contours reproduced from DUNDON (2006)

Moolarben
Stage 1 Optimisation (G1622)

Groundwater levels
Stage 1 - Upper Permian 2006

DATE: 29/4/2013

FIGURE No: **A3.4**



LEGEND:

- Piezometric contour (mAHD) *
- EL6288
- Approved Stage 1 project area
- Approved Stage 1 open cut
- Open Cut 1 & 2 proposed extension area
- Vegetation
- Major watercourse
- Watercourse
- Major road
- Road
- Railway
- A - A' Location of cross section

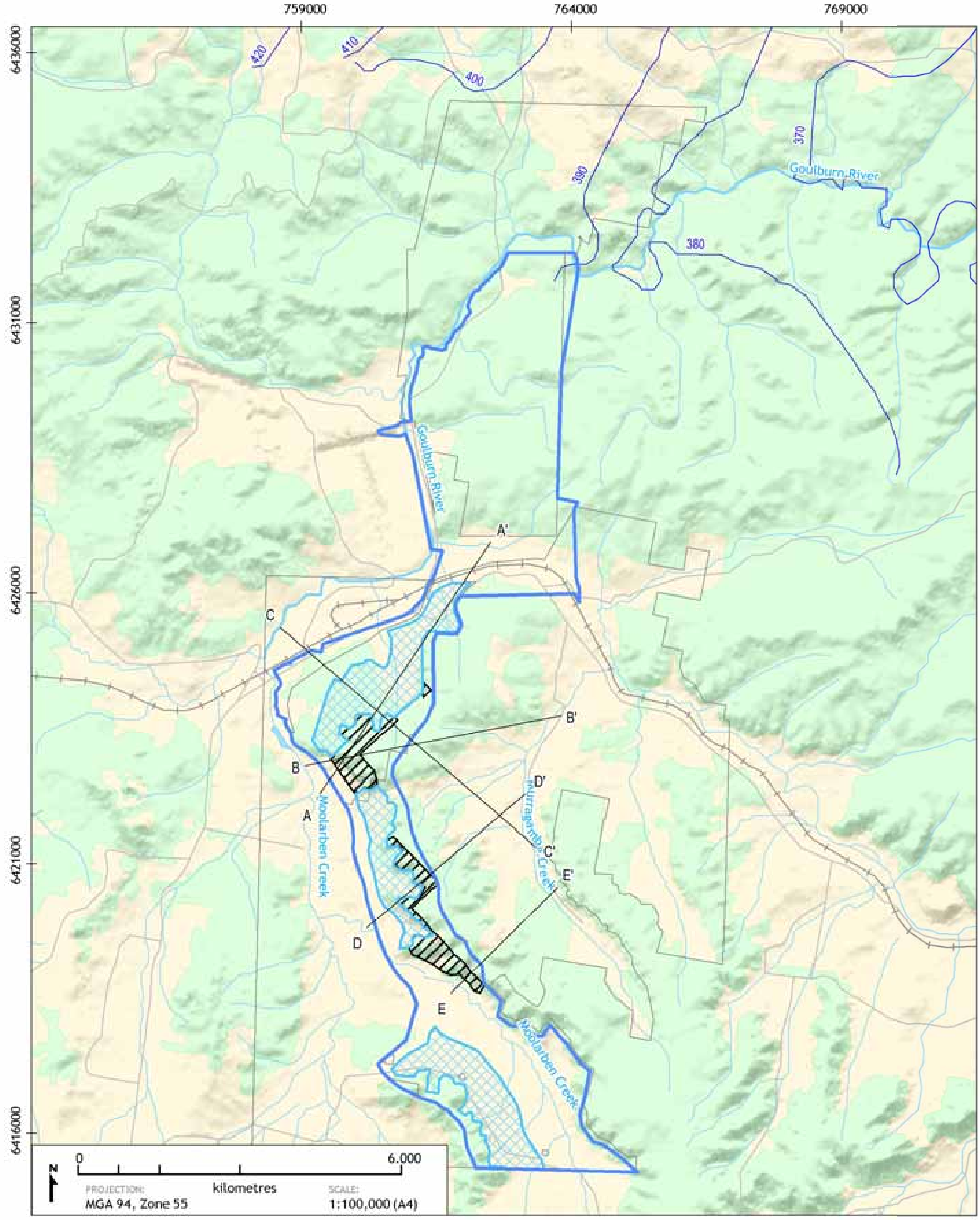
* Contours reproduced from DUNDON (2006)

Moolarben
Stage 1 Optimisation (G1622)

Groundwater levels
Stage 1 - Lower Triassic 2006

DATE: 29/4/2013

FIGURE No: **A3.5**



LEGEND:

- Piezometric contour (mAHD) *
- EL6288
- Approved Stage 1 project area
- Approved Stage 1 open cut
- Open Cut 1 & 2 proposed extension area
- Vegetation
- Major watercourse
- Watercourse
- Major road
- Road
- Railway
- A - A' Location of cross section

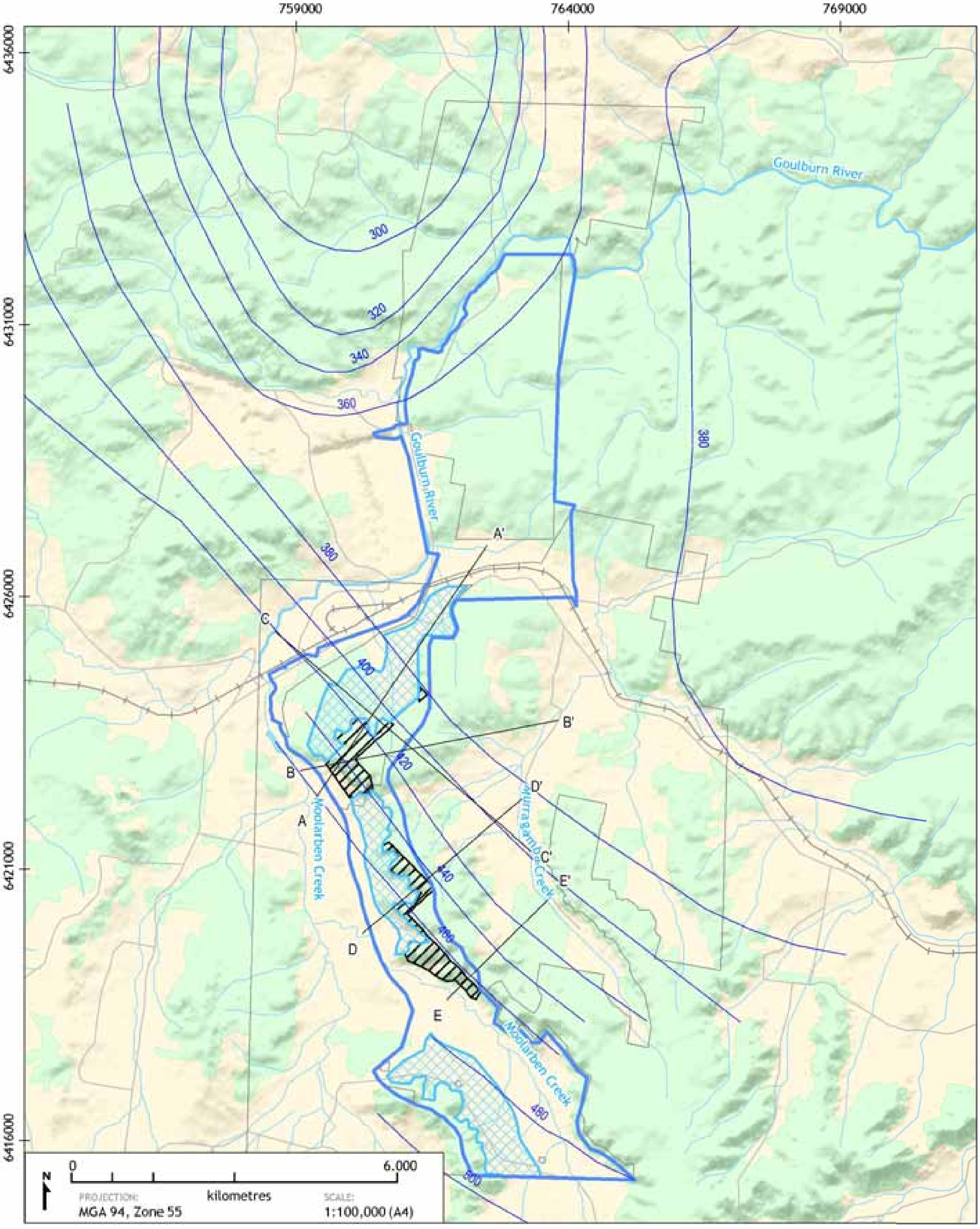
* Contours reproduced from DUNDON (2006)

Moolarben
Stage 1 Optimisation (G1622)

Groundwater levels
Stage 1 - Upper Triassic 2006

DATE: 29/4/2013

FIGURE No: **A3.6**



LEGEND:

- Piezometric contour (mAHD) *
- EL6288
- Approved Stage 1 project area
- Approved Stage 1 open cut
- Open Cut 1 & 2 proposed extension area
- Vegetation
- Major watercourse
- Watercourse
- Major road
- Road
- Railway
- A - A' Location of cross section

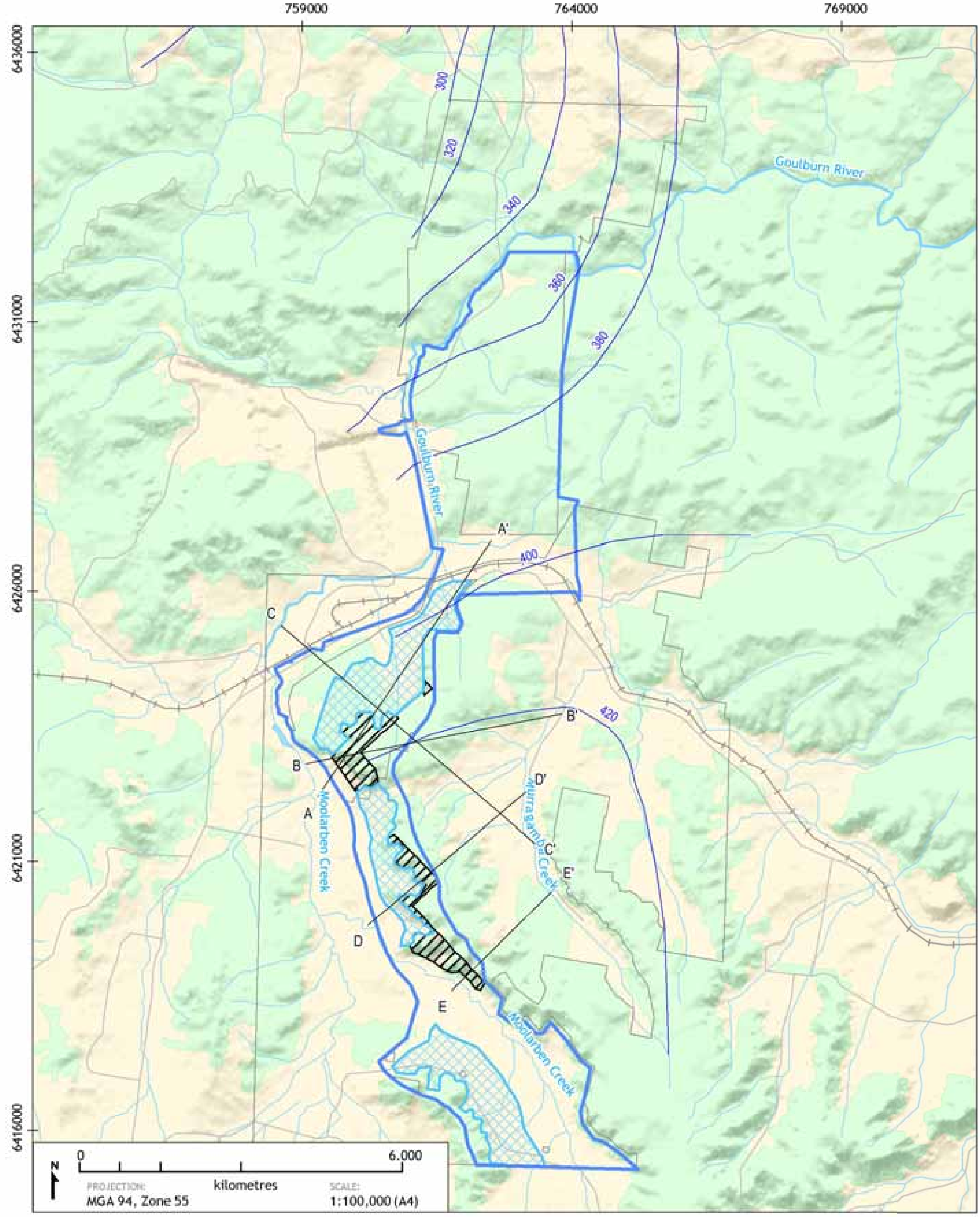
* Contours reproduced from RPS AQUATERRA (2011)

Moolarben
Stage 1 Optimisation (G1622)

Groundwater levels
Stage 2 - Ulan Seam 2011

DATE: 29/4/2013

FIGURE No: **A3.7**



LEGEND:

- Piezometric contour (mAHD) *
- EL6288
- Approved Stage 1 project area
- Approved Stage 1 open cut
- Open Cut 1 & 2 proposed extension area
- Vegetation
- Major watercourse
- Watercourse
- Major road
- Road
- Railway
- A - A' Location of cross section

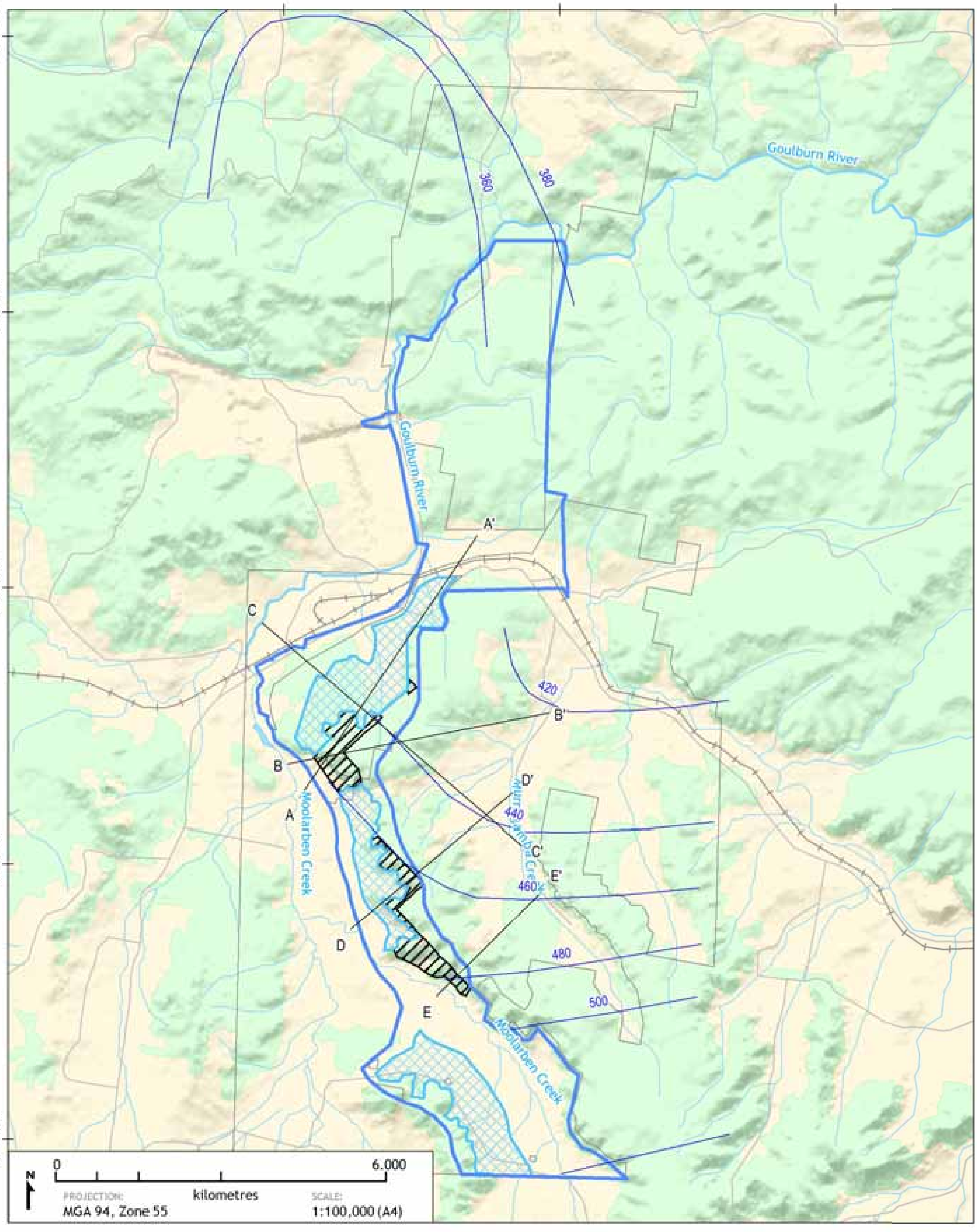
* Contours reproduced from RPS AQUATERRA (2011)

Moolarben
Stage 1 Optimisation (G1622)

Groundwater levels
Stage 2 - Lower Permian 2011

DATE: 29/4/2013

FIGURE No: **A3.8**



LEGEND:

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- EL6288
- Approved Stage 1 project area
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- Open Cut 1 & 2 proposed extension area
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- Major watercourse
- Watercourse
- Major road
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- Railway
- A - A' Location of cross section

* Contours reproduced from RPS AQUATERRA (2011)

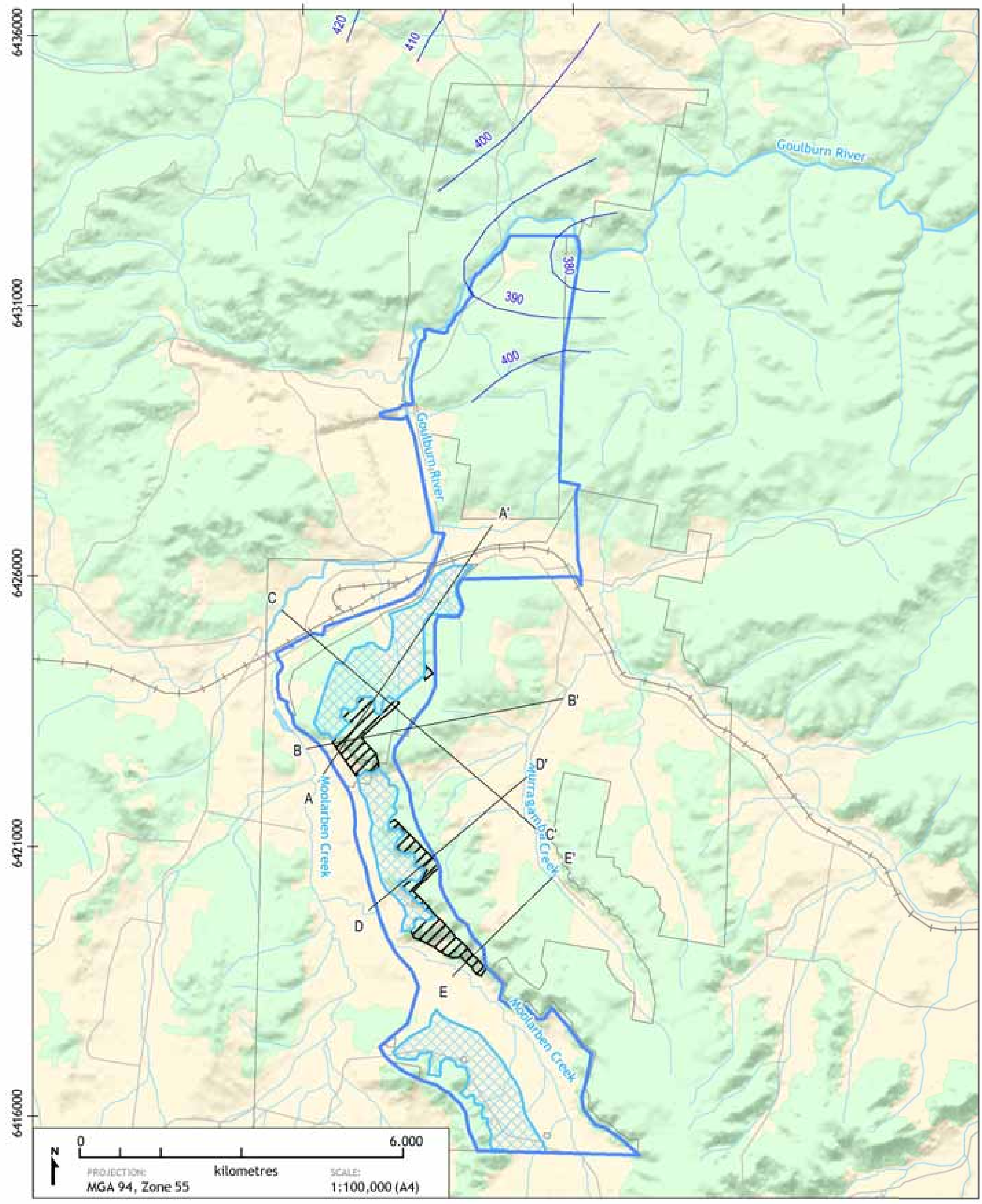
Moolarben
Stage 1 Optimisation (G1622)

Groundwater levels
Stage 2 - Middle & Upper Permian 2011

AGE GROUNDWATER & ENVIRONMENTAL

DATE: 29/4/2013

FIGURE No: **A3.9**



LEGEND:

- Piezometric contour (mAHD) *
- EL6288
- Approved Stage 1 project area
- Approved Stage 1 open cut
- Open Cut 1 & 2 proposed extension area
- Vegetation
- Major watercourse
- Watercourse
- Major road
- Road
- Railway
- A - A' Location of cross section

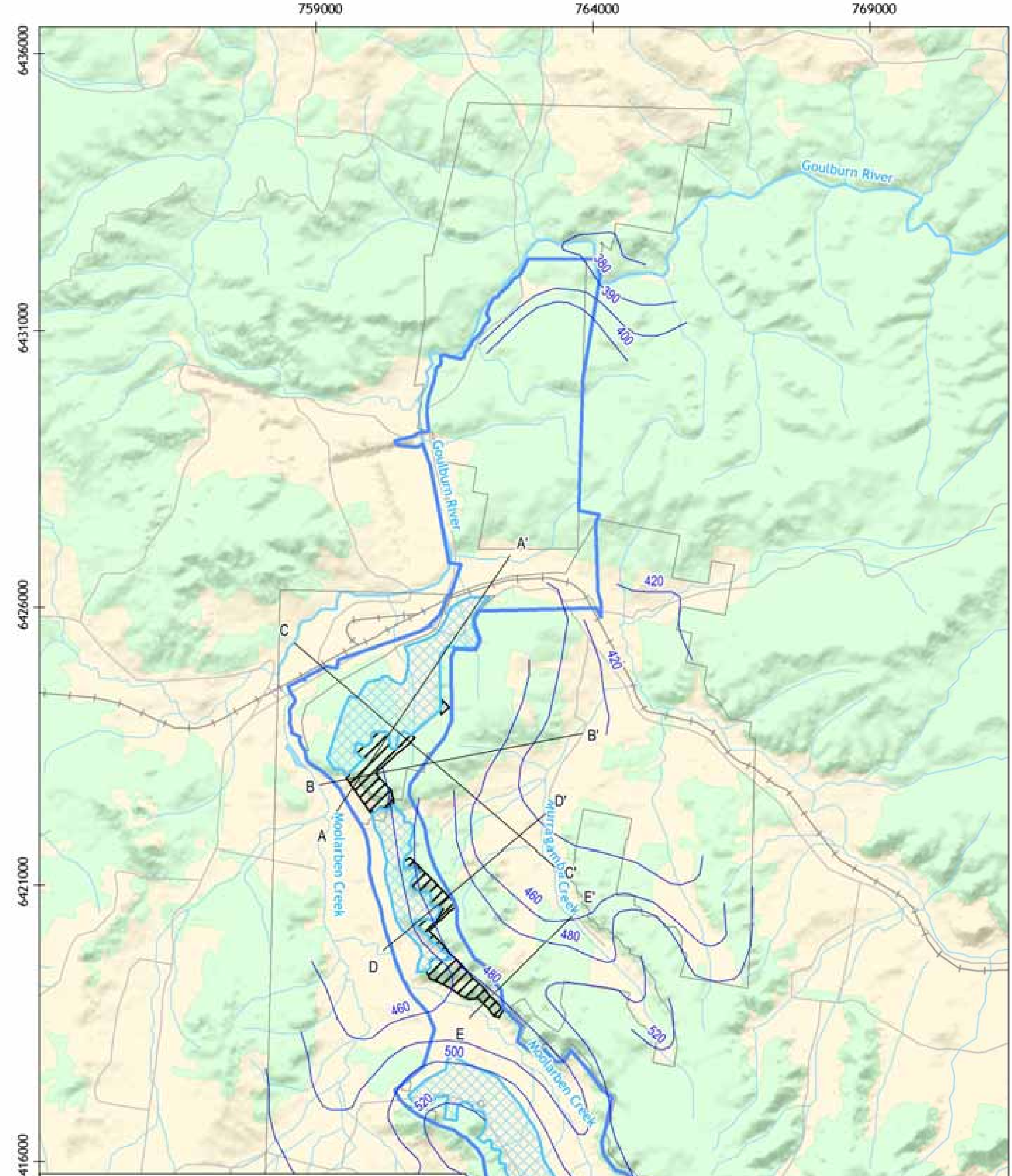
* Contours reproduced from RPS AQUATERRA (2011)

Moolarben
Stage 1 Optimisation (G1622)

Groundwater levels
Stage 2 - Upper & Lower Triassic 2011

DATE: 29/4/2013

FIGURE No: **A3.10**



LEGEND:

- Piezometric contour (mAHD) *
- EL6288
- Approved Stage 1 project area
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- Open Cut 1 & 2 proposed extension area
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- Major watercourse
- Watercourse
- Major road
- Road
- Railway
- A - A' Location of cross section

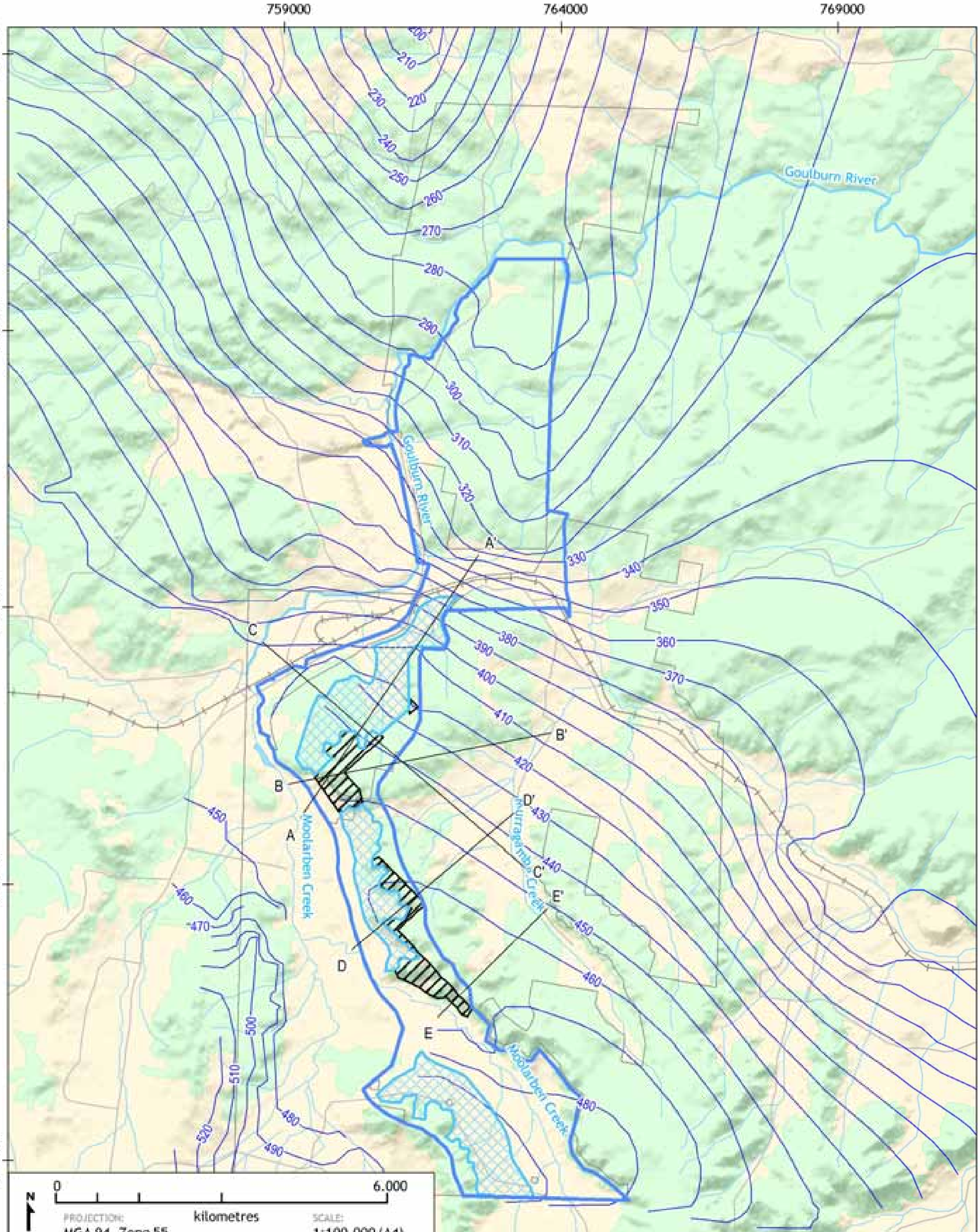
* Contours reproduced from RPS AQUATERRA (2011)

Moolarben
Stage 1 Optimisation (G1622)

Groundwater levels
Stage 2 - Surficial Aquifer 2011

DATE: 29/4/2013

FIGURE No: **A3.11**



LEGEND:

- Piezometric contour (mAHD) *
- EL6288
- Approved Stage 1 project area
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- Open Cut 1 & 2 proposed extension area
- Vegetation
- Major watercourse
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- A - A' Location of cross section

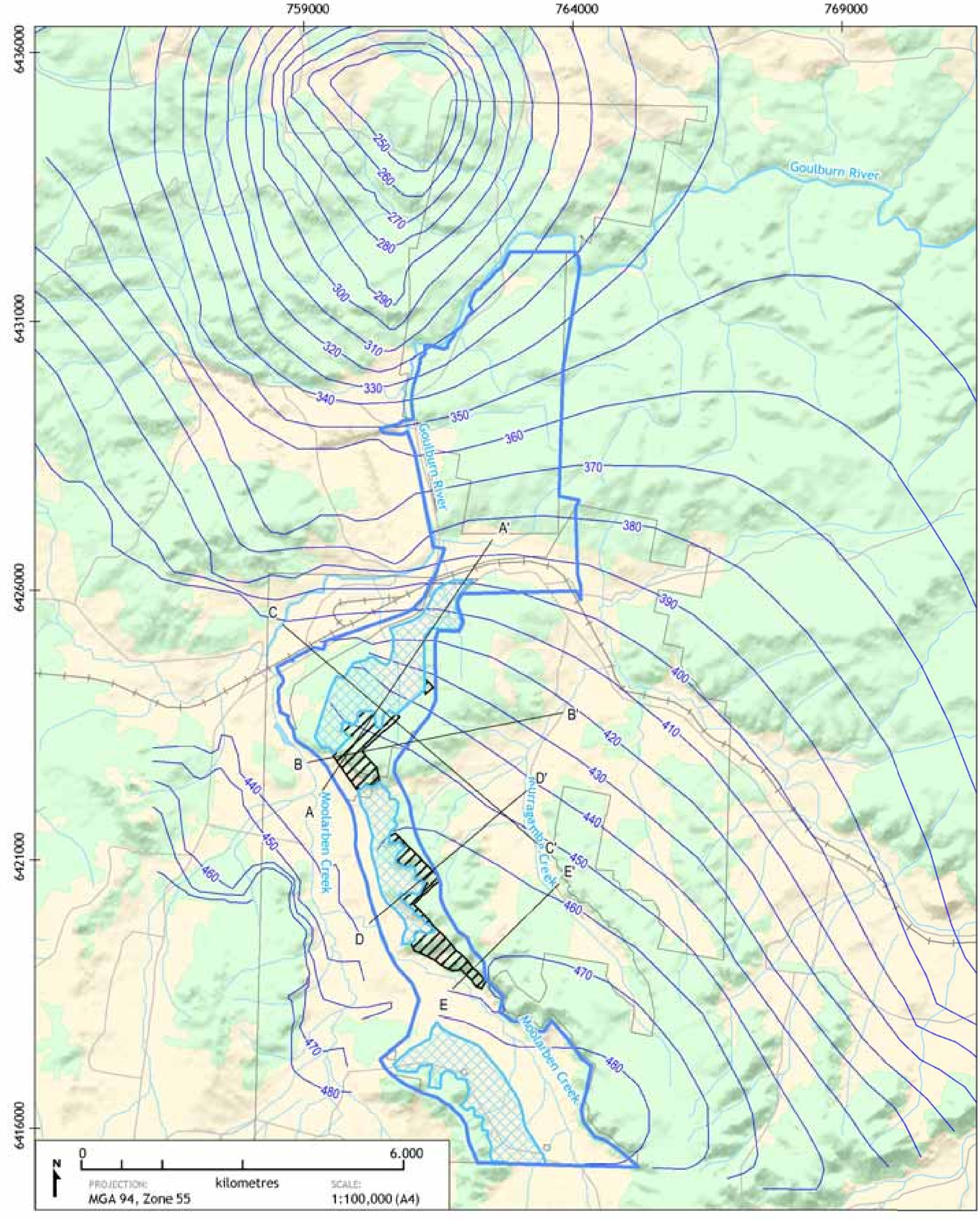
* Contours reproduced from DUNDON (2006)

Moolarben
Stage 1 Optimisation (G1622)

Groundwater levels
Stage 1 - Ulan Seam 2021

DATE: 29/4/2013

FIGURE No: **A3.12**



LEGEND:

- Piezometric contour (mAHD) *
- EL6288
- Approved Stage 1 project area
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- A - A' Location of cross section

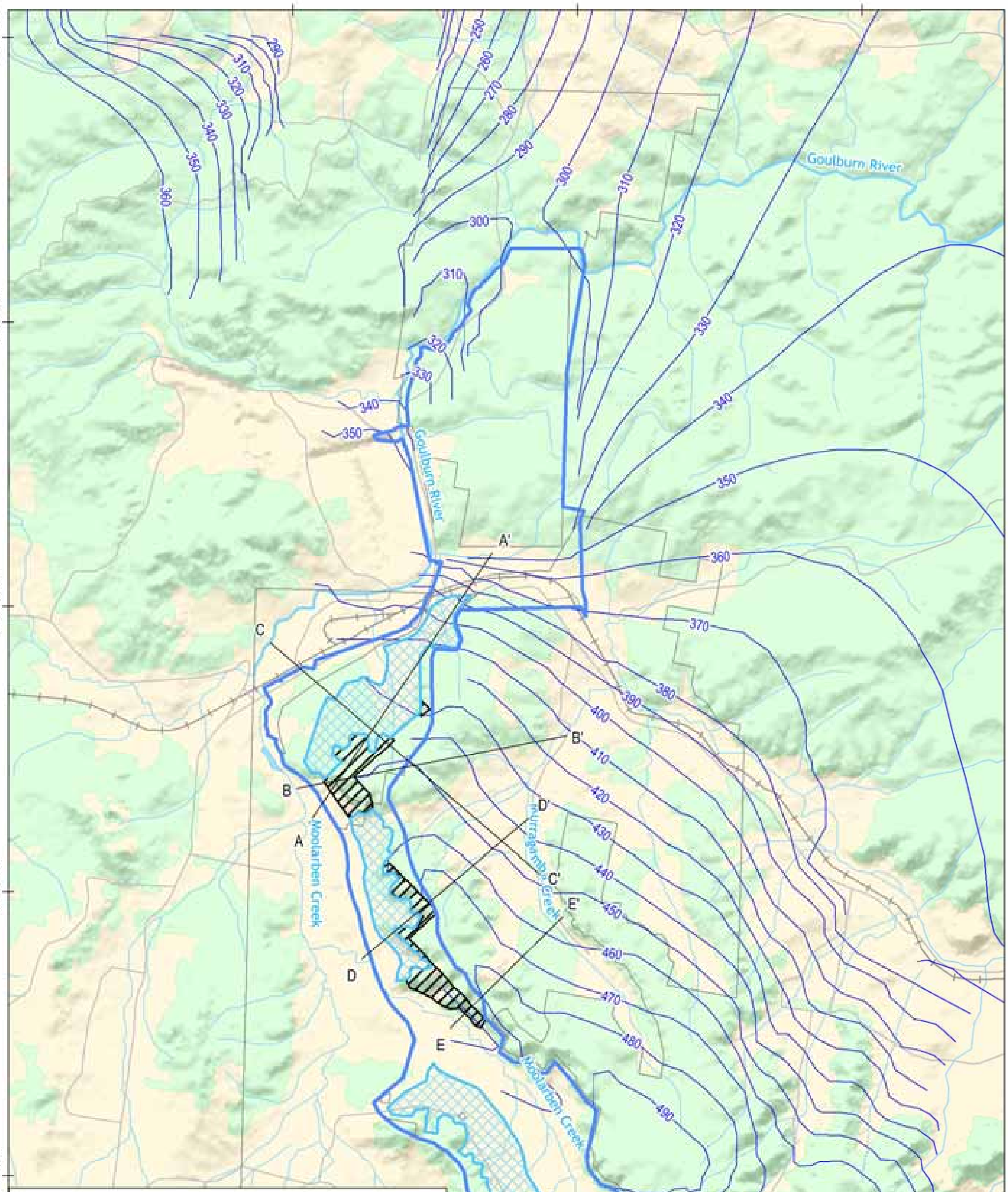
* Contours reproduced from DUNDON (2006)

Moolarben
Stage 1 Optimisation (G1622)

Groundwater levels
Stage 1 - Ulan Seam 2006

DATE: 29/4/2013

FIGURE No: **A3.1**



LEGEND:

- Piezometric contour (mAHD) *
- EL6288
- Approved Stage 1 project area
- Approved Stage 1 open cut
- Open Cut 1 & 2 proposed extension area
- Vegetation
- Major watercourse
- Watercourse
- Major road
- Road
- Railway
- A - A' Location of cross section

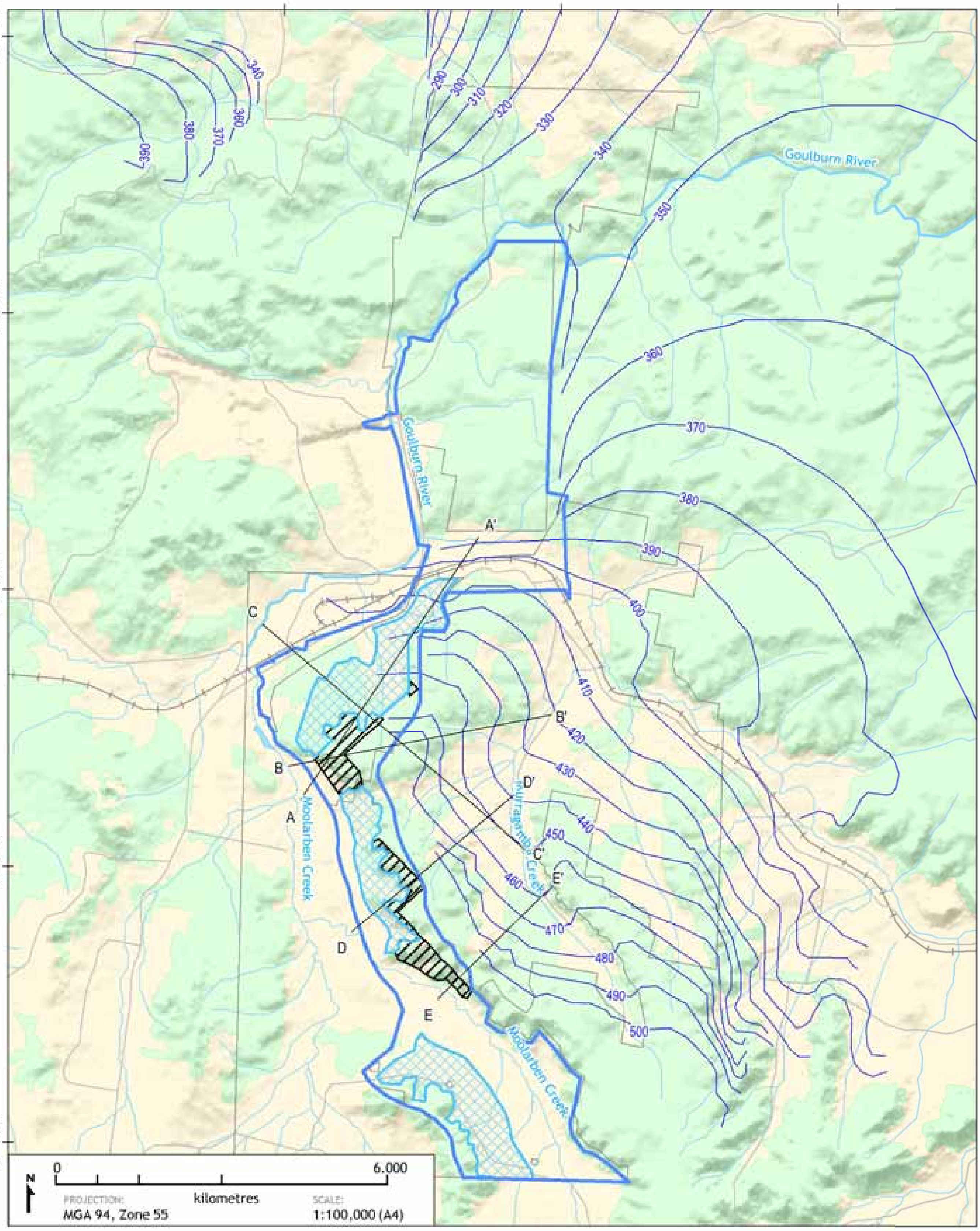
* Contours reproduced from DUNDON (2006)

Moolarben
Stage 1 Optimisation (G1622)

Groundwater levels
Stage 1 - Lower Permian 2021

DATE: 29/4/2013

FIGURE No: **A3.13**



LEGEND:

- Piezometric contour (mAHD) *
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- A - A' Location of cross section

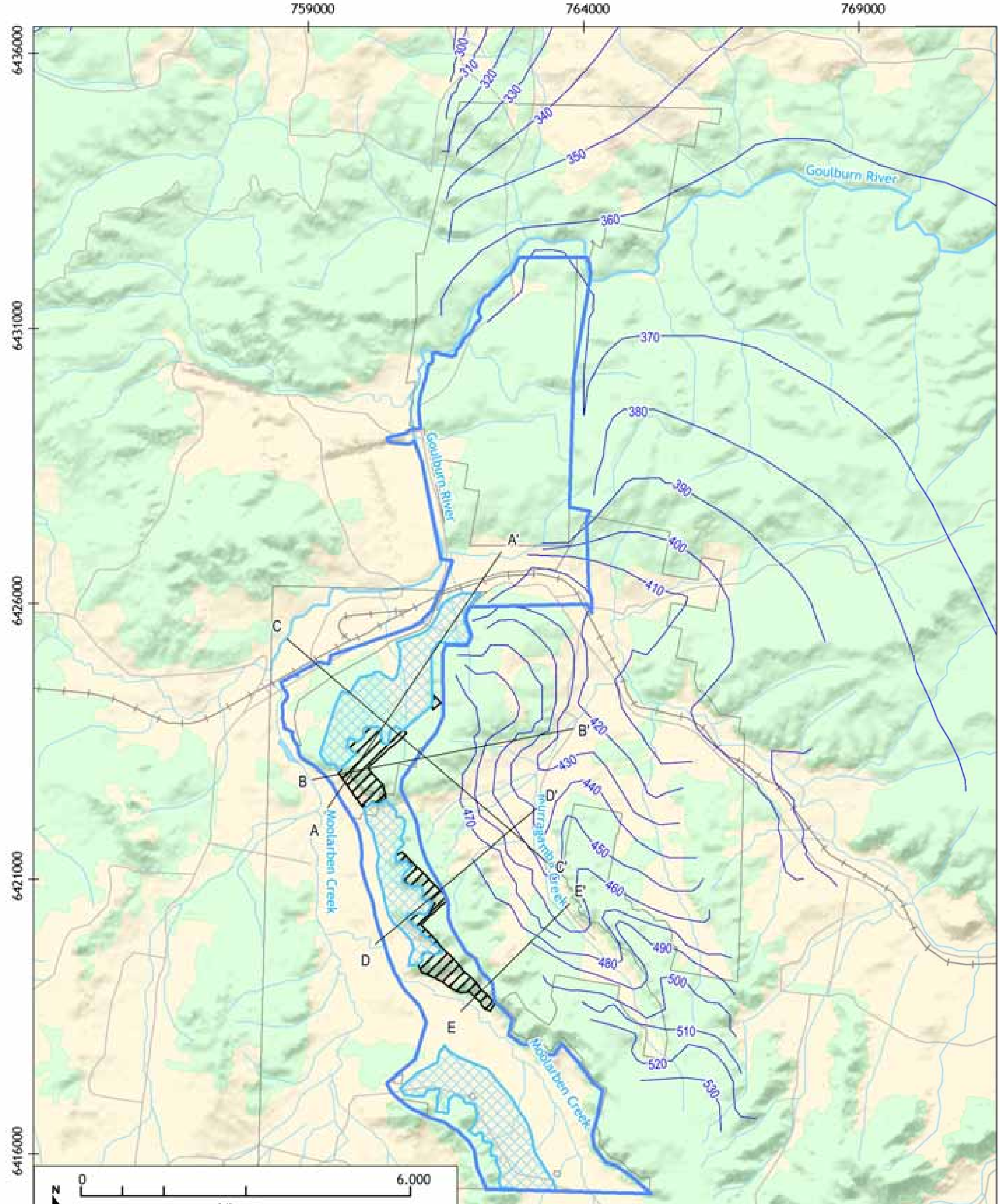
* Contours reproduced from DUNDON (2006)

Moolarben
Stage 1 Optimisation (G1622)

Groundwater levels
Stage 1 - Middle Permian 2021

DATE: 29/4/2013

FIGURE No: **A3.14**



LEGEND:

- Piezometric contour (mAHD) *
- EL6288
- Approved Stage 1 project area
- Approved Stage 1 open cut
- Open Cut 1 & 2 proposed extension area
- Vegetation
- Major watercourse
- Watercourse
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- Railway
- A - A' Location of cross section

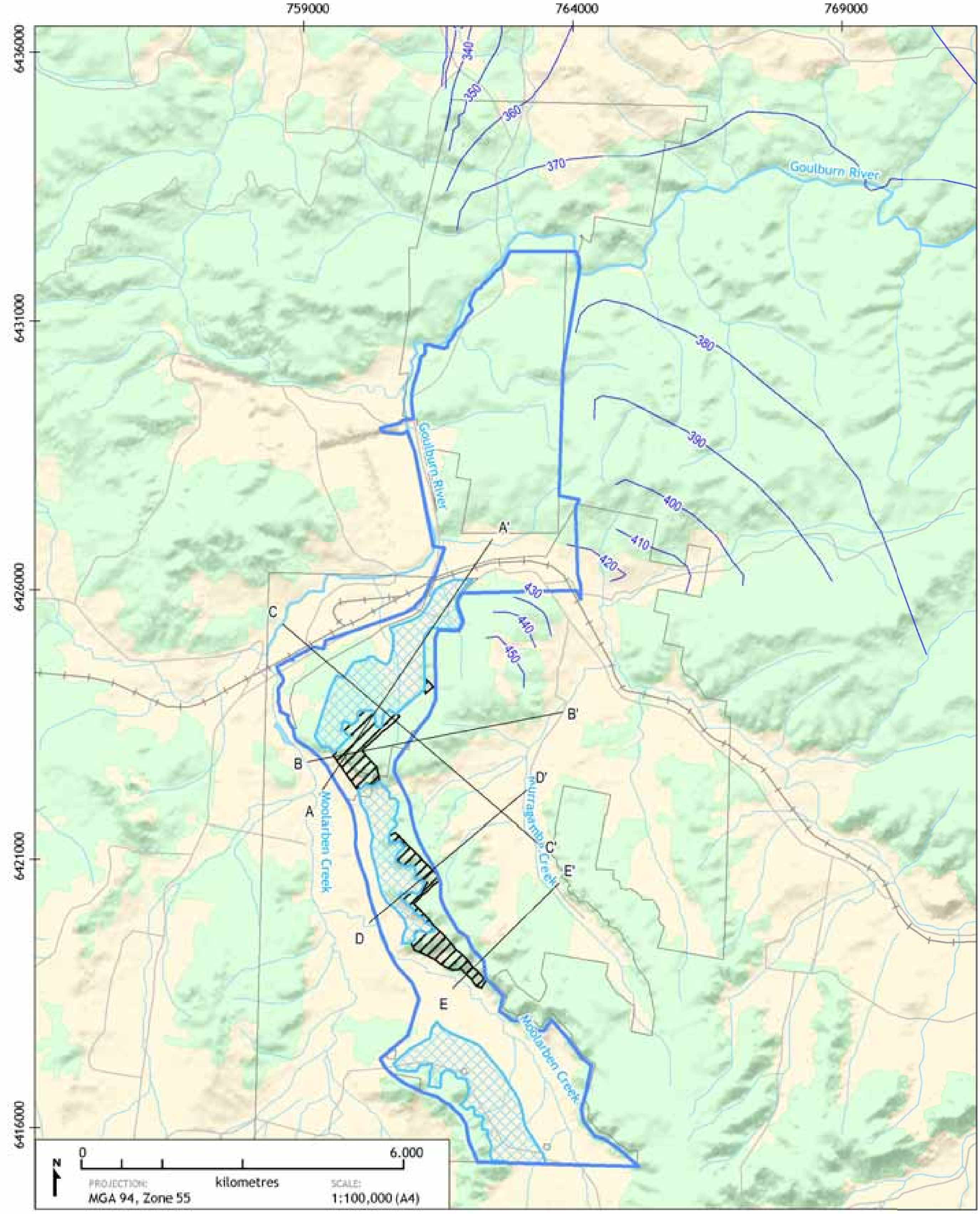
* Contours reproduced from DUNDON (2006)

Moolarben
Stage 1 Optimisation (G1622)

Groundwater levels
Stage 1 - Upper Permian 2021

DATE: 29/4/2013

FIGURE No: **A3.15**



LEGEND:

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- A - A' Location of cross section

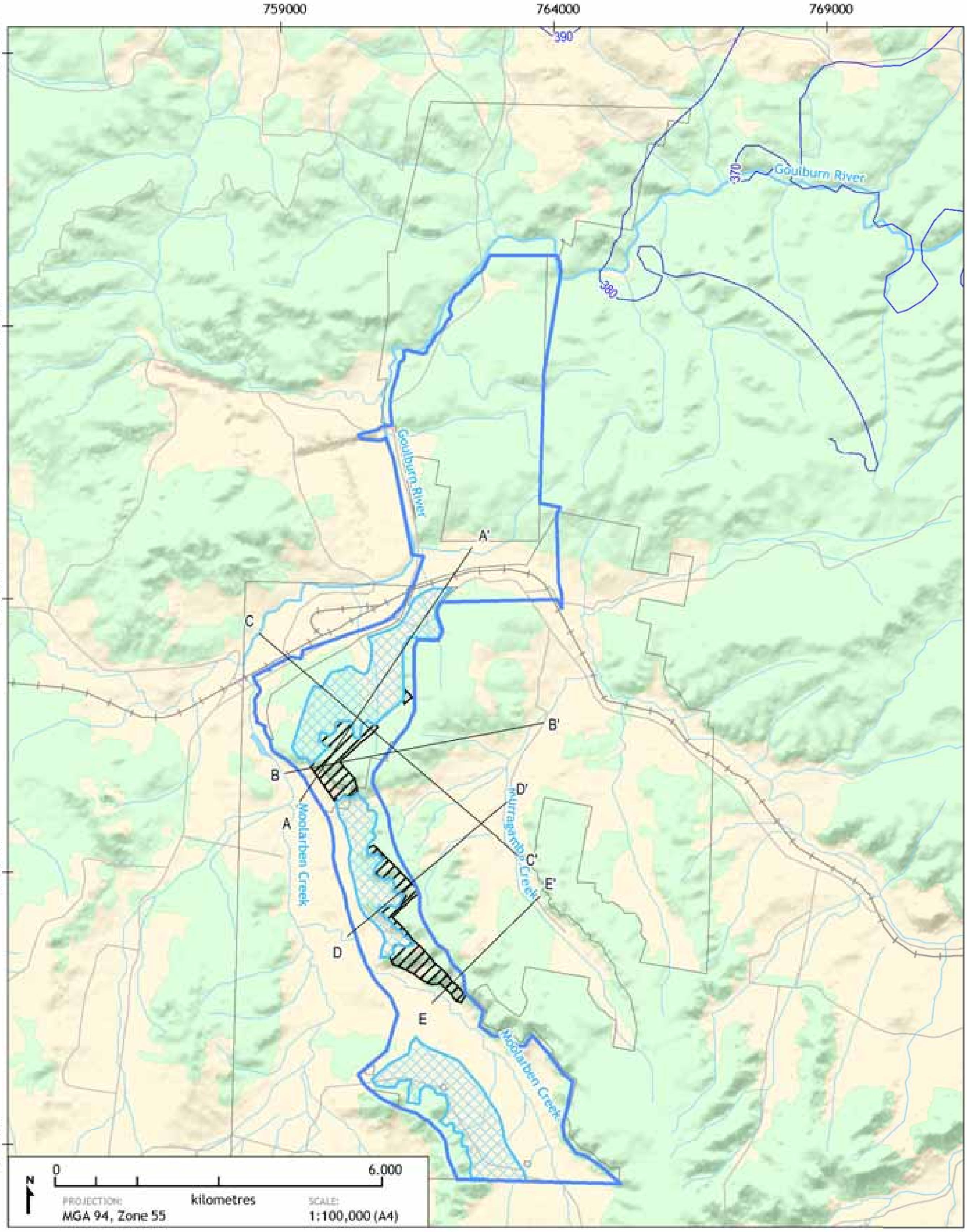
* Contours reproduced from DUNDON (2006)

Moolarben
Stage 1 Optimisation (G1622)

Groundwater levels
Stage 1 - Lower Triassic 2021

DATE: 29/4/2013

FIGURE No: **A3.16**



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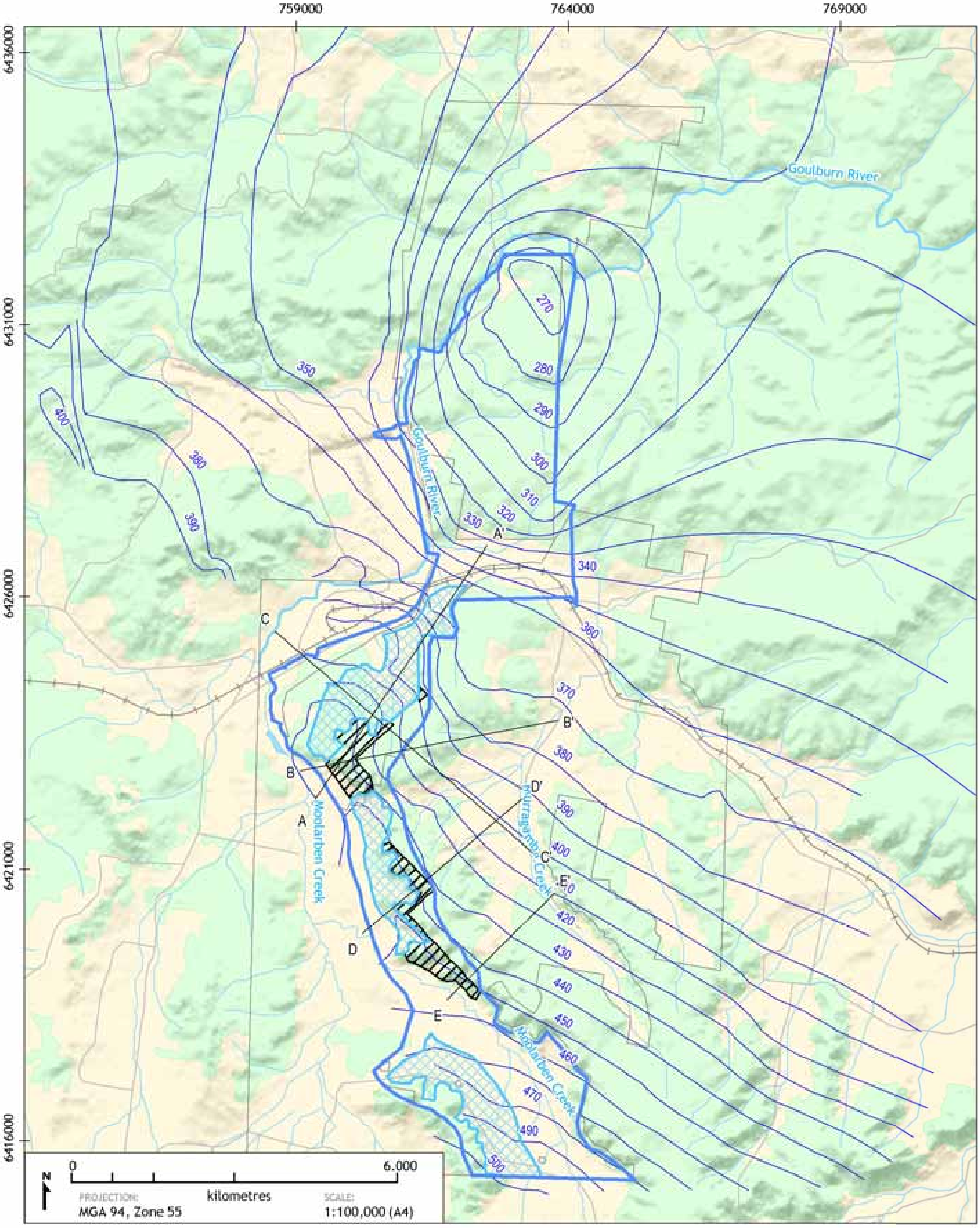
* Contours reproduced from DUNDON (2006)

Moolarben
Stage 1 Optimisation (G1622)

Groundwater levels
Stage 1 - Upper Triassic 2021

DATE: 29/4/2013

FIGURE No: **A3.17**



LEGEND:

- Piezometric contour (mAHD) *
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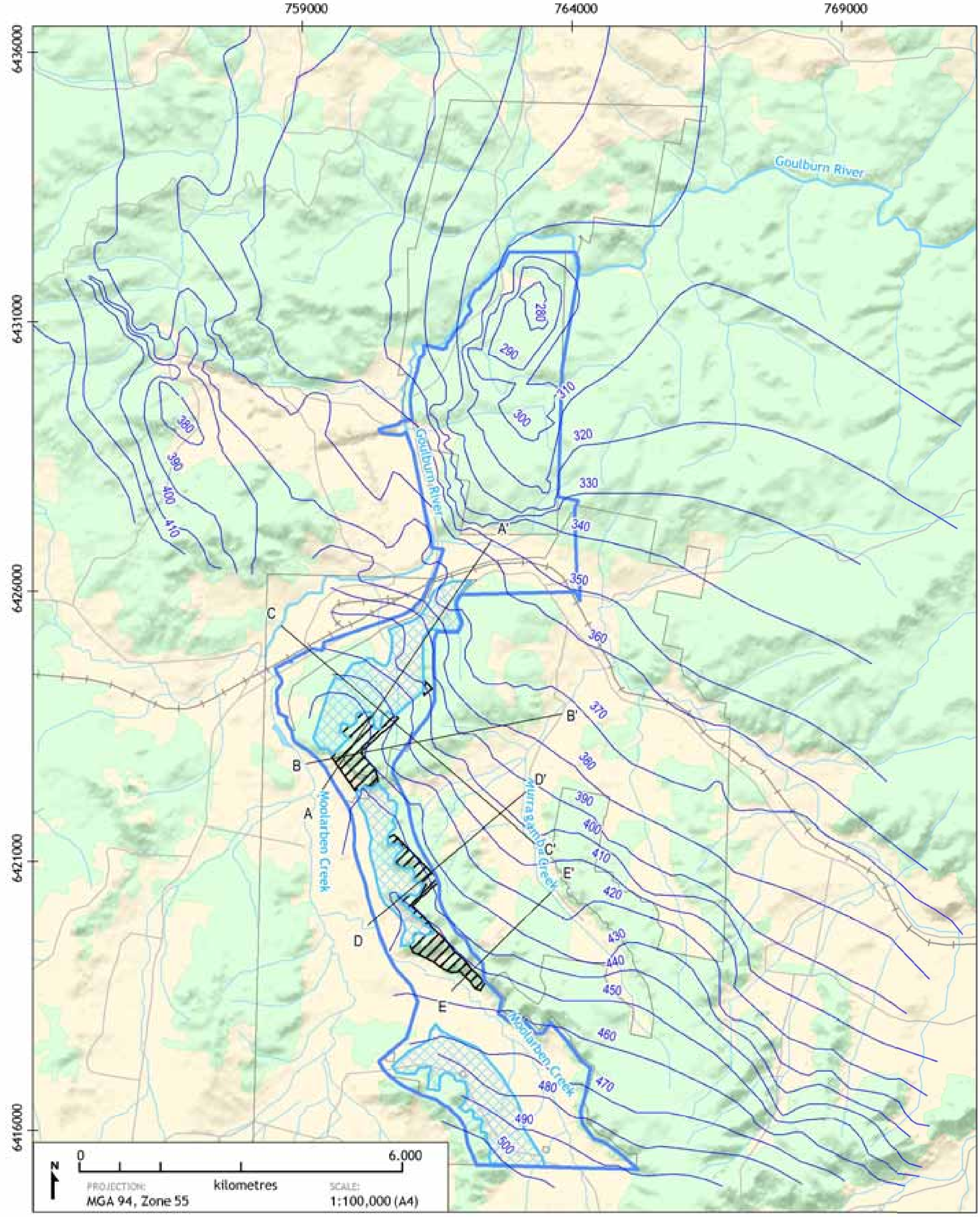
* Contours reproduced from DUNDON (2006)

Moolarben
Stage 1 Optimisation (G1622)

Groundwater levels
Stage 2 - Ulan Seam 2042

DATE: 29/4/2013

FIGURE No: **A3.18**



LEGEND:

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- Open Cut 1 & 2 proposed extension area
- Vegetation
- Major watercourse
- Watercourse
- Major road
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- A - A' Location of cross section

* Contours reproduced from RPS AQUATERRA (2011)

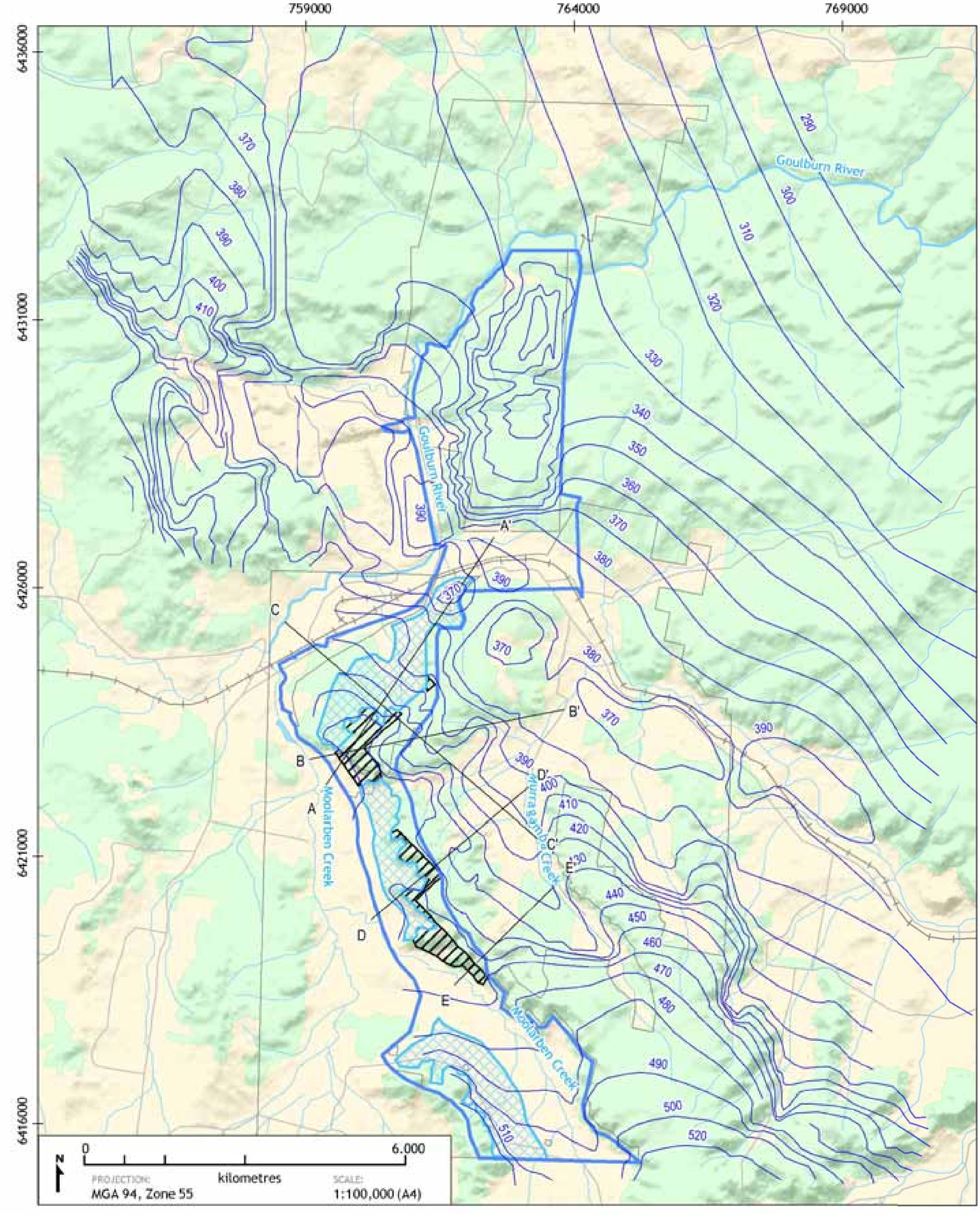
Moolarben
Stage 1 Optimisation (G1622)

Groundwater levels
Stage 2 - Lower Permian 2042

AGE GROUNDWATER & ENVIRONMENTAL

DATE: 29/4/2013

FIGURE No: **A3.19**



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- Piezometric contour (mAHD) *
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- Major watercourse
- Watercourse
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- A - A' Location of cross section

* Contours reproduced from RPS AQUATERRA (2011)

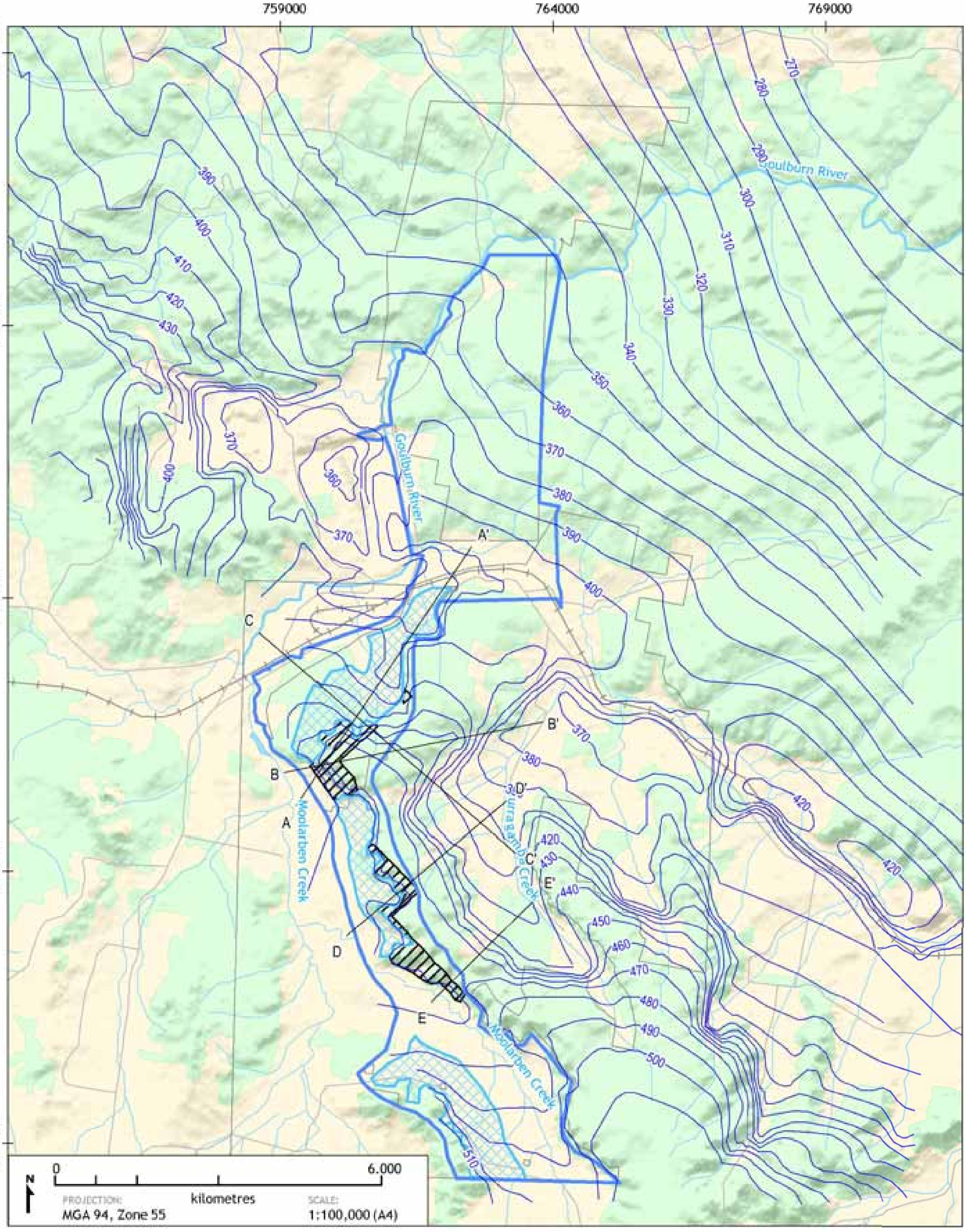
Moolarben
Stage 1 Optimisation (G1622)

Groundwater levels
Stage 2 - Middle Permian 2042

AGE Groundwater & Environmental

DATE: 29/4/2013

FIGURE No: **A3.20**



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- A - A' Location of cross section

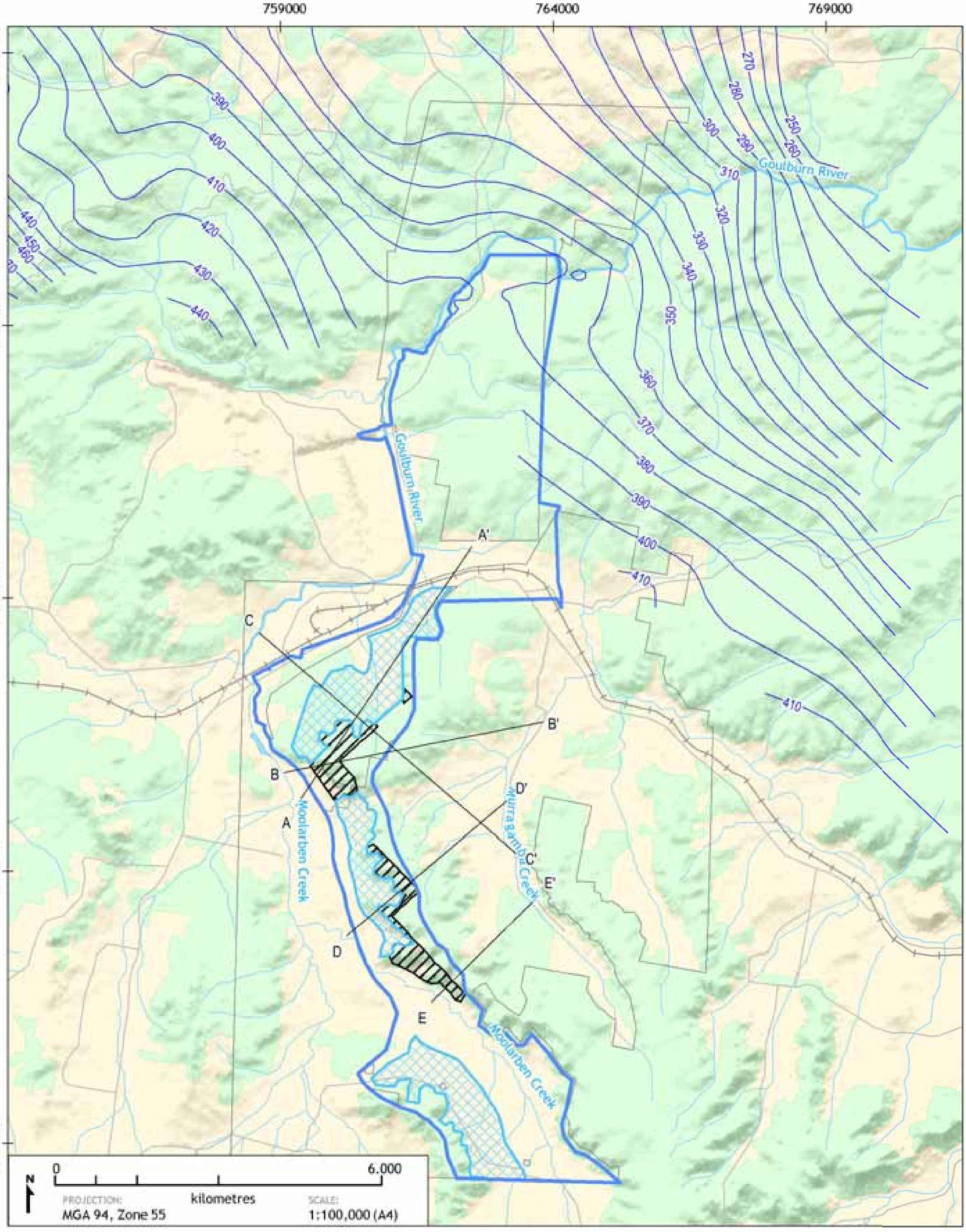
* Contours reproduced from RPS AQUATERRA (2011)

Moolarben
Stage 1 Optimisation (G1622)

Groundwater levels
Stage 2 - Upper Permian 2042

DATE: 29/4/2013

FIGURE No: **A3.21**



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- A - A' Location of cross section

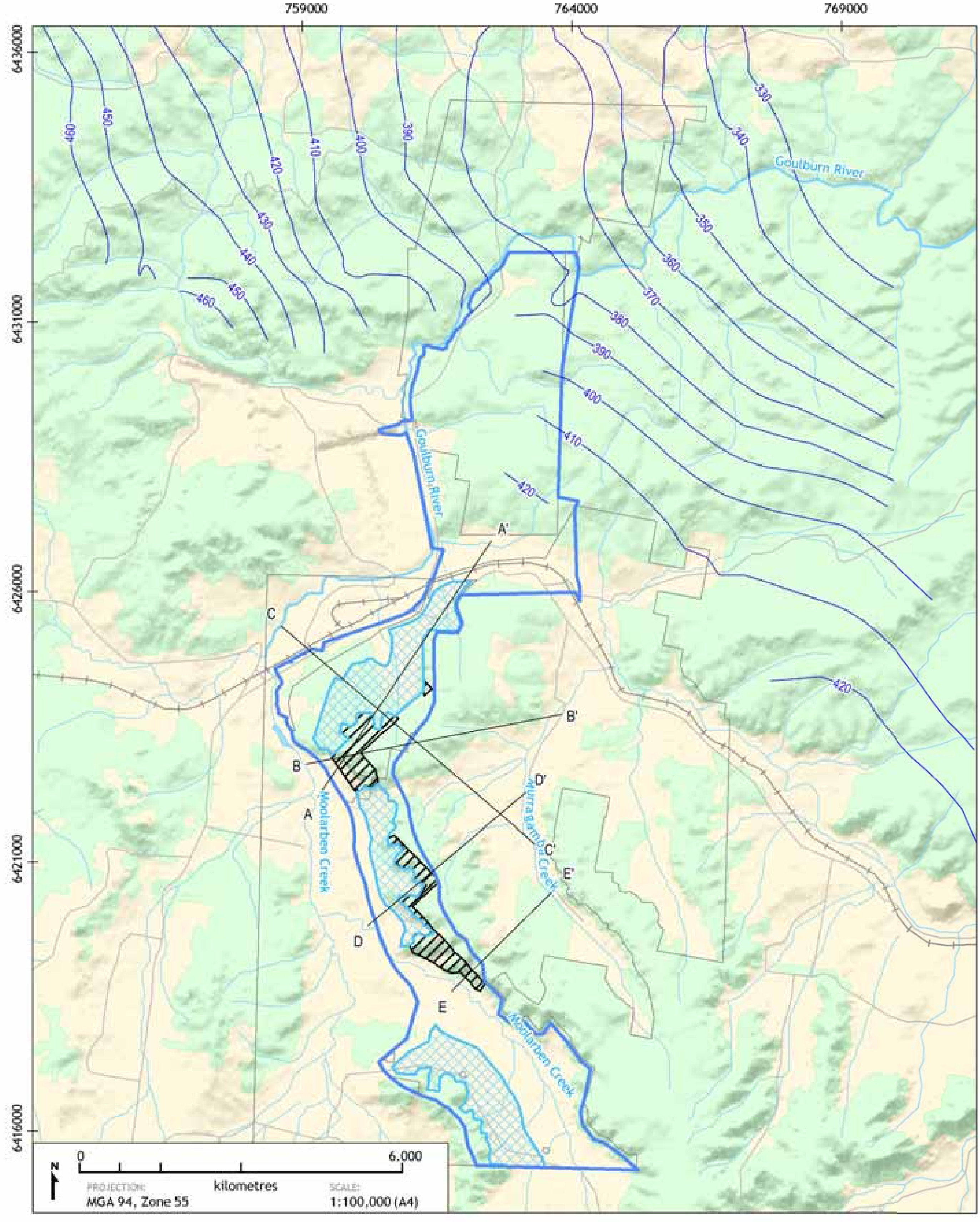
* Contours reproduced from RPS AQUATERRA (2011)

Moolarben
Stage 1 Optimisation (G1622)

Groundwater levels
Stage 2 - Lower Triassic 2042

DATE: 29/4/2013

FIGURE No: **A3.22**



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- A - A' Location of cross section

* Contours reproduced from RPS AQUATERRA (2011)

Moolarben
Stage 1 Optimisation (G1622)

Groundwater levels
Stage 2 - Upper Triassic 2042

DATE: 29/4/2013

FIGURE No: **A3.23**

Appendix K

Soils and agricultural impact assessment

Moolarben Coal Project Stage 1 Optimisation Modification, Environmental Assessment – May 2013

MOOLARBEN COAL
PART OF THE YANCOAL AUSTRALIA GROUP

EMM
EMGA Mitchell McLennan

www.moolarbencoal.com.au

Agricultural Impact Assessment

Moolarben Coal Project - Stage 1 Optimisation Modification

Prepared for Moolarben Coal Operations Pty Limited | 7 May 2013

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Agricultural Impact Assessment

Final

Report J12090RP1 | Prepared for Moolarben Coal Operations Pty Limited | 7 May 2013

Prepared by	**John Arnold**	Approved by	**Luke Stewart**
Position	Senior Environmental Planner	Position	Director
Signature		Signature	
Date	7/5/2013	Date	7/5/2013

Document Control

Version	Date	Prepared by	Reviewed by
A	5 March 2013	Tim Rhode	Luke Stewart
B	7 May 2013	John Arnold	Luke Stewart

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Executive Summary

ES1 Background

The Moolarben Coal Project (MCP) is an approved open cut and underground coal mine in the Western Coalfields of NSW, approximately 40 km north-east of Mudgee. EMGA Mitchell McLennan Pty Limited was engaged by Moolarben Coal Operations Pty Limited to undertake an agricultural impact assessment for the Moolarben Coal Project – Stage 1 Optimisation Modification.

The elements of the proposed modification to MP 05_0117 comprise:

- the extension of mining within Open Cuts 1 and 2;
- the construction and operation of additional water management infrastructure; and
- a minor change to the rehabilitation sequencing and final landform.

The project approval period will be extended to accommodate the proposed modification.

A Major Project Application for Stage 2 of the MCP, MP 08_0135, is currently being assessed by the Department of Planning and Infrastructure. If approved, Stage 2 will consist of one open cut pit, Open Cut 4, and two underground mines, Undergrounds 1 and 2, and associated additional infrastructure.

ES2 Purpose

The objectives of the assessment were to:

- identify the potential impacts of the proposed modification on soils, including rural land capability, agricultural land suitability and strategic agricultural land (SAL), as defined within the Strategic Regional Land Use Policy (DP&I 2012a);
- identify the potential impacts of the proposed modification on agricultural resources/industry; and
- identify measures that would avoid, minimise and monitor potential impacts.

This agricultural impact assessment has been completed as a desktop study, based on a soil survey reported in Soil, Rural Land Capability and Agricultural Suitability Assessment of the Moolarben Coal Project (Jammel, 2005) including laboratory analysis completed as part of the survey.

This assessment addresses the Strategic Regional Land Use Policy (DP&I 2012a), which requires state significant development applications for mining projects to submit an agricultural impact statement as part of the environmental impact statement. A key part of the policy provides Strategic Regional Land Use Plans (SLRUP) for defined regions in NSW, which identify strategic agricultural land (SAL) to assist future government decision-making regarding growth and development.

To date, the NSW Government has not yet released a SLRUP relevant to the vicinity of the MCP as the remaining plans are still in the drafting stage. Given this, a site verification to determine the presence of SAL in the proposed extension areas was undertaken.

ES3 Conclusions

The proposed extension areas will result in a total disturbance of approximately 178 ha. Currently these areas are mostly wooded with slopes generally greater than 15%, presenting a severe constraint to agricultural production.

The land capability class of the proposed extension areas is between Class IV and VII, with the majority Class VII 'extremely severe limitations' where most land uses are restricted and limitations cannot be overcome.

The agricultural suitability of the proposed extension areas are classified as Class 3, 4 and 5, with the majority being Class 5, land suitable for agriculture or best suited to only light grazing.

Verification assessments of the proposed extension areas, demonstrate that the areas do not contain biophysical strategic agricultural land or critical industry clusters. Therefore, an agricultural impact statement has not been completed as part of this report

The proposed extension areas will be mined as an open cut operation and result in permanent disturbance. Topsoil recovery and management activities will occur in accordance with the following management plans which will be revised to include the proposed extension areas:

- landscape management plan and sub-plans, comprising:
  - rehabilitation and off-set management plan;
  - final void management plan;
  - mine closure plan; and
- mining operation plans.

The plans will be extended as required to accommodate any changes in management that might be required as a result of mining activity within the proposed extension areas.

Consistent with MCO's commitment to returning areas disturbed by mining operations to their pre-mining land use, the majority of the proposed extension areas will be rehabilitated for biodiversity outcomes. Small areas currently used for agriculture will be reinstated with overriding principles of stability, sustainability and minimal maintenance.

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Tables

Figures

1 Introduction

1.1 Background

The Moolarben Coal Project (MCP) is an approved open cut and underground coal mine in the Western Coalfields of NSW, approximately 40 km north-east of Mudgee (Figure 1.1). EMGA Mitchell McLennan Pty Limited was engaged by Moolarben Coal Operations Pty Limited (MCO) to undertake an agricultural impact assessment for the Moolarben Coal Project – Stage 1 Optimisation Modification (proposed modification).

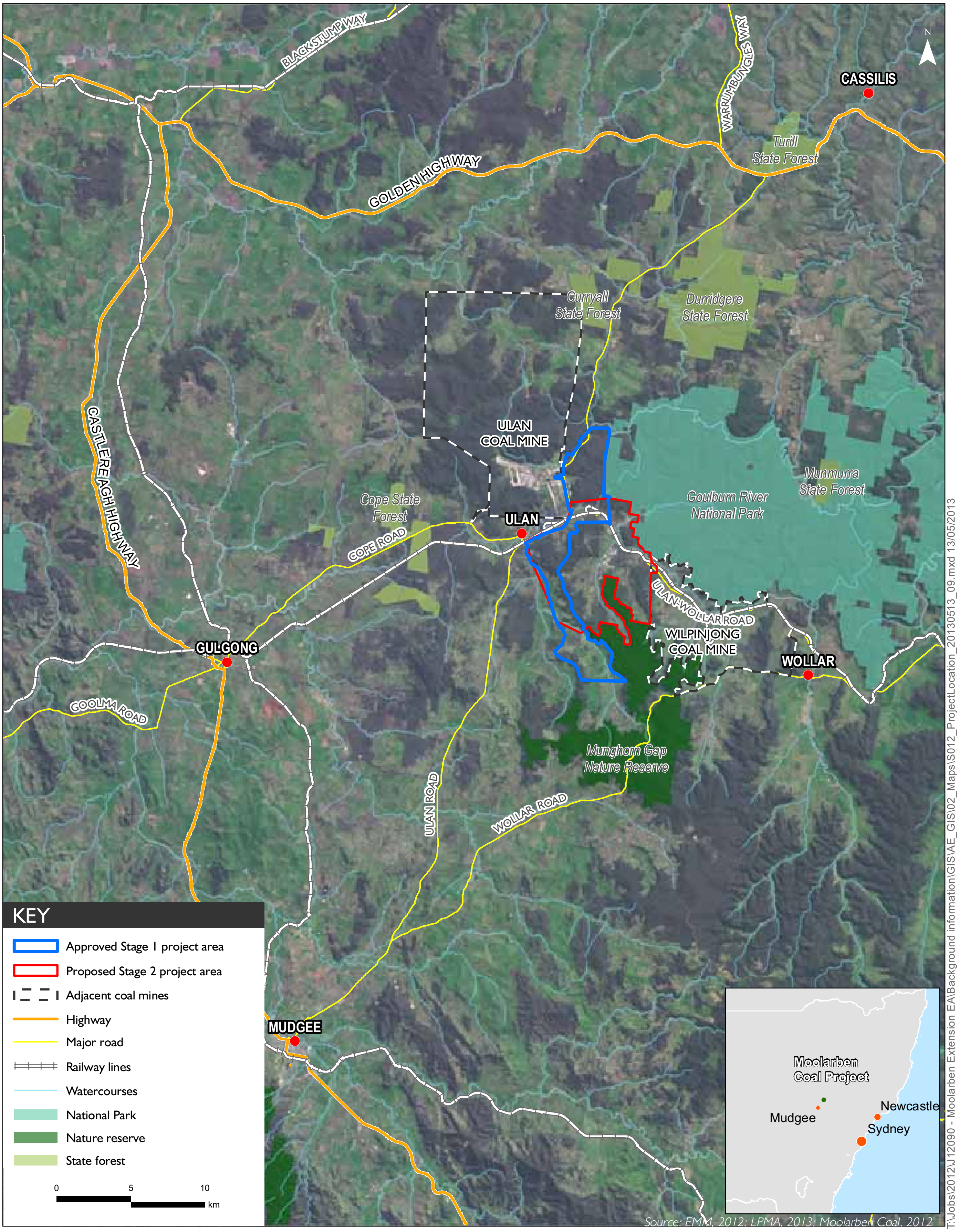
The MCP Stage 1 Major Project approval 05_0117 (MP 05_0117) was approved under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act) in 2007. Since gaining approval, MP 05_0117 has been modified on seven occasions to make administrative changes, changes to infrastructure and allow the construction of a borefield. The main components of the MCP Stage 1, as modified, comprise:

- three open cut pits, referred to as Open Cuts 1, 2 and 3, which have an approved combined maximum extraction rate of 8 million tonnes per annum (Mtpa) of run of mine (ROM) coal;
- one underground mine, referred to as Underground 4, which has an approved maximum extraction rate of 4 Mtpa of ROM coal;
- coal handling, processing, rail loop, load-out and water management infrastructure; and
- associated facilities including offices, bathhouses, workshops and fuel storages.

To date, mining has occurred within Open Cut 1 only, commencing at the south-western perimeter and progressing in a north-easterly direction.

The current disturbance limit granted under MP 05_0117 is restricting the extraction of large quantities of the deposit which are economically viable in today's market. The proposed modification will extend the disturbance boundary enabling increased resource utilisation, a longer life for Open Cuts 1 and 2 and promote the continuity of Stage 1 operations. All of the elements of the proposed modification are listed in Section 1.2.

The MCP is bordered by the Goulburn River to the north-west; privately owned grazing land to the north; Goulburn River National Park, Wilpinjong Coal Mine and Munghorn Gap Nature Reserve to the east; privately-owned grazing land to the south; and privately-owned grazing land, Ulan settlement and Ulan Coal Mine to the west.



EMM
MOOLARBENCOAL

MCP location plan

Moolarben Coal Project - Stage 1 Optimisation Modification

Agricultural assessment

Figure 1.1

1.2 Overview of proposed modification

The elements of the proposed modification to MP05_0117 comprise:

- the extension of mining within Open Cuts 1 and 2;
- the construction and operation of additional water management infrastructure; and
- a minor change to the rehabilitation sequencing and final landform.

The project approval period will be extended to accommodate the proposed modification.

No others changes are proposed under the modification.

The proposed modification elements are all within the Stage 1 project approval boundary, which forms the 'project area' for the proposed modification. Within the project area, Open Cut 1 and 2 extension areas are referred to collectively as the 'proposed extension areas'. It is noted that proposed extension areas include a disturbance buffer of up to 50 m that will enable the development of a services road and infrastructure if required, such as water pipelines. This ensures that all potential impacts associated with the proposed extension to mining have been assessed.

1.3 Relationship to other projects

A Major Project Application for Stage 2 of the MCP, MP 08_0135, is currently being assessed by the Department of Planning and Infrastructure (DP&I). If approved, Stage 2 will consist of one open cut pit, Open Cut 4, and two underground mines, Undergrounds 1 and 2, and associated additional infrastructure.

1.4 Assessment objectives

The objectives of this assessment are to:

- identify the potential impacts of the proposed modification on soils, including rural land capability, agricultural land suitability and strategic agricultural land (SAL), as defined within the Strategic Regional Land Use Policy (DP&I 2012a);
- identify the potential impacts of the proposed modification on agricultural resources/industry; and
- identify measures that would avoid, minimise and monitor potential impacts.

1.5 Assessment approach

1.5.1 Strategic Regional Land Use Policy

This assessment addresses the Strategic Regional Land Use Policy (DP&I 2012a), which requires state significant development applications for mining projects to submit an agricultural impact statement (AIS) as part of the environmental impact statement. A key part of the policy provides Strategic Regional Land Use Plans (SLRUP) for defined regions in NSW, which identify strategic agricultural land (SAL) to assist future government decision-making regarding growth and development.

To date, the NSW Government has not yet released a SLRUP relevant to the vicinity of the MCP as the remaining plans are still in the drafting stage. Given this, a site verification to determine the presence of SAL in the proposed extension areas was required. Within SRLUPs, SAL is defined as either biophysical strategic agricultural land (BSAL) or critical industry clusters (CIC). This assessment considered criteria within the nearby Upper Hunter SRLUP (DP&I 2012b) for this verification process.

1.5.2 Relevant documentation

This assessment used a desktop analysis based on a soil survey reported in *Soil, Rural Land Capability and Agricultural Suitability Assessment of the Moolarben Coal Project (Jammel 2005*). The survey was designed to provide sufficient information on land resources to allow the determination of soil family, land capability and agricultural suitability. While the assessment pre-dates the introduction of the Strategic Regional Land Use Policy and consideration of SAL, the field survey contains sufficient detail for interpretation and verification of SAL and assessment of potential agricultural impacts from the proposed modification.

An analysis of the field survey method (Jammel 2005) was undertaken in accordance with current soil survey and sampling guidelines to determine its suitability to be used in the SAL verification process. These guidelines, *Australian Soil and Land Survey: Field Handbook (McDonald et al 1990*), suggest a sampling density of between four and 16 samples per 100 hectares (ha) for a 1:25,000 scale survey. This depends on pre-existing resource information as well as the local knowledge and experience of the surveyor. Further, the guidelines also recommend that between 1% and 5% of all sites are sampled and subject to laboratory analysis and that between 10% and 30% of sites are described in detail (ie field profile morphological description).

Fieldwork investigations were conducted over the period August – September 2005. Jammel (2005) assessed 104 sites within 110 km^2 (11,000 ha). Thirty-three of which were described in full detail to a depth of 1.5 m of which six sites were selected as reference sites for laboratory analysis. Details regarding the compliance of the survey density with the current recommended guidelines are summarised in Table 1.1 (refer to Figure 1.2 for site sample plan).

Table 1.1 Survey compliance with current guidelines (McDonald et al. 1990)

Item	Recommendation	Actual	Compliance (Yes/No)
Total number of locations assessed	4 to 16 per 100 ha	Exploration Lease area equals 11,000 ha. 110 sites assessed equating to 1 site per 100 ha	**Yes**
Survey scale	1:25000	1:26000	**Yes**
Detailed sites	10-30 %	~30%	**Yes**
Sites subject to laboratory analysis	1-5%	~5%	**Yes**

In addition to the above, a free survey technique, often referred to as a relaxed grid technique (Gunn et al 1988) was used to verify mapped soil types identified in the Jammel report and boundaries were assigned to each.

The survey focused on areas likely to be affected by mining operations, although sampling beyond planned disturbance was also undertaken to enable soil units to be extended into the adjoining areas not proposed for future mining activity (Figure 1.2). Generally, sampling and profile inspection points were positioned to characterise all landform elements and soil units.

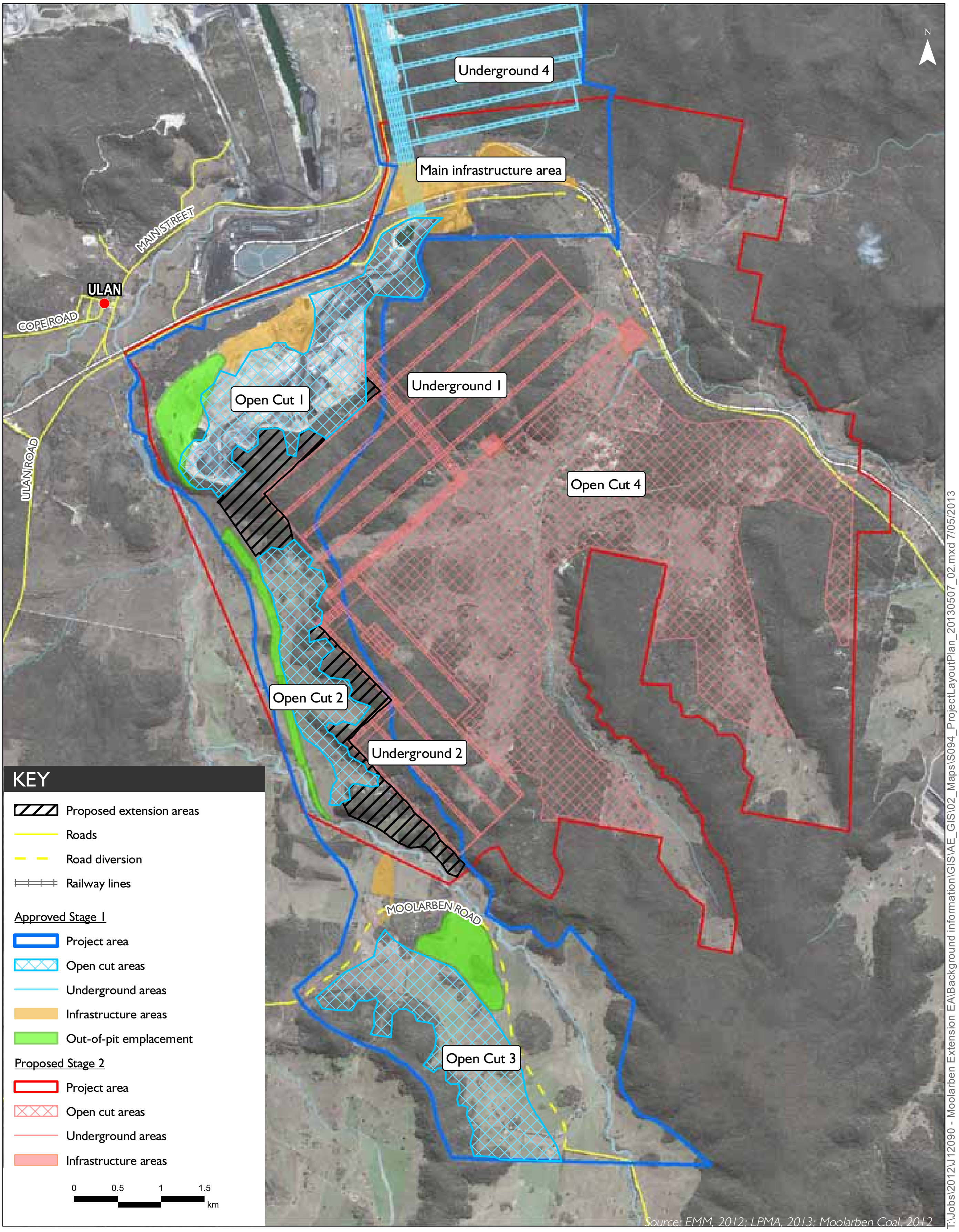
In summary, the soil survey completed by Jammel (2005) is of suitable sample density and description for use in this agricultural impact assessment.

1.6 Report structure

This report is structured to present relevant detail required to assess potential agricultural impacts that may result from the proposed modification. The report is generally consistent with guidance from the Department of Planning and Infrastructure (2012a, 2012b and 2012c)

The report is structure as follows:

- Chapter 2 - Regional land capability: provides a description of regional attributes including soils and geomorphology, water resources and pre-existing agricultural industries;
- Chapter 3 - Site verification: provides a description of soil land capability within the proposed extension areas and the relationship to BSAL;
- Chapter 4 - Impact assessment: includes an assessment of the impacts of the proposed modification to existing land capability;
- Chapter 5 – Management and monitoring: details the management and monitoring during the operational phase and planned rehabilitation of disturbed areas at mine closure;
- Chapter 6 - Conclusion.



Proposed modification layout plan

Moolarben Coal Project - Stage 1 Optimisation Modification

Agricultural assessment

Figure 1.2

2 Regional land capability context

This chapter describes the regional attributes (>1:25,000) including soils and geomorphology and water resources.

2.1 Regional rainfall

Weather Station 062013 (Gulgong Post Office) is the nearest weather station to the project area and is located at Latitude: 32.36 °S, Longitude: 149.53 °E. Highest rainfall is generally recorded between October and March annually, with the mean annual rainfall equal to 653.6 mm.

2.2 Characterisation of land and soil

2.2.1 Soil landscapes

The soil resources, land capability and agricultural suitability of the region have previously been classified by the following studies and publications at the specified broad scale:

- Landscapes of the Dubbo 1:250,000 Sheet (DLWC 1998);
- 1:100,000 Land Capability Series Sheet 8833 - Gulgong (Conservation Service of NSW 1982); and
- Agricultural Land Classification of Mudgee Shire (unpublished) (NSW Agriculture undated).

The soil landscapes of the project area, including the proposed extension areas, are based on those delineated by the Soil Landscapes of the Dubbo 1:250,000 Sheet (DLWC 1998).

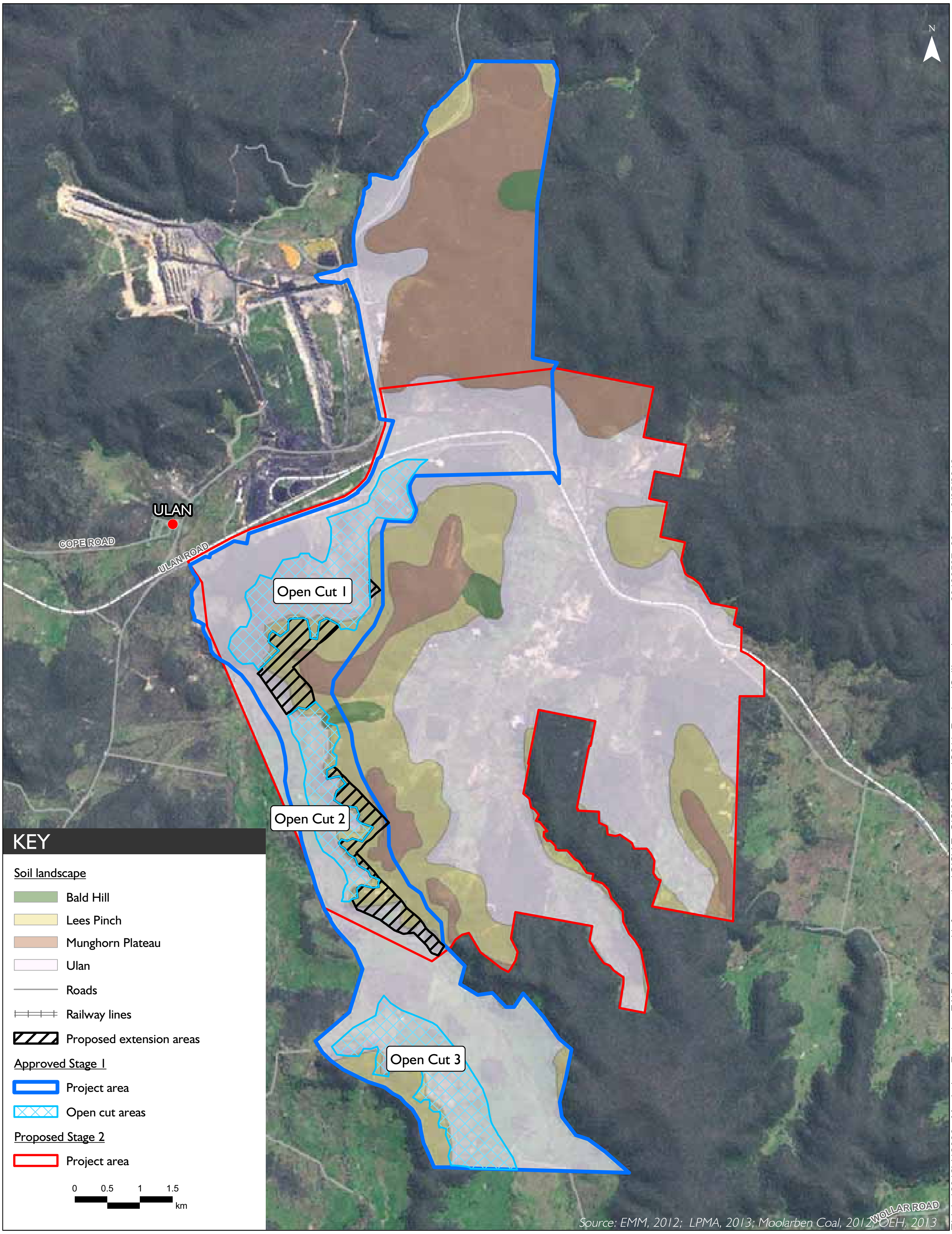
The Soil Landscapes of the Dubbo 1:250,000 Sheet (DLWC 1998) identifies four main soil landscapes in the surrounding region that also intercept the project area and the proposed extension areas, namely:

- Lees Pinch;
- Ulan;
- Bald Hill; and
- Munghorn Plateau.

The same soil landscapes are found in the proposed extension areas, with the exception of Bald Hill.

The landform characteristics, lithology, typical soils and limitations of these landscapes are summarised in Table 2.1 (adapted from DLWC 1998) and the mapped distribution of soils is shown in Figure 2.1.

The Lees Pinch soil landscape covers the majority of the proposed extension areas. Smaller areas of the western section of the Open Cut 1 extension area and the southern section of the Open Cut 2 extension areas contain the Ulan soil landscape. A small area containing the Munghorn Plateau soil landscape is also located in both open cut extension areas.



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Regional soil landscapes

Moolarben Coal Project - Stage 1 Optimisation Modification

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Figure 2.1

Table 2.1 Regional soil landscapes intersecting the project and extension areas

Landscape	Landform	Lithology	Typical Soils	Limitations
Lees Pinch	Sandstone plateau and hill slopes with boulder debris. Elevations between 400- 680 m. Slopes between 15-40%. Local relief from 60-240 m	Narrabeen Group and Illawarra Coal Measures shale sandstone, Wollar sandstone, conglomeratic sandstone, chert, shale coal, torbanite	Shallow siliceous sands, shallow acid soils, yellow earths, yellow podzolic soils	Steep slopes are high erosion hazard when cover is low. Very low fertility, acidic surface soils. Low to very low water holding capacity and high permeability
Ulan	Low undulating rises and creek flats. Elevations between 360-570 m. Slopes between 2-10%. Local relief varies between 10-40 m	Undifferentiated and Illawarra Coal Measures shale, sandstone, conglomerate, chert, coal and torbanite	Yellow podzolic, Yellow solodic /solonetz, yellow and brown earths, and earthy sands	Moderate to high erosion hazard and susceptible to soil structure degradation. Imperfectly drained on the lower slopes and depressions. High soil salinity levels and low soil fertility
Bald Hill	Low Hillocks with elevations from 460 – 600 m. Slopes 10-35%. Local relief from 60 – 120 m. Drainage lines are 300 – 500 m apart	Tertiary Basalt, Olivine basalt, dolerite, teschenite	Euchrozems – chocolate soils intergrades, chocolate soils	Steep slopes with rock outcrops; stoniness; moderate to high fertility and water holding capacity
Munghorn Plateau	Low Undulating hills form plateaux from 600 – 700 m. Slopes from 3 – 10% and local relief varies from 20 – 60 m	Narrabeen Group and Illawarra Coal Measures shale Sandstone, Wollar sandstone, conglomeratic sandstone, chert, shale coal, torbanite	Shallow siliceous sands, shallow acid soils, yellow earths, yellow podzolic soils	High to very high erosion hazard when ground cover is low. Low soil fertility and low water holding capacity

2.2.2 Soil fertility

The Soil Landscapes of the Dubbo 1:250,000 Sheet (DLWC 1998) identifies the following regional fertility rankings based on land capability assessment. Land capability fertility indicators were first published in the Soils of New South Wales: Their Characterisation, Classification and Conservation, Tech Handbook No.1 (Charman, 1978) and are also fundamental to the regional BSAL assessment in Section 2.6.3:

- Lees Pinch – low;
- Ulan – low to moderate on solodic soil;
- Bald Hill - moderate; and
- Munghorn Plateau - low.

The proposed extension areas are outside of the areas mapped by the NSW Office of Environment and Heritage (OEH) draft Inherent Soil Fertility Mapping guidelines for the Upper Hunter and New England north west strategic regional land-use areas.

2.3 Surface water

The hydrology of the catchment extending upstream from Ulan settlement is dominated by Moolarben Creek, which is a second order stream that drains the catchment to the headwaters of the Goulburn River.

The majority of Stage 1 mining operations, including Open Cuts 1, 2 and 3, are within the Moolarben Creek catchment, an area of about 126 km^2. Moolarben Creek is regulated by Moolarben Dam and from the short period of flow record available appears to have flow around 80% of the time.

Runoff from the steep upper slopes above Open Cuts 1 and 2 quickly becomes concentrated in numerous small ephemeral watercourses and gullies. These watercourses typically diminish at the proposed extension areas where the steep forested slopes meet the lower cleared slopes within the Moolarben Creek/Goulburn River valley. Runoff is discharged across these cleared areas of the catchment as either overland 'sheet flow' or via ill-defined watercourses that ultimately drain to Moolarben Creek and the Goulburn River.

The surface water assessment undertaken for the proposed modification developed a detailed water balance model to simulate the behaviour of the mine site water management system over the life of the mine, with and without the proposed modification. The assessment indicates that up to an additional 200 mega litres (ML) per annum (depending on the mining phase) of imported water is required as a result of the proposed modification, which can be satisfied from current water sources. The proposed mine site water management strategy and infrastructure will ensure that the proposed modification has a negligible impact on the quality of surface runoff and receiving waters.

The additional disturbance area associated with the proposed modification removes a small area of catchment (approximately 140 ha) draining to Moolarben Creek, to the overall catchment area. This small reduction in catchment area will have a negligible impact on the flow characteristics of Moolarben Creek.

2.4 Groundwater

Significant historical investigations, including the drilling and testing of over 100 monitoring bores, has been carried out by MCO. Conceptualisation and numerical groundwater modelling has also been completed as part of previous studies for the approved Stage 1. Therefore, the regional and local groundwater systems are well understood.

The groundwater assessment undertaken for the proposed modification indicates that groundwater inflows will remain within the predicted range from previous modelling. The only change compared to previous reported inflows would be the time period of mining. As pits will be progressively backfilled, no increase is expected in pit inflows, rather a continuation of inflows at previously modelled inflow rates.

Based on the groundwater assessment, the proposed modification will not significantly increase the rate and volume of groundwater seepage to the open cut pits and will therefore have a negligible impact on the wider groundwater regime over the already approved Stage 1 project. This includes negligible change in flows to the surface water features including Moolarben Creek, the Goulburn River and no impact to 'the Drip', an important local seepage feature located to the north of the Goulburn River. There are also no known groundwater dependent ecosystems (GDEs) or groundwater users that will be impacted by the proposed modification. The negligible additional impact is due to the fact the proposed modification is essentially dry, and the extension areas are largely within the boundary of the previously assessed mining footprint.

Existing groundwater licences held by MCO for the approved Stage 1 are sufficient to account for the expected water take due to the proposed modification. Given the limited alluvium associated with

Moolarben Creek (less than 1,500 mg/L of total dissolvable solids) it has not been considered as an aquifer for the purpose of this assessment.

2.5 Land capability

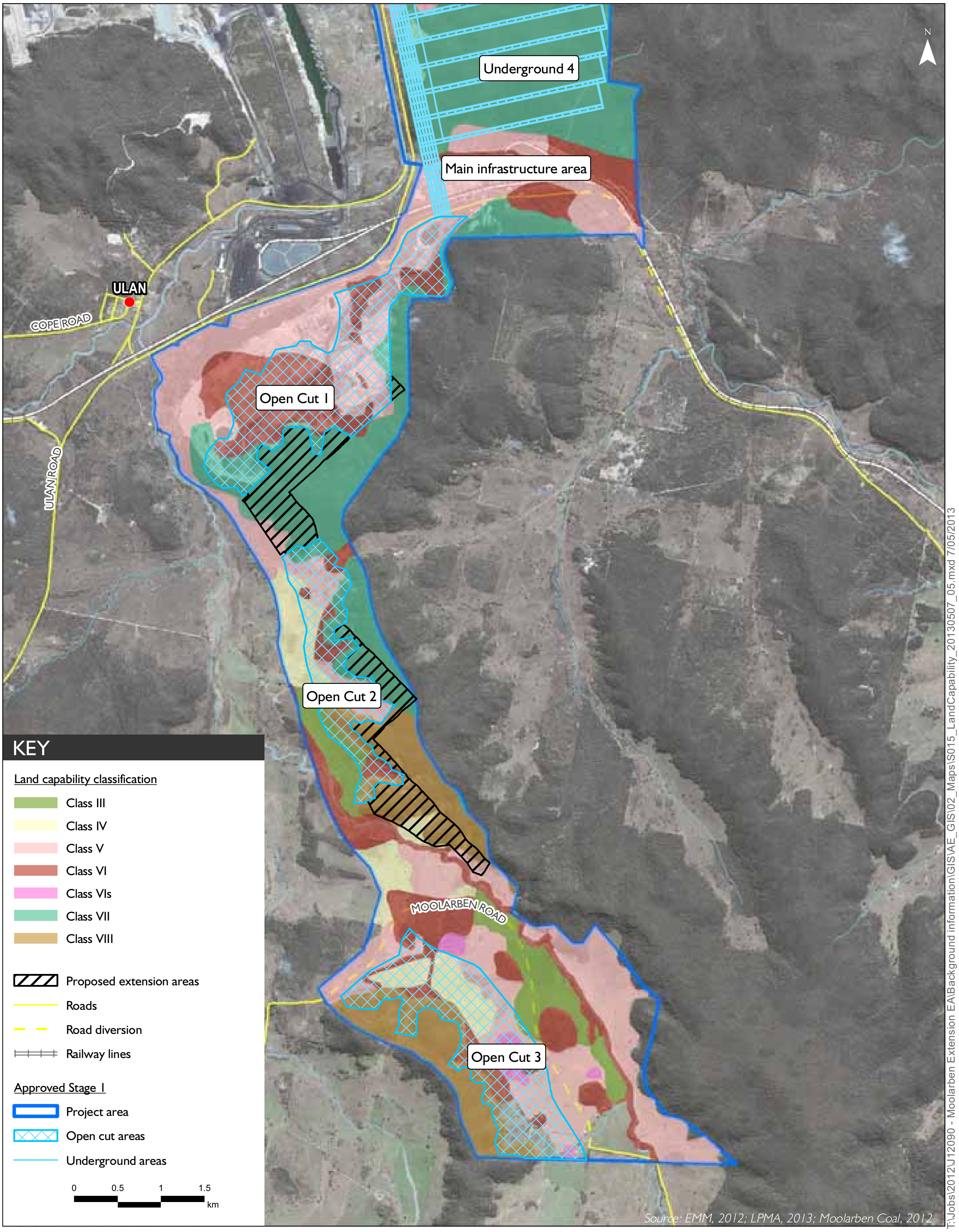
2.5.1 Regional overview

The Department of Land and Water Conservation report (1998) describes regional soil attributes and land capability in accordance with the standard NSW eight class system (Cunningham et al undated). The report identifies the following land capability classes for the regional soil landscapes that intersect the proposed extension areas:

- Lees Pinch:
  - shallow silceous sands – Class VI to Class VII;
  - yellow earths – Class V to Class VI; and
  - yellow podzolic soil – Class VI.
- Ulan:
  - yellow podzolic soil – Class III to Class IV; and
  - yellow solodic soil – Class IV.
- Bald Hill:
  - euchroozems – Class V to Class VII; and
  - chocolate soil – Class V.
- Munghorn Plateau:
  - silceous sands – Class V to Class VI;
  - yellow earths – Class V to Class VI; and
  - yellow podzolic soil – Class VI.

The system is based on the assessment of biophysical soil properties, with categories of land based on limitations such as erosion hazard, climate and slope. Table 2.2 describes the relevant classes for the proposed extension areas and potential impact of on-site and off-site management practices and land capability that may apply to the region.

Figure 2.2 shows that the vast majority of the proposed extension areas contain Class V to VI land, with a land capability of severely to very severely limited.



Land capability class within the Stage 1 project area

Moolarben Coal Project - Stage 1 Optimisation Modification

Agricultural assessment

Figure 2.2

Table 2.2 Land capability class for the proposed extension areas (DLWC, 1998)

Class	Description	Management practices
III	• **Moderate limitations –** can be managed by more intensive readily available and accepted management practices. • Land capable of most land uses (cropping with appropriate practices, grazing, forestry and nature conservation). However, to manage the limitations, cropping should change by reducing tillage and retaining stubble. Intensive grazing should change to rotational grazing.	• **On-site impact** on soil and land condition can be moderate if limitations are not managed. Soil and land condition can deteriorate as a consequence of water erosion, wind erosion, soil acidification, organic matter decline, soil structure decline or soil salinisation. • **Off-site impact** of land management practices can be significant if limitations not managed (eg salinity, leachate from acid sulphate soils, water erosion and water quality, wind erosion and air quality).
IV	• **Moderate to severe limitations –** for higher impact land management practices (eg cropping). Limitations can only be managed by specialised management practices with high level of knowledge, expertise, inputs, investment and technology. • Land is capable of a range of land uses (eg cropping with minimal or no cultivation and specialised practise, grazing, forestry and nature conservation). However, for some land uses (eg cropping and intensive grazing), practices need to be able to manage the limitations.	• **On-site impact** on soil and land condition can be moderate if limitations are not managed. Soil and land condition can deteriorate because of water erosion, wind erosion, soil acidification, organic matter decline, soil structure decline and salinisation. • **Off-site impact** of land management practices can be significant if limitations are not managed (eg salinity, leachate from acid sulphate soils, water erosion and water quality, wind erosion and air quality).
V	• **Severe limitations –** for higher impact land management practices (eg cropping) there are few methods available to overcome limitations. Highly specialised land management practices can overcome some limitations for high value crops/products. • Land capable of some land uses (grazing, forestry and nature conservation) and practices are available to manage the limitations.	• **On-site impact** on soil and land condition can be severe if not managed. Soil and land conditions can deteriorate as a consequence of water erosion, wind erosion, soil acidification, organic matter decline, soil structure decline or soil salinisation. • **Off-site impact** of land management practices can be severe if limitations not managed (eg salinity, leachate from acid sulphate soils, water erosion and water quality, wind erosion and air quality).
VI	• **Very severe limitations –** no management practices available to overcome limitations for a wide range of land uses (eg cropping, moderate to high intensity grazing, horticulture). Highly specialised practices can overcome some limitations for some high value products. No management practices are available to overcome limitations for a wide range of land uses (eg cropping, moderate to high intensity grazing, horticulture). Highly specialised land management practices can overcome limitations for some high value products. • This land is capable of a limited range of land uses (low impact grazing, forestry and nature conservation). Practices need to be able to manage the limitations.	• **On-site impacts** can be very severe if not managed. Soil and land condition can deteriorate as a consequence of water erosion, wind erosion, soil acidification, organic matter decline, soil structure decline or soil salinisation. • **Off-site impacts** can be very severe if limitations are not managed (eg salinity, leachate from acid sulphate soils, water erosion and water quality, wind erosion and air quality).
VII	• **Extremely severe limitations –** most land uses are restricted. Limitations cannot be overcome.	• **On-site** and **off-site** impacts of land management practices can be extremely severe if limitations not managed.

Table 4.1 in Chapter 4 includes a comparison of the areas of each land capability class impacted by the proposed extension.

2.6 Strategic Regional Land Use Policy

2.6.1 Regional strategic agricultural land

The criteria for SAL contained within the nearby Upper Hunter SRLUP have been used in the regional assessment. The Upper Hunter SRLUP identified SAL, which is made up of BSAL (discussed in Section 3.3) and critical industry clusters (CIC). A CIC is a localised concentration of interrelated productive industries based on agricultural product that provides significant employment opportunities and contributes to the identity of the region.

2.6.2 Verification

i Biophysical strategic cropping land

For soil landscapes to be considered BSAL they must meet the following criteria (DP&I, 2012b):

- land that falls under soil fertility classes 'high' or 'moderately high' under the Draft Inherent General Fertility of NSW (NRDD, 2013). Fertility status is derived from Charman (1978); and
- land capability classes I, II or III under the Land and Soil Capability Mapping of NSW; and
- reliable water of suitable quality, characterised by having rainfall of 350 mm or more per annum (9 out of 10 years); or properties within 150 m of a regulated river, or unregulated rivers where there are flows for at least 95% of the time (ie the 95th percentile flow of each month of the year is greater than zero) or 5th order and higher rivers; or groundwater aquifers (excluding miscellaneous alluvial aquifers, also known as small storage aquifers) which have a yield rate greater than 5L/s and total dissolved solids of less than 1,500 mg/L.

Or

- land that falls under soil fertility classes 'moderate' under the Draft Inherent General Fertility of NSW (OEH); and
- land capability classes I or II under the Land and Soil Capability (LSC) Mapping of NSW (OEH); and
- reliable water of suitable quality, characterised by having rainfall of 350 mm or more per annum (9 out of 10 years); or properties within 150 m of a regulated river, or unregulated rivers where there are flows for at least 95% of the time (ie the 95th percentile flow of each month of the year is greater than zero) or 5th order and higher rivers; or groundwater aquifers (excluding miscellaneous alluvial aquifers, also known as small storage aquifers) which have a yield rate greater than 5 L/s and total dissolved solids of less than 1,500 mg/L.

Table 2.3 provides an analysis of potential BSAL land based on regional scale mapping (>1:25,000).

Table 2.3 Regional BSAL assessment

Soil landscape unit	Fertility	Land capability class	Outcome
Lees Pinch	Low	V – VII	Not BSAL
Ulan	Low to Moderate on solodic soil	III – IV	Marginal BSAL land maybe present within 150 m of: • Moolarben Creek; • Spring Creek; • Moolarben Dam; and BSAL may be present where groundwater extraction exceeds 5L/s or rainfall exceeds 350 mm annually in 9 out of 10 years.
Bald Hill	Moderate	V – VI	Not BSAL
Munghorn Plateau	Low	VI	Not BSAL

Notes: 1. Red = failed criteria

2. Amber = marginal pass

The land capability class of the proposed extension areas includes class IV to VII and does not include class III or lower (refer to Figure 2.2). The groundwater and surface water assessments determined the Moolarben Creek catchment is not deemed to be a reliable water of suitable quality, being classified a 2nd order stream with flows identified approximately 80% of the time. Given the limited alluvium associated with Moolarben Creek (less than 1,500 mg/L of total dissolvable solids) it has not been considered as an aquifer for the purpose of this assessment.

Based on this information the soil landscapes of the proposed extension areas are unlikely to meet the above criteria for BSAL.

ii Critical industrial clusters

The proposed extension areas are within the project approval boundary of the current operations. These areas are currently wooded, sloped in excess of 15%, do not require additional water supply, and are not currently used for viticulture or equine-related activities or enterprises. The nearest viticultural enterprise is in Gulgong approximately 25 km to the south-west, and the nearest equine-related enterprise is located approximately 20 km to the south east in Wollar. Therefore, the proposed extension areas are not expected to impact CICs and no further verification of CICs is required (refer to Section 3.4).

2.6.3 Regional BSAL assessment summary

Whilst the data presented in this section indicates that BSAL is highly unlikely to be present within the proposed extension areas, verification at a site level is required given the regional scale of the land capability maps and data used.

Local site verification of potential BSAL within the project area and the proposed extension areas are discussed in Chapter 3.

No CICs will be affected by the proposed modification.

3 Site verification

This chapter presents site (1:25,000) assessment and verification of soil within the proposed extension areas for land capability and BSAL. Agricultural suitability is briefly discussed as a tool to describe alternative agricultural land uses for the proposed extension areas.

3.1 Land capability

The land capability assessment has been conducted in accordance with the standard NSW eight class system (Cunningham et al undated). Section 2.5 and Figure 2.2 presented the land classes relevant to the proposed extension areas. The proposed extension areas comprise land capability Class IV, V, VI, VII and VIII.

3.2 Agricultural suitability

Agricultural land suitability is used here as a tool for describing alternative agricultural land use (grazing) potential for the proposed extension areas. The regional assessment for BSAL showed very limited potential for BSAL units within the proposed extension areas.

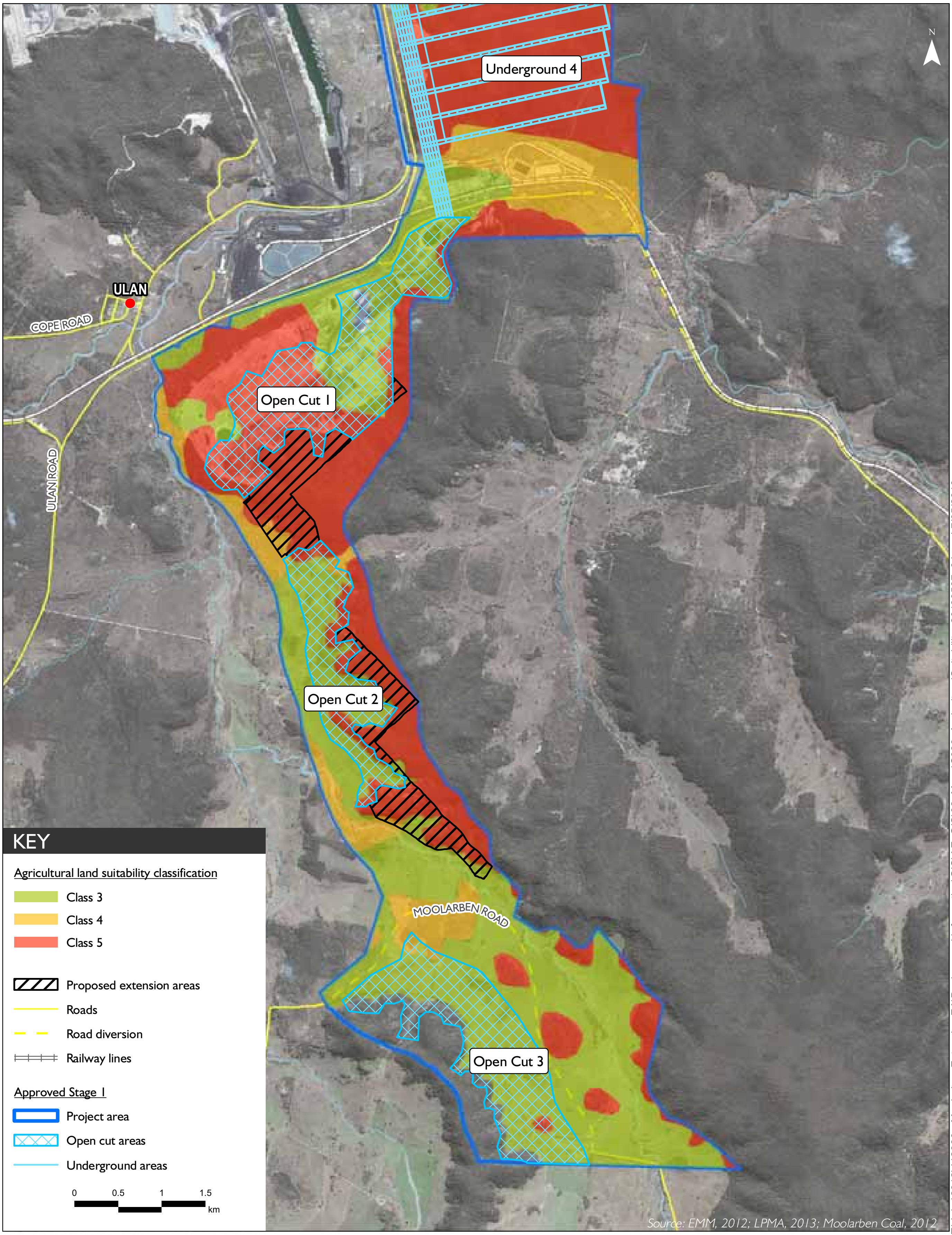
The agricultural suitability assessment was conducted in accordance with the five class system (Riddler 1996), which classifies land according to its productivity for a wide range of agricultural activities. The agricultural suitability assessment presented here was first reported in Jammel (2005).

Based on the Agricultural Land Classification of Mudgee Shire (unpublished) (NSW Agriculture, undated), the proposed extension areas comprise Class 3, 4 and 5 agricultural land, as shown in Figure 3.1.

The following sections provide a description of the class type and its relevance to the proposed extension areas.

- Class 3
  - grazing land or land well suited to pasture improvement. It may be cultivated or cropped in rotation with pasture;
  - predominantly on the valley floor and lower slopes of the project area. Small areas of farming for cereal crop production occur. However, the dominant land use is primarily cattle and sheep grazing on pastures (improved and native). Erosion hazard, soil structural breakdown and climatic factors limit the capacity for cultivation; and
  - limited occurrence at the southern extent of the Open Cut 2 extension area.
- Class 4
  - land suitable for grazing but not for cultivation. Production may be seasonally high, but the overall production level is low as a result of major environmental constraints; and
  - occurs in small locations throughout the valley floors and the lower slopes of the project area, and a small portion at the southern extent of the proposed extension areas. These areas are represented by either shallow/sandy or dispersible (sodic) soils or land with steep slopes. In conjunction with their edaphic limitation also have moderate to high erosion hazard restricting the agricultural productivity.

- Class 5
  - land unsuitable for agriculture or at best suited to only light grazing. Agricultural production is very low to zero as a result of severe constraints, including economic factors, which preclude land improvement;
  - associated with the escarpments and lower hills within and adjacent to the project areas and the majority of the proposed extension areas. Generally characterised by steeper slopes shallow soils and lower fertility land; and
  - negligible agricultural production is derived from these lands due to the significant constraints of slope, soil and location.



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Agricultural suitability within the Stage 1 project area

Moolarben Coal Project - Stage 1 Optimisation Modification

Agricultural assessment

Figure 3.1

3.3 Verification of biophysical strategic agricultural land

The Department of Planning and Infrastructure (DP&I) introduced criteria for identifying biophysical SAL land in a draft interim protocol for site verification and mapping of biophysical strategic agricultural land (DP&I 2012d). The criteria were developed to reliably and consistently identify NSW land with rare combination of natural resources highly suitable for agriculture. These lands intrinsically have the best quality landforms, soil and water resources which are naturally capable of sustaining high levels of productivity and require minimal management practices to maintain this high quality.

3.3.1 Method

The criteria relevant for the proposed extension areas are described in Table 3.1. Verification was completed by applying the criteria described in Table 3.1 to the 33 full profile soil descriptions completed by Jammel (2005) and utilising laboratory results also derived as part of the study for the Stage 1 EA.

It is important to note that the DP&I's protocol is designed so that as soon as a criterion fails to meet BSAL conditions, the relevant site area is not taken to be BSAL and no further assessment is needed.

Table 3.1 Summary of criteria for identifying BSAL (DP&I 2012d)

Criteria	Criteria and thresholds	Attributes
(a) water	Reliable water	• ≥ 350 mm rainfall per year • Land is underlain by a groundwater aquifer with a yield rate greater than 5 L/s and total dissolved solids of less than 1,500 mg/L
(b) slope	Slope ≤ 12% Slope ≤ 5%	• Slope in per cent (%) – artificial features such as contour banks and tracks, should be ignored in slope measurements
(c) rock outcrop	≤30% rock outcrop	• Abundance of rock outcrop
(d) soil type	Moderate or high fertility	• For each soil type, a combination of factors such as inherent fertility, soil permeability, soil structure, tilth and typical soil depth determine soil fertility. • The ranking is based on soil classification.
(e) surface rockiness	≤ 20% of area have unattached rock fragments >60 mm diameter	• Abundance and size of surface rocks
(f) gilgai	≤ 50% of the area have gilgais >500mm deep	• Density of gilgai depressions • Depth of gilgai
(g) total soil depth	≥750mm	• Depth to a physical or chemical barrier
(h) drainage	drainage better than very poor/poor	• Colour of the matrix • Presence and colour of mottles • Presence of a conspicuous bleach overlying bedrock
(i) pH	5 – 8.9 if measured in water or 4.2 – 8.1 if measured in calcium chloride	• Soil pH • Depth of sample
(j) soil salinity	≤4dS/m or are chlorides <800 mg/kg when gypsum is present	• Electrical conductivity or chloride content • Depth of sample
(k) soil water storage	≥75mm to a soil depth or physico-chemical limitation of ≤1000 mm	• Field texture • Presence of physico-chemical barriers • Determination of whether the soil is rigid or non-rigid • Drained upper limit – determined in the field • Lower limit – determined in a laboratory
(l) minimum area	≥20 ha	

Soil water storage assessment was based on estimated plant available water capacity according to soil texture class (measured in mm per cm of soil) as defined by CSIRO (2008) as shown in Table 3.2.

Table 3.2 Criteria for estimating plant available water content

Texture class	Estimate plant available water capacity (mm water/cm soil)
Sands	0.5
Sandy loam to clay	0.8-1.2
Heavy clay	1.5-2.0

3.3.2 Results

A comparison with the BSAL criteria of the 33 full profile descriptions, based on the suitability of samples taken from six representative locations undergoing laboratory analysis, was undertaken. It is noted that profile descriptions were mostly not within the proposed extension areas which are generally much steeper than the areas listed. This is considered a conservative approach to the assessment and appropriate for site verification purposes.

Each of the soil samples analysed failed the BSAL assessment due to one of three reasons:

1. Fertility (b) – this was assessed from field data and interpretation of Appendix 2 of BSAL Interim Assessment Protocol;

2. Soil depth (g) - If auger refusal occurred at a depth less than 750 mm then it was assumed that soil at this location failed the soil depth criteria; and

3. Drainage (h) - If soil was defined as imperfectly drained it was assumed that water is removed from the soil slowly in relation to supply, to keep the soil wet for a significant part of the growing season. Excess water moves slowly downward if precipitation is the major supply. In this case if mottling were described as gray or pale and greater than 20% then it was assumed that the soil profile failed the drainage criteria.

Therefore, the site does not contain any BSAL.

3.4 Verification of critical industrial clusters

CICs were not identified in the regional assessment. No further assessment of the proposed extension areas has been undertaken as part of this assessment.

4 Impact assessment

The proposed extension areas will result in a total disturbance of approximately 178 ha. The potential impacts of the proposed modification on soils and land classes and the potential impact to agricultural activities is considered in Sections 4.1 and 4.2.

4.1 Land capability

The proposed extension areas have a land capability class of between IV and VIII. None of the land is Class III or lower.

The majority (approximately 93%) of the Open Cut 1 extension area is Class VII 'extremely severe limitations' where most land uses are restricted and limitations cannot be overcome. The remaining portion of the Open Cut 1 extension area, in the south west corner is Class V 'severe limitations'.

The Open Cut 2 extension area includes Class IV, V, VI, VII and VIII. Small portions of the southern extent of the extension area are Class IV and V with the northern and middle portions Class VI, VII and VIII.

A comparison of the areas of each land capability class impacted by the proposed extension areas is provided in Table 4.1.

Table 4.1 Land capability class impacted by proposed modification

	Open cut 1 extension area		Open cut 2 extension area	
Land capability class	**(ha)**	**(%)**	**(ha)**	**(%)**
Class IV	0	0	5.7	6.1
Class V	6.3	7.4	4.7	5.0
Class VI	0.1	0.1	1.0	1.0
Class VII	78.1	92.5	27.8	29.8
Class VIII	0	0	54.5	58.1

4.2 Agricultural suitability

The agricultural suitability of the proposed extension areas are classified as Class 3, 4 and 5.

The majority (approximately 87%) of the proposed extension areas are Class 5, land unsuitable for agriculture or best suited to only light grazing, associated with the escarpments and lower hills associated with the proposed extension areas.

A small portion (approximately 4%) of Class 4 land suitable for grazing but not cultivation is located at the southern extent of the Open Cut 1 extension area, and a similarly small portion of Class 3 grazing land is located at the southern extent of the Open Cut 2 extension area.

A comparison of the areas of each agricultural suitability class is provided in Table 4.2.

Table 4.2 Agricultural suitability class impacted by proposed modification

	Open cut 1 extension area		Open cut 2 extension area	
Agricultural suitability class	**(ha)**	**(%)**	**(ha)**	**(%)**
Class 3	0	0	15.7	16.7
Class 4	6.1	7.2	1.8	1.9
Class 5	78.3	92.8	76.3	81.4

Other potential impacts of the proposed modification on agricultural land relate to surface and groundwater impacts and potential noise and air quality impacts. The proposed modification will have negligible impact on the rate and volume of groundwater seepage to the open cut pits, Moolarben Creek catchment, the quality of surface runoff and on receiving waters (refer to Chapters 14 and 15). Furthermore, the requirement for additional water can be satisfied from current water sources and MCO's existing licences.

Predicted noise and air quality impacts are below relevant criteria and will not require additional property acquisitions. It is noted, however, within two privately owned properties, six individual lots are predicted to experience noise levels of greater than 40 dB(A), on more than 25 % of the individual lot land area.

An assessment of the proposed modification against the SAL criteria identified in the SRLUP for biophysical SAL and CICs has been undertaken. No SAL has been identified within the project area or the proposed extension areas. As the project does not intercept BSAL or CICs no impacts to biophysical SAL, viticultural SAL and equine SAL, are expected.

5 Management and monitoring

The proposed modification will have only minor impacts to rehabilitation and final landform. MCO is committed to returning areas disturbed by mining operations to their pre-mining landuse. Rehabilitation at MCO is undertaken in accordance with a Mining Operations Plan (MOP) and the Landscape Management Plan (LMP).

5.1 Management of disturbance

MCP's Environmental Management Strategy (EMS) provides the framework for environmental management at MCP. The EMS is supported by various management and monitoring plans required under MP05_0117. This includes the Landscape Management Plan (LMP) that comprises three sub-plans, namely:

- rehabilitation and offset management plan;
- final void management plan; and
- mine closure plan.

The LMP includes a biodiversity mitigation strategy that aims to achieve a 'maintain and enhance' ecological outcome, resulting in a net positive biodiversity benefit in the post-developed landscape. The broad objectives of the strategy are to:

- avoid impacts on areas of high ecological value;
- enhance local vegetation cover;
- increase patch utilisation of isolated vegetation remnants by local biodiversity such as woodland birds;
- improve connectivity between Munghorn Gap Nature Reserve and Goulburn River National Park;
- improve connectivity between Dexter Mountain and Munghorn Gap Nature Reserve through revegetation and management; and
- secure the local conservation of endangered ecological communities, their habitats and important local biodiversity.

The LMP details specific management goals, the means of achieving the abovementioned objectives, assessment criteria and monitoring requirements.

Together with the LMP, the MOP provides the mechanism for rehabilitation. The scope of the MOP, which will be updated to capture the proposed modification, includes the activities associated with:

- further development of active mining with Open Cut 1;
- support infrastructure; and
- rehabilitation works.

MCO's Air Quality Management Plan (AQMP), Water Management Plan (WMP) and Noise Management Plan (NMP) are also relevant to the proposed modification, as they include measures to manage dust, erosion, sedimentation and noise. These plans will continue to be implemented under the proposed modification. These measures will help mitigate potential adverse impacts on any surrounding agricultural land.

The plans will be extended as required to accommodate any changes in management that might be required as a result of mining activity within the proposed extension areas.

5.2 Rehabilitation

Consistent with MCO's commitment to returning areas disturbed by mining operations to their pre-mining land use, Open Cut 1 will be principally rehabilitated to create Box Gum Woodlands and Sedimentary Ironbark Forests with stands of *Allocasurina spp.* Lands adjoining the northern part of Open Cut 2 and the haul road linking with Open Cut 1 that are under the control of MCO will also be revegetated to enhance vegetation cover and connectivity. A similar objective is proposed for the Open Cut 1 extension area which will be rehabilitated to Grassy White Box Woodlands and Broad-leaved Ironbark Forests with stands of Forest Oaks.

The Box Gum Woodland mosaic will contain some areas of relatively dense tree and/or shrub cover, providing good shelter habitat and some areas of natural grassland. Species will be chosen to improve faunal biodiversity and habitat.

The Open Cut 1 extension area will be seeded with a combination of native perennial grasses, shrubs and woodland species consistent with those species found in the local area. Species selection will be designed to promote the development of forest and woodland with structured understorey, mid-storey and tree canopy coverage. This will increase overall biodiversity values and promote survival of these vegetation types in the post-mining landscape.

Open Cut 2 will be principally reinstated to agricultural land following mining. However, given the majority of the Open Cut 2 extension area is vegetated, and in accordance with MCO's commitment to creating long term habitat corridors, the majority of the extension area will be rehabilitated with native vegetation to develop habitats similar to the existing undisturbed environment. A small portion in the south-western section will be restored to agricultural land.

The soil survey identified the dominant soils throughout the project area and the proposed extension areas. From the physical assessment and the chemical analysis of the soils it is determined that the soils are suitable for rehabilitation with the appropriate soil ameliorant and nutrient inputs applied.

6 Conclusion

The proposed extension areas will result in a total disturbance of approximately 178 ha. Currently these areas are mostly wooded with slopes generally greater than 15%, presenting a severe constraint to agricultural production.

The land capability class of the proposed extension areas is between Class IV and VII, with the majority Class VII 'extremely severe limitations' where most land uses are restricted and limitations cannot be overcome.

The agricultural suitability of the proposed extension areas are classified as Class 3, 4 and 5, with the majority being Class 5, land suitable for agriculture or best suited to only light grazing.

Verification assessments of the proposed extension areas, demonstrate that the areas do not contain biophysical strategic agricultural land or critical industry clusters. Therefore, an agricultural impact statement has not been completed as part of this report

The proposed extension areas will be mined as an open cut operation and result in permanent disturbance. Topsoil recovery and management activities will occur in accordance with pre-existing management plans developed for the project including:

- landscape management plan and sub-plans, comprising:
  - rehabilitation and off-set management plan;
  - final void management plan;
  - mine closure plan; and
  - mining operation plans.

MCO's LMP and MOP will be extended where required to accommodate any changes in management that might be required as a result of mining activity within the proposed extension areas.

Consistent with MCO's commitment to returning areas disturbed by mining operations to their pre-mining land use, the majority of the proposed extension areas will be rehabilitated for biodiversity outcomes. Small areas currently used for agriculture will be reinstated with overriding principles of stability, sustainability and minimal maintenance.

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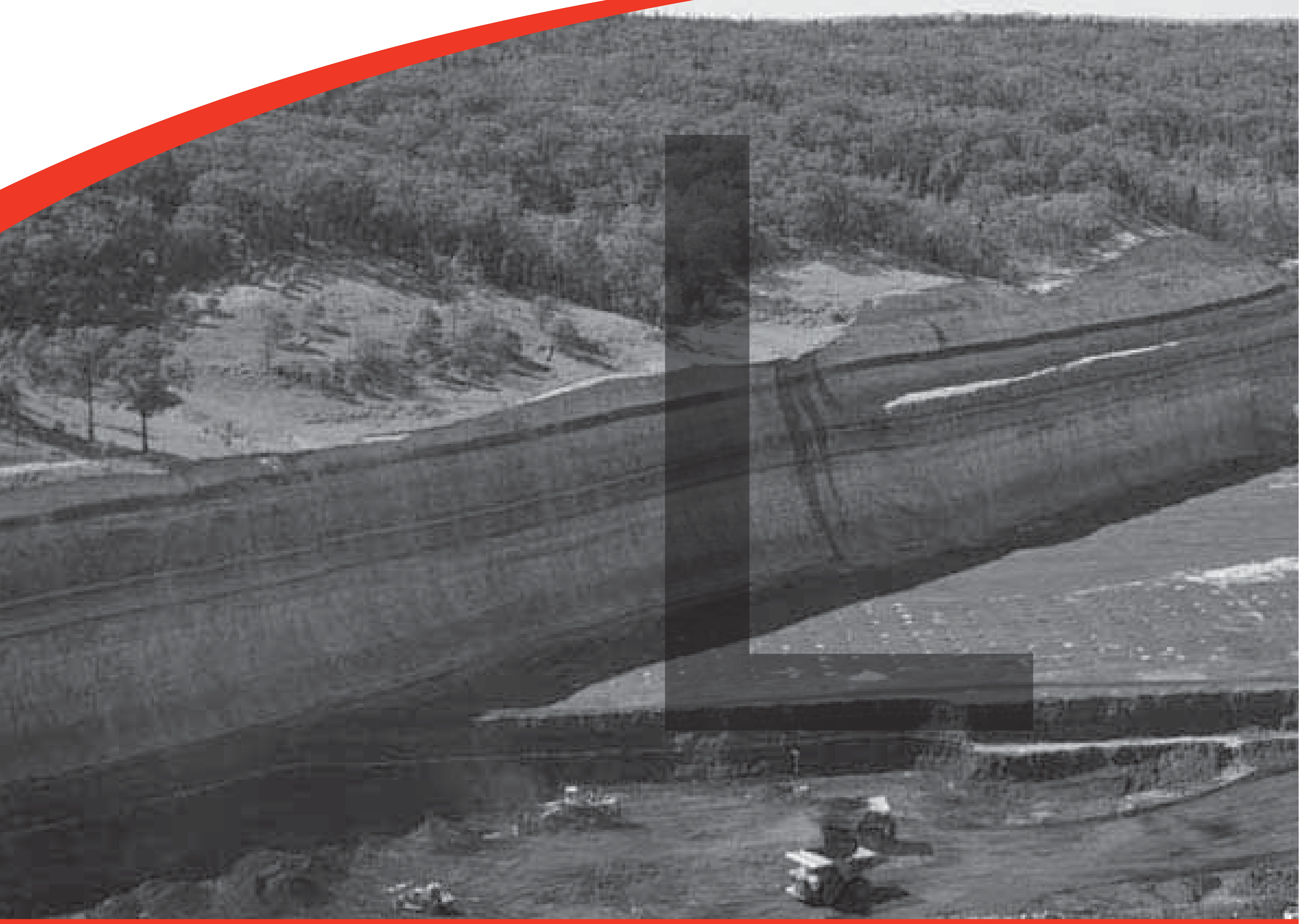
Appendix L



Economic impact assessment

Moolarben Coal Project Stage 1 Optimisation Modification, Environmental Assessment – May 2013

MOOLARBENCOAL
PART OF THE YANCOAL AUSTRALIA GROUP

EMM
EMGA Mitchell McLennan

Moolarben Coal Project Stage 1 Optimisation Modification

Economic Impact Assessment

Final Report

Prepared for

EMM

By

Gillespie Economics
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May 2013

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GLOSSARY

Benefit cost analysis – a method to assess the relative economic desirability (economic efficiency) of competing alternatives.

Benefit transfer - refers to borrowing economic values that have been determined for other study sites.

Depreciation - is an allowance or provision made in the books of a business for wear and tear on plant and articles.

Discount rate – the percentage rate of compound interest at which future benefits and costs are adjusted to their equivalent present-day values.

Discounting – the process of adjusting future benefits and costs to their equivalent present-day values.

Economic efficiency – is concerned with whether the well-being of society is improved by a proposal relative to without the proposal.

Externalities – an outcome that arises when an activity between two parties affects the activity of a third, without any compensation to or payment by the third party.

Intermediate good – a good that is used as an input into the production of other goods and services.

Neoclassical welfare economics – a branch of economics that uses microeconomic techniques such as benefit cost analysis to evaluate the economic well-being of the society.

Net present value – the difference between the present value of benefits and the present value of costs.

Opportunity cost – the potential return in the best, foregone alternative.

Partial equilibrium analysis – the analysis of relationships within a particular subsector of the economy, holding relationships in other subsectors of the economy constant.

Present value – the equivalent value today of a future benefit or cost.

Resource costs – resource costs are costs where there is an exchange of goods and services (resources). They are distinct from transfer payments, such as royalties, which are a cost to an individual firm but do not involve any exchange of resources

Threshold value method – a form of benefit cost analysis, where the quantified net benefits of a Project are compared to the unquantified costs. The quantified net benefits provide a threshold value that unquantified costs must exceed to make the Project questionable from an economic efficiency perspective.

ABBREVIATIONS

AUD – Australian dollars

BCA – benefit cost analysis

CO2-e – carbon dioxide equivalent

EcIA – economic impact assessment

EA – environmental assessment

EPBC Act - Commonwealth *Environment Protection and Biodiversity Conservation Act*

LGA – local government area

M – million

MLA - mining lease application

Mtpa – million tonnes per annum

NPV – net present value

ROM – run-of-mine

SD – statistical subdivision

USD – United States dollars

1 INTRODUCTION

1.1 BACKGROUND

The Moolarben Coal Project (MCP) is an approved open cut and underground coal mine in the Western Coalfields of NSW, approximately 40 km north-east of Mudgee (Figure 1.1). Gillespie Economics was engaged by EMGA Mitchell McLennan Pty Limited on behalf of Moolarben Coal Operations Pty Limited (MCO) to undertake an Economic Impact Assessment (EcIA) for the Moolarben Coal Project – Stage 1 Optimisation Modification (proposed modification).

The MCP Stage 1 Major Project approval 05_0117 (MP 05_0117) was approved under Part 3A of the Environmental Planning and Assessment Act 1979 (EP&A Act) in 2007. Since gaining approval, MP 05_0117 has been modified on seven occasions to make administrative changes, changes to infrastructure and allow the construction of a borefield. The main components of the MCP Stage 1, as modified, comprise:

- three open cut pits, referred to as Open Cuts 1, 2 and 3, which have an approved combined maximum extraction rate of 8 million tonnes per annum (Mtpa) of run of mine (ROM) coal;
- one underground mine, referred to as Underground 4, which has an approved maximum extraction rate of 4 Mtpa of ROM coal;
- coal handling, processing, rail loop, load-out and water management infrastructure; and
- associated facilities including offices, bathhouses, workshops and fuel storages.

To date, mining has occurred within Open Cut 1 only, commencing at the south-western perimeter and progressing in a north-easterly direction.

The current disturbance limit granted under MP 05_0117 is restricting the extraction of large quantities of the deposit which are economically viable in today's market. The proposed modification will extend the disturbance boundary enabling increased resource utilisation, a longer life for Open Cuts 1 and 2 and promote the continuity of Stage 1 operations. All of the elements of the proposed modification are listed in Section 1.2.

The MCP is bordered by the Goulburn River to the north-west; privately owned grazing land to the north; Goulburn River National Park, Wilpinjong Coal Mine and Munghorn Gap Nature Reserve to the east; privately-owned grazing land to the south; and privately-owned grazing land, Ulan settlement and Ulan Coal Mine to the west.

1.2 OVERVIEW OF PROPOSED MODIFICATION

The elements of the proposed modification to MP05_0117 comprise:

- the extension of mining within Open Cuts 1 and 2;
- the construction and operation of additional water management infrastructure; and
- a minor change to the rehabilitation sequencing and final landform.

The project approval period will be extended to accommodate the proposed modification.

No others changes are proposed under the modification: there will be no change to the maximum annual rate of coal production, mining methods, equipment, manning levels, coal handling and processing, external coal transport or operating hours.

The proposed modification elements are shown in Figure 1.2. They are all within the Stage 1 project approval boundary, which forms the 'project area' for the proposed modification. Within the project area, Open Cut 1 and 2 extension areas are referred to collectively as the 'proposed extension areas'.

It is noted that proposed extension areas include a disturbance buffer of up to 50 m that will enable the development of a services road and infrastructure if required, such as water pipelines. This ensures that all potential impacts associated with the proposed extension to mining have been assessed.

1.3 RELATIONSHIP TO OTHER PROJECTS

A Major Project Application for Stage 2 of the MCP, MP 08_0135, is currently being assessed by the Department of Planning and Infrastructure (DP&I). If approved, Stage 2 will consist of one open cut pit, Open Cut 4, and two underground mines, Undergrounds 1 and 2, and associated additional infrastructure. This EcIA is based on the assumption that Stage 2 of the MCP will be approved, enabling potential worst case impacts to be assessed.

1.4 REPORT PURPOSE

This report outlines the scope of the EcIA, describes the methods used and summarises the results of the assessment. In doing so, the EcIA satisfies the requirements of the *Environmental Planning and Assessment Act, 197*9 in relation to economic assessment of the proposed modification.

1.5 SCOPE OF WORK

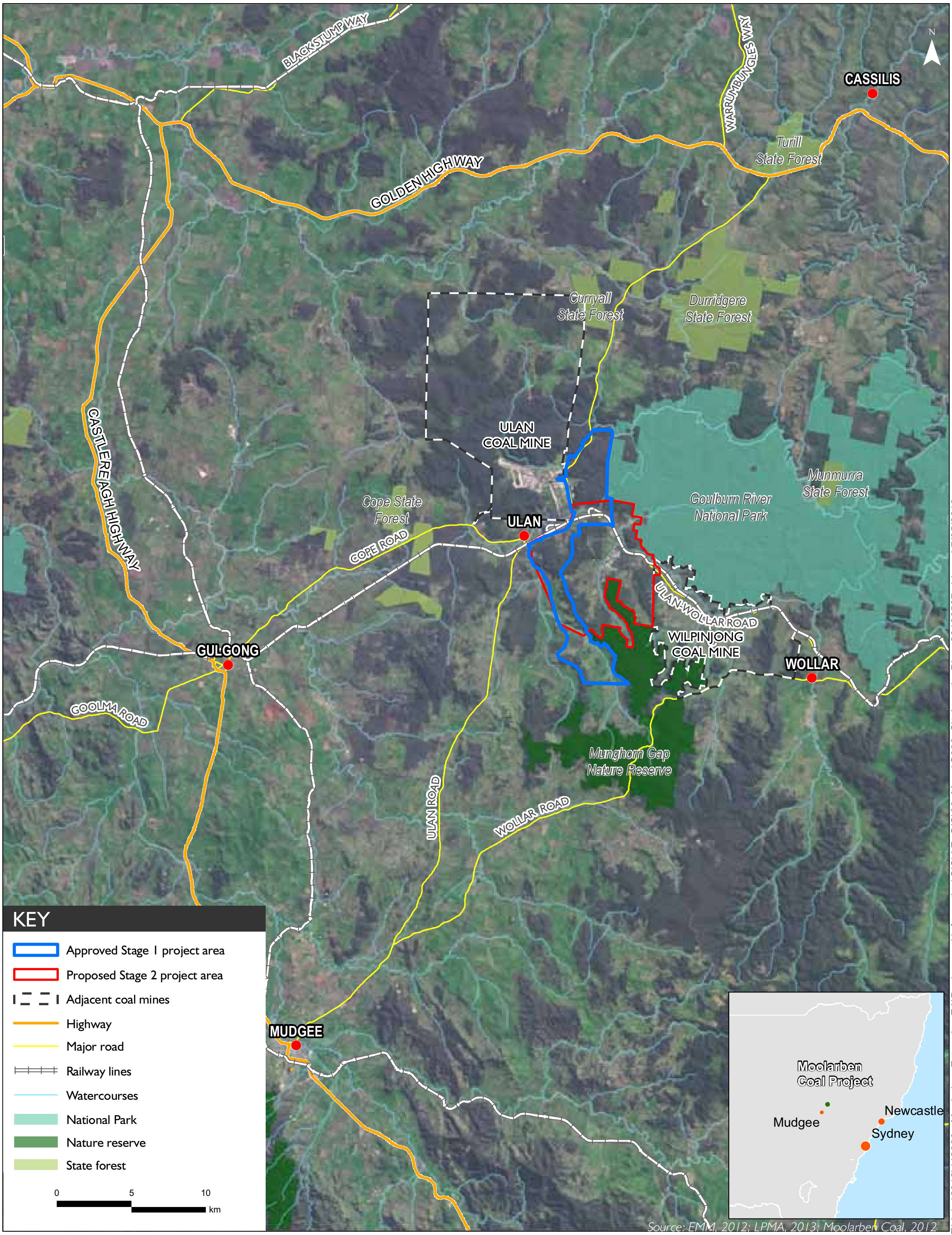
The scope of work relates to the preparation of a EcIA of the proposed modification. The NSW Department of Planning and Infrastructure's (NSW DP&I) draft *Guideline for Economic Effects and Evaluation in EIA* (James and Gillespie, 2002) identifies economic efficiency as the key consideration of economic analysis. BCA is the method used to consider the economic efficiency of proposals. The draft guidelines identified BCA as essential to undertaking a proper economic evaluation of proposed developments that are likely to have significant environmental impacts. NSW Government (2012) has prepared a draft *Guideline for the use of Cost Benefit Analysis in mining and coal seam gas proposals*. This guideline also identifies BCA as the appropriate method for evaluating mining proposals.

This report documents a BCA of the proposed modification.

1.5 REPORT STRUCTURE

The EcIA is structured as follows:

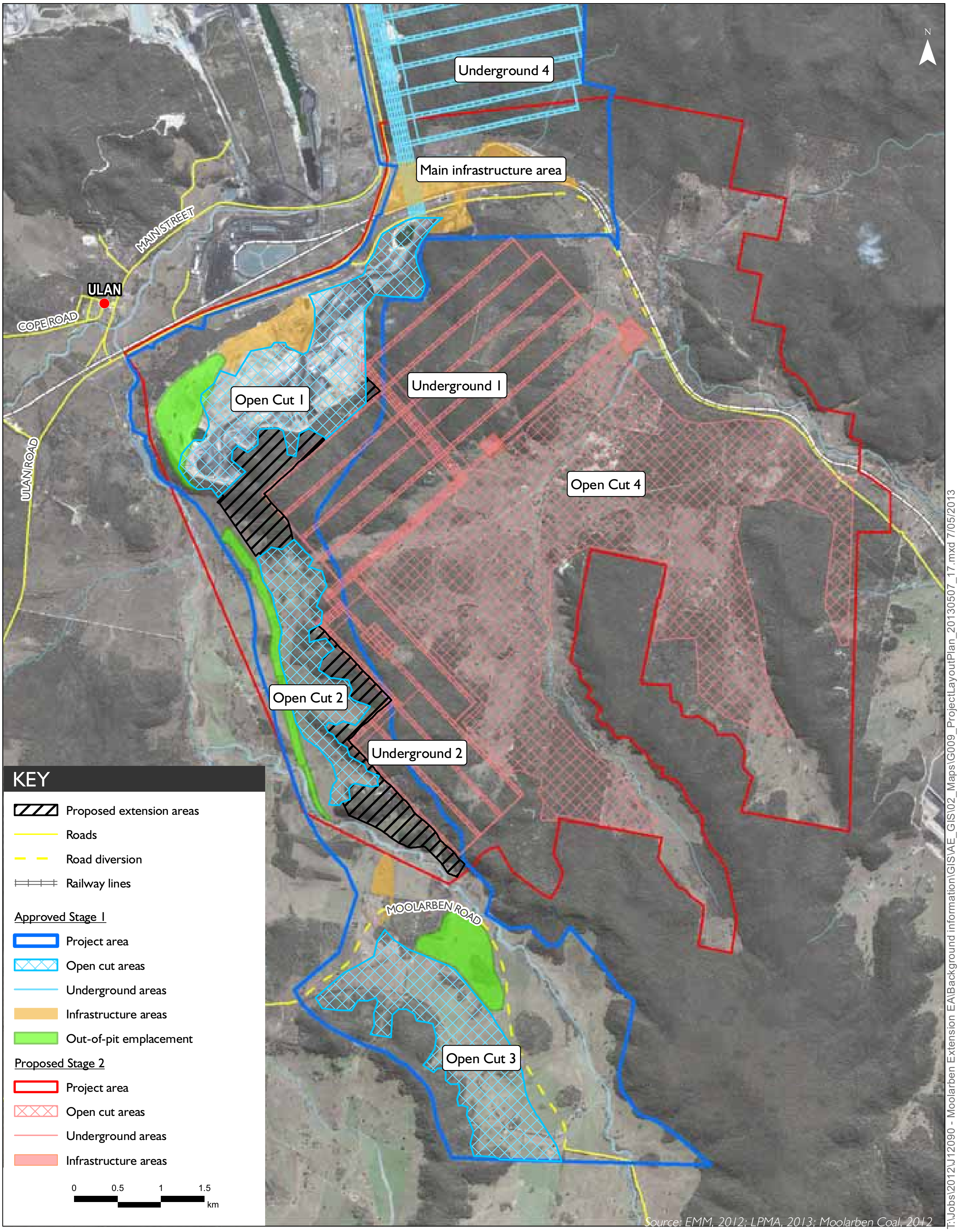
- Section 1 – Introduction (this section) – provides an overview of the proposed modification and outlines the scope of works for the EcIA;
- Section 2 – Benefit Cost Analysis – provides a description of the BCA methodology and describes the findings of the BCA for the proposed modification;
- Section 3 – Conclusions – provides a summary of the key findings of the EcIA for the proposed modification;
- Section 4 – References;
- Attachment 1 – Valuing Greenhouse Gas Emissions – provides a discussion of the approach taken to value greenhouse gas emissions from the proposed modification; and
- Attachment 2 – BCA Sensitivity Testing – tests the results of the BCA to changes in key assumptions.



MCP location plan

Moolarben Coal Project - Stage 1 Optimisation Modification

Figure 1.1



Proposed modification layout plan

Moolarben Coal Project - Stage 1 Optimisation Modification

Figure 1.2

2 BENEFIT COST ANALYSIS

2.1 INTRODUCTION

Introduction to BCA

BCA has its theoretical underpinnings in neoclassical welfare economics. Applications in NSW are guided by these theoretical foundations as well as the NSW Treasury (2007). BCA applications within the NSW environmental assessment framework are further guided by the NSW DP&I *Draft Guidelines for Economic Effects and Evaluation in EIA* (James and Gillespie 2002) and the NSW Government (2012) *Draft Guidelines for the use of Cost Benefit Analysis in mining and coal seam gas proposals*.

BCA is concerned with a single objective of the EP&A Act and governments i.e. economic efficiency. It provides a comparison of the present value of aggregate benefits to society, as a result of a project, policy or program, with the present value of the aggregate costs. These costs and benefits are defined and valued based on the microeconomic underpinnings of BCA. In particular, it is the values held by individuals in the society that are relevant, including both financial and non-financial values. Provided the present value of aggregate benefits to society exceed the present value of aggregate costs (i.e. a net present value of greater than zero), a project is considered to improve the well-being of society and hence is desirable from an economic efficiency perspective.

While BCA can provide qualitative and quantitative information on how costs and benefits are distributed, welfare economics and BCA are explicitly neutral on intra and intergenerational distribution of costs and benefits. There is no welfare criterion in economics for determining what constitutes a fair and equitable distribution of costs and benefits. Judgements about equity are subjective and are therefore left to decision-makers.

Similarly BCA does not address other objectives of the EP&A Act and governments. Decision-makers therefore need to consider the economic efficiency implications of a project, as indicated by BCA, alongside the performance of a project in meeting other conflicting goals and objectives of the EP&A Act and government.

Definition of Society

BCA includes the consideration of costs and benefits to all members of society i.e. consumers, producers and the broader society as represented by the government.

As a tool of investment appraisal for the public sector, BCA can potentially be applied across different definitions of society such as a local area, state, nation or the world. However, most applications of BCA are performed at the national level. This national focus extends the analysis beyond that which is strictly relevant to a NSW government planning authority. However, the interconnected nature of the Australian economy and society creates significant spillovers between States. These include transfers between States associated with the tax system and the movement of resources over state boundaries.

Nevertheless, “where major impacts spill over national borders, then BCA should be undertaken from the global as well as the national perspective” (Boardman et al 2001). For mining projects, impacts that spill over national borders include greenhouse gas costs and benefits to foreign owners.

BCA at a sub-national perspective is not recommended as it results in a range of costs and benefits from a project being excluded, making BCA a less valuable tool for decision-makers (Boardman et al 2001).

BCAs of mining projects are therefore often undertaken from a global perspective i.e. including all the costs and benefits of a project, no matter who they accrue to, and then truncated to assess whether there are net benefits to Australia. A consideration of the distribution of costs and benefits can then be undertaken to identify the benefits and costs that accrue to NSW and other regions. However, a project is considered to improve the well-being of society if it results in net benefits to the nation, even if it results in net costs to the local area.

Definition of the Project Scope

The definition of the project for which approval is being sought has important implications for the identification of the costs and benefits of a project. Even when a BCA is undertaken from a global perspective, and includes costs and benefits of a project that accrue outside the national border, only the costs and benefits associated with the defined project are relevant. For mining projects, typically only the costs and benefits from mining the coal and delivering it to Port or domestic users, are relevant.

Coal is an intermediate good i.e. it is an input to other production processes such as production of electricity and steel making. However, these other production processes themselves require approval and, in BCA, would be assessed as separate projects.

Net Production Benefits

BCA of mining proposals invariably involves a trade-off between:

- the net production benefits of a project; and
- the environmental, social and cultural impacts (most of which are costs of mining but some of which may be benefits).

Net production benefits can be estimated based on market data on the projected financial[1] value of coal less the capital and operating costs of projects, including opportunity costs of capital and land already in the ownership of mining companies. This is normally commercial in confidence data provided by the proponent. Production costs and benefits over time are discounted to a present value.

Environmental, Social and Cultural Impacts

The consideration of non-market impacts in BCA relies on the assessment of other experts contributing information on the biophysical impacts. The environmental impact assessment process results in detailed (non-monetary) consideration of the environmental, social and cultural impacts of a project and the proposed means of mitigating the impacts.

At its simplest level, BCA may summarise the consequences of the environmental, social and cultural impacts of a project (based on the assessments in the EIS), for people's well-being. These qualitatively described impacts can then be considered alongside the quantified net production benefits, providing important information to the decision-maker about the economic efficiency trade-offs involved with a project.

These environmental, social and cultural impacts generally fall into three categories, those which:

- "can be readily identified, measured in physical terms and valued in monetary terms;
- can be identified and measured in physical terms but cannot easily be valued in money terms; and
- are known to exist but cannot be precisely identified, measured or value" (NSW Treasury 2007).

Impacts in the first and second category can potentially be valued in monetary terms using benefit transfer or, subject to available resources, primary non-market valuation methods. Benefit transfer

[1] In limited cases the financial value may not reflect the economic value and therefore it is necessary to determine a shadow price for the coal.

involves using information on the physical magnitude of impacts and applying per unit value estimates obtained from non-market valuation studies undertaken in other contexts.

Primary non-market valuation methods include choice modelling and the contingent valuation method where a sample of the community is surveyed to ascertain their willingness to pay to avoid a unit change in the level of a biophysical attribute. Other methods include the property valuation approach where changes in environmental quality may result in changes in property value.

In attempting to value the impacts of a project on the well-being of people there is also the practical principle of materiality. Only those impacts which are likely to have a material bearing on the decision need to be considered in BCA (NSW Government, 2012).

Where benefits and costs cannot be quantified these items should be included in the analysis in a qualitative manner (NSW Treasury 2007).

Consideration of Net Social Benefits

The consideration of the net social benefits of a project combines the value estimate of net production benefits and the qualitative and quantitative estimates of the environmental, social and cultural impacts.

In combining these considerations it should be noted that the estimates of net production benefits of a project generally includes accounting for costs aimed at mitigating, offsetting or compensating for the main environmental, social and cultural impacts. This includes the costs of purchasing properties adversely affected by noise and dust, providing mitigation measures for properties moderately impacted by noise and dust, the costs of providing ecological offsets and the cost of purchasing groundwater and surface water entitlements in the water market etc. Including these costs effectively internalises the respective and otherwise, non-monetary environmental, social and cultural costs. To avoid double counting of impacts, only residual impacts, after mitigation, offset and compensation, require additional consideration.

Even when no quantitative valuation is undertaken of the environmental, social and cultural impacts of a project, the threshold value approach can be utilised to inform the decision-maker of the economic efficiency trade-offs. The estimated net production benefits of a project provides the threshold value that the non-quantified environmental, social and cultural impacts of a project (based on the assessments in the EIS), after mitigation, offset and compensation by the proponent, would need to exceed for them to outweigh the net production benefits.

Where the main environmental, social and cultural impacts of a project are valued in monetary terms, stronger conclusions can be drawn about the economic efficiency of a project i.e. the well-being of society.

Any other residual environmental, cultural or social costs that remain unquantified in the analysis[2] can also be considered using the threshold value approach. The costs of these unquantified environmental, cultural and social impacts would need to be valued by society at greater than the quantified net social benefit of a project to make it questionable from an economic efficiency perspective.

Steps in BCA of the Proposed Modification

BCA of the proposed modification involves the following key steps:

- Identification of the base case or “without” the proposed modification scenario;

[2] Including potential impacts that were unknown at the time of the preparation of the EIS or arise during the EIA process due to differences in technical opinions.

- Identification of the proposed modification and its implications;
- Identification of the incremental benefits and costs of the proposed modification relative to the base case;
- Quantification and valuation of the incremental benefits and costs of the proposed modification relative to the base case;
- Consolidation of value estimates over time to present values using discounting to account for temporal differences;
- Application of decision criteria, in particular net present value to determine if the present value of benefits of the proposed modification exceed the present value of costs; and
- Sensitivity testing to determine if the net present value estimate is sensitive to changes in assumptions about the magnitude of the physical impact of the proposed modification or the assumed unit value for impacts; and
- Consideration of any non-quantified benefits and costs to assess how large these impacts would need to be to change the net present value of the proposed modification.

The following sections present the findings of the proposed modification BCA based on financial, technical and environmental advice provided by the proponent and its specialist consultants.

2.2 IDENTIFICATION OF THE BASE CASE AND PROPOSED MODIFICATION

Identification of the "base case" or "without" the proposed modification scenario is required in order to facilitate the identification and measurement of the incremental economic benefits and costs of the proposed modification.

In this study, the base case or "without" the proposed modification scenario involves the continuation of mining in accordance with:

- the current approval, MP 05_0117 (as previously modified); and
- the Major Project Application for Stage 2 of the MCP, MP08_0135, which is currently being assessed by the DP&I.[3]

In contrast to the "base case", the proposed modification is as described in Section 1.2. With or without the proposed modification the mine life for the current approval combined with the Stage 2 approval would be the same and hence there is no change in timing of infrastructure decommissioning.

BCA is primarily concerned with the evaluation of a proposed modification relative to the counterfactual of no modification. Where there are a number of alternatives to a project then these can also be evaluated using BCA. However, alternatives need to be feasible to the proponent and to this end a number of alternatives to the proposed modification were considered by the proponent in the development of the proposed modification description. The EA proposed modification description section provides further detail on the modification alternatives considered.

The proposed modification assessed in the EA and evaluated in the BCA is considered by the proponent to be the most feasible alternative for minimising environmental and social impacts whilst maximising resource recovery and operational efficiency.

[3] While this is still being determined, the mine plan for the proposed modification, integrates with the current approval and the Stage 2 application.

2.3 IDENTIFICATION OF BENEFITS AND COSTS

Relative to the base case or "without" the proposed modification scenario, the proposed modification may have the potential incremental economic benefits and costs shown in Table 2.1.

Table 2.1
Potential Economic Benefits and Costs of the Modification

Category	Costs	Benefits
Net production benefits	• Opportunity cost of land and capital • Additional capital costs • Operating costs, including administration, mining, coal handling and transportation to port • Any additional site infrastructure decommissioning costs	• Value of coal • Residual value of capital and land at the cessation of the proposed modification
Potential environmental, social and cultural impacts	• Greenhouse gas generation • Operational noise impacts • Air quality impacts • Surface water impacts • Groundwater impacts • Flora and fauna impacts • Road transport impacts • Historic and Aboriginal heritage impacts • Visual impacts	• Any non-market benefits of employment

It should be noted that the potential environmental, social and cultural cost, listed in Table 2.1, are only economic costs to the extent that they affect individual and community wellbeing through direct use of resources by individuals or non-use. If the potential impacts are mitigated to the extent where community wellbeing is insignificantly affected, then no economic costs arise.

2.4 QUANTIFICATION/VALUATION OF BENEFITS AND COSTS

Consistent with NSW Treasury (2007), James and Gillespie (2002) and NSW Government (2002), the analysis has been undertaken in real values with discounting at 7 percent (%) and sensitivity testing at 4% and 10%. Where competitive market prices are available, they have generally been used as an indicator of economic values. Environmental, cultural and social values have been estimated, where possible, using market data and benefit transfer. Where impacts have been left unquantified the threshold value method is used to interpret them.

2.4.1 Production Costs and Benefits[4]

Economic Costs

Opportunity Cost of Land and Capital Equipment

The proposed modification will require the use of approximately 178 ha of land that is not already required for continuation of operations under the "without" the proposed modification scenario. While a large portion of this land is already in MCO ownership, there is an opportunity cost of using this land for the proposed modification instead of an alternative use. The opportunity costs is given by its land value which for the purpose of the analysis is assumed to be $2,000 per ha.

The proposed modification will utilise the existing fleet to operate the mine. There is potentially an opportunity cost associated with utilising some of this fleet capacity for the proposed modification instead of potential fleet rationalisation. Estimation of this opportunity cost was too complex to undertake as part of this assessment and hence an alternative approach of including the proponent's annual allocation of depreciation, across the entire mining operation, was used. While it is recognised that depreciation does not technically reflect the opportunity cost of capital (NSW Treasury 2007) it can be considered as proxy for the allocation of capital equipment costs (including capital equipment replacement) to each year.

Capital Cost

The capital costs of the proposed modification are estimated by MCO at $40M and are associated with sustaining capital and costs of environmental and social impact mitigation. These costs are included in the years that they are expected to occur.

Annual Operating Costs of the Mine

The annual operating costs of the proposed modification include costs associated with mining, coal handling and preparation plant (CHPP) operation, administration, rail, port, demurrage and marketing. These costs include labour costs, which reflect the value of labour resources in their next best use. The average annual operating cost of the proposed modification over a 20 year period (excluding royalties) is estimated at $48M. However, the incremental production provided by the proposed modification is not continuous, and varies considerably from year to year, and so care needs to be taken in the interpretation of this average value.

While royalties are a cost to the proponent they are part of the overall producer surplus benefit of the mining and processing activity that is redistributed by government. Royalties are therefore not included in the calculation of the resource costs of operating the proposed modification. Nevertheless, it should be noted that the proposed modification would generate total royalties over its life in the order of $163M, or $85M in present value terms at 7% discount rate.

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[4] All values reported in this section are undiscounted Australian dollars unless otherwise specified.

Decommissioning and Rehabilitation Costs for Surface Infrastructure

The proposed modification does extend the life of the Stage 1 approval however compared to the base case of Stage 1 and Stage 2 the Modification does not change the timing or extent of the surface infrastructure decommissioning as no additional infrastructure is required as part of the proposed modification. Rehabilitation costs associated with the mining footprint are included in operating costs above.

Economic Benefits

Value of Coal

The main economic benefit of the proposed modification is the additional export earnings that would be generated. This can be estimated from the increased thermal coal volumes that would be produced, together with an assumed export price of coal. The proposed modification is estimated to produce two qualities of thermal coal, 18% ash and 22.5% ash. Based on advice from MCO, the weighted export coal price for all the product coal is assumed to remain constant over time at USD$85/t. Based on advice from MCO a AUD:USD exchange rate of 1.01 is initially assumed with the long run average being 0.89.

There is obviously considerable uncertainty around the economic value of coal from the proposed modification. Consequently, variations in the assumed economic value of coal from the proposed modification have been included in the sensitivity analysis presented in Section 2.6.

Residual Value at End of the Evaluation Period

At the end of the proposed modification, capital equipment and land may have some residual value that could be realised by sale or alternative use. It is conservatively assumed that there is no additional residual value of capital and land as a result of the proposed modification.

2.4.2 Non-market Costs and Benefits

Greenhouse Gases

The proposed modification will generate additional greenhouse gas emissions. The economic analysis has conservatively included all Scope 1 and Scope 2 emissions attributable to the modification as well as Scope 3 emissions associated with rail transport of product coal to port.

To place an economic value on CO_2-e emissions, a shadow price of CO_2-e is required that reflects its social costs. The social cost of CO_2-e is the present value of additional economic damages now and in the future caused by an additional tonne of CO_2-e emissions. There is great uncertainty around the social cost of CO_2-e with a wide range of estimated damage costs reported in the economics literature. An alternative method to trying to estimate the damage costs of CO_2-e is to examine the price of CO_2-e credits. Again, however, there is a wide range of permit prices. For this analysis, a shadow price of AUD$23/t CO_2-e rising at 2.5 per cent per year in real terms for three years and then remaining constant was used. Sensitivity testing assuming a shadow price from AUD$8/t CO_2-e to AUD$40/t CO_2-e was also undertaken (refer to Attachment 1).

Operational Noise

The EA Noise and Vibration Impact Assessment (EMM, 2013a) identifies that no additional privately owned residences would be significantly impacted by the proposed modification and be subject to acquisition upon request. However, there are five additional properties that will be moderately impacted by noise from the proposed modification and will be within the noise management zone.

The impact of the proposed modification noise on nearby properties can potentially be valued using the property valuation method, where any change in property values as a result of the noise impacts, are estimated. An alternative approach, which has been used in this analysis, is to include the costs of mitigation measures, such as at receiver noise mitigation measures in the capital costs of the proposed modification. It is recognised that to the extent that any residual noise impacts occur, after mitigation, noise costs of the proposed modification included in the BCA will be understated.

Air Quality

The EA Air Quality and Greenhouse Gas Impact Assessment (TAS 2013) predicts that no additional privately-owned residences would be significantly impacted by dust from the proposed modification and hence no additional residences would be subject to acquisition upon request. Consequently, no additional economic costs were included in the BCA.

Surface Water

The EA Surface Water Impact Assessment (WRM, 2013) identifies that the proposed modification would require an increase in external demand by up to 200 mega litres (ML) per annum as a result of additional dust suppression demand. While MCO already holds sufficient existing water licences to meet this required increase in demand, there is an opportunity cost of using these water licences for the proposed modification instead of alternative uses. The opportunity cost of these water licences is given by their market value, which is assumed to be $2,000 per ML.

There will a loss of around 140 ha (1.1%) of the Moolarben Creek catchment as a result of the proposed modification. This is estimated to result in approximately 35 ML per annum in reduced catchment inflows to the Moolarben Creek. This reduction in inflows has been valued at the opportunity costs of water which is assumed to be $2,000 per ML.

Groundwater

The EA Groundwater Impact Assessment (AGE, 2013) concludes that the proposed modification will result in a negligible increase in seepage rates to the mine and ‘nil’ impact on surrounding groundwater regime over approved Stage 1. The proposed modification will not impact any Groundwater Dependent Ecosystems or groundwater users. There will be negligible impact on Moolarben Creek and no alluvial water take from the proposed modification. MCO holds sufficient water entitlements to account for any potential water take associated with the proposed modification. However, there is an opportunity cost with holding these for an additional five years. This opportunity cost has been estimated assuming a value of water of $2,000 per ML.

Flora and Fauna

The EA Ecological Assessment (EMM 2013b) reports that the proposed modification will result in the clearing of native vegetation including endangered ecological communities and non-threatened native vegetation. The clearing of native vegetation will result in some loss of non-use values held by the community for this biodiversity. However, MCO proposes to secure suitable biodiversity offsets. The provision of offsets will result in some gain in non-use values held by the community for this conserved biodiversity. The capital and management cost of the proposed offset have been included in the capital costs and operating cost of the proposed modification. Provided that the community values for impacted biodiversity are counterbalanced by the community values for the biodiversity offset no significant further economic cost would arise that would warrant inclusion in the BCA.

Road Transport

The proposed modification will not increase employee numbers or change traffic conditions but it will extend the Stage 1 mining operation by 5 years and hence extend the use of previously approved traffic and transport routes. However, all vehicle movements for coal and overburden haulage will remain on internal haul roads. Current traffic volumes are well within the capacity of the roads and intersections and under the current approval some intersection modifications were undertaken to enhance safety, including line marking and the removal of some trees south-west of the intersection so as to provide good sight distances for motorists. Continuation of the current level of road usage for 5 years is therefore not considered to have any significant road transport impacts for inclusion in the BCA.

Rail Transport

The proposed modification does not seek approval to increase current production levels and, therefore, no additional train movements will be required.

However, the proposed modification seeks to extend the Stage 1 mining operations by five years, from 2028 to 2033. This will consequently extend the use of previously approved rail movements and impacts assessed and approved under MP 05_0117. However, these rail movements were previously assessed as minor with no significant impacts on rail crossing delays or safety. Consequently, there are no significant impacts for inclusion in the BCA.

Aboriginal Heritage

The EA Aboriginal Cultural Heritage Assessment (SEA, 2013) field survey identified 30 Aboriginal sites comprising open artefact sites and rock shelters. These sites were in addition to the three previously recorded Aboriginal sites within or immediately adjacent to the proposed extension areas. As a result, a total of 33 sites known to occur directly within or immediately adjacent to the proposed extension areas have been identified.

Potential impacts to the identified Aboriginal sites were identified as being from direct (test excavation) and indirect (blasting) impacts from surface works. The assessment determined that the impacts from the proposed modification will be low within a local context and very low within a regional context. By extension, the cumulative impacts of the proposed modification within a regional context will also be very low.

Management and monitoring of Aboriginal cultural heritage will be conducted in accordance with the Stage 1 ACHMP. The implementation of mitigation measures specified in the ACHMP will minimise the impacts to Aboriginal cultural heritage in the proposed extension areas. Consequently, no economic costs have been included in the BCA.

Historic Heritage

The EA Historic Heritage Impact Assessment (EMM, 2013c) identifies that no historic heritage sites within the mining extension area will be impacted by the proposed modification. Consequently, no economic costs have been included in the BCA.

Visual Impacts

The EA Visual Impact Assessment (EMM, 2013d) identified a number of potential properties where visual impacts are expected. These impacts can potentially be valued using the property valuation method, where the change in property value, as a result of the amenity impacts, are estimated. An alternative approach, which has been used in this analysis, is to include the costs of mitigation measures, proposed in the Visual Assessment which includes targeted planting and screening along

Ullan-Cassillis Road and potentially at impacted properties, in the capital costs of the proposed modification. It is recognised that to the extent that any residual visual impacts occur, after mitigation, visual amenity costs of the proposed modification included in the BCA will be understated.

Social and Economic Value of Employment

Historically, the employment benefits of projects have tended to be omitted from BCA on the implicit assumption that labour resources used in a project would otherwise be employed elsewhere. Where this is not the case, Streeting and Hamilton (1991) and Boardman et al (1996) outline that otherwise unemployed labour resources utilised in a project should be valued in a BCA at their opportunity cost (wages less social security payments and income tax) rather than the wage rate which has the effect of increasing the net production benefits of a project. In addition, there may be social costs of unemployment that require the estimation of people's willingness to pay to avoid the trauma created by unemployment. These are non-market values.

It has also been recognised that the broader community may hold non-environmental, non-market values (Portney, 1994) for social outcomes such as employment (Johnson and Desvouges, 1997), particularly if there is unemployment or there are significant adjustment costs in moving between jobs (friction in the labour market).

In a recent study of the Metropolitan Colliery in the NSW Southern Coalfields, Gillespie Economics (2008) estimated the value the community would hold for the 320 jobs provided over 23 years at $756M (present value). In a similar study of the Bulli Seam Operations, Gillespie Economics (2009a) estimated the value the community would hold for the 1,170 jobs provided over 30 years at $870M (present value). In a study of the Warkworth Mine extension, Gillespie Economics (2009b) estimated the value the community would hold for 951 jobs from 2022 to 2031 at $286M (present value).

The proposed modification, integrated with other approvals, would essentially result in an additional five years of employment for 317 people. Using the more conservative Bulli Seam Operation employment value gives an estimated $39M for the non-market employment benefits of the project. This value has been included in the BCA. In the context of a fully employed economy there may be some contention about the inclusion of this value, particularly as it requires benefit transfer from a study of an underground mining operation in a region of NSW. Consequently, sensitivity testing that excludes this value has also been undertaken.

2.5 CONSOLIDATION OF VALUE ESTIMATES AND APPLICATION OF DECISION CRITERIA

2.5.1 Aggregate Costs and Benefits

The present value of the proposed modification costs and benefits, using a 7% discount rate, is provided in Table 2.2. The main decision criterion for assessing the economic desirability of a project to society is its net present value (NPV). NPV is the present value of benefits less the present value of costs. A positive NPV indicates that it would be desirable from an economic perspective for society to allocate resources to the project, because the community (producers and consumers) as a whole would obtain net benefits from the project.

The proposed modification is estimated to have total net production benefits of $430M. Assuming 100% foreign ownership, $188M of these net production benefits would accrue to Australia. The estimated net production benefits that accrue to Australia can be used as a threshold value or reference value against which the relative value of the residual environmental impacts of the proposed modification, after mitigation, may be assessed. This threshold value is the opportunity cost to society of not proceeding with the proposed modification. The threshold value indicates the price that the community must value the residual environmental impacts (be willing to pay) to justify in economic efficiency terms the no development option.

For the proposed modification to be questionable from an economic efficiency perspective, all incremental residual environmental impacts from the proposed modification, that impact Australia[5], would need to be valued by the community at greater than the estimate of the Australian net production benefits i.e. greater than $188M. This is equivalent to each household in the Mid-Western Region Local Government Area (LGA), NSW and Australia valuing residual environmental impacts of the proposed modification at $20,000, $70 and $23, respectively.

Instead of leaving the analysis as a threshold value exercise, an attempt has been made to investigate and quantify the main residual environmental impacts of the proposed modification. From Section 2.4.2, it is evident that the main impact that is quantified in this analysis relates to greenhouse gas impact from the proposed modification. The global greenhouse gas costs are estimated $7M (present value) with $0.1M (present value) accruing to Australia. There will also be an opportunity cost of using water licences for the proposed modification and reducing catchment flow into Moolarben Creek. However, this opportunity cost is negligible. Other impacts, including the impacts on biodiversity, visual amenity and noise amenity, have been internalised into the production costs of the proposed modification by the inclusion of the capital and operating costs of noise and visual impact mitigation measures and biodiversity offsets.

Overall, the proposed modification is estimated to have net social benefits to Australia of between $188M and $227M (depending on whether non-market employment benefits are included) and hence is desirable and justified from an economic efficiency perspective.

While the major environmental, cultural and social impacts have been quantified and included in the project BCA, any other residual environmental, cultural or social impacts that remain unquantified would need to be valued at greater than between $188M and $227M for the proposed modification to be questionable from an Australian economic efficiency perspective.

[5] Consistent with the approach to considering net production benefits, environmental impacts that occur outside Australia would be excluded from the analysis. This is mainly relevant to the consideration of greenhouse gas impacts.

Table 2.2
Benefit Cost Analysis Results of the Proposed Modification ($M Present Values at 7% Discount Rate)

	COSTS		BENEFITS	
	Description	**Value**	**Description**	**Value**
Net Production Benefits	Opportunity cost of land	$0	Value of coal	$974
	Opportunity cost of capital equipment	$45	Residual value of capital equipment at the cessation of the proposed modification	$0
	Development costs of the modification	$22	Residual value of land at the cessation of the proposed modification	$0
	Operating costs, including administration, mining, coal handling, transportation to Port and Port charges	$499		
	Additional surface infrastructure decommissioning and rehabilitation costs	$0		
	Production Sub-total	***$567M***	**-**	***$997M***
	Net Production Benefits		-	**$430M ($188M)**
Environmental, cultural and social impacts	Greenhouse gas emissions	$7 ($0.1)	Non-market benefits of employment	$39
	Agricultural production	Negligible	-	-
	Operational noise	Negligible. Mitigation measures included in capital costs	-	-
	Air quality	Negligible	-	-
	Surface water	Negligible	-	
	Groundwater	Negligible	-	-
	Flora and fauna	Some loss of values but offset. Cost of biodiversity offset included in capital and operating costs	-	-
	Road transport	Negligible		
	Road Rail transport	Negligible		-
	Historic and Aboriginal heritage	Negligible	-	-
	Visual impacts	Negligible. Costs of mitigation included in capital costs	-	-
	Externalities sub-total	***$7M($0.1M)***	-	***$39M***
NET SOCIAL BENEFITS (including employment benefits)				**$462M ($227M)**
NET SOCIAL BENEFITS (excluding employment benefits)				**$422M ($188M)**

Note: Totals may have minor discrepancies due to rounding. When impacts accrue globally, the numbers in brackets relates to the level of impact estimated to accrue to Australia

2.5.2 Distribution of Costs and Benefits

While BCA is primarily concerned with the aggregate benefits and costs of the project to Australia, the distribution of costs and benefits may also be of interest to decision-makers.

The total net production benefit is distributed amongst a range of stakeholders, including:

- MCO in the form of after tax profits;
- Commonwealth Government in the form of any Company tax payable ($104M present value at 7% discount rate) and any Minerals Resource Rent Tax from the proposed modification, which is subsequently used to fund provision of government infrastructure and services across Australia and NSW, including the region; and
- NSW Government via royalties ($85M present value at 7% discount rate) which are subsequently used to fund provision of government infrastructure and services across the State, including the region.

The potential externalities costs may accrue to a number of different stakeholder groups at the local, State, National and global level (Table 2.3). However, these are largely insignificant and internalised into the production costs of the modification.

Noise and visual impacts will occur at a local level, but will be at least partially compensated for via mitigation measures. Surface water effects will occur at the local level, but will also be compensated for through the holding of required licences. Greenhouse gas costs will occur at the national and global level and will also be compensated for via the payment of the Commonwealth Government's carbon tax. The economic costs associated with the clearing of native vegetation will occur at the State and National level and would be also be compensated for by the provision of biodiversity offsets. Other potential environmental impacts would largely occur at the local level and were found to be insignificant. Non-market benefits associated with employment provided by the proposed modification would largely accrue at the local or State level[6].

The environmental, social and cultural costs of the proposed modification that are not already included in the calculation of net production benefits and accrue to NSW are estimated at less than $1M. These are considerably less than the net production benefits that directly accrue to NSW through royalties ($85M). NSW will obtain additional benefits through infrastructure and services provided with a share of Commonwealth Government Company tax from the proposed modification. There are also additional benefits to NSW from the potential non-market employment benefits ($39M). Consequently, as well as resulting in net social benefits to Australia the proposed modification would result in net social benefits to NSW.

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[6] It should be noted that the study from which the employment values are transferred surveyed NSW households only.

Table 2.3
Distribution of Total Benefits and Costs (Present Values at 7% Discount Rate)

Value		Distribution			
		Local/Regional	**State**	**National**	**Global**
Benefits					
Net production benefits to the proponent	$242M	-	-	-	✓
Net production benefits to Commonwealth Government – Company tax	$104M	✓	✓	✓	-
Net production benefits to NSW Government – Royalties	$85M	✓	✓	-	-
Social benefit of employment	$39M	✓	✓	-	-
Total	***$469M***				
Costs					
Greenhouse gas emissions rest of world[1]	$7M	-	-	-	✓
Greenhouse gas emissions Australia[1]	$0.1M	✓	✓	✓	-
Agricultural production	Negligible	✓	-	-	-
Operational noise	Negligible. Mitigation measures included in capital costs	✓	-	-	-
Air quality	Negligible	✓	-	-	-
Surface water	Negligible	✓	-	-	-
Groundwater	Negligible	✓	-	-	-
Flora and fauna	Some loss of values but offset. Cost of biodiversity offset included in capital and operating costs	✓	✓	✓	-
Road transport	Negligible	✓	-	-	-
Road Rail transport	Negligible	✓	-	-	-
Historic and Aboriginal heritage	Negligible	✓	-	-	-
Total	***$7M***				
Net Social Benefits	**$462M**				

Note: Totals may have minor discrepancies due to rounding.

1 Assuming the global social damage cost of carbon is distributed in accordance with relative share of global gross domestic product.

2.6 SENSITIVITY ANALYSIS

The NPV presented in Table 2.2 is based on a range of assumptions around which there is some level of uncertainty. Uncertainty in a BCA can be dealt with through changing the values of critical variables in the analysis (James and Gillespie, 2002) to determine the effect on the NPV.

In this analysis, the BCA result was tested for changes to the following variables:

- opportunity cost of land and capital equipment;
- capital costs;
- operating costs;
- value coal;
- greenhouse gas impacts; and
- non-market value of employment.

The findings of the sensitivity analysis are provided in Attachment 2. This analysis indicated that the results of the BCA are not sensitive to reasonable changes in assumptions regarding any of these variables. In particular, significant increases in the values used for external impact such as greenhouse gas costs, had little impact on the overall economic desirability of the proposed modification.

The results were most sensitive to decreases in the value of product coal, although substantial and sustained reductions in assumed coal prices would be required to make the proposed modification undesirable from an economic efficiency perspective.

3 CONCLUSION

A BCA of the proposed modification indicated that it would have net production benefits to Australia of $188M. Provided the residual environmental, social and cultural impacts of the proposed modification that accrue to Australia are considered to be valued at less than $188M, the proposed modification can be considered to provide an improvement in economic efficiency and hence is justified on economic grounds.

Instead of leaving the analysis as a threshold value exercise, an attempt has been made to investigate and quantify the main residual environmental impacts of the proposed modification. The main impact that is quantified in this analysis relates to greenhouse gas impact from the proposed modification. The global greenhouse gas costs are estimated $7M (present value) with $0.1M (present value) accruing to Australia. There will also be an opportunity cost of using water licences for the proposed modification and reducing catchment flow into Moolarben Creek. However, this opportunity cost is negligible. Other impacts, including the impacts on biodiversity, visual amenity and noise amenity, have been internalised into the production costs of the proposed modification by the inclusion of the capital and operating costs of noise and visual impact mitigation measures and biodiversity offsets.

Overall, the proposed modification is estimated to have net benefits to Australia of between $188M and $227M (depending on whether non-market employment benefits are included) and hence is desirable and justified from an economic efficiency perspective.

While the major environmental, cultural and social impacts have been quantified and included in the project BCA, any other residual environmental, cultural or social impacts that remain unquantified would need to be valued at greater than between $188M and $227M for the proposed modification to be questionable from an Australian economic efficiency perspective.

While BCA is primarily concerned with the aggregate benefits and costs of the project to Australia, the distribution of costs and benefits may also be of interest to decision-makers.

The total net production benefit is distributed amongst a range of stakeholders, including:

- MCO in the form of after tax profits;
- Commonwealth Government in the form of any Company tax payable ($104M present value at 7% discount rate) and any Minerals Resource Rent Tax from the proposed modification, which is subsequently used to fund provision of government infrastructure and services across Australia and NSW, including the region; and
- NSW Government via royalties ($85M present value at 7% discount rate) which are subsequently used to fund provision of government infrastructure and services across the State, including the region.

The potential externalities costs may accrue to a number of different stakeholder groups at the local, State, National and global level (Table 2.3). However, these are largely insignificant and internalised into the production costs of the modification.

Noise and visual impacts will occur at a local level, but will be at least partially compensated for via mitigation measures. Surface water effects will occur at the local level, but will also be compensated for through the holding of required licences. Greenhouse gas costs will occur at the national and global level and will also be compensated for via the payment of the Commonwealth Government's carbon tax. The economic costs associated with the clearing of native vegetation will occur at the State and National level and would be also be compensated for by the provision of biodiversity offsets. Other potential environmental impacts would largely occur at the local level and were found to be insignificant. Non-market benefits associated with employment provided by the proposed modification would largely accrue at the local or State level[7].

The environmental, social and cultural costs of the proposed modification that are not already included in the calculation of net production benefits and accrue to NSW are estimated at less than $1M. These are considerably less than the net production benefits that directly accrue to NSW through royalties ($85M). NSW will obtain additional benefits through infrastructure and services provided with a share of Commonwealth Government Company tax from the proposed modification. There are also additional benefits to NSW from the potential non-market employment benefits ($39M). Consequently, as well as resulting in net social benefits to Australia the proposed modification would result in net social benefits to NSW.

7 It should be noted that the study from which the employment values are transferred surveyed NSW households only.

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ATTACHMENT 1 – VALUING GREENHOUSE GAS EMISSIONS

To place an economic value on carbon dioxide equivalent (CO_2-e) emissions a shadow price of carbon is required that reflects its social costs. The social cost of carbon is the present value of additional economic damages now and in the future caused by an additional tonne of carbon emissions.

A prerequisite to valuing this environmental damage is scientific dose-response functions identifying how incremental emissions of CO_2-e would impact climate change and subsequently impact human activities, health and the environment on a spatial basis. Only once these physical linkages are identified is it possible to begin to place economic values on the physical changes using a range of market and non market valuation methods. Neither the identification of the physical impacts of additional greenhouse gas nor valuation of these impacts is an easy task, although various attempts have been made using different climate and economic modelling tools. The result is a great range in the estimated damage costs of greenhouse gas.

The *Stern Review: Economics of Climate Change* (Stern, 2006) acknowledged that the academic literature provides a wide range of estimates of the social cost of carbon. It adopted an estimate of United States (US) $85 per tonne (/t) of carbon dioxide (CO_2) for the "business as usual" case (i.e. an environment in which there is an annually increasing concentration of greenhouse gas in the atmosphere).

Tol (2006) highlights some significant concerns with Stern's damage cost estimates including:

- that in estimating the damage of climate change Stern has consistently selected the most pessimistic study in the literature in relation to impacts;
- Stern's estimate of the social cost of carbon is based on a single integrated assessment model, PAGE2002, which assumes all climate change impacts are necessarily negative and that vulnerability to climate change is independent of development; and
- Stern uses a near zero discount rate which contravenes economic theory and the approach recommended by Treasury's around the world.

All these have the effect of magnifying the social cost of the carbon estimate, providing what Tol (2006) considers to be an outlier in the marginal damage cost literature.

Tol (2005) in a review of 103 estimates of the social cost of carbon from 28 published studies found that the range of estimates was right-skewed: the mode was US$0.55/t CO_2 (in 1995 US$), the median was US$3.82/t CO_2, the mean US$25.34/t CO_2 and the 95th percentile US$95.37/t CO_2. He also found that studies that used a lower discount rate and those that used equity weighting across regions with different average incomes per head, generated higher estimates and larger uncertainties. The studies did not use a standard reference scenario, but in general considered 'business as usual' trajectories.

Tol (2005) concluded that "it is unlikely that the marginal damage costs of CO_2 emissions exceed US$14/t CO_2 and are likely to be substantially smaller than that". Nordhaus's (2008) modelling using the DICE-2007 Model suggests a social cost of carbon with no emissions limitations of US$30 per tonne of carbon (US$8/t CO_2).

Tol (2011) surveyed the literature on the economic impact of climate change. Tol (2011) identifies the mean estimated from published studies is a marginal cost of carbon of $177/t C ($48/ tCO2-e) and a modal estimate of $49/t C ($13 tCo2-e) reflecting the fact that the mean estimate is driven by some very large estimates. For peer reviewed studies only, the mean estimate of the social cost of carbon is $80/tC ($22/tCo2-e).

An alternative method to trying to estimate the damage costs of CO_2 is to examine the price of carbon credits. This is relevant because emitters can essentially emit CO_2 resulting in climate change damage costs or may purchase credits that offset their CO_2 impacts, internalising the cost of the externality at the price of the carbon credit. The price of carbon credits therefore provides an alternative estimate of the economic cost of greenhouse gas. However, the price is ultimately a function of the characteristics of the scheme and the scarcity of permits, etc. and hence may or may not reflect the actual social cost of carbon.

In the first half of 2008 the carbon price under the European Union Emissions Trading Scheme was over €20/t CO_2 The average price was €22/t CO_2 in the second half of 2008, and €13/t CO_2 in the first half of 2009. In March 2012, the permit price reduced to under €10 /t CO_2.

In 2008, spot prices in the Chicago Climate Exchange were in the order of US$3.95/t CO_2. However, the Chicago Climate Exchange cap and trade system ended on December 31, 2010.

In 2011, the greenhouse penalty for benchmark participants in the New South Wales Government Greenhouse Gas Reduction Scheme that fail to reduce emissions rose to $15.50 t CO_2.

Under the Australian Commonwealth Government's Climate Change Plan (Department of Climate Change and Energy Efficiency 2011) around 500 of the biggest polluters in Australia will need to buy and surrender to the Government a permit for every tonne of carbon pollution they produce. For the first three years, the carbon price will be fixed like a tax, before moving to an emissions trading scheme in 2015. In the fixed price stage, starting on 1 July 2012, the carbon price will start at $23 a tonne, rising at 2.5 per cent a year in real terms. From 1 July 2015, the carbon price will be set by the market.

Given the above information and the great uncertainty around damage cost estimates, the BCA uses the carbon price proposed by Australian Government's Climate Change Plan i.e. $23 a tonne, rising at 2.5 per cent a year in real terms for three years, as reflective of the global social damage cost of carbon. From 2015 it is assumed that the carbon price remains constant. A range for the social cost of greenhouse gas emissions from AUD$8/t CO_2-e to AUD$40/t CO_2-e was used in the sensitivity analysis described in Section 2.6 of this report.

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ATTACHMENT 2 – BCA SENSITIVITY TESTING

Table A3-1
Benefit Cost Analysis Sensitivity Testing, Australian Net Benefits ($Millions NPV)

	4% Discount Rate	7% Discount Rate	10% Discount Rate
CENTRAL ANALYSIS	$282	$227	$189
INCREASE 20%			
Opportunity cost of land	$282	$227	$189
Opportunity cost of capital	$279	$224	$187
Capital costs	$281	$226	$188
Operating costs	$244	$197	$165
Coal value	$359	$287	$238
Non-market value of employment	$290	$235	$197
GREENHOUSE COSTS @ $40/TONNE (T)	$282	$227	$189

	4% Discount Rate	7% Discount Rate	10% Discount Rate
CENTRAL ANALYSIS	$282	$227	$189
DECREASE 20%			
Opportunity cost of land	$282	$227	$189
Opportunity cost of capital	$286	$230	$192
Capital costs	$284	$228	$191
Operating costs	$321	$257	$214
Coal value	$205	$167	$141
Non-market value of employment	$274	$219	$182
GREENHOUSE COSTS @ $8/T	$282	$227	$189

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