Australasian
Groundwater
and Environmental
Consultants Pty Ltd
(AGE)

Report on

Yancoal - Ashton Coal Longwalls LW201 to Lw204

Surface and Groundwater Impact Assessment

Prepared for

Yancoal Australia Limited

Project No. G1758N November 2016
www.ageconsultants.com.au ABN 64 080 238 642

Document details and history

Document details

Project number	G1758N
Document title	Yancoal – Ashton Coal. Longwall LW201 to LW204 - Surface and Groundwater Impact Assessment
Site address	Ashton Coal Mine, NSW
File name	G1758N_001_report_v03.01_Final

Document status and review

Edition	Comments	Author	Authorised by	Date
v.01.01	Issued to client for review	JB	CC	08/08/16
v.02.05	Issued to client for review	JB	CC	28/10/16
v.03.01	Final	JB	CC	07/11/16

Australasian Groundwater and Environmental Consultants Pty Ltd

AGE Head Office
Level 2 / 15 Mallon Street,
Bowen Hills, QLD 4006, Australia
T. +61 7 3257 2055
F. +61 7 3257 2088
brisbane@ageconsultants.com.au

AGE Newcastle Office
4 Hudson Street,
Hamilton, NSW 2303, Australia
T. +61 2 4962 2091
F. +61 2 4962 2096
newcastle@ageconsultants.com.au

Table of contents

Page No.

Table of contents (continued)

Page No.

List of figures

List of tables

List of appendices

Report on

Yancoal - Ashton Coal
Longwalls LW201 to LW204
Surface and Groundwater Impact Assessment

1 Introduction

1.1 Background

The Ashton Coal Project (Ashton) is located 14 km west of Singleton in the Hunter Valley region of New South Wales (NSW). Ashton Coal Operations Ltd (ACOL) operates the mine and is wholly owned and operated by Yancoal Australia Limited (Yancoal).

Ashton was granted development consent on 11 October 2002, and commenced operations in 2003 at the former north-east open cut mine (NEOC). Coal was extracted from the Permian Foybrook Formation from eleven seams of varying thickness, down to and including the Lower Barrett seam (LB). Underground mine development commenced in July 2006 in an area located predominantly south of the New England Highway. Open cut mining subsequently ceased in 2011.

The general layout of the underground mine includes up to eight longwall (LW) panels (LW1-LW4, LW5A, LW6A-LW6B, LW7A-LW7B and LW8). Extraction of the first longwall panel (LW1) in the Pikes Gully seam (PG) commenced on 12 March 2007. Mining in the PG was finished in October 2013, and Ashton currently extracts coal solely from the Upper Liddell seam (ULD).

Ashton proposes to mine a further two seams below the ULD, namely the Upper Lower Liddell seam (ULLD) and the Upper Barrett seam (UB). Longwall extraction is planned to be halted in the ULD in February 2017, starting in the ULLD in March 2017.

This report presents the estimated impacts from proposed extraction in the four first longwalls in the ULLD (LW201-LW204).

1.2 Objective

The objective of this assessment is to predict groundwater impact from proposed extraction in the four first longwalls in the ULLD (LW201, LW202, LW203 and LW204) to the satisfaction of the NSW government departments.

1.3 Scope

In order to achieve the above project objective, AGE undertook the following scope:

- describe the existing environment and assess how the groundwater system operates (system conceptualisation), focussing on the ULLD;
- re-build the Ashton numerical groundwater model originally developed by RPS (2009);
- review the potential impacts specifically related to the mining of LW201 to LW204 on groundwater levels (in the alluvium and fractured rock aquifers), groundwater quality, stream baseflow, groundwater dependent ecosystems (GDEs) and other groundwater users;
- review drawdown at the completion of LW204, on top of any cumulative impacts from proceeding or adjacent mining;
- analyse the sensitivity on key parameters affecting the model; and
- make recommendations resulting from the assessment, including suggested monitoring, mitigation and management strategies.

1.4 Regulatory framework

The planned mine progression requires consideration of the following NSW government legislation, policies and guidelines for groundwater:

- *Water Act 1912,* included in the *Water Management Act 2000* as of 1 July 2016;
- *Water Management Act 2000* and the Water Sharing Plan for Hunter Regulated River Water Source and Hunter Unregulated and Alluvial Water Sources;
- Groundwater Quality Protection Policy;
- Groundwater Dependent Ecosystems Policy;
- Groundwater Quantity Management Policy; and
- Aquifer Interference Policy (2012).

Appendix A provides a summary of the above legislation, policies and guidelines.

1.5 Water licensing

Water licences held by ACOL are summarised in Table 1-1. ACOL has a combined total surface water and groundwater entitlement of 2,203.5 ML/year assuming full allocation. It is noted that groundwater seepage from the alluvial groundwater source and from the surface water source is also accounted for under these entitlements.

Table 1-1 ACOL water licences

Licence No.	Reference	Category	Approved extraction (ML/year)
Surface water			
WAL 872	20AL201030	Glennies Creek (General Security)	12
WAL 984	20AL201282	Glennies Creek (General Security)	9
WAL 15583	20AL204249	Glennies Creek (General Security)	354
WAL 997	20AL201311	Glennies Creek (High Security)	11
WAL 8404	20AL200491	Glennies Creek (High Security)	80
WAL 1358	20AL203056	Glennies Creek (Supplementary)	5
WAL 1121	20AL201625	Hunter River (General Security)	335
WAL 6346	20AL203106	Hunter River (Supplementary)	15.5
WAL 1120	20AL201624	Hunter River (High Security)	3
WAL 19510	20AL211015	Hunter River (High Security)	130
WAL 23912	20AL211423	Bowmans Creek (Unregulated River)	14
WAL 29565	20AL212286	Bowmans Creek (Unregulated River)	266
Groundwater			
WAL 29566	20AL212287	Bowmans Creek (Aquifer Access)	358
	20BL169508	Mining, Dewatering, Industrial	100
	20BL173716	Mining, Industrial	511

2 Hydrogeological environment

2.1 Geology

The following main stratigraphic units occur at Ashton (from youngest to oldest):

- Quaternary alluvium; and
- Permian Whittingham Coal Measures, key units of interest include:
    - Regolith / weathered profile;
    - Conglomerate within the Lemington Seams ply profile (from here on referred to as the Lemington Conglomerate); and
    - Four main mining seams – PG, ULD, ULLD and LB.

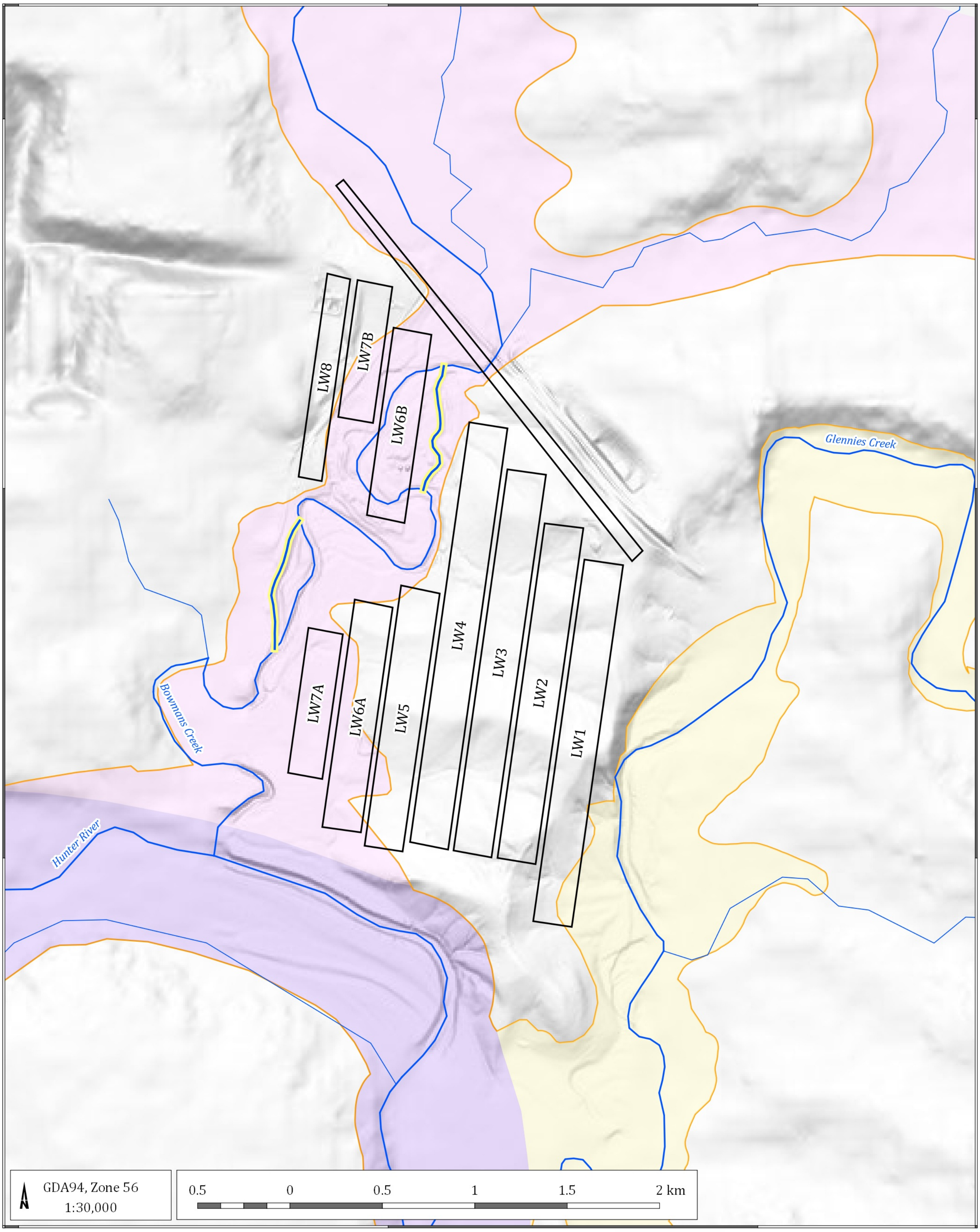
The Quaternary / recent aged alluvium is associated with the Hunter River, Glennies Creek and Bowmans Creek flood plains. The outline of the alluvial extents is shown on Figure 2-1. Along the drainage lines, the surficial alluvium is typically constrained within 500 m of the creeks and is between 7 m to 15 m thick. The alluvium bodies have been divided into two main types: a coarser grained permeable alluvium and a fine grained low permeability colluvium (refer figure 2-2).

The Whittingham Coal Measures comprise coal seams which occur with various splits and plies, with a coal thickness of between 2 m and 2.5 m. The coal seams are interbedded with units of siltstone, sandstone and shale, referred to as interburden in the mining context. The four target coal seams at Ashton are separated by approximately 30 m of interburden.

The Whittingham Coal Measures dip west south-west in the Ashton area, an orientation locally controlled by the Camberwell Anticline to the east of the mine and the Bayswater Syncline to the west. The top target seam at Ashton (PG) subcrops under the Glennies Creek alluvium approximately 300 m east of the mine, while the lower target seam (LB) subcrops under regolith approximately 2 km away from the east of the mine. In the western portion of the mining area, the overburden above the top target coal seam (PG) ranges in thickness between 100 m (north end of LW7) and 190 m (south end of LW7).

Groundwater occurs within the Quaternary Alluvium (in the Hunter River, Bowmans Creek and Glennies Creek) and the Permian Whittingham Coal Measures. Regional groundwater flow follows a west south-west direction imposed by the sedimentary beds in the area.

Locally, groundwater recharge occurs primarily via rainfall infiltration in the alluvium, direct infiltration in outcrop of the coal measures and indirect infiltration from the alluvium into the subcrop of the coal measures. The local hydraulic connectivity between the coal measures and the alluvium, however, is not well understood.



LEGEND

- Underground mine (Pikes Gully seam)
- Quaternary alluvium/colluvium
- Bowmans Creek alluvium
- Glennies Creek alluvium
- Hunter River alluvium
- Major drainage
- Minor drainage
- Diversion

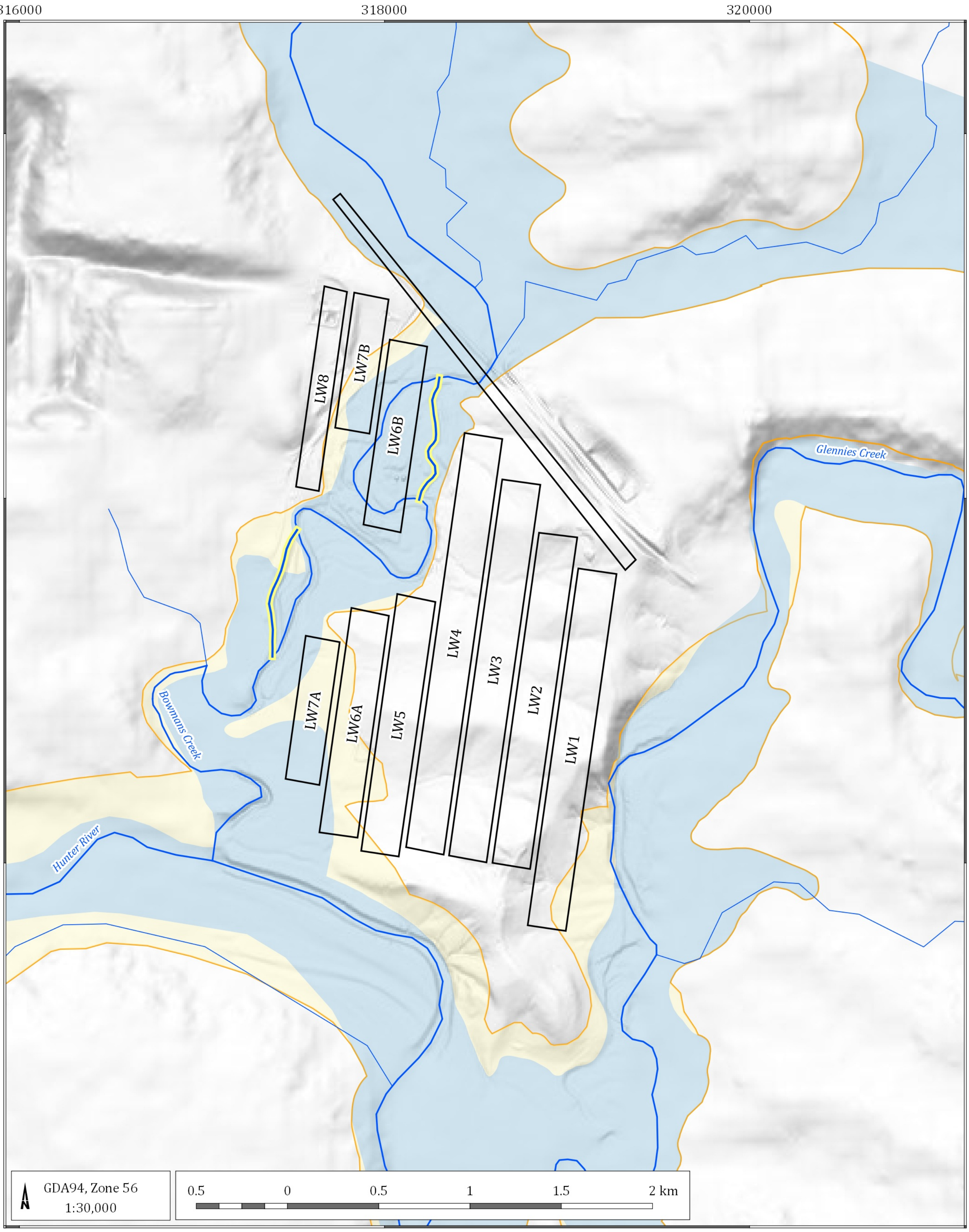
Ashton Coal - Longwalls LW201 to LW204 - Groundwater Impact Assessment (G1758N)

Alluvium bodies

DATE 28/10/2016

FIGURE No: **2-1**

G:/Groundwater Jobs/G1758N.Ashton_LW201_LW204/3_GIS/Workspaces/001_Deliverable1/02-01_G1758_Alluvium extents and boundaries.qgs



LEGEND

- Underground mine (Pikes Gully seam)
- Quaternary alluvium/colluvium
- Major drainage
- Minor drainage
- Diversion

Alluvium properties boundary

- Coarse grained
- Fine grained / Colluvium

Ashton Coal - Longwalls LW201 to LW204 - Groundwater Impact Assessment (G1758N)

Alluvium properties and extents

DATE 28/10/2016

FIGURE No: **2-2**

G:/Groundwater Jobs/G1758N.Ashton_LW201_LW204/3_GIS/Workspaces/001_Deliverable1/02-02_G1758_Alluvium properties and extents.qgs

2.2 Groundwater / surface water interaction

The strata collapse process associated with longwall coal mining has the ability to impact regional groundwater flow systems (Tammetta, 2015). The assessment of the potential and actual effects on groundwater systems has been the subject of numerous publications.

Dawkins (1999) states "that there is generally no significant loss of stream flow for underground mines deeper than 100 m as surface cracking and goaf zones are unlikely to be hydraulically connected, yet surface water can still be transferred to the groundwater system". The depth of cover over particular sections of underground mining of the PG Seam at the Ashton is marginally greater than 100 m, allowing for the potential for surface waters to enter the groundwater system. That said, the impacts of subsidence at Ashton are likely to reach coarse grained/conglomeratic water bearing units high in the geological sequence. Dawkins (1999) also states that ribside cracks may develop along the axis of an extracted longwall panel as the overburden falls in towards the subsidence trough. These cracks may not close up entirely, but may reduce in size as adjacent longwall panels are extracted. Further, if these types of cracks permeate the ground surface, the rate of surface water drainage to the groundwater table will likely increase (i.e. increased surface water groundwater connectivity).

The occurrence of subsidence induced surface cracking above and surrounding the Ashton underground workings is well documented in various SCT reports, and suggests the potential for surface water groundwater connectivity. However, alluvium water levels have been observed to not be impacted significantly during and post mining, whilst the underlying Permian strata have been depressurised due to the effects of subsidence. Figure 2-3 shows the historic water levels trend in BCA bores over LW6B and LW7B. Figure 2-4 shows the coal measures depressurising as a result of mining LW6B. The depressurisation extends above the PG Seam (through depressurisation) and below the PG Seam (possibly through an effect of unloading). The depressurisation effects are visible in the head pressures of the Lemington 5-6 ply at 28 mbgl. There is also an aspect of repressurisation of the seam units, namely Lemington 5-6, Lemington 9-10 and the Arties Seam. Other surface water bodies on site, such as agricultural dams, have not shown subsidence-related water loss.

The alluvium water trends match the cumulative rainfall departure (CRD) curve and are notably influenced by significant rainfall events. Underground inflows are relatively constant and independent of rainfall events. Groundwater abstraction from the underground is monitored and no correlation has been found between rainfall and changes to groundwater abstraction rates from the underground.

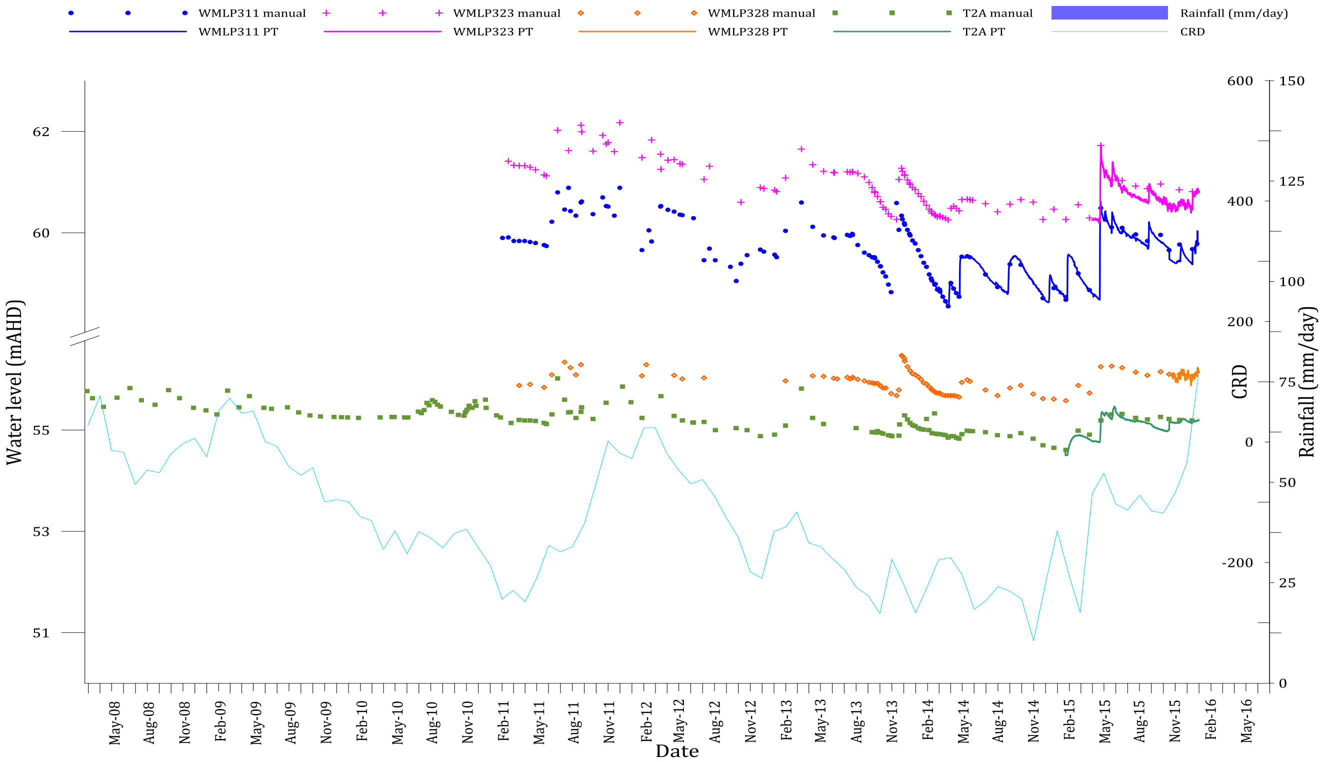


Figure 2-3 BCA water levels vs CRD

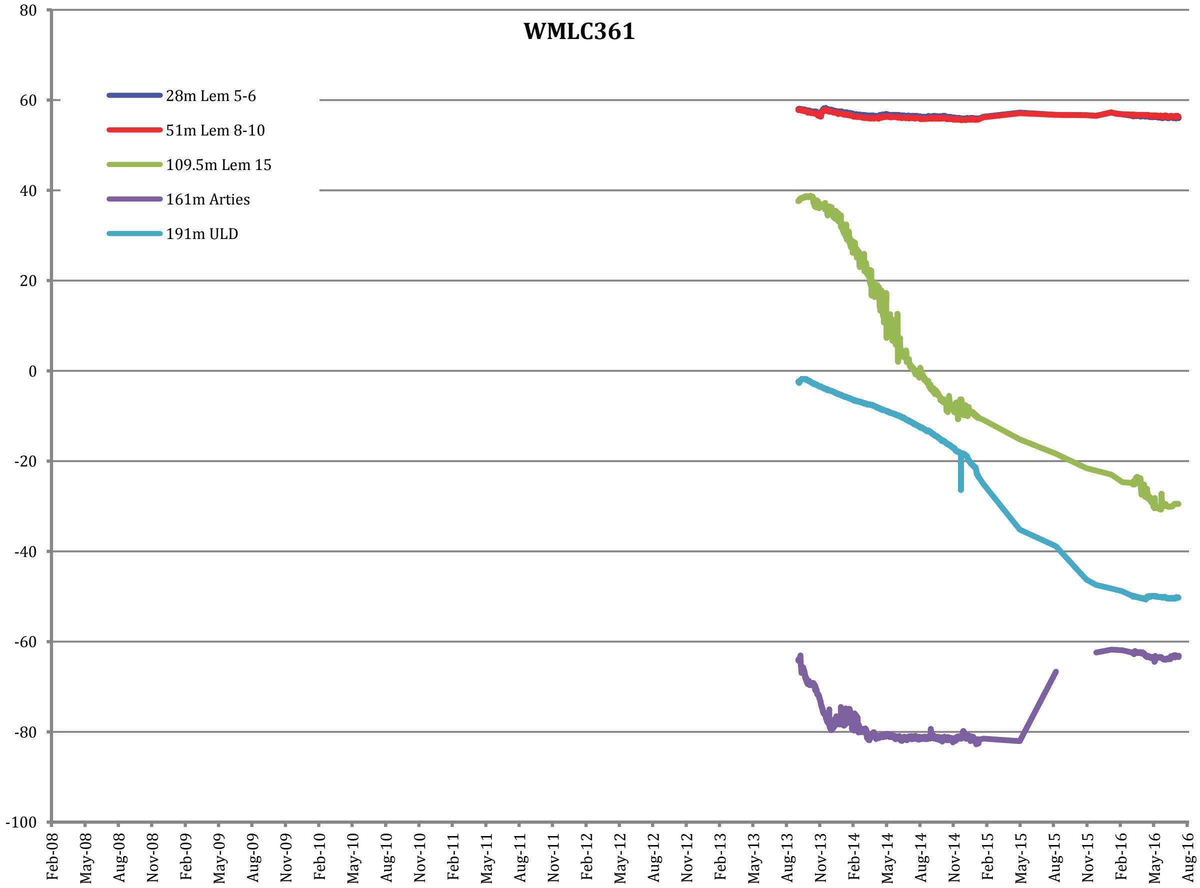


Figure 2-4 WML361 vibrating wire piezometer pressure head

3 Groundwater model 2016

3.1 Background

Several groundwater studies including numerical models have been prepared for the Ashton project, including:

- 2001 - An initial groundwater model was developed by HLA Envirosciences (2001) for the mine approval environmental impact statement (EIS). This model was created using MODFLOW, and included 120 columns, 120 rows and 7 layers.
- 2009 - The 2001 model was updated by Aquaterra in 2009 for the Bowmans Creek Diversion environmental assessment (EA). MODFLOW-SURFACT v4 (a version of MODFLOW) was the code selected for the model. The updated model included 188 columns, 252 rows and 15 layers.
- 2014 - Another update was performed by RPS (formerly Aquaterra / RPS-Aquaterra) upon completion of mining the PG. For this update, MODFLOW-SURFACT v4 was also used, and the model geometry and domain remained unchanged.
- 2016 – A new numerical groundwater flow model was developed by AGE in 2016 using MODFLOW-USG. MOFLOW-USG is the latest version of the MODFLOW code which uses unstructured grids instead of traditional rows and columns. This version of the model included 18 layers and 370468 total nodes.

MODFLOW-USG provides flexibility to a MODFLOW simulation by enabling use of triangular, rectangular or other polygon shaped geometries individually or in combination, to appropriately discretise the domain. This allows the model to have layers which pinch out, this means that not all layers need to have the same number of nodes. This feature also allows for an improved simulation of coal seams pinching out / sub-cropping beneath alluvium, a feature that was not able to be modelled in other modelling packages.

There are up to 25,193 nodes in the model built by AGE and nodes from lower layers can be in direct contact with the top layer of the model. For example in the current model, many of the layers pinch out around the Camberwell Anticline, allowing nodes representing coal seams (layers 8, 11, 14 and 17) to be in direct contact with the alluvium and regolith units represented as layer 1.

When compared to previous numerical models, the outline of the Glennies Creek alluvium (GCA) is slightly different in the current numerical model. In the most recent model, the Glennies Creek outline incorporates the RPS alluvium investigation outline and the digital version of the Hunter Coalfield Regional Geology alluvium outline at 1:100,000 scale (Glen and Beckett, 1993). The two outlines do not overlap in the southern part of LW1. The RPS outline was allocated parameters associated with a high permeability alluvium and the alluvium outside of this limit was associated with very low permeability. This differentiation was not present in previous versions of the numerical model.

3.2 Model calibration

A satisfactory calibration was achieved with the AGE numerical groundwater model and steep head changes were adequately reproduced by the model. However, during calibration, the automated calibration process focussed on the areas where large differences (or large residuals between observed and modelled heads) occur. Such large drawdown is observed within the Permian strata and more weight is normally given to these observation sites during the calibration process. The current model was calibrated with a focus on the observed alluvium water levels. This provides a greater focus on impacts to alluvium, whilst remaining statistically calibrated to the hard rock aquifer.

3.3 Sensitivity analysis

The current model has a particular focus on the alluvium and its interaction with the regolith and shallow coal seams. As such, sensitivity analysis was carried out on parameters that were most likely to impact the interaction and predictions between the alluvium and shallow coal seam / coal seam subcrop.

Sensitivity assessments were carried out on key hydrogeological parameters:

- Hydrogeological parameters of the GCA – sensitivity of the model predictions to the horizontal and vertical conductivity, specific yield and storativity (storage) of the alluvium were carried out and showed some minor changes to take and mine inflows. The model was sensitive to changes in hydraulic conductivity, particularly with regards to drawdown; that is, lower conductivities caused less drawdown. Also, reducing the vertical hydraulic conductivity to a very small value to attempt to replicated a low permeability liner on the GCA (as per the RPS model (2009), the model did not converge.
- Permeability of shallow coal - A sensitivity analysis modifying the permeability of shallow coal (particularly on Glennies Creek), and hence the interaction with regolith and alluvium, significantly changed the amount of recharge from the surface water body (river / creek) and the alluvium, mine inflows were also notably changed.
- Recharge to GCA from Glennies Creek – changes to the calibrated value for recharge of the GCA from the Glennies Creek surface water body needed to be reduced in light of the reduced hydraulic conductivity sensitivity analysis.

In summary, a sensitivity analysis modifying the permeability of shallow coal (particularly on Glennies Creek), and hence the interaction with regolith and alluvium, significantly changed the amount of recharge from the surface water body (river / creek) and the alluvium, mine inflows were also notably changed. The interaction was also dependent on the vertical hydraulic conductivity of the alluvium.

4 ULLD mine plan

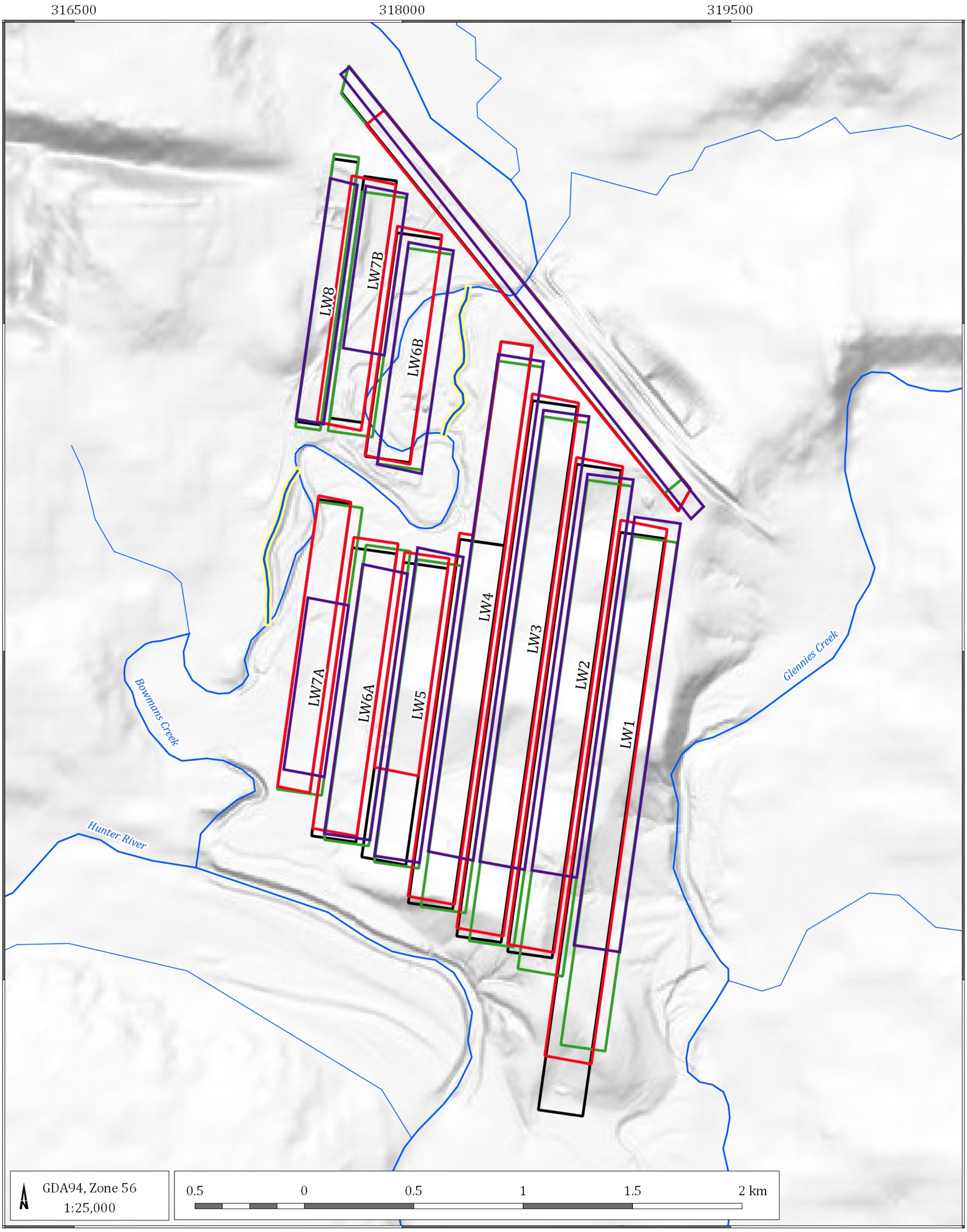
4.1 Mine schedule - LW201 to LW204

Table 4-1 presents the mine schedule utilised for the groundwater model simulations. This version of the mine plan was provided by the proponent on 18 May 2016. For reference, plans with the panel names are also presented in Figure 4-1.

Table 4-1 Ashton underground mine schedule

Seam	Longwall panel	Start date	End date	Duration (months)
Pikes Gully (PG)	LW1	Mar-2007	Oct-2008	19
	LW2	Nov-2007	Jul-2008	8
	LW3	Aug-2008	Mar-2009	6
	LW4	Apr-2009	Oct-2009	6
	LW5	Jan-2010	Jun-2010	5
	LW6A	Jul-2010	Nov-2010	4
	LW7A	Mar-2011	Aug-2011	4
	LW7B	Oct-2011	Jan-2012	3
	LW8	Feb-2012	Jun-2012	3
Upper Liddell (ULD)	LW101	Aug-2012	May-2013	10
Pikes Gully (PG)	LW6B	Jul-2013	Oct-2013	3
Upper Liddell (ULD)	LW102	Nov-2013	Jul-2014	9
	LW103	Aug-2014	Jun-2015	10
	LW104A	Jun-2015	Feb-2016	7
	LW104B	Feb-2016	Apr-2016	2
	LW105A	May-2016	Aug-2016	3
	LW106A	Sep-2016	Feb-2017	5
Upper Lower Liddell (ULLD)	**LW201**	**Mar-2017**	**Oct-2017**	**7**
	LW202	**Nov-2017**	**Jul-2018**	**8**
	LW203	**Aug-2018**	**May-2019**	**9**
	LW204	**Jun-2019**	**Mar-2020**	**9**
	LW205	Apr-2020	Sep-2020	5
	LW206A	Oct-2020	Mar-2021	5
Upper Liddell (ULD)	LW106B	Apr-2021	Aug-2021	4
	LW107A	Sep-2021	Dec-2021	3
	LW107B	Jan-2022	May-2022	4

Seam	Longwall panel	Start date	End date	Duration (months)
Upper Lower Liddell (ULLD)	LW206B	Jul-2022	Oct-2022	3
	LW207A	Nov-2022	Mar-2023	4
	LW207B	Apr-2023	Aug-2023	4
	LW208	Sep-2023	Nov-2023	2
Lower Barrett (LB)	LW301	Dec-2023	Oct-2024	10
	LW302	Nov-2024	Aug-2025	8
	LW303	Sep-2025	Jun-2026	9
	LW304A	Jul-2026	Jan-2027	6
	LW304B	Feb-2027	Apr-2027	3
	LW305	May-2027	Oct-2027	5
	LW306A	Nov-2027	Apr-2028	5
	LW306B	May-2028	Sep-2028	4
	LW307A	Oct-2028	Feb-2029	3
	LW307B	Feb-2029	May-2029	3
	LW308	Jul-2029	Sep-2029	2
Pikes Gully (PG)	Mains0_PG	Feb-2006	May-2008	27
Upper Liddell (ULD)	Mains1_ULD	Aug-2011	Jan-2016	53
Upper Lower Liddell (ULLD)	Mains2_ULLD	Oct-2016	Dec-2020	50
Lower Barrett (LB)	Mains3_LB	Aug-2021	Jul-2025	47



LEGEND

Underground Mine Level

- Pikes Gully Seam
- Upper Liddell Seam
- Upper Lower Liddell Seam
- Lower Barrett Seam

- Major drainage
- Minor drainage
- Diversion

Ashton Coal - Longwalls LW201 to LW204 - Groundwater Impact Assessment (G1758N)

Plan of Ashton underground longwall panels

DATE 08/08/2016

FIGURE No: **4-1**

4.2 Interaction with other mines

Adjacent mines considered as part of this assessment are presented in Table 4-2. Publicly available data was used to replicate the schedule of adjacent mining. The mine schedule for Glendell was not available beyond 2016; as such, the mine has been modelled as remaining dry for the duration of LW201-LW204.

Table 4-2 Summary of adjacent mining operations

Mine	Mining type	Seams targeted	Date from	Date to	Current Status
Ashton	Underground	Pikes Gully	2006	2013	Completed
Ashton	Underground	Upper Liddell	2012	2017	In progress
Ashton	Underground	Upper Lower Liddell	2017	2022	Planned
Ashton	Underground	Lower Barrett	2022	2025	Planned
Ashton NEOC	Open cut	Seams to Lower Barrett	2004	2010	Decommissioned Void being filled with rejects and tailings
Ravensworth	Underground	Pikes Gully	2007	2014	Care and maintenance (2014 to date)
Ravensworth - Narama	Open cut	Seams to Bayswater	1993	2015	Decommissioned# Void being backfilled
Ravensworth - South	Open cut	Seams to Bayswater	1989	2000	Decommissioned Void being backfilled
Ravensworth - No.2	Open cut	Seams to Bayswater	1970	1984	Decommissioned Void being backfilled
Integra	Open cut	Seams to Hebden	1992	1999	Decommissioned Void open
Glendell	Open cut	Seams to Lower Barrett	2009	2016#*	In progress Void being backfilled

Notes: *# as per publically available data*

** site operational. Void drain cells remain on to replicate pit remaining dry to end of mining LW201-LW204*

5 Groundwater predictions

5.1 Approved impacts

Ashton has undertaken two impact assessments as part of the approval process for the underground and open cut mines (2002 EIS and 2009 Bowmans Creek Diversion EA). As part of this process, Ashton undertook extensive groundwater investigations and modelling to assess the potential impacts to the groundwater and surface water system.

The following sections detail the predicted groundwater impacts, with a focus on impacts related to the extraction of coal from LW201 to LW204 in the ULLD. Simulated impacts were compared against the approved EIS (HLA, 2001) and Bowmans Creek Diversion EA (Aquaterra, 2009). A comparison of values from these two documents is presented in Table 5-1 below.

Table 5-1 2001 EIS and 2009 EA comparison values

Impact description	Location	2009 EA (End of mine life)	2001 EIS (End of mine life)
Drawdown	Bowmans Creek Alluvium (BCA)	< 3 m	No significant drawdown
	Glennies Creek Alluvium (GCA)	< 2 m	2.5 m
	Hunter River Alluvium (HRA)	< 1 m	No significant drawdown
Stream baseflow loss	BCA	0.13 ML/d	0.4-1.4 ML/day
	GCA	0.23 ML/d	0.6 ML/day
	HRA	0.06 ML/d	0.3 ML/day
Salinity	BCA	Likely decrease	Electrical Conductivity (EC): great variability - maximum increase of 70 µS/cm attributable to mining related impacts
	GCA	Likely decrease	Similar quality to pre-mining
	HRA	Likely decrease	N/A

5.2 Modelled impacts from ULLD LW201 to LW204

5.2.1 Groundwater impacts as drawdown

Modelled impact to groundwater heads is determined by calculating the difference between the "no-mine" case and the calibrated and predictive scenario cases for the equivalent stress periods. This process was further refined to assess the impacts of mining at LW201 to LW204. The modelled heads within the mined seams (PG, ULD and ULLD) were compared at the start of mining in LW201 and at the end of mining in LW204. Predicted groundwater impacts (presented as drawdown) immediately prior to the commencement of LW201, upon completion of mining of LW204 and the drawdown attributable only to the mining of LW201 to LW204 are presented in Figure 5-1 to Figure 5-4 as combined figures.

Key predicted groundwater level impacts attributable to the mining of LW201 to LW204 are summarised as follows:

- LW201 to LW204 only drawdown in the BCA is less than 1 m. Areas of drawdown greater than 1 m (and less than 2m) are small, localised and limited to the very edges of the alluvium boundaries (refer Figure 5-1c).
- LW201 to LW204 only drawdown in the GCA is also small and localised. Drawdown is generally less than 1 m and limited to the very edges of the high permeability alluvium and parts of the low permeability alluvium east of Glennies Ck (refer Figure 5-1c). Glennies Creek stage height will be maintained, as it is a regulated stream. As such, drawdown impacts will not likely present in monitoring bores due to recharge from the creek body itself.
- No drawdown greater than 1m is predicted in the HRA (refer Figure 5-1c).
- Drawdown in the PG and ULD will be steep within the mine area as the seams will be depressurised and continue to be actively dewatered during the life of the mine (refer Figure 5-2c and Figure 5-3c, respectively).
- Approximately 30 m to 50 m drawdown of the fractured rock Permian coal seam aquifer (hard rock water) is predicted to occur within the ULLD prior to the extraction of LW201. After completion of LW204, drawdown is predicted to be in the order of 100 m (refer Figure 5-4c).

A comparison of these impacts to approved impacts is presented in Section 5.3.

a. Total drawdown - prior to commencement of LW201 (Feb-17)

b. Total drawdown - upon completion of LW204 (Mar-20)

c. Drawdown attributed only to LW201-204 (Feb-17 Mar-20)

LEGEND

- Underground mine (Pikes Gully seam)
- drawdown contour (m)
- Major drainage
- Minor drainage
- Diversion

Alluvium properties boundary

- High permeability
- Low permeability

Drawdown (m)

0
1
2
5
10

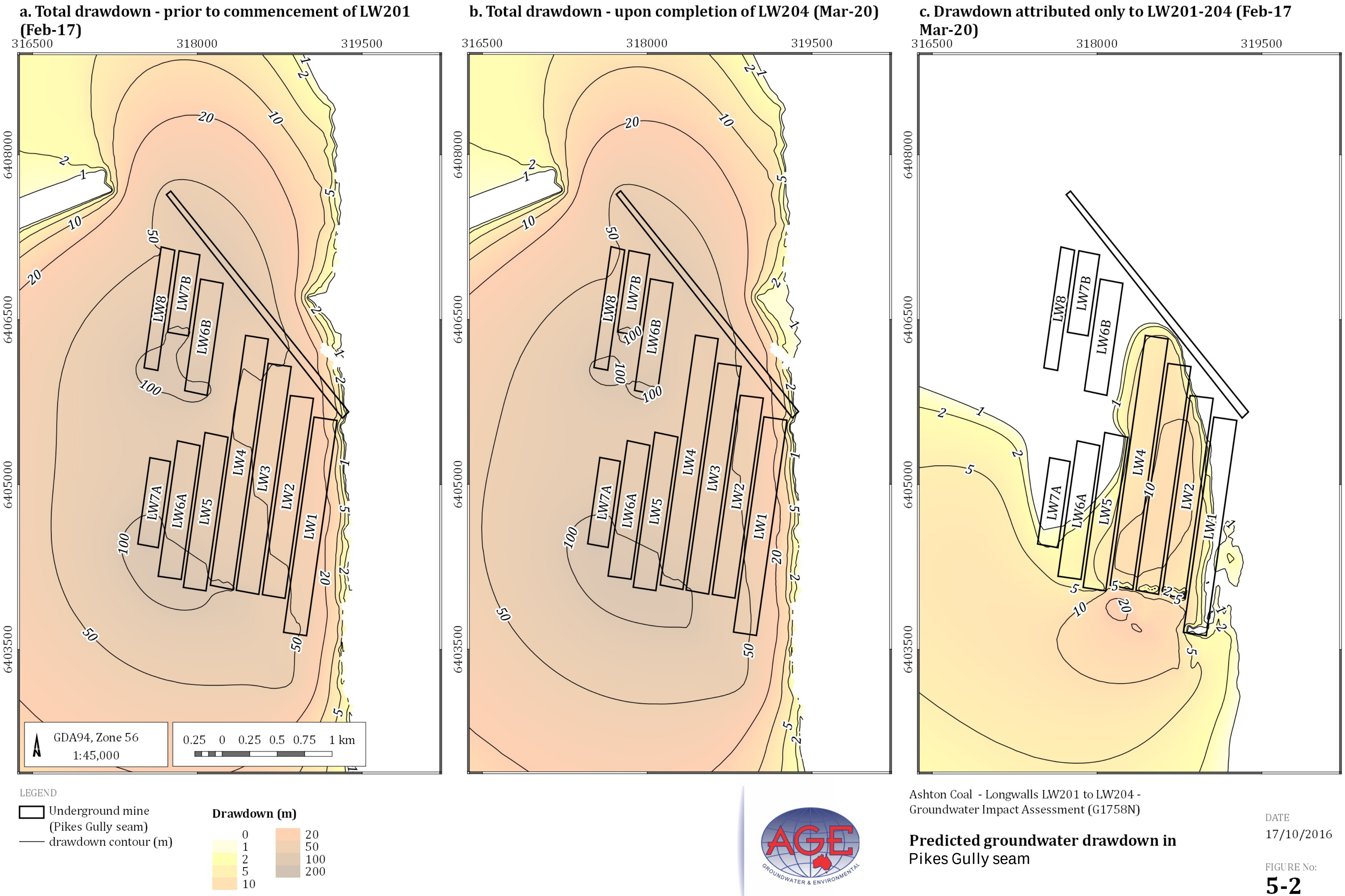
Ashton Coal - Longwalls LW201 to LW204 - Groundwater Impact Assessment (G1758N)

Predicted groundwater drawdown in alluvium

DATE
18/10/2016

FIGURE No:
5-1

G:/Groundwater Jobs/G1758N.Ashton_LW201_LW204/3_GIS/Workspaces/001_Deliverable1/00-00_G1758N_Predicted groundwater drawdown.qgs



Ashton Coal - Longwalls LW201 to LW204 - Groundwater Impact Assessment (G1758N)

Predicted groundwater drawdown in Pikes Gully seam

DATE
17/10/2016

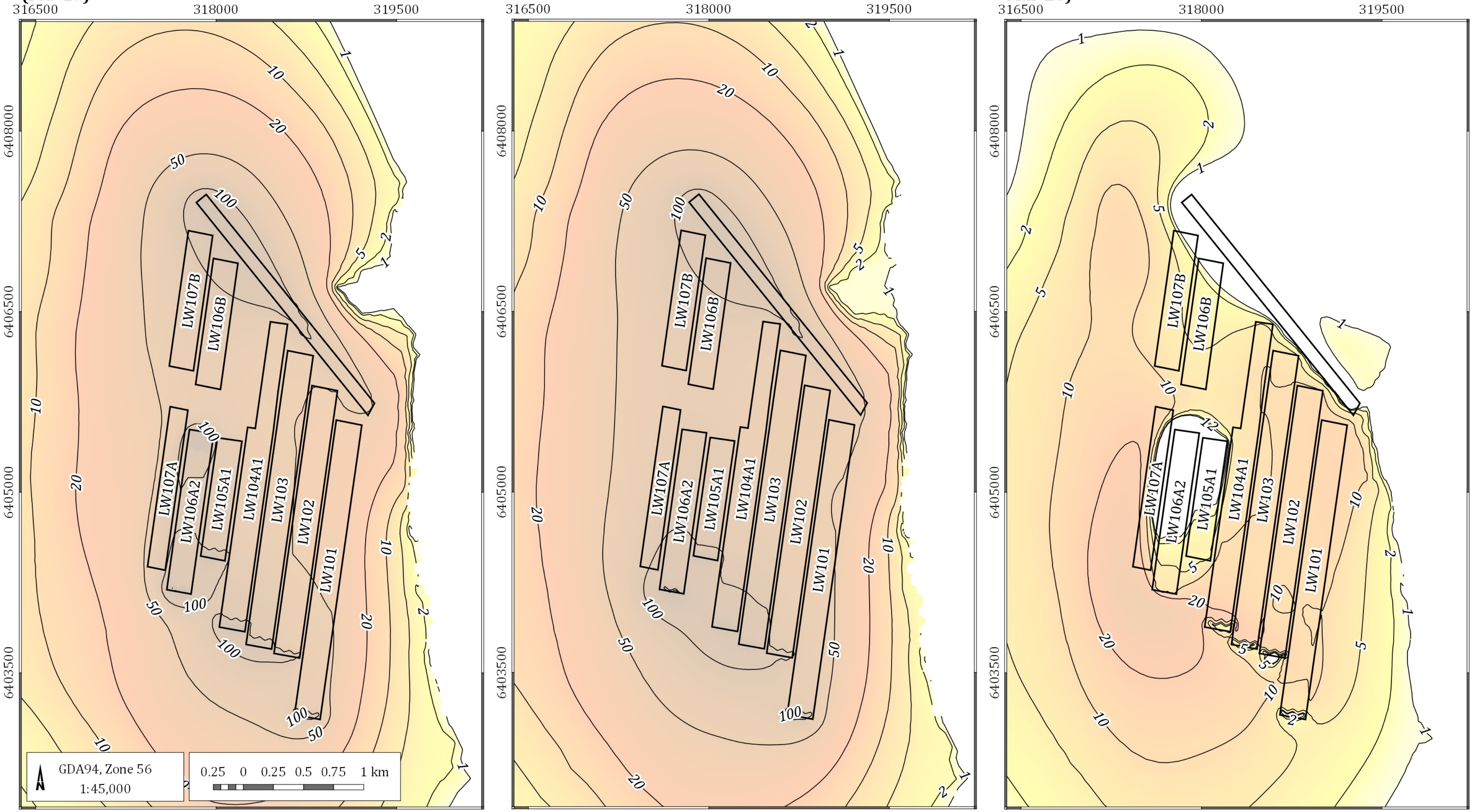
FIGURE No:
5-2

G:/Groundwater Jobs/G1758N.Ashton_LW201_LW204/3_GIS/Workspaces/001_Deliverable1/00-00_G1758N_Predicted groundwater drawdown.qgs

a. Total drawdown - prior to commencement of LW201 (Feb-17)

b. Total drawdown - upon completion of LW204 (Mar-20)

c. Drawdown attributed only to LW201-204 (Feb-17 Mar-20)



LEGEND

- Underground mine (Upper Liddell seam)
- drawdown contour (m)

Drawdown (m)

0, 1, 2, 5, 10, 20, 50, 100, 200

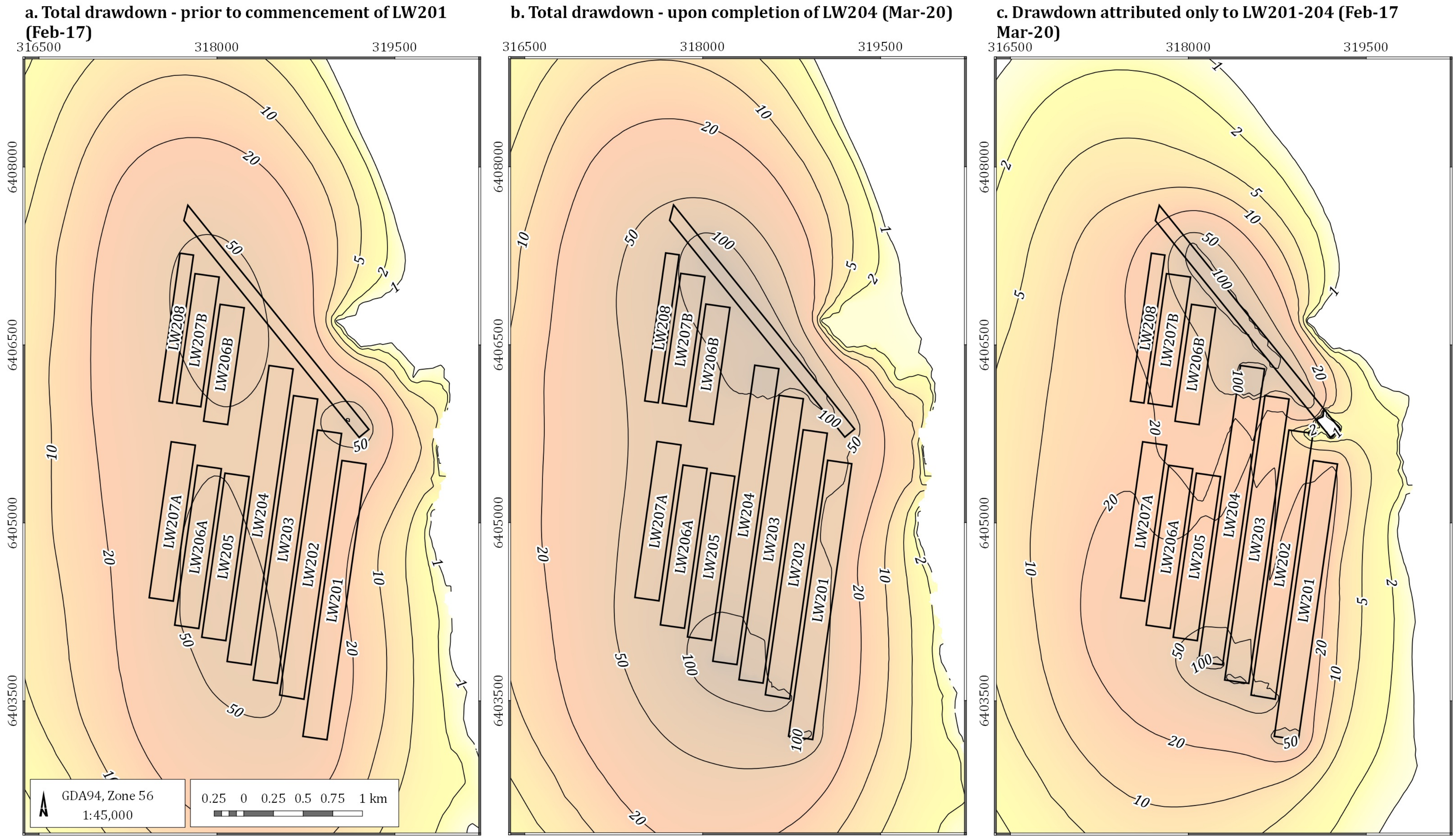
Ashton Coal - Longwalls LW201 to LW204 - Groundwater Impact Assessment (G1758N)

Predicted groundwater drawdown in Upper Liddell seam

DATE 17/10/2016

FIGURE No: **5-3**

G:/Groundwater Jobs/G1758N.Ashton_LW201_LW204/3_GIS/Workspaces/001_Deliverable1/00-00_G1758N_Predicted groundwater drawdown.qgs



LEGEND

Underground mine (Upper Lower Liddell seam)

drawdown contour (m)

Drawdown (m)

0, 1, 2, 5, 10, 20, 50, 100, 200

Ashton Coal - Longwalls LW201 to LW204 - Groundwater Impact Assessment (G1758N)

Predicted groundwater drawdown in Upper Lower Liddell seam

DATE 17/10/2016

FIGURE No: **5-4**

G:/Groundwater Jobs/G1758N.Ashton_LW201_LW204/3_GIS/Workspaces/001_Deliverable1/00-00_G1758N_Predicted groundwater drawdown.qgs

5.2.2 Baseflow impacts

Predicted impacts to stream baseflow in the Hunter River, Bowmans Creek and Glennies Creek in the model domain are displayed in Figure 5-5. The positive values for baseflow gain rate show that the Hunter River, Bowmans Creek and Glennies Creek were simulated in the model as gaining streams; that is, the aquifers are contributing water to the streams instead of the streams recharging the aquifers. The modelled impact on baseflow can be summarised as follows:

- Overall:
  - the overall impact of the mine is a general decrease in baseflow gain rate over the life of the project, however the decrease in baseflow gain rate is within approved impacts.
- Hunter River:
  - the baseflow gain rate in the modelled area of the Hunter River is estimated to be an average 0.53 ML/day – no mine scenario; and
  - the change in baseflow gain rate between the beginning of LW201 and end of LW204 is considered negligible, with a predicted baseflow gain rate of 0.51 ML/day at the beginning of LW201 and 0.505 ML/day at the end of LW204.
- Bowmans Creek:
  - the baseflow gain rate in the modelled area of the Bowmans Creek is estimated to be an average 0.48 ML/day – no mine scenario;
  - the baseflow gain rate is predicted to be 0.44 ML/day prior to LW201 and 0.42 ML/day upon completion of LW204; and
  - the reduction in baseflow gain rate for Bowmans Creek attributable to the mining of LW201-LW204 is estimated as 0.02 ML/day.
- Glennies Creek:
  - the baseflow gain rate in the modelled area of the Glennies Creek is estimated to be an average 0.62 ML/day – no mine scenario;
  - the baseflow gain rate is predicted to be 0.58 ML/day prior to LW201 and 0.57 ML/day upon completion of LW204; and
  - the reduction in baseflow gain rate for Glennies Creek attributable to the mining of LW201-LW204 is estimated as 0.01 ML/day.

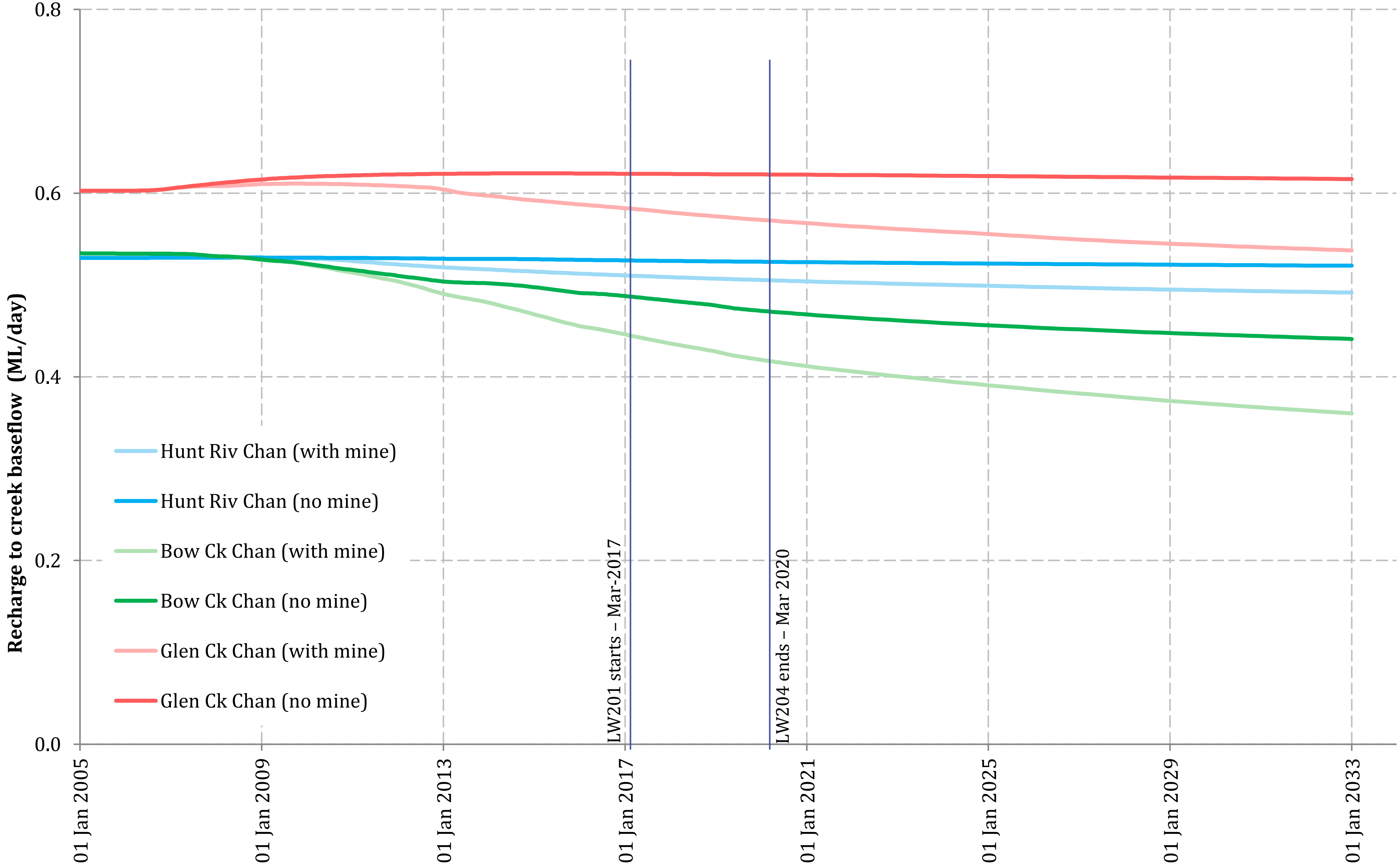


Figure 5-5 Predicted impact to stream baseflow in the Hunter River, Bowmans Creek and Glennies Creek predicted mine inflows

5.2.3 Mine inflows

Predicted Ashton underground mine inflows are presented graphically in Figure 5-6 and summarised for the LW201 to LW204 period in Table 5-2. Total and individual seam inflows are discretised, as are contribution for the various groundwater sources. Key points regarding inflows over the LW201 to LW204 period are as follows:

- total mine inflows increase from approximately 402 ML/yr (1,101 m^3/day) to 420 ML/yr (1,151 m^3/day);
- inflow from the Permian strata, Glennies Creek Channel, GCA, Bowmans Creek Channel, and Hunter River Channel water sources increases;
- inflow from the BCA remains relatively constant;
- inflow from the HRA decreases;
- the proportion of contribution to inflow from the various water sources remains relatively constant; and
- total mine inflows are within the limits predicted by the previous model and approved impacts.

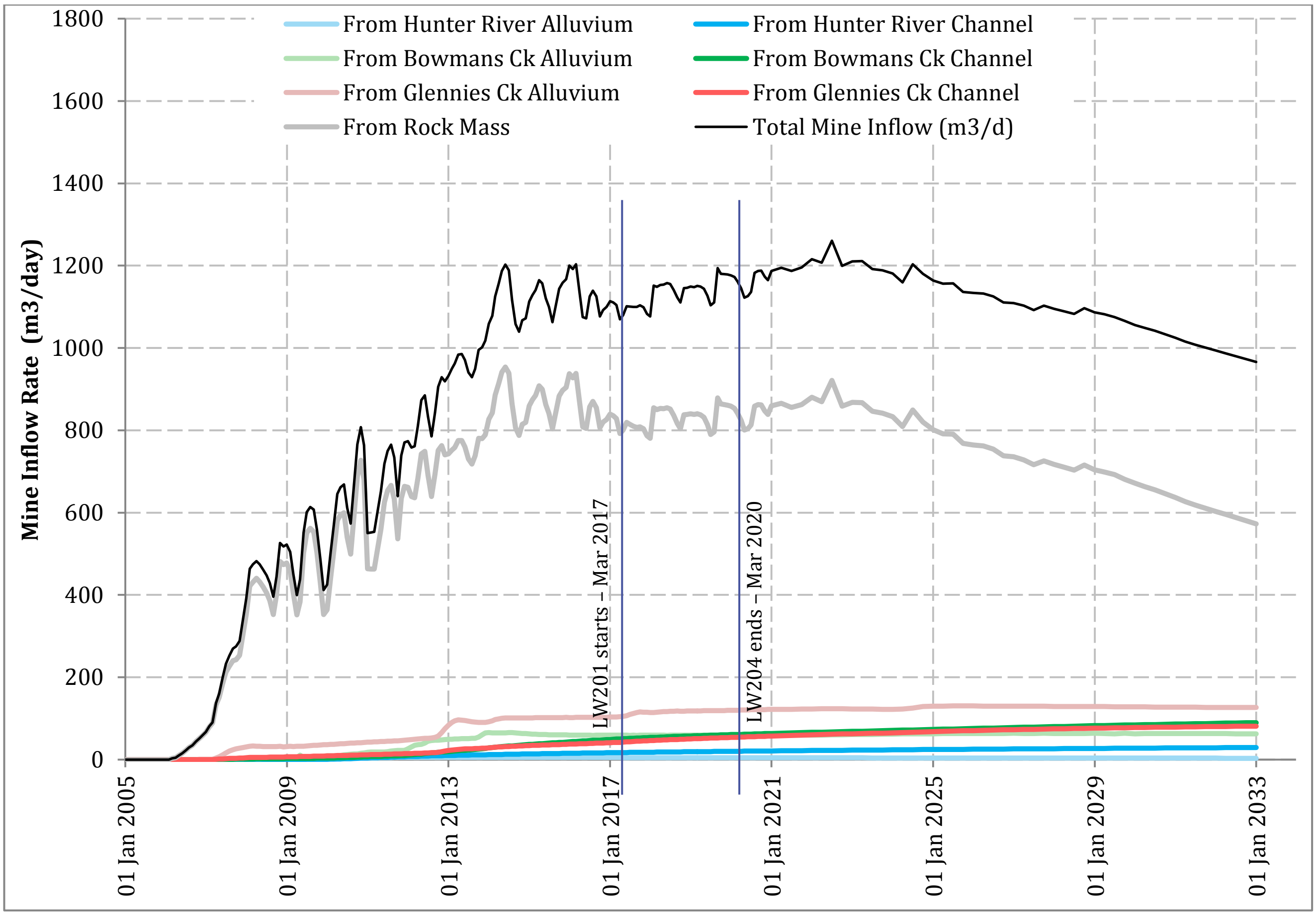


Figure 5-6 Predicted Ashton underground mine inflows

Table 5-2 Predicted Ashton underground mine inflows

	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021
Mine Inflow (ML/yr)					
Total Mine Inflow	402.13	410.35	415.09	422.48	432.31
From Hunter River Alluvium	1.82	1.78	1.72	1.67	1.63
From Hunter River Channel	6.12	6.58	7.00	7.37	7.65
From Bowmans Creek Alluvium	21.60	21.61	21.65	21.70	21.73
From Bowmans Creek Channel	17.93	19.67	21.03	22.19	23.02
From Glennies Creek Alluvium	38.00	42.09	43.17	43.77	44.42
From Glennies Creek Channel	15.08	16.90	18.42	19.72	20.67
From Permian strata	301.58	301.73	302.11	306.06	313.19
Mine Inflow (%)					
From Hunter River Alluvium	0%	0%	0%	0%	0%
From Hunter River Channel	2%	2%	2%	2%	2%
From Bowmans Creek Alluvium	5%	5%	5%	5%	5%
From Bowmans Creek Channel	4%	5%	5%	5%	5%
From Glennies Creek Alluvium	9%	10%	10%	10%	10%
From Glennies Creek Channel	4%	4%	4%	5%	5%
From Permian strata	75%	74%	73%	72%	72%

5.2.4 Potential impacts on water quality

Previous groundwater modelling predicted a risk of an increase in salinity due to potential mixing of fresher surface water and alluvium groundwater with the saline groundwater from the Permian strata (Aquaterra 2009). Based on the current conceptual model this is unlikely, due to the Permian strata being depressurised by subsidence.

Mining activities at Ashton, promote a downward vertical hydraulic gradient due to underground dewatering and subsidence. This minimises the potential risk of saline groundwater from the Permian strata flowing into alluvium and creeks. Therefore, mining activities at Ashton are not expected to cause an increase in the groundwater salinity of creeks and alluvial aquifers; however, there may be a slight decrease in salinity due to the reduced discharge from the Permian strata.

Other risks to water quality, including acid forming potential and heavy metal precipitation have not been observed as a potential issue for Ashton (HLA, 2001).

5.2.5 Potential impacts on groundwater dependent ecosystems

GDEs are defined by ARMCANZ / ANZECC (1996) as ecosystems which have their species composition and their natural ecological processes determined by groundwater.

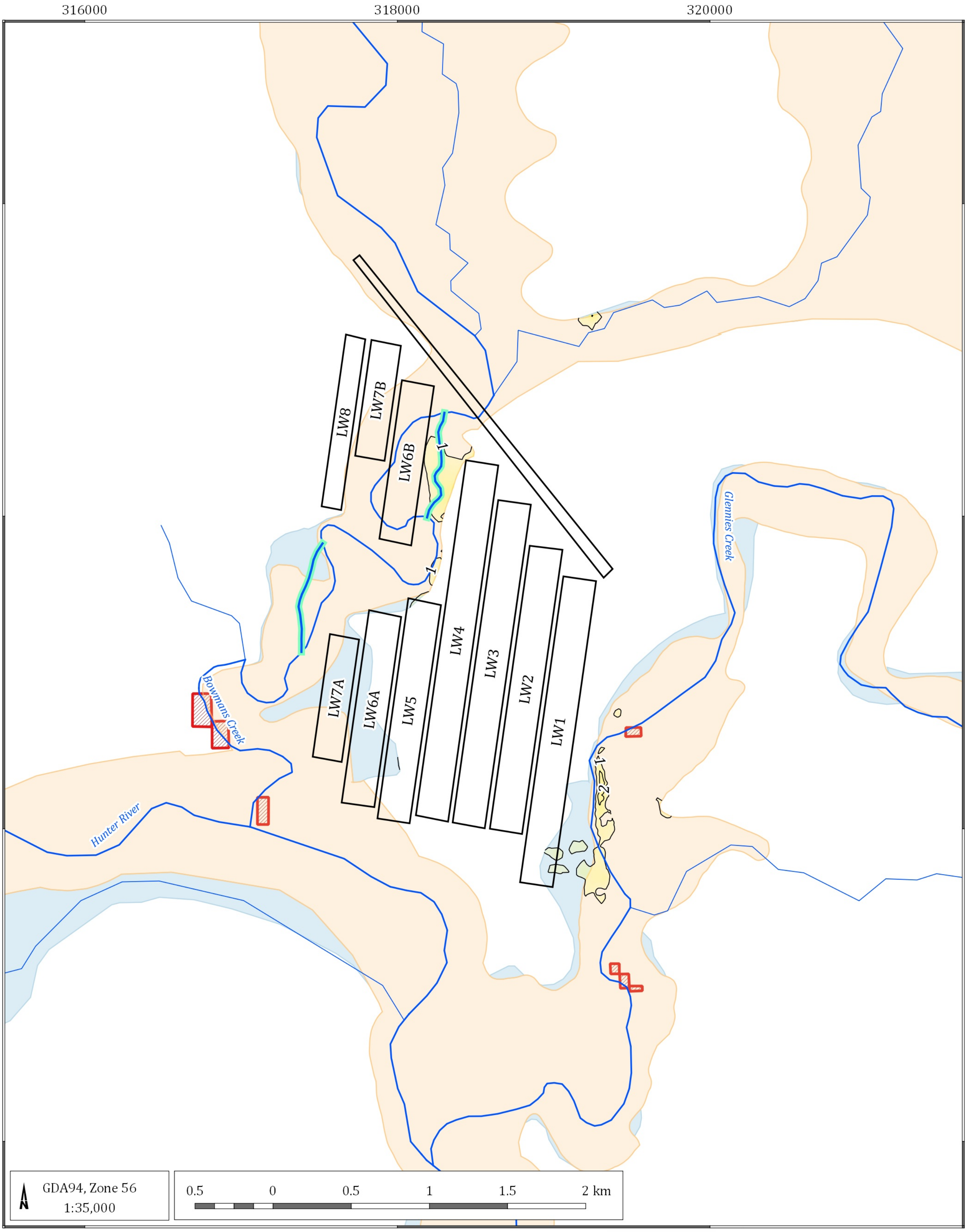
The River Red Gums (RRG) are the only identified GDEs in the vicinity of Ashton. Small stands of RRGs are located on the lower reaches of Bowmans Creek, within 1 km of the Hunter River confluence, and the lower reaches of Glennies Creek (Figure 5-7). These GDE's are likely to access shallow alluvial groundwater, supported by baseflow from creeks.

The predicted alluvial groundwater drawdown upon completion of LW204 does not extend to the known RRG stands (Figure 5-7), hence the RRG stands are not likely to be impacted by drawdown. Additionally, impact to the alluvial water level is likely to be mitigated by recharge from Glennies Creek, which is regulated by surface water discharge from Lake St Claire.

5.2.6 Potential impacts on existing groundwater users

There are no non-ACOL registered bores in surrounding areas that will be impacted by the underground mine. The reason for this is that most of the drawdown resulting from the underground mine occurs in close proximity to the mined area.

As simulated in previous and current versions of the Ashton groundwater model, drawdown generated by Ashton is not predicted to extend far enough to impact on private extraction bores in surrounding areas.



LEGEND

- Underground mine (Pikes Gully seam)
- River Red Gum areas
- Drawdown contour (m)
- Major drainage
- Minor drainage
- Diversion

Alluvium properties boundary

- High permeability
- Low permeability

Drawdown (m)

0
5
50
500

Ashton Coal - Longwalls LW201 to LW204 - Groundwater Impact Assessment (G1758N)

Drawdown in relation to groundwater dependent ecosystems

DATE 17/10/2016

FIGURE No: **5-7**

G:/Groundwater Jobs/G1758N.Ashton_LW201_LW204/3_GIS/Workspaces/001_Deliverable1/05-07_G1758_Groundwater dependent ecosystems.qgs

5.3 Comparison of revised groundwater impacts to 2001 EIS and 2009 EA

A comparison of predicted groundwater impacts against the approved EIS (HLA, 2001) and EA (Aquaterra, 2009) is presented in Table 5-3. Since the EIS and the EA provide impact estimations for the life of the mine, these values were used as reference for the comparison; however, the 2009 EA represents the current mine plan and is considered the most relevant.

Historical salinity monitoring can be found in the document "*Report on Yancoal Australia - Ashton Coal Project - End of Panel Report - LW104*" (G1758L Ashton End of Panel Report – LW104 - AGE 2016).

Table 5-3 Comparison of impacts to 2001 EIS and 2009 EA

Impact description	Location	Observed	2016 AGE model	2009 EA	2001 EIS
		Impact to March 2016 (to mid LW104 ULD)	Impact to end of LW204 - ULLD (March 2020)	Completed mine impact	Completed mine impact
Drawdown	BCA	No drawdown observed in WMP* bores (WMLP311, WMLP323, WMLP328, T2A)	< 1 m (>1m - <2 m in a very small and localised area)	< 3 m	No significant drawdown
	GCA	No drawdown observed in WMP bores (WML120B, WML129, WML239)	< 1 m (>1m - <2 m in a very small and localised area)	< 2 m	2.5 m
	HRA	No drawdown observed in WMP bores (WMLP279, WMLP280, WMLP337)	< 1 m	< 1 m	No significant drawdown
Stream baseflow loss	Bowmans Creek	-	0.02 ML/day	0.13 ML/day	0.4-1.4 ML/day
	Glennies Creek	-	0.01 ML/day	0.23 ML/day	0.6 ML/day
	Hunter River	-	negligible	0.06 ML/day	0.3 ML/day
Salinity	Bowmans Creek	No mining related impact observed in WMP bores (WMLP311)	Likely decrease in salinity	Likely decrease in salinity	Electrical conductivity (EC): great variability - maximum increase of 70 µS/cm attributable to mining related impacts

Impact description	Location	Observed	2016 AGE model	2009 EA	2001 EIS
		Impact to March 2016 (to mid LW104 ULD)	Impact to end of LW204 - ULLD (March 2020)	Completed mine impact	Completed mine impact
	Glennies Creek	No mining related impact observed in WMP bores (WML120B, WML239)	Likely decrease in salinity	Likely decrease in salinity	Similar water quality with mine
	Hunter River	No mining related impact observed in WMP bores (WMLP337)	Likely decrease in salinity	Likely decrease in salinity	N/A

Note: ** Water management plan (WMP)*

The following is a summary of the modelled impacts at the end of LW204 (Table 5-3):

- The predicted drawdown for the alluvial aquifers is within approved impacts; whilst the timing of the modelled impacts (to end of LW204) is not directly comparable to the approved impacts (to the end of mining the Lower Barrett), the results are in line the result of the previous model at the end of mining in the ULD seam. On this basis, the 2009 EA approved impacts are not expected to be exceeded at the end of mining.
- With the exception of some localised drawdown at the limits of the alluvium. This predicted drawdown is more pronounced in areas where coal seams subcrop below the alluvium. The difference in predicted impacts between the current model and previous model is due to MODFLOW-USG being able to better simulate and represent the seam subcrop / alluvium interaction.
- The predicted changes to stream baseflow are considerably reduced compared to the approved impacts on stream baseflow.
- Mining related impacts on groundwater quality have not been observed to date. According to the conceptual understanding of the groundwater system and modelled directions of groundwater flow, future impacts to groundwater quality are not expected and salinity is likely to decrease.
- Mine inflow rates and volume predictions were compared to those predicted in the 2009 EA. Both the mine inflow rates and volumes are within the limits of previous predictions and approved impacts.

6 Recommendations, monitoring, management and mitigation

This impact assessment considered the predicted impacts of the AGE groundwater model for Longwalls 201-204 in comparison with between the approved impacts modelled by the RPS groundwater model (2009 / 2014). The two models were built using similar modelling packages and a comparable conceptual model. However, the more recent model is considered to be more sophisticated with complexity applied as and when required.

Ashton has developed and implemented a site WMP to monitor and manage potential mining related impacts to the groundwater regime. The protocols in the WMP ensure that Ashton complies with Consent conditions and approved impacts.

The current groundwater monitoring program, as outlined in Ashton document (HSEC management system – plan – doc no: 3.4.1.8 – Water Management Plan – Version 8 – dated 11 May 2016), is comprehensive and aims to identify potential mining related impacts to the groundwater regime. The WMP outlines the following:

- groundwater monitoring network, with bores targeting alluvium and Permian units;
- monitoring frequency for groundwater levels and quality;
- groundwater levels and quality triggers for early identification of potential adverse impacts to the groundwater regime; and
- monitoring of groundwater abstraction from the underground workings.

The groundwater monitoring program focusses primarily on monitoring for potential impacts to the alluvial aquifer, which is the prime sensitive receptor. The groundwater monitoring network and level/quality impact assessment criteria for the alluvium aquifer are considered sufficient and appropriate to monitor impacts predicted by the groundwater model.

Ashton prepares a number of reports to assess if the impacts to Glennies Creek, Bowmans Creek and the Hunter River (and connected alluvium) are within the approved predictions, including monitoring and compliance reporting. These reports are considered appropriate.

Groundwater flow into the underground has been estimated with the numerical model. Monitoring of groundwater abstraction (volume and quality) provides a good understanding of the mine inflow. Data collected will continue to be incorporated into future groundwater modelling.

7 References

Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) and Australian and New Zealand Environment and Conservation Council (ANZECC), 1996. "*National Principles for the Provision of Water for Ecosystems*". ARMCANZ / ANZECC Occasional Paper No 3.

Australian Groundwater and Environmental Consultants (AGE), 2016. "*Report on Yancoal Australia - Ashton Coal Project - End of Panel Report - LW104*". Document reference G1758L.

HLA Envirosciences, 2001. "*Environmental Impact Statement - Ashton Coal Project*". Project reference U842.

Aquaterra, 2009. "*Bowmans Creek Diversion: Groundwater Impact Assessment Report*". Document reference S55G/600/011G.

Glen R.A. and Beckett J., 1993, "*Hunter Coalfield Regional Geology 1:100 000, 2nd edition*". Geological Survey of New South Wales, Sydney. (Digital map in vector format)

Appendix A Relevant legislation, policies and guidelines

A1 Regulatory framework

The proposed modification requires consideration of the following NSW government legislation, policy and guidelines for groundwater:

- Water Act 1912, included in the Water Management Act 2000 as of 1 July 2016;
- Water Management Act 2000 and the Water Sharing Plan for Hunter Regulated River Water Source and Hunter Unregulated and Alluvial Water Sources;
- Groundwater Quality Protection Policy;
- Groundwater Dependent Ecosystems Policy;
- Groundwater Quantity Management Policy; and
- Aquifer Interference Policy (2012).

The following sections summarise the intent of the above legislation, policy and guidelines, and how they apply to the proposed modification.

A1.1 Water Act 1912

The Water Act 1912 regulates water sources including rivers, lakes and groundwater aquifers across the State. It also manages the trade of water licences and allocations. The Water Management Act 2000 is progressively replacing the Water Act 1912 in NSW. The Water Management Act 2000 has replaced the Water Act 1912 for the alluvial and surface water sources, and as of 1 July 2016, all groundwater outside the alluvial zones including the fractured rock aquifer. Prior to July 2016, seepage of groundwater to the mining areas from the Permian groundwater regime required an aquifer access licence under Part 5 of the Water Act 1912; subsequently, water take is licenced under the Water Management Act 2000 and the North Coast Fractured and Porous Rock Water Sharing Plan.

A1.2 Water Management Act 2000

The Water Management Act 2000 provides for the “protection, conservation and ecologically sustainable development of the water sources of the State”. The Water Management Act 2000 provides clear arrangements for controlling land based activities that affect the quality and quantity of the State’s water resources. It provides for three primary types of approval in Part 3:

- water use approval – which authorise the use of water at a specified location for a particular purpose, for up to 10 years;
- water management work approval; and
- controlled activity approval which includes an aquifer interference activity approval – which authorises the holder to conduct activities that affect an aquifer such as activities that intersect groundwater, other than water supply bores and may be issued for up to 10 years.

A1.3 Water sharing plans

NSW Water Sharing Plans (WSPs) establish rules for sharing water between the environmental needs of the river or aquifer and water users, and between different types of water use such as town supply, rural domestic supply, stock watering, industry and irrigation.

Department of Primary Industries Water (DPI Water, formerly NSW Office of Water) is progressively developing WSPs for rivers and groundwater systems across NSW following the introduction of the Water Management Act 2000. The purposes of these plans are to protect the health of rivers and groundwater, while also providing water users with perpetual access licences, equitable conditions, and increased opportunities to trade water through separation of land and water rights.

Three WSP's apply to the area of aquifers and surface waters which are affected by the proposed modification, including:

- Hunter Regulated River Water Source WSP 2003 (Hunter Regulated WSP) - The Hunter Regulated WSP covers the Hunter River surface water flows and highly connected alluvials described in the plan. There are three relevant management zones within the Hunter Regulated WSP:
    - Management Zone 1 – all of the HRRWS upstream of the junction of the Hunter River and Glennies Creek;
    - Management Zone 2 – all of the HRRWS downstream of the junction of the Hunter River and Glennies Creek; and
    - Management Zone 3 – all of the HRRWS within the catchment of Glennies Creek.
- Hunter Unregulated and Alluvial Water Sources WSP 2009 (Hunter Unregulated and Alluvial WSP) - The Hunter Unregulated WSP includes the unregulated rivers and creeks within the Hunter River catchment, the highly connected alluvial groundwater (above the tidal limit), and the tidal pool areas. The Hunter Unregulated and Alluvial WSP is subdivided into water sources each with management zones, including:
    - There are two relevant Hunter Unregulated and Alluvial WSP management zones:
        - Management Zone 1 - Upstream Glennies Creek Management Zone; and
        - Management Zone 3 - Glennies Creek Management Zone.
    - Glennies Water Source; and
    - Jerrys Water Source – Jerrys Management Zone.
- North Coast Fractured and Porous Rock Groundwater Sources WSP 2016 (NCFPRGS WSP) – The NCFPRGS WSP commenced on 1st July 2016 and replaces licensing under the Water Act 1912, which covered seepage of groundwater from the Permian coal measures at the site, including groundwater hosted in the Permian coal seams, interburden and weathered profile. Ashton falls within the Sydney Basin – North Coast Groundwater Source of the North Coast Fractured and Porous Rock WSP.

The alluvium along the Hunter River, Glennies Creek and Bowmans Creek are classified as containing both "highly productive" and "less productive" groundwater sources by DPI Water, as discussed further under the Aquifer Interference Policy section.

A1.4 Aquifer Interference Policy

The Water Management Act 2000 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.

The AIP (Department of Primary Industries 2012) 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. "*

Proponents of aquifer interference activities are required to provide predictions of the volume of water to be taken from a water source(s) as a result of the activity. These predictions need to be calculated prior to granting of development consent and these volumes need to be measured and reported annually. 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 AIP 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 addition to the volumetric water licensing considerations, the AIP requires details of potential:

- "*water level, quality or pressure drawdown impacts on nearby water users who are exercising their right to take water under a basic landholder right;*
- *water level, quality or pressure drawdown impacts on nearby licensed water users in connected groundwater and surface water sources;*
- *water level, quality or pressure drawdown impacts on groundwater dependent ecosystems;*
- *increased saline or contaminated water inflows to aquifers and highly connected river systems;*
- *to cause or enhance hydraulic connection between aquifers; and*
- *for river bank instability, or high wall instability or failure to occur."*

In particular, the AIP 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.

A highly productive groundwater source is defined by the AIP as a groundwater source which has been declared in Regulations and datasets, based on the following criteria:

a) has a total dissolved solids (TDS) concentration less than 1,500 mg/L; and
b) contains water supply works that can yield water at a rate greater than 5 L/s.

"Highly productive" groundwater sources are further grouped by geology into alluvial, coastal sands, porous rock, and fractured rock. "Less productive" groundwater sources include aquifers that cannot be defined as "highly productive" according the yield and water quality criteria.

The alluvium along the Hunter River, Glennies Creek and Bowmans Creek meet the criteria of the "highly productive" and "less productive" alluvial water sources categories (Figure 2 2). The Permian coal measures (porous and fractured rock) are categorised as "less productive".

The activities at Ashton and the predicted impacts are approved under the Development consent (DA 309-11-2001) was granted in October 2002.