

WAMBO COAL PTY LIMITED



SOUTH BATES EXTENSION MODIFICATION

RESPONSE TO SUBMISSIONS PART B

For the Modification of DA 305-7-2003 (MOD 17)
Extension of the Approved South Bates Underground Mine

September 2017

Peabody



WAMBO COAL PTY LIMITED

**SOUTH BATES EXTENSION MODIFICATION
RESPONSE TO SUBMISSIONS – PART B**

(Modification 17 to DA 305-7-2003)

PROJECT NO. WAM-09-15

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1 INTRODUCTION

Wambo Coal Pty Limited (WCPL), a subsidiary of Peabody Energy Australia Pty Limited (Peabody), prepared the *South Bates Extension Modification Environmental Assessment* (the EA) (WCPL, 2017a) to support an application to modify the Wambo Coal Mine (Wambo) Development Consent (DA 305-7-2003 MOD 17) under section 75W of the New South Wales (NSW) *Environmental Planning and Assessment Act, 1979* (EP&A Act) (the Modification).

The EA was placed on public exhibition by the NSW Department of Planning and Environment (DP&E) from 30 March 2017 to 2 May 2017. The Modification was also referred to the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC).

The DP&E has requested that WCPL review and respond to the range of submissions that were received on the EA.

This document forms Part B of the Response to Submissions and provides additional information and clarification on the matters related to water resources that were raised in the submissions and by the IESC. Consideration of other matters raised in the submissions was addressed in a previous document (Part A of the Response to Submissions).

Table 1 provides a reconciliation of the submissions received from State and Local Government agencies to date, while Table 2 provides a reconciliation of submissions received from non-Government organisations (NGOs). Table 3 provides a reconciliation of public submissions.

Responses to submissions related to water resources made by Government agencies are provided in Section 2. A response to the advice from the IESC is provided in Section 3. Responses to submissions related to water resources made by NGOs are provided in Section 4, and responses to public submissions related to water resources are provided in Section 5.

Table 1
Reconciliation of Agency Submissions

Agency	Date	Responses Provided in this Document
NSW Dams Safety Committee (DSC)	27 April 2017	Yes
NSW Department of Planning and Environment (DP&E)	29 May 2017	Refer to Part A
NSW Division of Resources and Geoscience (DRG)	2 May 2017	Refer to Part A
NSW Environment Protection Authority (EPA)	3 May 2017 and 11 May 2017	Yes
Heritage Council of NSW (within the NSW Office of Environment and Heritage [OEH])	2 May 2017	Refer to Part A
OEH	3 May 2017	Refer to Part A
NSW Rural Fire Service (RFS)	11 April 2017	Refer to Part A
NSW Roads and Maritime Services (RMS)	28 April 2017	Refer to Part A
Subsidence Advisory NSW	6 July 2017 (No Objections)	Refer to Part A
Department of Primary Industries – Water (DPI Water)	6 September 2017	Yes
Advice of the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC)	31 July 2017	Yes

Table 2
Reconciliation of Non-Government Organisation Submissions

Organisation	Date	Nature of Submission	Responses Provided in this Document
Groundswell Gloucester Inc.	-	Objection	Yes
Hunter Communities Network (HCN)	2 May 2017	Objection	Yes
Hunter Environment Lobby Inc. (HEL)	1 May 2017	Objection	Yes
Lock the Gate Alliance	2 May 2017	Objection	Yes
Nature Conservation Council of NSW (NCC)	2 May 2017	Objection	Yes
Rivers SOS	-	Objection	Yes
Robson Civil	-	Support	-

Table 3
Reconciliation of Public Submissions

Name	Nature of Submission	Issue ID No.
Alan Leslie	Objection	4, 7
AnnaMaree McLaughlin	Objection	4, 7
Beverley Smiles	Objection	4, 7
Charlotte McCabe	Objection	4
Danielle Stien	Support	-
Doreen Lyon	Objection	4, 7
Fee Mozeley	Objection	4, 7
Frances Crane	Objection	7
Grant Wilkinson	Support	-
IH Moore & RA Moore	Objection	4, 7
Jan Davis	Objection	4, 7
Janet Fenwick	Objection	4, 5, 7
Judith Leslie	Objection	4,
Marg McLean	Objection	4, 6, 7
Margaret Edwards	Objection	-
Mark Anthony	Support	-
Mark Jones	Support	-
Matthew Remington	Support	-
Michael Campbell	Objection	4, 7
Peter Kane	Support	-
Robert McLaughlin	Objection	4, 7
Ronald Fenwick	Objection	4, 5, 7
Sharyn Munro	Objection	4, 7, 8
Shaun Ayshford	Support	-

Table 3 (Continued)
Reconciliation of Public Submissions

Name	Nature of Submission	Issue ID No.
Simon Davis	Support	-
Susie Russell	Objection	4
Tim Fitton	Support	-
Victoria Hellyer	Support	-
Name Withheld 1	Comments	7
Name Withheld 2	Objection	4, 7
Name Withheld 3	Objection	4
Name Withheld 4	Support	-
Name Withheld 5	Support	-
Name Withheld 6	Support	-
Name Withheld 7	Support	-
Name Withheld 8	Support	-
Name Withheld 9	Support	-
Name Withheld 10	Support	-
Name Withheld 11	Support	-

2 RESPONSES TO GOVERNMENT AGENCY SUBMISSIONS

Responses to issues raised by Government agencies related to surface water, groundwater and groundwater dependent ecosystems (GDEs) are provided in the subsections below.

2.1 SURFACE WATER

The DSC, EPA and DPI Water have commented on elements of the EA in relation to surface water. The EPA also made two recommendations. These comments and recommendations are addressed below.

Montrose Water Dam Notification Area

Issue

The DSC made the following comment regarding the Notification Area for the proposed Montrose Water Storage Dam:

The DSC prescribed the Montrose Water Dam at their meeting in June 2015 and once a design report for the dam is received a notification area will be delineated around the proposed dam. The proposed South Bates longwalls underlie both the proposed Montrose Dam and the proposed notification area that will be delineated around the Montrose Dam. In order to mine within a Notification Area the Mine must submit an application to the DSC and seek endorsement prior to beginning works within a Notification Area.

Response

Noted. WCPL will comply with all relevant DSC requirements.

As discussed in the EA, construction of the Montrose Water Storage Dam would follow extraction of the Modification longwalls.

Surface Water Management

Issue

The EPA requested further information and clarification regarding the surface water impact assessment criteria for North Wambo Creek.

Response

Table 2.3 of the *Surface Water Assessment* (Appendix C of the EA) provides a summary of the surface water quality monitoring data available at sites considered to be relevant to the Modification.

The water quality impact assessment criteria provided in Table 2.4 of the *Surface Water Assessment* (Appendix C of the EA) are consistent with the approved¹ surface water quality impact assessment criteria for site SW05 – North Wambo Creek Downstream. As described in the approved *Surface Water Monitoring Program* (SWMP), these criteria have been established based on the 20th and 80th percentiles of monitoring results for site SW05.

¹ The surface water quality impact assessment criteria are consistent with the criteria provided in the *Wambo Coal Surface Water Monitoring Program*, which was prepared in consultation with the Department of Primary Industries – Water (DPI Water) and the Division of Resources and Energy (now DRG), and was approved by the Secretary of the DP&E in 2015.

No surface water quality impact assessment criteria have been developed for SW04 – North Wambo Creek Upstream.

It is noted that the difference in salinity between the upstream part of North Wambo Creek (site SW04) and North Wambo Creek near Wollombi Brook (site SW05) was also reported in 2003, prior to development of the North Wambo and South Bates Underground Mines and construction of the North Wambo Creek Diversion.

Salinity data along North Wambo Creek presented by Gilbert & Associates (2003) is provided in Table 4.

Table 4
Summary Statistics of North Wambo Creek Monitoring Data Prior to 2003

Water Quality Parameter	Statistic	North Wambo Creek Upstream (SW04)	North Wambo Creek Near Wollombi Brook (SW05)
Electrical Conductivity (EC) (µS/cm)	Minimum	291	240
	Maximum	410	4,650
	Median	351	1,893
	Mean	351	1,839

Source: Gilbert & Associates (2003).

µS/cm = microSiemens per centimetre.

WCPL considers that the surface water quality impact assessment criteria in the EA and approved SWMP are appropriate triggers for determining unanticipated changes to the water quality at site SW05.

Issue

The EPA requested further detail regarding surface water management at Wambo, in particular:

- interaction with the United Wambo Open Cut Coal Mine Project;
- rainfall and storage design factors for water storages;
- discharge locations and volumes for water storages;
- water quality of water storages on premises; and
- modelling of salinity within the site water management system.

The EPA noted that surface water management on site would need to comply with the conditions of the Environment Protection Licence (EPL), the *Protection of the Environment Operations Act, 1997* and the *Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation, 2002*.

Response

The Modification would not alter:

- the location, timing, design or operation of sediment dams; or
- the location of other surface water storages.

The EA presented an update to the Site Water Balance prepared for the United Wambo Open Cut Coal Mine Project to incorporate the Modification. The updates to the Site Water Balance included:

- updating estimates of groundwater inflows to the underground workings to reflect the proposed changes to underground mining operations;
- changes to the run-of-mine (ROM) coal production and processing profile to incorporate the Modification;
- changing the timing for some mine water storages (Montrose Water Storage Dam, South Wambo Dam, underground storages and tailings storages); and
- change in the model start date from late 2015 to 1 January 2017.

The Site Water Balance prepared for the Modification is based on the assumption that both the Modification and the United Wambo Open Cut Coal Mine Project proceed (a cumulative assessment). The Development Consent (DA 305-7-2003) requires WCPL to re-calculate the site water balance for Wambo each year and, therefore, provides a mechanism for review of the site water balance in the event that the United Wambo Open Cut Coal Mine Project does not proceed.

Sediment dams at Wambo are designed in accordance with the Erosion and Sediment Control Plan (Version 8, April 2016), which includes the following design guidelines:

- Detailed design and sizing of a sediment basin should be undertaken by a competent person to ensure the basin has sufficient capacity and the water being discharged is of acceptable quality to meet regulatory requirements.
- Settling Zone: Capacity to store the runoff produced from the 85th percentile, 5 day rainfall event. For Wambo, the 5 day rainfall depth is an average of 26 millimetres (mm).
- Sediment Storage Zone: Assumes two months calculated soil loss estimated using the Revised Universal Soil Loss Equation method.

The United Wambo Open Cut Coal Mine Project proposes the following design criteria for storages:

- Sediment dams would be designed in accordance with *Managing Urban Stormwater: Soils and Construction* (the Blue Book), *Volume 1* and *Volume 2E - Mines and Quarries* to manage runoff produced from the 95th percentile, 5 day rainfall event.
- Mine water would be contained within mine water storage dams designed to provide sufficient freeboard to contain runoff produced from the 1 percent (%) Annual Exceedance Probability 24 hour storm event.

Figure 3 of the *Site Water Balance* (Appendix L of the EA) shows where a storage may spill in the event that a storm event occurs that cannot be accommodated within the design criteria, site operating rules and pumping capacity.

The Modification would not materially change off-site release of water, or the location, timing, design or operation of sediment dams. Table 5 presents a comparison of the estimated average releases.

Table 5
Estimated Average Releases

Component	United Wambo Open Cut Coal Mine Project	Incorporating the Modification (MOD 17)
Hunter River Salinity Trading Scheme (HRSTS) Releases	550 ML/annum	651 ML/annum
External Spills from Sediment Dams	5 ML/annum	6 ML/annum

Source: Hydro Engineering & Consulting Pty Ltd (HEC) (2016; 2017).

ML/annum = megalitres per annum.

HEC (2017) conducted a salt balance for the Modification using salinity values assigned to runoff from each storage catchment as well as to groundwater inflow, tailings bleed water and water sourced from Water Access Licences (Table 6).

Table 6
Simulated Salinity Values

Storage Catchment/Water Source	Modelled Salinity (mg/L)
C11 Void and Chitter Dam	4,600
CHPP Dams and Milk Can Dam	3,500
Dam 2, MW1 and MW2	1,000
Homestead and Main Homestead	4,600
Hunter Tailings and Tailings Bleed Water	9,600
MIA Dam	600
Wambo Open Cut and United Open Cut	4,000
North-East Tailings	2,750
Process Water Dam	4,300
South Bates	4,000
South Wambo Dam	400
W2	3,700
M1 to M6, U1 to U5, W1 and W3 to W10	1,000
Groundwater Inflow	6,000
Hunter River and Wollombi Brook Extraction	400

Source: HEC (2016).

mg/L = milligrams per litre. CHPP = Coal Handling and Preparation Plant.

The predicted salinity of water stored in all simulated water storages was presented by HEC (2017) in Appendix L of the EA, and is reproduced in Figure 1. The predicted salinity was calculated by dividing the simulated total salt tonnage held in all water storages (including open cuts and undergrounds) by the total stored water volume and therefore represents an 'average' salinity across all water storages. The salinity of water stored in individual water storages would vary.

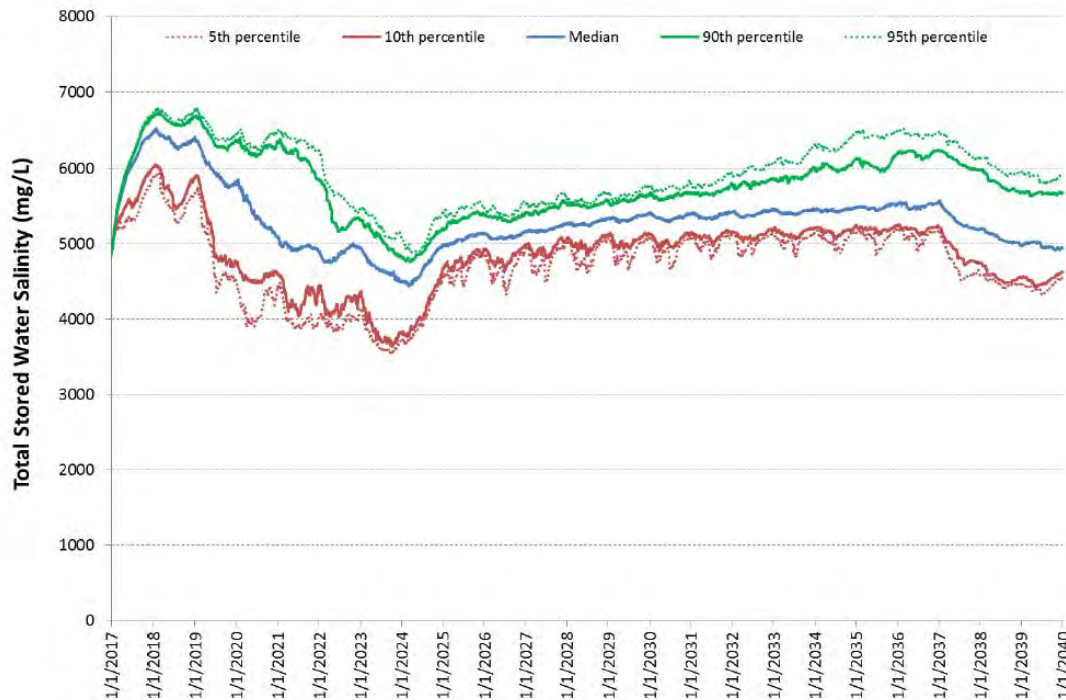


Figure 1 – Predicted Total Stored Water Salinity

Source: HEC (2017).

WCPL would design and operate the water management system to comply with the relevant requirements of EPL 529, the *Protection of the Environment Operations Act, 1997* and the *Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation, 2002*.

Water Management

Issue

The EPA recommended the following condition for the Development Consent:

Except as may be expressly provided by a licence under the Protection of the Environment Operations Act 1997 in relation of the activity, Section 120 of the Protection of the Environment Operations Act 1997 must be complied with in connection with the carrying out of any scheduled development works or activity.

Response

WCPL accepts the recommendation made by the EPA and notes that these recommendations are considered to be sufficiently addressed by Condition 23A, Schedule 4 of the current Development Consent (DA 305-7-2003).

WCPL consider that the inclusion of additional conditions in the Development Consent would result in duplication of existing requirements.

Issue

The EPA recommended the following condition for the Development Consent:

Except as may be expressly provided by a licence under the Protection of the Environment Operations Act 1997 in relation of the activity, the Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation 2002 must be complied with in connection with the carrying out of any scheduled development works or activity.

Response

WCPL is required to comply with the *Protection of the Environment Operations Act, 1997* and associated regulations. WCPL consider that the inclusion of additional conditions in the Development Consent would result in duplication of existing requirements.

Issue

The DPI Water recommended the following:

The Applicant must ensure that it has sufficient water for all stages of the development, and if necessary, adjust the scale of operations on site to match its available water supply.

Response

WCPL accepts the recommendation made by the DPI Water and notes that this recommendation is addressed by Condition 23, Schedule 4 of the current Development Consent (DA 305-7-2003):

The Applicant must ensure that it has sufficient water during each stage of the development, and if necessary, adjust the scale of mining operations to match its available water supply.

Note: The Applicant is required to obtain necessary licences for the development under the Water Act 1912 and Water Management Act 2000.

Issue

The DPI Water raised the following:

DPI also considers that justification is required that the currently held WAL of 70 shares in the Lower Wollombi Brook is sufficient for ensuring compliance with the Water Management Act 2000. Noting that the EA identified maximum predicted take from the Lower Wollombi Brook Water Source of 69 ML/yr, DPI is concerned that the take of water from North Wambo Creek in combination with modelled baseflow losses (noting the model doesn't account for stream losses), and including reversal in flow from Wollombi Brook, collectively may exceed available licensable take of 70 ML/yr.

Response

As described above, WCPL has an obligation under the *Water Management Act, 2000* and its Development Consent DA 305-7-2003 to hold sufficient water licences.

Based on the groundwater modelling, WCPL holds sufficient aquifer access licence shares to account for its predicted take from alluvial aquifers.

WCPL's licence (70 share components) comprises less than 2% of the total available shares in aquifer access licences in the Lower Wollombi Brook Water Source (3,720 shares) (DPI Water, 2017). In the event that future reviews identify the need for further groundwater entitlements, it is anticipated that WCPL could purchase additional entitlements on the open market.

Any measured loss of surface flow in North Wambo Creek would be licensed using WCPL's unregulated river access licence in the Lower Wollombi Brook Water Source (WAL 18437) which has 350 shares. WCPL would make any necessary adjustments to its pumping from Wollombi Brook and/or the scale of mining operations so that there would be sufficient licence entitlement.

North Wambo Creek

Issue

The DPI Water recommended the following:

An up-stream flow gauge site along North Wambo Creek should be established.

Response

WCPL would install an additional flow gauge on North Wambo Creek as part of any future Extraction Plan application under the natural section of North Wambo Creek in the Modification area.

Issue

The DPI Water recommended the following:

The WMP for Modification 17 must be developed in consultation with DPI Water and include a geomorphic context statement and be consistent with the River Styles assessment methodology.

Response

Under Conditions 22C and 30, Schedule 4 of the current Development Consent (DA 305-7-2003), WCPL would be required to prepare the Water Management Plan for the Modification longwalls in consultation with DPI Water.

WCPL commits to the preparation of a geomorphic context statement for North Wambo Creek for inclusion in any Extraction Plan application for proposed Longwall 23, 24 and/or 25.

Issue

The DPI Water recommended the following:

The proponent should provide a commitment to monitor and mitigate impacts to North Wambo Creek and identify appropriate geomorphic indicators to monitor system recovery and inform mitigation and rehabilitation techniques. It is recommended the proponent undertakes a pre-subsidence survey and energy profile analysis, pre- and post- subsidence channel profiles, for both lateral cross section and long profiles, and analysis of integrity of features and/or structures that may be considered for prevention of significant channel degradation. The WMP must allow for ongoing consultation with DPI Water over design options following analysis of likely scour and incision risk for existing conditions and following each longwall panel pass and associated subsidence.

Response

WCPL accepts the above recommendation, which is generally consistent with the monitoring and mitigation approach being implemented for the North Wambo Creek Diversion as part of the approved Extraction Plan for the South Bates Underground Mine.

Issue

The DPI Water recommended the following:

Longwall panel LW23 should be shortened to such an extent that prevents mining directly beneath North Wambo Creek.

Response

It is noted that the section of North Wambo Creek above the proposed Longwall 23:

- is completely devoid of mid-storey or over-storey vegetation (Plate 1) (i.e. Hunter Lowland Redgum Forest is not present);
- has no permanent standing water;
- on the basis of the above, provides limited fauna habitat;
- is not associated with highly productive groundwater; and
- is not used for water supply, and no portion of North Wambo Creek downstream of the area is used for water supply.

WCPL considers there is no policy or environmental justification for standing off the section of North Wambo Creek above proposed Longwall 23. WCPL would implement a monitoring, mitigation and remediation program so that there would be no significant change in water quality in North Wambo Creek downstream.

Notwithstanding, prior to undermining this section of North Wambo Creek, WCPL commits to preparing a geomorphic context statement for North Wambo Creek and developing a monitoring and remediation program for North Wambo Creek that includes assessment of scour and incision risk for existing conditions and following each longwall panel.



Plate 1 – North Wambo Creek in the Vicinity of Longwall 23 (Looking Upstream)

Source: Advisian (2016).

2.2 GROUNDWATER AND GROUNDWATER DEPENDENT ECOSYSTEMS

Issue

The DPI Water recommended the following:

Consideration should be given to removing the two western most longwall panels (LW24 and LW25) from the current proposal pending further investigation. DPI does not consider the existing information adequate to conclude the riparian Hunter Lowland Redgum Forest Endangered Ecological Community (EEC) is not a Groundwater Dependent Ecosystem (GDE) or that the proposal would not have significant impact on this community.

To assess whether future mining in this area is feasible it is recommended that the proponent prepares a standalone document that gathers information on site characterisation of the potential GDE, characterisation of the geological and hydrogeological systems in the vicinity of the potential GDE, formation parameters and how proposed activities are to impact on overburden, creek, alluvium and the potential GDE. The review of impact can make use of the existing model, however considerations on subsidence are required and how this may vary from model predictions. This assessment must include area specific data and critically review all impact data with observed impacts in similar developments on the mine or nearby sites.

Response

Table 14A of the Development Consent (DA 305-7-2003) includes the following subsidence impact performance measure for threatened communities, including Hunter Lowland Redgum Forest:

Minor cracking and ponding of the land surface or other impact.

Negligible environmental consequences

Condition 22C, Schedule 4 of the Development Consent (DA 305-7-2003) requires each Extraction Plan to:

describe the measures that would be implemented to ensure compliance with the performance measures in Tables 14A and 14B, and manage or remediate any impacts and/or environmental consequences

In the event that a subsidence impact performance measure is exceeded, Condition 22, Schedule 4 of the Development Consent (DA 305-7-2003) requires WCPL to remediate the impact or environmental consequence, or provide a suitable offset to the satisfaction of the DP&E to compensate for the impact or environmental consequence.

To address the recommendations of DPI Water, WCPL would accept a condition requiring the following:

Any Extraction Plan for second workings beneath the natural section of North Wambo Creek in the South Bates Extension Mine area must:

- a) incorporate monitoring data from clustered monitoring bores in proximity to Hunter Lowland Redgum Forest along North Wambo Creek;*
- b) incorporate monitoring data from vibrating wire piezometer sites above the South Bates Extension Mine area both within and beyond the area with potential for fracturing to surface;*
- c) include a geomorphic context statement for North Wambo Creek;*
- d) characterise geological and hydrogeological systems in the vicinity of Hunter Lowland Redgum Forest, including an assessment of the presence and extent of any shallow groundwater;*
- e) assess the potential environmental consequences of the proposed second workings on Hunter Lowland Redgum Forest associated with subsidence and groundwater drawdown incorporating any relevant information obtained since this consent;*

- f) include a monitoring and remediation program for North Wambo Creek that includes assessment of scour and incision risk for existing conditions and following each longwall panel; and
- g) describe the measures that would be implemented to ensure compliance with the performance measure in Table 14A for Hunter Lowland Redgum Forest, and manage or remediate any impacts and/or environmental consequences

to the satisfaction of the Secretary.

Issue

The DPI Water recommended the following:

Riparian Hunter Lowland Redgum Forest EEC should be investigated in detail to identify the presence and extent of shallow alluvial/colluvial groundwater system. This investigation should include two clustered monitoring bore sites in both the upper and lower extent of this location.

Response

WCPL accepts this recommendation. A proposed condition incorporating this recommendation is presented above.

Issue

The DPI Water recommended the following:

Several clustered bore sites and/or vibrating wire piezometers should be installed within the Porous Rock in the area above the proposed longwall panels within the Modification 17 project area. This installation must occur as soon as practical to supply baseline data. The sites selected should be both within and beyond the predicted area for connective fracture to surface and one site in proximity to mapped Critically Endangered Ecological Communities (CEEC). The full bore logs and downhole geophysics reports are to be provided to DPI Water. This drilling may then inform further investigation and a supplementary report on the pre-mining piezometric levels and water quality for all four coal seam aquifers, shallow interburden and, if present, the alluvial aquifer in proximity to the Hunter Lowland Redgum Forest.

Response

WCPL accepts this recommendation. A proposed condition incorporating this recommendation is presented above.

Issue

The DPI Water recommended the following:

Two clustered bore sites and/or vibrating wire piezometers should be included above LW11-16 South Bates Underground to inform on vertical extent aquifer depressurisation in a multi-seam environment. The sites selected should be both within and beyond the predicted area for connective fracture to surface. The full bore logs and downhole geophysics reports are to be provided to DPI Water.

Response

The proposed Modification longwalls are located in an area of single-seam extraction (that is, there is no previous or currently proposed mining above or below the proposed Modification longwalls). Therefore, aquifer depressurisation in a multi-seam environment (e.g. above Longwalls 11 to 16) is not directly relevant to the assessment and determination of this Modification.

As presented in the currently approved Extraction Plan for Longwalls 11 to 16, two multi-level vibrating wire piezometers (N2 and N3) are installed immediately adjacent to Longwalls 11 to 16 at South Bates Underground Mine to monitor changes in groundwater levels (Figure 2).

The DPI Water did not request additional monitoring sites above Longwalls 11 to 13 as part of its review of the Extraction Plan for Longwalls 11 to 13 in late 2015. The DPI Water received the complete Extraction Plan for Longwalls 11 to 16 in January 2017 and has not provided comment to date.

Extraction of Longwall 11 to 13 in the Whybrow Seam is complete, with extraction of Longwall 14 underway in the underlying Wambo Seam. Extraction of all longwalls (11 to 16) is scheduled for completion by June 2018.

It is not considered practical to install an additional monitoring site above the longwalls within a 9 month window – i.e. to arrange for a drill rig, order and obtain the relevant equipment, install a multi-level piezometer, allow for groundwater levels in the hole to stabilise following installation and then to obtain any meaningful data prior to completion of extraction (i.e. it may only be a matter of weeks before the piezometer is undermined and rendered unserviceable).

Issue

The DPI Water recommended the following:

DPI Water maintains the recommendation that a representative caved zone be applied and revision of the estimates on the extent for the subsidence hydrological connection to surface occurs to ensure consistency with the application of point 10 of Hebblewhite (2010).

Response

The document “Hebblewhite (2010)” referenced by the DPI Water does not outline any procedure involving 10 or more points. The *Groundwater Assessment* (Appendix B of the EA) outlines the 17 step procedure developed by HydroSimulations (the author of the *Groundwater Assessment*) for modelling fracturing above longwalls. This procedure was implemented in the numerical groundwater model (which incorporates 18 separate model layers).

Modelling conducted by HydroSimulations adopted a conservative approach to vertical connectivity enhanced by mining, with fracturing to surface assumed in the numerical model over the north-eastern ends of longwall panels.

The hydraulic conductivities adopted above extracted areas are based on transient calibration using observed groundwater drawdown/depressurisation during the period January 2003 to December 2014, which included the effects of North Wambo Underground Mine Longwalls 1 to 10 (mining with the same or similar longwall widths and similar depth of cover as the Modification longwalls).

It is considered that the groundwater model sufficiently represents the caved and fractured zones above the Modification longwalls. This is because the hydraulic conductivity in the layer above the mined coal seam is enhanced appropriately to represent both zones in the model.

The numerical groundwater was peer reviewed by Dr Frans Kalf (Attachment 1), who concluded that the model was fit for purpose.

Notwithstanding, the numerical groundwater model will be reviewed, and if necessary revised, as part of any future Extraction Plan applications.

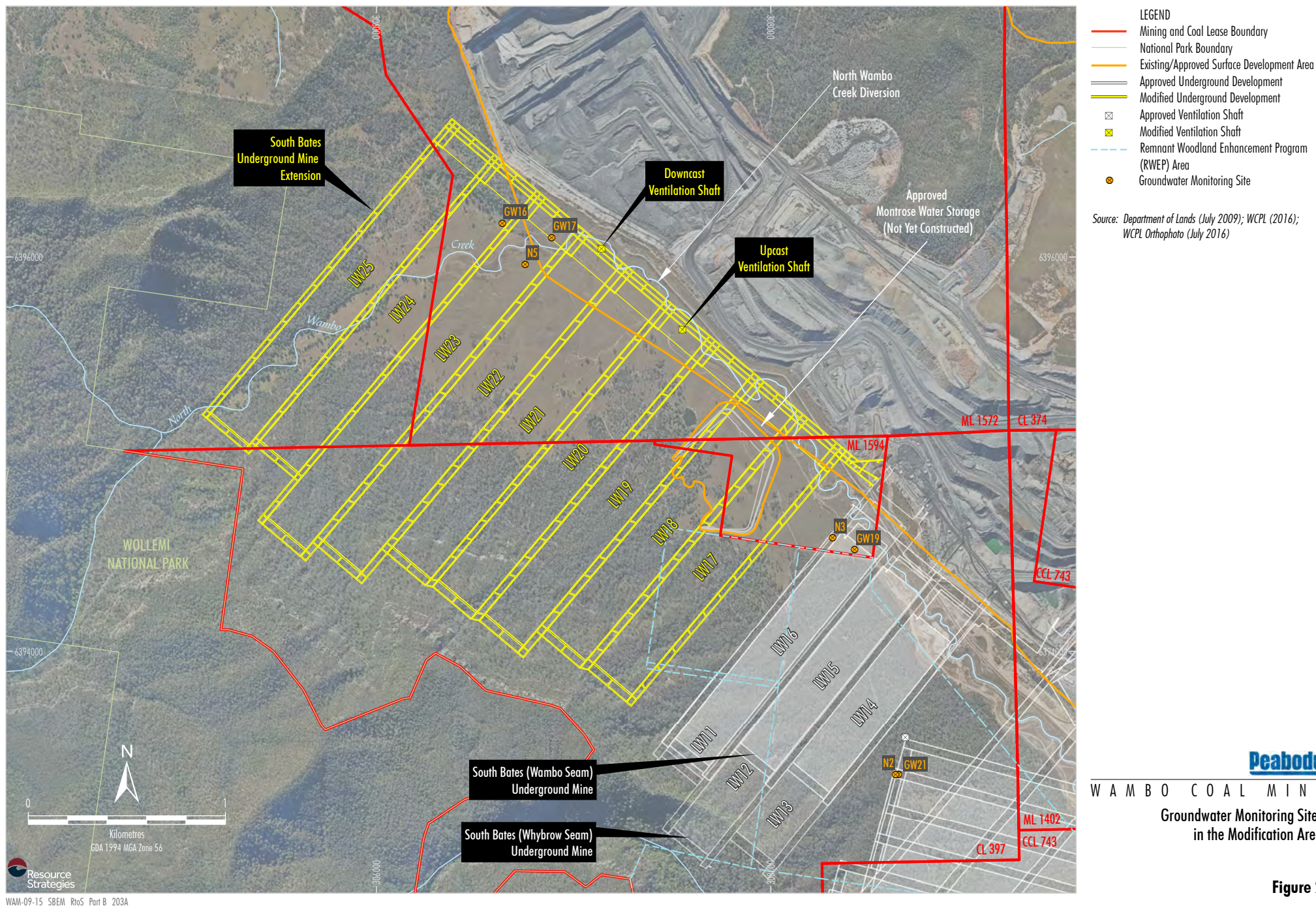


Figure 2

Issue

The DPI Water recommended the following:

The proponent should provide a supplementary report addressing the reasons for a predicted lower re-equilibrated groundwater levels across the Modification 17 area without generating changes in discharge dynamics.

Response

Examination of Darcy's Law shows that a lower hydraulic gradient (with lower pressure heads) must result from increases in hydraulic conductivity (in a fractured zone) without any necessary change in lateral groundwater flow.

The findings of the numerical groundwater were peer reviewed by Dr Frans Kalf (Attachment 1), who concluded "All drawdown predictions, and in particular water table drawdowns within alluvial sediments, are considered plausible".

Notwithstanding, any future Extraction Plan applications will be prepared in consultation with DPI Water and will include additional information on groundwater modelling outcomes incorporating any relevant information obtained since the determination of this Modification.

Issue

The DPI Water recommended the following:

It is recommended the groundwater assessment for LW 17-25 incorporates subsurface redirection of surface flows from North Wambo Creek into the underlying fracture zone above each longwall panel and the combined subsidence zone. This must consider the hydrograph presented by Alluvium 2016 report, indicating maximum instantaneous discharge rates (Q_{max}) of 43 m³/seconds to a 1:2 year ARI flow event and 153 m³/seconds to a 1:50 year flow event.

Response

It is not clear whether this recommendation is in relation to the Groundwater Assessment in general, or the numerical groundwater model.

The numerical groundwater model adopts the MODFLOW groundwater modelling platform, which is designed for regional and long-term impact assessment. Given the ephemeral nature of North Wambo Creek, the regional numerical groundwater model is not the most appropriate method to estimate intermittent surface water and groundwater interactions associated with ephemeral flow in North Wambo Creek due to the very different time scales for simulation of surface water flow and groundwater flow. The numerical groundwater model has been used primarily to estimate leakage from alluvial water sources and long-term baseflow takes.

The *Surface Water Assessment* (Advisian, 2016) describes the potential for temporary subsurface redirection of surface flows from North Wambo Creek:

As North Wambo Creek is an ephemeral creek, surface water flow only occurs during, and for short periods of time after, rainfall events. In times of heavy rainfall, the majority of the runoff would flow over the natural surface soil in the creek bed and would not be diverted into the dilated strata below. However, in times of low flow, and prior to any remediation, surface water flows or water in pools could be diverted into the dilated strata below the creek bed.

Consistent with the conclusion of Advisian (2016), it is expected that only a small portion of the flow (if any) from a 1:2 year Annual Recurrence Interval (ARI) flow or 1:50 year ARI flow would be diverted into cracking caused by subsidence, prior to the cracking being remediated. This is because any cracks would not be large enough to convey flows of a 1:2 year or 1:50 year ARI magnitude. This assessment conclusion is supported by the following experience at Wambo:

- South Bates Underground Mine extracted Longwalls 11 to 13 in 2016 and 2017 beneath the North Wambo Creek Diversion at depths of cover of between approximately 60 and 85 metres. Monitoring of inflows to the mine workings indicated no direct hydraulic connection to the North Wambo Creek Diversion (i.e. no observed significant changes in volumes and/or rates associated with rainfall).
- North Wambo Underground Mine extracted Longwalls 1 to 8a between late 2008 and late 2015 beneath North Wambo Creek (downstream of the Modification area) at depths of cover of between approximately 70 and 120 metres. Monitoring of inflows to the mine workings and alluvial water levels indicated no direct hydraulic connection to North Wambo Creek (i.e. no observed significant changes in volumes and/or rates associated with rainfall and/or extraction under alluvial areas).
- Homstead Mine extracted 10 longwalls beneath Stony Creek and Wambo Creek between 1991 and 1999. Subsurface diversion of flow to the mine workings was observed during the extraction of Panels 9 and 9A, although significant flow remained in the creek during times of heavy rainfall. Remediation (including grouting) was conducted on Wambo Creek. A recent report (AECOM, 2016) concluded that “during the 2010/2011 year flow events followed the expected pattern of increasing flow downstream, and there do not appear to have been any flow loss at the site of the August 1998 flow loss event”.

Issue

The DPI Water recommended the following:

The environmental assessment indicated there to be no GDE on North Wambo Creek due to groundwater depth > 30 m. DPI considers that further studies are required, such as drilling and transpiration studies, to justify this finding. DPI considers that the species composition indicates EEC could be present. For further information on indicator species please see the following links:

- o <http://www.environment.nsw.gov.au/determinations/HunterLowlandRedgumForestEndComListing.htm>
- o http://www.water.nsw.gov.au/_data/assets/pdf_file/0010/547939/gde_risk_assessment_guidelines_volume_3_final_accessible_smallest.pdf

Response

The *Flora Assessment* for the Modification (FloraSearch, 2017) mapped disturbed and highly fragmented remnants of Forest Red Gum – Rough-barked Apple – River Sheoak Forest adjacent to North Wambo Creek in the west of the Modification area. FloraSearch (2017) classified this vegetation as meeting the criteria for the *Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregions* Endangered Ecological Community (EEC) in consideration of the information presented in the NSW Scientific Committee - final determination (first link provided by the DPI Water above).

In relation to its potential groundwater dependence, FloraSearch (2017) concluded:

Remnant vegetation along North Wambo Creek is mostly 5 to 10 m above the water table and is likely to depend entirely on surface flows. There may be some potential for vegetation to access groundwater in two areas close to North Wambo Creek where the water table is 2 to 5 m below the surface (HydroSimulations, 2017). However, the vegetation associated with these areas is not different from that in nearby areas where the water table depth is greater. It is concluded that none of the plant communities on the Study Area are groundwater dependent.

The second link provided by the DPI Water above presents the outcomes of a study identifying GDEs on the coastal plains of NSW (Kuginis *et al.*, 2012). Appendix 7 of Kuginis *et al.* (2012) lists the types of communities that are groundwater dependent within the coastal plains of the Hunter-Central Rivers catchment management authority area.

Dr Colin Bower of FloraSearch (a botanist with over 30 years of experience) confirmed that the vegetation communities present in the Modification area (including the Forest Red Gum – Rough-barked Apple – River Sheoak Forest) are not listed in Kuginis *et al.* (2012), and are not similar to any of the communities listed in Kuginis *et al.* (2012) as potential GDEs.

Notwithstanding, WCPL commits to undertaking further investigations. A proposed condition incorporating this recommendation is presented further above.

3 RESPONSES TO IESC ADVICE

The IESC noted that the magnitude of potential impacts associated with the Modification is likely to be small, relative to the impacts caused by the existing mine and other larger mining operations in the area.

The IESC requested further detail on how the impacts will be effectively mitigated and/or managed.

3.1 SURFACE WATER

Issue [Item 9 of the Advice]

The IESC requested further information of the potential impacts of fracturing on North Wambo Creek and the North Wambo Creek Diversion, including:

- increases in the number of no-flow days and potential reduction in pool persistence, should fracturing result in the diversion of low and moderate flows to the subsurface;
- potential implications on existing and predicted future ponds, water quality and biota should less flow occur; and
- changes to water quality that may arise from diversion of flows to the subsurface, and potential re-emergence of this diverted water in North Wambo Creek, including changes to iron, salt and dissolved oxygen concentrations.

Response

Section 3.4.1 of the *Surface Water Assessment* (Appendix C of the EA) addresses potential impacts on streamflow in North Wambo Creek and the North Wambo Creek Diversion. The Modification has the potential to impact on flow in North Wambo Creek, the Diversion and the ephemeral drainage lines through:

- loss of water by evaporation and seepage from pools that form as a result of subsidence;
- change in groundwater baseflow; and
- loss of flow into surface cracks that direct flow into the shallow surface fracture zone or to the workings if direct hydraulic connection is established.

North Wambo Creek has been previously mined beneath by Longwalls 1 to 8a at the North Wambo Underground Mine. The surface impacts along the North Wambo Creek are expected to be similar to those previously observed at Wambo. The surface cracking observed above Longwalls 1 to 8a at the North Wambo Underground Mine typically had widths within the range of 10 to 50 mm, with widths up to approximately 100 mm in some locations. Significant diversion of flow was not observed above the previous longwalls and pool persistence was generally observed to increase as a result of subsidence ponding rather than decrease as a result of cracking.

As North Wambo Creek is an ephemeral creek, surface water flow only occurs during, and for short periods of time after, rainfall events. In times of heavy rainfall, the majority of the runoff would flow over the natural surface soil in the creek bed and would not be diverted into the dilated strata below. However, prior to any remediation, and in times of low flow, surface water flows or water in pools could be diverted into the dilated strata below the creek bed.

The *Subsidence Assessment* (Appendix A of the EA) indicates that the main risk of direct hydraulic connection is likely to occur in a short section of the North Wambo Creek Diversion that crosses the north-east corner of Longwall 17 where the depth of cover is shallow and the bedrock is near to, or at, the surface. However, experience from Longwall 11 at the South Bates Underground Mine which mined under the North Wambo Creek Diversion at a similar depth of cover and geometry for the full width of the Diversion, indicated no direct hydraulic connection.

The risk of fracturing resulting in the diversion of low flows to the subsurface prior to remediation is noted, although the volume of any flow diversion is difficult to quantify at this stage. Any potential impact could be remediated and is expected to be temporary (less than 6 months). Given the ephemeral nature of North Wambo Creek, there is not expected to be a significant impact on fauna that may use North Wambo Creek for refuge or feeding in the event of any temporary impact on flow as a result of surface cracking.

Advisian (Appendix C of the EA) made the following conclusion regarding potential changes to iron and salinity in North Wambo Creek:

Any cracking of exposed bedrock along North Wambo Creek has the potential to lead to a decrease in pH and the potential for iron staining. However, no existing iron staining was observed during the site inspection, so no significant pH impacts are predicted.

Subsidence is not expected to lead to any change in the EC of the flow in North Wambo Creek.

Advisian (Appendix C of the EA) made the following conclusion regarding potential changes to iron salinity in the North Wambo Creek Diversion:

Subsidence is not expected to lead to any change in the pH or EC of the flow in the Diversion.

Issue [Item 10 of the Advice]

The IESC requested clarification on the extent of baseflow reduction in North Wambo Creek. The IESC requested that if all, or a considerable portion of baseflow is to be lost, then assessment of the potential implications on the “maintenance of permanent pools within North Wambo Creek and GDEs (e.g. hyporheic fauna) associated with the creek’s alluvial sediments is required”.

Response

The numerical groundwater model outputs indicate that groundwater contributions to North Wambo Creek and the Diversion were approximately 0.02 megalitres per day. When this estimate is considered in the context of the length of North Wambo Creek and the Diversion (over 10 kilometres), this contribution is so small that it would occur as minor seepages that would be lost by evaporation except at times of flow and would not measurably contribute to downstream flow (e.g. in Wollombi Brook). For example, over a 100 metre length of creek, the groundwater contribution would average 0.002 litres per second.

As described in Section 3.4.1 of Appendix C of the EA, the approved Wambo operations, the Modification and other activities would cumulatively reduce this baseflow contribution.

There are no permanent pools along North Wambo Creek above the Modification longwalls. There are shallow pools that occur after flow and typically dry up within a few weeks due to evaporation and seepage. Therefore, there is considered to be no hyporheic zone above the Modification longwalls.

Photos showing North Wambo Creek above the Modification longwalls are provided in Plates 1 and 2.



Plate 2 – North Wambo Creek in the Vicinity of Longwall 24 (Looking Upstream)

Source: Advisian (2016).

Similarly, downstream of the Modification and North Wambo Creek Diversion, there are “persistent” pools that retain water for extended periods after inflow events but can dry-up in extended dry periods. These pools are not considered to be sustained by significant contributions from groundwater and therefore are not considered to support a significant hyporheic zone.

Issue [Item 11 of the Advice]

The IESC raised concerns regarding potential risks posed by discharges, either planned or unplanned, from the water management system.

The IESC requested water quality data incorporating the full suite of metals and organics on the basis that no geochemical assessment had been provided to inform the selection of a site-specific suite.

Response

The Modification involves an extension of existing mining at Wambo in the Whybrow Seam. The Whybrow Seam has been mined at Wambo since 1976 by underground and open cut mining methods.

In addition, the Modification would not alter:

- the location, timing, design or operation of sediment dams; or
- the location of other surface water storages.

Therefore, the Modification would not materially change the potential risks posed by discharges, either planned or unplanned, from the existing approved water management system.

Notwithstanding, it is noted that a Geochemistry Assessment has been conducted and was presented in Appendix G of the Wambo Development Project Environmental Impact Statement:

<https://peassetstorage.blob.core.windows.net/assets/files/operations/australia/wambo/2016/wambo%20eis%20volume%204.pdf>

Groundwater that accumulates in the underground workings would be pumped to the surface via underground sumps and access drifts, consistent with approved operations at the South Bates Underground Mine. The water management system has been designed to capture and reuse this water on-site, with the only off-site discharge being via the approved Wambo discharge point in accordance with EPL 529 and the HRSTS.

Issue [Item 12 of the Advice]

The IESC requested information on the availability of salinity credits under the HRSTS. The IESC requested further information on how WCPL will manage water on-site in the event that sufficient salinity credits cannot be obtained.

Response

Under the HRSTS, there are 1,000 total active salinity credits, each with a lifespan of 10 years. The expiry of the credits is staged so that 200 credits expire every 2 years. Every 2 years, 200 new credits are created and auctioned to replace those that have just expired (EPA, 2013).

The *Site Water Balance* for the Modification (Appendix L of the EA) assumes that WCPL holds 126 salinity credits by 2025 (i.e. following four credit auctions). This is considered reasonable.

In the event that sufficient salinity credits could not be obtained for a high rainfall scenario, WCPL could implement a number of alternatives, including altering production rates, storing water in the open cut pits and/or treating water prior to release.

Issue [Items 13 and 14a of the Advice]

The IESC requested further information on the water management system, including:

- water storages to be used by the Modification;
- the proposed purpose and management of each water storage;
- discharges and/or overflows from each water storage (including project-specific calculations of discharges); and
- the water quality of the water storages (including project-specific calculations of storage water quality/salt loads).

Response

The Modification would not alter:

- the location, timing, design or operation of sediment dams; or
- the location of other surface water storages.

Figure 3 of the *Site Water Balance* (Appendix L of the EA) shows the water storages to be used by the Modification and where a storage may spill in the event that a storm event occurs that cannot be accommodated within the design criteria, site operating rules and pumping capacity.

The Modification would not materially change off-site release of water, or the location, timing, design or operation of sediment dams. Table 5 in Section 2.1 presents a comparison of the estimated average releases.

HEC (2017) conducted a salt balance for the Modification using salinity values assigned to runoff from each storage catchment as well as to groundwater inflow, tailings bleed water and water sourced from Water Access Licences. The values are presented in Table 6 in Section 2.1.

The predicted salinity of water stored in all simulated water storages was presented by HEC (2017) in Appendix L of the EA, and is reproduced in Figure 1.

Issue [Items 14b and 14c of the Advice]

The IESC requested additional discussion of construction, parameterisation, calibration, limitations and assumptions for the suite of models used in the *Surface Water Assessment*.

The IESC requested further justification for the off-site creek flow data used and information on the location of the creek and similarity to creeks at Wambo.

Response

The Australian Water Balance Model (AWBM) was selected to model the flow regime of North Wambo Creek as it is a well-recognised, standard model developed specifically for assessment of runoff from Australian catchments.

Given the absence of a long-term reliable dataset that would allow direct analysis, the flow regime in North Wambo Creek was characterised by hydrologic modelling using long-term flow data from an analogous catchment (Apple Tree Creek) with comparable geology, landuse and climate.

As described in Section 2.4.1 of Appendix C of the EA, Apple Tree Creek has a comparable catchment area (29 km²) to that of North Wambo Creek (31 km² at FM2) and adjoins the northern and north-western boundary of North Wambo Creek. The headwaters of both catchments rise in the steep forested hills in Wollemi National Park. Longer term flow records collected by DPI Water (formerly NSW Office of Water) are available for Apple Tree Creek for the period June 1984 to February 1998.

Streamflow data was sourced from PINEENA (Version 9.3, 2010). Details of the Apple Tree Creek gauging station are provided in Table 7, and the location of this station is shown on a map here: <http://waterinfo.nsw.gov.au/pinneena/print/210-hunter.pdf>.

Table 7
Details of Apple Tree Creek Gauging Station

Gauging Station Name	Apple Tree Creek
Station Number	210120
Catchment Area (km ²)	29
Latitude	-32.5595
Longitude	150.847
Years of Data	15

The AWBM model parameters adopted for North Wambo Creek are outlined in Table 8.

Table 8
AWBM Parameters Adopted for North Wambo Creek

Parameter	Value
A1	0.2
A2	0.4
A3	0.4
C1	4.5
C2	70.0
C3	300.0
Baseflow Index (BFI)	0.75
Baseflow Recession Parameter (K_{base})	0.58

The modelled streamflow at Apple Tree Creek and North Wambo Creek were compared to flow records. Differences between the recorded and modelled flows are attributable to the fact that there are no rain gauges in the steep hilly, forested area that would more closely represent the actual catchment rainfall than the rainfall data from the nearest long term Bureau of Meteorology rain gauge at Bulga (South Wambo) (Appendix C of the EA).

The site water balance model was developed using the GoldSim® simulation package and was linked to output from the Hunter River IQQM (used by DPI Water). Model assumptions and parameters are outlined in detail in Section 3 of the *Site Water Balance* report (Appendix L of the EA).

3.2 GROUNDWATER

Issue [Item 2 of the Advice]

The IESC requested:

- confirmation that bores within 5 kilometres of Wambo have been evaluated; and
- further information on bores with a predicted maximum cumulative drawdown of more than 2 metres.

Response

All bores registered on the 'Pinneena' (v10.1) database within 5 kilometres of Wambo were considered. Figure 8 of the *Groundwater Assessment* (Appendix B of the EA) shows only the subset of these bores within the extent of the figure, with the full list of bores in the numerical groundwater model provided in Attachment H of Appendix B of the EA

Of the 197 bores listed in the Groundwater Assessment, 117 are monitoring/test/industrial bores and 11 are mine use/dewatering bores.

Attachment 2 provides an update of the list of groundwater bores (and predicted groundwater drawdown) including the details on the bore use registered in the 'Pinneena' database. This updated list demonstrates that the majority of the bores with a predicted maximum cumulative drawdown of more than 2 metres are bores used for monitoring or test purposes (i.e. are not used for groundwater supply).

Issue [Item 3 of the Advice]

The IESC requested further evaluation of groundwater quality data to understand potential impacts associated with:

- leakage of saline or potentially contaminated water from future void lakes (that could potentially be induced through depressurisation from the Modification); and
- leakage of stored water in historic underground workings to the Hunter River, Wollombi Brook or alluvial systems.

Response

The Modification does not change open cut mining operations or the location of final voids.

The numerical groundwater model for the Modification modelled the potential for the Modification to induce leakage from the final voids proposed by the United Wambo Open Cut Coal Mine Project (Section 5.7 of Appendix B of the EA).

Recovery hydrographs in the final voids and emplacement areas showed the groundwater levels had recovered by approximately 50 metres after 200 years. Groundwater levels remained below pre-mining levels and the recovery scenario showed that the final voids would remain groundwater sinks. On this basis there is considered to be negligible risk of leakage of saline or potentially contaminated water from future void lakes that could affect groundwater users, and no further analysis is considered to be required.

Modelling conducted by HydroSimulations also demonstrated no potential for increased flux of more saline water from the Permian strata to the alluvium (and associated surface water resources) for a period of at least 100 years (Appendix B of the EA). On this basis there is considered to be negligible risk and no further analysis is considered to be required.

On the basis of the above, it is considered that further analysis of groundwater quality data is not required to support the Modification. Detailed analysis of groundwater quality has been provided in support of the United Wambo Open Cut Coal Mine Project (Australasian Groundwater and Environmental Consultants Pty Ltd [AGE], 2016).

Issue [Item 4 of the Advice]

The IESC recommended further work to characterise vertical connectivity between Permian strata and alluvial aquifers, particularly:

- monitoring and analysis of data from nested piezometers located within the alluvial and Permian aquifers and comparison of the hydrographs with surface water hydrographs and rainfall;
- monitoring of inflows to mine workings to identify changes in volumes and/or rates; and
- collection and analysis of surface and groundwater quality data and suitable stable isotope or tracer data that could provide independent estimates of vertical mixing over time.

Response

Longwalls 1 to 8a at the North Wambo Underground Mine were extracted under North Wambo Creek between late 2008 and late 2015 at depths of cover between 70 and 120 metres. Longwalls 11 to 13 at the South Bates Underground Mine were extracted under the North Wambo Creek Diversion in 2016 and 2017 at depths of cover between 60 and 85 metres.

Data available from this mining includes:

- monitoring of groundwater levels and EC in alluvial bores above North Wambo Underground Mine;
- monitoring of groundwater pressure within Permian units above and adjacent to North Wambo Underground Mine and South Bates Underground Mine;
- monitoring of inflows to mine workings (with no observed significant changes in volumes and/or rates associated with rainfall and/or extraction under alluvial areas); and
- water quality analysis of surface water in the North Wambo Creek Diversion and water accumulated in mine workings which showed different chemical signatures.

The above data was incorporated into the Groundwater Assessment and considered in drawing assessment conclusions related to the Modification.

In the Modification area, the multi-level piezometer N5 monitors the Permian groundwater systems. N5 is proximal to the shallow piezometers GW16 and GW17, which are monitored for water level and water quality.

Modelling conducted by HydroSimulations adopted a conservative approach to vertical connectivity enhanced by mining, with fracturing to surface assumed over the north-eastern ends of longwall panels.

Issue [Item 5 of the Advice]

The IESC recommended that WCPL commit to regularly reviewing and recalculating groundwater take from the Lower Wollombi Brook Water Source to ensure it remains within licensed limits. The IESC also requested further information on obtaining additional licences should the actual take exceed the predicted take.

Response

Under the *Water Management Act, 2000*, WCPL has an obligation to remain within its licensed water take and to calculate and report groundwater take annually.

The Lower Wollombi Brook Water Source has 41 aquifer access licences with a total share component of 3,720 (DPI Water, 2017). WCPL's licence (70 share components) comprises less than 2% of the total available share component. In the event that future reviews identify the need for further groundwater entitlements, it is anticipated that WCPL could purchase additional entitlements on the open market.

Issue [Item 6 of the Advice]

The IESC requested larger versions of the groundwater drawdown plots provided in the EA.

Response

Larger versions of the groundwater drawdown plots are provided in Attachment 3 of this document.

Issue [Item 7a of the Advice]

The IESC requested sensitivity and uncertainty analysis, as recommended by the *Australian Groundwater Modelling Guidelines* (Barnett *et al.*, 2012). The IESC stated that the *Australian Groundwater Modelling Guidelines* recommend sensitivity analysis of hydraulic parameters, including storativity, hydraulic conductivity and recharge.

Response

Sensitivity analysis conducted on the numerical groundwater model for the Modification was presented in Section 4.9 of the *Groundwater Assessment* (Appendix B of the EA). The peer review by Dr Frans Kalf noted that the sensitivity analysis conducted was sufficiently intensive for key parameters. Substantial sensitivity analysis has been conducted by HydroSimulations for previous applications of this model.

The *Australian Groundwater Modelling Guidelines* (Barnett *et al.*, 2012) are not prescriptive as to which parameters are to be tested for sensitivity. Though aspirational, the *Australian Groundwater Modelling Guidelines* document is mindful that excessive model run times “may also preclude the application of comprehensive sensitivity and uncertainty analyses”.

The results of the numerical groundwater model will continue to be subject to verification with ongoing monitoring data as part of the Annual Review and Extraction Plan processes.

Issue [Item 7b of the Advice]

The IESC requested separate model layers for the alluvium and weathered material/regolith to “improve the representation of changes in saturation of the alluvium over time”.

Response

The numerical modelling package, MODFLOW-USG, allows for a single model ‘layer’ to represent more than one geological unit (or replaced material) where these geological units do not overlap.

Layer 1 of the numerical groundwater model is used for alluvium, regolith and waste rock emplacement areas, as these areas do not overlap.

The alluvium and regolith represented in Layer 1 of the model are separately assigned appropriate (and different) recharge parameters (Figure 20 of Appendix B of the EA), storage parameters (Table 12 of Appendix B of the EA) and hydraulic conductivities (Table 13 of Appendix B of the EA). Separate assessments are conducted for potential impacts on alluvial aquifers and shallow Permian aquifers in Section 5 of Appendix B of the EA. Drawdown presented in Figure 52 of Appendix B of the EA also shows the adopted alluvial extent so that the predicted drawdown in alluvium and regolith can be delineated.

Issue [Item 7c of the Advice]

The IESC requested a peer review of the numerical groundwater model that is specific to the current version and calibration.

Response

The numerical groundwater model was recalibrated, up to August 2015, as part of the assessment of DA 305-7-2003 MOD 12 and EPBC 2016/7636, as was presented in HydroSimulations (2016). This calibration was peer reviewed by Dr Frans Kalf in March 2016. This calibration and peer review was considered by the IESC in August 2016.

No further calibration of the numerical groundwater model was carried out as part of this Modification.

A peer review of the numerical groundwater model and Groundwater Assessment developed in support of this Modification was completed by Dr Frans Kalf. The peer review is presented in Attachment 1 of this document.

Issue [Item 8 of the Advice]

The IESC raised concerns that faults were not adequately characterised or included in the numerical groundwater model. The IESC recommended that future investigations at Wambo should consider analysing potential fault impacts on groundwater flow through a sensitivity analysis.

Response

WCPL has undertaken extensive surface and in-seam drilling and geological mapping to identify and characterise geological structures in the vicinity of Wambo.

HydroSimulations examined the information collected by WCPL and considers that faults and dykes in the immediate vicinity of the Modification longwalls are likely to represent a minor barrier to local groundwater flow but would have imperceptible regional effects. The igneous nature of the dykes means that they would tend to weather to impermeable clays, and the faults are relatively small, normal features that include a number of sealing clay layers. Larger, continuous dykes and faults are only present within the southern and eastern parts of the study area, which are located away from the environmental receptors and proposed mine development areas.

According to the Principle of Parsimony, the simplest conceptualisation of the geology should be favoured in a model. Implementation of a fault that has no observable hydrological effect would be contrary to this Principle.

In the groundwater model, as the geometry of strata in the vicinity of the fault is honoured, there is an implicit assumption of coal seam continuity. HydroSimulations has not assumed that faults act as barriers in the model. This acts conservatively (from the perspective of environmental receptors and water users) to propagate drawdown effects farther than would occur if the fault causes dislocation of the seam.

Issue [Item 30 of the Advice]

The IESC recommended that WCPL commit to:

1. regularly validate the groundwater model predictions;
2. undertake a thorough review of the groundwater model given it has been revised over a number of years to accommodate multiple modifications to mining at Wambo;
3. regularly update the groundwater model as recommended by the *Australian Groundwater Modelling Guidelines* (Barnett *et al.*, 2012); and
4. clearly define the level of variance between groundwater observations and model predictions that will trigger a review of the groundwater model.

Response

In relation to recommendation 1 above, WCPL undertakes a comprehensive review of groundwater monitoring results annually against the groundwater model predictions in the Annual Review (Condition 5, Schedule 6 of the Development Consent DA 305-7-2003).

In addition, as part of each Extraction Plan application, WCPL is required to present a revised assessment of potential impacts and environmental consequences incorporating relevant monitoring data obtained since the approval (Condition 22D, Schedule 4 of the Development Consent DA 305-7-2003).

In relation to recommendation 2 above, the numerical groundwater model was peer reviewed as part of this Modification. The number of recent revisions is not considered justification for additional review and is consistent with recommendation 3.

In relation to recommendation 4 above, the trigger values in the *Groundwater Monitoring Program* (GWMP) are designed to provide guidance on when a review of the groundwater model may be required. Any unexpected and/or unexplained trends identified during the Annual Review would also trigger a review of monitoring data and, where necessary, the groundwater model.

3.3 GROUNDWATER DEPENDENT ECOSYSTEMS

Issue [Item 15a.i of the Advice]

The IESC raised concerns with the dataset and observations (i.e. temporal and spatial extent) used to generate the depth to watertable maps presented in the Groundwater Assessment.

Response

The watertable maps were developed from the numerical groundwater model, which has been peer reviewed.

The numerical groundwater model incorporates topographic and geological information, and was transiently calibrated using reported observed groundwater drawdown/depressurisation at 86 groundwater monitoring sites during the period January 2003 to December 2014 (13,056 individual target points) with reference to site-specific hydraulic property data (HydroSimulations, 2016).

The overall mass balance at the end of the calibration period was excellent, with 0.0% error, and less than 0.1% error recorded for each individual time step. The weighted absolute Root Mean Square (RMS) value of 8.8 m and a Scaled RMS (SRMS) value of 3.9 % which is well below the target SRMS (10%) suggested in the Murray-Darling Basin Commission Groundwater Flow Modelling Guideline.

Based on the above, use of the Wambo numerical groundwater model is considered a reasonable and robust method to estimate the depth of the watertable.

Issue [Items 15a.ii and 15c of the Advice]

The IESC commented that the identification of potentially groundwater dependent vegetation did not give adequate consideration to vegetation that may periodically or opportunistically utilise groundwater such as the Central Hunter Valley Eucalypt Forest and Woodland and riparian vegetation. The IESC considered that the depth to watertable maps indicate that the Modification may prevent riparian vegetation from utilising groundwater.

Response

'Groundwater' is defined as the water beneath the earth's surface that has filtered down to the zone where the earth or rocks are fully saturated (NSW Department of Land and Water Conservation [DLWC], 2002). GDEs are taken to be ecosystems which have their species composition and their natural ecological processes determined by groundwater (DLWC, 2002).

'Groundwater' is differentiated from water bound in the soil matrix in the unsaturated zone above the watertable. The unsaturated zone is tapped by the roots of vegetation and a large proportion of the water which infiltrates into this zone is transferred back to the atmosphere by evaporation from the catchment surface and transpiration from stomata on the leaves of vegetation.

Soil moisture in the unsaturated zone is controlled by rainfall infiltration and is not influenced by the depth of the watertable or any drawdown influence on the watertable (e.g. due to mining).

Eamus *et al.* (2006) found that:

The greater the depth to groundwater, the lower the requirement for groundwater and the more tolerant the vegetation to water-table decline, owing to the corresponding increase in alternative water sources. These alternative sources are primarily the larger volume of unsaturated zone (with increasing depth) exploitable by the plant's root system.

Eamus *et al.* (2006) also noted that poor-quality groundwater (high in salt or heavy metals, for example) is less supportive of vegetation.

The groundwater in areas of Central Hunter Valley Eucalypt Forest and Woodland is deep (greater than 20 metres). As an example, monitoring site GW21 located adjacent to the Modification longwalls and within the Central Hunter Valley Eucalypt Forest and Woodland was drilled to a depth of over 35 metres prior to reaching the watertable.

Considering the above, it is improbable that Central Hunter Valley Eucalypt Forest and Woodland could access groundwater at these depths, or would rely on this water in preference to the extensive volume of unsaturated zone that would be exploited by the root systems. The Modification would not affect the ability of the Central Hunter Valley Eucalypt Forest and Woodland to continue to access water (soil moisture) in the unsaturated zone.

In consideration of the risks to riparian vegetation associated with groundwater drawdown, the following is noted:

- Riparian vegetation is mapped above the Modification longwalls in areas where the watertable is estimated to be between approximately 3 metres and over 10 metres below ground level.
- Salinity in the shallow groundwater system in the area has been observed to be highly variable, with one nearby shallow bore having EC less than 1,000 $\mu\text{S}/\text{cm}$ and another shallow bore having EC over 5,000 $\mu\text{S}/\text{cm}$.
- Dr David McKenzie (Appendix H of the EA) found that the soils along North Wambo Creek had very good water holding capacity because of a combination of minimal coarse fragments and favourable soil structure. This increases the likelihood that the vegetation is relying on soil moisture in the unsaturated zone (as opposed to groundwater).
- A study by Toky and Bisht (1992) found that Forest Red Gums (*Eucalyptus tereticornis*) (the dominant species in the riparian zone and distinctly different to River Red Gums [*Eucalyptus camaldulensis*]) had a rooting depth of 1.7 metres $\pm$ 0.16 with lateral root spread of over 4 metres (noting that rooting depth is also influenced by site conditions and climate, as well as the species).
- Dr Bower, an experienced botanist, observed that the vegetation composition and health of the riparian vegetation did not vary between areas of more shallow and deeper groundwater (Appendix D of the EA).
- The riparian vegetation is in a disturbed and fragmented condition, which reduces its biodiversity value.
- Significant monitoring programs have been undertaken at Wambo in areas of undermined vegetation. No observable effects to vegetation health due to reduced access to groundwater have been recorded at Wambo.
- In consideration of the above, it is likely that the riparian vegetation primarily depends on ephemeral surface flows and water within the unsaturated zone, and not groundwater.

Notwithstanding the above, in the event that the riparian vegetation was affected by groundwater drawdown, WCPL would be required to remediate or offset the impact to this NSW listed endangered ecological community in accordance with Condition 22, Schedule 4 of the Development Consent DA 305-7-2003.

Issue [Items 39 and 41 of the Advice]

The IESC requested:

- monitoring to quantify the condition and species composition of riparian vegetation along North Wambo Creek;
- monitoring focussed on areas where there may be potential impacts of subsidence and ponding on the Central Hunter Valley Eucalypt Forest and Woodland; and
- monitoring and development of appropriate mitigation plans for impacts to GDEs.

Response

As described above, it is considered that the vegetation above the Modification longwalls primarily depends on water within the unsaturated zone (i.e. soil moisture) and ephemeral surface flows.

The existing condition and species composition of riparian vegetation along North Wambo Creek and other vegetation above the Modification longwalls is characterised in the *Flora Assessment* (Appendix D of the EA).

A Biodiversity Management Plan would be prepared under Condition 22C, Schedule 4 of the Development Consent (DA 305-7-2003) prior to extraction of the Modification longwalls. The Biodiversity Management Plan would be required to:

- outline a monitoring program to assess whether WCPL is complying with the subsidence impact performance measures (which include ‘negligible environmental consequences’ to the Central Hunter Valley Eucalypt Forest and Woodland and riparian vegetation along North Wambo Creek); and
- describe the measures that would be implemented to ensure compliance with the subsidence impact performance measures, and manage or remediate any impacts and/or environmental consequences.

Issue [Items 15b and 40 of the Advice]

The IESC requested consideration of stygofauna.

The IESC recommended monitoring for stygofauna at “multiple reference sites upstream” and in alluvial aquifers where no drawdown is predicted.

Response

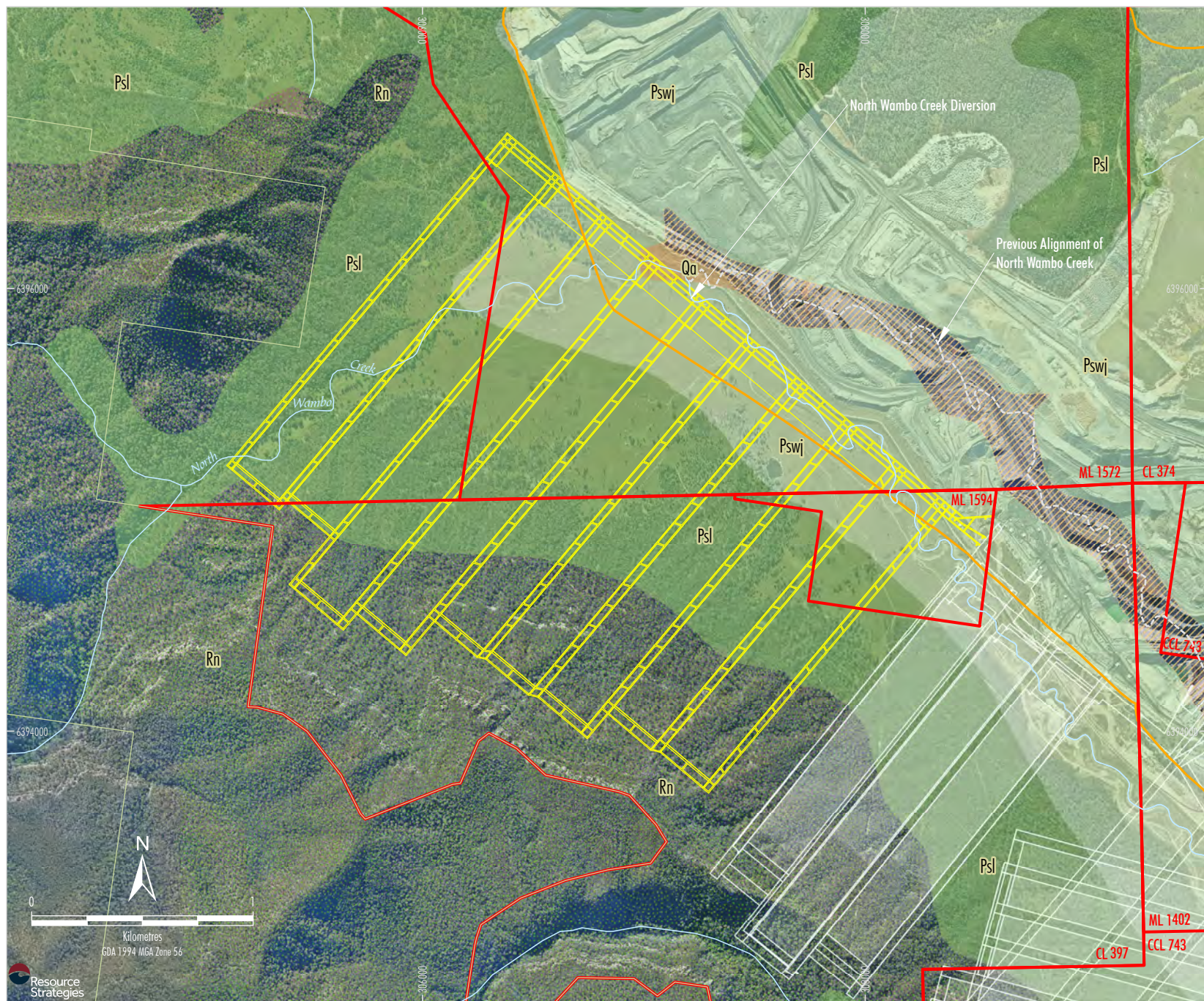
The shallow alluvial system located above the Modification longwalls is already in a highly modified state.

The alluvium above the Modification longwalls was once connected as part of a larger alluvial system associated with Wollombi Brook and its tributaries. The approved and existing Wambo open cut now forms an artificial barrier for any stygofauna present above the Modification longwalls (Figures 3a and 3b).

Given the alluvial system is now highly modified and fragmented, further assessment of stygofauna is not considered warranted.

There is no alluvium upstream of the Modification longwalls, and therefore there is not considered to be suitable stygofauna habitat for sampling or monitoring.

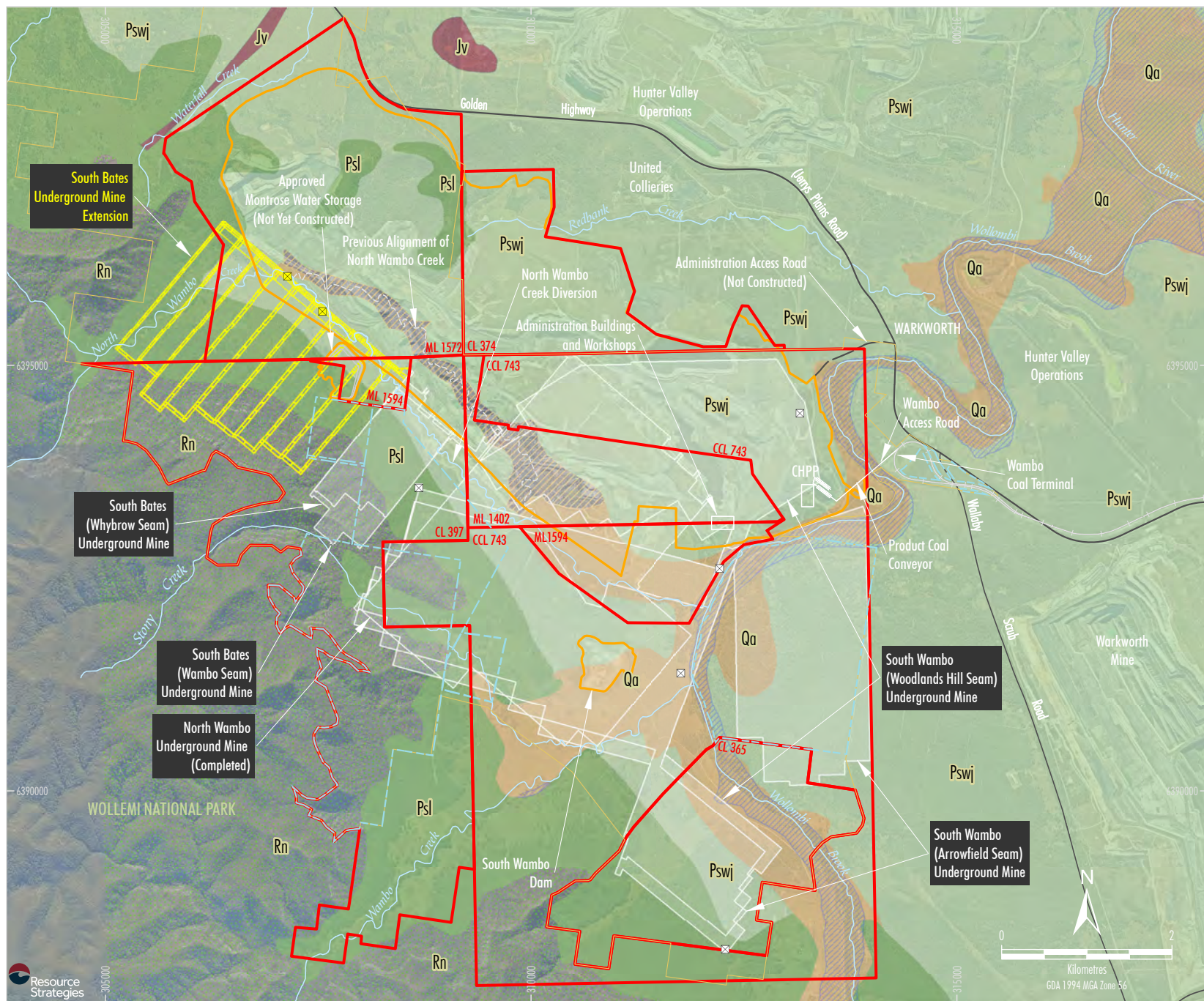
Numerous stygofauna studies have been conducted in alluvial aquifers surrounding Wambo (AGE, 2016; Hancock, 2004; Hancock and Boulton, 2009) and further studies are not proposed.



- LEGEND**
- Mining and Coal Lease Boundary
 - National Park Boundary
 - Existing/Approved Surface Development Area
 - Approved Underground Development
 - Modified Underground Development
- Quaternary**
- Qa Silt, Sand, Gravel
 - Removed by Open Cut Operations
- Triassic**
- Rn Widden Brook Conglomerate - Conglomerate and Sandstone
- Late Permian**
- Psl Newcastle Coal Measures - Coal Seams, Claystone (tuffaceous), Siltstone, Sandstone, Conglomerate
 - Pswj Wittingham Coal Measures - Coal Seams, Claystone, Tuff, Siltstone, Sandstone, Conglomerate
- Source: Department of Lands (July 2009); WCPL (2016); WCPL Orthophoto (July 2016); Glen and Beckett (1993)

Peabody
WAMBO COAL MINE
Regional Geology Mapping
in the Modification Area

Figure 3a



Peabody
WAMBO COAL MINE
Regional Geology Mapping
in the Wambo Area

Figure 3b

Issue [Item 15d of the Advice]

The IESC recommended further consideration of the potential for impacts on habitat availability for aquatic biota, instream organic matter processing rates, water supplies for riparian zone vegetation and other biota, changes to sediment regimes and changes to the persistence and geomorphology of pools along the current channel.

Response

The *Surface Water Assessment* (Appendix C of the EA) included an assessment of:

- potential changes in flow regime in North Wambo Creek (i.e. habitat availability and water supplies for vegetation) (Sections 3.4 and 5.4);
- changes to sediment regimes (Sections 3.1.2.6, 3.2.2.4 and 3.3.1.4); and
- changes to the persistence and geomorphology of pools (Sections 3.1.2, 3.2.2 and 3.4.1).

North Wambo Creek is an ephemeral creek, with surface water flow only occurring during, and for short periods of time after, rainfall events.

There are no permanent pools along North Wambo Creek above the Modification longwalls. There are shallow pools that occur after flow and typically dry up within a few weeks due to evaporation and seepage.

Advisian (Appendix C of the EA) concluded that any effect of the reduction in total flow would not be detectable from current variation in the flow regime. Advisian (Appendix C of the EA) also concluded there is not expected to be any measurable change in the range of total suspended solids concentrations downstream of the Modification once any scour protection works have been implemented.

Therefore, there is not expected to be significant impacts on habitat availability for aquatic biota, instream organic matter processing rates or water supplies for riparian zone vegetation and other biota.

3.4 SUBSIDENCE

Issue [Item 16 of the Advice]

In relation to the Subsidence Assessment, the IESC requested:

- presentation and discussion on site-specific subsidence data for single-seam operations;
- discussion of the potential for interactions between underground and open cut operations to affect subsidence predictions; and
- data and information relating to the successful use of proposed management strategies.

Response

The Incremental Profile Method is a broadly accepted and generally conservative subsidence prediction technique that was informed by extensive empirical data, including data from the Hunter Coalfields, and Wambo in particular.

The Subsidence Assessment presents site-specific single-seam subsidence monitoring data and compares this data against predictions using the Incremental Profile Method (Section 3.2 of Appendix A of the EA) for the following previous longwalls at Wambo:

- cross-line 7XL-Line across Longwall 11 in the Whybrow Seam at the current South Bates Underground Mine (located immediately adjacent to the Modification longwalls, in the same seam and with similar geometry);
- centreline CL11B-Line along Longwall 11 in the Whybrow Seam at the current South Bates Underground Mine (located immediately adjacent to the Modification longwalls, in the same seam and with similar geometry); and
- cross-line XL3-Line across Longwalls 1 to 6 in the Wambo Seam at the completed North Wambo Underground Mine (with similar geometry).

The Subsidence Assessment concluded that the standard Incremental Profile Method for the Hunter Coalfield provided acceptable predictions of subsidence, tilt and curvature for the above seven longwalls at Wambo.

Measured subsidence profiles for this site-specific single-seam subsidence monitoring data and the profiles as predicted by the Incremental Profile Method are presented in Figures 3.1 to 3.3 of the *Subsidence Assessment* (Appendix A of the EA).

As shown on Drawing MSEC848-02 of the *Subsidence Assessment* (Appendix A of the EA), the angle of draw from the Modification longwalls is located well outside the extent of open cut mining operations. The open cut is not expected to materially affect subsidence movements from the Modification longwalls.

The existing South Bates Underground Mine extracted longwalls at a similar distance to the open cut. The measured subsidence movements from Longwall 11 in the vicinity of the open cut are presented in Figure 3.2 of the *Subsidence Assessment* (Appendix A of the EA).

A geotechnical assessment of the open cut highwall will be conducted to confirm that any far-field movements from the longwalls can be accommodated.

Information on the implementation and success of the wide range of management measures implemented at Wambo is presented in Annual Reviews available on WCPL's website.

Issue [Items 42 and 43 of the Advice]

The IESC stated that the subsidence management plan was not publicly available on WCPL's website.

The IESC made a number of recommendations regarding the subsidence management plan.

Response

Under the current conditions of the Development Consent (DA 305-7-2003), WCPL is required to prepare "Extraction Plans" rather than "subsidence management plans". The Extraction Plans outline the measures to manage subsidence for a set of longwall panels.

Approved Extraction Plans are available on WCPL's website within the management plan section: <https://www.peabodyenergy.com/Operations/Australia-Mining/New-South-Wales-Mining/Wambo-Approvals,-Plans-Reports>.

The approved Extraction Plan addresses the recommendations of the IESC in Items 43a to 43e.

In relation to the approved Montrose Water Storage Dam, WCPL will construct the Montrose Water Storage Dam giving consideration to the subsided land surface and in accordance with its approved design criteria.

3.5 MODIFICATION JUSTIFICATION, MANAGEMENT MEASURES AND MONITORING

Issue [Items 23 and 24 of the Advice]

The IESC requested information on evaluation of options to alter panel length, width or extraction height to avoid, mitigate or reduce potential impacts on water resources. The IESC recommended that data from "early longwall panels" be analysed and used to inform possible changes to the mine layout and panel dimensions.

Response

A justification for the Modification, including consideration of alternatives was presented in Section 6.2 of the EA.

The layout and extent of the Modification layout was identified by:

- the presence of coal seams able to be economically mined in the vicinity of Wambo, including consideration of recent geological knowledge of the area;
- the ability to achieve WCPL's existing subsidence impact performance measures for significant natural and built features (in particular the Wollemi National Park escarpment);
- the presence of geological constraints;
- the constraints of the nearby open cut mining areas; and
- mining and exploration tenements held by WCPL;

The width of longwall extraction proposed (261 metre void width²) was based on the economic use of existing longwall mining equipment used by WCPL. The extraction height (between 2.8 and 3.0 metres) is also somewhat constrained by the cutting height of the existing longwall mining equipment.

The longwalls beneath North Wambo Creek are ‘supercritical’ in width, which means that small changes to the longwall width do not affect the maximum subsidence. For example, at a depth of cover of 100 metres, the longwall void width would need to be reduced from 261 metres to less than 140 metres to achieve any reduction in surface subsidence.

As described above, the Subsidence Assessment reviewed the subsidence monitoring data for seven previous longwalls at Wambo in single-seam conditions and concluded that the standard Incremental Profile Method for the Hunter Coalfield provided acceptable predictions of subsidence, tilt and curvature.

It is noted that the Modification is an extension to the existing South Bates Underground Mine, which has extracted three longwalls in the same seam, with similar geometry. The subsidence data from the first of these longwalls was presented in the *Subsidence Assessment* (Appendix A of the EA). The measured subsidence data at the existing South Bates Underground Mine has demonstrated that the subsidence prediction methodology is appropriate.

WCPL implements an adaptive management approach through its Extraction Plan process. In the event that anomalous subsidence was recorded this would be reported to the DP&E and appropriate contingency actions implemented.

Issue [Item 25 of the Advice]

The IESC recommended that the risk assessment include consideration of the failure of mitigation and/or management and identify contingencies.

Response

Trigger Action Response Plans (TARPs) and contingency measures for the Modification would be implemented in a similar manner as outlined in the Extraction Plan for the existing South Bates Underground Mine (available on WCPL’s website).

As outlined in the Water Management Plan and Biodiversity Management Plan components of the current approved Extraction Plan, relevant management and contingency measures could include:

- Implementation of streamflow loss remediation techniques (e.g. injection grouting or installation of a geomembrane).
- Provision of water offsets (i.e. retirement of an equivalent volume of water licence).
- Provision of biodiversity offsets in accordance with Condition 22, Schedule 4 of the Development Consent (DA 305-7-2003).
- Implementation of erosion and sediment control measures and stabilisation techniques.
- Re-grading of isolated depressions or highpoints and revegetation.
- Re-grading of slopes to minimise the potential for erosion.
- Remediation of creek beds to minimise bank and headwater erosion.

² The width of the longwall extraction face is 250 metres.

- Additional monitoring (e.g. increase in monitoring frequency).
- Consideration of changes to longwall extraction geometry in consultation with relevant regulatory authorities.

Issue [Item 27 of the Advice]

The IESC recommended additional groundwater monitoring sites are installed to the north, north-west, west, south-west and south of the Modification area.

Response

Additional groundwater monitoring bores have been and are being installed to the north and north-west of the Modification area as shown on Figure 4.

There are no groundwater users (environmental or third party users) to the south-west and south of the Modification area, and therefore no additional groundwater monitoring to the south-west and south is proposed.

Issue [Item 28 of the Advice]

The IESC recommended that the groundwater quality monitoring program is expanded.

Response

The existing GWMP approved under Condition 34, Schedule 4 of the Development Consent (DA 305-7-2003) will be reviewed within 3 months of the approval of the Modification (if approved) under Condition 6, Schedule 6 of the Development Consent (DA 305-7-2003).

This will include consideration of the IESC's recommendation.

Issue [Item 29 of the Advice]

The IESC recommended review of the groundwater trigger values and the TARPs in the *Surface and Groundwater Response Plan*.

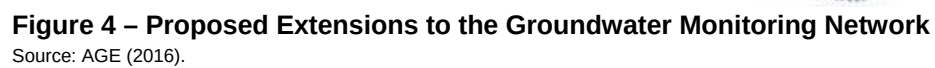
Response

The existing *Surface and Groundwater Response Plan* approved under Condition 35, Schedule 4 of the Development Consent (DA 305-7-2003) will be reviewed within 3 months of the approval of the Modification (if approved) under Condition 6, Schedule 6 of the Development Consent (DA 305-7-2003).

This will include consideration of the IESC's recommendations.

It is noted that mining first commenced in the Wambo area in 1969. Therefore, while the use "pre-impact" data to characterise baseline conditions is ideal, it is not feasible at Wambo.

As described in the GWMP, although ANZECC and ARMCANZ (2000) recommend 80th percentile values as being suitable for trigger values, a trigger would be initiated 20% of the time due to natural causes. Therefore for the trigger to be a meaningful indicator of a possible mining effect, an investigation is triggered when the 90th percentile value is exceeded on two or three consecutive monitoring events.



Issue [Items 32 to 35 of the Advice]

The IESC recommended that:

- the surface water quality monitoring program is expanded;
- the surface water monitoring program include additional sites upstream and downstream of the Modification area;
- establishment of reference sites; and
- review of surface water quality triggers and TARPs.

Response

The existing SWMP approved under Condition 33, Schedule 4 of the Development Consent (DA 305-7-2003) will be reviewed within 3 months of the approval of the Modification (if approved) under Condition 6, Schedule 6 of the Development Consent (DA 305-7-2003).

This will include consideration of the IESC's recommendation.

Issue [Items 36 and 37 of the Advice]

The IESC recommended that:

- the water management plan is revised to include an up-to-date version of the water management schematic; and
- in addition to reviewing the water balance annually, WCPL should commit to updating any other models that underpin the predictions of the water balance model.

Response

The existing *Site Water Balance* component of the *Water Management Plan* approved under Condition 30, Schedule 4 of the Development Consent (DA 305-7-2003) will be reviewed within 3 months of the approval of the Modification (if approved) under Condition 6, Schedule 6 of the Development Consent (DA 305-7-2003).

Future revisions of the *Site Water Balance* would include revision of the water management schematic to represent water management on-site at that time.

In accordance with Condition 25, Schedule 4 of the Development Consent (DA 305-7-2003), WCPL reviews the site water balance for Wambo annually and reports the results of this review in the Annual Review. Updates to the underlying model would occur in the event that the annual water balance reviews identified this was warranted.

3.6 CUMULATIVE IMPACTS

Issue [Item 17 of the Advice]

The IESC requested further information on the source model(s) that were used to derive the cumulative drawdown figures in the *Groundwater Assessment* (Figures 52 to 57 of Appendix B of the EA).

Response

The cumulative drawdown figures were generated from the numerical groundwater model described in Sections 3 and 4 of the *Groundwater Assessment* and shown on Figure 18 of the *Groundwater Assessment* (Appendix B of the EA).

A summary of the mine workings included in the model, including timing, is presented in Table 10 of the *Groundwater Assessment* (Appendix B of the EA).

Issue [Item 18 of the Advice]

The IESC requested further information on the cumulative effects of indirect impacts on vegetation from subsidence and groundwater drawdown.

Response

Approved areas of mining at Wambo under DA 305-7-2003 include the following:

- Approximately 500 hectares of vegetation within the angle of draw of the longwalls associated with the North Wambo Underground Mine (extraction completed in late 2015).
- Approximately 200 hectares of vegetation within the angle of draw of the longwalls associated with the approved South Bates Underground Mine (extraction underway).
- Approximately 300 hectares of additional vegetation within the angle of draw of the longwalls associated with the approved South Wambo Underground Mine (extraction not yet commenced).

Annual flora and fauna monitoring of subsidence areas at Wambo has occurred since 2006, including floristic monitoring, bird surveys and riparian monitoring.

No observable effects to vegetation health due to reduced access to groundwater have been recorded at Wambo.

Subsidence cracking within woodland areas has been observed (Plate 3), although no evidence of it affecting vegetation health has been observed in over 10 years of monitoring.



Plate 3 – Soil Cracking Observed at Wambo

Source: FloraSearch (2017).

Issue [Item 19 of the Advice]

The IESC stated that cumulative drawdown will propagate into the Wollemi National Park and requested an assessment of the hydrological impacts of this drawdown.

Response

The Wollemi National Park is formed on Narrabeen Group Sandstone that unconformably overlies the Permian coal measures and forms the prominent escarpment on elevated areas to the south-west of Wambo.

The Groundwater Assessment predicts that some depressurisation of the Permian groundwater systems will extend beyond the boundary of the National Park.

Given the depth to groundwater within the Wollemi National Park (greater than 100 metres) and the minor drawdown predicted (less than 2 metres), no significant hydrological impacts are anticipated.

Issue [Item 20 of the Advice]

The IESC requested assessment of cumulative impacts to stream and riparian biota in Wollombi Brook and North Wambo Creek (as a result of changes in water quality and streamflow).

Response

Water quality, streamflow and stream and riparian biota in North Wambo Creek have been affected by:

- historic clearing and grazing associated with agricultural activities;
- reduction in catchment area as a result of open cut mining activities that have been occurring in the Wambo area since 1969;

- the approved diversion of North Wambo Creek around open cut mining activities; and
- underground mining activities within the catchment since 1969.

An assessment of the stream and riparian biota in North Wambo Creek in 2003 (Resource Strategies, 2003) made the following observations:

North Wambo Creek is an intermittent stream. At the time of sampling, North Wambo Creek was characterised by a flowing pool-riffle or pool-run sequence near the confluence with Wollombi Brook; a series of isolated pools in the middle reaches and a dry channel in the upper reaches.

...

North Wambo Creek has been highly disturbed by historic and present grazing activities. The adjacent land use along North Wambo Creek consists of pasture for cattle grazing. Stock access has led to areas of bank destabilisation and erosion, trampling of riparian and aquatic vegetation and the introduction of cattle wastes into flowing and standing water bodies. These impacts were particularly evident around larger water bodies such as the large pool at site NW7 (Figure HD-3). They were however also evident at smaller pools such as those found in the middle reaches of North Wambo Creek. The impacts of cattle were noticeably absent near the confluence of North Wambo Creek with Wollombi Brook due to fencing, steep slopes and lack of pasture.

...

The SIGNAL A values for North Wambo Creek sites ranged from 4.6 to 5.6 and from 4.5 to 5.5 for Wambo Creek sites. The individual values suggest the water quality at these sites is “possibly mildly polluted” to “probably moderately polluted” (Chessman, 1995; Chessman et. al., 1997). The SIGNAL A values calculated for the pooled stream data (i.e. stream value) for North Wambo Creek and Wambo Creek were 5.4 and 5.3, respectively. The water quality results for North Wambo Creek and Wambo Creek indicate both streams had similar water quality characteristics at the time of sampling and support the SIGNAL A assessment (refer Section HD4.4).

A more recent assessment of North Wambo Creek and the North Wambo Creek Diversion concluded the following (Niche, 2016):

The ephemeral nature of this stream (i.e. the natural variation in flow) is the controlling factor determining the invertebrates found at this location, however sedimentation from previous land use and input from the stream diversion, is likely to exert some influence on community composition. North Wambo sites below the diversion scored in Band B and C, while within the diversion Site 1 Stage 2 and Site 12 (Stage 3) scored in Band D. Considering the catchment condition, it is reasonable to expect a stream health below reference quality (particularly within the stream diversion), with realistic long term expectations of aquatic health likely to be aligned with Band B.

The communities present particularly within the diversion consisted predominately of adult Hemiptera, Coleopterans, and Dipteran larvae. Poor stream health is expected for a recently established drainage channel, however it is encouraging that water is being retained and providing some habitat for pioneering invertebrates. It is expected that recovery of stream health will be a slow process and take a minimum of ten years to recover to a level comparable to pre- realignment condition.

Subsidence associated with the Modification may result in temporary changes in surface flow and water quality prior to remediation activities. There is not expected to be significant additional impacts on habitat availability for aquatic biota or water supplies for riparian zone vegetation and other biota with the implementation of the proposed remediation measures.

North Wambo Creek is an ephemeral stream, and therefore surface water flows in this creek do not materially contribute to baseflows in Wollombi Brook. Advisian’s analysis indicates flows in excess of 10 ML/day (0.1 m³/s) can be expected on only 50 days/year (14% of days), whereas, Wollombi Brook is generally considered a semi-perennial stream (with flow on over 80% of days). The pre-mining catchment of North Wambo Creek represented less than 3% of the total catchment of Wollombi Brook.

Cumulative impacts on streamflow and water quality in Wollombi Brook are mitigated through the following:

- licensing of water take in accordance with the NSW *Water Management Act, 2000*;
- discharge of mine water only in accordance with EPL 529 and the HRSTS; and
- remediation of subsidence impacts on contributing catchments in accordance with approved Extraction Plans.

Recent monitoring by Niche (2016) made the following conclusion regarding Wollombi Brook:

Wollombi Brook stream health is variable between sites and within sites through time. Overall Wollombi Brook shows signs of impairment (i.e. not close to reference condition) scoring in either Band B or Band C. These results are expected considering the historical long term agricultural land use impacts to its catchment. Wambo Coal is unlikely the source of this streams condition particularly since upstream site, Site 7, shows similar impaired AUSRIVAS scores.

Issue [Item 21 of the Advice]

The IESC requested further discussion regarding change to the overall water balance both locally and regionally, including recharge changes, reduction in regional groundwater flow and streamflow reductions.

Response

Water balance changes due to the extension compared with what has been approved are reported in Section 4.4 and quantified in Table 15 of the *Groundwater Assessment* (Appendix B of the EA). The separate water balance components are regional averages but the differences are due to the local effects of the Modification and additional open cut mining during the period of the extension. In the numerical groundwater model, rainfall recharge changes are applied only in areas of open cut operations.

Sections 5.2 and 5.3 of the *Groundwater Assessment* (Appendix B of the EA) discuss pre-mining regional groundwater flow directions and local changes during mining that can be inferred from the drawdown maps in Figures 52 to 57, where groundwater is seen to be drawn towards the temporary sinks created by mining. The specific effects of the Modification relative to what has been approved are quantified in Figures 58 to 63. Changes in regional flow directions are evident in the water level contour maps in Figures 26 to 27 at the level of the Whybrow Seam, the subject of the Modification, which show capture by the mine. Figures 66 to 69, which show equilibrium water levels after 200 years, indicate that regional groundwater flow is interrupted by the residual effects of open cut operations.

Groundwater modelling suggests very minor stream flow reductions due to the Modification (in excess of what has been approved) due to baseflow capture at North Wambo Creek and increased leakage from Wollombi Brook (Figures 38 to 41 and Section 4.7 of Appendix B of the EA). The maximum effect of about 0.2 litres per second would be inconsequential to natural stream flow.

4 RESPONSES TO NON-GOVERNMENT ORGANISATIONS

Responses to issues raised by NGOs related to surface water and groundwater are provided below.

Previous Impacts to Wambo Creek

Issue

Groundswell Gloucester Inc., HCN, the Lock the Gate Alliance, NCC and Rivers SOS raised concern regarding previous subsidence impacts on Wambo Creek, and WCPL's obligation to repair the creek under the conditions of Singleton Shire Council Development Consent DA 108/91.

Response

It is noted that remediation of previous impacts on Wambo Creek is subject to the conditions of a separate consent (DA 108/91), which is not the subject of this Modification.

The Modification would not involve additional subsidence impacts on Wambo Creek which is located more than 4 kilometres (km) from the Modification longwalls.

Any remediation required on Wambo-owned land as a result of the Modification would be undertaken in accordance with the Extraction Plan to be developed for the Modification.

The existing SWMP, *Erosion and Sediment Control Plan* and *Surface and Groundwater Response Plan* would continue to be implemented for the Modification (with any appropriate revisions or amendments). These plans would include measures to monitor and manage potential subsidence impacts on watercourses, including longitudinal geomorphological surveys and TARPs (with a process to determine triggers and appropriate remedial actions for changes in grade and associated erosion, flow diversion, pool development and surface cracking).

Potential Surface Water Impacts on Watercourses

Issue

Groundswell Gloucester Inc., HCN, HEL, Lock the Gate Alliance and the NCC raised concerns regarding existing and potential impacts to North Wambo Creek and associated alluvial aquifers.

Response

It is accepted that immediately downstream of the natural section of North Wambo Creek above the Modification longwalls, North Wambo Creek has been diverted (i.e. redesigned) around the approved Wambo open cut operations. This included removal of alluvium across the full width of the channel with consequent desaturation of the adjacent upstream and downstream alluvium. This impact was assessed as part of the Wambo Development Project, is approved and has occurred.

The Modification would have negligible impact on stream baseflow and long-term water quality of North Wambo Creek, beyond the effects of the approved mine layout.

North Wambo Creek is not associated with highly productive groundwater identified by DPI Water.

There is no privately-owned land on North Wambo Creek and there are no Water Access Licences or extraction points or bores along North Wambo Creek that are used for domestic or stock use (i.e. surface water and the alluvial groundwater along North Wambo Creek are not used for water supply).

Wambo Creek and Wollombi Brook Catchment

Issue

The NCC raised concerns regarding the existing and future cumulative impacts on groundwater systems in the Wambo Creek and Wollombi Brook catchments.

Response

It should be noted that the Modification is not located within the Wambo Creek catchment and would not involve additional subsidence impacts on Wambo Creek which is located more than 4 km from the Modification longwalls.

The *Surface Water Assessment* (Advisian, 2016) concluded that the Modification would not have a significant impact on the quality of surface water around Wambo.

The *Groundwater Assessment* (HydroSimulations, 2017) concluded that there would be negligible additional drawdown along the highly productive Wollombi Brook or Hunter River alluvium as a result of the Modification. The Modification would have no discernible or negligible impact on stream baseflow or natural river leakage for Wollombi Brook or Wambo Creek, beyond the effects of the approved mine layout.

Consistent with the currently approved *Surface and Groundwater Response Plan*, in the event that a groundwater quality or trigger level specified in the GWMP or a surface water quality or trigger level specified in the SWMP is exceeded, an investigation would be conducted in accordance with the *Surface and Groundwater Response Plan*.

5 RESPONSES TO PUBLIC SUBMISSIONS

Responses to comments and issues raised by members of the public related to surface water and groundwater are addressed in Table 9. A reconciliation of which issues were raised in each submission is provided in Table 3.

Responses to other comments and issues not related to surface water and groundwater were provided in a previous document (Part A of the Response to Submissions).

Table 9
Responses to Public Submissions

Issue ID No.	Subject	Issues Raised	Response
4	Surface Water	Concerns were raised regarding previous subsidence impacts on Wambo Creek, and WCPL's obligation to repair Wambo Creek under the conditions of Singleton Shire Council Development Consent DA 108/91.	It is noted that remediation of previous impacts on Wambo Creek is subject to the conditions of a separate consent (DA 108/91), which is not the subject of this Modification. The Modification would not involve additional subsidence impacts on Wambo Creek which is located more than 4 km from the Modification longwalls. Any remediation required on Wambo-owned land as a result of the Modification would be undertaken in accordance with the Extraction Plan to be developed for the Modification. The Extraction Plan requires the approval of DP&E and is prepared in consultation with the DPI Water. The existing SWMP, <i>Erosion and Sediment Control Plan</i> and <i>Surface and Groundwater Response Plan</i> would continue to be implemented for the Modification. Further detail is provided in Section 3.1.
5	Surface Water	Concerns were raised regarding historical and present monitoring of flow in Wambo Creek.	WCPL progressively installed nine continuous recording flow gauging stations along North Wambo Creek, Stony Creek and Wambo Creek between 2008 and 2009. These include three locations along Wambo Creek (FM5, FM6 and FM9) and two locations along Stony Creek (FM7 and FM8). Damage has occurred to some of these gauging stations. WCPL undertook a review of its flow gauging stations in 2015. As a result, new gauging stations have been installed on Stony Creek (and one of its tributaries) and on Wambo Creek (WCPL, 2017b).
6	Groundwater	Concerns were raised regarding impacts on the water resources of the Wambo Creek, Wollombi Brook and the Hunter River catchments.	It should be noted that the Modification is not located within the Wambo Creek catchment and would not involve additional subsidence impacts on Wambo Creek which is located more than 4 km from the Modification longwalls. The <i>Surface Water Assessment</i> (Advisian, 2016) concluded that the Modification would not have a significant impact on the quality of surface water around Wambo. The <i>Groundwater Assessment</i> (HydroSimulations, 2017) concluded that there would be negligible additional drawdown along the highly productive Wollombi Brook or Hunter River alluvium as a result of the Modification. The Modification would have no discernible or negligible impact on stream baseflow or natural river leakage for Wollombi Brook or Wambo Creek, beyond the effects of the approved mine layout. Consistent with the currently approved <i>Surface and Groundwater Response Plan</i>, in the event that a groundwater quality or trigger level specified in the GWMP or a surface water quality or trigger level specified in the SWMP is exceeded, an investigation would be conducted in accordance with the <i>Surface and Groundwater Response Plan</i>.

Table 9 (Continued)
Responses to Public Submissions

Issue ID No.	Subject	Issues Raised	Response
7	Groundwater	Concerns were raised regarding impacts on North Wambo Creek, alluvial aquifers, drawdown of privately-owned bores and the provision of compensatory water.	It is accepted that immediately downstream of the natural section of North Wambo Creek above the Modification longwalls, North Wambo Creek has been diverted (i.e. redesigned) around the approved Wambo open cut operations. This included removal of alluvium across the full width of the channel with consequent desaturation of the adjacent upstream and downstream alluvium. This impact was assessed as part of the Wambo Development Project, was approved and has occurred. The Modification would have negligible impact on stream baseflow and long-term water quality of North Wambo Creek, beyond the effects of the approved mine layout. North Wambo Creek is not associated with highly productive groundwater identified by DPI Water. There is no privately-owned land on North Wambo Creek and there are no Water Access Licences or extraction points or bores along North Wambo Creek that are used for domestic or stock use (i.e. surface water and the alluvial groundwater along North Wambo Creek are not used for water supply). The <i>Groundwater Assessment</i> (HydroSimulations, 2017) concluded that there would be negligible additional drawdown along the highly productive Wollombi Brook or Hunter River alluvium as a result of the Modification. The Modification would have no discernible or negligible impact on stream baseflow or natural river leakage for Wollombi Brook, North Wambo Creek, Wambo Creek or Stony Creek, beyond the effects of the approved mine layout. Consistent with the currently approved <i>Surface and Groundwater Response Plan</i>, in the event that a groundwater quality or trigger level specified in the GWMP is exceeded, an investigation would be conducted in accordance with the <i>Surface and Groundwater Response Plan</i>. The <i>Surface and Groundwater Response Plan</i> includes a TARP (Trigger Action Response Plan) that must be implemented in the event that a complaint is received from a private bore holder in relation to decreasing levels in a private bore, or groundwater monitoring of private bores identifies a decreasing trend approaching 2 metres below the modelled statistical trends. If investigations determine that compensatory water supplies are to be initiated, as a direct result from Wambo's operations, then Wambo will commence consultation with the affected landowners to establish an agreed suitable compensatory supply of water, until further monitoring can determine signs of increasing water levels. An assessment of potential impacts on privately-owned bores was completed as part of the <i>Groundwater Assessment</i> by HydroSimulations (2017). Of the bores listed for private use, no bores have drawdown in excess of 2 metres due to the Modification.

6 REFERENCES

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ATTACHMENT 1

**PEER REVIEW OF THE
GROUNDWATER ASSESSMENT**



KALF AND ASSOCIATES Pty Ltd
Hydrogeological, Numerical Modelling Specialists

KA Peer Review of HydroSimulations
Groundwater Assessment of the
Wambo South Bates Extension Modification

Dr F. Kalf
B.Sc. M.App.Sc PhD
6 March 2017

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Background and Brief Summary

This report is the Kalf and Associates Pty Ltd (KA) peer review commissioned by Wambo Coal Pty Ltd (WCPL) for the HydroSimulations (HS) hydrogeological and groundwater modelling assessment of the South Bates Extension Modification. This final KA review follows from an earlier KA review of the draft version of the HydroSimulations report that subsequently involved exchanges by email regarding various issues with HydroSimulations after they responded to the initial review. For the modelling assessment described herein the Modelling Guideline documents (NWC 2012, MDBC 2001) content have been taken into account. A model appraisal is also included as an appendix at the end of this report.

WCPL is seeking approval to extend mining of the Whybrow Seam at the South Bates Underground with the additional Longwall panels 17 to 25 known as the South Bates Extension.

Modelling of the proposed mining has included the influence of previous and currently mined zones, the proposed Modification, and open cut and underground mines in the surrounding regional areas.

Two modelling scenarios were simulated to determine the influence of the Extension Modification. This included a scenario A for the Approved Mine Plan and a scenario B that included the Modification as well as incorporating the influence of all other mines as modelled in Scenario A.

Figures 26 to 31 (HS 2017) show the predicted groundwater levels at the end of mining for the two scenarios in the Whybrow, Woodlands Hill and Arrowfield Seams. In addition HydroSimulations have also included KA requested pressure head sections that provide useful and important conceptualisation of the mining influence in north-south and east-west hydrogeological sections across the mining zone (Figures 32 to 37, HS 2017). Drawdown due to the Extension Modification is predicted to be essentially within the mine footprint as indicated in the HydroSimulations report with no drawdown increase between the Approved and Modification scenarios in the alluvium/regolith.

The peak annual inflow rate predicted for the Approved Mine Plan Scenario A to the South Bates underground is predicted to be 0.9 ML/day at the end of 2018 whilst for Scenario B the inflow would peak at 1.0 ML/day at the end of 2018. For Scenario A inflow to the South Wambo Underground is predicted to peak at 3.1 ML/day in 2030, and for Scenario B to 2.9 ML/day in 2037. Peak annual inflow due to the Modification is predicted to be 376 ML/year, which is 60 ML/year higher than for the Approved Mine plan.

The proposed South Bates Modification compared to the Approved scenario would have negligible effect on baseflow at Stoney and Wambo creeks whilst at North Wambo Creek a reduction in baseflow of 0.014 ML/day is predicted at its upper reaches. A reduction of baseflow of 0.01 ML/day is predicted at Wollombi Brook due to the Modification compared to the Approved scenario according to the HS report.

The majority of the recovery of the groundwater system would occur slowly over a period of 200 years.

Groundwater quality in the region of the mine site is highly variable and with a range of relatively fresh groundwater in association with streams and brackish to saline groundwater elsewhere. The Modification would not have a significant effect on the quality of groundwater or surface water around Wambo region. Cumulative mining in the area will reduce poorer

quality brackish to saline Permian groundwater from reaching the alluvium during mining and continue to do so during the recovery period.

No private bore water levels in the alluvium will be influenced above the AIP 2m drawdown limit due to Modification mining although three private bores would have drawdown much greater than 2m due to cumulative drawdown if these bores access the water bearing Permian strata, but less than 2m drawdown if they extract groundwater from the regolith strata.

Peer Review Assessment

Previous Studies and Reviews

There are numerous previous studies in the region that are listed in the HS report in the Conclusions and References section. HS has conducted a number of hydrogeological and modelling assessments in the immediate region. These include earlier modifications for North Wambo Underground; South Bates (Wambo Seam) Underground Mine and South Wambo Underground. Previous groundwater models that have been constructed in the area are described in sections 3.1 (HS 2017).

KA (2016a) conducted a peer review of the South Wambo Underground Mine Modification. KA (2016b) also conducted a peer review of the Umwelt Wambo Coal Mine Project.

Hydrogeological and Modelling Description

The hydrogeological description of the region and modelling work described in the HS (2017) report is detailed, comprehensive and has been completed and presented in a professional manner. The report covers a wide range of topics that are included within the main headings of: Introduction; Hydrogeological Setting; Groundwater simulation model; Scenario analyses; Potential effects; Conclusions and References. There are ten appendices that provide measured, calibrated and predicted groundwater hydrographs and predicted drawdowns in registered bores and groundwater monitoring. A description of the 'ramp function' derived and adopted by HS for assessing the influence of fracturing above longwalls on the groundwater system is also provided in an appendix in HS (2017).

Model Conceptualisation and Design

HydroSimulations have used a method of cell construction that is the basis of a relatively new groundwater modelling computer code issued by the United States Geological Survey known as MODFLOW-USG (USG Beta) as opposed to the availability of the well-known MODFLOW-SURFACT (MS) code previously used by HS. Because of a previously generated model for this area using MS, HS have adopted the same cell structure in the current Wambo South Bates Extension Modification USG model.

One of the main advantages of USG code is that it is possible to focus into the overall mesh with much higher resolution cells in various orientations compared to MS as well as allowing, overall, a significant reduction in cell count. While the mesh generation is different to MS, practically all of the boundary conditions applied are similar to those used in the MS computer code. HS have conducted comparison between USG (using a version USG-Beta) and MS in another groundwater modelling project peer reviewed by KA where they found model results to be essentially the same as those produced by MS.

Model conceptualisation for Wambo South Bates Modification by HS is considered suitable. The model comprises 18 layers which have been divided into a total of about 1.95 million square cells 50m by 50m in size. This layering and sub-division is suitable and sufficient to

delineate the different relevant hydrogeological units that are listed in their Section 3.3 (HS 2017).

The model extent (19km N by 16km S) and boundaries chosen are suitable as depicted in the report, as well as the various ephemeral and perennial stream channels based on the previous MS model description. Rivers and creeks have been modelled using USG 'river' package with the ability to set stage such that the perennial streams can act either as gaining, losing or ephemeral streams with baseflow drainage by setting stream stage at the base elevation of the bed layer. This is considered a suitable alternative to the use of both the 'river' package and 'drains' to simulate stream flow changes. The model uses variable gross recharge and evapotranspiration as input and output respectively, which is suitable, rather than application of variable net recharge.

Hydraulic parameters are based on measured values, including core samples, and those used in previous modelling studies of the Wambo mining site and in the region and are listed in Table 8 in section 3.3 (HS 2017).

Model Calibration

The new model conversion from MS to USG code included a re-calibration under transient conditions. Manual (trial and error) calibration was conducted using target points at numerous groundwater monitoring sites. Calibration was similar to previous MOD12 groundwater mining assessment where the calibration fit statistic was 3.9% SRMS (scaled root mean square) which is well within the target of 10% as suggested in the modelling guidelines document (MDBC 2001). Comparison made between measured and modelled hydrographs in the HS (2017) report are considered to be quite acceptable given the extensive mining activity and available knowledge about mining sequences and timing.

All data was used for calibration without verification which is normally the case depending on the duration of the water level record available. Verification can be conducted after an additional few years of Modification mine operation.

Model Simulation

Steady-state simulation was used to set up initial conditions and was combined with transient runs in the HS model. This is a suitable and desirable methodology. Mining was simulated using the standard 'drain' methodology with increases in hydraulic parameters above simulated longwalls. This was achieved with the use of the 'ramp function' to increase, in particular, the bulk vertical hydraulic conductivity of strata above the proposed longwalls (Appendix I, HS 2017). Fracture zones heights were determined using the 'Ditton Geology Model A' equation that takes into consideration the longwall panel widths, cover depths, mining heights and local geological factors (Table 11 section 3.6.2 ,HS 2017).

Because of controversy by some practitioners regarding the use of the 'ramp function', KA considers that validation of the use of this function, and in particular the adopted increase in horizontal and vertical hydraulic conductivity above the longwalls, would be beneficial during future monitoring, with comparisons made between predictions and measurements of head, if possible above, or near to the longwalls. That is, at existing monitoring bores, additional monitoring piezometers and in zones where cracking to the surface is predicted.

KA also wishes to highlight the assumptions made in the HS report (Section 3.6.2, page 35 last paragraph) with regard to cracking from the mining zone to the alluvium of North Wambo creek. In particular that the leakage volumes would be small and that the migration would be limited by barriers of host material above each coal pillar: "*Continuous cracking from the void to the alluvium may occur along approximately 1 km of the North Wambo Creek where it traverses the northern ends*

of Longwalls 23 to 25 (Figure 21). There is expected to be some transfer of higher quality creek water through the cracks into the underlying regolith and fracture zone. While the volumes would be small, there should be some beneficial effect on the water quality in the regolith which is known to be saline at bore GW17. The extent of migration of perturbed salinity water through fractured material would be limited by barriers of host material above each coal pillar”.

Unsaturated conditions and water tables were simulated in the HS model using the Van Genuchten (VG) and Brooks and Corey (BC) moisture relationships. These parameters were used to assist and achieve convergence and were not applied to simulate any particular hydrogeological facies (i.e. strata composition). Sensitivity of the VG and BC values was also conducted.

For cumulative drawdown assessment 13 neighbouring mine working zones were included as listed in section 3.5.4 (HS 2017).

The transient water balance presented in Table 18 (HS 2016) is considered plausible as is the water balance at the end of mining in Table 19 which indicates that Modification mining will have a relatively minor effect.

Groundwater Monitoring and Mitigation

No groundwater impact mitigation measures are proposed for the Extension Modification. Groundwater monitoring is to continue within the approved Groundwater Monitoring Program (GWMP) for both water quality and water levels. The groundwater monitoring sites are listed in Table 5 together with trigger levels listed in Table 6 (HS 2017).

Conclusions and Considerations

This peer review has assessed the adequacy of the hydrogeological data and the numerical model for predicting the drawdown influences of the proposed South Bates Extension Modification mining at the operational Wambo mine. The hydrogeological description, conceptualisation, model design, simulations and reporting have been conducted in a professional manner and described in detail. No fatal flaws have been detected in the description or modelling work conducted. All drawdown predictions, and in particular water table drawdowns within alluvial sediments, are considered plausible. However, additional specific monitoring is warranted in those areas where cracking to the surface has been predicted particularly where North Wambo creek traverses the longwalls. In addition observation of the rate of any apparent surface water leakage below ground in those areas along North Wambo creek overlying the longwalls, particularly during periods of high rainfall and runoff that may require contingency measures for removal. Monitoring bore data should be reviewed and compared with modelling results every 3 years.

References

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Kalf and Associates Pty Ltd (KA) 2016b. *Umwelt Wambo Coal Mine Project. Report prepared for Wambo Coal Pty Ltd. 24 November.*

APPENDIX

Model Appraisal Check List

	ISSUES	Not applicable or Unknown					COMMENTS
1.0	THE REPORT						
1.1	Is there a clear statement of project objectives in the modelling report?		Missing	Deficient	Adequate	Very good	
1.2	Is the level of model complexity clear or acknowledged?		Missing	No	Yes		
1.3	Is a water or mass balance reported?		Missing	Deficient	Adequate	Very good	
1.4	Has the modelling study satisfied project objectives?		Missing	Deficient	Adequate	Very good	
1.5	Are the model results of any practical use?			No	Maybe	Yes	
2.0	DATA ANALYSIS						
2.1	Has hydrogeology data been collected and analysed?		Missing	Deficient	Adequate	Very good	
2.2	Are groundwater contours or flow directions presented?		Missing	Deficient	Adequate	Very good	
2.3	Has all relevant potential recharge data been collected and analysed?		Missing	Deficient	Adequate	Very good	
2.4	Has all relevant potential discharge data been collected and analysed?		Missing	Deficient	Adequate	Very good	
2.5	Have the recharge and discharge datasets been analysed for their groundwater response?		Missing	Deficient	Adequate	Very good	
2.6	Are groundwater hydrographs used for calibration?			No	Maybe	Yes	
2.7	Have consistent data and standard elevation units been used?			No	Yes		
3.0	CONCEPTUALISATION						
3.1	Is the conceptual model consistent with project objectives and the required model complexity?		Unknown	No	Maybe	Yes	
3.2	Is there a clear description of the conceptual model?		Missing	Deficient	Adequate	Very good	
3.3	Is there a graphical representation of the modeller's conceptualisation?		Missing	Deficient	Adequate	Very good	
3.4	Is the conceptual model unnecessarily simple or unnecessarily complex?			Yes	No		
4.0	MODEL DESIGN						
4.1	Is the spatial extent of the model appropriate?			No	Maybe	Yes	
4.2	Are the applied boundary conditions plausible and unrestrictive?		Missing	Deficient	Adequate	Very good	
4.3	Is the software appropriate for the objectives of the study?			No	Maybe	Yes	
5.0	CALIBRATION						
5.1	Is there sufficient evidence provided for model calibration?		Missing	Deficient	Adequate	Very good	
5.2	Is the model sufficiently calibrated against spatial observations?		Missing	Deficient	Adequate	Very good	
5.3	Is the model sufficiently calibrated against temporal observations?		Missing	Deficient	Adequate	Very good	
5.4	Are calibrated parameter distributions and ranges plausible?		Missing	No	Maybe	Yes	
5.5	Does the calibration statistic satisfy		Missing	Deficient	Adequate	Very	

	agreed performance criteria?					good	
5.6	Are there good reasons for not meeting agreed performance criteria?		Missing	Deficient	Adequate	Very good	Performance criteria have been met
6.0	VERIFICATION						
6.1	Is there sufficient evidence provided for model verification?		Missing	Deficient	Adequate	Very good	All data used for calibration Verification with ongoing monitoring
6.2	Does the reserved dataset include stresses consistent with the prediction scenarios?		Unknown	No	Maybe	Yes	
6.3	Are there good reasons for an unsatisfactory verification?		Missing	Deficient	Adequate	Very good	
7.0	PREDICTION						
7.1	Have multiple scenarios been run for climate variability?		Missing	Deficient	Adequate	Very good	
7.2	Have multiple scenarios been run for operational management alternatives?		No	Deficient	Adequate	Very good	
7.3	Is the time period for prediction comparable with the duration of the calibration period?		Missing	Greater than	Similar to	Less than	
7.4	Are the model predictions plausible?			No	Maybe	Yes	
8.0	SENSITIVITY ANALYSIS						
8.1	Is the sensitivity analysis sufficiently intensive for key parameters/		Missing	Deficient	Adequate	Very good	
8.2	Are sensitivity results used to qualify the reliability of model calibration?		Missing	Deficient	Adequate	Very good	
8.3	Are sensitivity results used to qualify the accuracy of model prediction?		Missing	Deficient	Adequate	Very good	
9.0	UNCERTAINTY ANALYSIS						
9.1	If required by the project brief, is uncertainty quantified in any way?		Missing	No	Adequate	Yes	
9.2	Is the model 'fit-for-purpose'?			No		Yes	

ATTACHMENT 2

**PREDICTED DRAWDOWN EFFECTS ON
GROUNDWATER BORES**

Work No.	Licence	Owner Type	Use	Comment	Final Depth (m)	Standing Water Level (mBGL)	Easting	Northing	Elevation (mAHD)	Lithology (interpreted by HydroSimulations)	Predicted Drawdown (m)	
											Drawdown difference between Approved and Modified Scenario	Maximum cumulative drawdown
GW005327	20BL009540	Private	Unknown	Within WCPL Owned Land	10.4	6.1	314683	6394498	59.92	Permo-Triassic	0	0
GW017462	20BL008224	Private	Water supply for livestock				315339	6391460	98.43	Regolith	0	0
GW030732			Monitoring		16		316678	6398365	56.25		0	0
GW030733			Monitoring		15.9	12.8	316661	6397633	56.69		0	0
GW030740			Monitoring		16.3	12.9	316641	6397642	54.61		0	0
GW037184		Private	Exploration or research	Within WCPL Owned Land	21	5.8	309685	6393911	81.31	Permo-Triassic	0	0
GW037998		Private	Irrigated agriculture	Within WCPL Owned Land	10.9		311589	6392530	62.38	Alluvium	0	6
GW037999		Private	Irrigated agriculture	Within WCPL Owned Land	13.7		311482	6392713	64.01	Permo-Triassic	0	6
GW038000		Private	Irrigated agriculture	Within WCPL Owned Land	9.4		311457	6392620	63.59	Alluvium	0	9
GW038579		Private	Exploration or research	Within WCPL Owned Land	20.9	2.3	309738	6393882	78.4	Permo-Triassic	0	0
GW043225			Irrigated agriculture		22.5	12.1	303653	6398949	116		0	0
GW043673		Private	Exploration or research	Within WCPL Owned Land	9.4		311486	6392467	63.11	Alluvium	0	12
GW043674		Private	Exploration or research	Within WCPL Owned Land	8.2		311303	6392525	64.6	Alluvium	0	2
GW043675		Private	Exploration or research	Within WCPL Owned Land	8.5		311433	6392527	63.73	Alluvium	0	1
GW043676		Private	Exploration or research	Within WCPL Owned Land	10.6		311480	6392805	64.24	Permo-Triassic	0	5
GW047240	20CA209896	Private	Irrigated agriculture		12.7		316827	6397095	55.22	Alluvium	0	0

Work No.	Licence	Owner Type	Use	Comment	Final Depth (m)	Standing Water Level (mBGL)	Easting	Northing	Elevation (mAHD)	Lithology (interpreted by HydroSimulations)	Predicted Drawdown (m)	
											Drawdown difference between Approved and Modified Scenario	Maximum cumulative drawdown
GW060326		Private	Mining	Within WCPL Owned Land	9.8	6.7	314104	6393348	58.38	Alluvium	0	0
GW060327		Private	Mining	Within WCPL Owned Land	9.8	6.7	314181	6393442	58.24	Alluvium	0	0
GW060328		Private	Mining	Within WCPL Owned Land	10	7	314205	6393534	57.69	Alluvium	0	0
GW060329		Private	Mining	Within WCPL Owned Land	6.4	2.6	311904	6392474	60.91	Alluvium	0	0
GW060330		Private	Mining	Within WCPL Owned Land	6.2	3.8	311727	6392163	62.13	Alluvium	0	14
GW060363	20BL132753	Private	Irrigated agriculture	Within WCPL Owned Land	6.3		311698	6392317	61.01	Alluvium	0	10
GW060364		Private	Irrigated agriculture	Within WCPL Owned Land	5.1		311636	6392808	63.17	Permo-Triassic	0	0
GW060365		Private	Irrigated agriculture	Within WCPL Owned Land	6.6		311691	6392686	62.06	Alluvium	0	0
GW060366		Private	Irrigated agriculture	Within WCPL Owned Land	5.2		311196	6392646	65.06	Alluvium	0	0
GW060750	20BL132130	Private	Household		24.4	7.8	314310	6394923	58.99	Permo-Triassic	0	0
GW065117		Private	Irrigated agriculture	Within WCPL Owned Land	6		311154	6390735	64.23	Alluvium	0	30
GW066606		(Unknown)	Household	Within WCPL Owned Land	2.5	1	311207	6390674	60	Alluvium	0	0
GW078055		Private	Monitoring	Purpose = 'Test bore' (WCPL test bore?)	198.5		310105	6390490	73.48	Permo-Triassic	4	56
GW078574	20BL167170	Private	Irrigated agriculture		12		309174	6390605	89.07	Regol or Permo-T	0	18
GW078575	20BL167171	Private	Irrigated agriculture		12		309505	6389687	80.23	Regol or Permo-T	0	32
GW078576	20BL167172	Private	Irrigated agriculture	KHARLIBE	7		309764	6389784	78.42	Regol or Permo-T	0	37

Work No.	Licence	Owner Type	Use	Comment	Final Depth (m)	Standing Water Level (mBGL)	Easting	Northing	Elevation (mAHD)	Lithology (interpreted by HydroSimulations)	Predicted Drawdown (m)	
											Drawdown difference between Approved and Modified Scenario	Maximum cumulative drawdown
GW078577	20WA208559		Irrigated agriculture		10		309969	6389973	72.91	Alluvium	0	41
GW079059	20BL153300	NSW Office of Water	Monitoring	NSW Office of Water			314596	6394852	56.96	Alluvium	0	0
GW079060		NSW Office of Water	Monitoring	NSW Office of Water	14.6	7.18	314596	6394852	56.92	Alluvium	0	0
GW079780		(Unknown)	Unknown	Within WCPL Owned Land			309589	6393932	77.28	Regolith	0	0
GW080502	20BL168017	Mining	Mining	Purpose = "mining", BROSI PROPERTY	250	105	308897	6390160	99.8	Permo-Triassic	-2	30
GW080513	20BL168880		Mining		10	7.53	312345	6394818	99.8		0	0
GW080514	20BL168881		Monitoring	Within WCPL Owned Land	55	42.7	310973	6394353	113.34	Permo-Triassic	0	2
GW080515	20BL168882		Monitoring	Within WCPL Owned Land	8.1	5.7	313418	6394794	56.38	Alluvium	0	0
GW080516	20BL168883		Unknown	Within WCPL Owned Land	15	7.11	312899	6394954	71.93	Permo-Triassic	-1	17
GW080517	20BL168884		Monitoring	Within WCPL Owned Land	15	7.24	313573	6394742	55.44	Permo-Triassic	0	0
GW080518	20BL168885		Monitoring	Within WCPL Owned Land	10.8	6.95	313586	6394232	57.65	Permo-Triassic	0	0
GW080519	20BL168885		Unknown	Within WCPL Owned Land	10.5	7.42	313622	6394161	57.98	Permo-Triassic	0	0
GW080951		(Unknown)	Unknown		3.1	3.14	314619	6394878	55	Alluvium	0	0
GW080952		(Unknown)	Unknown		1.6	1.59	314643	6394905	54	Alluvium	0	0
GW080963	20BL170103	NSW Office of Water	Monitoring	NSW Office of Water	84	60	315994	6397210	55.35	Permo-Triassic	0	1
GW200361	20BL170638		Unknown	Within WCPL Owned Land		3.12	311833	6392209	60.97	Alluvium	0	0

Work No.	Licence	Owner Type	Use	Comment	Final Depth (m)	Standing Water Level (mBGL)	Easting	Northing	Elevation (mAHD)	Lithology (interpreted by HydroSimulations)	Predicted Drawdown (m)	
											Drawdown difference between Approved and Modified Scenario	Maximum cumulative drawdown
GW200615	20BL168886	Mines	Monitoring	Within WCPL Owned Land	11.5	7.49	313434	6394246	63.01	Permo-Triassic	-1	8
GW200616	20BL168886	Mines	Monitoring	Within WCPL Owned Land	8.5	5.68	313473	6394446	58.85	Alluvium	0	0
GW200617	20BL168888	Mines	Monitoring	Within WCPL Owned Land	9	4.75	309987	6393974	90.64	Permo-Triassic	0	3
GW200618	20BL168888	Mines	Monitoring	Within WCPL Owned Land	11.5	5.26	310100	6393820	83.03	Permo-Triassic	0	3
GW200619	20BL168888	Mines	Monitoring	Within WCPL Owned Land	11.5	5.39	310182	6393656	77.32	Permo-Triassic	0	3
GW200620	20BL168888	Mines	Monitoring	Within WCPL Owned Land	49	39.09	310489	6394097	104.62	Permo-Triassic	0	2
GW200621	20BL168887	Mines	Monitoring		37	24.89	312857	6395909	80.54	Permo-Triassic	0	94
GW200622	20BL168887	Mines	Monitoring		30	29.95	312901	6395806	82.84	Permo-Triassic	0	94
GW200623	20BL168887	Mines	Monitoring		31	13.84	312982	6395319	65.27	Permo-Triassic	0	42
GW200624	20BL168939	Mines	Drainage of groundwater	Within WCPL Owned Land	260	6	310166	6392650	77.34	Permo-Triassic	0	139
GW200625	20BL168940	Mines	Mining	Within WCPL Owned Land	270		310901	6393375	83.56	Permo-Triassic	-1	48
GW200634	20BL168999	Mines	Monitoring	Within WCPL Owned Land	20		311470	6391252	59.65	Permo-Triassic	0	28
GW200635	20BL168999	Mines	Monitoring	Within WCPL Owned Land	20		311659	6391236	59.4	Permo-Triassic	0	22
GW200636	20BL168999	Mines	Monitoring	Within WCPL Owned Land	20		311749	6391078	60.15	Permo-Triassic	0	18
GW200637	20BL168999	Mines	Monitoring	Within WCPL Owned Land	15	8.45	311662	6391094	59.92	Alluvium	0	25
GW200638	20BL168999	Mines	Monitoring	Within WCPL Owned Land	20	5.18	311452	6391103	60.21	Permo-Triassic	0	30
GW200639	20BL168999	Mines	Monitoring	Within WCPL Owned Land	20	8.46	311455	6390889	60.22	Permo-Triassic	0	32

Work No.	Licence	Owner Type	Use	Comment	Final Depth (m)	Standing Water Level (mBGL)	Easting	Northing	Elevation (mAHD)	Lithology (interpreted by HydroSimulations)	Predicted Drawdown (m)	
											Drawdown difference between Approved and Modified Scenario	Maximum cumulative drawdown
GW200640	20BL168999	Mines	Monitoring	Within WCPL Owned Land	50		311638	6390920	60.61	Permo-Triassic	0	30
GW200641	20BL168999	Mines	Monitoring	Within WCPL Owned Land	20	7.01	311761	6390921	61.41	Permo-Triassic	0	21
GW200642	20BL168999	Mines	Monitoring	Within WCPL Owned Land	20	15.12	311696	6390688	59.88	Permo-Triassic	0	31
GW200643	20BL168999	Mines	Monitoring	Within WCPL Owned Land	15	7.3	311454	6390685	65.38	Permo-Triassic	0	35
GW200827	20BL172237		Monitoring		9		312505	6391469	69.44	Permo-Triassic	0	0
GW200828	20BL172237		Monitoring		11.5		310061	6393206	75.4	Permo-Triassic	0	2
GW200829	20BL172237		Monitoring		36		308641	6393376	119.35	Permo-Triassic	0	13
GW200830	20BL172240		Monitoring		16.8		313335	6392745	66.03	Permo-Triassic	0	0
GW200833	20BL172255		Monitoring		54		311340	6389530	91.49	Permo-Triassic	-4	37
GW200834	20BL172257		Monitoring		15		313695	6389546	63.77	Permo-Triassic	-1	1
GW200835	20BL172256		Monitoring		11		308424	6394517	102.68	Permo-Triassic	0	27
GW200942	20BL167947		Monitoring		37	32	312325	6395750	91.82	Permo-Triassic	0	22
GW200943	20BL167947		Monitoring		30	27	312332	6395760	91.82	Permo-Triassic	0	31
GW017647	20BL009858				9.1	7.6	307326	6399905	72.02	Alluvium	0	0
GW021773	20BL014201				12.5	9.1	309532	6401950	69.23	Alluvium	0	0
GW053690	20BL119580				11.3	10.1	308429	6402268	67.19	Alluvium	0	0
GW053708	20BL117803				13.4		304231	6403327	75.88	Alluvium	0	0
GW201125	20BL168820				12		308386	6402778	70.36	Alluvium	0	0
GW018045	20BL010054				27.4	6.1	302941	6398556	140.31	Permo-Triassic	0	0
GW018046	20BL010053				18.3	9.3	303013	6398866	136.46	Permo-Triassic	0	0
GW018434	20BL010847				11	10.1	311134	6401457	27.27	Regolith	0	0
GW018464	20BL010603				13	11.9	317783	6400471	54.9	Alluvium	0	0

Work No.	Licence	Owner Type	Use	Comment	Final Depth (m)	Standing Water Level (mBGL)	Easting	Northing	Elevation (mAHD)	Lithology (interpreted by HydroSimulations)	Predicted Drawdown (m)	
											Drawdown difference between Approved and Modified Scenario	Maximum cumulative drawdown
GW022685	20BL015155				14.6	9.8	309073	6401387	70.68	Alluvium	0	0
GW049187	20BL108626				10	8.5	303025	6403550	75.49	Regolith	0	0
GW053173	20BL118414				14.8	5.2	309098	6401449	70.84	Alluvium	0	0
GW064382	10BL157687				60	18.5	303908	6394477	414.36	Permo-Triassic	0	0
GW078477	20BL167575				102.5		304018	6398990	109.76	Permo-Triassic	0	0
GW201532	20BL172923				27	19	301010	6403253	97.25	Permo-Triassic	0	0
GW017644	20BL009861				11.6		306708	6399431	75.33	Alluvium	0	0
GW017798	20BL009821			Within WCPL Owned Land	12.2		307290	6399042	86.59	Regolith	0	0
GW017800	20BL009819			Within WCPL Owned Land	27.4		304413	6398000	133.22	Permo-Triassic	1	1
GW017801	20BL009818			Within WCPL Owned Land	42.7		304320	6397443	148.96	Permo-Triassic	1	2
GW018047	20BL010041				36.3		302620	6398920	145.5	Permo-Triassic	0	0
GW018371	20BL010483				12.2		317683	6398775	55.33	Alluvium	0	0
GW029155	20BL022682				10.1		305403	6402148	71.99	Alluvium	0	0
GW042364					13.3		316764	6397649	55.68	Alluvium	0	0
GW067099	20BL143751				14	9.2	312664	6401979	70	Alluvium	0	0
GW067109	20BL144341				13	9.4	310153	6400884	60	Alluvium	0	0
GW078722	20BL167495				15		304737	6402674	73.62	Permo-Triassic	0	0
GW200664	20BL169641				16.1		309638	6402500	69.58	Permo-Triassic	0	0
GW200831	20BL172242		Monitoring	WCPL monitoring bore	12		306639	6396174	113.05	Regolith	13	28
GW200832	20BL172242		Monitoring	WCPL monitoring bore	14		306885	6396081	110.51	Regolith	7	19

Work No.	Licence	Owner Type	Use	Comment	Final Depth (m)	Standing Water Level (mBGL)	Easting	Northing	Elevation (mAHD)	Lithology (interpreted by HydroSimulations)	Predicted Drawdown (m)	
											Drawdown difference between Approved and Modified Scenario	Maximum cumulative drawdown
GW201008	20BL172683				15		308112	6402680	70.2	Permo-Triassic	0	0
GW201121	20BL168820				11.9		308675	6402724	68.13	Alluvium	0	0
GW201122	20BL168820				12		308502	6403116	70.39	Alluvium	0	0
GW201127	20BL168820				14.6		308239	6402959	69.79	Alluvium	0	0
GW201223	20BL170498				14		312903	6402123	65.4	Alluvium	0	0
GW201260	20BL171852				15	9.59	312196	6401176	65.11	Permo-Triassic	0	0
GW202134	20BL170596				8.86		318272	6403565	#N/A	Regolith	0	0
GW017648	20BL009859				12.8	9.1	307397	6400276	70.28	Alluvium	0	0
GW018370	20BL010484				11.9		317573	6399112	55.69	Alluvium	0	0
GW018549	20BL012095				9.1	5.5	313134	6401987	63.61	Alluvium	0	0
GW032632	20BL025579				33.5		303253	6402568	98.06	Permo-Triassic	0	0
GW053123	20BL118095				13.1	2.1	309609	6402013	69.81	Alluvium	0	0
GW053292	20BL119690				10		317670	6398097	53.33	Alluvium	0	0
GW053709	20BL119757				12.2	2.4	304370	6402898	74.56	Alluvium	0	0
GW057775	20BL120623				13.4	4.6	309122	6401542	70.75	Alluvium	0	0
GW059178	20BL128781				13.9	11.8	303887	6403536	76.35	Alluvium	0	0
GW078379	20BL166638				14	9.53	308341	6402759	70.5	Alluvium	0	0
GW017646	20BL009860				11		306937	6399774	72.71	Alluvium	0	0
GW045123	20BL105224				12.2		309154	6402621	81.72	Regolith	0	0
GW053932	20BL120968				7.3		312637	6402070	61.27	Alluvium	0	0
GW200666	20BL169641				8		310333	6402255	70.28	Alluvium	0	0
GW200669	20BL169641				7		310088	6402049	66.88	Alluvium	0	0
GW201006	20BL172683				14.4		307924	6402680	70.69	Alluvium	0	0
GW201123	20BL168820				15		308277	6402702	70.43	Permo-Triassic	0	0

Work No.	Licence	Owner Type	Use	Comment	Final Depth (m)	Standing Water Level (mBGL)	Easting	Northing	Elevation (mAHD)	Lithology (interpreted by HydroSimulations)	Predicted Drawdown (m)	
											Drawdown difference between Approved and Modified Scenario	Maximum cumulative drawdown
GW201126	20BL168820				13.44		308609	6402945	69.68	Alluvium	0	0
GW201214	20BL170497				11		313539	6402384	61.58	Alluvium	0	0
GW201216	20BL170497				6		313502	6402051	69.99	Alluvium	0	0
GW078332	20BL166324				42.68		303704	6401464	96.1	Permo-Triassic	0	0
GW017799	20BL009820			Within WCPL Owned Land	12.2		306598	6398412	108.68	Regolith	0	7
GW200008	20BL150172				10	5.93	312623	6398421	86.54	Regolith	0	0
GW060780	20BL132167			Not in use	25.5		305926	6399385	104.24	Permo-Triassic	0	5
GW065014	20BL166572				14.5		305777	6400368	85.03	Regolith	0	0
GW027120	20BL020353				13.4	8.8	309521	6401149	68.74	Alluvium	0	0
GW037734	20BL031436				13.4	9.7	309616	6401644	67.07	Alluvium	0	0
GW042993	20BL104637 and 20BL121565				8.8		309721	6403001	75.18	Alluvium	0	0
GW201262	20BL171855				15	10.52	311852	6400928	66.28	Permo-Triassic	0	0
GW027121	20BL016019				15.8	10.1	309561	6401797	69.14	Permo-Triassic	0	0
GW078208	20BL166957				19.2	10.14	309950	6402647	70.53	Permo-Triassic	0	0
GW078380	20BL166639				22.5	9.41	308813	6402676	66.82	Permo-Triassic	0	0
GW078381	20BL166640				22.5	16.53	309634	6403370	77.53	Permo-Triassic	0	0
GW078382	20BL166640				15.8	10.88	309818	6403200	75.13	Permo-Triassic	0	0
GW078383	20BL166640				21.7	10.3	309775	6402970	73.72	Permo-Triassic	0	0
GW078384	20BL166642				13.2	9.2	310403	6402799	74.11	Alluvium	0	0
GW201562	20BL173062			Coal & Allied owned land	47.4	33.3	317699	6394412	88.4	Permo-Triassic	0	2
GW201565	20BL173065				29.5	3.4	318354	6393926	76.4	Permo-Triassic	0	0
GW045122	20BL105223				12.2		309572	6402567	70.49	Alluvium	0	0

Work No.	Licence	Owner Type	Use	Comment	Final Depth (m)	Standing Water Level (mBGL)	Easting	Northing	Elevation (mAHD)	Lithology (interpreted by HydroSimulations)	Predicted Drawdown (m)	
											Drawdown difference between Approved and Modified Scenario	Maximum cumulative drawdown
GW067101	20BL144340			Coal & Allied owned land	15.6	12.2	310826	6401143	66	Permo-Triassic	0	2
GW067110	20BL144342			Coal & Allied owned land	16.7	9.8	310760	6400495	58	Permo-Triassic	0	3
GW200665	20BL169641				13.8		310339	6402252	70.28	Alluvium	0	0
GW200667	20BL169641				16.4		310438	6402179	69.3	Permo-Triassic	0	0
GW200668	20BL169641				16.44		310083	6402052	66.88	Permo-Triassic	0	0
GW200670	20BL169641				16		310245	6402370	69.66	Permo-Triassic	0	0
GW201120	20BL168820				32.75		308664	6402721	68.46	Permo-Triassic	0	0
GW201124	20BL168820				34.1		308272	6402688	70.41	Permo-Triassic	0	0
GW201128	20BL168820				17		308877	6402939	68.5	Permo-Triassic	0	0
GW201261	20BL171854			Coal & Allied owned land	15	8.28	311233	6400727	67.2	Permo-Triassic	0	4
GW201263	20BL171856			Coal & Allied owned land	18	10.53	310776	6400546	67.22	Permo-Triassic	0	3
GW201564	20BL173064			Coal & Allied owned land	30.6	9.37	317319	6395338	57.63	Permo-Triassic	0	8
GW053931	20BL120263				10.4		312626	6402625	67.34	Regolith	0	0
GW200681	20BL171905				19.4		310494	6403291	86.08	Permo-Triassic	0	0
GW201217	20BL170497				11.35		313600	6402238	59.94	Alluvium	0	0
GW034569	20BL030566				12.2	9.8	316745	6398696	55.06	Regolith	0	0
GW056696	20BL123304				10.5		313297	6401651	75.46	Regolith	0	0
GW200682	20BL171905				30.4		310511	6403229	86.06	Permo-Triassic	0	0
GW201213	20BL170497				12		313429	6402130	60.62	Alluvium	0	0
GW201224	20BL170498				15		312927	6401839	64.96	Permo-Triassic	0	0
GW034568	20BL027195				12.2	8.5	316674	6398325	53.61	Alluvium	0	0
GW078770	20BL167426				10		318094	6398098	61.82	Regolith	0	0

Work No.	Licence	Owner Type	Use	Comment	Final Depth (m)	Standing Water Level (mBGL)	Easting	Northing	Elevation (mAHD)	Lithology (interpreted by HydroSimulations)	Predicted Drawdown (m)	
											Drawdown difference between Approved and Modified Scenario	Maximum cumulative drawdown
GW200802	20BL151941				11.9	10.5	318025	6396083	71.89	Regolith	0	0
GW030734					16.5		316578	6397861	55.98	Permo-Triassic	0	0
GW030735					14		316447	6397858	55.57	Alluvium	0	0
GW030736					17.5		316628	6397985	54.21	Permo-Triassic	0	0
GW201212	20BL170497				18.8		313501	6401824	60.77	Permo-Triassic	0	0
GW201566	20BL173069				37.5	32	318281	6395675	80.79	Permo-Triassic	0	0
GW201215	20BL170497				42		313508	6402047	60.51	Permo-Triassic	0	1
GW201218	20BL170497				60		313328	6401783	69.1	Permo-Triassic	0	0
GW201219	20BL170497				54		313601	6401922	66.38	Permo-Triassic	0	0
GW201221	20BL170498				60		312891	6401639	64.73	Permo-Triassic	0	0
GW201222	20BL170498				16		312883	6401639	65.44	Permo-Triassic	0	0
GW201225	20BL170498				17.3		312823	6401692	64.71	Permo-Triassic	0	0

ATTACHMENT 3

**DRAWDOWN CONTOURS FROM THE
GROUNDWATER ASSESSMENT**

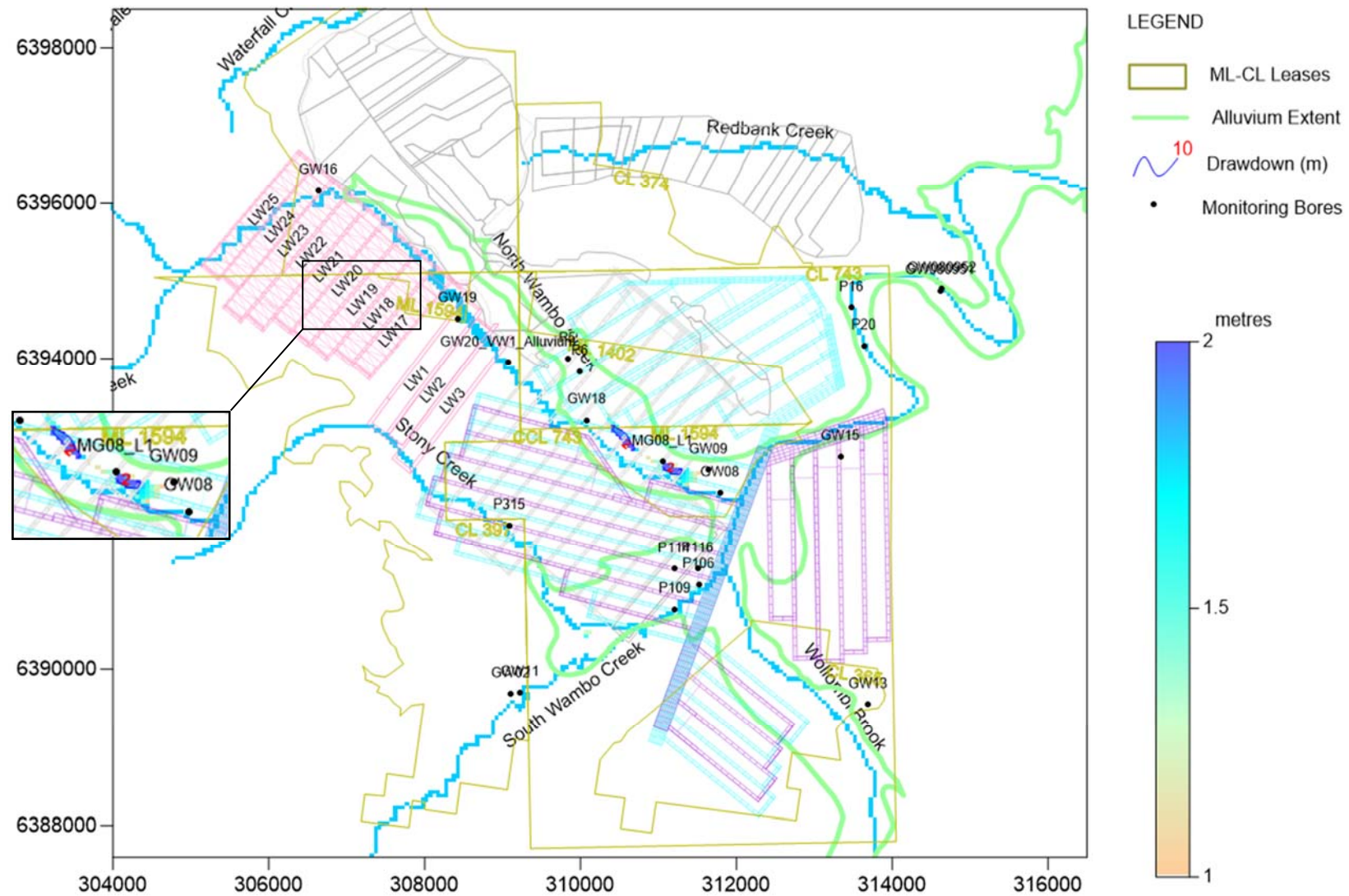


Figure C-1 –Cumulative Maximum Drawdown (m) in Alluvium / Regolith during the Model Prediction Period (SP32-SP56) for Modification Scenario

Source: HydroSimulations (2017).



Source: HydroSimulations (2017).

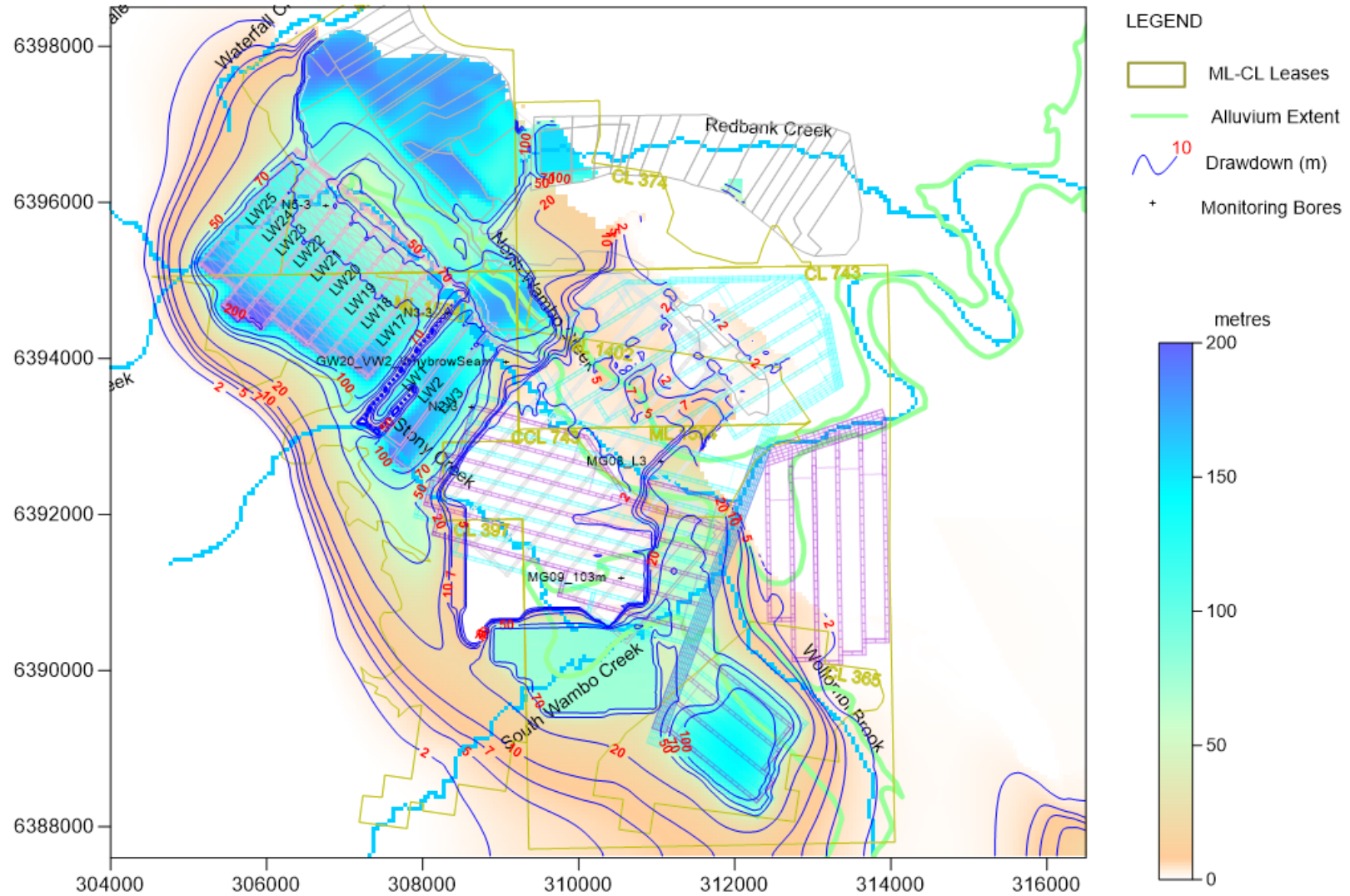


Figure C-3 –Cumulative Maximum Drawdown (m) in Whybrow Seam during the Model Prediction Period (SP32-SP56) for Modification Scenario

Source: HydroSimulations (2017).



Source: HydroSimulations (2017).

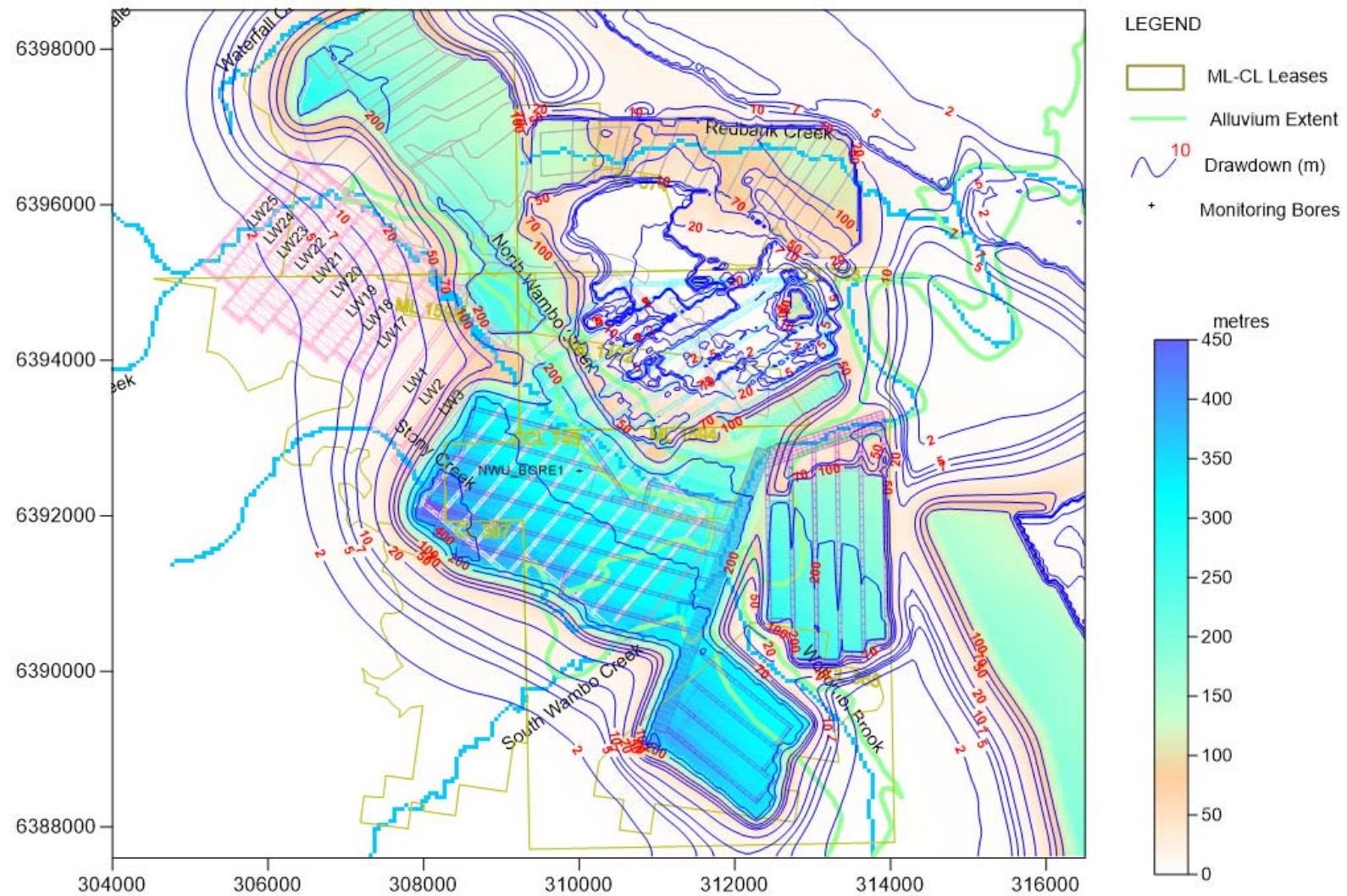


Figure C-5 –Cumulative Maximum Drawdown (m) in Woodlands Hill Seam during the Model Prediction Period (SP32-SP56) for Modification Scenario

Source: HydroSimulations (2017).

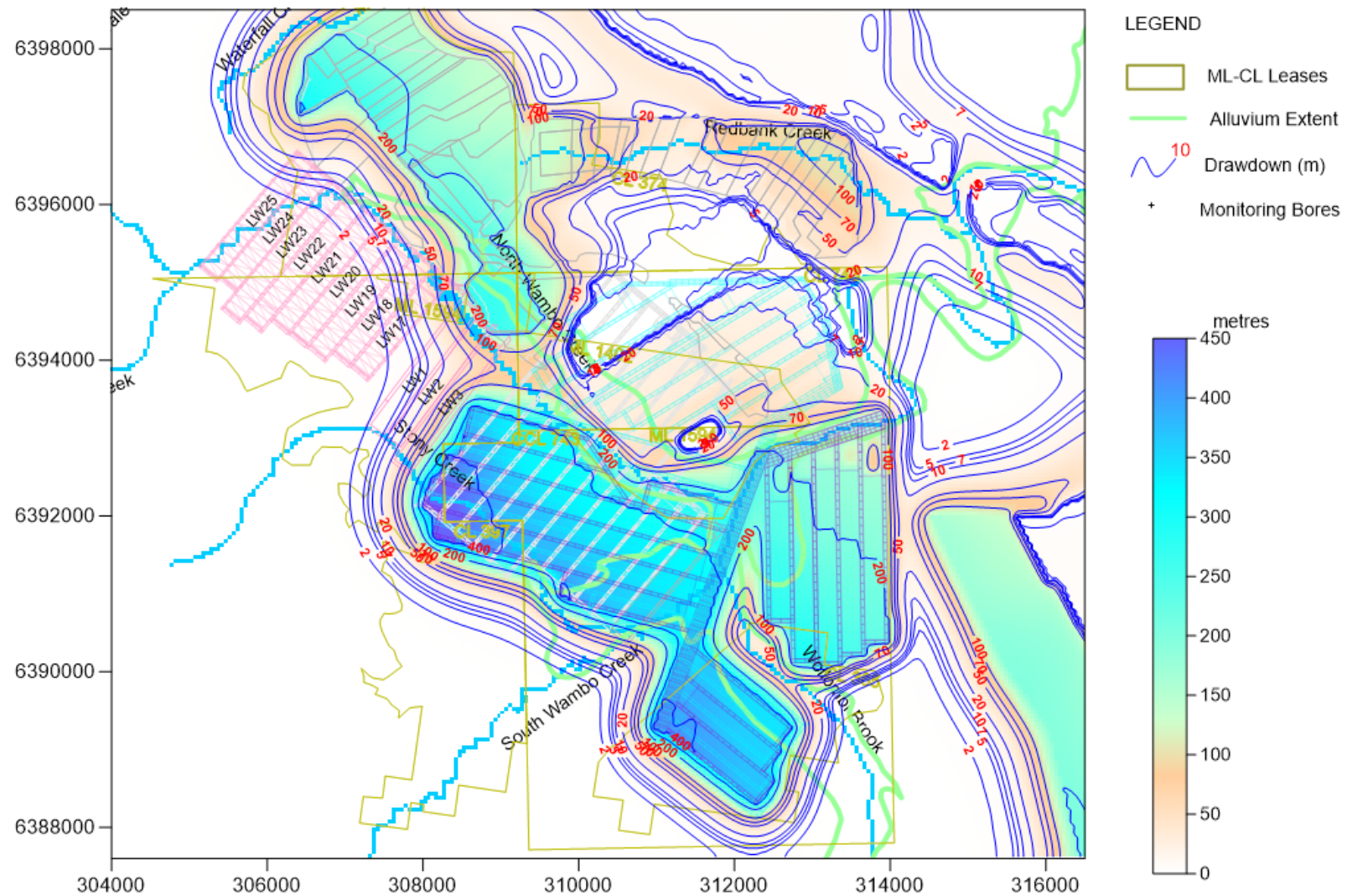


Figure C-6 –Cumulative Maximum Drawdown (m) in Arrowfield Seam during the Model Prediction Period (SP32-SP56) for Modification Scenario

Source: HydroSimulations (2017).