4.0 Key Environmental Impacts

This section assesses potential changes to environmental impacts associated with the commencement of coal extraction from longwall 6 (LW6) over and above the impacts that have been previously assessed and approved as part the NRE No.1 Preliminary Works Project (as modified to include LW4 and LW5) (MP 10_0046). This assessment relies on investigations and assessments that have been previously produced for the current Underground Expansion Project (MP 09_0013) and should be read in this context and with reference to those investigations and assessments. It is relevant to note that the first 400 metres of coal extraction from LW6 forms a small part of the broader scope of the Underground Expansion Project, which is proposed to be brought forward as part of this modification application.

Key environmental issues associated with the proposed modification, including subsidence, hydrogeology, surface water, ecology and socio-economics are considered in this section. Other relevant environmental factors are considered in **Section 5.0**.

4.1 Subsidence

A Subsidence Assessment report was prepared by SCT Operations Pty Ltd (SCT) in September 2013 to predicted subsidence levels and to assess potential subsidence impacts associated with the Underground Expansion Project (MP 09_0013) (as amended in the Preferred Project Report). This section provides a summary of the findings of the Subsidence Assessment as they relate to the LW6 Modification Area.

Relevant subsidence specialist reports considered as part of this modification are provided in **Appendix C**.

4.1.1 Existing Environment

Coal has previously been mined in three seams across the Underground Expansion Project Area, including LW6 Modification Area:

- Bulli Seam – mined from the late nineteenth century through to the 1950's using a variety of mining techniques, including board and pillar extraction;
- Balgownie Seam – located approximately 10 metres below the Bulli Seam, the Balgownie Seam was mined as one of the first longwall mining operations in Australia from 1970 through to 1982; and
- Wongawilli Seam – mining of the Wongawilli Seam, approximately 20 metres below the Balgownie Seam, commenced in April 2012 with the extraction of LW4 and LW5.

The previous mining undertaken within these three seams provides a complex environment in which to assess subsidence. It also indicates that some subsidence has occurred in the area as a consequence of historical mining operations.

Figure 5 illustrates areas of previous mining in proximity to the LW6 Modification Area. Recent measurement and monitoring of subsidence above LW4 and LW5 provides a good basis for predicting the magnitude of subsidence above the remaining longwall panels proposed as part of the Underground Expansion Project Area, with sufficient accuracy to enable robust subsidence management strategies to be developed.

Surface features are primarily defined by the undeveloped nature of the area, comprising Cataract Creek, Cataract River and its tributaries, sections of rainforest in valleys, a series of upland swamps and Hawkesbury Sandstone rock formations.

4.1.2 Assessment Methodology

The Subsidence Assessment (SCT, 2013) was undertaken to assess the revised mining layout proposed as part of the Preferred Project Report for the Underground Expansion Project (MP 09_0013) and has taken into account amendments that were made to the mine plan for the project in response to the ongoing assessment of that project. The Subsidence Assessment was updated on the basis of the following new information sources:

- an alternative mine subsidence modelling approach;
- a full geological assessment of the Wonga East area;
- extensive research into historical subsidence and the extent of mine workings in the Bulli and Balgownie Seams; and
- recent mine workings undertaken in LW4 and LW5, with measured data gathered as a result of mining progress.

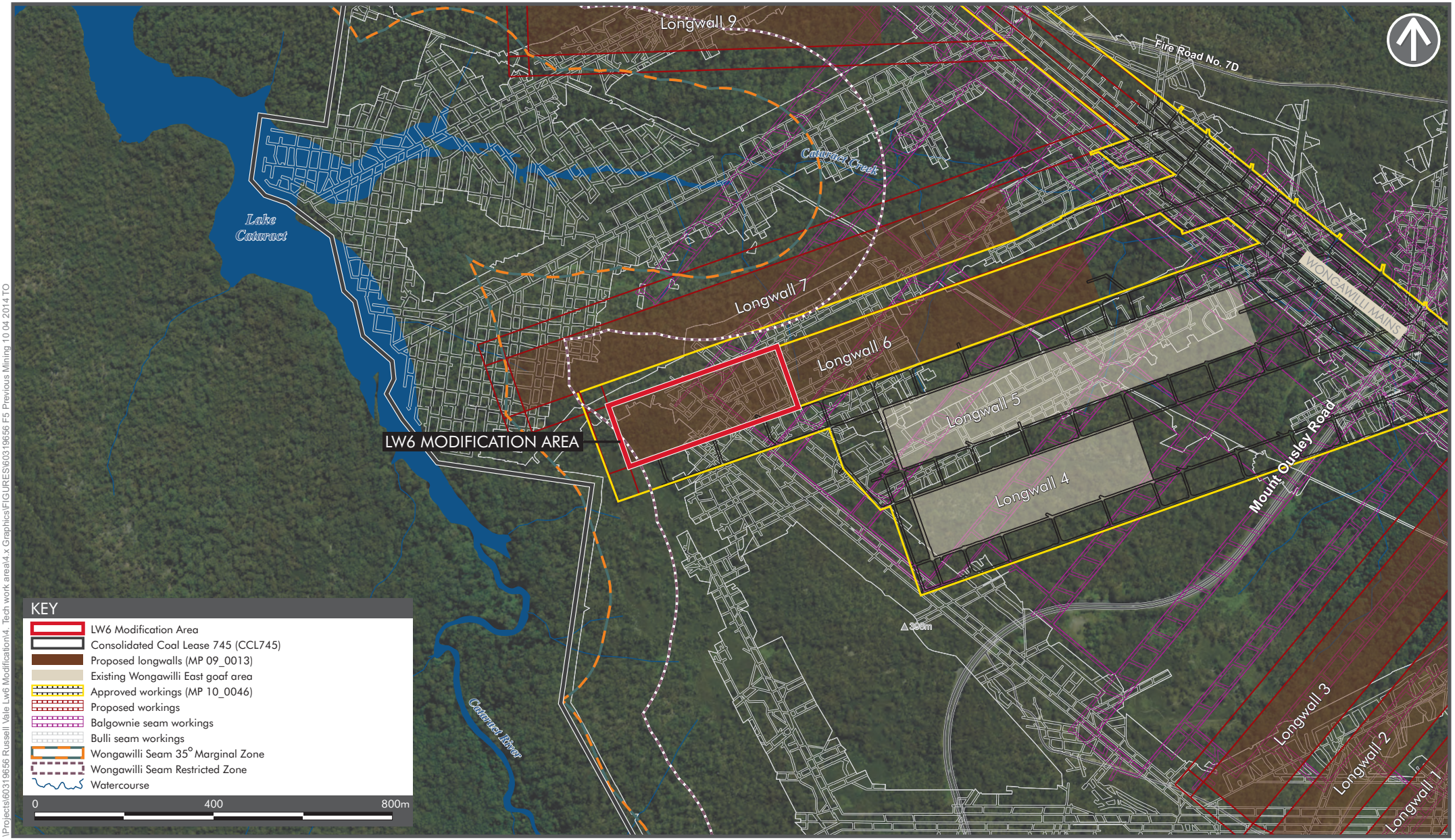
The method used to predict subsidence in the context of a multi-seam mining environment was primarily based on existing monitoring data for the Bulli, Balgownie and Wongawilli seams. Subsidence contours were estimated for each seam based on the availability of existing monitoring data, including:

- Subsidence profiles measured in the 1990's for the Bulli Seam, with adjustments made based on surface observations for the Balgownie Seam;
- Measured subsidence data sourced from the mine archives for the Balgownie Seam; and
- Subsidence predictions for the Wongawilli Seam based on measured subsidence profiles for LW4 and LW5.

Contours generated for each seam were drawn on a 10 metre by 10 metre grid with the cumulative subsidence profile for the three seams determined by superimposing the three plots and adding the respective subsidence contours. Contours of the surface topography were obtained using LiDAR data on a 10 metre by 10 metre grid, to which the cumulative subsidence profile was then added or subtracted from the surface topography.

Predicted tilts and strains were estimated using the Holla and Barclay method (2000) which is based on monitoring and experience of mining within the Southern Coalfields. Subsidence measurements obtained for LW4, LW5 and the historical data for the Balgownie Seam were used to demonstrate that the Holla and Barclay method provides a reasonable and conservative estimate of incremental maximum tilts and strains across longwall panels, even within multi-seam mining environments.

Conservative values for the upper limit of valley closure across Cataract Creek were estimated using the ACARP method, developed by Waddington, Kay and Associates (2003). An alternative approach was also used based on the incremental closure predicted from the nearest panel.



\Projects\60319656 Russell Vale Lw6 Modification\4. Tech work area\4.x Graphics\FIGURES\60319656 F5 Previous Mining 10 04 2014 TO

AECOM

PREVIOUS MINING UNDERTAKEN IN PROXIMITY TO LW6 MODIFICATION AREA

Russell Vale LW6 Modification

FIGURE 5

This page has been left blank intentionally.

4.1.3 Potential Impacts

4.1.3.1 Predicted Subsidence Effects

Table 2 provides a summary of the predicted subsidence parameters anticipated to occur above LW6 assuming extraction of coal across the full Underground Expansion Project (as modified through the Preferred Project Report for that project). The predicted subsidence outcomes assume full extraction of LW6 and the adjacent LW7, and are therefore likely to overestimate the subsidence impacts of extracting only the first 400 metres of LW6.

Actual subsidence measurements taken for LW4 and LW5 have been included in parentheses for comparison against modelling predictions.

Table 2 – Predicted Subsidence for the Russell Vale Colliery Underground Expansion Project (LW4, LW5 and LW6)

Subsidence Parameter	Long Wall Panel		
	LW4	LW5	LW6
Overburden depth to Wongawilli Seam (m)	300	265	285
Previous Bulli and Balgownie Seam subsidence (m)	1.9	0.9	1.5
Predicted subsidence for Wongawilli Seam (measured data) (m)	2.1 (1.6)	1.9 (1.5*)	2.1
Predicted tilt for Wongawilli Seam and (measured data) (mm/m)	35 (30)	36 (16*)	38
Predicted tensile strain for Wongawilli Seam and (measured data) (mm/m)	10.5 (7.5)	10.8 (4.5*)	11
Predicted compressive strain for Wongawilli Seam and (measured data) (mm/m)	21 (14)	22 (14*)	23
Predicted maximum closure on Cataract Creek (Southern Tributary) (mm)	N/A	210 (20*)	400

*Mining in progress at the time of the assessment (SCT, 2013)

Maximum subsidence over LW6 within the Wongawilli Seam is predicted to be up to 2.1 metres, taking into account the conservative additional effects of full extraction of LW6 and the adjacent LW7. Previous mining in the Bulli and Balgownie Seams is estimated to have caused 1.5 metres of subsidence.

Maximum tilt over LW6 is expected to peak at 38 millimetres per metre (mm/m). The peak value predicted represents the maximum expected tilt across the panel footprint and is most likely to be experienced where overlain by Bulli and/or Balgownie Seam goaf edges or changes in the gradient of the surface topography. Across the majority of the longwall panel, tilts are anticipated to be in the range of 50 to 90 per cent of the peak value.

Maximum strains over LW6 are expected to peak at 23 mm/m. The predicted peak value represents the maximum expected strain across the panel footprint. Across the majority of the longwall panel, strains are anticipated to be in the range of 20 to 30 per cent of the peak value.

The upper limit of valley closure across Cataract Creek was estimated using the ACARP Method, and is predicted in the range of up to 400 millimetres adjacent to the end of LW6 and up to 210 millimetres for LW5. These closure estimates are recognised as being conservative upper limit values, as they are estimated based on experience of closure in deep gorges at high stress levels. Monitoring undertaken for LW5 at the time of assessment indicates that measured closure values are much lower than the maximum upper limit values estimated using the ACARP Method (refer to actual data presented in parentheses in **Table 2**). Given the topography, significant valley closure along the section of Cataract River adjacent to LW6 is considered unlikely.

Subsidence beyond the goaf edge for LW6 is expected to be similar to the subsidence observed during mining of LW4 and LW5. Vertical movements of greater than 20 mm are expected to be limited to within a distance of 0.7 times the overburden depth from the nearest goaf edge, equivalent to an angle of draw of 35 degrees. This results in a subsidence profile which falls predominantly within the footprint of the panel being mined. Far field horizontal movements are expected to be of low magnitude but may still be perceptible at up to 1.5 to 3 times the overburden depth from the nearest goaf edge.

Figure 6 presents the contours for predicted subsidence over LW6 and the cumulative impact associated with the predicted subsidence for LW4 and LW5, extracted within the Wongawilli Seam. Unlike the data presented in **Table 2**, these contours do not include cumulative subsidence effects as a result of extraction from LW7 (and are therefore slightly less than the data in **Table 2**) and provide a more realistic prediction of impacts that may result from initial extraction within LW6. Notwithstanding, the contours presented in **Figure 6** assume full extraction of LW6 (rather than only the first 400 metres) and therefore overestimate subsidence levels, particularly towards the end of the proposed 400 metre extraction area (towards the north-east end). Importantly, **Figure 6** shows a subsidence area primarily contained within the panel footprint, in line with the existing subsidence profiles for the recently extracted LW4 and LW5.

In areas where previous mining has occurred in the Bulli and/or Balgownie Seams, vertical subsidence within the Wongawilli Seam is expected to be greater due to a reduction in bridging capacity of the overlying strata. In unmined areas or areas where substantial coal pillars exist within the previously mined seams, vertical subsidence is anticipated to be more in line with movements expected for single-seam mining. The impact of mining within a multi-seam environment is evident in a comparison of **Figure 5** and **Figure 6**, as increased levels of subsidence are predicted below areas of previous mining.

4.1.3.2 Potential Impacts on Surface Features

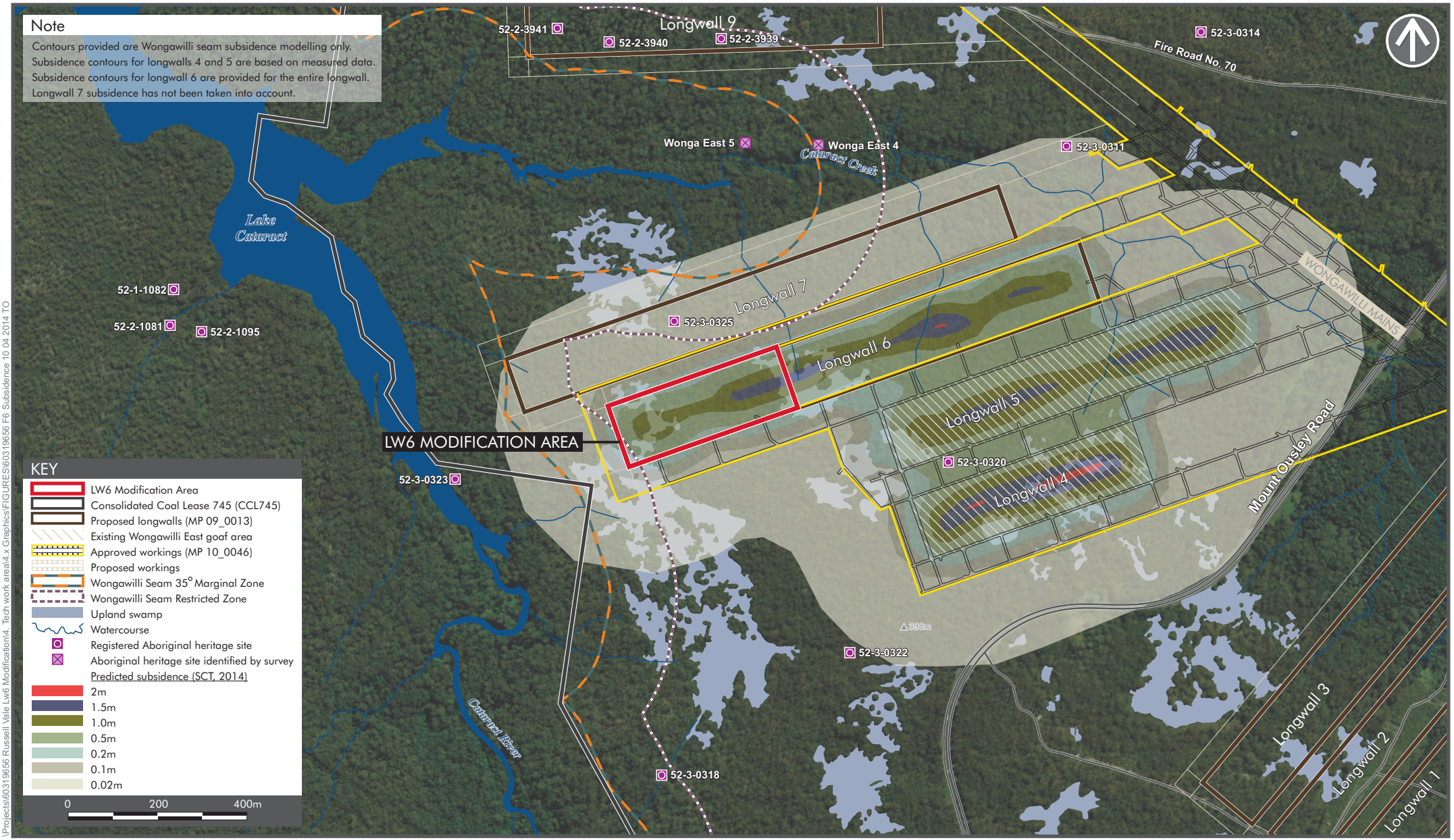
Potential subsidence impacts on surface features, as a result of mining of the LW6 Modification Area, have been considered in terms of impacts to natural features, archaeological heritage sites and surface infrastructure.

Cataract Reservoir

A Marginal Zone of a 35 degree angle of draw from the full supply level (FSL) of Lake Cataract has been used as the basis for the design and layout of longwall panels proposed for the Underground Expansion Project (as amended by the Preferred Project Report). The Marginal Zone has been calculated based on 0.7 times the depth (0.7D) of the coal seam, to form a protection barrier in line with the NSW Dams Safety Committee's restrictions for mining within a Notification Area. The purpose of the barrier is to protect the reliability of supply and the structural integrity of the reservoir from the potential impacts of mining. An additional buffer, referred to as the Restricted Zone, has been calculated based on an additional 0.5 times the depth (0.5D) of the coal seam. Mining may only be undertaken within the Restricted Zone where approval has been obtained from the NSW Dams Safety Committee. The Marginal Zone and the Restricted Zone for Lake Cataract, Cataract River and Cataract Creek are shown on **Figure 6**.

The presence of previously mined Bulli Seam workings within the Marginal Zone is expected to reduce the effectiveness of the barrier between the reservoir and the proposed LW6. However, potential pathways for flow or leakage from the reservoir into the mine workings are considered unlikely given the presence of overlying strata with sufficiently low hydraulic conductivity separating the two seams and the reservoir.

A significant benefit of previous mining activity undertaken within the Bulli and Balgownie Seams is that the dykes and faults through the area are very well defined. As such, the presence of geological fault structures, such as Dyke D8 and the Corrimal Fault, are considered in the assessment and subsidence resulting from the potential instability of faults has been included in the subsidence modelling for the site. In addition, experience from previous mining, and experience of faults within the Southern Coalfields more broadly, indicates that the Corrimal Fault is unlikely to be hydraulically conductive or to present a risk of water ingress if intercepted during mining. The Dyke D8 is considered to be the only geological structure with potential for increased hydraulic conductivity. However, a separation exists between the reservoir and the mine along the dyke and previous mining within the Bulli and Balgownie Seams does not indicate a history of increased inflow, despite previous workings being undertaken adjacent to the dyke directly under Cataract Creek.



\Projects\60319656 Russell Vale Lw6 Modification\4. Tech work area\4.x Graphics\FIGURES\60319656 F6 Subsidence 10 04 2014 TO

AECOM

SUBSIDENCE

Russell Vale LW6 Modification

FIGURE 6

This page has been left blank intentionally.

Cataract River

Cataract River is located generally to the west of the longwall panels proposed as part of the Underground Expansion Project. Only the southern portions of LW6 and LW7 are proposed to be mined directly below the slopes that lead down to Cataract River (but not beneath the river itself). The LW6 Modification Area is located on the northern side of the ridge and any downslope horizontal subsidence movements are expected to occur mainly on the northern slope toward Cataract Creek.

There is considered to be little potential for significant valley closure movements along the section of Cataract River adjacent to the start of LW6. The maximum valley closure over Cataract River, modelled using the ACARP method, is approximately 30 mm from LW6 which is unlikely to result in any significant or perceptible impact.

Section 4.3 provides further detail on the assessment of impacts on surface water.

Cataract Creek

The layout of longwall panels proposed for the Underground Expansion Project has been designed to avoid undermining of Cataract Creek.

Experience in Hawkesbury Sandstone river channels suggests that where valley closure is less than 200 millimetres across major river channels, such as Cataract Creek, a total loss of surface flow is unlikely to occur. By adopting a target of closure of less than 200 millimetres, coupled with in-field monitoring and an adaptive management approach to coal extraction, it is anticipated that the potential for loss of surface flow can be adequately managed.

It is expected that measured closure as a result of extraction of longwalls will be significantly lower than the predicted values for closure, as provided in **Table 2**. Monitoring undertaken during the extraction of LW5 indicates that closure across Cataract Creek commenced when LW5 was approximately 400 metres from the creek. At the time of assessment, the incremental closure across Cataract Creek as a result of extraction of LW5 was 20 millimetres, compared with the conservative predicted value of 210 millimetres (refer to **Table 2**). Closure movement across the creek has continued at a steady rate of around 12 millimetres per 100 metres of longwall retreat. The steady, predictable response allows planning for a pre-determined level of closure across Cataract Creek well in advance of reaching any given set target. This knowledge, coupled with a commitment to adaptive management of coal extraction will ensure that the threshold closure value of 200 millimetres is not exceeded, and that mining operations are modified accordingly should monitoring indicate that this threshold is being approached.

As such, it is anticipated that additional closure over Cataract Creek is likely to occur as a result of extraction of LW6. However, an adaptive management strategy is proposed to manage the impacts of subsidence and closure over Cataract Creek within the target of 200 millimetres, based on closure monitoring and cessation of mining in the likelihood of significant perceptible impacts of valley closure on Cataract Creek. Adaptive management is considered to be an effective method of managing the potential for subsidence impacts on Cataract Creek. Given the distance of the LW6 Modification Area from Cataract Creek, little to no increased closure in the main channel of the creek is expected.

There is also considered to be potential for valley closure across numerous first, second, and third order creeks in areas where longwall panels are located directly below the slopes that lead down to these creeks or where creeks are within about 300 metres of the longwall panel goaf edge. A first order tributary of Cataract Creek is located in proximity to the proposed LW6 Modification Area (refer to **Figure 6**) and is likely to experience impacts associated with valley closure. These potential impacts would also be subject to an adaptive management approach.

Section 4.3 provides further detail on the assessment of impacts on surface water.

Upland Swamps

Thirty-two upland swamps are located across land overlying the proposed Underground Expansion Project. Two of these swamps, CRUS1 and CCUS4, are partially mapped within the LW6 Modification Area as indicated on **Figure 6**.

Many of these swamps have experienced subsidence as part of previous mining operations in both the Bulli and Balgownie Seams. CCUS4 has been previously mined under as part of longwall extraction of the Balgownie Seam, which resulted in a vertical subsidence of 0.8 metres with no observed adverse effects on the swamp.

The proposed mining of the LW6 Modification Area is not expected to cause significantly different impacts to those already experienced. Perceptible fracturing of the sandstone strata below swamps is expected as a result of mine subsidence and, based on observations from previous mining, an associated short term loss of piezometric pressure within the surface layers of some swamps is expected. However, previous mining and subsidence of swamps does not appear to have affected their long term condition.

More work is required to determine the relationship between mining subsidence and the long term health of swamps. The proposed extraction of the LW6 Modification Area below CRUS1 and CCUS4 provides the opportunity to monitor ground movements, groundwater impacts and any ecological changes in response to longwall extraction to provide evidence to guide the management of longwall mining in proximity to these upland swamps. The development of a monitoring and review strategy involving relevant experts is proposed to manage mining impacts on these swamps and will include a review of the recovery of these features from previous impacts and the implication of this recovery for future swamp protection strategies. This method would be incorporated into the abovementioned adaptive management approach to provide a risk-based operational assessment of actual impacts with appropriate responses given effect through amendments to extraction activities where required to protect swamp health and associated ecological values.

Section 4.3 provides further detail on the assessment of impacts on upland swamps and their ecology.

Hawkesbury Sandstone Cliffs and Rock Formations

The only significant cliff formation in the area is associated with Brokers Nose on the Illawarra Escarpment, which is located approximately 2.5 kilometres south-east of LW6. Brokers Nose is remote from proposed mining and there is considered to be no potential for mining subsidence to impact the cliff formations along the Illawarra Escarpment.

Most sandstone cliff formations in the area are less than five metres high and none are considered to be significant based on the assessment criteria presented in the PAC Bulli Seam Operations report. Some perceptible cracking on hard rock surfaces is expected to be apparent as a result of proposed mining. Minor rock falls are expected on up to five per cent of the length of sandstone cliff formations that are mined directly beneath. Several short sections of cliffs and steep slopes are located to the north and west of LW6.

Impacts on steep slopes are expected to be limited to the potential for subsidence cracks to develop at topographic high points that are directly mined under and at the start of longwall panels that commence mining in a downslope direction. The environmental consequences of impacts on steep slopes are considered to be generally negligible although some cracks may need to be filled in where they are crossed by vehicle access tracks.

Aboriginal Heritage Values

Three Aboriginal heritage sites are mapped within the 0.02 metre subsidence contour for LW6, as identified in **Figure 6**. An additional four Aboriginal heritage sites are located within a 600 metre radius of the LW6 Modification Area. However, none of these sites are located within the panel footprint or proposed to be directly undermined as part of this modification.

A rock shelter with deposits is located at Aboriginal Heritage Information Management System (AHIMS) site 52-3-0311 and is considered unlikely to be impacted by mining of the proposed LW6 Modification Area given its location. Mining of the LW6 Modification Area would result in a reduced subsidence profile compared with the profile shown in **Figure 6**, with impacts primarily located within the 400 metre panel footprint.

Grinding grooves, such as the axe grinding groove located at AHIMS site 52-3-0320, may experience impacts associated with cracking of bare rock areas. However, the frequency of cracking decreases with distance from the goaf edge of the panel being mined, such that impacts are expected to be imperceptible at a distance of 0.4 times the overburden depth, approximately 120 metres to 150 metres from the goaf edge. As a result, the probability of cracking occurring at AHIMS site 52-3-0320 is considered to be low.

A rock shelter with deposits, located at site AHIMS 52-3-0325, is associated with detached boulders and is unlikely to be significantly impacted as a result of mining within the LW6 Modification Area.

Section 4.4 provides further detail for the assessment of impacts on Aboriginal cultural heritage values.

Mount Ousley Road

Impacts of mine subsidence on Mount Ousley Road are limited by the distance of the road from the nearest goaf edge. Low levels of vertical subsidence of less than 100 millimetres are expected around Mount Ousley Road as a result of mining of all longwall panels proposed as part of the Underground Expansion Project. Mining of LW4 has already resulted in subsidence of 30 millimetres at Mount Ousley Road. Impacts are anticipated to be imperceptible, although remedial work may be required to prevent water ingress into minor tension cracks, formed as a result of previous mining, is recommended to protect the road sub-base. Given the distance between the road and the proposed LW6 Modification Area, impacts of subsidence on Mount Ousley Road as a result of this modification are unlikely.

Other Surface Infrastructure

There are four electricity transmission lines located in two corridors between Mount Ousley Road and the Illawarra Escarpment. All four transmission lines have been previously undermined by extraction from the Bulli and Balgownie Seams. Predicted subsidence for LW1, LW2 and LW3, proposed as part of the Underground Expansion Project, is likely to impact on the structural integrity of several transmission towers, requiring the construction of cruciform bases. However, given the distance between the transmission towers and the proposed LW6 Modification Area, impacts of subsidence on the transmission lines as a result of this modification are unlikely.

There is considered to be no potential for significant horizontal far field effects to impact on the Picton Road Interchange or telecommunications infrastructure located at Brokers Nose on the Illawarra Escarpment.

4.1.4 Mitigation and Management

Major subsidence consequences have been eliminated through consideration of the mine layout. Where effects could not be avoided through the layout of the mine, narrower longwalls and wide chain pillars have been included in the mine plan in order to reduce potential subsidence impacts. The avoidance of mining directly under the main channel of Cataract Creek provides a buffer against closure related impacts.

Subsidence monitoring is currently being upgraded for the Russell Vale Colliery in line with industry best practice, including the use of repeat surveys in three dimensions with far field GPS control over a distributed array of monitoring points. Survey monitoring would be used to establish a baseline of subsidence movements cross the Underground Expansion Project assessment area and an area within a 3 kilometre radius from the proposed mining area to monitor far field effects. High resolution point to point measurement of valley closure across Cataract Creek will continue to occur at a number of crossing points.

Subsidence assumptions and predictions would be confirmed through ongoing monitoring, and adjustments to the start and finish points of the longwall would be made, where necessary, to manage consequences of potential subsidence impacts.

As noted earlier in this section, an adaptive management approach will be implemented to ensure that potential subsidence effects from mining within the first 400 metres of LW6 is monitored and where elevated impacts are observed, extraction activities would be amended accordingly to avoid or minimise those impacts. Given the relatively short length of long wall panel proposed to be extracted as part of this modification, the residual risk associated with subsidence effects would be limited. This low risk section of panel extraction would be used as a basis to inform an adaptive management approach for the broader Underground Expansion Project.

Further mitigation of the potential impacts of subsidence is addressed in subsequent sections of this document, as it relates to each specific impact.

This page has been left blank intentionally.

4.2 Hydrogeology

The following groundwater assessments have been undertaken to determine the impacts of mining within the LW 6 modification area on groundwater:

- a Groundwater Impact Assessment completed by GeoTerra (2012a) as part of the Environmental Assessment for the Underground Expansion Project;
- a supplementary groundwater assessment completed by SCT (2014) as part of the Russell Vale Preliminary Residual Matters Report for the Underground Expansion Project.

These two assessments have been used as the basis of assessment of the current modification application and are provided in **Appendix D**.

4.2.1 Existing Environment

Groundwater is typically encountered within four primary subsurface systems in the Wonga East area, (Geoterra, 2012a), including around LW6. These subsurface systems include:

- unconsolidated, perched ephemeral aquifers located within upland swamps. These perched aquifers support the groundwater dependent ecosystems of CRUS1 and CCUS4;
- perched ephemeral aquifers within the Hawkesbury Sandstone stratum located generally within 20 metres of the ground surface;
- deeper basement Hawkesbury Sandstone which can be described as the groundwater table for the region. This groundwater system is hydraulically separate from overlying perched groundwater systems; and
- A deeper groundwater system below the low permeability Bald Hill Claystone providing a degree of separation between the Hawkesbury Sandstone and underlying Bulgo Sandstone.

Shallow groundwater systems are recharged by rainfall infiltrating the subsurface, with deeper systems recharging by lateral groundwater flows. Fluctuations in groundwater levels for shallow groundwater systems are dependent on surface topography and proximity to surface water bodies such as Cataract Creek and Cataract Reservoir.

There are several existing groundwater monitoring wells located in the Wonga East area as outlined in **Table 3** and as shown on **Figure 7**.

Table 3 – Existing Groundwater Bores in the Wonga East Area

Bore	Depth (mbgs)
NRE1 A	47.2
NRE1 B	173.1
NRE1 C	24.0
NRE1 D	174.0
NRE1 GW01	170.1
NRE1 GW01a	27.0
SWM3	332.2

Shallower monitoring bores have also been installed within the Wonga East area relating to groundwater dependent ecosystems including Upland Swamps, and are discussed further in **Section 4.3.1**.

4.2.2 Assessment Methodology

The GeoTerra (2012) groundwater impact assessment included:

- conceptualisation of the local groundwater flow processes;
- measurement of hydraulic parameters in the field;
- simulation using computer based mathematical modelling with FEFLOW Model simulation of the proposed workings was used to predict groundwater depressurisation and mine water seepage impacts on the overburden strata and catchment of Cataract Creek, Cataract River and Lake Cataract;

- imposition of changes brought about by the proposed extraction; and
- assessment of the resulting impacts.

The SCT groundwater assessment (2014) reviewed and presented the results of:

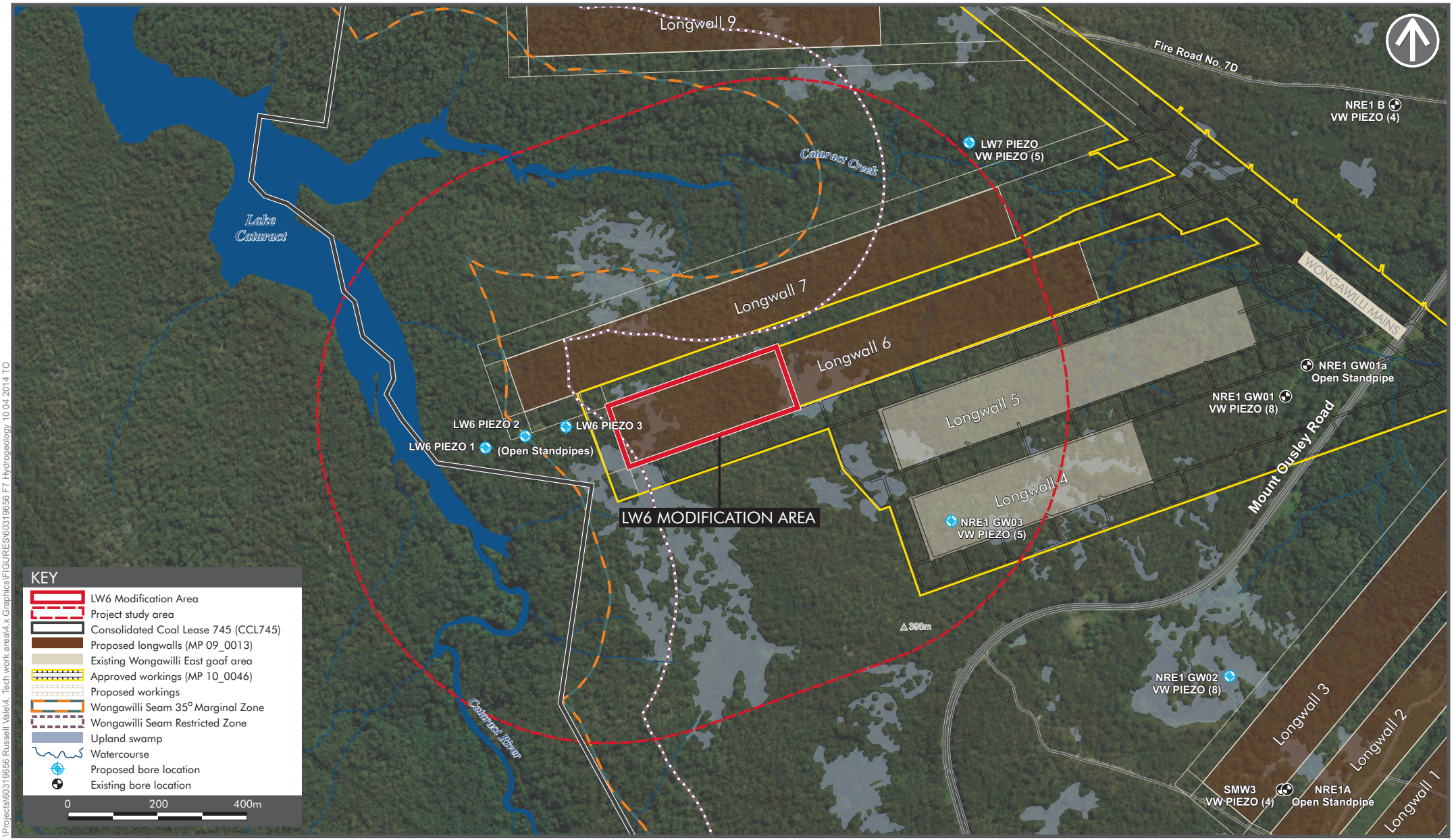
- a mine water balance specifically for the Wongawilli Seam but also including the Bulli and Balgownie Seam operations where information was relevant to the Preferred Project Report for the Underground Expansion Project;
- piezometric pressure monitoring within the overburden strata around the site but particularly in the Wonga East area; and
- hydraulic conductivity measurements representative of the overburden strata including data available from other relevant sites.

The review presented the factual data, clarified assumptions, and estimated the effect of 'unknowns' based on available data to help develop a conceptual groundwater model suitable to use as a basis for a more extensive numerical groundwater model based on this data.

In addition, a MODFLOW Surfact based groundwater model is currently being prepared by Groundwater Exploration Consultants with reference to:

- the 2012 Aquifer Interference Policy, issued by the NSW Office of Water (NOW); and
- the 2012 Australian Groundwater Modelling Guidelines, issued by the National Water Commission.

It is expected that this numerical model will be available to inform the assessment and determination of the Underground Expansion Project, with potential additional interpretive value for this modification application if finalised within a compatible timeframe.



\Projects\60319656 Russell Vale\4. Tech work area\4.x Graphics\FIGURES\60319656 F7 Hydrogeology 10 04 2014 TO

AECOM

HYDROGEOLOGY

Russell Vale LW6 Modification

FIGURE 7

This page has been left blank intentionally.

4.2.3 Potential Impacts

This section considers the potential impacts on groundwater as a result of the extraction of coal and consequential subsidence associated in and around the LW6 Modification Area.

The process of longwall mining creates fracturing and deformation of the overlying strata can result in changes in the permeability and storage properties of the deformed overburden. In addition, the removal of coal from the coal seam causes groundwater to flow into the underground mine from the surrounding strata.

Potential impacts associated with the extraction of coal from the first 400 metres of LW6 include:

- inflow of water to the underground mine and the management of that mine water;
- impacts on groundwater levels during and after mining;
- impacts on baseflow and stream leakage to and from the surface waterways during and after mining; and
- impacts on groundwater quality via mining-induced mixing of groundwater from different strata.

4.2.3.1 Aquifer Interference

The observed ingress of groundwater into the mine workings, from monitoring undertaken as part of the water balance for extraction of LW4 and LW5, is approximately 1.1 megalitres (ML) per day (SCT, 2014). Ingress of groundwater is considered to be primarily attributed to subsidence movements and tension cracks observed on a section of the ridge south of Cataract Creek, which is likely to be the primary source of seepage of surface flows into the mine workings. The overburden strata in this area are considered to have a high hydraulic conductivity to a depth of at least 140 metres below the surface.

SCT (2014) estimates that the current water make of ingress into the mine workings (LW 4 and LW5) comprises:

- 0.3 ML/day from mining development headings in the Wongawilli Seam;
- 0.2 ML/day for up dip inflow in the Bulli and Balgownie Seams;
- 0.1 ML/day additional inflow from mining LW4; and
- 0.5 ML/day from mining LW5.

LW6 is anticipated to contribute additional groundwater ingress, with a magnitude similar to the inflow estimated for LW5 (i.e. around 0.5 ML/day). Additional flows are expected to originate from the higher conductivity recharge zones located along the ridgeline between Cataract Creek and Cataract River. Horizontal shear planes are also likely to be mobilised as a result of extraction of LW6, with the potential to create some additional flow into the mine workings. As a result, the total cumulative groundwater inflow anticipated to occur after the extraction of the LW6 Modification Area is approximately 1.6ML/day.

The site is subject to a groundwater licence (10BL602992) which limits water extraction from the mine workings to 365 ML per year, which is equivalent to an average extraction of 1 ML/day. The expected increase in groundwater ingress due to mining of the LW6 Modification Area is therefore anticipated to exceed the limits of the current groundwater licence for the site. On this basis, the Proponent will be required to secure an additional groundwater allocation through its existing licence or the application of a new groundwater licence for the site.

4.2.3.2 Management of Mine Water

Groundwater that enters the mine workings from the surrounding strata will be extracted, collected in underground sumps and pumped to the surface via the existing underground mine water infrastructure. Mine water from LW6 will be processed at the existing surface facilities area, in line with the current approved operations. The Proponent is currently permitted to discharge up to 2.5 ML/ day under dry weather conditions in accordance with the site's existing Environment Protection Licence (EPL 12040). This limit is sufficient to accommodate additional water from the LW6 Modification Area.

No changes are proposed to current management of mine water on the site. Consequently, management of mine water is not anticipated to generate impacts beyond those currently being managed under existing approvals.

4.2.3.3 Impacts on Groundwater during and after Mining

The potential impacts of mining within Wonga East area on groundwater within the overlying strata were predicted by Geoterra (2012a) and are summarised in **Table 4**. These impacts are based on the full scope of the original Underground Expansion Project, and as such, overestimate the potential impacts of extraction from the first 400 metres of LW6.

Table 4 – Potential Groundwater Impacts Summary for Wonga East (Geoterra, 2012)

Strata	Impacts
Shallow to mid Hawkesbury Sandstone	Temporary lowering of the upper Hawkesbury Sandstone phreatic surface by up to 4 m at the northern end of extraction in the Wonga East area with subsequent recovery of the phreatic surface and no observable change in water quality.
Deep Hawkesbury Sandstone	Temporary lowering and subsequent recovery of the phreatic surface, with no observable change in water quality.
Bald Hill Claystone	Due to partial erosion into and through the Bald Hill Claystone in the valley of Cataract Creek, the Hawkesbury Sandstone and upper Bulgo Sandstone may not be hydraulically separated within the eroded area. However, where it is not eroded, the semi confining integrity of the Bald Hill Claystone is anticipated to remain following subsidence.
Narrabeen Group and Illawarra Coal Measures	Hydraulic interconnection and depressurisation of the sedimentary overburden under the Bald Hill Claystone, up to the mid / upper

The groundwater assessment undertaken by SCT (2014) suggests that there is potential for the mining of LW6 to result in the drawdown of overlying aquifers. This potential has been assessed using the most recent monitoring results from groundwater inflows into LW5. Mining of LW4 and LW5 within the Wongawilli Seam, and previous mining undertaken in the Bulli and Balgownie Seams is considered to have contributed to increased vertical hydraulic conductivity along a section of the ridge south of Cataract Creek, creating greater potential for drawdown.

However, the magnitude of downward flow appears to be largely restricted by the naturally low vertical hydraulic conductivity of the deeper overburden strata, particularly around the level of the Stanwell Park Claystone, and the relatively large depth of mining. In the vicinity of LW6 and LW7, the naturally low vertical hydraulic conductivity of the overburden strata and depth of mining is expected to restrict inflows from basal shear planes at the base of Cataract Creek into the mine to low levels provided the zone of depressurisation does not reach high enough to interact with the basal shear planes. Consequently, the monitoring data from LW5 indicates that extraction of LW6 is unlikely to create drawdown that will significantly affect baseflow in Cataract Creek.

4.2.3.4 Stream Baseflow Impacts

The Subsidence Impact Assessment (refer to **Section 4.1**) indicates that mining of LW6 may result in surface cracking impacts with the potential for consequential effects on base flow and stream leakage to and from surface water ways.

Upland Swamps

Mine subsidence due to extraction within the LW6 Modification area is likely to result in fracturing of the base of small sections of upland swamps, CRUS1 and CCSU4, in areas undermined by or in proximity the extraction. Fracturing or cracking of the base of the swamps could affect shallow aquifer levels within the swamps. However, Geoterra (2012) has predicted that localised fracturing of the swamp bed would result in minor to negligible changes to duration and flow, in line with current variability experienced under climatic influences.

Vertical cracking of deeper strata is unlikely to result in increased hydraulic connectivity due to the presence of the Bald Hill Claystone layer and a constrained vertical flow zone in the upper Bulgo Sandstone. These confining layers are considered to provide a barrier to free drainage, preventing the loss of water into the proposed mine workings.

4.2.3.5 Cataract Creek

Geoterra (2012a) indicates that modelled subsidence induced cracking could potentially affect stream flow in the waterways overlying and downstream of the proposed workings at Wonga East, although the anticipated stream flow losses would have little impact on the Cataract Reservoir water storage volume. In addition, the impacts would be restricted to short reaches where flow infiltrates into cracks in the bed, then remerges further downstream, as

opposed to contributing to groundwater inflows into the underground mine. The predicted stream baseflow changes to Cataract Creek are 0.06 – 0.07 ML/day (Geoterra, 2012a).

The SCT groundwater assessment supports this prediction as monitoring of mine inflows undertaken during the mining of LW5 have not recorded any perceptible increase in inflow as mining approached Cataract Creek. If a significant source of inflow was from the creek, an increase in flow rate into the underground mine workings would be expected as the flow path length between the creek and the mine decreased. The resolution of the underground monitoring is of the order of 0.1ML/day indicating any potential increase in flow from Cataract Creek into the mine during mining of LW5 was less than about 0.1ML/day.

There were no visual indications of flow loss from Cataract Creek and no losses were recorded, but it should be recognised that flow meter systems able to be installed in creek channels without major construction works only have a resolution of the order of ±0.5ML/day and therefore may not be able to detect changes with a magnitude of 0.1ML/day or any transient flows that may have been necessary to recharge groundwater within the overburden strata. However, given the distance of the LW6 Modification Area from Cataract Creek, little to no water loss from the main channel of the creek is expected.

4.2.4 Mitigation and Management

4.2.4.1 Adaptive Management Measures

Mitigation measures for managing the impacts of extracting the first 400 metres of LW6 on groundwater include:

- application of an adaptive management approach to extraction of LW6, based on amended on mining activities in response to observed groundwater effects identified through surface and groundwater monitoring;
- quantitative and qualitative monitoring of shallow and deep groundwater before, during and after the extraction of LW6;
- undertaking additional monitoring that may be required in accordance with a LW6 Water Management Plan (or existing Water Management Plan updated to reflect extraction of the first 400 metres of LW6);
- manage of impacts in accordance with the Trigger Action Response Plan (TARP) and triggers;
- development and implementation of adaptive management contingency measures in the event that elevated impacts are detected; and
- provision for additional groundwater monitoring if subsidence is detected in areas beyond current predictions.

4.2.4.2 Monitoring Measures

Monitoring locations proposed for extraction of the first 400 metres of LW6 are outlined in **Table 5** below.

Table 5 – Proposed Groundwater Bores to be Installed for LW6 Modification

Bore	Target Depth (mbgs)
NRE1 GW02	362.0
NRE1 GW03	372.7
NRE1 GW04	355.0
LW6 PIEZO 1	333.0
LW6 PIEZO 2	341.0
LW6 PIEZO 3	347.0
LW7 PIEZO	332.0

Groundwater monitoring will be undertaken at the locations listed in **Table 5** as follows:

- groundwater quality:
  - bimonthly prior to mining;
  - monthly during mining; and
  - quarterly post mining.
- Standing water levels will be monitored:
  - daily prior to mining;
  - twice daily (automatic) and monthly (manual) during mining; and
  - quarterly post mining.

Mine inflows will be monitored monthly during and post mining to ensure that mine water make is in line with the allocation stipulated in the groundwater licence (10BL602992), including any additional groundwater allocation that may be granted/ acquired. Further, an end of extraction report will be prepared, summarising monitoring undertaken during mining of LW6 and outlining any changes in the groundwater. Results of the monitoring programs will be reviewed one year after pillar extraction has been completed and an updated ongoing monitoring and remediation program will be developed in association with NOW and the SCA.

4.3 Surface Water

The Environmental Assessment for the Underground Expansion Project is based on several surface water assessment components, including a Water Management Report (Beca, 2011), a Stream Assessment (WRM Geoterra, 2012b) and an Upland Swamp Assessment (Biosis, 2012). Further relevant information is provided in the Environmental Assessments conducted for the NRE No.1 Preliminary Works Project and modification of approval for that project to allow for extraction of LW4 and LW5. This section provides a summary of the findings of theses assessments as they relate to the LW6 Modification Area.

Relevant surface water specialist reports considered as part of this modification are provided in **Appendix E**.

4.3.1 Existing Environment

Topography within the LW6 Modification Area and surrounding lands undulates with natural gullies and depressions. Rain water falling within the Lake Cataract catchment flows as overland flow towards these depressions eventually reaching Lake Cataract located to the north-west of the LW6 Modification Area footprint.

Cataract River drains towards Lake Cataract to the west of the LW6 Modification Area footprint. At its closest point, Lake Cataract is approximately 300 m to the west/south-west of the proposed LW6 extraction. Lake Cataract forms part of the water storage reservoir servicing the Sydney Metropolitan Area and surrounds, predominantly for potable consumption purposes.

Access to the area forming the catchment for Lake Cataract is strictly controlled by the Sydney Catchment Authority (SCA). The Proponent has agreements in place with SCA allowing access to surface infrastructure (primarily ventilation shafts and associated infrastructure) within the catchment.

Falling within the LW6 Modification Area footprint are two Upland Swamps of Special Significance listed under the *Threatened Species Conservation Act 1995*. As shown in **Figure 8**, these consist of:

- CRUS1 located to the south and encroaching into the western portion of the LW6 Modification Area footprint. CRUS1 spans an area of approximately 11.4 ha and drains west directly into Lake Cataract; and
- CCUS4 within the east of the LW6 Modification Area footprint covering an area of approximately 1.8 ha. CCUS4 drains north into Cataract Creek and eventually into Lake Cataract to the north-west.

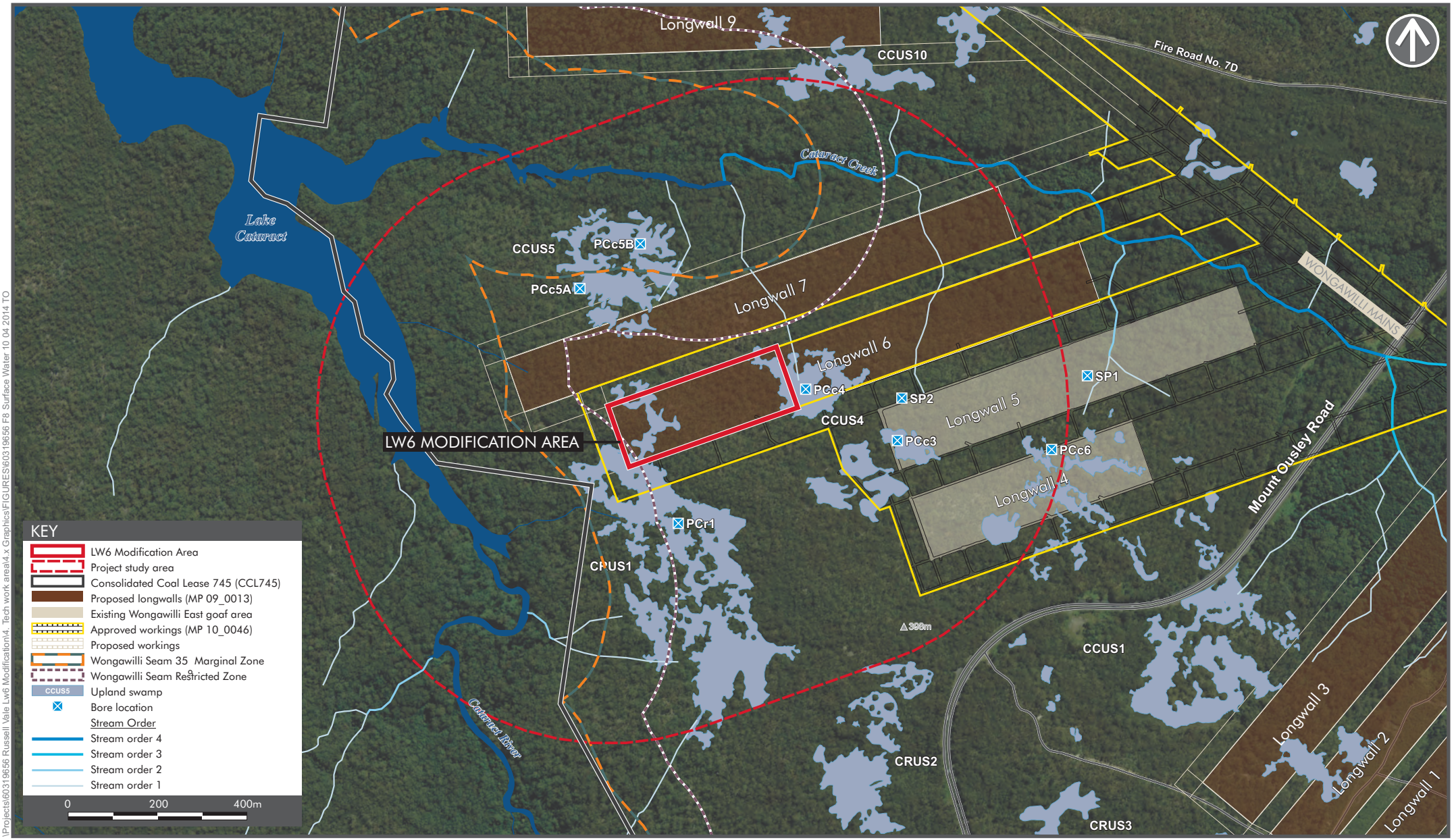
A further two Upland Swamps of Special Significance are located within proximity to but outside the LW6 Modification Area footprint (CCUS5 and CCUS1 to the north and south-east of the LW6 Modification Area footprint respectively). Monitoring has indicated that CCUS4 has experienced subsidence of up to 0.9 m due to previous underground mining with no observed adverse impacts (SCT, 2013). Potential impacts associated with subsidence at this swamp were effectively managed in accordance with the Subsidence Management Plan development LW4 and LW5.

Bores monitoring shallow groundwater flows for swamps located within and around the LW6 Modification Area are listed in **Table 6**.

Table 6 – Water Bores Installed in the LW6 Modification Area and Surrounds

Bore	Upland Swamp	Depth (mbgs)	Intake Screen (m)
PCc2	CCUS2	1.6	1.1 – 1.6
PCc3	CCUS3	1.2	0.7 – 1.2
PCc4	CCUS4	0.9	0.4 – 0.9
PCc5A	CCUS5	1.24	0.7 – 1.2
PCc5B	CCUS5	1.31	0.8 – 1.3
PCc6	CCUS6	1.2	0.7 – 1.2
PCr1	CRUS1	0.55	0.3 – 0.55
PB4	BCUS4	0.6	0.25 – 0.6
SP1	-	0.6	0.1 – 0.6
SP2	-	1.05	0.55 – 1.55

As shown in **Figure 2**, the LW6 Modification Area footprint falls within the Lake Cataract Notification Area, which requires notification of the NSW Dams Safety Committee to determine if there is potential for Lake Cataract to be adversely affected by mining activities. The Proponent has already engaged with the Committee in relation to potential impacts associated with the Underground Expansion Project and will continue to do so with respect to this modification. A small portion of the western part of the LW6 Modification Area footprint also falls within the Wongawilli Seam Restricted Zone, but is located outside of the Wongawilli Seam 35 degree angle of draw.



\Projects\60319656 Russell Vale Lw6 Modification\4. Tech work area\4.x Graphics\FIGURES\60319656 F8 Surface Water 10 04 2014 TO

AECOM

SURFACE WATER

Russell Vale LW6 Modification

FIGURE 8

This page has been left blank intentionally.

4.3.2 Assessment Methodology

A review has been completed of available information relating to surface water in the LW6 Modification Area including:

- *Underground Expansion Project Preferred Project Report Including Response to Submissions* (Gujarat NRE, undated);
- *NRE No. 1 Colliery Project Application (09_0013) Environmental Assessment (*ERM, 2013); and
- *Longwalls 4 and 5; Maingates 6, 7 and 8 – Application for s75W Modification 1 to MP 10_0046 – Preliminary Works Project* (Cardno, 2012a).

The environmental assessment completed for the Underground Expansion Project included a Surface Water Assessment. This assessment included:

- a desktop survey of available information;
- field monitoring of streams and swamps identified within the Underground Expansion Project study area; and
- computational modelling of stream flows for pre and post mining conditions.

For the purpose of this assessment to support the modification application to allow extraction of the first 400 metres of LW6, a study area of 600 metres surrounding the LW6 Modification Area has been adopted. This is based on study area parameters recommended by the Southern Coalfields Inquiry and is consistent with previous investigations completed for the NRE No.1 Preliminary Works Project (including the modification to include extraction of LW4 and LW5).

4.3.3 Potential Impacts

The proposed modification would only involve underground extraction of coal. No changes to current approved surface works, including surface water management measures, is proposed as part of this modification.

Similar to impacts experienced across the site during previous underground mining activities, the proposed modification has the potential to generate the following potential impacts to surface water as a result of the proposed modification include:

- valley closure and streambed cracking as a result of subsidence movements which may in turn alter stream hydrology in watercourses discharging to Lake Cataract (primarily Cataract Creek and its tributaries);
- an increase in the connectivity between surface and groundwater, which may result in the alteration of water quality in watercourses;
- subsidence induced cracking of swamp beds of upland swamps CRUS1 and CCUS4;
- changes to topography within the LW6 Modification Area footprint and residual effects surrounding the footprint which may alter the characteristics of hydrology in the Lake Cataract catchment; and
- impacts to the structural integrity of Lake Cataract creating drawdown of water to the subsurface stored within the reservoir.

Given the scale of the proposed extraction from LW6, potential impacts over and above existing mining operations are likely to be negligible to low.

4.3.3.1 Changes to Watercourse Hydrology and Connectivity to Groundwater

The two closest watercourses to LW6 are Cataract Creek and Cataract River.

Following completion of LW4 and LW5, flows in Cataract Creek are predicted to decline by approximately 0.07 ML/day. This equates to an approximate 0.6 per cent reduction in flows of Cataract Creek with flow losses expected to be accommodated within the underlying Hawkesbury Sandstone and upper Bulga Sandstone strata. A decrease is also expected in seepage from Cataract Creek and its tributaries' streambeds due to a reduction in the groundwater gradient drawing surface water to the subsurface (GeoTerra, 2012b).

Changes in flow conditions in Cataract River to the south-west of the LW6 Modification Area are expected to be negligible with no anticipated cracking of Cataract River bedding (SCT, 2013). As detailed in **Section 4.1.3**, valley closure of greater than 200 millimetres has the ability to cause losses of surface water to the subsurface. This subsidence effect would be monitored and subject to an adaptive management approach to ensure that extraction activities do not lead to loss of surface water to the subsurface.

4.3.3.2 Upland Swamps

Some subsidence induced cracking of the beds of upland swamps CRUS1 and CCUS4 is anticipated as a result of the proposed modification due to their soil profiles being relatively dry, having limited humic content, and containing significant exposed sandstone. This may result in the loss of water to the subsurface and potential impacts to associated habitats. However, previous mining of the Bulli and Balgownie seams has occurred beneath CRUS1 and CCUS4 with no adverse impacts documented. During the extraction of coal from LW5, CCUS4 subsided approximately 0.8 metres with no observable adverse impacts (Hansen Bailey, 2014). Based on observed subsidence at CCUS4 as a result of undermining of LW5, impacts relating to subsidence below the CRUS1 and CCUS4 upland swamps is likely to be manageable are manageable in accordance with Subsidence and Swamp Management Plans.

4.3.3.3 Topography Alteration

Subsidence movements may alter the surface topography within and surrounding the LW6 Modification Area as detailed in **Section 4.1**. Alterations may include the formation of localised depressions and the alteration of overland flow paths for rainwater runoff within the LW6 Modification Area and surrounds. It is not anticipated however that overland flow paths would be changed to the extent that the hydrological characteristics of the overall Lake Cataract catchment would be altered.

4.3.3.4 Lake Cataract Reservoir

As noted in **Section 2.1**, the LW6 Modification Area falls within the Lake Cataract Notification Area, with the south-west portion of LW6 falling within the Wongawilli Seam Restricted Zone as shown in **Figure 8**. However, the extent of LW6 falls outside of the Wongawilli Seam 35 degree angle of draw of Lake Cataract providing an adequate buffer to ensure the structural integrity of the reservoir is maintained. Approval from the NSW Dams Safety Committee would be sought prior to any mining occurring within the Notification Area.

4.3.4 Mitigation and Management

An adaptive approach to managing surface water impacts as a result of the LW6 Modification is proposed. This would include the development of a Water Management Plan for the LW6 Modification Area (or an appropriate amendment of an existing plan to reflect inclusion of the first 400 metres of LW6) detailing:

- trigger, action, response plans (TARPs) for monitoring;
- monitoring of Cataract Creek and its tributaries' flow characteristics, including flow depths, flow rates, water quality (particularly iron), surface ponding loss, valley closure and any other relevant parameters;
- collection of baseline data and monitoring of CCSU4 and CRSU1 prior to, during and following extraction of coal from LW6 as detailed in **Table 6**;
- discharge of surface water from the site in accordance with EPL 12040; and
- operations are to be conducted in accordance with conditions of the existing project approval (MP 10_0046).

4.4 Aboriginal Heritage

An Aboriginal Heritage Assessment report was prepared by ERM in November 2012 in relation to the Underground Expansion Project, with supplementary assessment prepared for the Preferred Project Report by Biosis in September 2013. This section provides a summary of the findings of these assessments as they relate to the LW6 Modification Area.

Relevant Aboriginal heritage specialist reports considered as part of this modification are provided in **Appendix F**.

4.4.1 Existing Environment

As part of Underground Expansion Project, an AHIMS database search was conducted for an area 12km by 12km surrounding the Underground Expansion Project which identified 254 recorded Aboriginal cultural heritage sites. Four of these AHIMS sites are located within proximity to the LW6 Modification Area. Two sites identified during field surveys for previous assessments have also been identified in the proximity of the LW6 Modification Area. These sites are listed in **Table 7** and their location in proximity to the LW6 Modification Area shown in **Figure 9**. All of these sites lie outside the immediate footprint of the LW6 Modification Area, with the closest site (52-3-0325) located around 100 metres from LW6, above proposed future LW7.

Table 7 – Aboriginal Cultural Heritage Sites Around the LW6 Modification Area

AHIMS Site Number	Site Name	Site Type	Scientific Significance (Biosis, 2013)
52-3-0320	Bulli Mine Shaft Site 25	Axe grinding groove	3 – low
52-3-0322	Bulli Mine Shaft Site 31	Axe grinding groove	3 – low
52-3-0323	Bulli Mine Shaft Site 26	Shelter with deposit	5 – moderate
52-3-0325	Bulli Mine Shaft Site 27	Shelter with art	4 – moderate
N/A	Wonga East 4	Shelter with deposit	5 - moderate
N/A	Wong East 5	Shelter with stone arrangement	3 – low

4.4.2 Assessment Methodology

As part of the Underground Expansion Project, ERM (2012) undertook a desktop review, field survey targeting drainage lines and previously identified sites and consultation with local Aboriginal stakeholders. This assessment was supplemented as part the Preferred Project Report by Biosis (2013), who provided details of the changes to the original project and an updated impact assessment based on these changes.

4.4.3 Potential Impacts

The proposed modification has the potential to impact on Aboriginal cultural heritage sites through subsidence associated with longwall mining.

Of the six sites in proximity to the LW6 Modification Area, only two fall within the area predicted to experience subsidence of up to 20 mm or less:

- site 52-3-0320 located between LW4 and LW5; and
- site 52-3-0325 located approximately 100 m north of LW6, above proposed future LW7.

Potential impacts on site 52-3-0320 as a consequence of subsidence generated by the initial extraction of 400 metres of LW6 are considered to be negligible, noting that:

- subsidence at this location is predicted to be less than 20 mm;
- the site has already experienced subsidence associated with LW4 and LW5 without significant impact. It is highlighted that subsidence at this location is likely to be greater from LW4 and LW5 than the incremental contribution from the first 400 metres of LW6; and
- potential impacts at this location have been assessed as being very low (Biosis, 2013) for the broader Underground Expansion Project, which has taken into account full extraction of the complete LW6 panel.

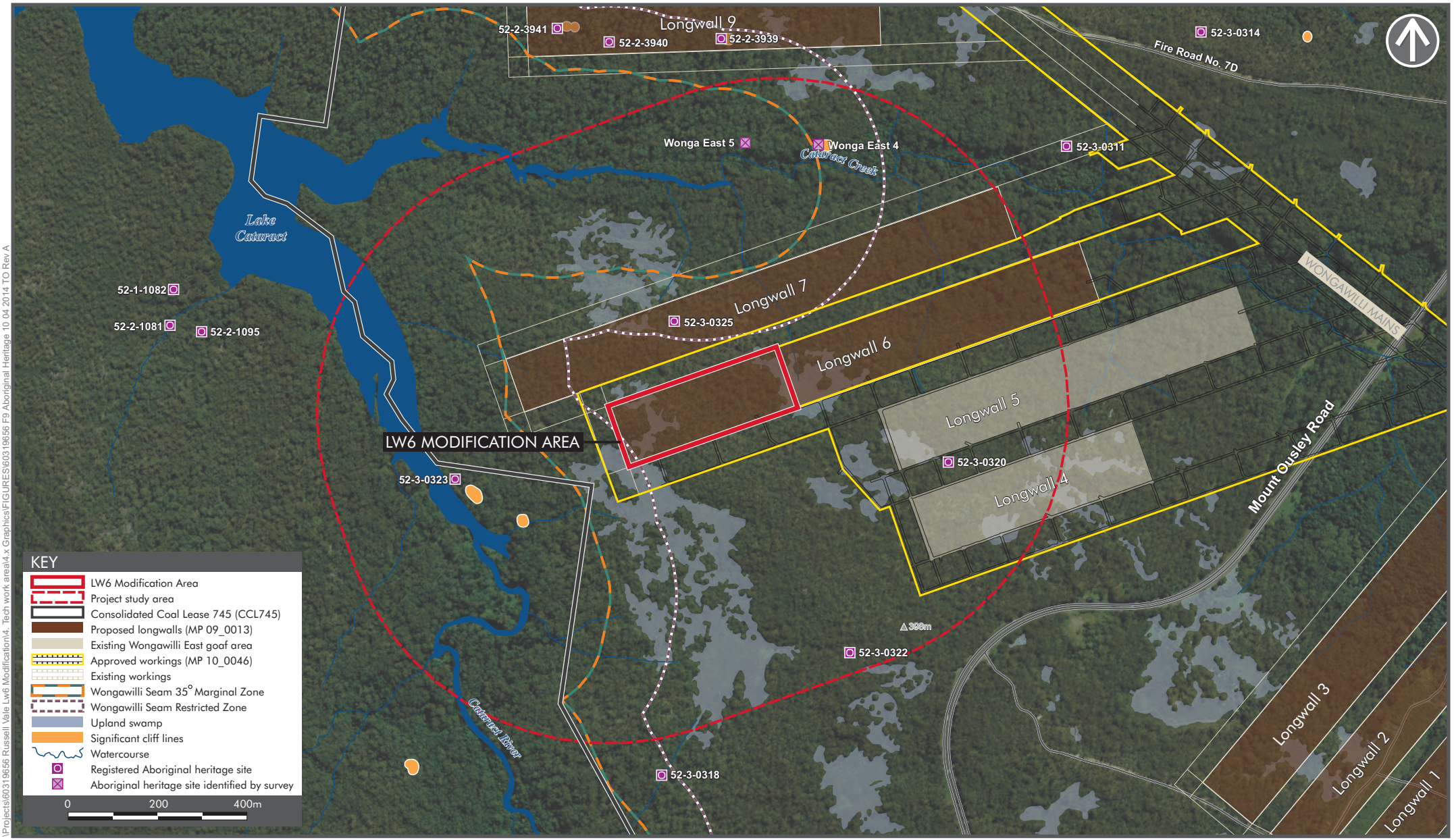
Site 52-3-0325 lies directly above proposed future LW7 and has been assessed as part of the Underground Expansion Project, noting a predicted subsidence effect at that location of up to 1.4 m as a consequence of extraction from LW7. Potential impacts to site 52-3-0325 as a consequence of the Underground Expansion Project have been assessed as being very low (Biosis, 2013). Noting that predicted subsidence impacts associated with extraction of the first 400 metres of LW6 are significantly lower (less than 20 mm compared with up to 1.4 m), the potential impacts to this site as a consequence of the proposed modification are considered to be negligible.

All other Aboriginal heritage sites in proximity to the LW6 Modification Area lie outside the predicted subsidence zone for extraction from the first 400 metres of LW6. On this basis, they are unlikely to be affected.

4.4.4 Mitigation and Management

Sites 52-3-0320 and 52-3-0325 would be monitored during extraction of the first 400 metres of LW6, to ensure that predicted negligible impacts at these sites are achieved in practice and to inform an adaptive management approach should early signs of impacts be detected.

If any identified Aboriginal cultural heritage sites show adverse impacts during the monitoring period, additional management and mitigation measures would be determined by a qualified archaeologist.



\Projects\60319656 Russell Vale Lw6 Modification\4. Tech work area\4.x Graphics\FIGURES\60319656 F9 Aboriginal Heritage 10 04 2014 TO Rev A

AECOM

ABORIGINAL HERITAGE

Russell Vale LW6 Modification

FIGURE 9

This page has been left blank intentionally.

4.5 Ecology

This section is based on ecological impact assessments prepared in support of the Underground Expansion Project (Biosis, 2012; Cardno, 2012b; ERM, 2013a; ERM, 2013b), as updated with additional ecological assessments presented in the Preferred Project Report for that project (Biosis, 2013).

Relevant ecology specialist reports considered as part of this modification are provided in **Appendix G**.

4.5.1 Existing Environment

Several terrestrial flora and fauna and aquatic ecological assessments have been prepared for the Wonga East area, and collectively provide a comprehensive inventory of the ecology in the area. These assessments include:

- *NRE No. 1 Mine: Assessment of Subsidence Impacts on Aquatic Habitat and Biota* (Cardno, 2012b);
- *NRE No. 1 Colliery Stage 2 Terrestrial Flora and Fauna Assessment* (ERM, 2013b);
- *NRE No. 1 Colliery Major Expansion: Upland Swamp Impact Assessment* (Biosis, 2012); and
- *NRE No. 1 Colliery – Underground Expansion Project: Preferred Project Report – Biodiversity* (Biosis, 2013).

4.5.1.1 Terrestrial Ecology

The ecological assessment included in the Preferred Project Report for the Underground Expansion Project (Biosis, 2013), identifies:

- seven flora species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and/or the *Threatened Species Conservation Act 1995* that have the potential to occur in the Wonga East area and which are susceptible to subsidence-related impacts. Of these species, only two have the potential to be dependent on habitat in the area:
  - *Acacia baueri* ssp *aspera* (vulnerable under the TSC Act), which is dependent on rocky outcrop habitats; and
  - Prickly Bush-pea (*Pultenaea aristata*) (vulnerable under both the EPBC Act and TSC Act), which is dependent on upland swamp habitats;
- thirteen fauna species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and/or the *Threatened Species Conservation Act 1995* that have the potential to occur in the Wonga East area and which are susceptible to subsidence-related impacts. Of these species, only seven have the potential to be dependent on habitat in the area:
  - Large-eared Pied Bat (*Chalinolobus dwyeri*) (vulnerable under both the EPBC Act and TSC Act), which may be dependent on cliff habitats above proposed future LW9;
  - Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*) (vulnerable under the TSC Act), which may which may be dependent on cliff habitats above proposed future LW9;
  - Large-footed Myotis (*Myotis macropus*) (vulnerable under the TSC Act), which may which may be dependent on cliff habitats above proposed future LW9 and Cataract Creek;
  - Broad-headed Snake(*Hoplocephalus bungaroides*) (vulnerable under the EPBC Act and endangered under the TSC Act), which may be depending on rocky outcrop habitats;
  - Giant Burrowing Frog (*Heleioporus australiacus*) (vulnerable under both the EPBC Act and TSC Act), which may be dependent on the creek habitats shown in **Figure 10**;
  - Littlejohn's Tree Frog (*Litoria littlejohni*) (vulnerable under both the EPBC Act and TSC Act), which may be dependent on the creek habitats shown in **Figure 10**; and
  - Stuttering Frog (*Mixophyes balbus*) (vulnerable under both the EPBC Act and TSC Act), which may be dependent on habitats along Cataract Creek, as shown in **Figure 10**.

4.5.1.2 Aquatic Ecology

Several aquatic species have been assessed as likely to occur in the Wonga East area as part of the assessments conducted for the Underground Expansion Project:

- Macquarie Perch (*Macquaria australasica*);
- Trout Cod (*Maccullochella macquariensis*);
- Murray Cod (*Maccullochella peelii*);
- Silver Perch (*Bidyanus bidyanus*);
- Adam's Emerald Dragonfly (*Archaeophya adamsi*); and
- Sydney Hawk Dragonfly (*Austrocordulia leonardi*).

Aquatic monitoring results for threatened fish species in Cataract Creek have confirmed the presence of Murray Cod, Macquarie Perch and Silver Perch. However, Murray Cod was recorded for the first time in 2012/2013 and Silver Perch has not been recorded since the 2010/2011 monitoring period.

Neither of the two threatened dragonfly species has been recorded during aquatic surveys in the Wonga East area since 2008.

4.5.1.3 Upland Swamps

Thirty-two upland swamps are located across land overlying the proposed Underground Expansion Project, seven of which meet the criteria to be classified as Swamps of Special Significance. Two of these swamps, CRUS1 and CCUS4, are partially mapped within the LW6 Modification Area as indicated in **Figure 10**.

4.5.2 Assessment Methodology

The assessments undertaken to inform the Underground Expansion Project have included:

- a literature review;
- a desktop assessment of the area including database searches;
- vegetation mapping, including field surveys;
- assessment of historic impacts associated with extraction from the Bulli and Balgownie seams;
- baseline aquatic monitoring;
- mapping of upland swamps and ground truthing; and
- assessment of the 'special significance' of upland swamps.

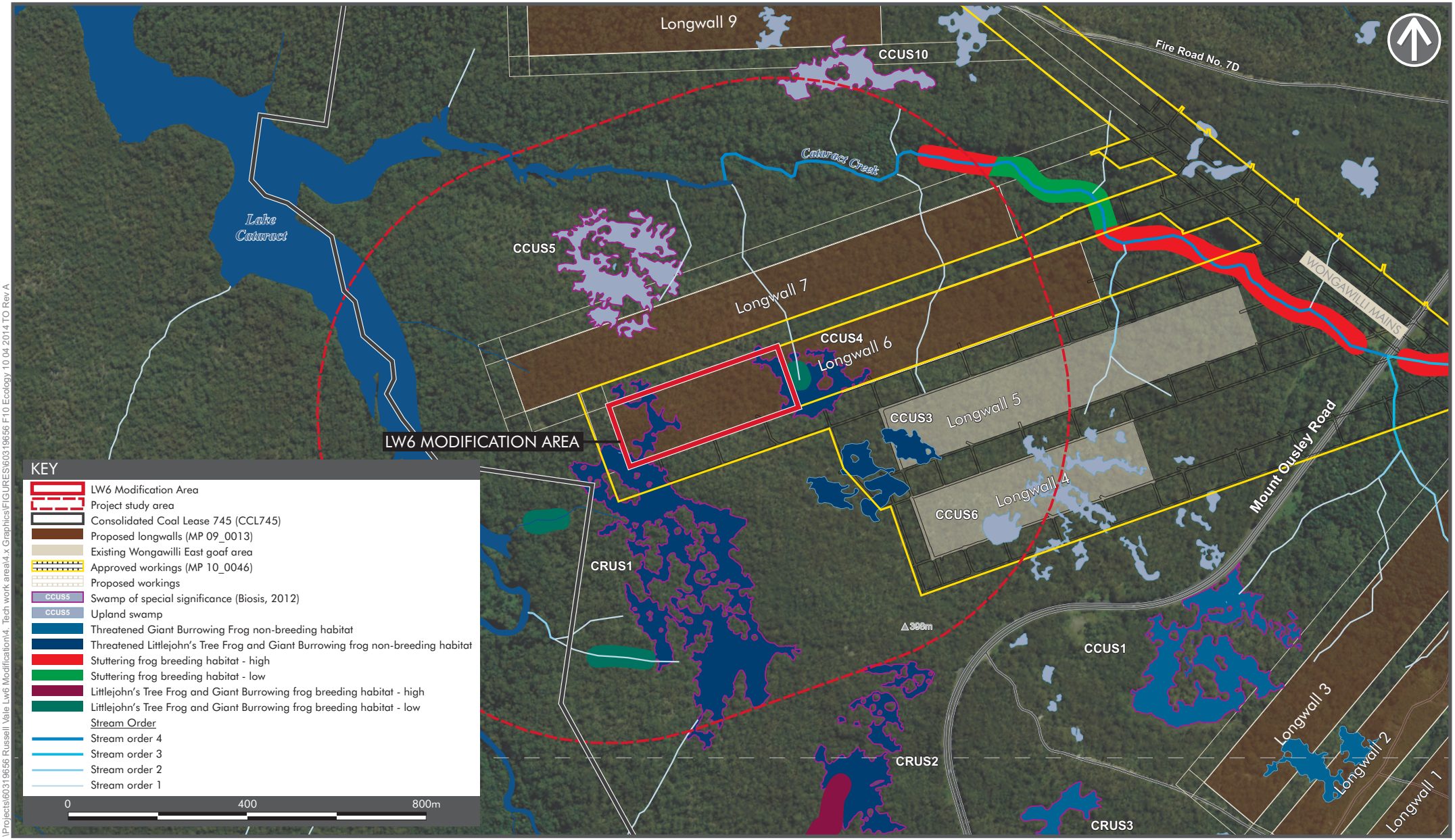
4.5.3 Potential Impacts

As the proposed extraction of the first 400 metres of LW6 involves underground mining with no direct surface disturbance, the principal potential ecological impact mechanism relates to indirect impacts associated with mining-induced subsidence. Potential subsidence-related impacts include:

- impacts to rocky outcrops and cliffs as a result of subsidence;
- groundwater drawdown affecting groundwater dependent ecosystems, including upland swamps;
- loss of base flow in local watercourses as a result of bed cracking and/ or groundwater drawdown.

4.5.3.1 Impacts on Threatened Terrestrial Fauna

The updated ecological assessment presented in the Preferred Project Report for the Underground Expansion Project considers the risk of impact to the threatened terrestrial fauna species listed in **Section 4.5.1.1**. The assessment concludes that the Underground Expansion Project in its entirety presents a low risk to listed threatened fauna.



\Projects\60319656 Russell Vale Lw6 Modification\4. Tech work area\4.x Graphics\FIGURES\60319656 F10 Ecology 10 04 2014 TO Rev A

AECOM

ECOLOGY

Russell Vale LW6 Modification

FIGURE 10

This page has been left blank intentionally.

Table 8 summarises potential impacts on threatened terrestrial fauna species in relation to extraction from the first 400 metres of LW6.

Table 8 – Potential for Impacts on Threatened Terrestrial Fauna (Proposed LW6 Modification)

Species	Potential for Impact
Large-eared Pied Bat (*Chalinolobus dwyeri*)	Potential habitat for the Large-eared Pied Bat exists above proposed future LW9. This habitat is located more than 600 metres from the proposed extraction from LW6 and outside the extent of significant subsidence effects. On this basis, it is unlikely that the proposed modification would have a significant impact on this species.
Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*)	Potential habitat for the Eastern Bentwing-bat exists above proposed future LW9 and along Cataract Creek. As noted above in relation to the Large-eared Pied Bat, significant subsidence-related impacts around proposed future LW9 are not anticipated as a result of the proposed modification. There is potential for additional closure to occur along Cataract Creek as a result of extraction from LW6, although this risk is considered to be low noting that only the first 400 metres of LW6 would be extracted as part of the proposed modification. An adaptive management strategy is proposed to manage the impacts of subsidence and closure over Cataract Creek within the target of 200 millimetres, based on closure monitoring and cessation of mining in the likelihood of significant perceptible impacts of valley closure on Cataract Creek. Based on effective implementation of this adaptive management approach, potential impacts on Eastern Bentwing-bat habitat along Cataract Creek, and on the species itself are unlikely to be significant.
Large-footed Myotis (*Myotis macropus*)	Potential habitat for the Large-footed Myotis exists above proposed future LW9 and along Cataract Creek. Impacts on this species are unlikely to be significant for the same reasons outlined above in relation to the Eastern Bentwing-bat.
Broad-headed Snake(*Hoplocephalus bungaroides*)	Based on expected subsidence impacts (refer to **Section 4.1**), potential disturbance of rocky outcrop habitats suitable for the Broad-headed Snake are anticipated to be minimal. Some perceptible cracking on hard rock surfaces may occur directly above extraction areas, with some potential for rock falls. Based on the limited extent of rocky outcrop features above the first 400 metres of LW6 and the presence of other suitable habitat in the region, potential impacts on the Broad-headed Snake are unlikely to be significant.
Giant Burrowing Frog (*Heleioporus australiacus*)	As shown in **Figure 10**, there is no potential high quality breeding habitat for the Giant Burrowing Frog in proximity to the LW6 Modification Area, although the upland swamps above and around the LW6 Modification area may provide potential non-breeding habitat and in the case of CCUS4, potential for low quality breeding habitat. As detailed in **Section 4.3.3.2**, there is potential for limited subsidence induced cracking of the beds of upland swamps CRUS1 and CCUS4 as a result of extraction from the LW6 Modification Area with potential for loss of water to the subsurface. However, based on previous experience of subsidence under CCSU4 of around 0.8 metres with no observable adverse effects (Hansen Bailey, 2014), potential for significant impacts to the ecological values of CRSU1 or CCUS4

Species	Potential for Impact
	and the Giant Burrowing Frog is likely to be low. While CRUS1 and CCSU4 may provide habitat for the Giant Burrowing Frog, and in the case of CCSU4 some low quality breeding habitat potential, it is noted that significant areas of equal or higher quality habitat exists outside the area potentially affected by extraction from the first 400 metres of LW6. On this basis, potential impacts on the Giant Burrowing Frog are likely to be minimal.
Littlejohn's Tree Frog (*Litoria littlejohni*)	Potential impacts on Littlejohn's Tree Frog are expected to be minimal for the same reasons outlined above in relation to the Giant Burrowing Frog, noting the similar habitats mapped for these two species (refer to **Figure 10**).
Stuttering Frog (*Mixophyes balbus*)	Potential breeding habitat for the Stuttering Frog has been identified along Cataract Creek, outside of the area expected to be affected by subsidence generated by extraction of coal from the first 400 metres of LW6 (refer to **Figure 10**). There is potential for subsidence induced cracking to affect base flows in Cataract Creek (Geoterra, 2012) which, based on the assessment for complete development of the original Underground Expansion Project, may be up to 0.06-0.07 ML/ day. During mining of LW5, no evidence of loss of base flow from Cataract Creek has been observed. Based on the distance of the LW6 Modification Area from Cataract Creek, the limited extent of predicted subsidence effects from extraction of the first 400 metres of LW6 and experienced during mining of LW5, there is likely to be a low risk of direct or indirect impacts on Cataract Creek as a result of the proposed modification. On this basis, the potential for adverse impacts on the Stuttering Frog or its habitat is also considered to be low.

4.5.3.2 Impacts on Threatened Aquatic Fauna

The main aquatic habitat present in the Wonga East area is along Cataract Creek, which provides habitat for several threatened fish species. There are unlikely to be any direct impacts to Cataract Creek as a result of the project, however possible fracturing of CCUS4, a tributary of Cataract Creek, may result in decreased inflows to Cataract Creek. However, the risk of significant loss of water from CCSU4 is considered to be low, particularly in light of experience from historical mining activities that resulted in subsidence in this area of around 0.8 metres with no observed adverse effects on the swamp. Further, CCSU4 provides only a minor contribution to base flows within Cataract Creek, and the potential for significant flow on effects to the creek as a result of potential impacts on CCSU4 would be minor. On this basis, potential impacts on threatened aquatic fauna and habitats along Cataract Creek are expected to be negligible.

4.5.3.3 Impacts on Threatened Flora

The updated ecological assessment presented in the Preferred Project Report for the Underground Expansion Project considers the risk of impact to the threatened flora species listed in **Section 4.5.1.1**. The assessment concludes that the Underground Expansion Project in its entirety presents a low risk to listed threatened flora.

Table 8 summarises potential impacts on threatened terrestrial fauna species in relation to extraction from the first 400 metres of LW6.

Table 9 – Potential for Impacts on Threatened Flora (Proposed LW6 Modification)

Species	Potential for Impact
Acacia baueri ssp *aspera*	Based on expected subsidence impacts (refer to **Section 4.1**), potential disturbance of rocky outcrop habitats suitable for *Acacia bauera* ssp *aspera* are anticipated to be minimal. Some perceptible cracking on hard rock surfaces may occur directly above extraction areas, with some potential for rock falls. Based on the limited extent of rocky outcrop features above the first 400 metres of LW6 and the presence of other suitable habitat in the region, potential impacts on *Acacia bauera* ssp *aspera* are unlikely to be significant.
Prickly Bush-pea (*Pultenaea aristata*)	Suitable habitat exists for the Prickly Bush-pea in upland swamp areas (including CRUS1 and CCSU4) and adjacent woodland. As noted in relation to other swamp-dependent species, potential impacts on CRSU1 and CCSU4 are expected to be minimal, and although there is residual potential for bed cracking leading to loss of water to the subsurface, the extent of such cracking is likely to be low. Based on historical mining activities, subsidence of around 0.8 metres below CCSU4 has not resulted in observed adverse impacts on the swamp. It is also relevant to noted that extensive habitat areas of equal or better quality exist for the Prickly Bush-pea exist outside of the limited are of potential impact from extraction within the LW6 Modification Area. As such, the potential impact of the proposed modification on the Prickly Bush-pea is considered to be low.

4.5.3.4 Impacts on Upland Swamps

Potential impacts on the ecology of upland swamps as a result of the proposed modification are expected to be low, based on predicted subsidence effects and limited potential for water loss to the subsurface as a result of bed cracking. Further details of potential impacts on upland swamps is provided separately in relation to subsidence (refer to **Section 4.1.3.2**), groundwater (refer to **Section 4.2.3.4**) and surface water (refer to **Section 4.3.3.2**).

4.5.4 Mitigation and Management

The proposed modification would not directly impact on ecology, and indirect impacts through subsidence, groundwater and surface water effects have been assessed to be of minimal risk. Potential residual impacts on ecology, including in relation to threatened species and upland swamps, would be mitigated and managed through the measures proposed to manage subsidence, groundwater and surface water impacts. These measures include an adaptive management approach, informed by monitoring during coal extraction, which would respond to observed elevated impacts with appropriate review and amendment of mining activities to ensure protection of the surrounding environment.

4.6 Socio-economics

4.6.1 Existing Environment

The Illawarra area has a long history of mining and manufacturing, and in part has relied on the continuation of these industries to provide direct and indirect benefits to the local community. This has included employment for local residents, training opportunities for up-skilling of employees and continued economic investment in industry-related infrastructure and businesses. As at February 2013 the Russell Vale Colliery provided employment to 368 full-time employees and contractors from the Wollongong local government area and surrounding areas (ERM, 2013).

In addition to supporting ongoing employment positions, the Russell Vale Colliery continues to invest in the local area both directly and indirectly, and makes a positive contribution to regional, State and national economies.

Further details of the social and economic contexts of the Russell Vale Colliery and surrounding areas is provided in *NRE No. 1 Colliery Project Application (09_0013) Environmental Assessment* (ERM, 2013) report.

4.6.2 Assessment Methodology

The following documents have been reviewed in the context of the proposed modification and the socio-economic context of the Russell Vale Colliery:

- *Draft Underground Expansion Project Preferred Project Report Including Response to Submissions* (Gujarat NRE, undated);
- *NRE No. 1 Colliery Project Application (09_0013) Environmental Assessment (*ERM, 2013); and
- *Longwalls 4 and 5; Maingates 6, 7 and 8 – Application for s75W Modification 1 to MP 10_0046 – Preliminary Works Project* (Cardno, 2012a).

4.6.3 Potential Impacts

As outlined in **Section 2.5.1**, without approval for continued operations on the site, the Russell Vale Colliery will need to be placed into care and maintenance shortly following completion of the main gate roads for LW6 (expected to be completed in April 2014). Continued operation of the site ahead of a determination of the current application for the Underground Expansion Project is fundamental to ensuring the continued benefits of operation of the Russell Vale Colliery. These benefits include:

- ongoing employment of more than 300 employees;
- continuation of payments made to suppliers of operational inputs and materials related to site operations, including transport providers transporting coal for export to Port Kembla Coal Terminal;
- continuation of payments to consultants and contractors for operational maintenance and associated Site compliance monitoring;
- continued support of local businesses and spending on goods;
- maintenance of community development and ongoing opportunities for the Proponent to identify and support community development programs in the local and regional community; and
- continued payment of royalties to Government.

The proposed modification would not generate additional need for community infrastructure and services. The potential amenity impacts of ongoing operations at the Russell Vale Colliery are currently regulated under the existing project approval and Environment Protection Licence for the site. Amendments to current environmental performance standards in those approvals are not proposed as part of this modification application.

4.6.4 Mitigation and Management

Through the continued operation of the site in accordance with existing approvals, potential impacts on the surrounding environment and local communities will be appropriately mitigated and managed.

Without approval to continue operation of the site pending determination of the broader Underground Expansion Project application, significant adverse social and economic impacts are expected, particularly in relation to employment and local and regional investment.

This page has been left blank intentionally.