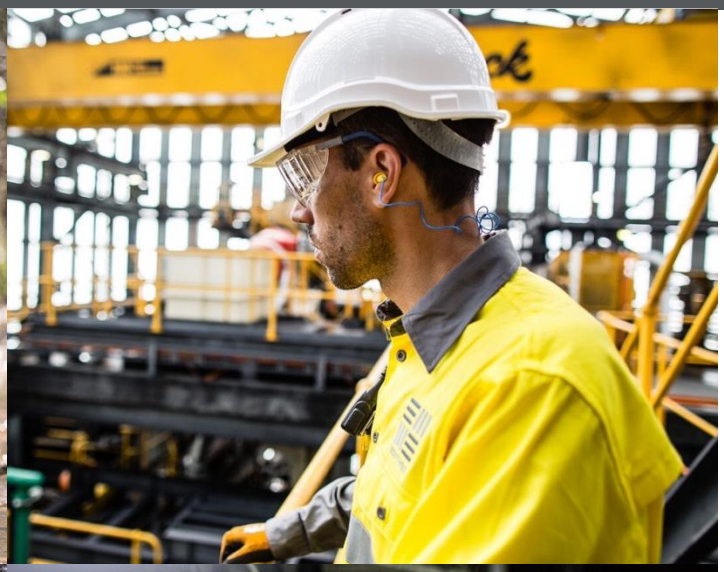
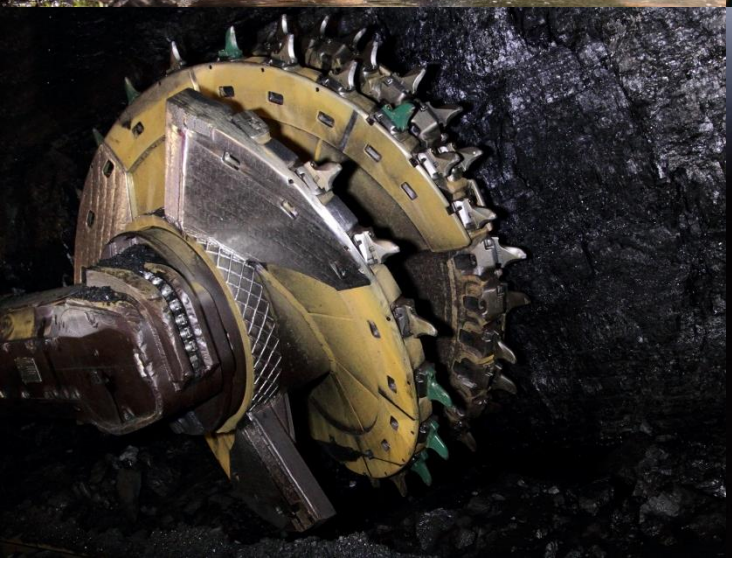
SOUTH32

Illawarra Coal
End of Panel Report





Dendrobium Area 3B Longwall 12 End of Panel Report

May 2017

Executive Summary

This End of Panel (EoP) report has been prepared in accordance with Schedule 3 Condition 9 of the Dendrobium Development Consent (DA 60-03-2001). The EoP report outlines the measured and observed impacts during the extraction of Dendrobium Area 3B (DA3B) Longwall 12 and analyses the monitoring results against relevant impact assessment criteria and predictions in the DA3B Subsidence Management Plan (SMP).

Longwall 12 is within Consolidated Coal Lease 768 and was extracted using longwall equipment from the 22 February 2016 to the 31 January 2017.

The extraction of coal from DA3B provides benefits at international, national, state and local levels due to the coal's unique characteristics. Illawarra Coal provides 70% of BlueScope Steel's coking coal requirements. Continuing benefits occur through continuity of employment, expendable income, export earnings and government revenue.

Illawarra Coal provides local jobs for over 1300 direct employees throughout its operations with an employment flow-on effect in the Illawarra and Wollondilly regions of 2.6 full time equivalent jobs (IRIS, 2011). More than 400 local businesses provide their goods and services to the company. Illawarra Coal is a major contributor to the economy of the region, contributing 4.7% of household income and 5.3% of industry value added. As of March 2017 Dendrobium Mine had 265 direct employees. These jobs are reliant on maintaining continuity of longwall coal extraction.

Monitoring was conducted to measure subsidence at creeks, swamps and other landscape features within the zone of influence of Longwall 12.

The observed incremental horizontal movements at 3D monitoring points, resulting from the extraction of Longwall 12 were within the range of those measured at previously extracted longwalls at Dendrobium Mine and elsewhere in the Southern Coalfield.

The maximum observed total closures at each of the Wongawilli Creek cross-lines were less than predicted after the completion of Longwall 12.

Total observed subsidence and closure at the majority of cross lines was less than predicted. The total observed subsidence at WC21 J-Line, WC21 K-Line and WC21 L-Line was greater than predicted. The observed total closure along WC21 H-Line was greater than predicted. The observed total closure along WC21 F-Line was equal to prediction.

Total observed subsidence and closure at the majority of cross lines was less than predicted. The total observed subsidence at DCCXC-Line and DCCXD-Line was greater than predicted. The observed total closure along DCCXC-Line and DCCXE-Line was greater than predicted. Slight opening was measured at DCCXC-Line.

The observed total subsidence and closure for the Swamp Cross-Lines was less than predicted.

The observed impacts on surface infrastructure following the extraction of Longwall 12 were within predictions. Impacts were observed to fire trails and access tracks as well as the Maldon – Dombarton railway corridor. Minor remediation works were implemented at two sites on access tracks.

There were no observed surface impacts to Wongawilli or Donalds Castle Creek resulting from Longwall 12. Rock fracturing occurred within tributaries WC21 and fracturing in LA4/B resulted in flow diversion. Soil surface cracking was observed on or near fire trails and tracks and rock fracturing was observed to rock outcrops.

Groundwater levels lower than baseline and recession rates greater than baseline were recorded for Swamp 10. Soil moisture levels below baseline were recorded in Swamp 5 and Swamp 11, as well as reference sites.

A reduction in threatened fauna habitat was observed within streams impacted by subsidence.

No impacts to archaeological sites were observed.

In addition to the impacts described above, a number of TARPs were triggered or continued during the reporting period. Dams Safety Committee (DSC) Level 3 groundwater TARPs have been reached in four bores monitoring the Bulgo Sandstone in Area 3A near Sandy Creek and Lake Cordeaux. A level 3 groundwater TARP has been reached in Swamp 10 as well as a Level 3 soil moisture TARP in Swamp 11.

The water quality TARP for Dissolved Oxygen (DO) was triggered for Donalds Castle Creek (Level 2), Wongawilli Creek (Level 1) and tributary LA4 (Level 2). Water flow TARPs were triggered for the DCS2 and DC13S1 sub-catchments but there were no triggers for the larger Donalds Castle or Wongawilli Creek catchments.

A number of swamp triggers were met as defined by the revised TARPs in the Swamp Impact Monitoring Management and Contingency Plan (SIMMCP). Impacts to the first and second order streams SC10C, WC17, DC13, WC21 and the upper reaches of Donalds Castle Creek has resulted in a reduction of aquatic and stream pool habitat which has resulted in a number of TARP triggers.

Impacts to built and natural features observed during monitoring of Longwall 12 have been within the performance measures for Dendrobium Mine. Monitoring will continue in accordance with the SMP and as outlined in this report.

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FIGURES

ATTACHMENTS

1. Introduction

Dendrobium Longwall 12 is located within Consolidated Coal Lease 768. Longwall 12 was extracted from 22 January 2016 to 31 January 2017 using longwall equipment.

This EoP report has been prepared in accordance with Condition 18 of the DA3B SMP Approval. The EoP report outlines the measured and observed impacts of Longwall 12 and analyses the monitoring results against relevant impact assessment criteria and predictions made in the SMP and associated management plans and reports.

The DA3B SMP was approved by Department of Trade and Investment, Regional Infrastructure and Services NSW (DTI) on the 5 February 2013 and the Department of Planning and Environment (DP&E) on the 6th of February 2013. The SMP approval is provided as **Attachment A**.

Schedule 3 Conditions 9 and 10 of the Development Consent is provided in **Table 1**.

Table 1: Longwalls 9 – 13 SMP Approval Condition for End of Panel Reporting

SMP Approval Condition	Relevant Section in EoP Report
Schedule 3 of Development Consent DA60-03-2001 – MOD 7 **9.** Within 4 months of the completion of each longwall panel, or as otherwise permitted by the Director-General, the Applicant shall: 1. prepare an end-of-panel report – reporting all subsidence effects (both individual and cumulative) for the panel and comparing subsidence effects with predictions; – describing in detail all subsidence impacts (both individual and cumulative) for the panel; – discussing the environmental consequences for watercourses, swamps, water yield, water quality, aquatic ecology, terrestrial ecology, groundwater, cliffs and steep slopes; and – comparing subsidence impacts and environmental consequences with predictions; and 2. Submit the report to the Department, DPI, SCA, DECC, DWE and any other relevant agency to the satisfaction of the Director-General	*Sections 4 to 8, Attachments B to F*

10. The Applicant shall include a comprehensive summary, analysis and discussion of the results of monitoring of subsidence effects, subsidence impacts and environmental consequences in each AEMR	*The AEMR (July to June) is submitted in August each year*

The impact predictions for Longwall 12 are described in the following reports:

- BHPBIC, November 2012 -DA3B SMP
- South32, October 2015 – DA3B Watercourse Impact Monitoring Management and Contingency Plan (WIMMCP), Revision 1.5
- South32, October 2015 – DA3B Swamp Impact, Monitoring, Management and Contingency Plan, Revision 1.5

Impacts have been reported by the Illawarra Coal Environmental Field Team (ICEFT) and specialist consultants during and following mining.

Economic effects associated with longwall extraction are discussed in Section 2. An overview of the consultation involved with Dendrobium operations is provided in Section 3. Subsidence movement predictions and measurements are in Section 4. Predicted and observed impacts of Longwall 12 on man-made and natural features are provided in Sections 5 and 6 respectively. The Longwall 12 monitoring program and proposed future monitoring in the SMP Area is provided in Section 7 and a summary of the TARPs including remediation measures are outlined in Section 8.

2. Economic Effects

The extraction of underground coal reserves from DA3B provides benefits at international, national, state and local levels due to the coal's unique characteristics. Illawarra Coal provides 70% of BlueScope Steel's coking coal requirements. Continuing benefits occur through continuity of employment, expendable income, export earnings and government revenue.

Illawarra Coal provides local jobs for over 1300 direct employees throughout its operations with an employment flow-on effect in the Illawarra and Wollondilly regions of 2.6 full time equivalent jobs (IRIS, 2011). More than 400 local businesses provide their goods and services to the company. Illawarra Coal is a major contributor to the economy of the region, contributing 4.7% of household income and 5.3% of industry value added. As of March 2017 Dendrobium Mine had 265 direct employees. These jobs are reliant on maintaining continuity of longwall coal extraction.

3. Stakeholder Consultation

Monitoring and provision of ongoing information to the community has been undertaken during the extraction of DA3B. Information on South32 operations is provided to the community through the following mechanisms:

- Community information sheets and letter box drops,
- Media releases and other media activities,
- General community surveys and reports,
- Dendrobium Community Newsletter – distributed to the community,
- Internet site http://www.south32.net/our-operations/australia/illawarra-coal/regulatory-document
- Dendrobium Community Consultative Committee (DCCC) Meetings,
- Landholder relations program,
- Annual review, and
- Information days.

Illawarra Coal aims to mitigate the potential impacts subsidence may cause on individuals through various means outlined in **Table 2**.

Table 2: Social Impact Variables Associated with Subsidence

Potential Impact	Monitoring Variables	Mechanism
Subsidence Impacts	- Level of community concern relating to subsidence - Awareness of subsidence, its effects and management - Level of perceived community risk associated with subsidence - Level of satisfaction with the company's subsidence management practices - The extent to which the community attributes environmental, social and economic change within the community to mining activities	- The DCCC meetings including presentations and explanations of how and why subsidence occurs, and its potential impacts - A biennial telephone survey of residents in the communities in which Illawarra Coal operates. The survey aims to determine the community's perception of the company's overall performance

4. Predicted and Observed Subsidence

Subsidence movements resulting from the extraction of Longwall 12 were monitored along various lines and points within the SMP Area. A comparison of the observed and predicted movements has been prepared by MSEC (MSEC888, 2017) and is included as **Attachment B**.

Monitoring points and lines associated with Longwall 12 include:

- Wongawilli Creek Closure Lines,
- Avon Dam Closure Lines,
- Area 3B 3D and Avon Dam 3D Monitoring Points,
- Tributary Cross Lines,
- Swamp Cross Lines, and
- Airborne Laser Scans (ALS) of the area.

The locations of these monitoring lines and points are shown in **Figure 1** (MSEC888, 2017).

4.1. Wongawilli Creek Closure Lines

Closure movements across Wongawilli Creek were measured using 2D surveys at the Wong X B-Line and Wong X C-Line. The maximum observed closures at these cross lines were less than predicted.

4.2. Avon Dam Closure Lines

Closure lines across Avon Dam were installed in February 2016, prior to the start of Longwall 12. Closure movements across the Dam were measured using 2D surveys at Avon Dam A-Line to E-Line.

Avon Dam B-Line to E-Line recorded closure less than predicted. Closure at Avon Dam A-Line was recorded at 21 mm, slightly above the predicted closure of 20 mm but within the order of accuracy of the survey measurements.

4.3. Dendrobium Area 3B 3D and Avon Dam Monitoring Points

Vertical and horizontal movements above and in the vicinity of Longwall 12 were measured using 3D monitoring points. The location of these monitoring points is shown in **Figure 1**.

Horizontal movement recorded at marks located outside the extents of Longwall 12 was low with vectors generally orientated towards the extracted goaf. The horizontal movement vectors for the marks located above the longwall is where the greatest movement was measured and these movements generally oriented towards the finishing end of the longwall.

Only low-level horizontal movements were recorded at the Avon Dam 3D monitoring points.

The observed incremental horizontal movements at the 3D monitoring points, resulting from the extraction of Longwall 12 were within the range measured at Dendrobium Mine and elsewhere in the Southern Coalfield (**Figure 2**).

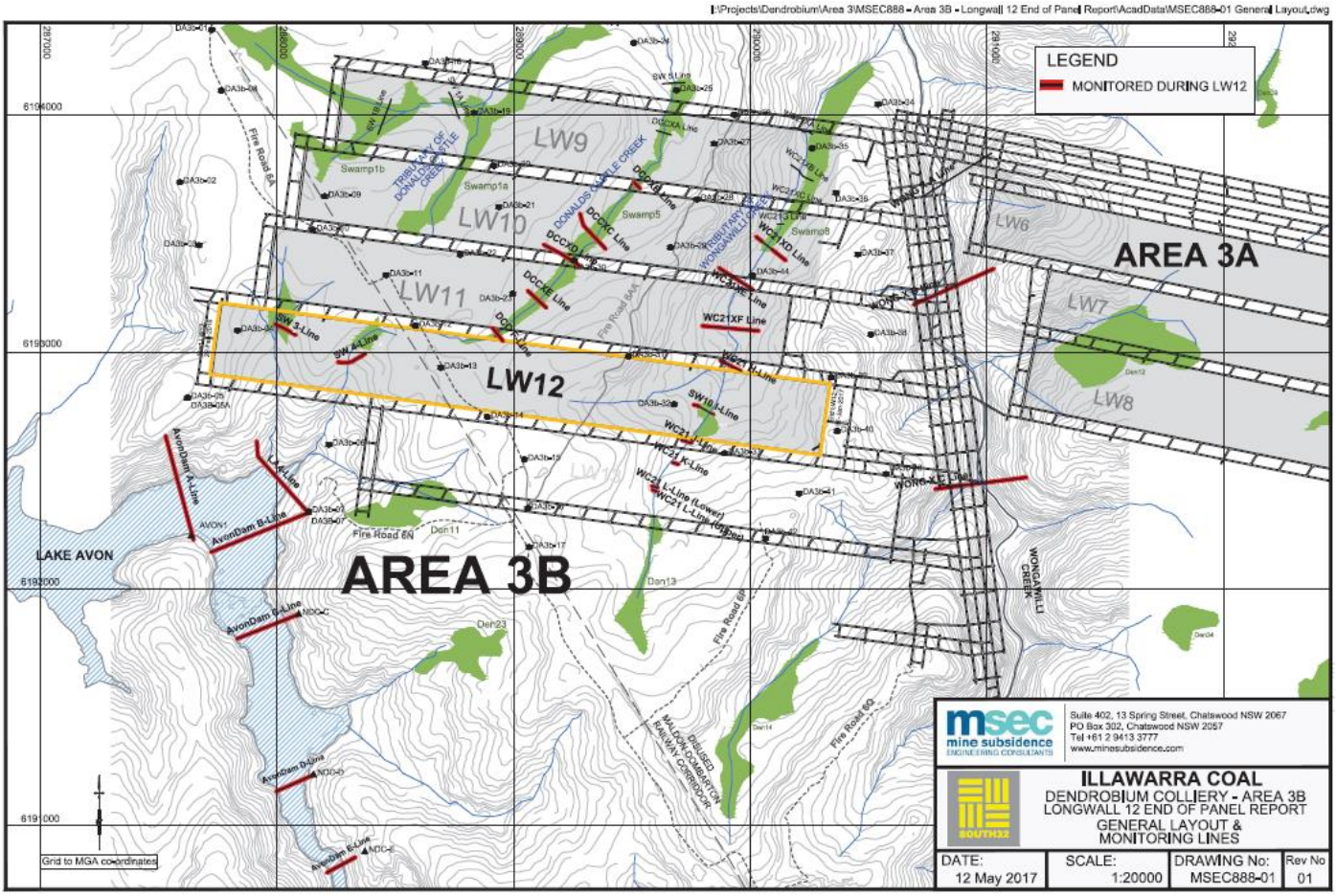

Figure 1: Dendrobium Mine Area 3B monitoring points and lines

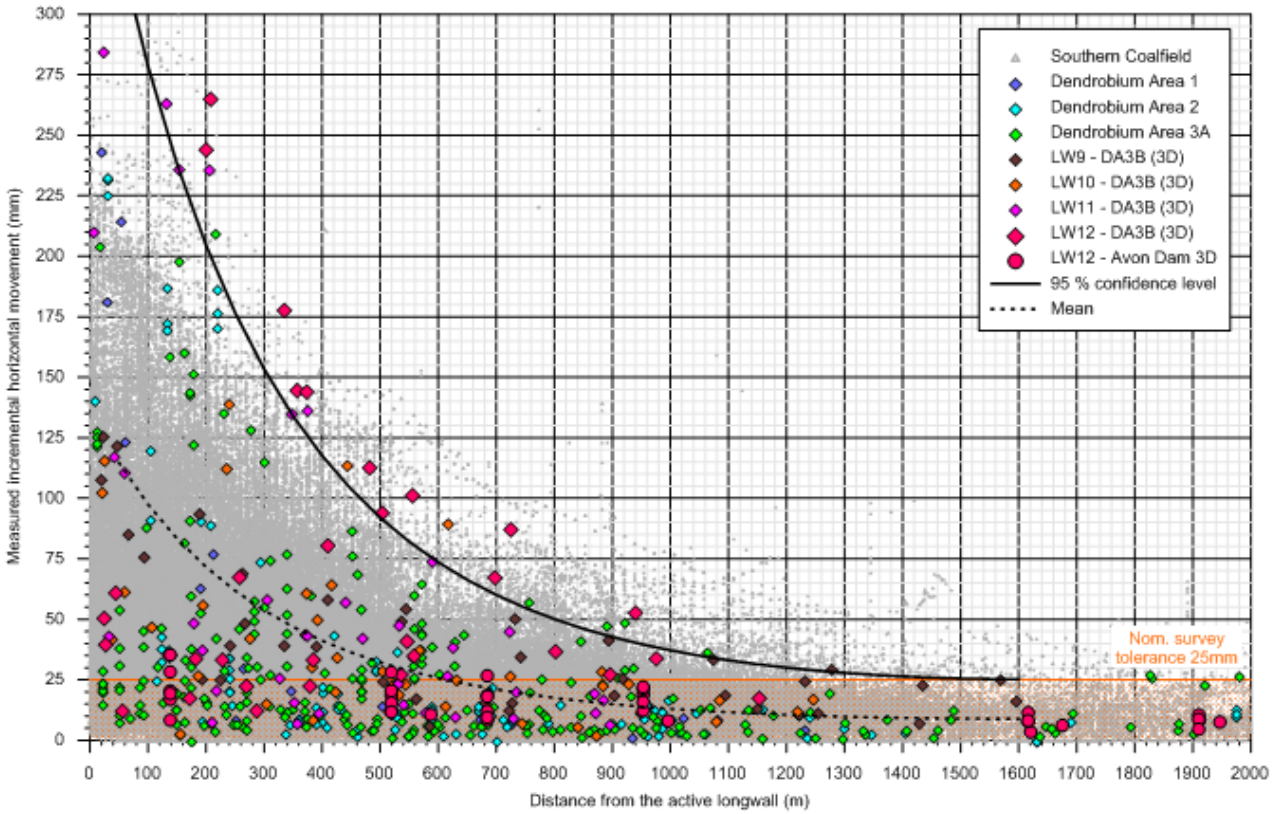

Figure 2: Observed incremental horizontal movement for DA3B 3D and Avon Dam monitoring points

4.4. Wongawilli Creek Tributary and Lake Avon Tributary Cross Lines

Mine subsidence movements across Wongawilli Creek tributary WC21 were measured with 2D survey techniques using the WC21 D-Line, WC21 E-Line, WC21 F-Line, WC21 H-Line, WC21 I-Line, WC21 J-Line, WC21 K-Line, WC21 L-Line (lower) and WC21 L-Line (upper).

The observed total closure for the WC21 F-Line was the same as predicted.

The observed total closure for the WC21 H-Line of 236 mm is slightly greater than the predicted total closure of 225 mm, however within the order of accuracy for measurement.

The observed total closure at WC21 D-Line, WC21 E-Line,WC21 I-Line, WC21 J-Line, WC21 K-Line, and WC21 L-Lines (Upper and Lower) was less than predicted.

The measured total vertical subsidence at the WC21 J-Line, K-Line and L-Lines are up to approximately 50 mm greater than the predicted total vertical subsidence. The exceedances for vertical subsidence along these monitoring lines are similar to the order of accuracy of the predictive method. Remaining WC21 closure lines recorded vertical subsidence less than predicted.

The mine subsidence movements across a tributary to Avon Dam- LA4- have been measured with 2D survey techniques using the LA4-Line. The measured total vertical subsidence and closure for the LA4-Line are less than the predicted values.

4.5. Donalds Castle Creek Cross Lines

The mine subsidence movements across Donalds Castle Creek lines were measured with 2D survey techniques using the DCCXB-Line, DCCXC-Line, DCCXD-Line, DCCXE-Line and DCCXF-Line.

The total measured vertical subsidence for the DCCXD-Line of 1403 mm is greater than the predicted total vertical subsidence of 1200 mm, however within the order of accuracy for the predictive method.

The total measured closures for the DCCX C-Line and E-Line of 464 mm and 385 mm are greater than the predicted values of 450 mm and 350 mm, respectively. These measurements are within the order of accuracy for the predictive method.

The total measured movements greater than predicted for the DCCX C-Line, D-Line and E-Line occurred during the extraction of Longwalls 9 to 11. Only small incremental movements were measured at these monitoring lines due to the extraction of Longwall 12.

The observed total closures along DCCXD-Line and DCCXF-Line were less than predicted. A net opening of 7mm was measured along the DCCXB-Line.

The total measured vertical subsidence for the DCCXB-Line, DCCXC-Line, DCCXE-Line, DCCXF-Line was less than predicted.

4.6. Swamp Cross Lines

The mine subsidence movements across the Swamp Cross Lines were measured with 2D survey techniques using the SW3 Line, SW 4 Line and SW 10 Line.

The observed total subsidence and total closures for these monitoring lines were less than predicted.

4.7. Airborne Laser Scan

The changes in surface level due to the extraction of Longwalls 9 to 12 have been measured using Airbourne Laser Scan (ALS) / Light Detection and Ranging (LiDAR) surveys. The initial surface level contours have been determined from the base survey carried out in January 2013, with post-mining surveys undertaken following completion of each longwall.

The changes in surface level were determined by taking the differences between the surface levels measured before and after each longwall. **Figure 3** shows the incremental change in surface level following extraction of Longwall 12. The survey following completion of Longwall 11 was not flown until 2 months after the commencement of Longwall 12 and, therefore, the measured contours do not include the first 530 m of extraction for this longwall. **Figure 4** shows the total change in surface level following extraction of Longwalls 9 to 12.

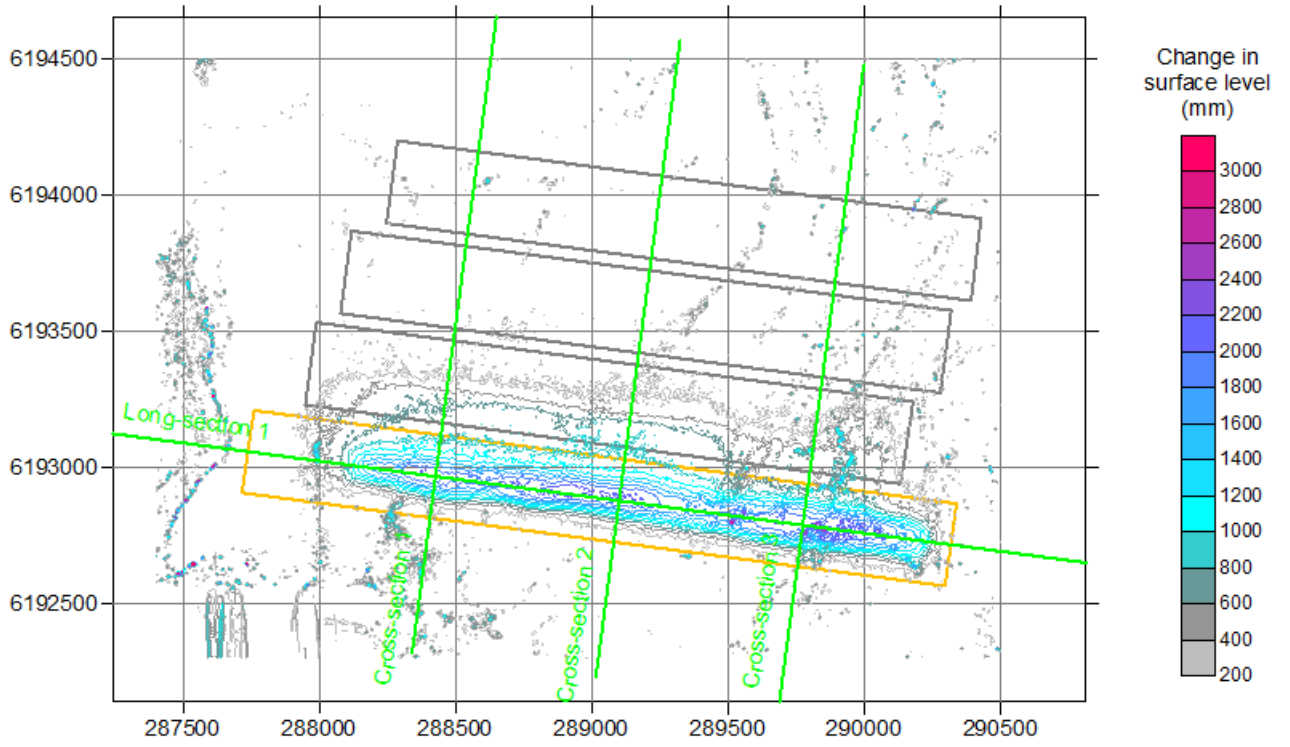

Figure 3: Measured incremental changes in surface level due to the extraction of Longwall 12

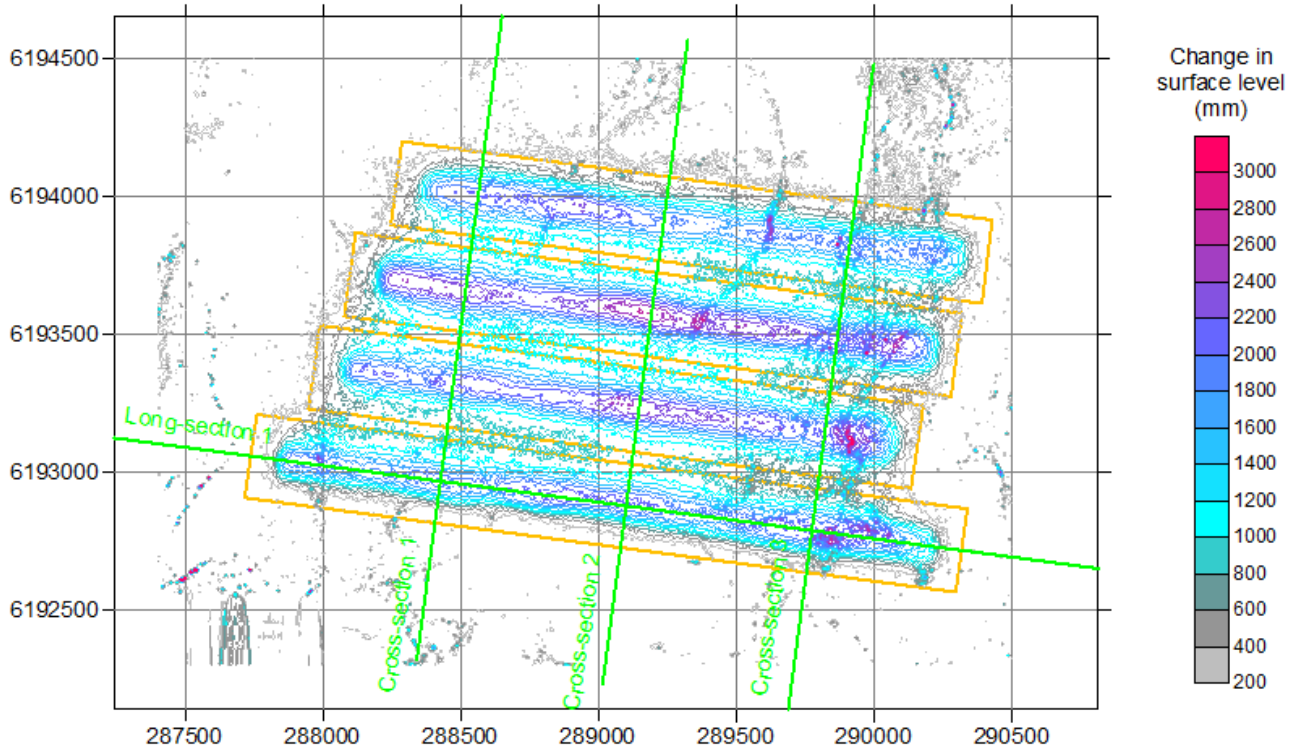

Figure 4: Measured total changes in surface level due to the extraction of Longwalls 9 to 12

The contours can contain artefacts (i.e. locally increased or decreased movements), particularly in the locations of steeply incised terrain, such as at cliffs and steep slopes.

The comparisons of the measured changes in surface level and the predicted vertical subsidence along Cross-sections 1 to 3 and Long-section 1 are provided in **Figure 5** to **Figure 8** below.

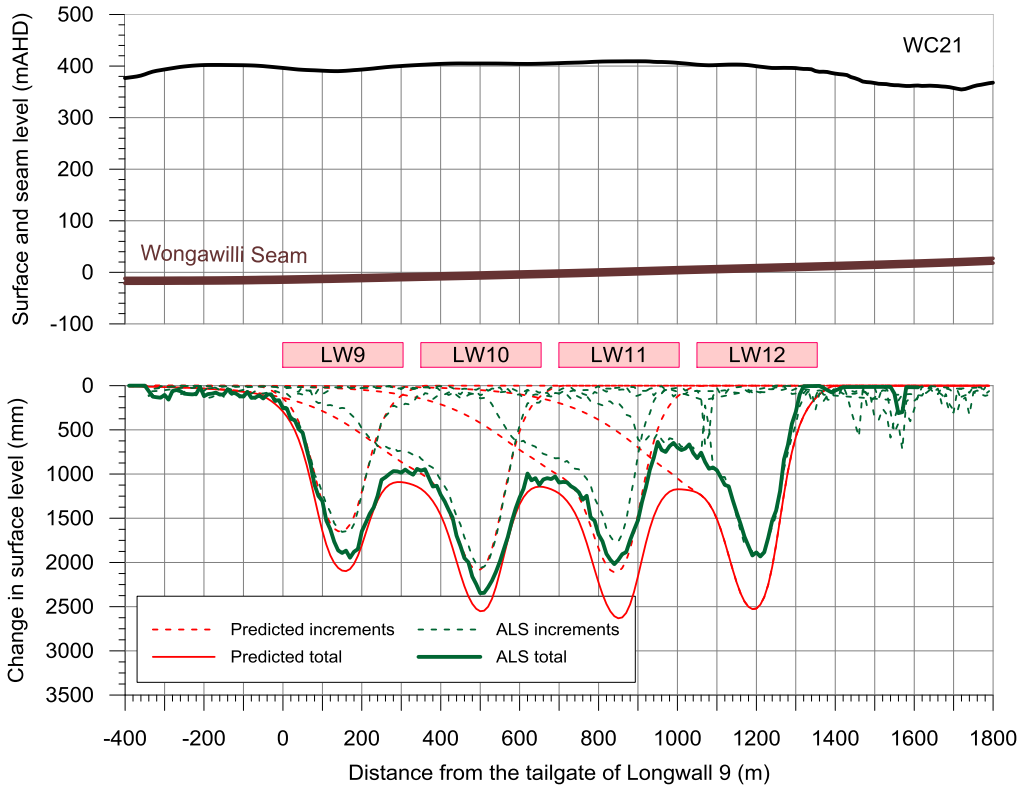

Figure 5: Observed changes in surface level and predicted subsidence along Cross-section 1

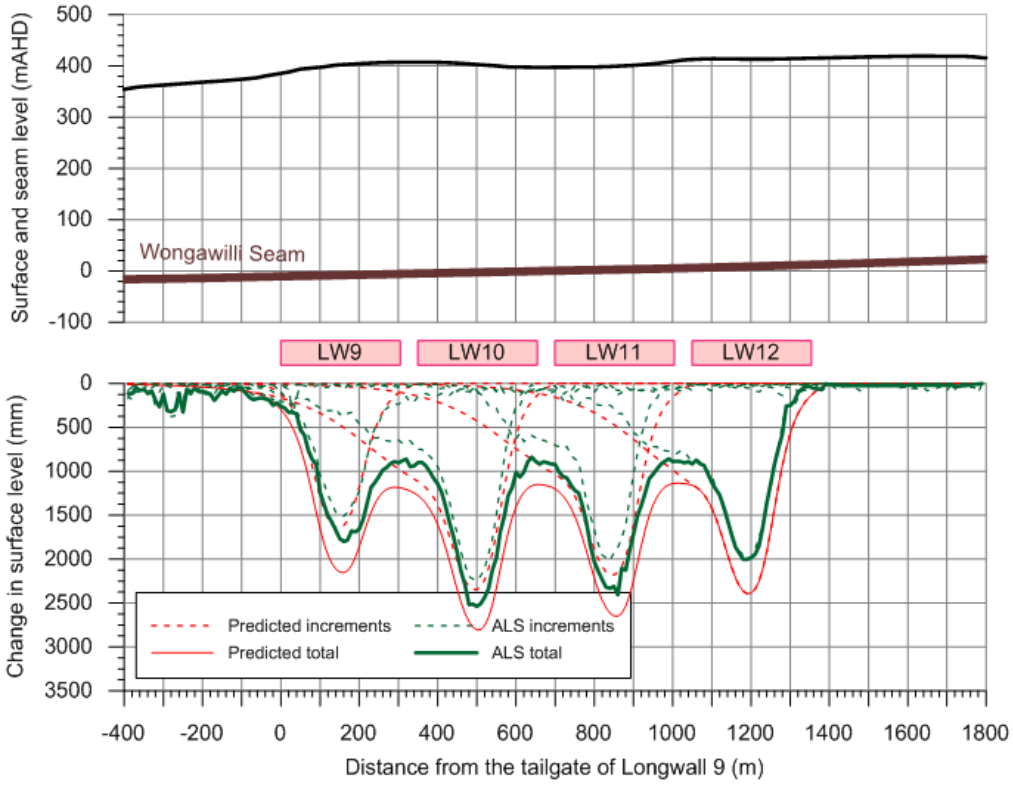

Figure 6: Observed changes in surface level and predicted subsidence along Cross-section 2

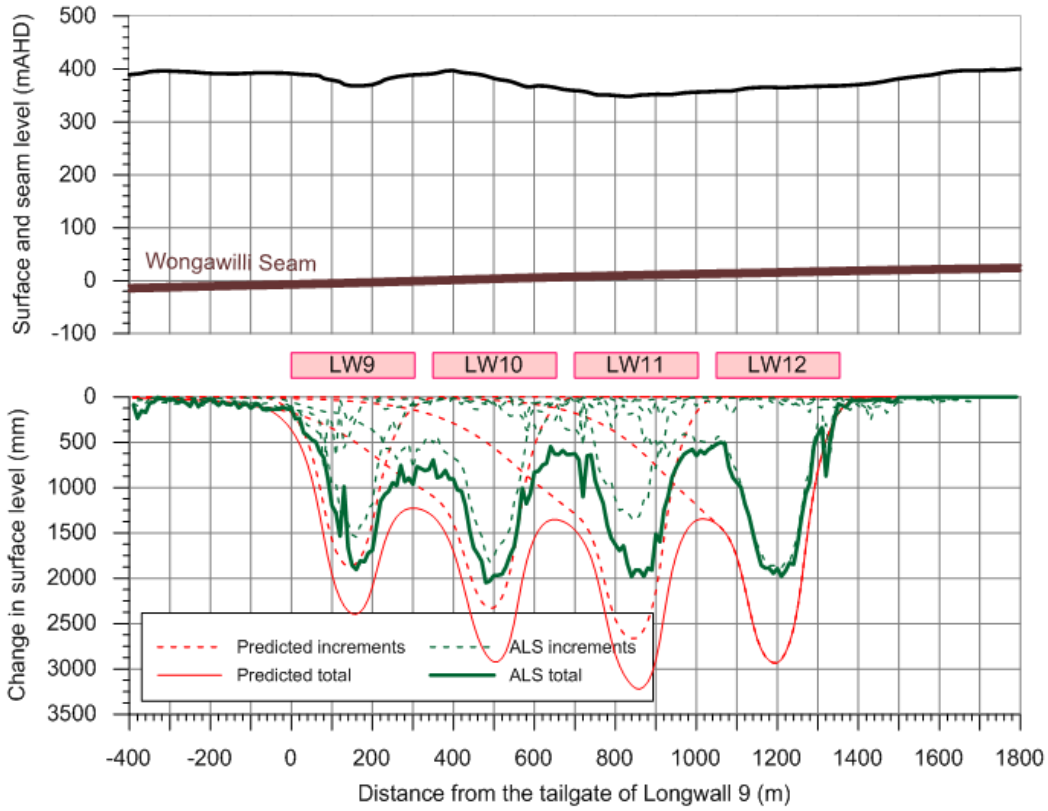

Figure 7: Observed changes in surface level and predicted subsidence along Cross-section 3

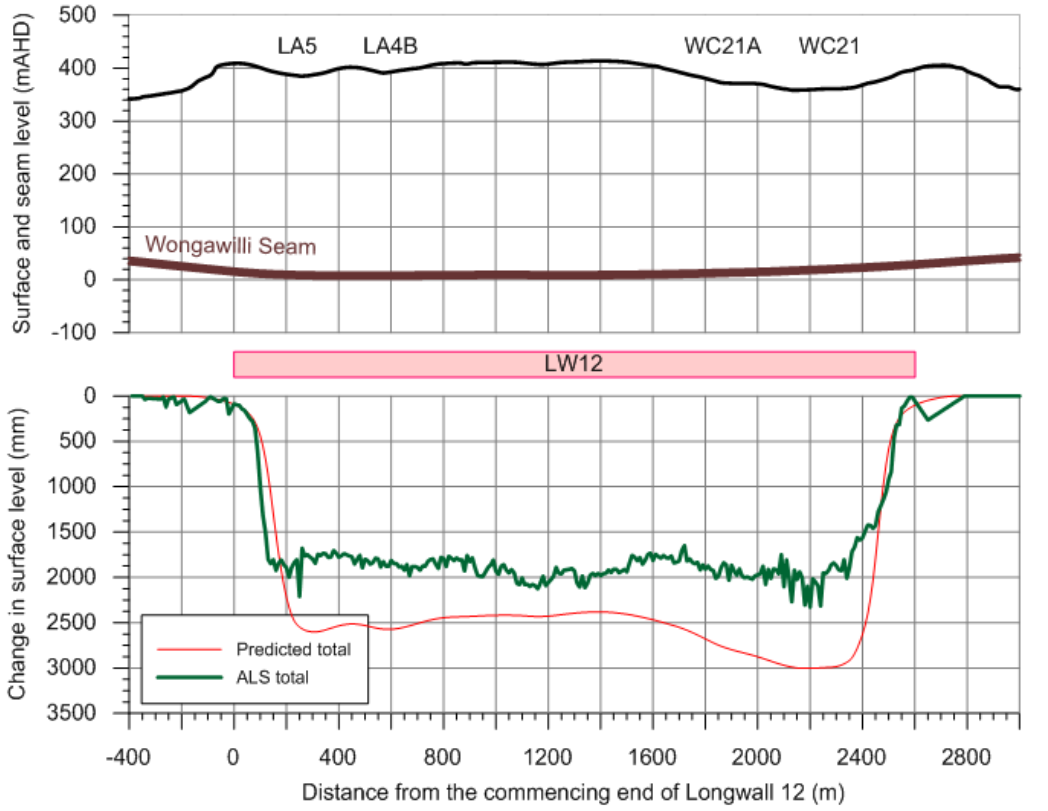

Figure 8: Observed Changes in Surface Level and Predicted Subsidence along Long-Section 1

The profiles of the measured changes in surface level reasonably match the predicted profiles of vertical subsidence along each of the cross-sections and long-section. There are localised areas outside of the longwalls where the measured changes in surface level exceed the predicted vertical subsidence; however these are artefacts of the LiDAR surveys and are not real movements. Similarly, there is a localised change in surface level above the maingate of Longwall 12 along Cross-section 3 that is unlikely to be a real movement.

It is considered that the ground movements measured using the LiDAR surveys are consistent with the predictions provided in Report No. MSEC865.

5. Impacts to Built Features

The built features in the vicinity of Longwall 12 are shown in Drawing MSEC888-03 (**Attachment B**); and include:

- Fire trails and four wheel drive tracks
- Disused Maldon – Dombarton Railway Corridor
- Survey control marks, and
- Exploration boreholes

Cordeaux Dam Wall is located in excess of 5km north of Longwall 12. The Upper Cordeaux No. 2 Dam Wall is located in excess of 6km south-east of Longwall 12. It is unlikely these dam walls would experience any measurable far-field horizontal movements resulting from Longwall 12.

Twenty surface impacts have been identified on built features within the Longwall 12 mining area **(Table 4)**. These impacts consist of soil cracks and uplift on seismic trails, Fire Road 6A, Access Track 6000/ 6AA and the disused Maldon – Dombarton Railway Corridor.

Nineteen of these impacts are a Level 1 trigger according to the Dendrobium Landscape Impacts, Triggers and Response Plan, specifically:

- Crack at the surface, which should not result in any significant erosion or further ground movement
- Crack in a fire trail which should not result in erosion or impede access
- Crack or fracture up to 100mm width
- Crack or fracture up to 10m length

Examples of the Level 1 surface impacts are shown in **Photo 1** to **Photo 3** below. Following WaterNSW approval, the crack *DA3B_LW12_017* was filled with soil material due to its location on Access Track 6000/6AA. **Photo 4** shows the result following remediation. Further examples are included in the DA3B Longwall 12 End of Panel Landscape Report (**Attachment C1**).

Photo 1: DA3B_LW12_014- Uplift across railway corridor, looking southeast

Photo 2: DA3B_LW12_020 - Soil cracks on access track. Taken on 15/11/2016

Photo 3: DA3B_LW12_017 – Soil cracking across AT6AA. Taken on 9/11/2017

Photo 4: Remediation of DA3B_LW12_017. Taken on 18/01/2017

One surface impact affecting built features, impact *DA3B_LW12_025,* was recorded as a Level 2 trigger according to the Dendrobium Landscape Impacts, Triggers and Response Plan (**Table 10**), specifically:

- Crack or fracture between 10m and 50m in length
- A crack in the fire trail, which could result in significant erosion or impede vehicle access
- Crack or fracture between 100 and 300mm width

Impact *DA3B_LW12_025* was a soil crack across an access track over Longwall 12. The crack was up to 0.110m wide, 10m long and up to 1.1m deep. Due to the width of the crack, and its location on an access

track, the crack was filled following approval from WaterNSW. **Photo 5** and **Photo 6** show the crack before and after remediation.

Photo 5: DA3B_LW12_025 –Soil cracking across access track. Taken on 18/05/2017

Photo 6: DA3B_LW12_025 –Section of remediated cracking across access track. Taken on 18/05/2017

MSEC predicted impacts for surface infrastructure, resulting from the extraction of Longwalls 9 to 18, and these are provided in MSEC459. These assessments were reviewed and updated based on the re-calibrated subsidence model and are provided in Report No. MSEC792. Comparisons between the MSEC assessments and the observed impacts resulting from the extraction of Longwall 12 are provided in **Table 3**.

Table 3: Summary of the Assessed and Observed Impacts for Surface Infrastructure Resulting from the Extraction of Longwall 12

Surface Infrastructure	MSEC Assessed Impacts	Observed Impacts
Fire Trails and Tracks	Cracking of unsealed road surfaces	Localised surface cracking observed at tracks, fire trails and seismic lines
Survey Control Marks	Vertical and horizontal movements which could require re-establishment	No reported physical impacts Survey Control Marks to be re-established after completion of mining
Disused Maldon-Dombarton Railway	Possible fracturing of rock cuttings, spalling, and/or mobilisation of rock joints	Displacement and uplift across rail corridor, visible as bump on railway ballast

As shown in **Table 3** the observed impacts on surface infrastructure, resulting from the extraction of Longwall 12, are generally similar to or less than predicted.

6. Impacts to Natural Features

The monitoring program for Longwall 12 was conducted in accordance with the SMP, WIMMCP and SIMMCP. The monitoring program is outlined in Section 7. The results of the ICEFT monitoring are provided in **Attachment C1** and the Impact Reports submitted during Longwall 12 extraction are provided as **Attachment C2**. The results of monitoring undertaken by specialist consultants are provided as **Attachments D** to **F**. **Figure 9** illustrates the location of surface impacts identified during Longwall 12 extraction.

6.1. Natural Features

The ICEFT have conducted detailed monitoring of natural features including swamps, watercourses, rock outcrops and the general landscape within DA3B.

Five surface impacts to natural features were identified by the ICEFT during Longwall 12. Impacted features include tributaries LA4, LA4B and WC21 as well a rock outcrop over the Longwall 12 mining area. The impacts are described in the DA3B Longwall 12 End of Panel Landscape Report (**Attachment C1**) and included **(Table 4)** below.

Impacts were assessed against the relevant TARP (for watercourse, swamp or landscape) which results in assigning a trigger level to each impact (Level 1, Level 2, Level 3). Trigger levels for fractures were determined based on:

- The width and length of the fracture
- Whether the fracture contributed to any observable loss or diversion of surface water, and
- Any erosion or potential for erosion caused by the fracture

One surface impact to a rock outcrop was identified as a result of Longwall 12 extraction. Impact *DA3B_LW12_026* is a Level 2 rock fracture according to the Dendrobium Landscape Impacts, Triggers and Response Plan **(Table 10)**, specifically:

- Crack or fracture between 10m and 50m in length
- A crack in the fire trail, which could result in significant erosion or impede vehicle access
- Crack or fracture between 100 and 300mm width

The fracturing was approximately 25m long and up to 0.20m wide **(Photo 7)**. On a follow-up inspection, an additional adjacent fracture was identified **(Photo 8)**.

Photo 7: DA3B_LW12_026 - Fracturing to rock outcrop. Taken on 20/01/2017

Photo 8: DA3B_LW12_026 - Additional fracturing to sandstone outcrop. Taken on 03/02/2017

Wongawilli and Donalds Castle Creeks

No surface impacts were identified to Wongawilli Creek or Donalds Castle Creek during Longwall 12 extraction.

First and Second Order Streams

Seven first and second order streams were monitored during Longwall 12 extraction: LA4, LA4A, LA4B LA5, LA6, WC16 and WC21.

One Level 1 impact (rock fracturing) was observed in WC21 within the zone of influence for Longwall 12 **(Photo 9)**. No flow diversion was associated with the fracturing. This was assessed under the Dendrobium Watercourse Impacts, Triggers and Response Plan **(Table 12)**, specifically:

- Crack or fracture up to 100mm width at its widest point with no observable loss of surface water or erosion
- Crack or fracture up to 10m in length with no observable loss of surface water or erosion

Two Level 2 impacts were recorded in tributary LA4B and one impact to LA4 **(Photo 10** to **Photo 12).** These impacts are rock fracturing with associated flow diversion, and were assessed under the Dendrobium Watercourse Impacts, Triggers and Response Plan **(Table 12)**, specifically:

- Crack or fracture between 100 and 300mm width at its widest point or any fracture which results in observable loss of surface water or erosion
- Crack or fracture between 10 and 50m length
- Soil surface crack that causes erosion that is likely to stabilise within the monitoring period without intervention

Although not associated with any visible surface impacts, a reduction in surface flow was observed at tributary WC21 **(Photo 13**: Reduction in surface flow at WC21_Pool 41. Taken on 24/11/2016.**)** and WC21A. This occurred over Longwall 12 shortly after mining in the area.

Photo 9: DA3B_LW12_019 – Fracturing to the face of a step in WC21_Step 48. Taken on 9/11/2016.

Photo 10: DA3B_LW12_008 – Uplift on Rockbar upstream of the basal step of Swamp 4. Taken on 20/05/2016.

Photo 11: DA3B_LW12_005- Rock fragment transported downstream at tributary LA4. Taken on 5/07/2016.

Photo 12: DA3B_LW12_010 - Fracture to channel in LA4B. Taken on 25/05/2016.

Photo 13: Reduction in surface flow at WC21_Pool 41. Taken on 24/11/2016.

Rockfalls

There were no impacts involving fracturing and rockfall during the extraction of Longwall 12. Inspections of the landscape will continue in order to identify impacts from future longwalls.

Table 4: Summary of Landscape Impacts. Other triggers also shown.

Site ID	Easting	Northing	Impact Type	Feature Affected	Identification Date	Impact Level	Description	Refer to Impact Report/s Dated
DA3B_LW12_001	287851	6193085	Surface Cracking	Seismic Track	6/04/2016	1	Soil Cracking on seismic track, approx. 3.9m length, 0.08m width, 0.56m depth.	16/04/2016
DA3B_LW12_002	287856	6193130	Surface Cracking	Seismic Track	6/04/2016	1	Soil Cracking on seismic track, approx. 1.9m length, 0.01m width, 0.155m depth.	16/04/2016
DA3B_LW12_003	287827	6193060	Surface Cracking	Seismic Track	12/04/2016	1	One continuous soil crack 20m from seismic track. 5.5m length, 0.07m width, 0.53m depth.	13/04/2016
DA3B_LW12_004	287814	6193085	Surface Cracking	Seismic Track	12/04/2016	1	Multiple soil cracks on seismic track. 2.6m length, 0.05m width, 0.37m depth.	13/04/2016
DA3B_LW12_005	288128	6192557	Rock Fracturing	LA4	3/05/2016	2	Rock fracturing and uplift in watercourse LA4 rockbed.	4/05/2016, 6/07/2016
DA3B_LW12_006 (Addressed in Surface and Shallow Groundwater Assessment)	*288137*	*6192566*	*Water Quality*	*LA4*	*3/05/2016*	*2*	*DO trigger, now Level 2. Water quality trigger for dissolved oxygen at site LA4_S1.*	*4/05/2016, 23/05/2016*
DA3B_LW12_007	287947	6193233	Surface Cracking	Seismic Track	20/05/2016	1	Soil Cracks on seismic track north of Swamp 3. 2.2m length, 0.008m width.	23/05/2016
DA3B_LW12_008	288300	6192957	Rock Fracturing	LA4B	20/05/2016	2	Fracturing and uplift to rockbar in tributary LA4B at the basal step of Swamp 4.	23/05/2016, 6/07/2016
DA3B_LW12_009	288403	6193000	Surface Cracking	Seismic Track	25/05/2016	1	Soil cracking to seismic track adjacent to Swamp 4.	26/05/2016
DA3B_LW12_010	288303	6192988	Rock Fracturing	LA4B	25/05/2016	2	Rock fracturing to sandstone channel on tributary LA4B. Flow diversion evident.	26/05/2016
DA3B_LW12_011	288416	6193009	Surface Cracking	Seismic Track	30/05/2016	1	Soil cracking on seismic track south of Swamp 4.	31/05/2016
DA3B_LW12_012	288407	6192908	Surface Cracking	Seismic Track	30/05/2016	1	Discontinuous soil crack on seismic track south of Swamp 4.	31/05/2016
DA3B_LW12_013	288676	6192976	Surface Cracking	FR6A	27/06/2016	1	Discontinuous soil cracking on Fire Trail 6AA with associated uplift.	27/06/2016, 6/07/2016

DA3B_LW12_014	288630	6192929	Surface Cracking	Rail Corridor	22/07/2016	1	Displacement and uplift across rail corridor, visible as bump on railway ballast.	26/07/2016
DA3B_LW12_015	289379	6192828	Surface Cracking	AT6AA	5/10/2016	1	Multiple soil cracks and associated uplift of tree roots in a 7m x 2m area on Fire Road 6AA.	5/10/2016
DA3B_LW12_016	289382	6192912	Surface Cracking	AT6AA	5/10/2016	1	Soil crack across Fire Road 6AA.	5/10/2016
DA3B_LW12_017	289457	6192953	Surface Cracking	AT6AA	11/10/2016	1	Soil cracking across Fire Road 6AA. Max 2m length, 0.03m width.	13/10/2016
DA3B_LW12_018	289425	6192930	Surface Cracking	AT6AA	11/10/2016	1	Soil cracking across Fire Trail 6AA. Longest continuous crack is approximately 4m length and 0.08m width.	13/10/2016
DA3B_LW12_019	289682	6192531	Rock Fracturing	WC21	9/11/2016	1	Hairline fracture and associated uplift to step between WC21_Pool 49 and 48. No water loss is expected.	9/11/2016
DA3B_LW12_020	289377	6192711	Surface Cracking	Seismic Track	15/11/2016	1	Soil cracking on seismic. Discontinuous.	15/11/2016
DA3B_LW12_021	289492	6192809	Surface Cracking	Seismic Track	15/11/2016	1	Uplift and soil cracking over a 10m section of seismic track.	15/11/2016
DA3B_LW12_022	289747	6192807	Surface Cracking	Seismic Track	15/11/2016	1	Discontinuous soil cracks and associated hairline cracks on seismic track.	15/11/2016
DA3B_LW12_023	289437	6192786	Surface Cracking	Access Track	24/11/2016	1	Soil cracking across access track to WC21. Max 0.003m width, 1.5m length.	24/11/2016
DA3B_LW12_024	289765	6192905	Surface Cracking	Access Track	24/11/2016	1	Soil cracking and uplift on access track adjacent to WC21. 3m length, 0.01m of uplift.	24/11/2016
DA3B_LW12_025	289703	6192697	Surface Cracking	Access Track	24/11/2016	2	Soil cracking in sediment, exposing underlying rock fracturing. Max 10m length, 0.110m width, 1.1m depth.	24/11/2016
DA3B_LW12_026	290125	6192832	Rock Fracturing	Sandstone Outcrop	20/01/2017	2	Rock fractures on sandstone outcrop. 25m length, 0.02m width, 0.15m depth.	24/01/2017
Wongawilli Ck (FR6) *(Addressed in Surface Water Assessment)*	290957	6197417	Water Quality	Wongawilli Creek	23/01/2017	1	Electrical Conductivity of 189 µS/cm was recorded at Wongawilli Ck (FR6), above the 154.1 µS/cm trigger level.	2/02/2017

Swamp 10 *(Addressed in Surface and Shallow Groundwater Assessment)*	289815	6192702	Shallow Groundwater	Swamp 10	24/11/2016	3	Rate of water level recession exceeds highest baseline rate at site S10_01.	24/11/2016
Swamp 11 *(Addressed in Surface and Shallow Groundwater Assessment)*	288631	6192391	Soil Moisture	Swamp 11	2/03/2017	3	Soil moisture at S11_S01 and S11_S02 exceed lowest recorded baseline level.	2/03/2017

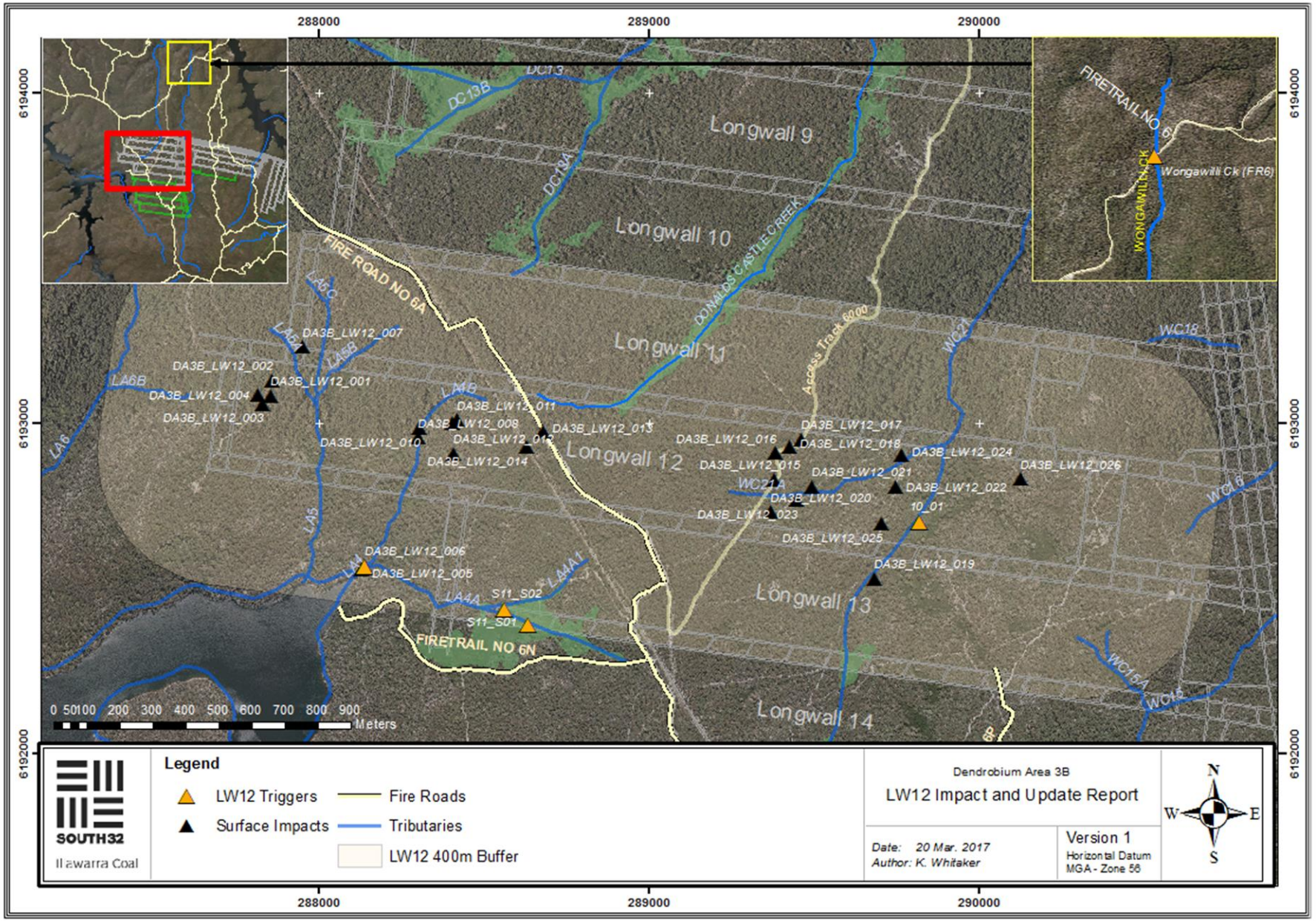

Figure 9: Location of Longwall 12 Surface Impacts. Non-surface impact triggers also shown (discussed in below section)

6.2. Shallow Groundwater

Shallow groundwater in swamps is monitored in accordance with the SIMMCP. Changes to groundwater are reported when measurements of water level drop below baseline levels or when rates of recession exceed those recorded during baseline monitoring. For further details refer to the relevant impact reports **(Attachment C2)** and Surface and Shallow Groundwater Assessment **(Attachment D1** and **D2)**.

Swamps 1a and 1b

Thirteen instrumented groundwater monitoring sites have been installed in Swamps 1a and 1b. Eleven have been undermined by Longwall 9 and one by Longwall 10. No sites were undermined by Longwall 12. Eight of the bores have recorded post-mining water levels lower than baseline and six have recorded post-mining water level recession exceeding baseline conditions. Swamp 1a and 1b have been reported at a Level 3 and Level 2 Trigger, respectively. No further shallow groundwater effects attributed to the extraction of Longwall 12 have been recorded at these swamps.

Swamp 3

Due to the relatively small size of Swamp 3, one groundwater monitoring site has been installed. Longwall 11 passed under the site and the post-mining rate of water level recession is greater than the fastest rate recorded before mining at the equivalent horizon. Swamp 3 is a Level 3 Trigger according to the SIMMCP TARP: Rate of groundwater level reduction exceeds rate of groundwater level reduction during baseline period at >80% of monitoring sites (within 400 m of mining) within the swamp. No further shallow groundwater effects attributed to the extraction of Longwall 12 have been recorded at Swamp 3.

Swamp 5

Eight groundwater monitoring sites have been installed in and around Swamp 5, six of which are located within the upland swamp vegetation community. Three sites have been mined under by Longwall 9, one by Longwall 10, and two (05_05 and 05_01) by Longwall 11.

The swamp is at a Level 3 Trigger. No further effects attributed to the extraction of Longwall 12 have been recorded at Swamp 5. The mining effect is unclear at site 05_05 due to limited baseline data.

Swamp 8

Two out of three shallow boreholes installed in the vicinity of Swamp 8 show a response to previous Longwalls 9 to 11. The sites are not located with Swamp EEC boundary so are not assessed against the TARP.

Swamp 10

Due to the relatively small size of Swamp 10, one groundwater monitoring site has been installed. Following Longwall 12 mining beneath the swamp the rate of recession is greater than the baseline period. The borehole also went dry with no response to small rainfall events. The swamp is a Level 3 Trigger.

Swamp 11

Longwall 12 mined close to Swamp 11 in early 2016. Rate of recession remains lower than baseline and water levels have not dropped below the lowest levels experienced in the baseline period. No effects attributed to the extraction of Longwall 12 have been recorded at Swamp 11.

Further analysis will be undertaken as part of Longwall 13 monitoring.

6.3. Soil Moisture

Soil moisture sensors, measuring dielectric constant, have been installed in swamps and monitored to a depth of 1m. Swamps 5 and 11 and Reference Swamps 14 and 87 have been installed with loggers, measuring soil moisture hourly at 200mm increments (to 1m). Other sites are measured manually with a probe during inspection of the site. Soil moisture is recorded in units of *millimetres of water per 100mm of soil* around the 100mm radius of the sensor using a raw count calibrated to obtain absolute volumetric soil water content, with the results averaged through the soil profile.

Swamp 5

Four soil moisture profiles are monitored in Swamp 5, two with loggers and two measured manually during inspections. Mean moisture levels at the four sites dropped below baseline levels following Longwall 10 and 11 and were reported as a Level 3 Trigger in the Longwall 11 End of Panel Report in accordance with the SIMMCP TARP: Soil moisture level lower than baseline level at >80% of monitoring sites (within 400m of mining) within a swamp (in comparison to reference swamps).

Following extraction of Longwall 12 additional declines in moisture levels were observed at the sites. This may be attributed to the unusually hot, dry summer period that the decline in moisture levels coincided with, as observed in reference soil moisture sites.

Swamp 8

One soil moisture profile is monitored adjacent to Wongawilli tributary WC21. Site S08_S05 was within the zone of influence of Longwall 11 and mined beneath by Longwall 12. The mean soil moisture level has dropped below that recorded in the baseline period. The site is not located within the Swamp EEC boundary and therefore is not assessed against the TARP.

Swamp 11

Three soil moisture sites are located in Swamp 11, S11_S01 with a logger and S11_S02 and S11_S05 recorded manually during inspection at the sites. S11_S01 and S11_S02 are located within 400m of Longwall 12 and within the swamp boundary and are therefore assessed against the TARP. Both sites recorded mean soil moisture levels below that observed in the baseline period, a Level 3 Trigger according to the SIMMCP TARP. Swamp 11 site S11_S05 (outside the Longwall 12 mining area) also recorded a decline below baseline levels, as did reference soil moisture sites.

6.4. Surface Water Quality

TARPs are defined in the WIMMCP for three locations downstream of the mining area, Wongawilli Creek (FR6), Donalds Castle Creek (FR6) and Lake Avon tributary site LA4_S1. The TARPs are based on pH, Electrical Conductivity (EC) and Dissolved Oxygen (DO) and defined by the value three standard deviations (SD) from the baseline mean (mean plus 3SD for EC and mean minus 3SD for pH and DO).

Monitoring is carried out on a monthly basis and weekly when the longwall is within 400m of a feature. Wongawilli Creek (FR6) and Donald's Castle Creek (FR6) were monitored weekly when access was available. Triggers for Wongawilli Ck (FR6) and LA4_S1 were initially identified following inspections at the sites. Triggers for Donalds Castle Ck (FR6) were identified during the Surface Water Assessment (Attachment D1).

TARP triggers for the monitoring period are detailed in **Attachment D1** and summarised in **Table 5.**

Table 5: Summary of Water Quality Triggers

DATE	CATCHMENT / LOCATION	PARAMETER	VALUE	TARP	TRIGGER LEVEL
23/02/2016	Donalds Castle Ck (FR6)	DO	37.5	40.1	2
08/09/2016	Donalds Castle Ck (FR6)	DO	39.2	40.1	
23/02/2016	Wongawilli Ck (FR6)	DO	31	50.5	1
25/01/2017	Wongawilli Ck (FR6)	SpC	189	154.1	1
03/05/2016	LA4_S1	DO	60	69.5	2
20/05/2016	LA4_S1	DO	64.4	69.5	

6.5. Surface Water Flow

Flow gauges have been installed on Sandy Creek (Area 3A); Wongawilli Creek (Area 3B and 3A) and its tributary WC21 (DA3B); Donalds Castle Creek and its tributary DC13 (DA3B) and Lake Avon tributary LA4 (Area 3B). The historical flow record has been plotted alongside the record from a

nearby ‘control’ gauge (i.e. a gauge that was not mined under, either at all or not during the period of interest). The hydrographs are shown in **Attachment D1**.

An Australian Water Balance Model (AWBM; Boughton 2004) was constructed and calibrated for each of the sites, focussing on ‘history-matching’ of observed and modelled flows during the pre-mining period at each monitoring site. The flow during the ‘post-mining’ period plus specific sub-periods covering the extraction of Longwall 12 was predicted while holding all parameters constant.

The predicted post-mining flows were compared against observed flows. Differences in the pre and post-mining period are then highlighted and used to infer and quantify any effects of mining.

The Catchment Water Balance TARP is described in the WIMMCP as:

- **Level 1:** a change in measured discharge (between pre- and post-mining) **6-12%** less than average annual precipitation;
- **Level 2:** a change in measured discharge (between pre- and post-mining) **12-18%** less than average annual precipitation;
- **Level 3:** a change in measured discharge (between pre- and post-mining) **>18%** less than average annual precipitation.”

Table 6: Summary of Water Flow Triggers

CATCHMENT	SITE	TARP TRIGGER	YIELD CHANGE	COMMENTS
Donalds Castle	DCS2	Level 3	-28%	Sub-catchment of Donalds Castle Creek
	DC13S1	Level 3	-22%	Sub-catchment of Donalds Castle Creek
	DCU	Not Triggered		Donalds Castle Creek Catchment
Wongawilli Creek	WC15S1	Not Triggered		Sub-catchment of Wongawilli Creek (not mined under)
	WC21S1	Not Triggered		Sub-catchment of Wongawilli Creek
	WWL	Not Triggered		Wongawilli Creek Catchment
Lake Avon Tributary	LA4S1	Not Triggered		Tributary to Lake Avon

While not a trigger, analysis of surface flow results at sub-catchment sites LA4S1 and WC21S1 also indicate a mining impact.

No surface flow triggers have been identified for the larger WWL or DCU catchments.

6.6. Deep Groundwater

Groundwater at Dendrobium Mine was assessed by examining spatial and temporal responses measured in downhole vibrating wire piezometers, and comparison of observed groundwater head drawdowns with those anticipated by numerical groundwater modelling. Groundwater inflow to the mine has also been compared to the flows anticipated by the numerical model. Variations in groundwater salinity have been examined in several geological formations. These groundwater assessments are provided in **Attachment D3**. Monitoring site locations are shown in **Figure 10**

Mine Inflow

The average daily inflow to DA3B during extraction of Longwall 12 was 4.5ML/d. This represents approximately 60% of total mine inflow for Dendobium Mine (7.4ML/d) during the period. From 2013 up to the completion of Longwall 11, inflows to DA3B increased in proportion to total mined area, with no apparent correlation with rainfall. During Longwall 12 DA3B shows a correlation with DA3A and a lagged response to high rainfall events.

Groundwater Quality

Groundwater salinity (as indicated by EC) shows no significant spatial variation in either Bulgo Sandstone or Hawkesbury Sandstone bores. There is a general increase in salinity with depth from the Hawkesbury Sandstone to the Bulgo Sandstone and down to the coal measures. Groundwater in the Hawkesbury Sandstone is variable but typically has an EC of between 80 and 500µS/cm, whereas inflow to the mine typically has an EC in the range of 1000 to 3000µS/cm. This is a natural phenomenon and indicates that groundwater inflow to the mine is dominated by groundwater from the deep geological strata. There is no evidence for adverse change to groundwater quality as a result of mining.

Groundwater Levels

Groundwater levels are monitored by an extensive network of vibrating wire piezometers that extend vertically from near the surface to within the coal measures.

Mining of longwall 12 resulted in continued depressurisation of the target coal seam and overlying strata.

Drawdown in the Hawkesbury Sandstone is spatially variable but largest above and immediately adjacent to Longwall 12. Outside this, drawdown was generally negligible with the exception of borehole S2001 (790m to the south) where drawdown was evident.

Drawdown response to Longwall 12 was markedly different between the Bulgo Sandstone and Hawkesbury Sandstone. This further supports the concept that the Hawkesbury Sandstone retains

perched aquifers and that mining-induced vertical fracture networks extend to the upper part of the Bulgo Sandstone, but do not (everywhere) extend above the base of the Hawkesbury Sandstone.

In the Wongawilli and Bulli coal seams, the lowest groundwater pressures occurred in the vicinity of Longwall 12 (as expected), although partial depressurisation above the longwall is evident prior to the start of Longwall 11 as a result of previous mining at Areas 3B and 3A, and at neighbouring mines.

The largest change in groundwater level (drawdown) during the extraction of Longwall 12 occurred within the Scarborough Sandstone and to a lesser extent in the Bulgo Sandstone in Area 3B. This is attributed to subsidence-induced fracturing above the extracted longwalls in Area 3B and resulting depressurisation of the fracture network. Incremental drawdown in the Scarborough Sandstone was in the order 50 to 105m, and the Bulgo Sandstone in the order of 30 to 40m (based on piezometers not damaged by mining induced movements). Both Scarborough and Bulgo units recorded the largest drawdown directly to the south of Longwall 12 with drawdown decreasing to between 4m and 7m approximately 1km south of Longwall 12. Farther afield, borehole S2194 (approximately 1.8km to the south of Longwall 12) recorded incremental drawdowns of 11m and 18m in the Scarborough and Bulgo units respectively, corresponding with depressurisation of underlying coal units. The observed incremental drawdown is consistent with numerical model predictions.

The observed drawdown in the lower Hawkesbury Sandstone in Area 3B due to the extraction of Longwall 12 is less than the modelled drawdown in the vicinity of the longwall, and of a similar magnitude elsewhere.

The numerical model predictions of groundwater inflow to the mine continue to match well with observed inflows, particularly in Area 3B. The model tends to be conservative in drawdown of overlying strata, particularly in the deeper strata, where the model predicts larger drawdowns than observed.

DSC Monitoring

The estimated net loss (seepage from and reduced seepage to) Avon reservoir at the end of Longwall 12 is less than 0.4 ML/d and therefore within the tolerable loss limit of 1 ML/day prescribed by the DSC (DSC 2014).

The Secondary DSC TARP 4 (Area 3A Groundwater monitoring – Bores S1867, S1870, S1992, S1994) reached Level 3 during extraction of Longwall 12. Piezometric head measured in all Bulgo piezometers (within a borehole) dropped below the Cordeaux Dam water level.

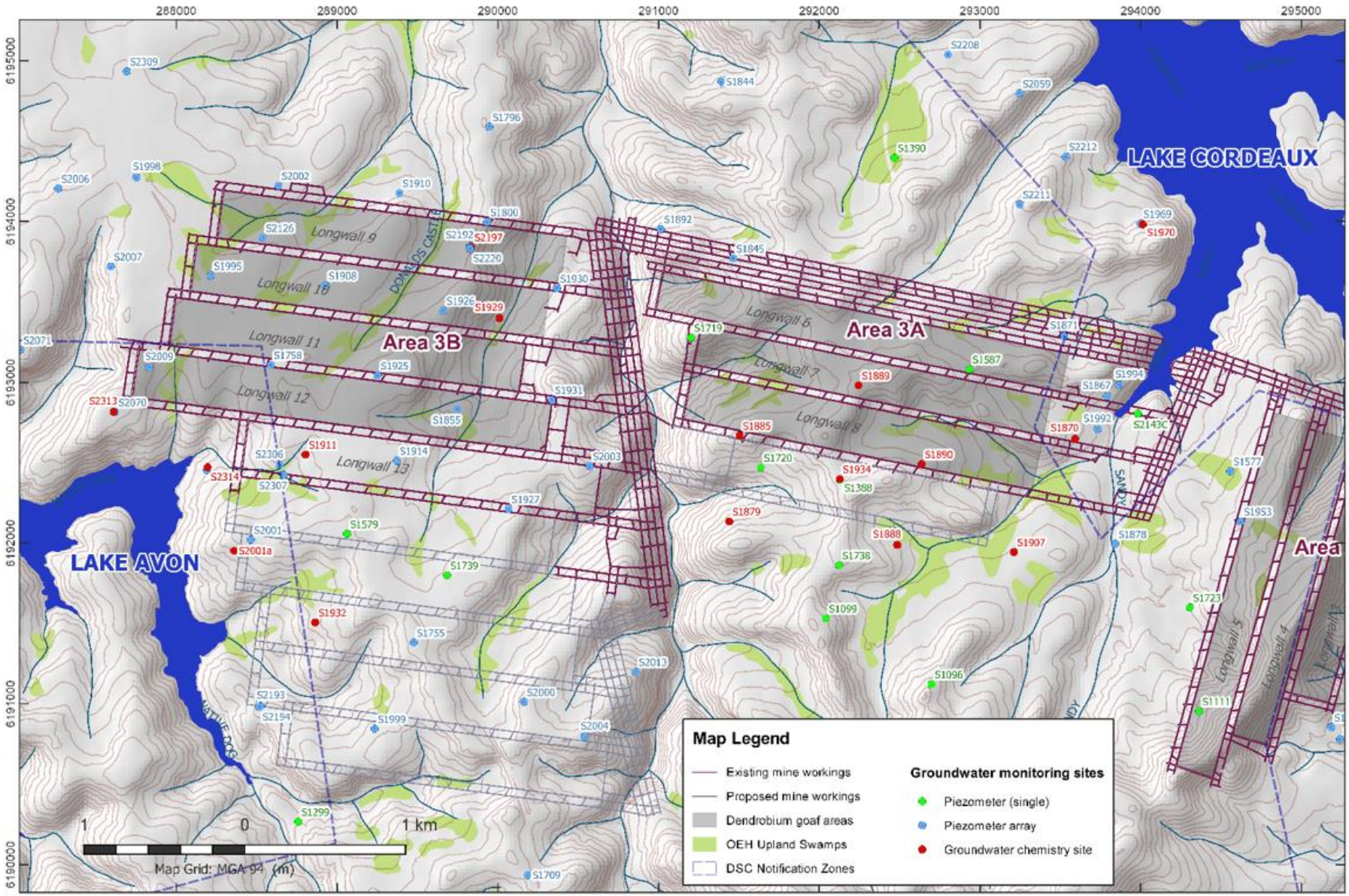

Figure 10: Deep groundwater monitoring network around Dendrobium Areas 2, 3A and 3B

6.7. Terrestrial Ecology

Attachment E1 reports on the Dendrobium Terrestrial Ecology Monitoring Program for Dendrobium Areas 2, 3A and 3B. **Attachment E2** reports on additional Littlejohn's Tree Frog monitoring in Dendrobium Areas 3A and 3B.

A Terrestrial Ecology Monitoring Program is in place for Dendrobium Mine. It incorporates 11 years of monitoring in Dendrobium Area 2, 7 to 13 years in Dendrobium Area 3A and 4 years in Dendrobium Area 3B. Monitoring includes a minimum of two years baseline surveys for pre-impact sites within Area 2 and Area 3. Monitoring of control sites has been occurring for a minimum of three years for Dendrobium Area 3B and up to a maximum of 11 years for Area 2.

The following ecological features are monitored:

- Vegetation within upland swamps in Dendrobium Area 2, Area 3A and Area 3B.
- Littlejohn's Tree Frog (*Litoria littlejohni*) along selected streams providing suitable habitat in Dendrobium Area 3A and Area 3B.

The program includes monitoring and analysis of six upland swamp sites as post-mining sites (Swamp 1 (S1), Swamp 15B (S15B), Swamp 15A(2) (S15A(2)), Swamp 1A (S1A), Swamp 1B (S1B) and Swamp 5 (S5)). The remaining swamps were monitored and analysed as controls or pre-mining sites. Parameters analysed include Total Species Richness (TSR) and species composition as well as swamp size and the extent of groundwater dependent swamp sub-communities.

Analysis of LiDAR data indicates the extent of upland swamps has declined at all control and impact swamps in Dendrobium 3A and 3B when compared to the baseline year of 2012. Results indicate that no swamp size TARP trigger levels have been met for impact swamps in Dendrobium Area 3B as the observed decline in swamp extent from 2015 to 2016 was preceded by an increase in swamp extent from 2014 to 2015.

Change in the extent of upland swamp sub-communities from 2012 through to 2016 was similar to the trend observed for total swamp extent. An exception to this trend was Swamp 1A and Swamp 5 where three consecutive years of decline of the sub-community Upland Swamps: Banksia Thicket (Swamp 5 only) and Upland Swamps: Tea-Tree Thicket (Swamp 1A and Swamp 5) were recorded. These declines were greater than the mean (±SE) decline in the control group, indicating a Level 2 ecosystem functionality TARP trigger at these swamps.

Caution is urged when interpreting the results of the swamp size and ecosystem functionality LiDAR monitoring given that a number of factors unrelated to mining-induced impacts may drive some of the observed decreases in swamp size and extent of groundwater dependent sub-communities. Changes in swamp size and extent of groundwater dependent communities observed at each swamp may be the

result of responses to natural phenomena such as recent and long-term climate conditions, fire patterns and stochastic events (e.g. storm damage).

A statistically significant decline in Total Species Richness (TSR) was detected at Swamp 1 (Dendrobium Area 2) and Swamp 15B (Dendrobium 3A). Declines in TSR were observed immediately following each site being mined beneath and have continued for at least four years post-mining. Yearly changes in species composition were detected in most sites, regardless of area or treatment. This variation is due to natural turnover of species and is to be expected with changes in rainfall, temperature, natural succession and other seasonal factors. When accounting for the yearly effects, a statistically significant change in species composition in post-mining data to pre-mining data was found at Swamp 1 (Dendrobium Area 2), Swamp 15B (Dendrobium 3A) and Swamp 15A(2) (Dendrobium 3A). The change detected at Swamp 1 however was detected for a four year period post-mining between 2007 and 2010, however in recent years (2010 to 2016), the change in species composition when compared to pre-mining data was not apparent.

Monitoring of seven streams in 2016 (SC10C, WC17, 6CDL, DC(1), DC13, WC21 and LA4A) as part of the Littlejohn's Tree Frog program were analysed as post-mining sites. Within Dendrobium Area 3A, adult Littlejohn's Tree Frogs were recorded again in 2016 at WC17 for the first time since 2013. Similarly, Littlejohn's Tree Frog was recorded again in 2016 at SC10C following the absence of adults between 2012 and 2014.

When assessing the presence of Littlejohn's Tree Frog at SC10C over the course of time, it is clear that despite detecting the species in 2016, a local reduction in the available breeding habitat has occurred where mining impacts have occurred. This reduction in habitat has been evident for four consecutive winter monitoring surveys.

Similarly for Dendrobium Area 3B, while Littlejohn's Tree Frogs were recorded at DC13 adult, egg mass and tadpole numbers remain low when compared to control sites and pre-mining data at the site. This is a likely reflection of the reduction in habitat for over two consecutive years post-mining. Following an assessment against the TARP for terrestrial fauna - threatened frog species, it was determined that a Level 3 had been triggered for DC13. A reduction in habitat was also noted throughout approximately 57% of the WC21 monitoring transect. Following an assessment against the TARP it was determined that a Level 2 trigger had been reached for WC21 in 2016. No triggers have been reached for the remaining impact sites.

Monitoring of upland swamps and Littlejohn's Tree Frog sites will continue throughout 2017 in Dendrobium Area 3A and Dendrobium Area 3B.

The monitoring program will continue to achieve the following four key objectives:

- Ongoing monitoring of biophysical characteristics within Dendrobium Area 2 and Dendrobium Area 3.

- Determine if mining results in changes to the biological integrity of the Dendrobium mining area through comparison of baseline and control data with that collected through ongoing monitoring.
- Provide input to the design of any rehabilitation programs that may be necessary.
- Monitor the success of any remedial works.

Photo 14: Littlejohn's Tree Frog in metamorphosis, photographed at WC21, summer 2017 (Biosis, 2017).

6.8. Erosion in Swamps

The SIMMCP requires monitoring and assessment to determine any areas of erosion in swamps resulting from mining impacts. TARPs have been established as follows:

- Level 1: The increase in length of erosion within a swamp (compared to its pre-mining length) is 2% of the swamp length or area; and/or

  Erosion in a localised area (not associated with cracking or fracturing) which would be expected to naturally stabilise without CMA and within the period of monitoring.

- Level 2: The increase in length of erosion within a swamp (compared to its pre-mining length) is 3% of the swamp length or area; and/or

  Soil surface crack that causes erosion that is likely to stabilise within the monitoring period without intervention; and/or

  Gully knickpoint forms or an existing gully knickpoint becomes active.

- Level 3: The increase in length of erosion within a swamp (compared to its pre-mining length) is 4% of the swamp length or area; and/or

  Soil surface crack that causes erosion that is unlikely to stabilise within the monitoring period without intervention.

- Exceeding Prediction

  Mining results in the total length of erosion within a swamp (compared to its pre-mining length) to increase >5% of the length or area of the swamp compared to any increase in total erosion length in a reference swamp (ie increase in length or area of erosion in an impact swamp less any increase in length or area in erosion in a reference swamp is >5%).

Impact assessment includes analyses of LiDAR results, combined with infield observations. No notable areas of erosion were identified following completion of Longwall 12. Any erosion observed was found to be present during the baseline period or was less than 2% of the length or area of the swamp.

Erosion monitoring in conjunction with analysis of LiDAR results will continue.

6.9. Aquatic Ecology

Cardno Ecology Lab undertakes a monitoring program designed to detect mining-related subsidence impacts to indicate the condition of aquatic ecology. The monitoring program is based on a Before, After, Control, Impact (BACI) design that provides a measure of natural spatial and temporal variability

in key aquatic ecology indicators at potential impact and control sites before, during and after mining. This enables changes in the mining area to be distinguished from changes due to natural variability.

The monitoring program focuses on the following key indicators:

- Habitat condition, assessed using the Riparian, Channel and Environmental (RCE) Inventory method and by establishing a photographic record through time;
- Aquatic macroinvertebrates sampled in accordance with the Australian River Assessment System (AUSRIVAS);
- Aquatic macroinvertebrates sampled quantitatively using artificial collectors;
- Sampling of fish using bait traps and backpack electrofishing; and
- Limited in situ water quality sampling is undertaken to assist with interpretation of trends in the above indicators.

Monitoring is undertaken within Wongawilli Creek, WC21 (a tributary of Wongawilli Creek) and Donalds Castle Creek, and at comparable Control sites established on Wongawilli, Sandy, Donalds Castle and Kentish creeks. Univariate and multivariate statistical analyses of data obtained from the AUSRIVAS sampling and artificial collectors were used to examine changes to aquatic ecology that may have occurred and to assess whether such changes are associated with mining. Surveys were undertaken in 2010, 2011, 2013, 2014 and 2015. The latest published results were summarised in the Dendobium Longwall 11 End of Panel Report**.** Results of the latest monitoring are expected late 2017.

Cardno were commissioned to complete a specific Review of Aquatic Flora and Fauna for Dendrobium Area 3B Longwall 12 **(Attachment E3)**. Data used in the assessment included Cardno fieldwork in March 2017 as well as observations provided by the ICEFT.

Physical impacts were observed in Lake Avon tributary LA4B, including fracturing and flow diversion as discussed in **Attachment C1**. Fracturing and a reduction in aquatic habitat was observed in the upper reach of LA4B following Longwall 12 extraction. While fracturing was also observed to a rockbar in the lower reach of LA4, directly downstream from LA4B, aquatic habitat was maintained in this area. Water quality triggers were recorded in LA4, however these appear to be temporary and not a mining impact. LA4/4B is not assessed under the TARP according to the Dendrobium Area 3B WIMMCP.

Wongawilli Creek was surveyed as part of the April 2017 fieldwork for the broader DA3B assessment. Based on preliminary findings of the survey there does not appear to be any change to aquatic habitat in Wongawilli Creek. Though water quality triggers were recorded in downstream site Wongawilli Ck (FR6), these appear to be temporary and not a mining impact.

WC21 has been mined beneath by previous Longwalls 9 to 11 with fracturing of bedrock, flow diversions and associated reductions in pool water levels and flow. During the April 2017 fieldwork, aquatic ecology site X2 consisted of a few small and disconnected pools, likely as a result of rainfall. Site 6, downstream from mining had surface flow.

Water was also observed in site X3, located approximately 80m downstream from Longwall 12, during the April 2017 survey. A reduction in water level at this location was identified during Longwall 12 however it coincided with an extended dry period. Additional monitoring will determine the further response to Longwall 12.

There was no evidence of any change to macroinvertebrate and fish data at the site further downstream on WC21 (Site 6) following extraction of Longwalls 9 to 12 (CEL 2017), further suggesting that impacts observed in WC21 are localised to the areas directly affected by habitat loss. Monitoring of this site will continue throughout 2017 as part of the ongoing monitoring program.

While no aquatic ecology triggers have been recorded for the Longwall 12 sites, there has been some reduction in aquatic habitat of the mining area.

6.10. Cultural Heritage

The assessment of cultural heritage and archaeological sites potentially impacted by Longwall 12 was conducted by Niche **(Attachment F)**. Aboriginal archaeological sites within 400m of Longwall 12 were inspected **(Figure 11)**.

No impacts to sites were observed **(Table 7)**. There are no European heritage sites identified near Longwall 12.

Table 7: Aboriginal Archaeological Sites in Relation to Longwall 12

AHIMS Number	Site Name	Site Type	Changes observed
52-2-1627	Browns Site 12 (52-2-1628)	Shelter with art	None
52-2-1775	Upper Avon 39 (52-2-1775)	Shelter with deposit	None
52-2-1776	Upper Avon 40 (52-2-1776)	Shelter with art and deposit	None
52-2-1778	Upper Avon 41 (52-2-1778)	Shelter with deposit	None
52-2-2209	Dendrobium 2 (52-2-2209)	Shelter with deposit	None

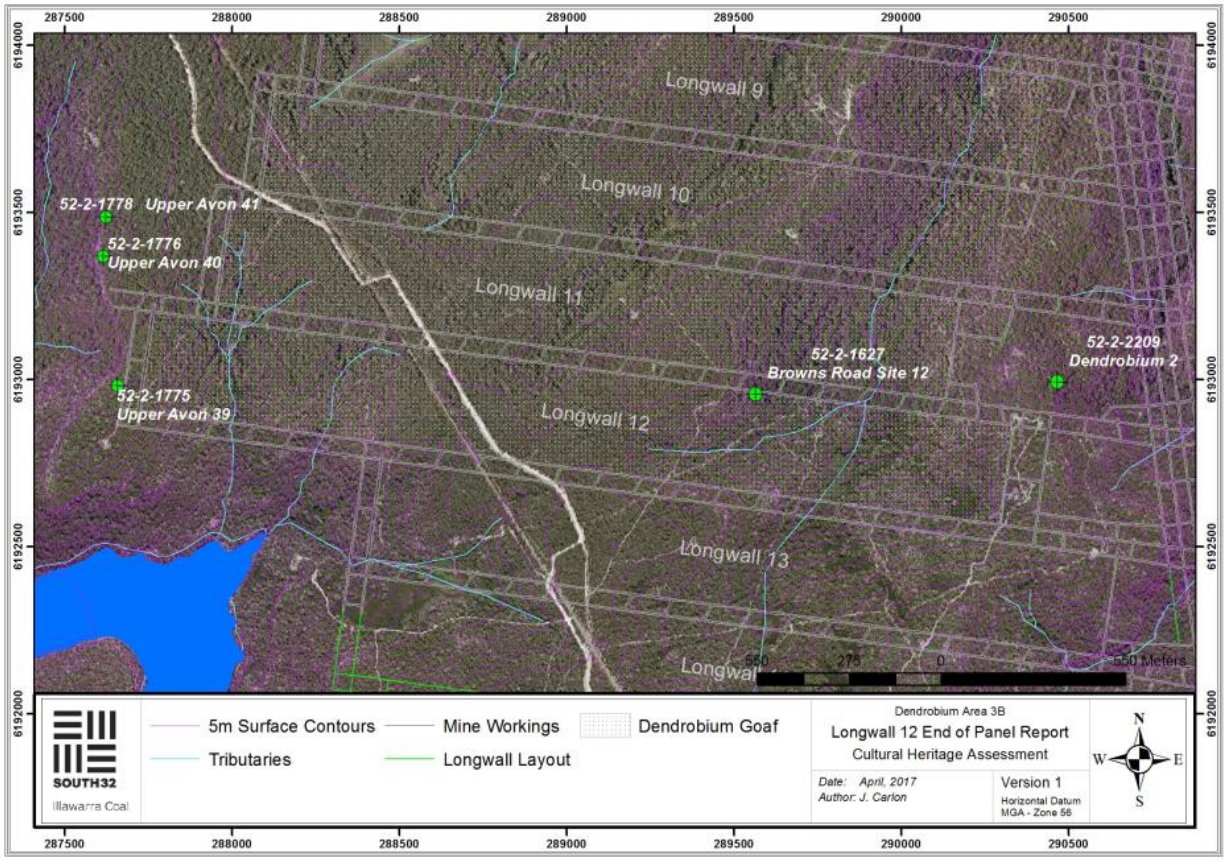

Figure 11: Aboriginal archaeological sites within 400m of Longwall 12, DA3B

6.11. Summary of TARP Triggers

Built Features

Twenty impacts have been identified on access tracks within the Longwall 12 mining area. These impacts consist of soil cracking or uplift to fire trails, access tracks and seismic lines, as well as the disused Maldon – Dombarton Railway Corridor.

Nineteen of these impacts are Level 1 and one is Level 2 according to the DA3B Landscape Impacts, Triggers and Response Plan.

Surface impacts to Natural Features

Five surface impacts to natural features were identified by the ICEFT. Level 2 fracturing was observed to tributaries LA4 and LA4B and Level 1 fracturing to tributary WC21. These were classified according to the DA3B WIMMCP.

Level 2 fracturing was identified to a rock outcrop over the eastern end of Longwall 12.

Shallow Groundwater

Due to the relatively small size of Swamp 10, one groundwater monitoring site has been installed. Since Longwall 12 passed under the site, the post-mining rate of water level recession is greater than the fastest rate recorded before mining at the equivalent horizon. This is a Level 3 Trigger according to the SIMMCP.

Soil Moisture

Three soil moisture profiles are monitored in Swamp 11. Sites S11_S01 and S11_S02 were within 400m of Longwall 12 and soil moisture levels dropped below baseline levels. Swamp 11 is at a Level 3 Trigger according to the SIMMCP TARP.

Surface Water Quality

Trigger values for water quality are defined in the WIMMCP. TARPs have been defined for three locations downstream of the mining area (Wongawilli Creek (FR6) and Donalds Castle Creek (FR6) and Lake Avon (LA4_S1)). The TARPs are based on the field parameters pH, EC and DO and defined by the value three standard deviations (SD) from the baseline mean (mean plus 3SD for EC and mean minus 3SD for pH and DO).

During Longwall 12, LA4_S1 and Donalds Castle Creek (FR6) met a Level 2 DO Trigger and Wongawilli Creek (FR6) met a Level 1 Trigger for DO and SpC.

Surface Water Flow

Data from flow gauges installed on catchments of Wongawilli Creek (Areas 3B and 3A); Donalds Castle Creek and a tributary (LA4) of Lake Avon (Area 3B) has been used to construct an AWBM and compare observed and modelled flows during the pre-mining and post-mining periods. Differences in the pre and post-mining period are used to infer and quantify any effects that mining has on the catchment and to determine TARP levels within the WIMMCP.

The DCS2 and DC13S1 sub-catchments of Donalds Castle Creek have Level 3 triggers recorded. The overall catchment of Donalds Castle Creek and Wongawilli Creek have not triggered a TARP.

While no other TARPs have been triggered, there is an apparent response to mining in sub-catchments LA4S1 and WC21S1.

Deep Groundwater

The Secondary DSC TARP 4 (Area 3A Groundwater monitoring – Bores S1867, S1870, S1992, S1994) is at Level 3. Piezometric head measured in all Bulgo piezometers (within a borehole) have dropped below the Cordeaux Dam water level.

Terrestrial Ecology

Swamps 1A and 5 have reached a Level 2 Ecosystem Function Trigger. This is defined as three monitoring periods of decline in groundwater dependent swamp sub-communities relative to baseline in which the decline is greater than the observed decline in the control group and exceeds the standard error of the control group.

A statistically significant change in Total Species Richness (TSR) was recorded in Swamp 1(DA2) and in DA3A Swamps 15A and 15B. Swamp 15A and 15B are a Level 2 trigger for Ecosystem Function.

DA3A tributaries WC17 and SC10C are at a Level 1 trigger for Littlejohn Tree Frog habitat.

In DA3B, tributary DC13 is at a Level 3 trigger for recording a reduction in habitat for greater than two years. Tributary WC21 is at a Level 2 trigger for a reduction in habitat for 2 years. A reduction in habitat at site DC(1) has been recorded.

Aquatic Ecology

Under the aquatic ecology TARP for DA3B, a reduction in aquatic habitat at a monitoring site for 1 year constitutes a Level 1 Trigger, a reduction for 2 years following the active subsidence period (i.e. when a Longwall is within 400 m of a feature) is a Level 2 Trigger and a reduction for more than 2 years or a complete loss of habitat following the active subsidence period is a Level 3 Trigger.

No triggers were identified for aquatic ecology sites in Wongawilli Creek or tributary WC21. Mining-induced reduction to aquatic habitat was localised to the mining area.

Cultural Heritage

No impacts to Aboriginal archaeological sites were observed **(Table 7)**. There are no European heritage sites identified near Longwall 12.

Table 8: Summary of TARP Triggers Observed During Longwall 12 Extraction

Site ID	Identification Date	Activating Longwall	Feature Affected	Impact Type	Description	Impact Level	TARPs Used	Refer to Report/s Dated
DA3B_LW12_001	6/04/2016	LW12	Seismic Track	Surface Cracking	Soil Cracking on seismic track, approx. 3.9m length, 0.08m width, 0.56m depth.	1	Area 3B SMP Volume 2 Table 2	6/04/2016
DA3B_LW12_002	6/04/2016	LW12	Seismic Track	Surface Cracking	Soil Cracking on seismic track, approx. 1.9m length, 0.01m width, 0.155m depth.	1	Area 3B SMP Volume 2 Table 2	6/04/2016
DA3B_LW12_003	12/04/2016	LW12	Seismic Track	Surface Cracking	One continuous soil crack 20m from seismic track. 5.5m length, 0.07m width, 0.53m depth.	1	Area 3B SMP Volume 2 Table 2	13/04/2016
DA3B_LW12_004	12/04/2016	LW12	Seismic Track	Surface Cracking	Multiple soil cracks on seismic track. 2.6m length, 0.05m width, 0.37m depth.	1	Area 3B SMP Volume 2 Table 2	13/04/2016
DA3B_LW12_005	3/05/2016	LW12	LA4	Rock Fracturing	Rock fracturing and uplift in watercourse LA4 rockbed.	2	WIMMCP TARP	4/05/2016, 6/07/2016
DA3B_LW12_006 (Addressed in Surface and Shallow Groundwater Assessment)	*3/05/2016*	LW12	*LA4*	*Water Quality*	Mean minus 3SD for DO	*2*	WIMMCP TARP	4/05/2016, 23/05/2016
DA3B_LW12_007	20/05/2016	LW12	Seismic Track	Surface Cracking	Soil Cracks on seismic track north of Swamp 3. 2.2m length, 0.008m width.	1	Area 3B SMP Volume 2 Table 2	23/05/2016
DA3B_LW12_008	20/05/2016	LW12	LA4B	Rock Fracturing	Fracturing and uplift to rockbar in tributary LA4B at the basal step of Swamp 4.	2	WIMMCP TARP	23/05/2016, 6/07/2016
DA3B_LW12_009	25/05/2016	LW12	Seismic Track	Surface Cracking	Soil cracking to seismic track adjacent to Swamp 4.	1	Area 3B SMP Volume 2 Table 2	26/05/2016
DA3B_LW12_010	25/05/2016	LW12	LA4B	Rock Fracturing	Rock fracturing to sandstone channel on tributary LA4B. Flow diversion evident.	2	WIMMCP TARP	26/05/2016
DA3B_LW12_011	30/05/2016	LW12	Seismic Track	Surface Cracking	Soil cracking on seismic track south of Swamp 4.	1	Area 3B SMP Volume 2 Table 2	31/05/2016

DA3B_LW12_012	30/05/2016	LW12	Seismic Track	Surface Cracking	Discontinuous soil crack on seismic track south of Swamp 4.	1	Area 3B SMP Volume 2 Table 2	31/05/2016
DA3B_LW12_013	27/06/2016	LW12	FR6A	Surface Cracking	Discontinuous soil cracking on Fire Trail 6AA with associated uplift.	1	Area 3B SMP Volume 2 Table 2	27/06/2016, 6/07/2016
DA3B_LW12_014	22/07/2016	LW12	Rail Corridor	Surface Cracking	Displacement and uplift across rail corridor, visible as bump on railway ballast.	1	Area 3B SMP Volume 2 Table 2	22/07/2016
DA3B_LW12_015	5/10/2016	LW12	AT6AA	Surface Cracking	Multiple soil cracks and associated uplift of tree roots in a 7m x 2m area on Fire Road 6AA.	1	Area 3B SMP Volume 2 Table 2	5/10/2016
DA3B_LW12_016	5/10/2016	LW12	AT6AA	Surface Cracking	Soil crack across Fire Road 6AA.	1	Area 3B SMP Volume 2 Table 2	5/10/2016
DA3B_LW12_017	11/10/2016	LW12	AT6AA	Surface Cracking	Soil cracking across Fire Road 6AA. Max 2m length, 0.03m width.	1	Area 3B SMP Volume 2 Table 2	17/10/2016
DA3B_LW12_018	11/10/2016	LW12	AT6AA	Surface Cracking	Soil cracking across Fire Trail 6AA. Longest continuous crack is approximately 4m length and 0.08m width.	1	Area 3B SMP Volume 2 Table 2	17/10/2016, 9/11/2016
DA3B_LW12_019	9/11/2016	LW12	WC21	Rock Fracturing	Hairline fracture and associated uplift to step between WC21_Pool 49 and 48. No water loss is expected.	1	WIMMCP TARP	9/11/2016
DA3B_LW12_020	15/11/2016	LW12	Seismic Track	Surface Cracking	Soil cracking on seismic. Discontinuous.	1	Area 3B SMP Volume 2 Table 2	16/11/2016
DA3B_LW12_021	15/11/2016	LW12	Seismic Track	Surface Cracking	Uplift and soil cracking over a 10m section of seismic track.	1	Area 3B SMP Volume 2 Table 2	16/11/2016
DA3B_LW12_022	15/11/2016	LW12	Seismic Track	Surface Cracking	Discontinuous soil cracks and associated hairline cracks on seismic track.	1	Area 3B SMP Volume 2 Table 2	16/11/2016
DA3B_LW12_023	24/11/2016	LW12	Access Track	Surface Cracking	Soil cracking across access track to WC21. Max 0.003m width, 1.5m length.	1	Area 3B SMP Volume 2 Table 2	24/11/2016

DA3B_LW12_024	24/11/2016	LW12	Access Track	Surface Cracking	Soil cracking and uplift on access track adjacent to WC21. 3m length, 0.01m of uplift.	1	Area 3B SMP Volume 2 Table 2	24/11/2016
DA3B_LW12_025	24/11/2016	LW12	Access Track	Surface Cracking	Soil cracking in sediment, exposing underlying rock fracturing. Max 10m length, 0.110m width, 1.1m depth.	2	Area 3B SMP Volume 2 Table 2	24/11/2016
DA3B_LW12_026	20/01/2017	LW12	Sandstone Outcrop	Rock Fracturing	Rock fractures on sandstone outcrop. 25m length, 0.02m width, 0.15m depth.	2	Area 3B SMP Volume 2 Table 2	24/11/2016
Wongawilli Ck (FR6)	25/01/2017, 23/02/2017	LW12	Wongawilli Creek	Water Quality	Mean minus 3SD for DO and SpC	1	WIMMCP TARP	2/02/2017,
Donalds Castle Ck (FR6)	23/02/2016, 08/09/2016	LW12	Donalds Castle Creek	Water Quality	Mean minus 3SD for DO	2	WIMMCP TARP	19/05/2017
DCS2	N/A	LWs 9 - 12	Stream	Water Flow	-28% yield	3	WIMMCP TARP	25/05/2016
DC13S1	N/A	LWs 9 - 12	Stream	Water Flow	-22% yield	3	WIMMCP TARP	25/05/2016
Swamp 1A	N/A	Area 3B	Swamp	Vegetation	Three years of decline in groundwater dependant swamp sub-communities	2	SIMMCP TARP	25/05/2017
Swamp 5	N/A	Area 3B	Swamp	Vegetation	Three years of decline in groundwater dependant swamp sub-communities	2	SIMMCP TARP	25/05/2017
Swamp 15A	N/A	Area 3A	Swamp	Vegetation	Statistically significant change in species composition	2	DA3A Terrestrial Flora and Fauna TARP	25/05/2017

Swamp 15B	N/A	Area 3A	Swamp	Vegetation	Statistically significant change in species composition	2	DA3A Terrestrial Flora and Fauna TARP	25/05/2017
DSC Bores S1867, S1870, S1992, S1994	18/6/2015	Area 3A	Groundwater	Bulgo Groundwater Level	Below Cordeaux level	3	DSC Management Plan	Dec. 2016
Swamp 10	24/11/2016	LW12	Swamp 10	Shallow Groundwater	Rate of recession exceeds baseline rate	3	SIMMCP TARP	24/11/2017
Swamp 11	2/03/2017	LW12	Swamp 11	Soil Moisture	Soil moisture below lowest in baseline period	3	SIMMCP TARP	2/03/2017
DC13	N/A	Area 3B	Stream	Habitat	Reduction in Littlejohn's Tree Frog habitat for more than 2 years	3	WIMMCP TARP	25/05/2017
WC21	N/A	Area 3B	Stream	Habitat	Reduction in Littlejohn's Tree Frog habitat for 2 years	2	WIMMCP TARP	25/05/2017
WC17	N/A	Area 3A	Stream	Habitat	No significant statistical difference between Before After Control Impact sites	1	WIMMCP TARP	25/05/2017
SC10C	N/A	Area 3A	Stream	Habitat	No significant statistical difference between Before After Control Impact sites	1	WIMMCP TARP	25/05/2017

7. Longwall 12 Monitoring Program

A Comprehensive monitoring program for Longwall 12 is in place as required by the DA3B SMP Approval. The monitoring commitments outlined in the SMP (and as amended by applicable management plan) is shown in **Table 9**.

Table 9: Monitoring Associated with Longwall 12

ASPECT	MONITORING SITES ASSOCIATED WITH LONGWALL 12	MONITORING REQUENCY	RECOMMENDED FUTURE MONITORING
Watercourses	**Observational, Photo Point and Water Monitoring**		
	• Wongawilli Creek • Donalds Castle Creek • WC21 • WC16 • WC18 • LA4 • LA4A • LA4B • LA5 • LA6 • Swamps 1a, 3, 4, 5, 8, 10,11 and 13	Monthly 2 years pre and post mining, weekly when longwall is within 400m of monitoring site SLMMP Sites: pre and post mining, monthly when longwall is within 400m of monitoring site	• WC15 • Swamp 14 • Wongawilli Creek – Continue as required • Donalds Castle Creek – Continue as required • WC21, WC16 and WC18 – Continue as required • DC13 – Continue as required • LA4, 4A, 4B and LA5 - continue as required • Swamps 1a, 3, 4, 5, 8, 10, 11 and 13 – Continue as required
	Water Quality		
	• WWU1 (Wongawilli Creek headwaters) • WWU4 (Wongawilli Creek upstream) • WC Pool 49 (Wongawilli Creek adjacent to LW15) • WC_Pool 46 [*Previously named WWM1*] (Wongawilli Creek adjacent to LW12) • WWM2 (Wongawilli Creek adjacent to LW11) • WC_Pool 43b [*Previously named WWM3*] (Wongawilli Creek downstream of LW9) • Wongawilli Ck (FR6) [*Previously named WWL2*] (Wongawilli Creek downstream) • WC21_Pool 5 [*Previously named WC21S1*] (Wongawilli Creek tributary downstream of mining) • WC21 Pool 30 (Wongawilli Creek tributaries over mining) • WC21 Pool 53 (Wongawilli Creek tributaries over mining) • WC15_Pool 9 [*Previously*	Monthly monitoring during and post mining for two years until required	Continue water quality sample sites as required by the SMP

	named WC15S1] (Wongawilli Creek tributary downstream of mining) **Lake Avon** • LA4_S1, LA4_S2, LA5_S1, LA5_S2, LA_1, LA2_Pool 5, LA3_Pool 4 **Donalds Castle Creek:** • Donalds Castle Ck (FR6) [*Previously named DCU3*] (Donalds Castle Creek lower) • DCL3 (Donalds Castle Creek @ Cordeaux River) • DC_Pool 22 [*Previously named DCS2*] (Donalds Castle Creek downstream of mining) • DC13_Pool 2b [*Previously named DC13S1*] (Donalds Castle Creek tributary downstream of mining)		
Swamps	**Observational, Photo Point and Water Monitoring**		
	• Swamps 1a, 3, 4, 5, 8, 10, 11 and 13	Pre and post mining for two years, monthly when longwall is within 400m of monitoring site	• Swamp 14 • Swamps 3, 4, 5, 8, 10, 11 and 13- Continue as required by the SMP
	Shallow Groundwater Level		
	• Swamp 01A: 01a_01, 01a_02, 01a_03, 01a_04, 01a_04i, 01a_04ii, 01a_04iii, 01a_04iv, 01a_04v • Swamp 01B: 01b_01, 01b_02, 01b_02i, 01b_02ii, 01b_02iii, 01b_02iv, 01b_03 • Swamp 3: 03_01. • Swamp 05: 05_01, 05_02, 05_03, 05_03i, 05_03ii, 05_03iii, 05_04, 05_05, 05_06 • Swamp 08: 08_01, 08_02, 08_03, 08_04, 08_05, 08_06 • Swamp 10: 10_01 • Swamp 11: S11-H1, S11-H2, S11-H3 • Swamp 13: 13_01	For open hole sites: • Monthly monitoring pre, during and post mining for two years to be removed annually • Reference sites 6 monthly For instrumented sites: • Automatic groundwater level monitoring , during and post mining (4 hour interval or similar) • Monitoring post mining for five years to be reviewed annually	• Swamp 01A: 01a_01, 01a_02, 01a_03, 01a_04, 01a_04i, 01a_04ii, 01a_04iii, 01a_04iv, 01a_04v • Swamp 01B: 01b_01, 01b_02, 01b_02i, 01b_02ii, 01b_02iii, 01b_02iv, 01b_03 • Swamp 3: 03_01. • Swamp 05: 05_01, 05_02, 05_03, 05_03i, 05_03ii, 05_03iii, 05_04, 05_05, 05_06 • Swamp 08: 08_01, 08_02, 08_03, 08_04, 08_05, 08_06 • Swamp 10: 10_01 • Swamp 11: S11-H1, S11-H2, S11-H3 • Swamp 13: 13_01 • Swamp 14: 14_01, 14_02
	Soil Moisture		
	• Swamp 05: S05_S01, S05_S02, S05_S03, S05_S03i, S05_S03ii, S05_S03iii, S05_S04, S05_S05, S05_S08 • Swamp 08: S08_S01, S08_S02, S08_S03, S08_S04, S08_S05,	• 6 monthly baseline and reference site monitoring • Weekly monitoring when longwall is within 400m of swamp	• Swamp 05: S05_S01, S05_S02, S05_S03, S05_S03i, S05_S03ii, S05_S03iii, S05_S04, S05_S05, S05_S08 • Swamp 08: S08_S01,

	S08_S06 • Swamp 11: S11_S01, S11_S02, S11_S05 • Swamp 13: S13_S01, S13_S02, S13_S03 Reference Sites: • Swamp 2: S02_S01 • Swamp 7: S07_S05, S07_S06 • Swamp 15A: S15a_S01, S15a_Piezo, S15a_S04, S15a_S06 • Swamp 22: 22_01, 22_02 • Swamp 24: S24_S01 • Swamp 25: S25_S01 • Swamp 33: S033_S01, S033_S03 • Swamp 84: S84_S02 • Swamp 85: S85_S01, S85_S02 • Swamp 86: S86_S01, S86_S02 • Swamp 87: S87_S01, S87_S02 • Swamp 88: S88_S01, S88_S02	• 6 monthly monitoring for 2 years post mining	S08_S02, S08_S03, S08_S04, S08_S05, S08_S06 • Swamp 11: S11_S01, S11_S02, S11_S05 • Swamp 13: S13_S01, S13_S02, S13_S03 • Swamp 14: 14_01, 14_02 Reference Sites: • Swamp 2: S02_S01 • Swamp 7: S07_S05, S07_S06 • Swamp 15A: S15a_S01, S15a_Piezo, S15a_S04, S15a_S06 • Swamp 22: 22_01, 22_02 • Swamp 24: S24_S01 • Swamp 25: S25_S01 • Swamp 33: S033_S01, S033_S03 • Swamp 84: S84_S02 • Swamp 85: S85_S01, S85_S02 • Swamp 86: S86_S01, S86_S02 • Swamp 87: S87_S01, S87_S02 • Swamp 88: S88_S01, S88_S02
Landscape	**Targeted Sites**		
	Cliffs No clifflines associated with Longwall 12 **Fire Trails** Fire road 6A (Across Longwalls 10-18)	• Baseline monitoring campaign prior to monitoring • Monthly monitoring during any subsidence period • Monitoring to continue 6 monthly for 2 years following the completion of mining	**Cliffs** • DA3-CF19 • DA3-CF20 • DA3-CF21 • DA3-CF22 • DA3-CF23 **Fire Trails** Fire Road 6A (across LWs 10-18) - Continue as required by the SMP
	Inspection of Active Mining Area – Landscape Features, Vegetation, Watercourses		
	All mapped cliff, steep slopes, watercourse, swamp and fire trail sites in subsidence area General observation of active	• Weekly monitoring when longwall extraction is within 400m of feature	Continue monitoring of all mapped cliffs, steep slopes, watercourse, swamp and fire trail sites in subsidence area

	mining areas		Continue general observation of active mining areas

Swamps	Observational, Photo Point and Water Monitoring		
	• Swamps 01a, 01b, 03, 04, 05, 08, and 13	• Pre and post mining for two years, monthly when longwall is within 400m of monitoring site	• Swamps 1a, 3, 4, 5, 8, 10, 11 and 13- Continue as required by the SMP
	Shallow Groundwater Level		
	• Swamp 01A: 01a_01, 01a_02, 01a_03, 01a_04, 01a_04i, 01a_04ii, 01a_04iii, 01a_04iv, 01a_04v • Swamp 01B: 01b_01, 01b_02, 01b_02i, 01b_02ii, 01b_02iii, 01b_02iv, 01b_03 • Swamp 3: 03_01. • Swamp 05: 05_01, 05_02, 05_03, 05_03i, 05_03ii, 05_03iii, 05_04, 05_05, 05_06 • Swamp 08: 08_01, 08_02, 08_03, 08_04, 08_05, 08_06 • Swamp 10: 10_01	For open hole sites: • Monthly monitoring pre, during and post mining for two years to be removed annually • Reference sites 6 monthly For instrumented sites: • Automatic groundwater level monitoring , during and post mining (4 hour interval or similar) • Monitoring post mining for five years to be reviewed annually	• Swamp 01A: 01a_01, 01a_02, 01a_03, 01a_04, 01a_04i, 01a_04ii, 01a_04iii, 01a_04iv, 01a_04v • Swamp 01B: 01b_01, 01b_02, 01b_02i, 01b_02ii, 01b_02iii, 01b_02iv, 01b_03 • Swamp 3: 03_01. • Swamp 05: 05_01, 05_02, 05_03, 05_03i, 05_03ii, 05_03iii, 05_04, 05_05, 05_06 • Swamp 08: 08_01, 08_02, 08_03, 08_04, 08_05, 08_06 • Swamp 10: 10_01 • Swamp 11: S11-HI, S11-H2, S11-H3 – continue as required • Swamp 13: 13_01 – continue as required
	Soil Moisture		
	• Swamp 05: S05_S01, S05_S02, S05_S03, S05_S03i, S05_S03ii, S05_S03iii, S05_S04, S05_S05, S05_S08 • Swamp 08: S08_S01, S08_S02, S08_S03, S08_S04, S08_S05, S08_S06	• 6 monthly baseline and reference site monitoring • Weekly monitoring when longwall is within 400m of swamp • 6 monthly monitoring for 2 years post mining	• Swamp 05: S05_S01, S05_S02, S05_S03, S05_S03i, S05_S03ii, S05_S03iii, S05_S04, S05_S05, S05_S08 • Swamp 08: S08_S01, S08_S02, S08_S03, S08_S04, S08_S05, S08_S06 • Swamp 11: S11_S01, S11_S02, S11_S05 • Swamp 13: S13_S01, S13_S02, S13_S03 • Swamp 14: 14_01, 14_02 • Swamp 23: 23_01, 23_02 • Swamp 35A: 35a_01 • Swamp 35B: 35b_01 Reference Sites: • Swamp 2: S02_S01 • Swamp 7: S07_S05, S07_S06 • Swamp 15A: S15a_S01, S15a_Piezo, S15a_S04, S15a_S06 • Swamp 22: 22_01, 22_02 • Swamp 24: S24_S01 Swamp 25: S25_S01 • Swamp 33: S033_S01, S033_S03 • Swamp 84: S84_S02 • Swamp 85: S85_S01, S85_S02 • Swamp 86: S86_S01, S86_S02 • Swamp 87: S87_S01, S87_S02 • Swamp 88: S88_S01, S88_S02

Landscape	Targeted Sites		
	Cliffs No clifflines associated with Longwall 10 **Fire Trails** Fire road N.6A (Across Longwalls 10-18)	• Baseline monitoring campaign prior to monitoring • Monthly monitoring during any subsidence period • Monitoring to continue 6 monthly for 2 years following the completion of mining	**Cliffs** No clifflines associated with Longwall 12 **Fire Trails** Fire Road No.6A (across LWs 10-18) - Continue as required by the SMP
	Inspection of Active Mining Area – Landscape Features, Vegetation, Watercourses		
	All mapped cliff, steep slopes, watercourse, swamp and fire trail sites in subsidence area General observation of active mining areas	• Weekly monitoring when longwall extraction is within 400m of feature	Continue monitoring of all mapped cliffs, steep slopes, watercourse, swamp and fire trail sites in subsidence area Continue general observation of active mining areas

8. Management of Impacts and Remediation

The DA3B SMP outlines features that may require preventative, mitigative, and/or remedial measures. Management and rehabilitation of these features are considered in the SMP, SIMMCP and WIMMCP.

Table 10 provides the TARP for landscape features, including cultural heritage. **Table 11** and **Table 12** provide SIMMCP and WIMMCP TARPs respectively.

No remedial measures have been undertaken to date as a result of Longwall 12 extraction. Impacts have occurred as a result of Longwall 12 and these have been within the performance measures for Dendrobium Mine. Ongoing monitoring, assessments and consultation will determine the requirements for remediation works.

The Secretary wrote to Illawarra Coal 28 August 2015 to request, under Condition 4 of Schedule 3 (DA_60-03-2001), that Illawarra Coal prepare a remediation program for the impacts to WC21. This Plan is to comply with the Area 3B SMP Approval Conditions including Condition 9 Performance Measures for Area 3B. The Plan was submitted to the Secretary 4th of March 2016. Investigative works at the site are continuing and will inform an updated rehabilitation plan.

SMP approval for Area 3B Longwalls 14 and 15 was granted on 16 December 2016. Shedule 3, Condition 11 of the approval requires preparation of a remediation program for Donalds Castle Creek in consultation with OEH, WaterNSW and DRE. This is currently being prepared for submission.

Sites within Areas 3A and 3B have been identified for research into swamp rehabilitation; these proposed sites and techniques have been submitted to DP&E in a Swamp Rehabilitation Research Plan.

Table 10: Dendrobium Area 3B Landscape TARP

Monitoring	Trigger	Action
LANDSCAPE FEATURES		
AREA 2 **Cliffs** • A2-CL1 (above LW4) **Steep Slopes** • A2-SL1 and A2-SL2 (above LWs 4 & 5) **Watercourses** • A2-WC10 and A2-WC11 (above LW3) • A2-WC13 & A2-WC16 (above LWs 4 & 5) **Swamp** • A2-SW1 (above LWs 4 & 5) **4WD Track** • A2-FT1 (above LWs 4 & 5) **Crinanite Surface Extent** • A2-CN1 & A2-CN2 (above LWs 3 & 4)	***Level 1 **** • Rock fall from a cliff which is left mostly intact (<10% length), resulting in insignificant ground disturbance • Surface movement or rock displacement with negligible soil surface exposed • Crack at the surface, which should not result in any significant erosion or further ground movement • Crack in a fire trail which should not result in erosion or impede access • Crack or fracture up to 100mm width • Crack or fracture up to 10m length • Erosion in a localised area which would be expected to naturally stabilise without CMA and within the period of monitoring	• Continue monitoring program • Report impacts to key stakeholders • Summarise impacts and Report in the End of Panel Report and AEMR
AREA 3A **Cliffs** All mapped cliff sites in subsidence area (Refer to Dendrobium Area 3A SMP Figures 19.3 for location of sites) **Steep Slopes** All mapped steep slopes in subsidence area *Refer to Dendrobium Area 3A SMP Figures 19.3 for location of sites* **Watercourses/ Swamps** All mapped watercourse and swamps in subsidence area	***Level 2 **** • Rock fall or overhang collapse at a cliff site, where characteristics of the cliff have changed, and there has been significant ground disturbance • Surface movement or rock displacement that has exposed significant areas of soil • A crack at the surface, which could result in significant erosion or movement at the surface • A crack at the surface with potential risk to safety and/or fauna entrapment • A crack in the fire trail, which could result in significant erosion or impede vehicle access • Crack or fracture between 100 and 300mm width • Crack or fracture between 10 and 50m length • Significant erosion at any location, which is not likely to naturally stabilise within the period of monitoring, or is located in a sensitive area e.g. swamps, creek, lake shore, and may result in increased sediment transport to Cordeaux Dam, or has been previously identified as Level 1, but is not	• *Actions as stated for Level 1* • Review monitoring frequency • Notify relevant technical specialists and seek advice on any CMA required • Provide safety signage and barricades as appropriate • Implement approved repairs to ensure safety and serviceability on fire trails • Implement agreed CMAs as approved *Note: CMAs are to be proposed based on appropriate management of environmental and other consequences of impacts i.e. cracking at the surface with insignificant consequences may not require specific CMAs other than ongoing monitoring to confirm there are no ongoing impacts*

Monitoring	Trigger	Action
Refer to Dendrobium Area 3A SMP Figure 19.3	likely to naturally stabilise within the monitoring period	
Fire Trails All mapped fire trails in subsidence area *Refer to Dendrobium Area 3A SMP Figure 19.3* **AREA 3B** **Cliffs** All mapped cliff sites in subsidence area *Refer to Dendrobium Area 3B SMP Figures 18.1 for location of sites*	***Level 3 **** • Major cliff collapse where the characteristics of the cliff change significantly and there is significant ground disturbance that is unlikely to naturally stabilise within the monitoring period • Crack or fracture over 300mm width • Crack or fracture over 50m length • Mass movement of a slope causing large areas of exposed soil with potential for further movement	• *Actions as stated for Level 2* • Immediately notify DoPI, DPIM, SCA, resource managers and relevant technical specialists and seek advice on any CMA required • Site visits with stakeholders if required • Review monitoring program and modify if necessary within 1 month • Implement increased monitoring if required within 2 weeks • Develop site CMA in consultation with key stakeholders within 1 month, (pending stakeholder availability) and seek approvals • Completion of works following approvals • Issue CMA report within 1 month of works completion • Conduct initial follow up monitoring & reporting within 2 months of CMA completion • Review the relevant TARP and Management Plan in consultation with key stakeholders *Note: CMAs are to be proposed based on appropriate management of environmental and other consequences of impacts i.e. cracking at the surface with insignificant consequences may not require specific CMAs other than ongoing monitoring to confirm there are no ongoing impacts*
Sandy Creek Waterfall	***Exceeding Prediction*** • Rock fall at Sandy Creek Waterfall or from its overhang • Structural integrity of the waterfall, its overhang and its pool are impacted • More than negligible cracking within 30 m of the waterfall • More than negligible diversion of water from the lip of the waterfall	• Actions as stated for Level 3 • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation

Table 11: Dendrobium Area 3B Swamp TARP

Performance Measures	*Potential Impacts*	*Performance Triggers*	*Management Strategies*	*Offsets*	*Other Actions*
Negligible erosion of the surface of the swamp	Gully erosion or similar	*Level 1:* The increase in length of erosion within a swamp (compared to its pre-mining length) is **2%** of the swamp length or area; and/or Erosion in a localised area (not associated with cracking or fracturing) which would be expected to naturally stabilise without CMA and within the period of monitoring. *Level 2*: The increase in length of erosion within a swamp (compared to its pre-mining length) is **3%** of the swamp length or area; and/or Soil surface crack that causes erosion that is likely to stabilise within the monitoring period without intervention; and/or Gully knickpoint forms or an existing gully knickpoint becomes active. *Level 3:* The increase in length of erosion within a swamp (compared to its pre-mining length) is **4%** of the swamp length or area; and/or Soil surface crack that causes erosion that is unlikely to stabilise within the	a) upfront mine planning b) erosion monitoring (ie ALS, observation) c) coir logs d) knickpoint control e) water spreading f) weeding g) fire management h) reporting i) investigation and review j) update future predictions	Offset required **immediately**, if no remediation considered practicable. Offset required **2 years** following remediation, if it is ineffective. This period can be extended to **5 years**, with the agreement of the Secretary.	

		monitoring period without intervention. <u>*Exceeding Prediction*</u> Mining results in the total length of erosion within a swamp (compared to its pre-mining length) to increase **>5%** of the length or area of the swamp compared to any increase in total erosion length in a reference swamp (ie increase in length or area of erosion in an impact swamp less any increase in length or area in erosion in a reference swamp is **>5%**).			
Minor changes in the size of the swamps **Minor changes** in the ecosystem functionality of the swamps **No significant change** to the composition or distribution of species within the swamps	Swamp vegetation changes: - Swamp size - Species richness, distribution, composition and diversity - Vegetation sub-communities	**Swamp Size** <u>*Level 1:*</u> A trending decline in the extent of an upland swamp (combined area of groundwater dependent communities) for two consecutive monitoring periods, greater than observed in the Control Group, and exceeding the standard error (SE) of the Control Group. <u>*Level 2:*</u> A trending decline in the extent of an upland swamp (combined area of groundwater dependent communities) for three consecutive monitoring periods, greater than observed in the Control Group, and exceeding the SE of the Control Group. <u>*Level 3:*</u> A trending decline in the extent of an upland swamp (combined area of groundwater dependent communities) for four consecutive monitoring periods, greater than observed in the Control Group, and exceeding the SE of the Control Group. <u>*Exceeding Prediction:*</u> Mining results in a trending decline in the extent of an upland swamp (combined area of groundwater dependent communities) for five consecutive monitoring periods, greater than observed in the Control Group,	a) upfront mine planning b) vegetation monitoring c) water spreading d) seeding/planting e) weeding f) fauna monitoring g) fire management h) grouting of controlling of controlling rockbars and bedrock base and/or use of other remediation techniques i) reporting j) investigation and review k) update future predictions	Offset required **immediately**, if no remediation considered practicable. Offset required **5 years** following remediation, if it is ineffective. This period can be extended to **10 years**, with the agreement of the Secretary.	Monitoring period for swamp size is related to capture of Lidar data at the end of each longwall ~ 1 year Triggers for groundwater decline result in increased intensity and frequency of vegetation monitoring

		and exceeding the SE of the Control Group. **Ecosystem Functionality** *Level 1:* A trending decline in the extent of any individual groundwater dependent community within a swamp for two consecutive monitoring periods, greater than observed in the Control Group, and exceeding the SE of the Control Group. *Level 2:* A trending decline in the extent of any groundwater dependent community within a swamp for three consecutive monitoring periods, greater than observed in the Control Group, and exceeding the SE of the Control Group.. *Level 3:* A trending decline in the extent of any groundwater dependent community within a swamp for four consecutive monitoring periods, greater than observed in the Control Group, and exceeding the SE of the Control Group.. *Exceeding Prediction:* Mining results in a trending decline in the extent of a groundwater dependent community within a swamp for five consecutive monitoring periods, greater than observed in the Control Group, and exceeding the SE of the Control Group. **Species Composition and Distribution** *Level 1:* A **2%** (or otherwise statistically significant) decline in species			

		richness or diversity during a period of stability or increase in species richness/diversity in reference swamps for **two** consecutive years; and/or *Level 2:* A **5%** (or otherwise statistically significant) decline in species richness or diversity during a period of stability or increase in species richness/diversity in reference swamps for **three** consecutive years. *Level 3:* An **8%** (or otherwise statistically significant) decline in species richness or diversity during a period of stability or increase in species richness/diversity in reference swamps for **four** consecutive years. *Exceeding Prediction:* Mining results in a **>10%** (or otherwise statistically significant) decline in species richness or diversity during a period of stability or increase in species richness/diversity in reference swamps for **five** consecutive years.			
Maintenance or restoration of the structural integrity of the bedrock base of any significant permanent pool or controlling rockbar within the swamps	Subsidence impacts (ie cracking) on bedrock base or controlling rockbar	*Level 1:* Fracturing observed in the bedrock base of any significant permanent pool which results in observable loss of surface water of **10%** compared to baseline for the pool (in addition to any decrease in reference pools). *Level 2:* Fracturing observed in the bedrock base of any significant permanent pool which results in observable loss of surface water of **20%** compared to baseline for the pool (in addition to any decrease in reference pools). *Level 3:* Fracturing observed in the bedrock base of any significant permanent pool which results in observable loss of surface water of **20%** compared to baseline for the pool for **>20%** of the time over a period of **1**	a) upfront mine planning b) subsidence monitoring c) surface water monitoring d) groundwater monitoring e) grouting of controlling of controlling rockbars and bedrock base and/or use of other remediation techniques f) CMAs g) reporting	Offset required **immediately**, if no remediation considered practicable. Offset required **2 years** following remediation, if it is ineffective. This period can be extended to **5 years**, with the	

		year (in addition to any decrease in reference pools). *Exceeding Prediction* Structural integrity of the bedrock base of any significant permanent pool or controlling rockbar cannot be restored, ie pool water level within the swamp after CMAs continues to be **>20%** lower than baseline for **>20%** of the time over a period of **1** year.	h) investigation and review i) update future predictions	agreement of the Secretary.	
Minor changes in the ecosystem functionality of the swamps	Falls in surface or near-surface groundwater levels in swamps *NB. Not linked specifically to a PM and would not be considered a breach if predictions were exceeded.*	*Level 1:* Groundwater level lower than baseline level at any monitoring site within a swamp (in comparison to reference swamps); and/or Rate of groundwater level reduction exceeds rate of groundwater level reduction during baseline period at any monitoring site (measured as average mm/day during the recession curve). *Level 2:* Groundwater level lower than baseline level at **50%** of monitoring sites (within 400 m of mining) within a swamp (in comparison to reference swamps); and/or Rate of groundwater level reduction exceeds rate of groundwater level reduction during baseline period at a **50%** of monitoring sites (within 400m of mining) within the swamp. *Level 3:* Groundwater level lower than baseline level at **>80%** of monitoring sites (within 400m of mining) within a swamp (in comparison to reference swamps); and/or	a) upfront mine planning b) groundwater monitoring c) implementation of swamp research program d) weeding e) fire management f) reporting g) update future predictions		Triggers for groundwater decline result in increased intensity and frequency of vegetation monitoring and/or further investigations of subsidence impacts on bedrock base and rockbars

		Rate of groundwater level reduction exceeds rate of groundwater level reduction during baseline period at **>80%** of monitoring sites (within 400 m of mining) within the swamp.			
Minor changes in the ecosystem functionality of the swamps	Falls in soil moisture levels in swamps *NB. Not linked specifically to a PM and would not be considered a breach if predictions were exceeded.*	*Level 1:* Soil moisture level lower than baseline level at **any** monitoring sites (within 400 m of mining) within a swamp (in comparison to reference swamps). *Level 2:* Soil moisture level lower than baseline level at **50%** of monitoring sites (within 400m of mining) within a swamp (in comparison to reference swamps). *Level 3:* Soil moisture level lower than baseline level at **>80%** of monitoring sites (within 400m of mining) within a swamp (in comparison to reference swamps).	a) upfront mine planning b) soil moisture monitoring c) water spreading d) weeding e) fire management f) reporting g) update future predictions		Triggers of soil moisture decline result in increased intensity and frequency of vegetation monitoring and/or further investigations of subsidence impacts on bedrock base and rockbars

Table 12: Dendrobium Area 3B Watercourse TARP

Monitoring	Trigger	Action
OBSERVATIONAL, PHOTO POINT AND WATER MONITORING		
Native Dog, Wongawilli and Donalds Castle Creeks, WC21, WC15, LA4, DC13, LA5, ND1, WC6, WC7, WC8, WC9, WC12, WC16 and WC18 General observation of streams in active mining areas when longwall is within 400m	***Level 1*** * • Crack or fracture up to 100mm width at its widest point with no observable loss of surface water or erosion • Crack or fracture up to 10m length with no observable loss of surface water or erosion • Erosion in a localised area (not associated with cracking or fracturing) which would be expected to naturally stabilise without CMA and within the period of monitoring • Observable release of strata gas at the surface • Observable increase in iron staining within the mining area	• Continue monitoring program • Submit an Impact Report to OEH, DoPE, T&I, Water NSW and other relevant resource managers • Report in the End of Panel Report • Summarise actions and monitoring in AEMR
•Relevant Performance Measure(s): • Wongawilli Creek - minor environmental consequences • Donalds Castle Creek - minor environmental consequences • Waterfall WC-WF54 – negligible environmental consequences	***Level 2 **** • Crack or fracture between 100 and 300mm width at its widest point or any fracture which results in observable loss of surface water or erosion • Crack or fracture between 10 and 50m length • Soil surface crack that causes erosion that is likely to stabilise within the monitoring period without intervention • Observable increase in iron staining within the mining area continues to outside the mining area i.e. 400m from the longwall	• *Actions as stated for Level 1* • Review monitoring frequency • Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved (subject to stakeholder feedback) •
	Level 3 * • Crack or fracture over 300mm width at its widest point • Crack or fracture over 50m length • Fracturing observed in the bedrock base of any significant permanent pool which results in observable loss of surface water • Soil surface crack that causes erosion that is unlikely to stabilise within the monitoring period without intervention	• *Actions as stated for Level 2* • Site visit with OEH, DoPE, T&I, Water NSW and other resource manager/s (if requested) • Implement additional monitoring or increase frequency if required • Develop site CMA (subject to stakeholder feedback). This may include: grouting of rockbar and bedrock base of any significant pool where it is appropriate to do so in consultation with OEH, DoPE, T&I, Water NSW and other stakeholders • Completion of works following approvals and at a time agreed between

Monitoring	Trigger	Action
	• Gas release results in vegetation dieback, mortality or loss of aquatic habitat • Observable increase in iron staining within the mining area continues more than 600m from the longwall •	BHPBIC, DoPE, T&I and Water NSW (i.e. may be after mining induced movements and impacts are complete), including monitoring and reporting on success • Review relevant TARP and Management Plan in consultation with key stakeholders
	Exceeding Prediction • Structural integrity of the bedrock base of any significant pool or controlling rockbar cannot be restored i.e. pool water level within the pool after CMAs continues to be lower than baseline period • Gas release results in vegetation dieback that does not revegetate • Gas release results in mortality of threatened species or ongoing loss of aquatic habitat • Iron staining and associated increases in dissolved iron resulting from the mining is observed in water at Wongawilli Creek downstream monitoring site WONGAWILLI CK (FR6) • Iron staining and associated increases in dissolved iron resulting from the mining is observed in water at the Donalds Castle Creek downstream monitoring site Donalds Castle Ck (FR6) • Rock fall at WC-WF54 or its overhang • Impacts on the structural integrity of WC-WF54, its overhang or its pool	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation • Provide residual environmental offset for any mining impact where CMAs are unsuccessful as required by Condition 14 Schedule 3 of the Development Consent
•WATER QUALITY		
Wongawilli Creek Wongawilli Ck (FR6) Baseline means: • pH 5.98 • EC 98.8 uS/cm • DO 89.5%	***Level 1*** * • One exceedance of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean during the monitoring period: – pH 4.45 – EC 154.1 uS/cm – DO 50.5%	• Continue monitoring program • Submit an Impact Report to OEH, DoPE, T&I, Water NSW and other relevant resource managers • Report in the End of Panel Report • Summarise actions and monitoring in AEMR
	Level 2 * • Two exceedances of the ±3 standard deviation level (positive for	• *Actions as stated for Level 1* • Review monitoring frequency

Monitoring	Trigger	Action
•Relevant Performance Measure(s): • Wongawilli Creek - minor environmental consequences •	EC, negative for pH and DO) from the baseline mean during the monitoring period: – pH 4.45 – EC 154.1 uS/cm – DO 50.5%	• Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved (subject to stakeholder feedback) •
	Level 3 * • Three exceedances of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean during the monitoring period: – pH 4.45 – EC 154.1 uS/cm – DO 50.5%	• *Actions as stated for Level 2* • Site visit with OEH, DoPE, T&I, Water NSW and other resource manager/s (if requested) • Implement additional monitoring or increase frequency if required • Review relevant TARP and Management Plan in consultation with key stakeholders • Develop site CMA (subject to stakeholder feedback). This may include: – Limestone emplacement to raise pH where it is appropriate to do so – Grouting of fractures in rockbar and bedrock base of any significant pool where flow diversion results in pool water level lower than baseline period • Completion of works following approvals and at a time agreed between BHPBIC, DoPE, T&I and Water NSW (i.e. may be after mining induced movements and impacts are complete), including monitoring and reporting on success
	Exceeding Prediction • Mining results in two conecutive exceedances of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean during the monitoring period: – pH 4.45 – EC 154.1 uS/cm – DO 50.5%	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation • Provide residual environmental offset for any mining impact where CMAs are unsuccessful as required by Condition 14 Schedule 3 of the Development Consent

Monitoring	Trigger	Action
Donalds Castle Creek Donalds Castle Ck (FR6) Baseline means: • pH 5.41 • EC 116.0 uS/cm • DO 85.6% •Relevant Performance Measure(s): • Donalds Castle Creek - minor environmental consequences	***Level 1*** * • One exceedance of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean during the monitoring period: – pH 3.60 – EC 185.8 uS/cm – DO 40.1%	• Continue monitoring program • Submit an Impact Report to OEH, DoPE, T&I, Water NSW and other relevant resource managers • Report in the End of Panel Report • Summarise actions and monitoring in AEMR
	Level 2 * • Two exceedances of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean during the monitoring period: – pH 3.60 – EC 185.8 uS/cm – DO 40.1%	• *Actions as stated for Level 1* • Review monitoring frequency • Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved (subject to stakeholder feedback) •
	Level 3 * • Three exceedances of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean during the monitoring period: – pH 3.60 – EC 185.8 uS/cm – DO 40.1%	• *Actions as stated for Level 2* • Site visit with OEH, DoPE, T&I, Water NSW and other resource manager/s (if requested) • Implement additional monitoring or increase frequency if required • Review relevant TARP and Management Plan in consultation with key stakeholders • Collect laboratory samples and analyse for: – pH, EC, major cations, major anions, Total Fe, Mn & Al – Filterable suite of metals • Develop site CMA (subject to stakeholder feedback). This may include: – Limestone emplacement to raise pH where it is appropriate to do so – Grouting of fractures in rockbar and bedrock base of any significant pool where flow diversion results in pool water level lower than baseline period • Completion of works following approvals and at a time agreed between BHPBIC, DoPE, T&I and Water NSW (i.e. may be after mining induced movements and impacts are complete), including monitoring and reporting on success

Monitoring	Trigger	Action
	Exceeding Prediction • Mining results in two conecutive exceedances of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean during the monitoring period: – pH 3.60 – EC 185.8 uS/cm – DO 40.1%	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation • Provide residual environmental offset for any mining impact where CMAs are unsuccessful as required by Condition 14 Schedule 3 of the Development Consent
Lake Avon Lake Avon tributary (LA4_S1) Baseline means: • pH 5.38 • EC 90.8 uS/cm • DO 89.9% (24 months of baseline data available - to be updated with additional baseline data) •Relevant Performance Measure(s): • Lake Avon - negligible reduction in the quality of surface water inflows to Lake Avon	***Level 1*** * • One exceedance of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean during the monitoring period: – pH 4.90 – EC 129.8 uS/cm – DO 69.5%	• Continue monitoring program • Submit an Impact Report to OEH, DoPE, T&I, Water NSW and other relevant resource managers • Report in the End of Panel Report • Summarise actions and monitoring in AEMR
	Level 2 * • Two exceedances of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean during the monitoring period: – pH 4.90 – EC 129.8 uS/cm – DO 69.5%	• *Actions as stated for Level 1* • Review monitoring frequency • Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved (subject to stakeholder feedback) •
	Level 3 * • Three exceedances of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean during the monitoring period: – pH 4.90 – EC 129.8 uS/cm – DO 69.5%	• *Actions as stated for Level 2* • Site visit with OEH, DoPE, T&I, Water NSW and other resource manager/s (if requested) • Implement additional monitoring or increase frequency if required • Review relevant TARP and Management Plan in consultation with key stakeholders • Collect laboratory samples and analyse for: – pH, EC, major cations, major anions, Total Fe, Mn & Al – Filterable suite of metals • Develop site CMA (subject to stakeholder feedback). This may include:

Monitoring	Trigger	Action
		– Limestone emplacement to raise pH where it is appropriate to do so – Grouting of fractures in rockbar and bedrock base of any significant pool where flow diversion results in pool water level lower than baseline period • Completion of works following approvals and at a time agreed between BHPBIC, DoPE, T&I and Water NSW (i.e. may be after mining induced movements and impacts are complete), including monitoring and reporting on success
	Exceeding Prediction • Mining results in two conecutive exceedances of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean of the Lake Avon inflows during the monitoring period: – pH 4.90 – EC 129.8 uS/cm – DO 69.5%	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation • Provide residual environmental offset for any mining impact where CMAs are unsuccessful as required by Condition 14 Schedule 3 of the Development Consent
•POOL WATER LEVEL		
Mapped pools in the mining area: • Wongawilli Creek • Donalds Castle Creek • • •Relevant Performance Measure(s): • Wongawilli Creek - minor environmental consequences • Donalds Castle Creek - minor environmental consequences •	***Level 1*** * • Fracturing not resulting in diversion of flow	• Continue monitoring program • Submit an Impact Report to OEH, DoPE, T&I, Water NSW and other relevant resource managers • Report in the End of Panel Report • Summarise actions and monitoring in AEMR
	Level 2 * • Fracturing resulting in diversion of flow	• *Actions as stated for Level 1* • Review monitoring frequency • Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved (subject to stakeholder feedback)
	Level 3 * • Fracturing resulting in diversion of flow such that <10% of the pools have water levels lower than baseline period	• *Actions as stated for Level 2* • Site visit with OEH, DoPE, T&I, Water NSW and other resource manager/s (if requested) • Implement additional monitoring or increase frequency if required • Review relevant TARP and Management Plan in consultation with key stakeholders • Develop site CMA (subject to stakeholder feedback). This may include: grouting of rockbar and bedrock base of any significant pool where it is

Monitoring	Trigger	Action
		appropriate to do so in consultation with OEH, DoPE, T&I, Water NSW and other stakeholders • Completion of works following approvals and at a time agreed between BHPBIC, DoPE, T&I and Water NSW (i.e. may be after mining induced movements and impacts are complete), including monitoring and reporting on success
	Exceeding Prediction • Fracturing resulting in diversion of flow such that >10% of the pools have water levels lower than baseline period	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation • Provide residual environmental offset for any mining impact where CMAs are unsuccessful as required by Condition 14 Schedule 3 of the Development Consent
•**Waterfall WC-WF54** •Relevant Performance Measure(s): • Waterfall WC-WF54 – negligible environmental consequences	***Exceeding Prediction*** • Fracturing in Wongawilli Creek within 30m of the waterfall which results in observable flow diversion • Fracturing in Wongawilli Creek which results in observable flow diversion from the lip of the waterfall	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation • Provide residual environmental offset for any mining impact where CMAs are unsuccessful as required by Condition 14 Schedule 3 of the Development Consent
MODELLED PERIODS OF RECESSIONAL, BASEFLOW AND SMALL STORM UNIT HYDROGRAPH PERIODS		
Subcatchments of Wongawilli and Donalds Castle Creeks and Lake Avon tributaries ** •	***Level 1 **** • Change 6-12% less than average annual precipitation ***	• Continue monitoring program • Submit an Impact Report to OEH, DoPE, T&I, Water NSW and other relevant resource managers • Report in the End of Panel Report • Summarise actions and monitoring in AEMR
	Level 2 * • Change 12-18% less than average annual precipitation ***	• *Actions as stated for Level 1* • Review monitoring frequency • Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved (subject to stakeholder feedback)
	Level 3 * • Change >18% less than average annual precipitation ***	• *Actions as stated for Level 2* • Site visit with OEH, DoPE, T&I, Water NSW and other resource manager/s (if requested) • Implement additional monitoring or increase frequency if required • Develop site CMA (subject to stakeholder feedback). This may include:

Monitoring	Trigger	Action
		grouting of rockbar and bedrock base of any significant pool where it is appropriate to do so in consultation with OEH, DoPE, T&I, Water NSW and other stakeholders • Completion of works following approvals and at a time agreed between BHPBIC, DoPE, T&I and Water NSW (i.e. may be after mining induced movements and impacts are complete), including monitoring and reporting on success • Review relevant TARP and Management Plan in consultation with key stakeholders
Inflows to Lake Avon and Cordeaux River ** •Relevant Performance Measure(s): • Lake Avon - negligible reduction in the quantity of surface water inflows to Lake Avon • Cordeaux River - negligible reduction in the quantity of surface water flows from Wongawilli Creek to Cordeaux River	***Exceeding Prediction*** • Measured surface water flow reduction in Wongawilli Creek at its confluence with Cordeaux River that is greater than predicted by the groundwater model (to the satisfaction of the Director General - Condition 13 of the SMP) that cannot be attributed to natural variation • Surface water flow reduction into Lake Avon is greater than predicted by the groundwater model (to the satisfaction of the Director General - Condition 13 of the SMP) that cannot be attributed to natural variation	• *Actions as stated for Level 3* • Investigate reasons for the exceedance • Update future predictions based on the outcomes of the investigation • Provide residual environmental offset for any mining impact where CMAs are unsuccessful as required by Condition 14 Schedule 3 of the Development Consent
AQUATIC ECOLOGY		
Pool water level, interconnectivity between pools and loss of connectivity, noticeable alteration of habitat • Wongawilli Creek catchment – 8 sites • Donalds Castle Creek catchment – 1 site	***Level 1 **** • Reduction in aquatic habitat for 1 year •	• Continue monitoring program • Submit an Impact Report to OEH, DoPE, T&I, Water NSW and other relevant resource managers • Report in the End of Panel Report • Summarise actions and monitoring in AEMR
	Level 2 * • Reduction in aquatic habitat for 2 years following the active subsidence period	• *Actions as stated for Level 1* • Review monitoring frequency • Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved (subject to stakeholder feedback)
	Level 3 * • Reduction in aquatic habitat for >2 years or complete loss of habitat following the active subsidence period	• *Actions as stated for Level 2* • Site visit with OEH, DoPE, T&I, Water NSW and other resource manager/s (if requested) • Implement additional monitoring or increase frequency if required • Review relevant TARP and Management Plan in consultation with key stakeholders

Monitoring	Trigger	Action
		• Develop site CMA (subject to stakeholder feedback). This may include: grouting of rockbar and bedrock base of any significant pool where it is appropriate to do so in consultation with OEH, DoPE, T&I, Water NSW and other stakeholders • Completion of works following approvals and at a time agreed between BHPBIC, DoPE, T&I and Water NSW (i.e. may be after mining induced movements and impacts are complete), including monitoring and reporting on success
TERRESTRIAL FAUNA – THREATENED FROG SPECIES		
Pool water level, interconnectivity between pools and loss of connectivity, noticeable alteration of habitat • Wongawilli Creek catchment – 2 sites • Donalds Castle Creek catchment – 2 sites • Lake Avon tributary – 1 site • Native Dog tributary – 1 site	***Level 1 **** • Reduction in habitat for 1 year •	• Continue monitoring program • Submit an Impact Report to OEH, DoPE, T&I, Water NSW and other relevant resource managers • Report in the End of Panel Report • Summarise actions and monitoring in AEMR
	Level 2 * • Reduction in habitat for 2 years following the active subsidence period	• *Actions as stated for Level 1* • Review monitoring frequency • Notify relevant technical specialists and seek advice on any CMA required • Implement agreed CMAs as approved (subject to stakeholder feedback)
	Level 3 * • Reduction in habitat for > 2 years or complete loss of habitat following the active subsidence period	• *Actions as stated for Level 2* • Site visit with OEH, DoPE, T&I, Water NSW and other resource manager/s (if requested) • Implement additional monitoring or increase frequency if required • Review relevant TARP and Management Plan in consultation with key stakeholders • Develop site CMA (subject to stakeholder feedback). This may include: grouting of rockbar and bedrock base of any significant pool where it is appropriate to do so in consultation with OEH, DoPE, T&I, Water NSW and other stakeholders • Completion of works following approvals and at a time agreed between BHPBIC, DoPE, T&I and Water NSW (i.e. may be after mining induced movements and impacts are complete), including monitoring and reporting on success