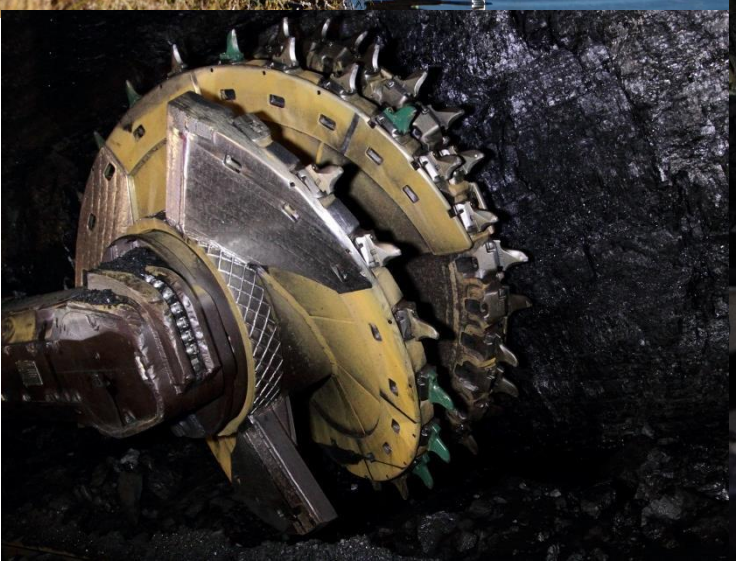
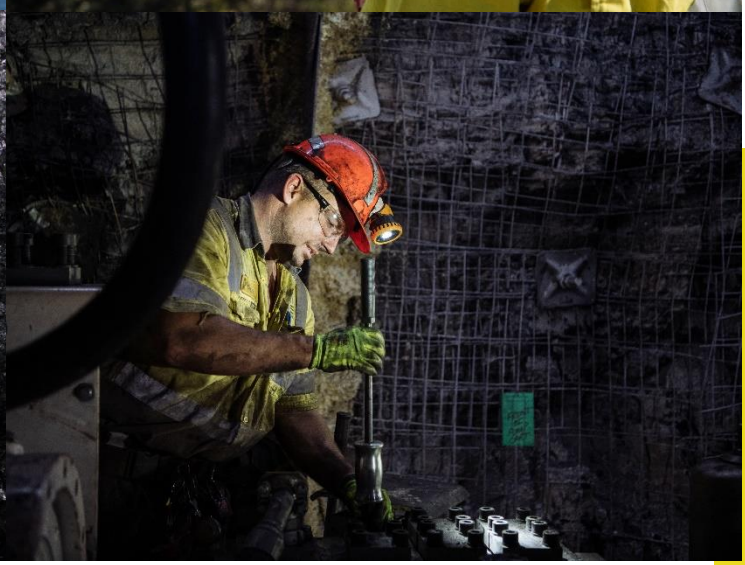
Illawarra Metallurgical Coal
End of Panel Report



DENDROBIUM AREA 3B LONGWALL 17 END OF PANEL REPORT

April 2022

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 17, and presents monitoring results and analyses compared to relevant impact assessment criteria and predictions in the DA3B Subsidence Management Plan (SMP).

Dendrobium Longwall 17 is located within Consolidated Coal Lease 768 and is the ninth panel to be extracted in DA3B. Extraction of Longwall 17 commenced on 12 December 2020 and was completed on 13 October 2021. The extracted longwall has a length of 1901 metres (m), a void width of 305m (including first workings) and a maximum cutting height up to 3.9m.

The extraction of underground coal reserves from DA3B provides benefits at international, national, state and local levels. Illawarra Metallurgical Coal (IMC) provides an essential supply of coking coal to BlueScope Steel for its steelmaking production, and for export to overseas customers. Operations at Dendrobium Mine represent continuing significant capital and operating investments in the Southern Coalfield of New South Wales.

Continuing benefits occur through continuity of employment, export earnings and government revenue. From the operations of Dendrobium Mine, IMC paid approximately $32 million in government royalties during the 2020/2021 financial year.

Subsidence movements resulting from the extraction of Longwall 17 were monitored along lines and points within the SMP Area. The measured ground movements after the extraction of Longwall 17 are generally similar to or less than the predicted values.

During the extraction of Longwall 17, forty new surface impacts were identified. These impacts are labelled as "*DA3B_LW17_001*" to "*DA3B_LW17_040*". Thirty of these impacts were observed on natural features. The remaining ten impacts were observed on built features such as fire roads and other access tracks, which were remediated (or predicted to self-remediate) in accordance with Corrective Management Actions (CMAs).

At *LA4_S1*, a Trigger Action Response Plan (TARP) Level 3 was recorded for Electrical Conductivity (EC) and pH. No adverse changes in water quality are noted in Lake Avon and Lake Cordeaux. New or recurrent iron staining has been noted on Wongawilli Creek, WC21 and LA5. The observations are likely related to recovery of groundwater levels and the reactivation of iron-rich springs near creek channels.

TARP triggers for surface water hydrology were identified at Donalds Castle Creek (*DCS2; DCU*); DC13 (*DC13S1*); WC21 (*WC21S1*); WC15 (*WC15S1*), LA4 (*LA4S1*), LA3 (*LA3S1*) and LA2 (*LA2S1*). Water flow performance measures were met for Longwall 17.

Analysis of available surface water flow observation records for Wongawilli Creek did not trigger a TARP for any months assessed during the Longwall 17 period.

The average daily inflow to DA3B during Longwall 17 extraction was 5.2 megalitres per day (ML/day) which represents 64% of total mine inflow for the period. Compared with the previous longwall, the total mine inflow increased by 23% and the inflow in Area 3B increased by 36%.

Seepage losses from Avon Dam have been estimated by regional and local scale numerical models to be in the range 0.09 to 0.69 ML/day as at the end of Longwall 17. The estimates are within the tolerable loss limit of 1 ML/day prescribed by Dams Safety NSW.

Longwall 17 passed beneath, or within 400m of, Swamps 14, 23, 149 and 35a. A Level 3 TARP for shallow groundwater remains in place at Swamp 14 from previous Longwalls. Shallow groundwater at Swamp 23 has been increased to a Level 3 TARP. Soil Moisture at Swamp 14 has been increased to a Level 3 TARP.

Reduction in aquatic habitat for over 2 years at Donalds Castle Creek and WC21 constitutes a Level 3 TARP trigger. No TARPs have been triggered with respect to Wongawilli Creek.

Two out of five Aboriginal cultural heritage sites located within the Subject Area were visited. No impacts were observed as a result of the extraction of Longwall 17.

An interim report was submitted on 11 February 2022 with

This report is an updated version (of interim report submitted on 11 February 2022) to include the Terrestrial Ecology Monitoring Program Annual Report 2021 (**Attachment H**). An extension of time for the report was approved by DPIE on 15 November 2021.

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Attachment D – Surface Water and Shallow Groundwater Assessment (HGEO)

Attachment E – Groundwater Assessment (HGEO)

Attachment F – Aquatic Ecology Assessment (Cardno)

Attachment G – Heritage Assessment (Niche)

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1 INTRODUCTION

1.1 Approval and Legislative Requirements

Dendrobium Longwall 17 is located within Consolidated Coal Lease 768 and is the ninth panel to be extracted in DA3B. Extraction of Longwall 17 commenced on 12 December 2020 and was completed on 13 October 2021. The extracted longwall has a length of 1901m, a void width of 305m (including first workings) and a maximum cutting height up to 3.9m. The finishing end of Longwall 17 was shortened by 236m from the extent indicated in the SMP Application.

This EoP report has been prepared in accordance with Schedule 3 Condition 9 of the Development Consent (DA60-03-2001 – MOD 8) (Table 1). The EoP report outlines the measured and observed impacts of Longwall 17 and the analyses of monitoring results compared to relevant impact assessment criteria and predictions made in the SMP and associated management plans and reports.

The DA3B SMP was approved by the then Department of Trade and Investment, Regional Infrastructure and Services NSW (DTI) on the 5 February 2013 and the then Department of Planning and Environment (DP&E) on the 6 February 2013. Subsequent approval for Longwall 17 SMP was granted on the 11 July 2019 by DPIE, which is provided as **Attachment A**.

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

Table 1: Approval conditions excerpt from the Dendrobium Development Consent (DA60-03-2001 – MOD 8).

Development Consent Approval Condition	Relevant Section in EoP Report
Schedule 3 of Development Consent DA60-03-2001 – MOD 8 **9.** Within 4 months of the completion of each longwall panel, or as otherwise permitted by the Secretary, the Applicant must: a) 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 b) Submit the report to the Department, DRG, WaterNSW, OEH, DoI and any other relevant agency to the satisfaction of the Secretary.	*Sections 2 to 8, Attachments B to H* *The Annual Review (July to June) is submitted in August each year*

10. The Applicant must include a comprehensive summary, analysis and discussion of the results of monitoring of subsidence effects, subsidence impacts and environmental consequences in each Annual Review.	

The impact predictions for Longwall 17 are described in the following reports:

- Dendrobium Area 3B Subsidence Management Plan (SMP);
- Dendrobium Area 3B Watercourse Impact, Monitoring, Management and Contingency Plan (WIMMCP) (August 2020);
- Dendrobium Area 3B Swamp Impact, Monitoring, Management and Contingency Plan (SIMMCP) (October 2020 amendment); and
- Dendrobium Subsidence, Landscape Monitoring and Management Plan (SLMMP) (November 2012).

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

1.2 Economic Benefits

The extraction of underground coal reserves from DA3B provides benefits at international, national, state and local levels. IMC provides an essential supply of coking coal to BlueScope Steel for its steelmaking production, and for export to overseas customers. Mining operations at Dendrobium Mine represents continuing significant capital and operating investments in the Southern Coalfield of New South Wales.

Continuing benefits occur through continuity of employment, income, export earnings and government revenue. From the operations of Dendrobium Mine, IMC paid approximately $32 million in government royalties during the 2020/2021 financial year.

1.3 Stakeholder Consultation

Provision of monitoring data and ongoing information to the community has been undertaken during the extraction of DA3B. Information on IMC operations is provided to the community and key stakeholders 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 reports; and

- Frequent consultation with WaterNSW and Dam Safety NSW (i.e. technical working group committee)

IMC aims to mitigate the potential impacts subsidence may cause 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. Minutes are published publicly on the South32 website. • A triennial telephone survey of residents in the communities in which IMC operates. The survey aims to determine the community's perception of the company's overall performance.

2 PREDICTED AND OBSERVED SUBSIDENCE

Subsidence movements resulting from the extraction of Longwall 17 were monitored along lines and points within the SMP Area. A comparison of the observed and predicted movements has been prepared by Mine Subsidence Engineering Consultants (MSEC) and is included as **Attachment B**.

Monitoring points and lines associated with Longwall 17 include (Figure 1):

- Wongawilli Creek Closure Lines;
- Avon Dam Closure Lines;
- Tributary Cross Lines;
- Swamp 23 Cross Lines;
- Waterfall 54;
- DA3B and Avon Dam 3D Monitoring Points; and
- Airborne Laser Scans (ALS) of the area.

The predicted subsidence effects have been obtained using the re-calibrated subsidence model presented in Reports Nos. MSEC792, MSEC865 and MSEC992.

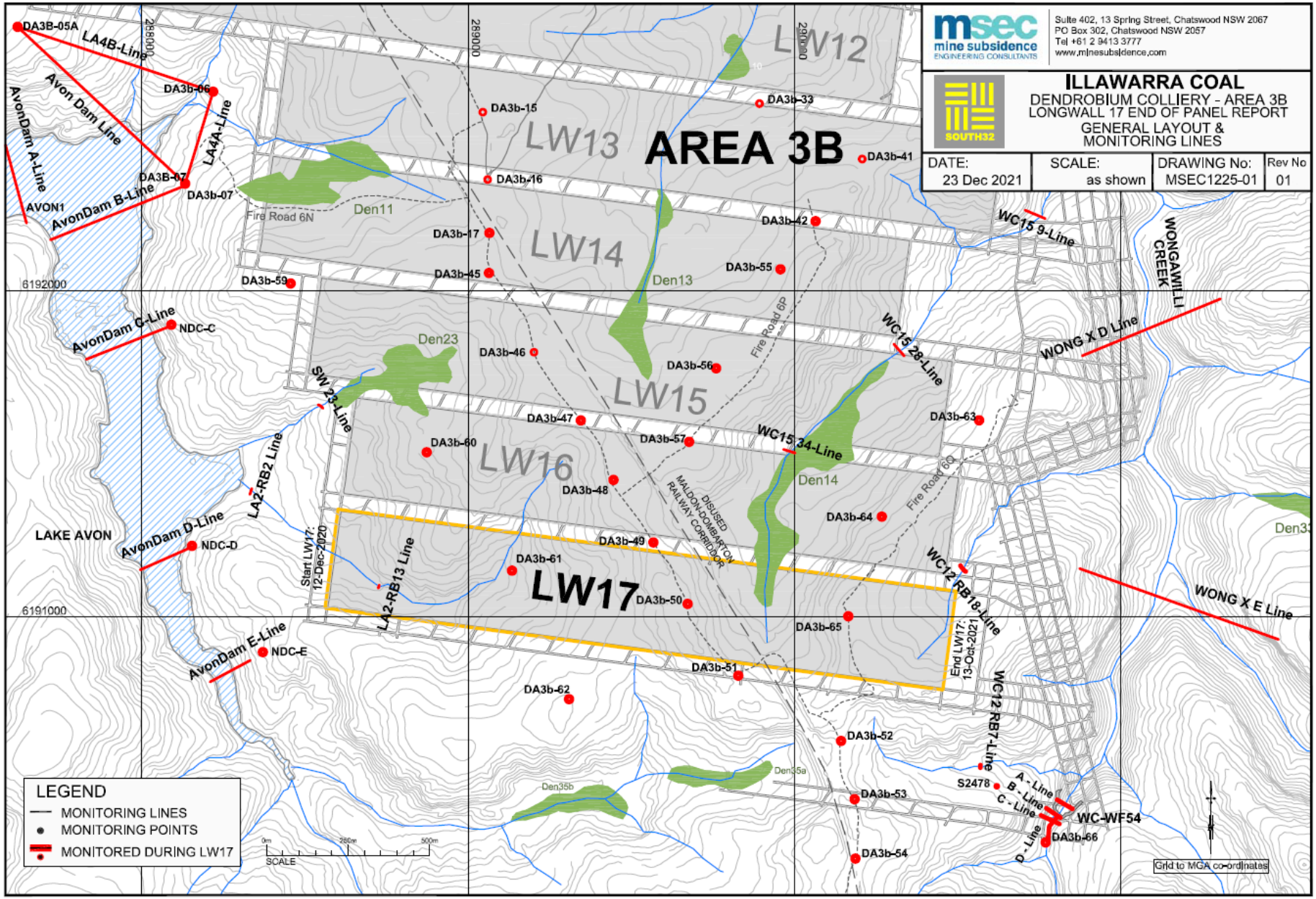

Figure 1: Overview of subsidence monitoring sites, comprised of monitoring lines and monitoring points.

2.1 Wongawilli Creek Closure Lines

The closure movements across Wongawilli Creek have been measured using 2D survey techniques at the Wong X D-Line and Wong X E-Line. The Wong X A-Line, Wong X B-Line and Wong X C-Line were not measured at the completion of Longwall 17 due to their distances from the Longwall.

The maximum measured total closure at each of the Wongawilli Creek closure lines are similar to or less than the predictions after the completion of Longwall 17 (Figure 2). The measured total closure at the Wong X C-Line is similar to but slightly greater than the predicted total closure. The exceedance represents less than 3% of the predicted value and is in the order of survey tolerance.

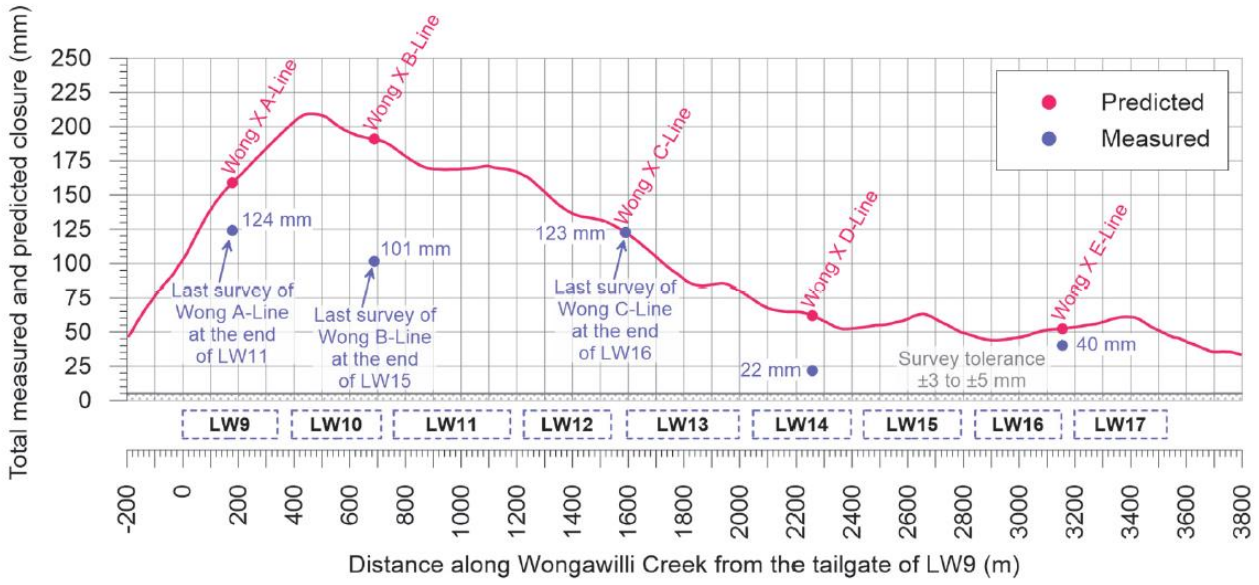

Figure 2: Measured and predicted total closure along Wongawilli Creek after the extraction of Longwall 17. (Source: Attachment B).

2.2 Avon Dam Closure Lines

The baseline surveys of Avon Dam closure lines were carried out prior to the commencement of Longwall 12 (in February 2016) and, therefore, the closure lines have measured the accumulated movements due to the extraction of Longwall 12 through to Longwall 17 only.

The maximum measured total closure at the Avon Dam monitoring lines is less than the maximum predicted value at the completion of Longwall 17. Measured total closure at the Avon Dam A-Line is less than the predicted value at the completion of Longwall 17. Net opening movements have been measured at the Avon Dam B-Line to E-Line due to the conventional subsidence effects being greater than the valley-related effects. The absolute magnitudes of the measured opening movements are less than the absolute magnitudes of the predicted closure movements (Figure 3).

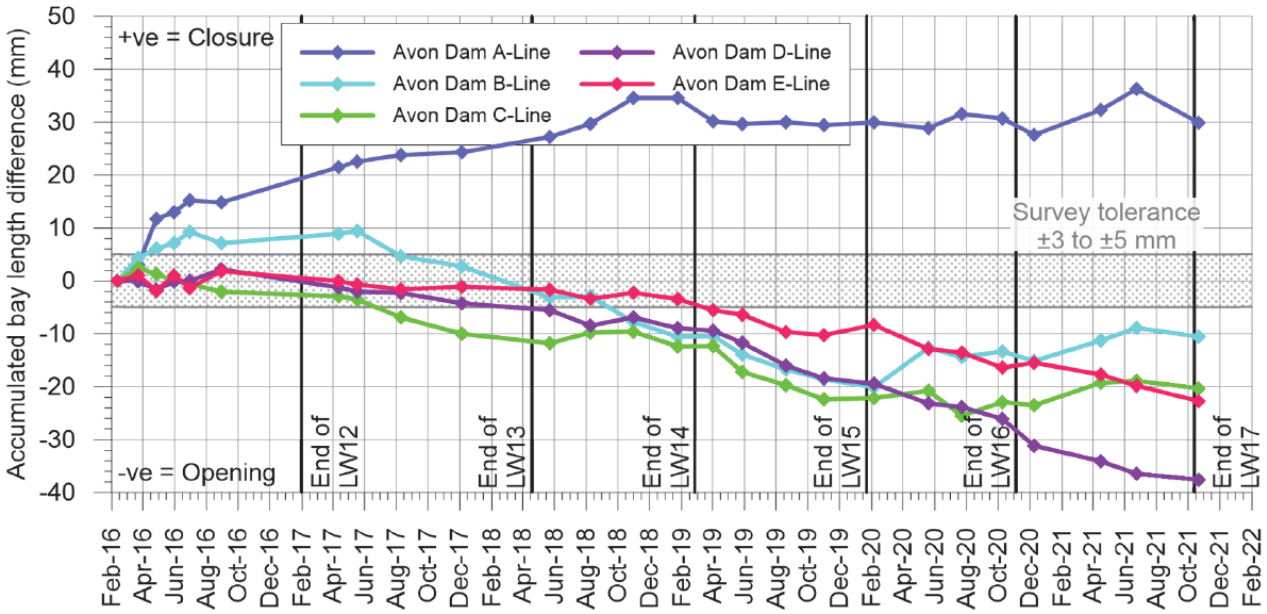

Figure 3: Measured accumulated closure for the Avon Dam closure lines. (Source: Attachment B).

2.3 Wongawilli Creek Tributaries and Avon Dam Tributary Cross Lines

The mine subsidence movements across WC15, a tributary to Wongawilli Creek, have been measured using 2D survey techniques. These monitoring lines were established in December 2018 during the mining of Longwall 14. The subsidence measured at WC15 RB28-Line and WC15 RB34-Line are less than the predicted values. Low-level net uplift was measured at WC15 RB9-Line which is in the order of survey tolerance for absolute height. The closure measured at WC15 RB9-Line, WC15 RB28-Line and WC15 RB34- Line are less than the predicted values at the completion of Longwall 17 (Figure 4).

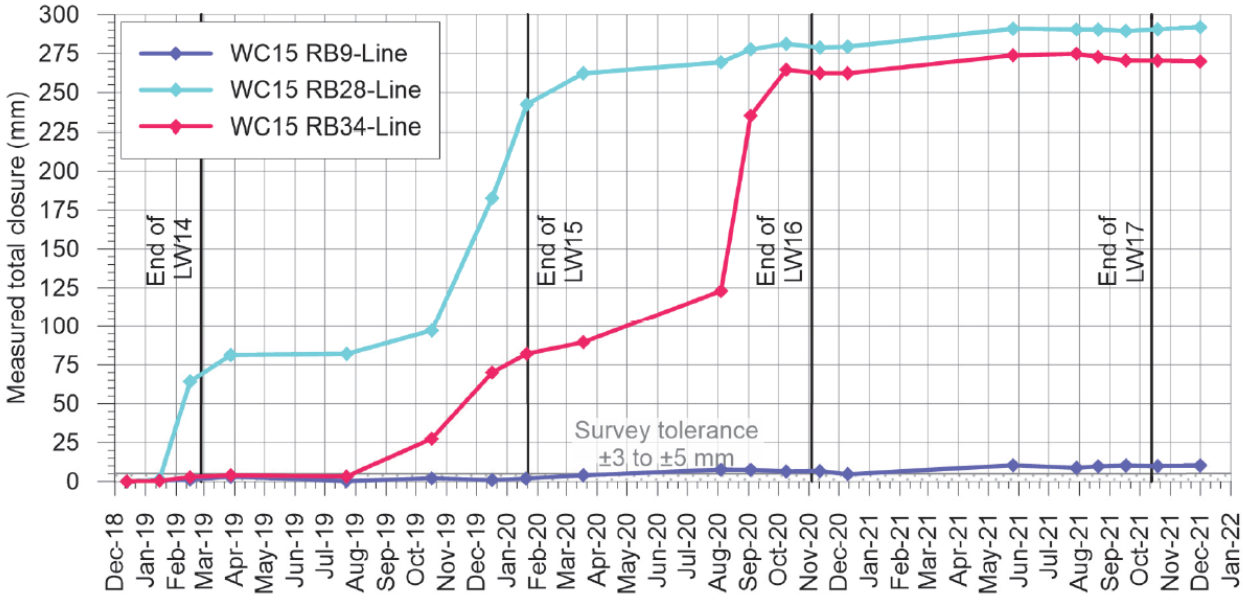

Figure 4: Measured accumulated closure for the WC15 cross lines. (Source: Attachment B).

The mine subsidence movements across WC12 and WC7, tributaries to Wongawilli Creek, have been measured using 2D survey techniques at the WC12 RB18-Line and WC7 RB7-Line, respectively. The WC12 monitoring line was established during the mining of Longwall 15 and, therefore, it does not include the effects of Longwall 9 to Longwall 14 and part of Longwall 15. The WC7 monitoring line was established during the mining of Longwall 17 and, therefore, it does not include the effects of the previous longwalls. Low-level vertical subsidence and closure have been measured at the WC7 RB7-line which is similar to the order of survey tolerance. The ground movements measured at the WC12 RB18-Line are less than the predictions (Figure 5).

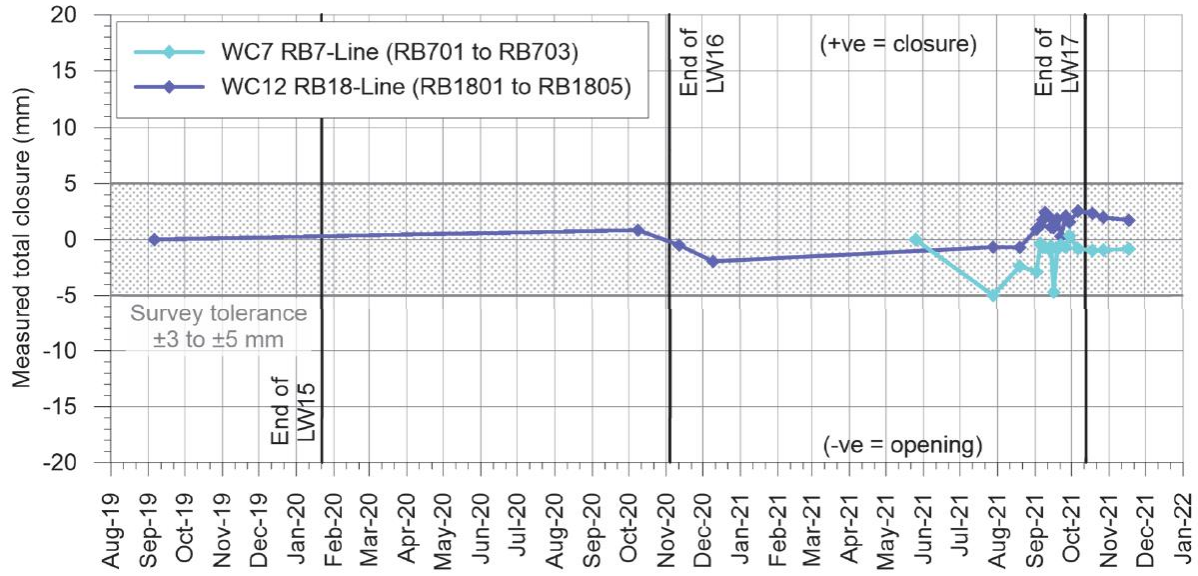

Figure 5: Measured accumulated closure for the WC12 and WC7 cross lines. (Source: Attachment B).

The mine subsidence movements across LA2, a tributary to Lake Avon, have been measured using 2D survey techniques at the LA2 RB2-Line and LA2 RB13-Line. These two monitoring lines were established during the mining of Longwall 15 and, therefore, they do not include the effects of Longwall 9 to Longwall 14 and part of Longwall 15. Low-level vertical subsidence and closure have been measured at the LA2 RB2-Line which are similar to the order of survey tolerance. The ground movements measured using LA2 RB13-Line are less than the predictions (Figure 6).

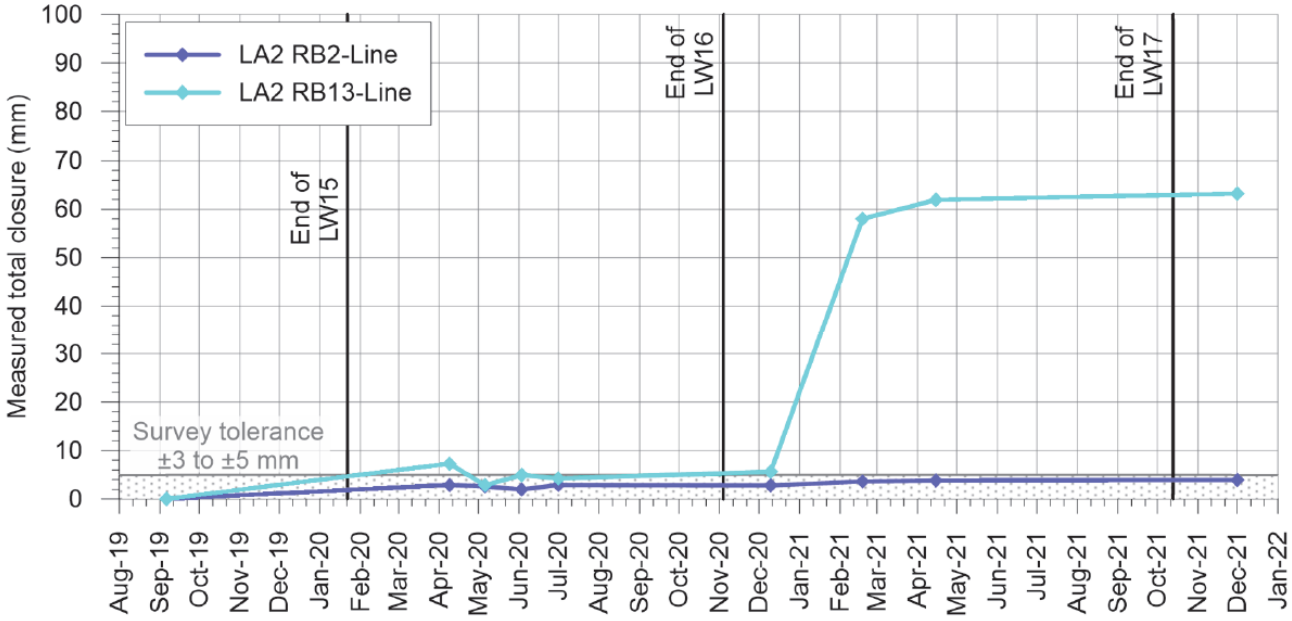

Figure 6: Measured total closure for the LA2 cross lines. (Source: Attachment B).

The closure across Avon Dam and two tributaries to Avon Dam (LA4A and LA4B), were measured using the Avon Dam GPS (Figure 7). The measured total closure at the LA4A monitoring line is less than the predicted value at the completion of Longwall 17. Net opening movements have been measured at the LA4B and Avon monitoring lines due to the conventional subsidence effects being greater that the valley-related effects. The magnitudes of the measured opening movements are less than the magnitudes of the predicted closure movements.

The maximum measured total closure across Lake Avon is less than the maximum predicted value at the completion of Longwall 17. It is considered that the ground movements measured using these monitoring lines are consistent with the predictions.

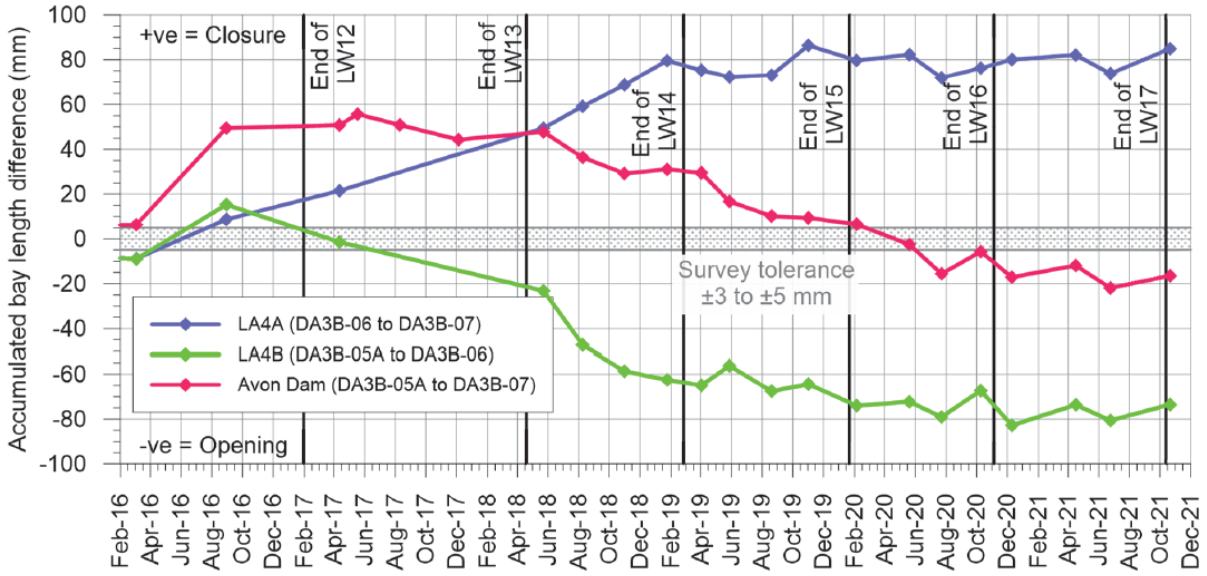

Figure 7: Measured accumulated closure for Tributaries LA4A, LA4B and the Avon Dam. (Source: Attachment B).

2.4 Wongawilli Creek - Waterfall 54

The mine subsidence effects at *Waterfall 54*, on Wongawilli Creek, have been measured using 2D survey techniques. The monitoring lines were established before the commencement of mining of Longwall 16. The ground movements measured at monitoring lines WF54 A-Line, WF54 B-Line and WF54 C-line are less than the predicted values. Longwall 17 finished approximately 105m inbye of the approved finishing end to reduce the closure at the waterfall. Net incremental contraction was measured between DA3b-65 and DA3b-66, however contraction has occurred due to the movement of mark DA3B-65 directly above LW17 rather than due to movement at *Waterfall 54* (Figure 8).

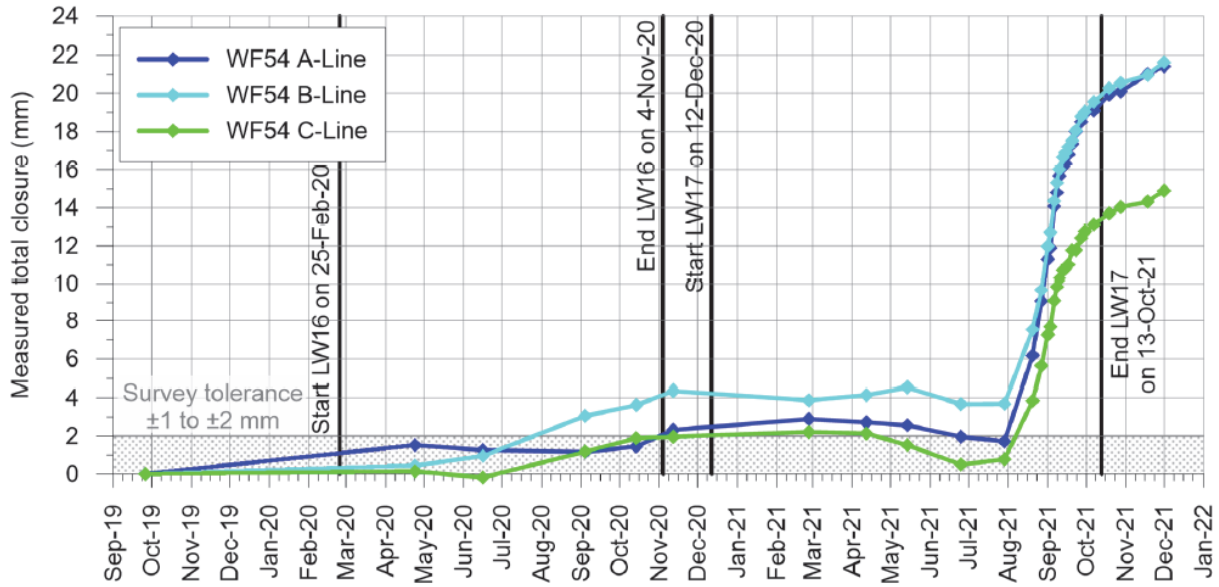

Figure 8: Measured incremental changes in distance between the GNSS units due to Longwall 17. (Source: Attachment B).

2.5 Swamp 23 Cross Line

The mine subsidence movements across swamp 23 have been measured using 2D survey techniques. The remaining swamp cross lines were not measured during Longwall 17. The measured closure at the SW23-Line is considerably less than the predicted value. The vertical subsidence was not measured at this monitoring line.

2.6 Dendrobium Area 3B 3D and the Avon Dam 3D monitoring points

The far-field horizontal movements near Longwall 17 have been measured using DA3B 3D monitoring points and the Avon Dam 3D monitoring points (Figure 1). The accuracies of the measured absolute positions (i.e. Eastings and Northings) are in the order of ±20 mm.

The vectors of incremental horizontal movement above Longwall 17 are orientated towards the south and towards the east, i.e. towards the longwall finishing end, or in the downslope direction (Figure 9). The greatest movements have been measured directly above Longwall 17 and, to a lesser extent, above the adjacent Longwall 16. Only low level incremental horizontal movements have been measured outside the extents of the mining area.

The comparison between the maximum measured incremental horizontal movements at the DA3B 3D and Avon Dam 3D monitoring points with those previously measured in Dendrobium Area 1 (DA1 3D), Dendrobium Area 2 (DA2 3D) and Dendrobium Area 3A (DA3A 3D), as well as other collieries in the Southern Coalfield, is provided in Figure 10. The mean and the 95 % confidence level for the 3D monitoring data at Dendrobium Mine are also shown in Figure 10.

The measured incremental horizontal movements resulting from the extraction of Longwall 17 are typically within the range of those measured at similar distances from previously extracted longwalls at Dendrobium Mine and elsewhere in the Southern Coalfield.

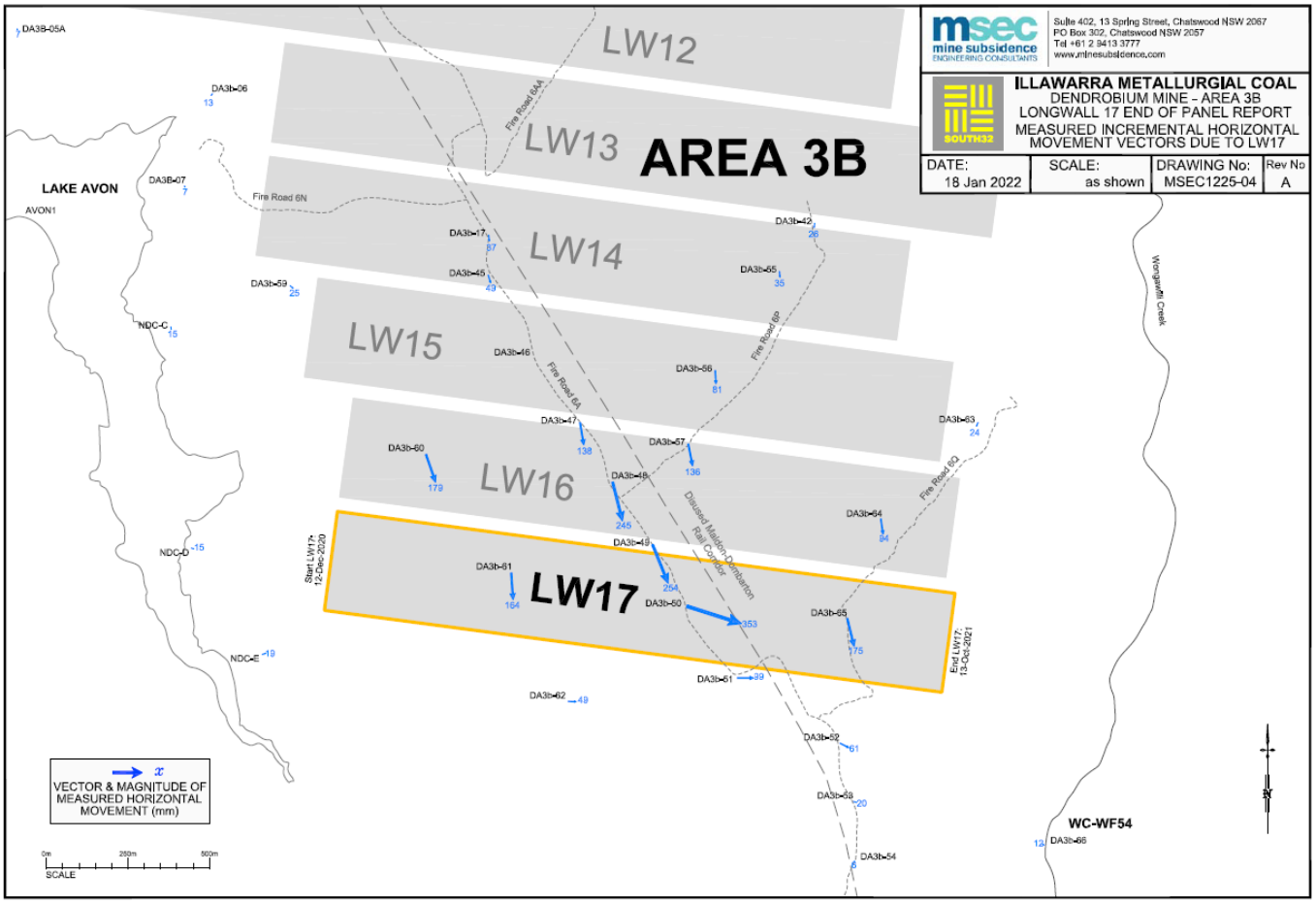

Figure 9: Incremental horizontal movement vectors following the extraction of Longwall 17. (Source: Attachment B).

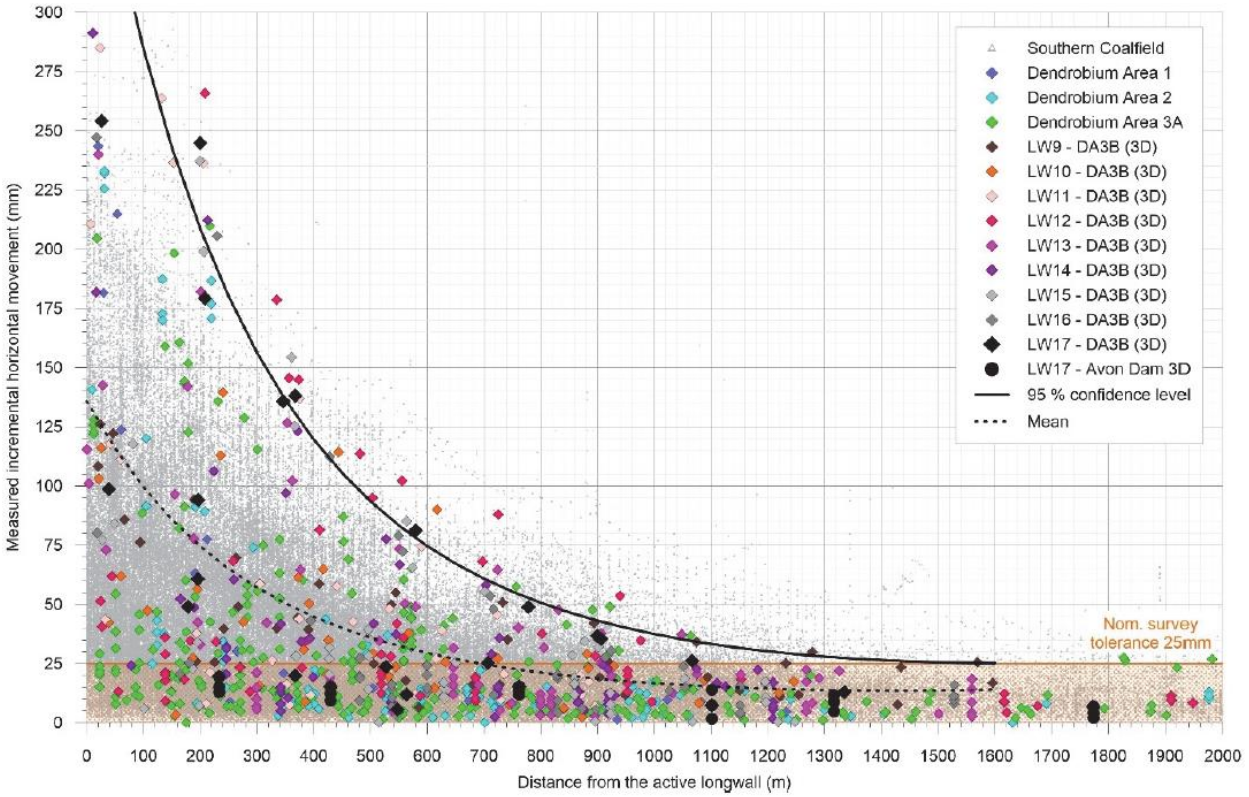

Figure 10: Measured incremental horizontal movements at Dendrobium Mine. (Source: Attachment B).

2.7 Airborne Laser Scanner (ALS) / LiDAR Surveys

The changes in surface level due to the extraction of Longwall 9 to Longwall 17 have been measured using Airborne Laser Scanning (ALS) / Light Detection and Ranging (LiDAR) surveys. The original survey carried out in January 2013 (i.e. prior to the extraction of Longwall 9) does not cover the full extent of Longwall 17. Hence, the survey carried out in January 2016 (i.e. prior to the mining of Longwall 12) has been adopted as the base survey. The post mining surface level contours have been determined from the subsequent surveys carried out after the completion of each longwall. The changes in surface level were determined by calculating the differences between pre-mining surface levels and post-mining surface levels, incrementally (Figure 11), and cumulatively (Figure 12).

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 (Figure 13 to Figure 16). The maximum measured changes in surface level above each of the longwalls are similar to or less than the maximum predicted values. Also, the measured changes in surface level above each of the chain pillars are similar to or less than the predicted values in these locations.

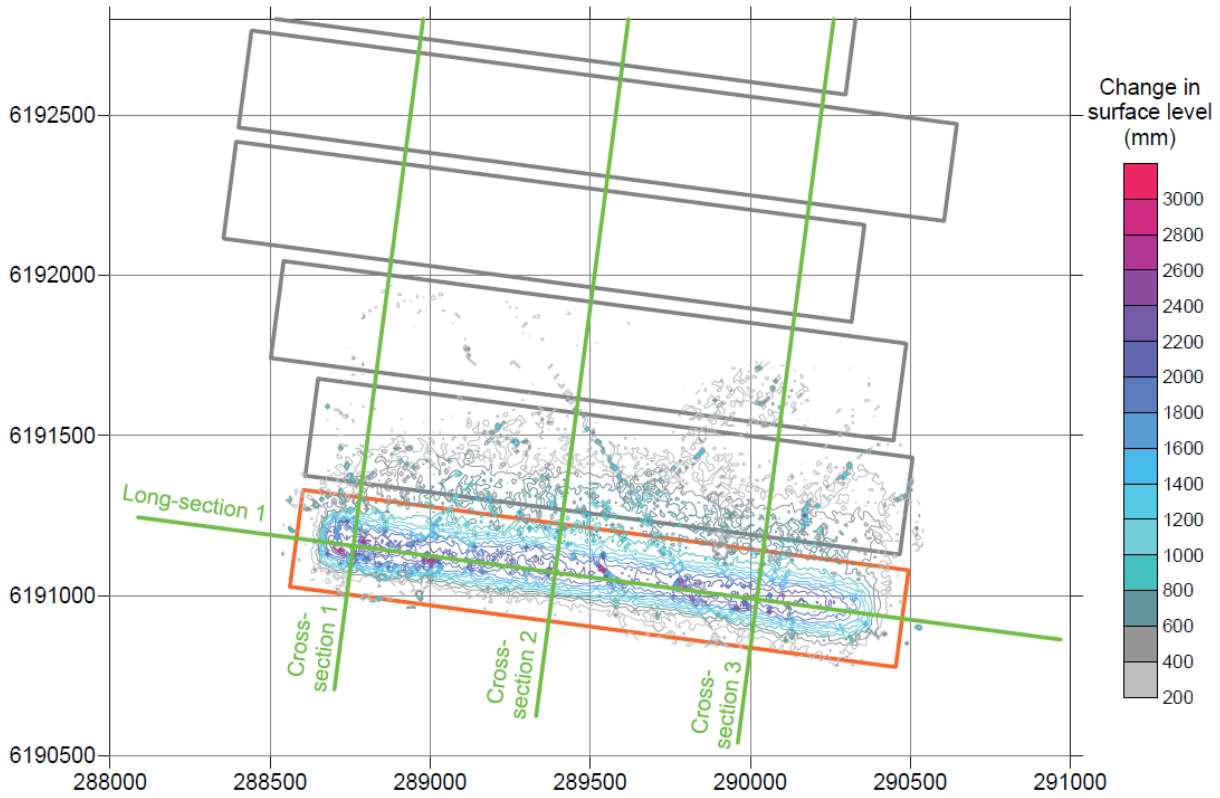

Figure 11: Measured incremental changes in surface level due to the extraction of Longwall 17. (Source: Attachment B).

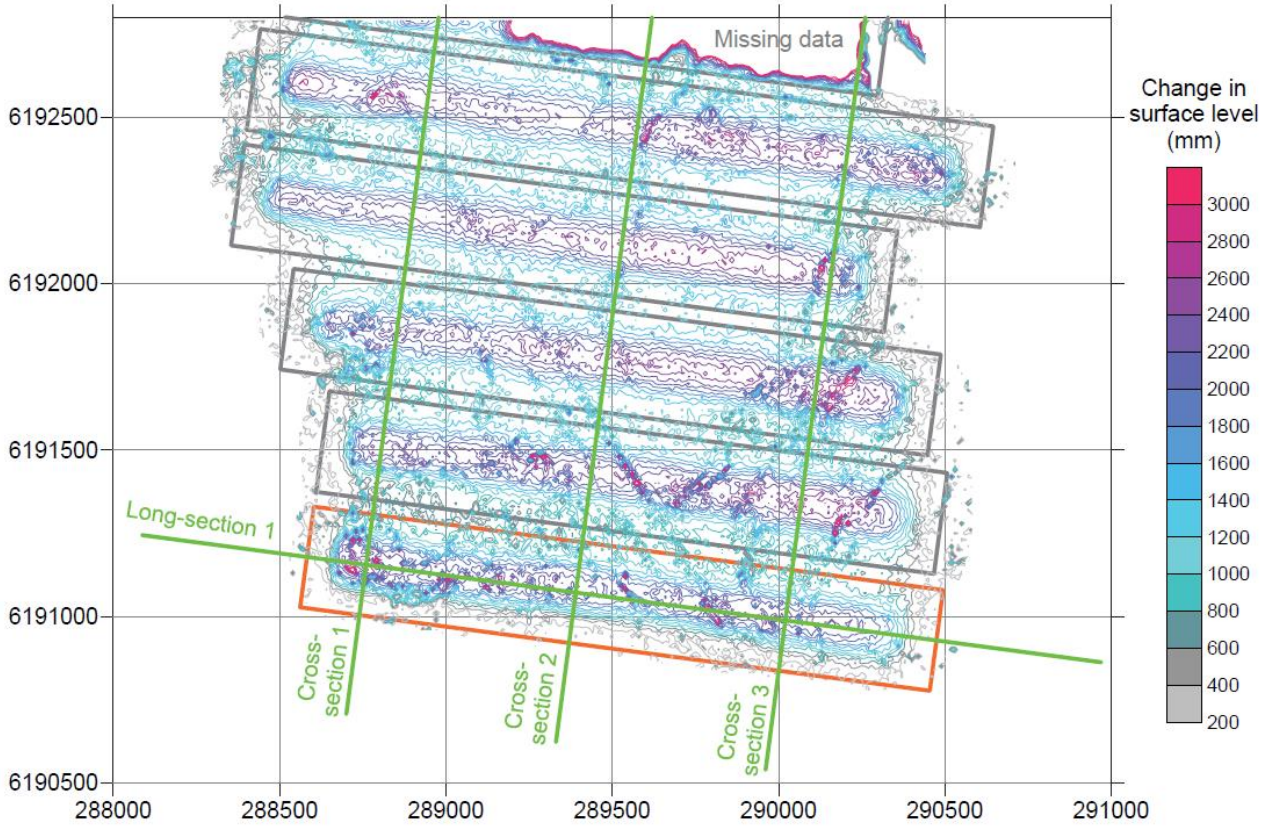

Figure 12: Measured cumulative changes in surface level due to the extraction of Longwall 12 to Longwall 17. (Source: Attachment B).

The measured change in surface level along Long-section 1 (Figure 16) is greater than the predicted vertical subsidence above the commencing end of Longwall 17 (i.e. left side of figure). However, this may be partly due to the surveying tolerance and the effects of the horizontal movements and sloping terrain on the LiDAR surveys.

The ground directly above the commencing end of Longwall 17 has moved towards the longwall (i.e. following the extraction face). The natural surface dips towards the west in this location (i.e. towards Avon Dam). The mining-induced horizontal movement, therefore, results in the measured changes in level at a fixed position to be greater than the true vertical subsidence above the commencing end of Longwall 17. 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. Elsewhere, the low-level movements are in the order of accuracy of the measurement method. It is considered that the subsidence movements measured using the LiDAR surveys are consistent with the predicted subsidence movements.

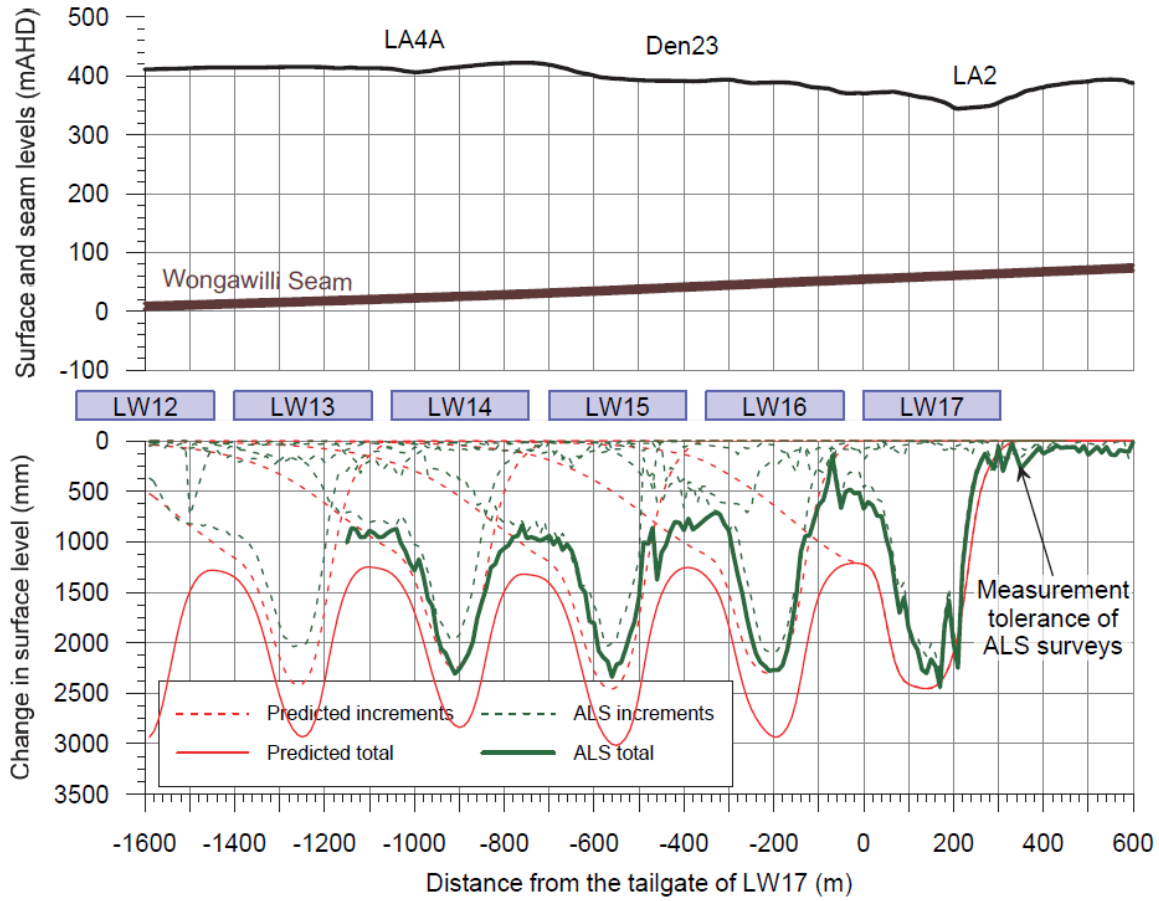

Figure 13: Measured changes in surface level and predicted vertical subsidence along Cross-section 1. (Source: Attachment B).

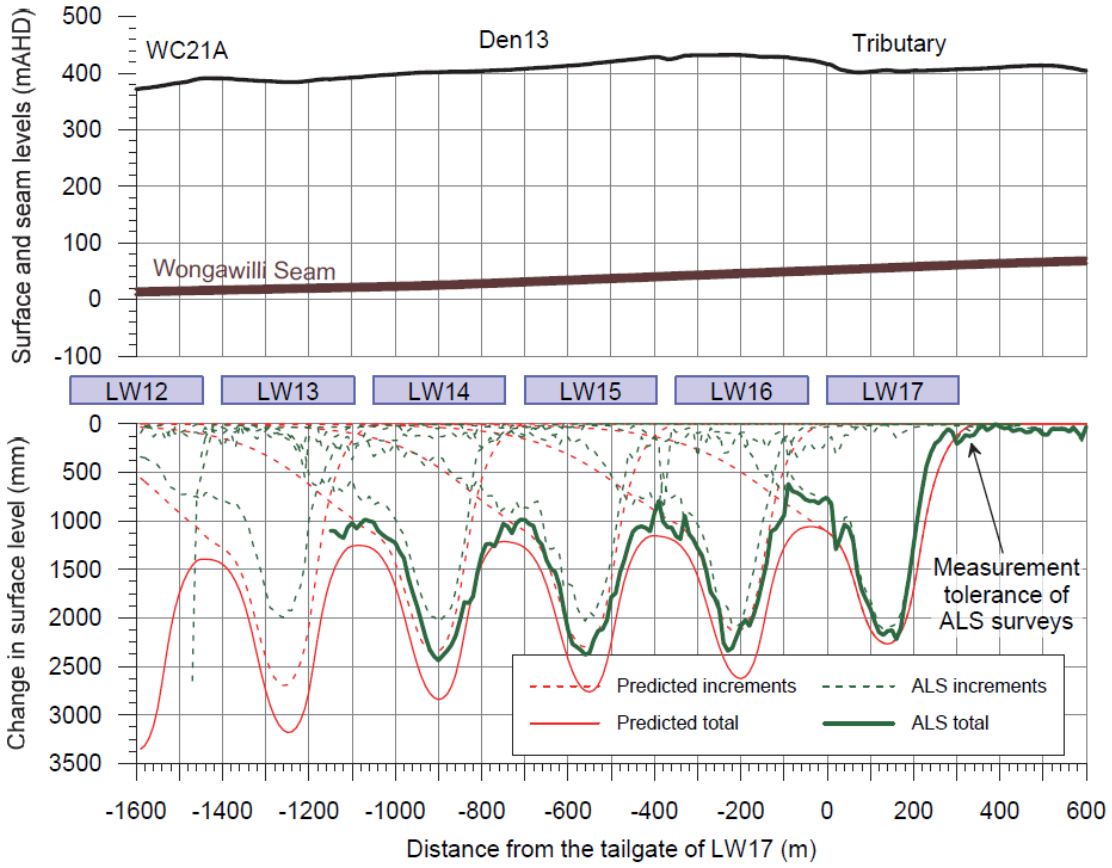

Figure 14: Measured changes in surface level and predicted vertical subsidence along Cross-section 2. (Source: Attachment B).

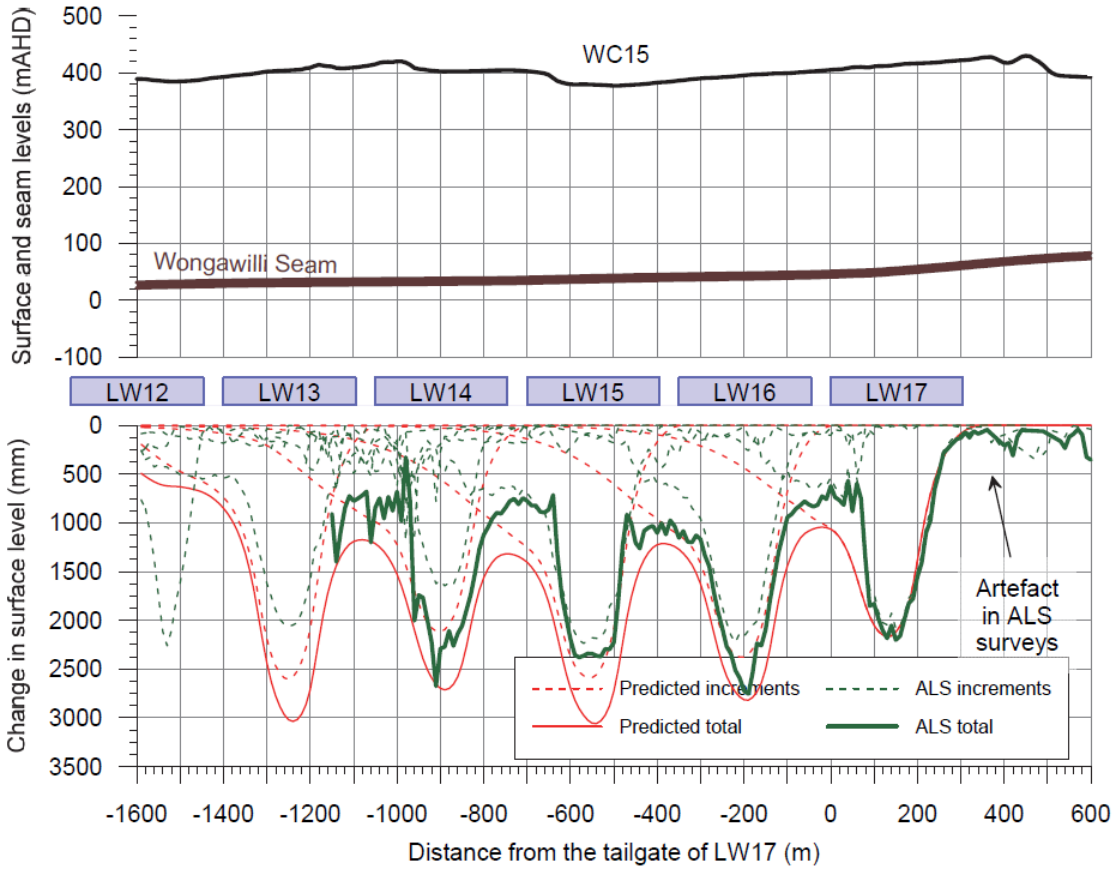

Figure 15: Measured changes in surface level and predicted vertical subsidence along Cross-section 3. (Source: Attachment B).

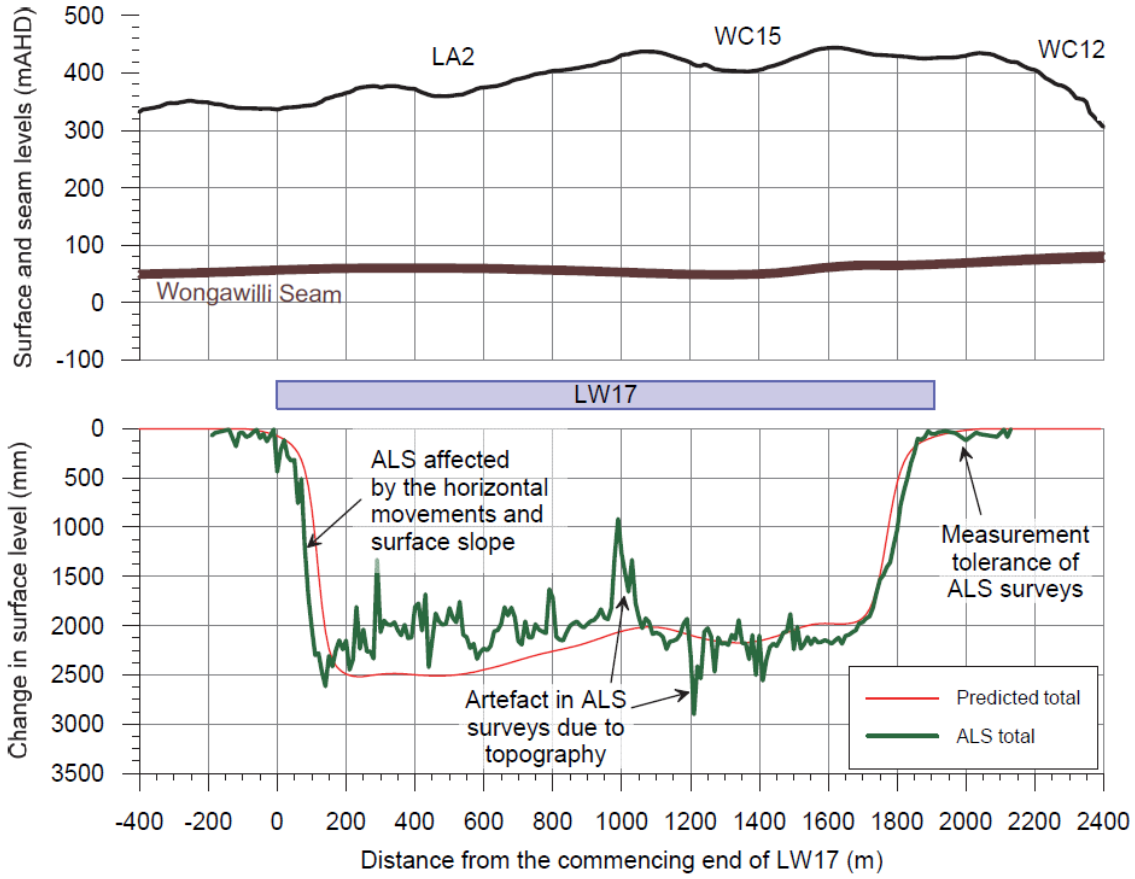

Figure 16: Measured changes in surface level and predicted vertical subsidence along Long section 1. (Source: Attachment B).

3 IMPACTS TO NATURAL FEATURES

During the extraction of Longwall 17, forty new surface impacts were identified. These impacts are labelled as *DA3B_LW17_001* to *DA3B_LW17_040*. An update is provided for one existing Longwall 9 impact; this impact is labelled as *DA3B_LW9_019 (Update).* Other triggers are addressed in their respective sections, with further detail in the attached specialist assessments.

The monitoring program for Longwall 17 was conducted in accordance with the SMP, Watercourse Impact Monitoring Management and Contingency Plan (WIMMCP) and Swamp Impact Monitoring Management and Contingency Plan (SIMMCP). The monitoring program is outlined in Section 6. The results of the IMCEFT monitoring are provided in **Attachment C1**; the impact reports submitted during the extraction of Longwall 17 are provided in **Attachment C2**. The results of monitoring undertaken by specialist consultants are provided in **Attachments D to G**. Figure 19 illustrates the location of surface impacts identified during the extraction of Longwall 17.

3.1 Landscape Features

Subsidence includes vertical and horizontal movement of the land surface, which can result in surface and subsurface cracking, uplifting, buckling, dilation and tilting. These impacts can affect watercourse hydrology and morphology, swamp hydrology and ecological function, and other landscape features by means of surface cracking, which can lead to erosion and rockfalls. Potential mine subsidence impacts within DA3B are discussed in the DA3B SMP, WIMMCP and SIMMCP.

An overview of impacts observed during the extraction of Longwall 17 is provided in the following sections. For specific details on the impacts, refer to the relevant impact reports (**Attachment C2**).

3.1.1 Impacts to First and Second Order Streams

Eight first and second order streams were monitored as part of the Longwall 17 monitoring program; LA2, LA3, WC15, WC12, WC9, WC7, ND1 and ND1C. Impacts observed at watercourses during Longwall 17 are described in Table 3, with Photo 1 to Photo 13 showing the impacts recorded.

Table 3: Summary of impacts to first and second order streams.

Site ID	Easting	Northing	Impact Type	Feature Affected	Identification Date	Trigger Level	Description	Refer to Impact Report/s Dated
DA3B_LW17_001 Photo 1	288554	6191211	Rock Fracturing, Uplift and Fragmentation.	LA2	5/02/2021	2	Rock fracturing, uplift and fragmentation to *LA2_Channel 6B.*	10/02/2021
DA3B_LW17_002 (Update) Photo 2	289050	6191110	Rock Fracturing, Uplift and Fragmentation.	LA2	10/02/2021 & 10/03/2021	2	Rock fracturing, uplift and fragmentation to *LA2_Rockbar 25* and *LA2_Pool 25.*	16/02/2021 & 12/03/2021
DA3B_LW17_003 Photo 3	289038	6191109	Rock Fracturing, Uplift and Rockfall.	LA2	10/02/2021, 10/03/2021, 13/04/2021	2	Rock fracturing, uplift and rockfall to *LA2_Rockbar 24*, *LA2_Pool 24* and *LA2_Step 24*.	16/02/202, 12/03/2021 & 14/04/2021
DA3B_LW17_004 Photo 4	288700	6191113	Rock Fracturing and Uplift.	LA2	10/03/2021	2	Rock fracturing and uplift to *LA2_Rockbar 10.*	12/03/2021
DA3B_LW17_005 Photo 5	288723	6191096	Rock Fracturing	LA2	10/03/2021	2	Rock fracturing to *LA2_Pool 12.*	12/03/2021
DA3B_LW17_006 Photo 6	288752	6191099	Rock Fracturing, uplift and Soil Cracking	LA2	10/03/2021	2	Rock fracturing, soil cracking and uplift to *LA2_Pool 14.*	12/03/2021
DA3B_LW17_007 Photo 7	288700	6191113	Rock Fracturing & Uplift	LA2	10/03/2021	2	Rock fracturing and uplift to *LA2_Rockbar 14.*	12/03/2021
DA3B_LW17_012 Photo 8	288663	6191142	Rock Fracturing	LA2	13/04/2021	2	Rock fracturing and displacement around *LA2_Pool 9* and upstream rockbar.	14/04/2021
DA3B_LW17_013 Photo 9	288651	6191158	Rock Fracturing	LA2	13/04/2021	2	Rock fracturing to *LA2_Channel 8.*	14/04/2021
DA3B_LW17_025 Photo 10	287973	6192580	Iron Staining	LA5	1/07/2021	1	Iron staining in tributary LA5.	6/07/2021
DA3B_LW17_031 Photo 11	290859	6193467	Iron Staining	Wong-awilli Creek	2/08/2021	3	Iron staining in Wongawilli Creek.	9/08/2021

DA3B_LW17_034 Photo 12	288736	6191097	Rock Fracturing	LA2	10/9/2021	2	Rock fracturing and cracking to LA2 tributary.	21/09/2021
DA3B_LW9_019 (Update) Photo 13	290241	6193909	Iron Staining	WC21	2/08/2021	3	Iron staining extending into Wongawilli Creek.	9/08/2021

Photo 1: *DA3B_LW17_001,* rock fracturing, uplift and fragmentation on rockbar. Taken on 5/02/2021.

Photo 2: DA3B_LW17_002, width of rock fracturing on LA2. Taken on 10/09/2021.

Photo 3: *DA3B_LW17_003*, rockfall to step on LA2. Taken on 10/09/2021.

Photo 4: *DA3B_LW17_004,* rock fracturing on LA2. Taken on 10/09/2021.

Photo 5: *DA3B_LW17_005*, rock fracturing on LA2. Taken on 10/03/2021.

Photo 6: *DA3B_LW17_006,* rock fracturing and uplift on LA2. Taken on 10/09/2021.

Photo 7: *DA3B_LW17_007,* section of rock fracturing on LA2. Taken on 10/03/2021.

Photo 8: *DA3B_LW17_012,* displacement of rockbar on LA2. Taken on 10/09/2021.

Photo 9: *DA3B_LW17_013,* rock fracturing on LA2. Taken on 13/04/2021.

Photo 10: *DA3B_LW17_025,* iron staining at *LA5_S1*. Taken on 1/07/2021.

Photo 11: *DA3B_LW17_031,* iron staining from spring outflowing into Wongawilli Creek. Taken on 28/07/2021.

Photo 12: *DA3B_LW17_034,* rock fracturing on LA2. Taken on 10/09/2021.

Photo 13: *DA3B_LW9_019,* iron staining at *WC21_Pool 10*. Taken on 1/07/2021.

3.1.2 Impacts to Other Landscape Features

Impacts recorded on steep slopes, steps and general landscape features are presented below (Table 4).

Table 4: Summary of Impacts to other landscape features.

Site ID	Easting	Northing	Impact Type	Feature Affected	Identification Date	Trigger Level	Description	Refer to Impact Report/s Dated
DA3B_LW17_008 Photo 14	288895	6191074	Rockfall	Steep Slope/Step	10/03/2021	2	Rockfall at Steep slope/step adjacent to LA2.	12/03/2021
DA3B_LW17_009 Photo 15	2889238	6191070	Rockfall	Steep Slope/Step	10/03/2021	2	Rockfall at Steep slope/step adjacent to LA2.	12/03/2021
DA3B_LW17_010 Photo 16	288700	6191147	Rock Fracturing	Steep Slope/Step	13/04/2021	1	Rock Fracturing to step on the northern slope of LA2 valley.	14/04/2021
DA3B_LW17_011 Photo 17	288721	6191139	Rock Fracturing	Steep Slope/Step	13/04/2021	2	Rock fracturing to step/steep slope.	14/04/2021

DA3B_LW17_016 Photo 18	289395	6191018	Rock Fracturing	Rock Outcrop	25/05/2021	1	Rock fracturing to a rock outcrop, west of *Fire Road 6A*.	28/05/2021
DA3B_LW17_017 Photo 19	289523	6191142	Rock Displacement	Rock Outcrop	25/05/2021	1	Rock displacement from soil, west of *Fire Road 6A*.	28/05/2021
DA3B_LW17_019 Photo 20	289584	6191060	Soil Cracking and Rock Fracturing	Bushland	8/06/2021	3	Soil cracking and rock fracturing in bushland west of *Fire Road 6A.*	9/06/2021
DA3B_LW17_021 Photo 21	289613	6191009	Rock Fracturing	Steep Slope/Step	8/06/2021	1	Rock fracturing to step/steep slope.	9/06/2021
DA3B_LW17_022 Photo 22	289813	6190889	Rock Fracturing	Bushland	22/06/2021	1	Fracturing to rock outcrop in bushland to east of *Fire Road 6A.*	25/06/2021
DA3B_LW17_023 Photo 23	289765	6190961	Rock Fracturing	Bushland	22/06/2021	2	Fracturing to rock outcrop in bushland to east of *Fire Road 6A.*	25/06/2021
DA3B_LW17_024 Photo 24	289682	6190942	Rock Fracturing	Rock outcrop	24/06/2021	1	Fracturing to rock outcrop adjacent to *Fire Road 6A.*	25/06/2021
DA3B_LW17_032 Photo 25	290091	6190867	Rock Displacement	Steep Slope/Step	17/08/2021	1	Rock displacement from soil at the base of steep slope/step, east of *Fire Road 6A.*	25/8/2021
DA3B_LW17_035 Photo 26	289585	6191040	Rock Fracturing	Rock Outcrop	15/9/2021	1	Rock fracturing with an associated rockfall to a large rock outcrop/steep slope.	21/09/2021
DA3B_LW17_036 Photo 27	289533	6191165	Rock Fracturing	Rock Outcrop	15/9/2021	1	Rock fracturing to a large rock outcrop/steep slope.	21/09/2021
DA3B_LW17_037 Photo 28	289536	6191147	Rock Fracturing	Rock Outcrop	15/9/2021	2	Multiple rock fracturing to a large rock outcrop/steep slope.	21/09/2021
DA3B_LW17_038 Photo 29	289567	6191065	Rock Movement	Rock Outcrop	15/9/2021	1	Rock movement and soil cracking to a large rock outcrop/steep slope.	21/09/2021
DA3B_LW17_039 Photo 30	289778	6190934	Rock Movement	Rock outcrop	21/10/2021	1	Rock movement, rock and soil profile separation at rock outcrop.	8/11/2021

DA3B_LW17_040 Photo 31	289779	6190944	Rock Fracturing	Rock outcrop	21/10/2021	1	Rock fracturing to exposed rock outcrop.	8/11/2021

Photo 14: *DA3B_LW17_008,* rockfall north of LA2. Taken on 10/03/2021.

Photo 15: *DA3B_LW17_009,* rockfall north of LA2. Taken on 10/03/2021.

Photo 16: *DA3B_LW17_010,* rock fracturing north of LA2. Taken on 10/09/2021.

Photo 17: *DA3B_LW17_011,* rock fracturing north of LA2. Taken on 13/04/2021.

Photo 18: *DA3B_LW17_016,* rock fracturing west of *Fire Road 6A*. Taken on 25/05/2021.

Photo 19: *DA3B_LW17_017,* rock displacement west of *Fire Road 6A*. Taken on 25/05/2021.

Photo 20: *DA3B_LW17_019,* soil cracking west of *Fire Road 6A*. Taken on 8/06/2021.

Photo 21: *DA3B_LW17_021,* rock fracturing west of *Fire Road 6A*. Taken on 8/06/2021.

Photo 22: *DA3B_LW17_022,* rock fracturing east of *Fire Road 6A*. Taken on 22/06/2021.

Photo 23: *DA3B_LW17_023,* rock fracturing east of *Fire Road 6A*. Taken on 22/06/2021.

Photo 24: *DA3B_LW17_024,* rock fracturing adjacent to *Fire Road 6A*. Taken on 24/06/2021.

Photo 25: *DA3B_LW17_032,* rock displacement east of *Fire Road 6A*. Taken on 17/08/2021.

Photo 26: *DA3B_LW17_035,* rock fracturing and rockfall west of *Fire Road 6A*. Taken on 15/09/2021.

Photo 27: *DA3B_LW17_036,* rock fracturing west of *Fire Road 6A*. Taken on 15/09/2021.

Photo 28: *DA3B_LW17_037,* rock fracturing west of *Fire Road 6A*. Taken on 15/09/2021.

Photo 29: *DA3B_LW17_038,* rock displacement west of *Fire Road 6A*. Taken on 15/09/2021.

Photo 30: *DA3B_LW17_039,* rock displacement east of *Fire Road 6A*. Taken on 21/10/2021.

Photo 31: *DA3B_LW17_040,* rock fracturing east of *Fire Road 6A*. Taken on 21/10/2021.

3.2 Surface Water Quality

The monitoring of water quality parameters provides a means of detecting and assessing the effects of streambed fracturing or induction of ferruginous springs. Monitoring includes measurement of field parameters such as pH, EC, DO, oxygen reduction potential (ORP) and a suite of laboratory-tested analytes. At *LA4_S1*, a TARP Level 3 was recorded for pH and EC (Table 5).

Table 5: Summary of water quality TARP triggers during the extraction of Longwall 17.

Monitoring Site	Observation	Longwall 17 Water Quality Trigger
LA4_S1	EC	3
	pH	3

Rainfall during 2021 and during Longwall 17 extraction was well above average, totalling 1448mm, the highest rainfall year since 2007. Heavy rainfall was experienced in March, May and November 2021. This follows similarly high rainfall in 2020 (1436 mm). As a result, there has been a broad recovery in stream flow, shallow groundwater levels and soil moisture across all catchments since the severe drought of 2017-2019.

At many stream monitoring sites including reference sites, water electrical conductivity (EC) has decreased over the last two years due to higher than average rainfall and significant increase in runoff compared with the previous two years. The decreasing trend follows slightly more saline conditions at most locations during the 2017-2019 drought which resulted in low flows and evaporative concentration of salts. Similarly, DO has trended higher over the last two years period due to higher flows and stream turbulence.

Anomalous water quality effects are noted in watercourses that have been directly mined under by previous longwalls (e.g. WC21, SC10C, LA4, DCC). Those effects include transient or persistent increases in EC, increases (or decreases) in pH and increases in dissolved metal concentrations such as Fe, Mn, Al and Zn. Water quality TARPs were triggered at Lake Avon tributary site *LA4_S1* for EC and pH. With the exception of Sandy Creek, adverse changes in water quality are not apparent at down-stream monitoring sites on 3rd order watercourses. No adverse changes in water quality are noted in Lake Avon and Lake Cordeaux.

Iron staining in creek beds is commonly associated with watercourses that have been directly mined beneath or are within the mining area of influence. Over the last two years, new or recurrent iron staining has been noted on Wongawilli Creek, WC21, LA5 and SC10C. The observations of iron staining are likely related to recovery of groundwater levels and the reactivation of iron-rich springs near creek channels.

Further details are presented in **Attachment D**.

3.3 Surface Water Hydrology

The four surface water hydrology assessment methods are as follows:

(A) General hydrological behaviour compared with Reference Sites,

(B) The frequency and duration of ecologically-significant cease-to-flow events compared with Reference Sites;

(C) Changes to median flow compared with Reference Sites which is now the agreed measure of the water resource availability in each sub-catchment; and

(D) Comparison of qualitative flow data from gauging stations and semi-quantitative field observations by IMCEFT along the “middle reach” of Wongawilli Creek.

Table 6 summarises these surface water hydrology assessments at monitoring sites against the TARPs.

The assessments indicate that sub-catchments in the upper part of the Donalds Castle Creek catchment (i.e. *DC13S1* and *DCS2*) have been and continue to be affected by mining, as are the tributaries LA4, LA3 and LA2 of Lake Avon. The findings for *DC13S1*, *DCS2* (both at Level 3 for all three flow assessments) are similar to those for the EoP report for Longwalls 15 to Longwall 16.

Similarly, the flow characteristics at *WC21S1* and *WC15S1* within the Wongawilli Creek catchment have altered as a result of mining, with these sites at Levels 2 or 3 for the three assessments. As with the sub-catchments above, the effects at WC21 and WC15 are similar to those for the previous EoP reports. Despite Longwall 16 terminating within 50 m of WC12, and the end of Longwall 17 mining under WC12, no mining-related effects are discernible beyond natural variability/method accuracy.

As in recent EoP reports, analysis indicates that mild mining effects are probable at the Donalds Castle Creek downstream monitoring site (*DCU*). Specifically, the newly designed TARP assessments indicate that the general pattern of flow (Assessment A) and the median flows (Assessment C) do not trigger, which suggest that any mining effects or impacts on those indicators are of similar magnitude or less than natural variability. However, the new Assessment B, which examines cease-to-flow duration and frequency, indicates that the watercourse at *DCU* has been experiencing a mild increase in the number of cease-to-flow days compared to the Reference sites (TARP Level 1).

Changes to stream flow characteristics are not evident at the downstream gauge on Wongawilli Creek Lower (*WWL*), despite mining-related effects being clear and significant at upstream tributaries (e.g. WC21, WC15). This suggests that some or all flow lost in headwater catchments is returned downgradient, or that upstream diversions or losses are not significant in relation to the larger catchment water balance given the natural variability and the accuracy of flow measurements. These possible reasons are even more relevant at *DCU*, where the losses identified in upstream sites *DC13S1* and *DCS2* are 40-60% of median flow at Q50. Such losses should be clearly apparent at *DCU* if they were transmitted downstream, but the assessment has not detected a change in median flow at Q50 beyond natural variability (i.e. variability at two Reference sites).

Analysis of post-mining behaviour of water levels at *Waterfall 54* is consistent with pre-mining records, and therefore Longwall 17 did not have an effect (either no effect or an effect that cannot be discerned beyond natural variability).

Analysis of available surface water flow observation records for Wongawilli Creek did not trigger TARP Assessment D for any of the months assessed during the Longwall 17 period.

Water flow performance measures were met for Longwall 17 (Table 7). Further details are presented in **Attachment D**.

Table 6: Summary of Surface Water TARPS for Longwall 17.

Site	Watercourse	Catchment Mined Under	Position of sub-catchment relative to mining	A) Low flow Q%ile outside Reference Site Q%ile	B) Change in cease-to-flow frequency (beyond natural)	C) Change in median flow, Q50 (beyond natural)	Comment
DC13S1	DC13	Yes	Above Longwalls	Level 3	Level 2	Level 3	Similar to Longwall 14 to Longwall 16.
DCS2	Donalds Castle Creek	Yes	Above Longwalls	Level 3	Level 3	Level 3	Similar to Longwall 14 to Longwall 16.
DCU	Donalds Castle Creek	Yes	Downstream	Not triggered	Level 1	Not triggered	Similar to Longwall 14 to Longwall 16. Findings supported by rainfall-runoff modelling.
WC21S1	WC21	Yes	Above Longwalls	Level 3	Level 2	Level 3	Similar to Longwall 14 to Longwall 16.
WC15S1	WC15	Yes	Above Longwalls	Level 3	Level 2	Level 3	Similar to Longwall 15 to Longwall 16.
WC12S1	WC12	Yes	Above Longwalls	Not triggered	Not triggered	Not triggered	Second panel under catchment. No discernible effect. Findings supported by rainfall-runoff modelling.
WWL	Wongawilli Creek	Yes	Downstream	Not triggered	Not triggered	Not triggered	Similar to Longwall 14 to Longwall 16. Findings supported by rainfall-runoff modelling.
LA4S1	LA4	Yes	Above Longwalls	Level 1	Level 2	Level 3	Similar to Longwall 14 to Longwall 16.
LA3S1	LA3	Yes	Above Longwalls	Level 3	Level 3	Level 3	Similar to Longwall 16.
LA2S1	LA2	Yes	Above Longwalls	Not triggered	Level 1	Level 3	Effects are similar to those following Longwall 16, but low-flow frequency has increased.
ND1S1	ND1	Yes	Headwater	Not triggered	Not triggered	Not triggered	Longwall 17 is first panel under this sub-catchment. No discernible effects. Findings supported by rainfall-runoff modelling.

Site Watercourse	Position of sub-catchment relative to mining	D) Surface flow observations		Comment
Wongawilli Creek	Between DA3A and DA3B	All months	Not triggered	Refer to Performance Measures

Table 7: Summary of surface water Performance Measures for Longwall 17.

Wongawilli Creek – minor environmental consequences	**This Performance Measure is met.**
Donalds Castle Creek – minor environmental consequences	**This Performance Measure is met.**
Avon Dam – negligible reduction in the quantity of surface water inflows to Avon Dam	**This Performance Measure is met.**
Cordeaux River – negligible reduction in the quantity if surface water inflow to the Cordeaux River at its confluence with Wongawilli Creek.	**This Performance Measure is met.**

Further details are presented in **Attachment D.**

3.4 Deep Groundwater Hydrology

Groundwater monitoring at Dendrobium Mine is conducted in accordance with the 'Dendrobium Mine Area 3B SMP Groundwater Management Plan' (South32 2012) and the 'Dendrobium Area 3B Subsidence Management Plan' (BHP Billiton 2015). The aims of the Groundwater Management Plan are to:

- Monitor groundwater levels and quality, commencing at least one year prior to mining affecting the system;
- Project potential groundwater changes during mining (short term) and post-mining (long term) with particular attention to the effect of changes to groundwater regime, impact on the catchment yield and interaction with the stored waters;
- Identify hydraulic characteristics of overlying and intercepted groundwater systems, and determine changes to groundwater systems due to coal extraction and dewatering operations;
- Report any pumping tests and groundwater/surface water simulation studies; and
- Collect water level data from all agreed groundwater-monitoring locations.

Further details are presented in **Attachment E.**

3.4.1 Mine Water Balance

The System Control and Data Acquisition (SCADA) system calculates a daily Mine Water Balance. The Water Balance is an accurate measure of all water that enters, circulates and leaves the mine, including via air moisture and coal moisture content. Mine water seepage (groundwater inflow), which cannot be directly measured, is determined by mass balance for each goaf and is therefore known to a reasonable accuracy. Key metrics of the Mine Water Balance are reported against TARP levels to Dams Safety NSW Monthly.

The average daily inflow to DA3B during Longwall 17 extraction was 5.2 ML/day which represents approximately 64% of total mine inflow for the period (a similar proportion to Longwall 16). Compared with the previous longwall, the total mine inflow increased by 23% and the inflow in Area 3B increased by 36%. The increase in total mine inflow is mainly due to an increase of inflow in DA3B.

Groundwater ingress to DA3B has increased steadily since the start of mining (2013), initially correlating with the total area mined. However, the rate of increase has declined (flattened) during the mining of Longwalls 12 and 13 and the water balance decreased during the extraction of Longwall 14 and Longwall 15 (Figure 17). This overall trend reflects a declining groundwater inflow per unit area mined due to progressive depressurisation of the surrounding strata by previous mining (a decline in driving head). The decline in groundwater inflow to Area 3B during Longwall 14 and Longwall 15 is likely to be partly due to the unusually dry conditions during 2018-2019. As of longwall 12, peaks in inflow to Area 3B appear to correlate with periods of high rainfall with a lag time of between two and three months. Prior to Longwall 12, the influence of rainfall on the water balance was less distinct.

The presence of modern water in mine inflow is monitored by analysing tritium. Samples are collected from goaf inflow and development seepage. The results are reported monthly to Dams Safety NSW.

Tritium is an isotope of hydrogen (3H), which decays exponentially according to its half-life (12.32 years) and is

typically only detectable in surface water samples and in groundwater that recharged within 4 to 5 half-lives (50 to 70 years). Detection of tritium above deep groundwater baseline levels in mine inflow samples would indicate a component of modern water in the sample (as it does for samples from Area 2). Tritium in samples collected from Area 3B goaf outflow is typically within or close to baseline concentrations in deep groundwater, implying that the component of modern water in mine inflow to DA3B is very low. Laboratory processing time for tritium analysis can take 6 to 12 months. The most recent analysis is from a sample collected on 22/02/2021, during the initial stages of Longwall 17.

Carbon-14 (14C) has been analysed in mine water, groundwater and surface water samples since 2020 as an additional indicator of modern water. 14C is a radioactive isotope of carbon with a half-life of 5,730 years. All samples collected from the goaf outflow tank (DWS203) have low percentage modern carbon (≤ 3.1%) which, together with low corresponding tritium concentrations, implies that inflow to Area 3B is mostly from old, deep groundwater sources with only a very small proportion of modern water.

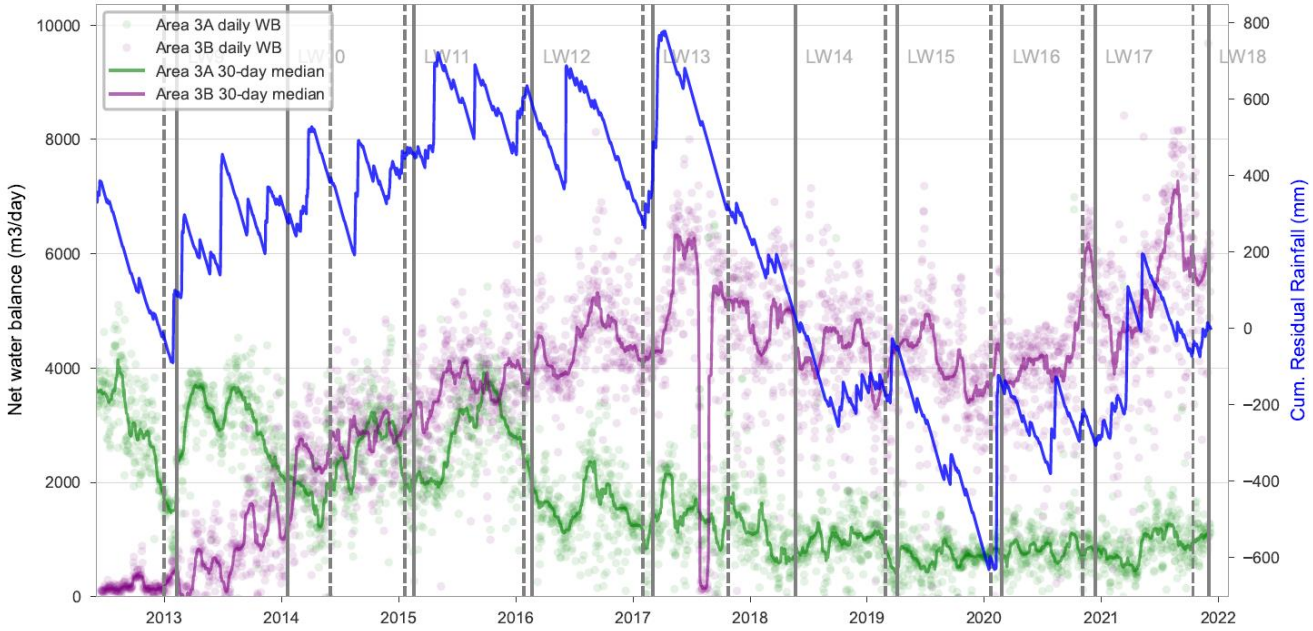

Figure 17: Groundwater inflow to the mine for DA3A and DA3B (kL/d).

3.4.2 Deep Groundwater Levels

Mining of Longwall 17 resulted in continued depressurisation of the target coal seam and overlying strata. The observed changes in groundwater levels are in line with, or less than, numerical model predictions that support mining approvals. As expected, the greatest depressurisation is within the Wongawilli Coal Seam, and decreases with height above the seam.

Since 2018, IMC has carried out investigation drilling above extracted longwalls (Longwalls 6, 7, 12, 13, 14, 15, 16 and 17) to characterise the height of fracturing and assess groundwater conditions in strata above the longwall goaf. Investigations to date have found that mining-induced fracturing is highly variable but appears to extend to the surface in both Dendrobium Area 3A and 3B. Piezometers installed after longwall extraction indicate significant depressurisation throughout all strata and throughout the Hawkesbury Sandstone (HBSS) in most holes.

Holes in both areas show positive pressure heads in some sensors in the upper Colo Vale Sandstone (CVSS) and Bald Hill Claystone (BACS) and evidence for localised perching and groundwater recovery which continued

in 2021. However shallow groundwater levels remain below pre-mining levels. Drawdown in the HBSS reduces with distance and is typically negligible at distances greater than 1.2km from the goaf footprint.

Piezometers located to the north and west, and within 1km of the longwall footprint show a gradual decline in groundwater pressures in most strata with the rate of decline increasing with depth and proximity to the longwall. Those observations are consistent with the gradual expansion of a drawdown cone away from the mine and are in line with numerical modelling predictions. The most strongly affected strata are within 500m of extracted longwalls.

A hydrogeological investigation of the Elouera fault was carried out to assess the structural and hydrogeological characteristics of the Elouera Fault zone. Six inclined cored holes have been drilled at two sites along the fault, four of which have intersected the fault plane. Extensive permeability and tracer testing has shown that the fault zone is heterogeneous on a scale of tens of metres and does not form a continuous conduit to groundwater flow. The fault likely forms a weak transverse barrier to groundwater flow due to minor lithology offsets.

3.4.3 Avon Dam Baseflow Loss

Piezometers installed along the barrier zone between Avon Dam and extracted longwalls in Area 3B show declines in piezometric heads to levels below contemporaneous water levels in Lake Avon. The observed levels imply hydraulic gradients away from the lake and towards the mine adjacent to extracted longwalls. Testing of strata permeability before and after mining of adjacent longwalls indicates that permeability increases by at least an order of magnitude at some locations as a result of strata movement, with minor, or no change in strata permeability at other locations.

Seepage losses from Avon Dam have been estimated by regional and local scale numerical models to be in the range 0.09 to 0.69 ML/day as at the end of Longwall 17. The estimates are within the tolerable loss limit of 1 ML/day prescribed by Dams Safety NSW and supported by the low levels of tritium and 14C in mine inflow water in Area 3B.

3.4.4 Groundwater Chemistry

Previous reviews have shown that there is no clear spatial pattern in the distribution of groundwater quality in HBSS and Bulgo Sandstone bores. Groundwater salinity (EC) for samples collected from monitoring bores in DA3A and DA3B show a general increase with depth below surface. Due to frequent catchment closures not all bores were accessed for sampling during Longwall 17. However, of the samples collected, most are within 20% of the previous groundwater sample. Samples collected from two groundwater bores located adjacent to Lake Avon show a trend of declining EC over the last 3 longwalls. It is recommended that quarterly sampling and analysis be carried out for the next 12 months at those bores.

3.5 Impacts to Upland Swamps

3.5.1 Shallow Groundwater and Soil Moisture

Trigger levels for changes to groundwater and soil moisture levels at surface and near-surface monitoring sites at DA3B swamps have been established within the SIMMCP for Area 3B (South32, 2020b). Shallow groundwater level and soil moisture characteristics have been identified as an indicator of potential changes in ecosystem functionality of Upland Swamps.

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. Groundwater level hydrographs for each shallow piezometer are presented in **Attachment D**. Each hydrograph is plotted with ground elevation and the elevation of the piezometer base, longwall timing, groundwater level recession rate (in mm/day), and the dates that longwalls pass under (if relevant) a piezometer. Assessment of mining effects is based on these hydrographs.

The soil moisture TARP has been assessed by comparing the moisture content of the soil profile during the longwall assessment period against that of the baseline period. If the average soil moisture level drops below the minimum level recorded during the baseline period, a TARP is triggered.

Both shallow groundwater levels and soil moisture levels in reference swamps recovered throughout 2020 and 2021 in response to high rainfall following the 2017-2019 drought period.

Longwall 17 passed beneath, or within 400m of Swamps 14, 23, 149 and 35a. It was predicted that these swamps would be affected by mine subsidence due to mining in DA3B (South32 2020c). Soil moisture and shallow groundwater assessments for these swamps are summarised in Table 8 and Table 9.

Trigger levels are assessed differently by the IMCEFT and HGEO. The IMCEFT report triggers when groundwater or moisture decrease below the baseline level during the mining period whilst the HGEO assessment is conducted following the completion of Longwall 17 and considers other factors such as longer-term climatic conditions and reference swamp comparisons.

Further details are presented in **Attachment D**.

Table 8: Summary of soil moisture level TARP status at Longwall 17 impact sites.

Swamp	Sensors and TARP triggers			HGEO Comment	IMCEFT TARP Level	HGEO TARP Level
	Not Triggered	Triggered	Not within mine influence			
14		14_S01 14_S02		Soil moisture at S14_S01 below baseline in contrast to recovery at reference swamps 22, 85 and 86. S14_S02 shows lower moisture levels and durations compared with baseline and reference swamps.	Level 3 (LW15)	Level 3
23	23_S01 23_S02			No TARP trigger (previously Level 2). Both sensors show recovery in 2020 and 2021 with moisture levels varying within the baseline range.	Level 1 (LW14)	No Trigger
35a			35a_S01	No TARP trigger.	No Trigger	No Trigger
149				Installed in 2021.	No Trigger	No Trigger

Table 9: Summary of shallow groundwater level TARP status at Longwall 17 impact sites.

SWAMP	PIEZOMETERS WITH AN OBSERVED RESPONSE			HGEO COMMENT	IMCEFT TARP LEVEL	HGEO TARP LEVEL
	YES	UNCLEAR	NO			
14	14_01 14_02			Evidence for impact to swamp groundwater levels at *14_01* and *14_02* following Longwalls 16 and 15 respectively. Effects confirmed post-Longwall 17 assessment.	Level 3 (LW16)	Level 3 (LW16)
23	23_01 23_02			Evidence for impact to swamp groundwater levels and duration at *23_01* and *23_02*, following passage of Longwalls 15 and 16.	Level 3 (LW16)	Level 3
35a			35a_01	No evidence of mining effects from Longwall 17. Groundwater levels slightly lower than pre-2017, similar to reference Swamp 87 and Swamp 7.	No Trigger	No Trigger
149			149_01	No data available. Swamp likely to be affected.	No Trigger	No Trigger

3.5.2 Erosion in Upland Swamps

The SIMMCP describes the monitoring and assessment to determine any areas of erosion in swamps resulting from mining. Mining induced tilting, cracking, desiccation and/or changes in vegetation health that could result in increased runoff and erosion, which intern could alter water distribution in the swamp. TARPs have been established within the SIMMCP (See Appendix A: Table 19).

Impact assessment of Upland Swamp erosion includes analyses of ALS/LiDAR results, combined with infield observations. ALS results detected no erosion in swamps. Other apparent localised movements were inspected infield with no erosion or subsidence related impacts identified. These apparent localised movements are likely to be due to the effects of the horizontal movements and sloping terrain on the ALS surveys.

3.6 Terrestrial Ecology

Assessment of terrestrial ecology is included in the Terrestrial Ecology Monitoring Program Annual Report 2021 (**Attachment H**).

3.7 Aquatic Ecology

Cardno was commissioned by South32 to undertake a review of aquatic flora and fauna in relation to the extraction of Longwall 17. Cardno has been undertaking ongoing monitoring of watercourses within the DA3B mining area including Wongawilli Creek, Donalds Castle Creek and several associated tributaries. The overall objective of the monitoring is to determine whether the extent and nature of observed impacts, primarily subsidence-induced fracturing of bedrock, diversion and loss of aquatic habitat, are consistent with the predictions made in the Aquatic Flora and Fauna Assessment (AFFA) (Cardno Ecology Lab 2012) and DA3B SMP (BHPBIC 2012).

The monitoring requirements recommended in the AFFA and included in the SMP incorporates a Before, After, Control, Impact (BACI) sampling design to monitor mine subsidence impacts on the aquatic environment with collection of at least two years of baseline data, followed by monitoring during extraction, and at least two years of post-extraction monitoring. The following indicators were monitored at impact and control sites within and outside the SMP area as a measure of aquatic health:

- Aquatic habitat condition - using a modified version of the Riparian, Channel and Environmental Inventory method (Chessman *et al.* 1997);
- Macroinvertebrates, including threatened species of dragonfly (Adams emerald dragonfly and Sydney hawk dragonfly), using AUSRIVAS and standardised artificial collectors;
- Limited in-situ water quality – using a portable probe; and
- Fish abundance using backpack electrofishing and bait traps.

Table 10 compares the predicted impacts against the observed impacts and Table 11 summarises the aquatic ecology assessment against the TARPS.

Further details of the Aquatic Ecology Assessment methodology can be found in **Attachment F.**

Table 10: Summary of predicted and observed impacts to aquatic ecology associated with Longwall 17.

Attribute	Predicted Physical Impacts	Predicted Impacts on Aquatic Ecology	Observed Impacts to Aquatic Ecology
Wongawilli Creek			
Ponding, flooding and scouring of stream banks due to tilt	No significant change predicted.	No measurable effects due to tilt.	None identified by IMCEFT during extraction of Longwall 17.
Fracturing of bedrock and diversion of surface flows	No significant fracturing resulting in surface water flow diversions. Minor, isolated fractures of the streambed may occur within 400m from the proposed Longwalls. Minor fracturing of the creek bed and subsequent diversion of flows would not have significant geochemical effects. Formation of ferruginous springs is unlikely but could occur at the margins orupslope of swamps (Ecoengineers 2011).	No significant changes in the quantity or quality of permanent aquatic habitat due to fracturing of bedrock and diversion of surface flows.	No reductions in pool water levels and flow or changes in water quality observed by South32 during extraction of Longwall 17, and, thus no suggestion of impacts occurring to aquatic habitat and biota Iron staining observed in Wongawilli Creek is unlikely to be related to Longwall 17 extraction. Nevertheless, previous assessment (Cardno 2020b) does not suggest significance impacts to aquatic ecology occurred. This will be confirmed following completion of the latest ongoing monitoring report (Cardno *in prep).*

Attribute	Predicted Physical Impacts	Predicted Impacts on AquaticEcology	Observed Impacts to Aquatic Ecology
Donalds Castle Creek and Tributaries			
Ponding, flooding and scouring of stream banksdue to tilt	Reversals in grade may occur along Tributary WC21, adjacent to the tailgates of Longwalls 10 and 11. These could result in small increases in the levels of ponding, flooding and scouring of streambanks in highly localised areas along thetributaries. The impacts resulting from such changes are expected to be small relative to those that occur naturally during floods.	Localised changes in habitat availability and connectivity may occur along the tributaries due totilt but will be difficult to detect because of the large variability innatural flows within these ephemeral systems.	No impacts observed due to tilt.
Fracturing of bedrock and diversion of surfaceflows	Fracturing of the bedrock is likely to occur. In ephemeral creeks with alluvial deposits, fractures are likely to be in-filled by deposits during flow events. In areas with exposed bedrock, some diversion of surface flows into underlyingstrata and drainage of pools may occur, particularly during low flows. It is unlikely, that this would result in a significant impact on the overall quantityor quality of water flowing from the catchment.	There is unlikely to be any significant long-term changes in the quantity, quality or connectivity of aquatic habitats. Any losses of habitat and connectivity that do occur would be minor, localised and transient.	None observed in Donalds Castle Creek during extraction of Longwall 17. Fracturing of bedrock and diversion of flows in LA2 (a drainage line of Avon River) would have resulted in a reduction in quantity and connectivity of ephemeral aquatic habitat in this drainage line. Given the abundance of comparable first and second order stream habitat in the upper Avon and Cordeaux Catchments, associated impacts to aquatic biota is expected to be minor. Iron staining observed in WC21 and LA5 is unlikely to be related to Longwall 17 extraction. Nevertheless, previous assessment (Cardno 2020) does not suggest significant impacts to aquatic ecology occurred. This will be confirmed following completion of the latest ongoing monitoring report (Cardno *in prep*).

Table 11: Summary of Aquatic Ecology TARP sites and their respective trigger levels.

TARP	Wongawilli Creek	Donalds Castle Creek	WC21
Level 1 – Reduction in aquatic habitat for 1 year	Not triggered	Triggered September 2014	Triggered September 2014
Level 2 – Reduction in aquatic habitat for 2 years following the active subsidence period (i.e. when a longwallwithin 400m of a feature, such as a creek, is completed)	Not triggered	Triggered 24 October 2015	Triggered 24 October 2015
Level 3 – Reduction in aquatic habitat for >2 years or complete loss of habitat following the active subsidenceperiod	Not triggered	Triggered During 2017 Aquatic Ecology Surveys(Cardno 2018)	Triggered During 2017 Aquatic Ecology Surveys(Cardno 2018)

3.8 Cultural Heritage

Following the extraction of Longwall 17, an inspection of Aboriginal cultural heritage sites within the Longwall 17 study area (as defined in Niche 2022; **Attachment G**) was conducted on 23 December 2021 (Figure 18). Two out of five Aboriginal cultural heritage sites for Longwall 17 were visited, with Dendrobium 7 and Dendrobium 8 not able to be visited safely due to ongoing Longwall 18 extraction. Dendrobium 6 consists of an Isolated Artefact and would not be able to be relocated for this assessment. No impacts were observed at Browns Road Site 8 or Upper Avon 35. Site Inspection assessments for these sites are summarised in Table 12.

Further details of the methodology and TARPS used by Niche for the Aboriginal Cultural Heritage Assessment can be found in **Attachment G**.

Table 12: Aboriginal cultural heritage sites status following the extraction of Longwall 17.

AHIMS Number	Site Name	Observed Subsidence Related Changes
52-2-1623	Browns Road Site 8	None
52-2-1771	Upper Avon 35	None
52-2-2246	Dendrobium 6	This Isolated Artefact is a surface find that has a negligible chance of impact from subsidence related effects (Biosis 2012). This site was not inspected during this survey and is not expected to be impacted by the extraction of Longwall 17.
52-2-2248	Dendrobium 7	This Shelter with Art was unable to be safely visited for the Longwall 17 EoP monitoring, due to the current extraction of Longwall 18. The site will be inspected for the Longwall 18 EoP.
52-2-3068	Dendrobium 8	This Shelter with Art was unable to be safely visited for the Longwall 17 EoP monitoring, due to the current extraction of Longwall 18. The site will be inspected for the Longwall 18 EoP.

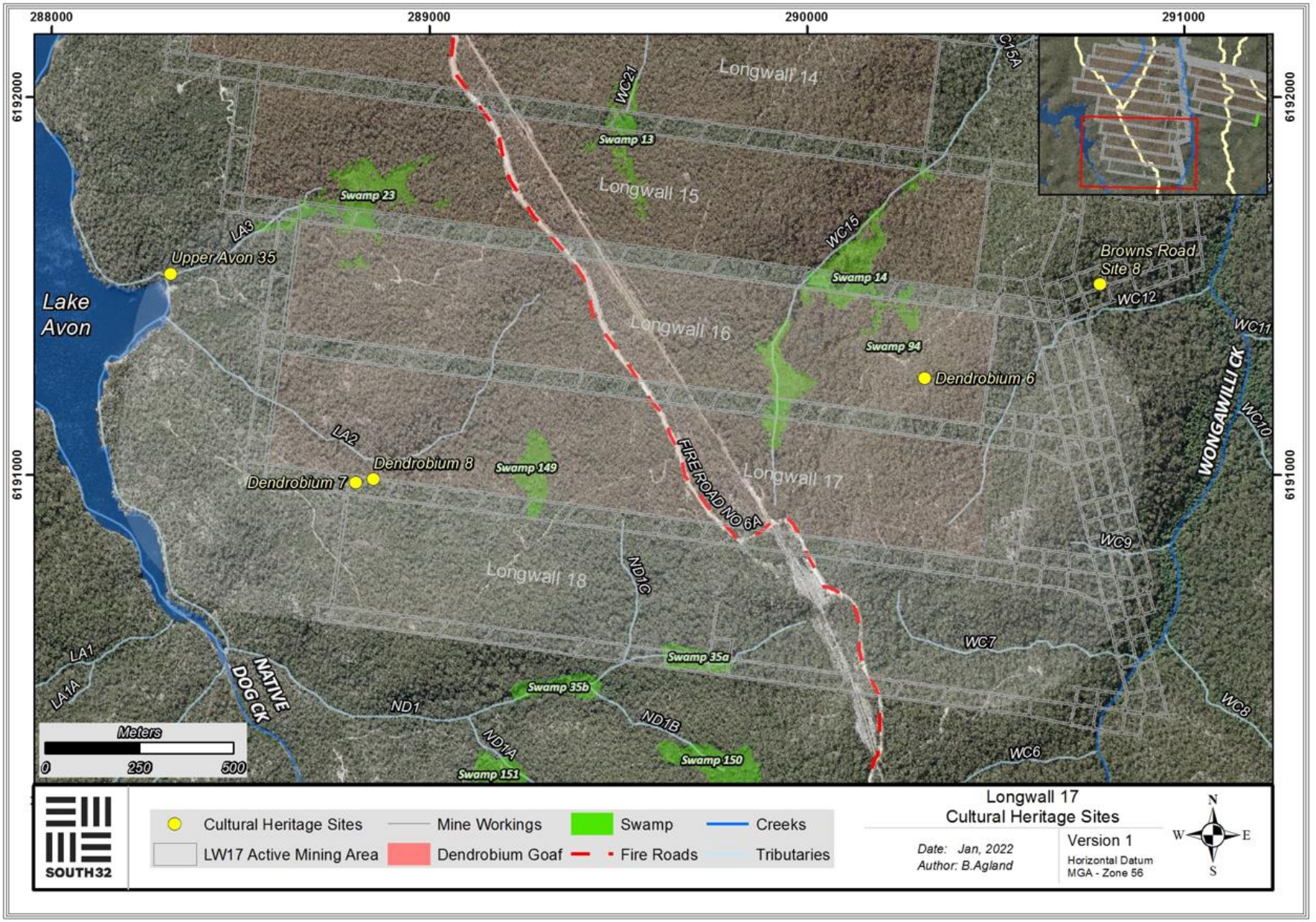

Figure 18: Aboriginal Cultural Heritage sites within the Longwall 17 study area.

4 IMPACTS TO BUILT FEATURES

The built features in proximity to Longwall 17 are shown in **Attachment B**; and include:

- Fire trails and other access tracks;
- Disused Maldon-Dombarton Railway Corridor;
- Survey control marks; and
- Avon Dam.

Cordeaux Dam Wall is located more than 5 km north of Longwall 17, at its closest point. The Upper Cordeaux No.2 Dam Wall is located more than 5 km south-east of Longwall 17, at its closest point. It is unlikely these dam walls would experience any measurable far-field horizontal movements resulting from Longwall 17 and, therefore, they have not been assessed further.

Ten impacts associated with built features were identified during the extraction of Longwall 17 (Table 14 and Table 15). These impacts consist of soil cracks on access tracks, *Fire Road 6A* (FR6A) and the disused Maldon Dombarton Railway Corridor. All impacts were either remediated (bymeans of in-filling) or were observed as self-remediating.

It has been considered that the observed impacts on the surface infrastructure, due to the mining of Longwall 17, are similar to or less than the predicted.

Table 13: Summary of predicted impacts in comparison to observed impacts relevant to Longwall 17.

Built feature	MSEC assessed impacts	Reported impacts
Fire trails and four-wheel drive tracks	Cracking of unsealed road surfaces	Soil / surface cracking observed on or near the fire trails, access tracks and railway corridor, with widths ranging between approximately 20mm and 70mm.
Disused Maldon-Dombarton Railway	Possible fracturing of rock cuttings, spalling, and/or mobilisation of rock joints	Surface cracking and rock fracturing along the railway corridor above Longwall 17.
Avon Dam	Adverse impacts not anticipated	No reported impacts to the dam walls. Refer to associated groundwater report for further details on impacts to the stored water.
Survey control marks	Vertical and horizontal movements which could require re-establishment	No reported damage to the survey control marks. The marks to be re-established after completion of mining, as required.

4.1 Level 1 Surface Cracking

Eight impacts (Photo 32 to Photo 39) to built features were reported as Level 1 impacts in accordancewith the DA3B SMP; 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; and
- erosion in a localised area, which would be expected to naturally stabilise without CMA and within the period of monitoring.

Table 14: Summary of Level 1 impacts to built features.

Site ID	Easting	Northing	Impact Type	Feature Affected	Identification Date	Trigger Level	Description	Refer to Impact Report/s Dated
DA3B_LW17_015 Photo 32	289590	6190995	Soil Cracking	Access Track	18/05/2021	1	Soil cracking to access track to the west of *Fire Road 6A*.	20/05/2021
DA3B_LW17_018 Photo 33	289614	6191150	Soil Cracking	Fire Road 6A	25/05/2021	1	Soil cracking to *Fire Road 6A.*	28/05/2021
DA3B_LW17_020 Photo 34	289639	6191117	Soil Cracking	Fire Road 6A	8/06/2021	1	Soil cracking to *Fire Road 6A.*	9/06/2021
DA3B_LW17_026 Photo 35	289876	6190939	Soil Cracking	Rail Corridor	7/07/2021	1	Soil cracking across rail corridor and adjacent bushland.	9/07/2021
DA3B_LW17_028 Photo 36	289997	6191083	Soil Cracking	Access Track	26/07/2021	1	Soil cracking to access track to the east of Swamp 14.	29/07/2021
DA3B_LW17_029 Photo 37	289892	6190893	Soil Cracking	Rail Corridor	26/07/2021	1	Soil cracking across rail corridor/ballast.	29/07/2021
DA3B_LW17_030 Photo 38	289675	6191031	Soil Cracking	Fire Road 6A	26/07/2021	1	Soil cracking along *Fire Road 6A.*	29/07/2021
DA3B_LW17_033 Photo 39	289983	6191068	Soil Cracking	Access Track	23/08/2021	1	Soil cracking to an access track to the east of Swamp 14.	25/8/2021

Photo 32: *DA3B_LW17_015,* soil cracking on access track. Taken on 18/05/2021.

Photo 33: *DA3B_LW17_018,* soil cracking on *Fire Road 6A*. Taken on 25/05/2021.

Photo 34: *DA3B_LW17_020,* soil cracking on *Fire Road 6A*. Taken on 8/06/2021.

Photo 35: *DA3B_LW17_026,* soil cracking on railway corridor. Taken on 7/07/2021.

Photo 36: *DA3B_LW17_028,* soil cracking on access track. Taken on 26/07/2021.

Photo 37: *DA3B_LW17_029,* soil cracking on railway corridor. Taken on 26/07/2021.

Photo 38: *DA3B_LW17_030,* soil cracking on *Fire Road 6A*. Taken on 26/07/2021.

Photo 39: *DA3B_LW17_033,* soil cracking on access track. Taken on 23/08/2021.

4.2 Level 2 Surface Cracking

Two impacts (Photo 40 and Photo 41) to built features were reported as Level 2 impacts in accordance with the DA3B SMP; specifically:

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

Table 15: Summary of Level 2 impacts to built features.

Site ID	Easting	Northing	Impact Type	Feature Affected	Identification Date	Trigger Level	Description	Refer to Impact Report/s Dated
DA3B_LW17_014 Photo 40	289658	6191068	Soil Cracking	Fire Road 6A	18/05/2021	2	Multiple soil cracks extending over *Fire Road 6A* and adjacent clearing.	20/05/2021
DA3B_LW17_027 Photo 41	289871	6190919	Soil Cracking	Rai Corridor	7/07/2021 & 15/07/2021	2	Soil cracking across rail corridor and adjacent bushland.	9/07/2021 & 29/07/2021

Photo 40: *DA3B_LW17_014,* soil cracking extending over *Fire Road 6A*. Taken on 18/05/2021.

Photo 41: *DA3B_LW17_027,* soil cracking extending over railway corridor. Taken on 15/07/2021.

5 SUMMARY OF TARP TRIGGERS

A summary of TARP triggers during the extraction of Longwall 17 is presented below in Table 16; additionally, an overview of Longwall 17 surface impacts and triggers is presented in Figure 19.

Table 16: Summary of TARP Triggers during the extraction of Longwall 17.

Site ID	Impact Type	Feature Affected	Identification Date	Trigger Level	Description	Refer to Impact Report/s Dated
DA3B_LW17_001	Rock Fracturing, Uplift and Fragmentation.	LA2	5/02/2021	2	Rock fracturing, uplift and fragmentation to *LA2_Channel 6B.*	10/02/2021
DA3B_LW17_002 (Update)	Rock Fracturing, Uplift and Fragmentation.	LA2	10/02/2021 & 10/03/2021	2	Rock fracturing, uplift and fragmentation to *LA2_Rockbar 25* and *LA2_Pool 25.*	16/02/2021 & 12/03/2021
DA3B_LW17_003 (Update) Photo 3	Rock Fracturing, Uplift and Rockfall.	LA2	10/02/2021, 10/03/2021 13/04/2021	2	Rock fracturing, uplift and rockfall to *LA2_Rockbar 24*, *LA2_Pool 24* and *LA2_Step 24*.	16/02/2021, 12/03/2021 & 14/04/2021
DA3B_LW17_004	Rock Fracturing and Uplift.	LA2	10/03/2021	2	Rock fracturing and uplift to *LA2_Rockbar 10.*	12/03/2021
DA3B_LW17_005	Rock Fracturing	LA2	10/03/2021	2	Rock fracturing to *LA2_Pool 12.*	12/03/2021
DA3B_LW17_006	Rock Fracturing, uplift and Soil Cracking	LA2	10/03/2021	2	Rock fracturing, soil cracking and uplift to *LA2_Pool 14.*	12/03/2021
DA3B_LW17_007	Rock Fracturing & Uplift	LA2	10/03/2021	2	Rock fracturing and uplift to *LA2_Rockbar 14.*	12/03/2021
DA3B_LW17_008	Rockfall	Steep Slope/ Step	10/03/2021	2	Rockfall at Steep slope/step adjacent to LA2.	12/03/2021
DA3B_LW17_009	Rockfall	Steep Slope/ Step	10/03/2021	2	Rockfall at Steep slope/step adjacent to LA2.	12/03/2021
DA3B_LW17_010	Rock Fracturing	Steep Slope/ Step	13/04/2021	1	Rock Fracturing to step on the northern slope of LA2 valley.	14/04/2021
DA3B_LW17_011	Rock Fracturing	Steep Slope/ Step	13/04/2021	2	Rock fracturing to step/steep slope.	14/04/2021

DA3B_LW17_012 Photo 8	Rock Fracturing	LA2	13/04/2021	2	Rock fracturing and displacement around *LA2_Pool 9* and upstream rockbar.	14/04/2021
DA3B_LW17_013	Rock Fracturing	LA2	13/04/2021	2	Rock fracturing to *LA2_Channel 8.*	14/04/2021
DA3B_LW17_014	Soil Cracking	Fire Road 6 A	18/05/2021	2	Multiple soil cracks extending over *Fire Road 6A* and adjacent clearing.	20/05/2021
DA3B_LW17_015	Soil Cracking	Access Track	18/05/2021	1	Soil cracking to access track to the west of *Fire Road 6A*.	20/05/2021
DA3B_LW17_016	Rock Fracturing	Rock Outcrop	25/05/2021	1	Rock fracturing to a rock outcrop, west of *Fire Road 6A*.	28/05/2021
DA3B_LW17_017	Rock Displacement	Rock Outcrop	25/05/2021	1	Rock displacement from soil, west of *Fire Road 6A*.	28/05/2021
DA3B_LW17_018	Soil Cracking	Fire Road 6A	25/05/2021	1	Soil cracking to *Fire Road 6A.*	28/05/2021
DA3B_LW17_019	Soil Cracking and Rock Fracturing	Bushland	8/06/2021	3	Soil cracking and rock fracturing in bushland west of *Fire Road 6A.*	9/06/2021
DA3B_LW17_020	Soil Cracking	Fire Road 6A	8/06/2021	1	Soil cracking to *Fire Road 6A.*	9/06/2021
DA3B_LW17_021	Rock Fracturing	Steep Slope/ Step	8/06/2021	1	Rock fracturing to step/steep slope.	9/06/2021
DA3B_LW17_022	Rock Fracturing	Bushland	22/06/2021	1	Fracturing to rock outcrop in bushland to east of *Fire Road 6A.*	25/06/2021
DA3B_LW17_023	Rock Fracturing	Bushland	22/06/2021	2	Fracturing to rock outcrop in bushland to east of *Fire Road 6A.*	25/06/2021
DA3B_LW17_024	Rock Fracturing	Rock outcrop	24/06/2021	1	Fracturing to rock outcrop adjacent to *Fire Road 6A.*	25/06/2021
DA3B_LW17_025	Iron Staining	LA5	1/07/2021	1	Iron staining in tributary LA5.	6/07/2021
DA3B_LW17_026	Soil Cracking	Rail Corridor	7/07/2021	1	Soil cracking across rail corridor and adjacent bushland.	9/07/2021
DA3B_LW17_027	Soil Cracking	Rail Corridor	7/07/2021 & 15/07/2021	2	Soil cracking across rail corridor and adjacent bushland.	9/07/2021 & 29/07/2021

DA3B_LW17_028	Soil Cracking	Access Track	26/07/2021	1	Soil cracking to access track to the east of Swamp 14.	29/07/2021
DA3B_LW17_029	Soil Cracking	Rail Corridor	26/07/2021	1	Soil cracking across rail corridor/ballast.	29/07/2021
DA3B_LW17_030	Soil Cracking	Fire Road 6A	26/07/2021	1	Soil cracking along *Fire Road 6A.*	29/07/2021
DA3B_LW17_031	Iron Staining	Wongawilli Creek	2/08/2021	3	Iron staining in Wongawilli Creek.	9/08/2021
DA3B_LW17_032	Rock Displacement	Steep Slope/ Step	17/08/2021	1	Rock displacement from soil at the base of steep slope/step, east of *Fire Road 6A.*	25/8/2021
DA3B_LW17_033	Soil Cracking	Access Track	23/08/2021	1	Soil cracking to an access track to the east of Swamp 14.	25/8/2021
DA3B_LW17_034	Rock Fracturing	LA2	10/9/2021	2	Rock fracturing and cracking to LA2 tributary.	21/09/2021
DA3B_LW17_035	Rock Fracturing	Rock Outcrop	15/9/2021	1	Rock fracturing with an associated rockfall to a large rock outcrop/steep slope.	21/09/2021
DA3B_LW17_036	Rock Fracturing	Rock Outcrop	15/9/2021	1	Rock fracturing to a large rock outcrop/steep slope.	21/09/2021
DA3B_LW17_037	Rock Fracturing	Rock Outcrop	15/9/2021	2	Multiple rock fracturing to a large rock outcrop/steep slope.	21/09/2021
DA3B_LW17_038	Rock Movement	Rock Outcrop	15/9/2021	1	Rock movement and soil cracking to a large rock outcrop/steep slope.	21/09/2021
DA3B_LW17_039	Rock Movement	Rock outcrop	21/10/2021	1	Rock movement, rock and soil profile separation at rock outcrop.	8/11/2021
DA3B_LW17_040	Rock Fracturing	Rock outcrop	21/10/2021	1	Rock fracturing to exposed rock outcrop.	8/11/2021
DA3B_LW9_019 (Update)	Iron Staining	WC21	2/08/2021	3	Iron staining extending into Wongawilli Creek.	9/08/2021
Swamp 23 (HGEO)	Shallow Groundwater	Swamp 23	N/A	3	Evidence for impact to swamp groundwater levels and duration at *23_01* and *23_02*, following passage of Longwalls 15 and 16.	HGEO (2022b)

Swamp 14 (HGEO)	Soil Moisture	Swamp 14	N/A	3	Soil moisture at *S14_S01* below baseline in contrast to recovery at reference Swamps 22, 85 and 86. *S14_S02* shows lower moisture levels and durations compared with baseline and reference swamps.	HGEO (2022b)
LA4_S1	Water Quality Trigger	*LA4*	18/02/2021	2	Trigger for pH at *LA4_S1*.	17/03/2021
LA4_S1	Water Quality Trigger	*LA4*	18/02/2021	2	Trigger for electrical conductivity at *LA4_S1*.	17/03/2021
LA4_S1	Water Quality Trigger	*LA4*	18/02/2021	3	Trigger for pH at *LA4_S1*.	9/06/2021
LA4_S1	Water Quality Trigger	*LA4*	18/02/2021	3	Trigger for electrical conductivity at *LA4_S1*.	6/07/2021
DCU	Surface Water Hydrology	Donalds Castle Creek	N/A	1	Frequency and duration of ecologically-significant cease-to-flow events.	HGEO (2022b)
DCS2	Surface Water Hydrology	Donalds Castle Creek	N/A	3	General hydrological behaviour.	HGEO (2022b)
				3	Change in cease-to-flow frequency (beyond natural)	
				3	Changes to median flow.	
DC13S1	Surface Water Hydrology	Donalds Castle Creek	N/A	3	General hydrological behaviour.	HGEO (2022b)
				2	Change in cease-to-flow frequency (beyond natural)	
				3	Changes to median flow.	
WC21S1	Surface Water Hydrology	WC21	N/A	3	General hydrological behaviour.	HGEO (2022b)
				2	Change in cease-to-flow frequency (beyond natural)	
				3	Changes to median flow.	
WC15S1	Surface Water Hydrology	WC15	N/A	3	General hydrological behaviour.	HGEO (2022b)

				2	Change in cease-to-flow frequency (beyond natural)	
				3	Changes to median flow.	
LA4S1	Surface Water Hydrology	LA4	N/A	1	General hydrological behaviour.	HGEO (2022b)
				2	Change in cease-to-flow frequency (beyond natural)	
				3	Changes to median flow.	
LA3S1	Surface Water Hydrology	LA3	N/A	3	General hydrological behaviour.	HGEO (2022b)
				3	Change in cease-to-flow frequency (beyond natural)	
				3	Changes to median flow.	
LA2S1	Surface Water Hydrology	LA2	N/A	1	Change in cease-to-flow frequency (beyond natural)	HGEO (2022b)
				3	Changes to median flow.	
Donalds Castle Creek	Aquatic Ecology	Donalds Castle Creek	N/A	3	Reduction in aquatic habitat for >2 years or complete loss of habitat following the active subsidence period	Cardno (2022)
WC21	Aquatic Ecology	WC21	N/A	3	Reduction in aquatic habitat for >2 years or complete loss of habitat following the active subsidence period	Cardno (2022)

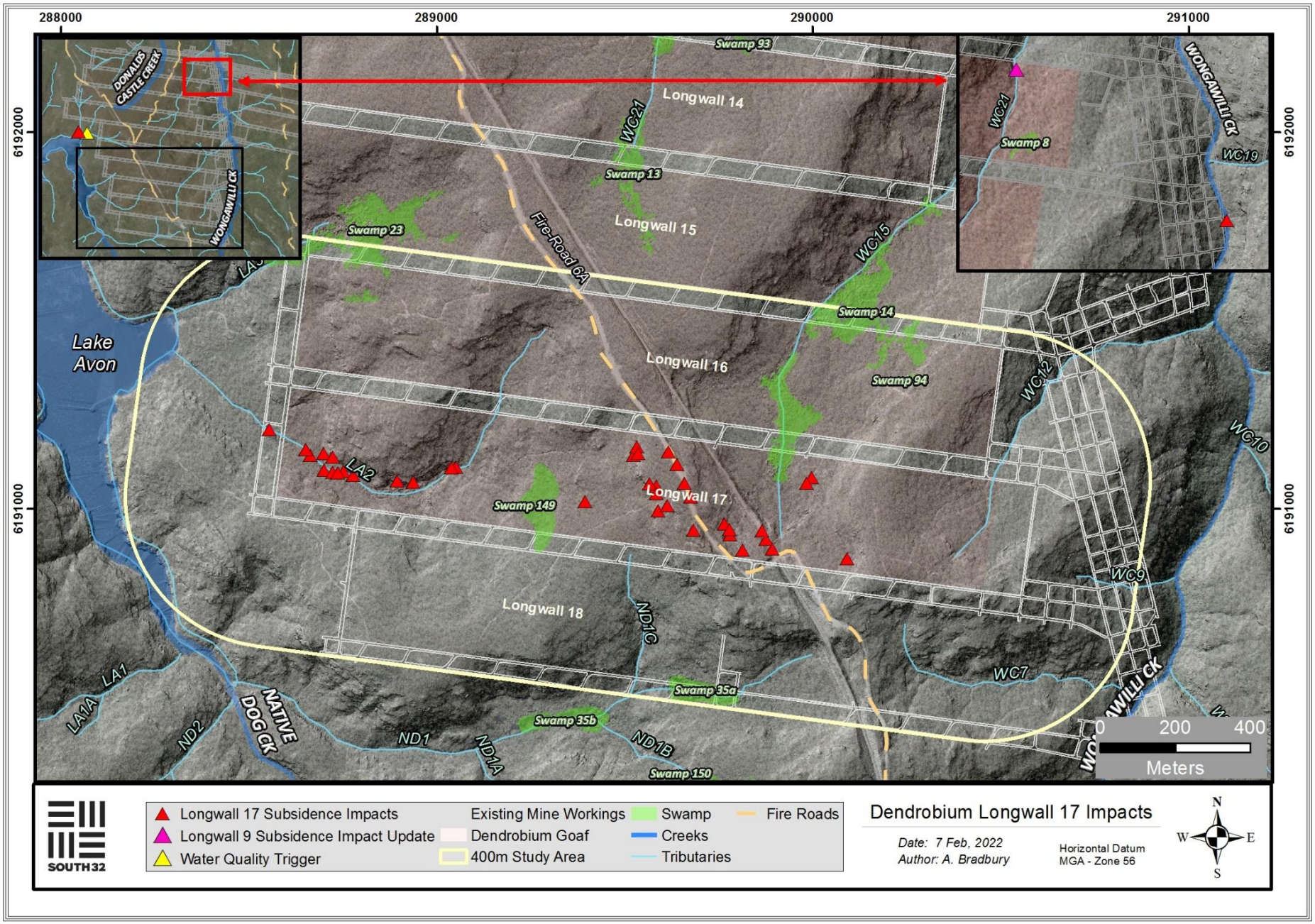

Figure 19: Overview of surface impacts observed during the extraction of Longwall 17.

6 LONGWALL 17 MONITORING PROGRAM

Table 17: Summary of monitoring sites associated with the extraction of Longwall 17. Recommended monitoring sites associated with the extraction of Longwall 18 are also included.

Aspect	Monitoring Sites Associated with Longwall 17	Monitoring Frequency	Recommended Future Monitoring for Longwall 18
Watercourses	**Observational, photo point and water monitoring**		
	• Donalds Castle Creek • Lake Avon • LA2 • LA3 • LA4A • Swamp 23 • Swamps 10, 11, 13 and 14 • WC12, WC15 and WC21 • Wongawilli Creek • WC6, WC7, WC8, WC9 • ND1, ND1C • Swamps 35a and 35b • Native Dog Creek	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	• Donalds Castle Creek • Lake Avon • LA2 • LA3 • Swamp 23 • Swamps 13 and 14 • WC12, WC15 and WC21 • Wongawilli Creek • WC6, WC7, WC8, WC9 • Swamp 35a/b • Swamp 149, 150, 151 • Native Dog Creek • ND1, ND1C
	Water Quality		
	Wongawilli Creek • WWU1 (Wongawilli Creek headwaters) • WWU4 (Wongawilli Creek upstream) • WC_Pool 104 (Wongawilli Creek adjacent to LW17) • WC_Pool 87 (Wongawilli Creek adjacent to LW15) • WC_Pool 69 (Wongawilli Creek adjacent to LW12) • WC_Pool 49 (Wongawilli Creek downstream of LW9) • WWM2 (Wongawilli Creek adjacent to LW11) • WC_FR6 (Wongawilli Creek downstream) • WC21_Pool 5 (Wongawilli Creek tributary downstream of mining) • WC21_Pool 30 (Wongawilli Creek tributary over mining) • WC21_Pool 53 (Wongawilli Creek tributary over mining) • WC12_Pool 1 (Wongawilli Creek tributary downstream of mining) • WC15_Pool 9 (Wongawilli Creek tributary downstream of mining) **Lake Avon** • LA_1, LA1, LA2_Pool 5, LA3_Pool 4	Monthly monitoring during and post mining for two years until required	**Wongawilli Creek** • WWU1 (Wongawilli Creek headwaters) • WWU4 (Wongawilli Creek upstream) • WC_Pool 104 (Wongawilli Creek adjacent to LW17) • WC_Pool 87 (Wongawilli Creek adjacent to LW15) • WC_Pool 69 (Wongawilli Creek adjacent to LW12) • WWM2 (Wongawilli Creek adjacent to LW11) • WC_Pool 49 (Wongawilli Creek downstream of LW9) • WC_FR6 (Wongawilli Creek downstream) • WC21_Pool 5 (Wongawilli Creek tributary downstream of mining) • WC21_Pool 30 (Wongawilli Creek tributaries over mining) • WC21_Pool 53 (Wongawilli Creek tributary over mining) • WC12_Pool 1 (Wongawilli Creek tributary downstream of mining) • WC15_Pool 9 (Wongawilli Creek tributary downstream of mining) **Lake Avon and tributaries** • LA_1, LA1, LA2_Pool 5, LA3_Pool 4

Aspect	Monitoring Sites Associated with Longwall 17	Monitoring Frequency	Recommended Future Monitoring for Longwall 18
	Donalds Castle Creek: • DCC_FR6 (Donalds Castle Creek lower) • DC_Pool 22 (Donalds Castle Creek downstream of mining) • DCL3 (Donalds Castle Creek further downstream site) **Native Dog Creek** • NDC_Pool 1 • ND1_Pool 2 • ND2_Pool 3 **Reference Site** • LC5_S1 • NDC1 • CR36_S1		**Donalds Castle Creek:** • DCC_FR6 (Donalds Castle Creek lower) • DC_Pool 22 (Donalds Castle Creek downstream of mining) • DCL3 (Donalds Castle Creek further downstream site) **Native Dog Creek** • NDC_Pool 1 • ND1_Pool 2 • ND2_Pool 3 **Reference Site** • LC5_S1 • NDC1 • CR36_S1
Swamps	**Observational, Photo Point and Water Monitoring**		
	• Swamps 10, 11 13, 14, 23 and 35a/b	Pre and post mining for two years, monthly when longwall is within 400m of monitoring site.	• Swamps 13, 14, 23, 35a/b, 149, 150, 151
	Shallow Groundwater Level		
	• Swamp 05: 05_01, 05_04 • Swamp 10: 10_01 • Swamp 11: S11-H1, S11-H2, S11-H3 • Swamp 13: 13_01 • Swamp 14: 14_01, 14_02 • Swamp 23: 23_01, 23_02 • Swamp 35a: 35a_01 • Swamp 35b: 35b_01 **Reference Sites** • Swamp 2: 02_S01 • Swamp 7: 07_S05, 07_S06 • Swamp 15A: S15a_S01, S15a_Piezo, S15a_S04, S15a_S06 • Swamp 22: 22_01, 22_02 • Swamp 25: S25_S01 • Swamp 33: S33_S01, S33_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	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 13: 13_01 • Swamp 14: 14_01, 14_02 • Swamp 23: 23_01, 23_02 • Swamp 35a: 35a_01 • Swamp 35b: 35b_01 • Swamp 149: 149_01 • Swamp 150: 150_01 • Swamp 151: 151_01 **Reference Sites** • Swamp 2: 02_S01 • Swamp 7: 07_S05, 07_S06 • Swamp 15A: S15a_S01, S15a_Piezo, S15a_S04, S15a_S06 • Swamp 22: 22_01, 22_02 • Swamp 25: S25_S01 • Swamp 33: S33_S01, S33_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

Aspect	Monitoring Sites Associated with Longwall 17	Monitoring Frequency	Recommended Future Monitoring for Longwall 18
	Soil Moisture		
	• 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_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: S33_S01, S33_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 baseline and reference site monitoring • Weekly monitoring when longwall is within 400m of swamp • 6 monthly monitoring for 2 years post mining	• Swamp 13: S13_S01, S13_S02, S13_S03 • Swamp 14: 14_01, 14_02 • Swamp 23: 23_02 • Swamp 35a: 35a_01 • Swamp 35b: 35b_01 • Swamp 149: 149_01 • Swamp 150: 150_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: S33_S01, S33_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 • DA3-CF25 • DA3-CF26 • DA3-CF41 • DA3-CF42 • DA3-CF43 **Fire Trails** • Fire Road 6A (across active mining area) • Fire Road 6N • Fire Road 6P	• Monthly monitoring during any subsidence period • Monitoring to continue 6 monthly for 2 years following the completion of mining	**Cliffs** • No Clifflines **Fire Trails** • Fire Road 6A (across active mining area) • Fire Road 6N • Fire Road 6P • Fire Road 6Q
	Inspection of Active Mining Area – Landscape Features, Vegetation, Watercourses		
	Continue monitoring of all mapped cliff, steep slopes, watercourse, swamp and firetrail sites in subsidence area. Continue 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.

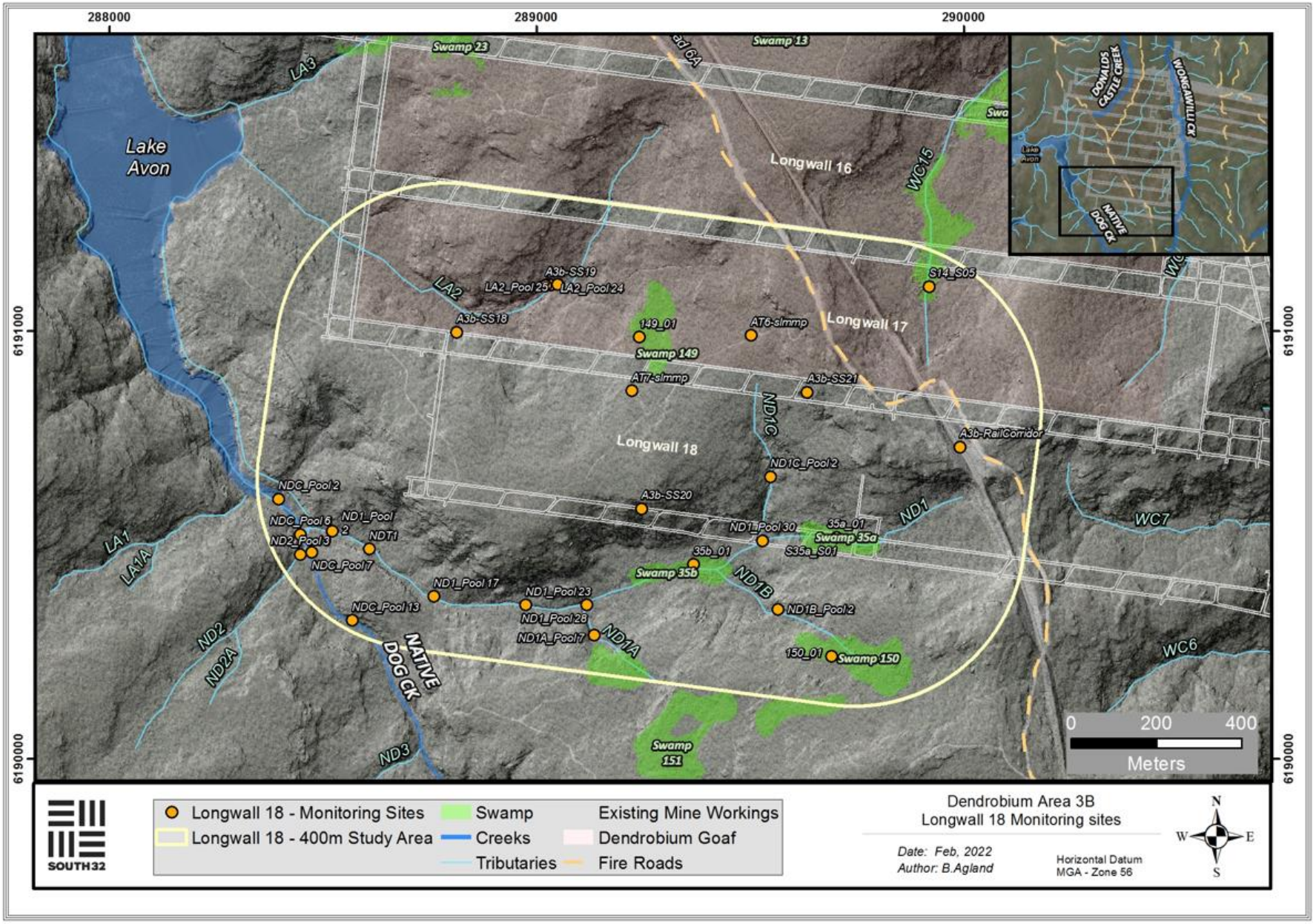

Figure 19: **Overview of monitoring sites relevant to Longwall 18 active mining area.**

7 REFERENCES

BHP Billiton-Illawarra Coal (BHPBIC), 2012. Dendrobium Area 3B. Subsidence Management Plan. Volume 2- Subsidence Management Plan.

BHP Billiton, 2015. Dendrobium Area 3B Subsidence Management Plan Volume 2: Subsidence Management Plan. Management Plan PDM-001-9.6.1D.

Biosis Research, 2012. Dendrobium Area 3B Longwalls 9 to 18: Aboriginal Cultural heritage Assessment Report. An unpublished report for BHP Billiton Illawarra Coal.

Cardno, 2020. SC10C Recovery Assessment. Dendrobium Area 3A.

Cardno, 2022. Longwall 17 End of Panel Report Aquatic Flora and Fauna Review. Prepared for Illawarra Coal

Cardno, *in prep*. Dendrobium Area 3B. Aquatic Ecology Monitoring 2010 to 2021.

Cardno Ecology Lab, 2012. Dendrobium Area 3B SMP – Aquatic Flora and Fauna Assessment. Report Prepared for BHPBIC. Report No. EL1112029A

Chessman, B.C Growns, J.E and Kotlash, A.R., 1997. Objective derivation of macroinvertebrate family sensitivity grade numbers for the SIGNAL biotic index: Application to the Hunter River system, New South Wales. Marine and Freshwater Research, 48, pp. 159-172.

Ecoengineers, 2011. Dendrobium Area 3B Subsidence Management Plan. Surface and Shallow Groundwater Assessment. Report prepared for BHPBIC.

HGEO, 2022a. Dendrobium Mine – End of Panel Groundwater Assessment for Longwall 17 (Area 3B). D22166. Report by HGEO Pty Ltd for South32 Illawarra Metallurgical Coal.

HGEO, 2022b. Dendrobium Mine – End of Panel Surface Water and Shallow Groundwater Assessment for Longwall 17 (Area 3B). D22165. Report by HGEO Pty Ltd for South32 Illawarra Metallurgical Coal.

MSEC, 2015. Dendrobium Area 3B – Longwalls 12 to 18 –Review of the subsidence predictions and impact assessments for natural and built features in Dendrobium Area 3B based on observed movements and impacts during Longwalls 9 and 10.

MSEC, 2016. The effects of the proposed modifications to the ends of Longwalls 12 to 18 in Area 3B at Dendrobium Mine on the subsidence predictions and impact assessments.

MSEC, 2022. End of Panel Subsidence Monitoring Review Report for Dendrobium Longwall 17. MSEC1225, January 2022 Prepared for Illawarra Metallurgical Coal.

Niche, 2012. Dendrobium Area 3B Terrestrial Ecological Assessment. Report prepared for BHPBIC. September 2012

Niche, 2020. Dendrobium Colliery Longwall 15 End of Panel Report - Aboriginal Heritage Assessment (#5721). Prepared for Illawarra Metallurgical Coal.

Niche, 2022. Dendrobium Colliery Longwall 17 End of Panel Report - Aboriginal Cultural Heritage Assessment (#7073). Prepared for Illawarra Metallurgical Coal.

South32, 2012. Dendrobium Mine Groundwater Management Plan. South32 Illawarra Coal, Management Plan Rev 1.5.

South32, 2020a. Dendrobium Area 3B Watercourse impact monitoring management and contingency plan (Management Plan). South32 Illawarra Metallurgical Coal.

South32, 2020b. Dendrobium Area 3B Swamp impact, monitoring, management and contingency plan (Management PlanNo. Rev 1.9). South32 Illawarra Coal.

South32, 2021. Dendrobium Area 3B – Longwall 17 End of Panel Landscape Report. November 2021.

Watershed Hydrogeo, 2019a. Discussion of surface water flow TARPs (No. R011i5), Report for South32 Illawarra Metallurgical Coal.

8 APPENDIX A – IMPACTS, TRIGGERS AND RESPONSE

Table 18: Dendrobium Area 3B Landscape TARPs.

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 *Refer to Dendrobium Area 3A SMP Figure 19.3*	***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,	• *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
Fire Trails All mapped fire trails in subsidence area *Refer to Dendrobium Area 3A SMP Figure 19.3*	and may result in increased sediment transport to Cordeaux Dam, or has been previously identified as Level 1, but is not likely to naturally stabilise within the monitoring period	
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 19: 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	<u>*Level 1:*</u> 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. <u>*Level 2*</u>: 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. <u>*Level 3:*</u> 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. <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%**).	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.	
Minor changes in the size of the swamps **Minor changes** in the ecosystem functionality of the swamps **No significant change** to the composition or	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.	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	Offset required **immediately**, if no remediation considered practicable. Offset required **5 years** following remediation, if it is ineffective.	Monitoring period for swamp size is related to capture of LiDAR (ALS) data at the end of each longwall ~ 1 year Triggers for groundwater decline result in increased intensity and frequency of

distribution of species within the swamps		*Level 3:* 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. *Exceeding Prediction:* 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, 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.	bedrock base and/or use of other remediation techniques i) reporting j) investigation and review k) update future predictions	This period can be extended to **10 years**, with the agreement of the Secretary.	vegetation monitoring

		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** 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.	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 h) investigation and review i) 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.	
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.	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

		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 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 20: Dendrobium Area 3B Watercourse TARP.

Monitoring	Trigger	Action
OBSERVATIONAL, PHOTO POINT AND WATER MONITORING		
Wongawilli Creek, Donalds Castle Creek and WC-WF54 **Relevant Performance Measure(s):** • Wongawilli Creek - minor environmental consequences • Donalds Castle Creek - minor environmental consequences • Waterfall WC-WF54 – negligible environmental consequences 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 • Observation that a pool on a subject creek has ceased to flow	• Continue monitoring program • Submit an Impact Report to BCD, DPIE, MEG, Water NSW • Report in the End of Panel Report • Summarise actions and monitoring in AEMR
	Level 2 * • Observation that a single pool on a subject creek is dry in consecutive monitoring events • Observation that two or more pools on a subject creek are dry in a single monitoring event • Observation that the subject creek has ceased to flow in consecutive monitoring event	• *Actions as stated for Level 1* • Carry out Water Flow Assessment Method D • Review monitoring frequency • Submit letter report to DPIE, MEG and WaterNSW and seek advice on any CMA required. • Implement agreed CMAs as approved (subject to agency feedback)
	• 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 • Submit letter report to DPIE, MEG and WaterNSW and seek advice on any CMA required. • Implement agreed CMAs as approved (subject to agency 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 • 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	• *Actions as stated for Level 2* • Offer site visit with BCD, DPIE, MEG, WaterNSW • 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 BCD, DPIE, MEG, WaterNSW • Completion of works following approvals and at a time agreed between S32, DPIE, MEG and WaterNSW (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 agencies

Monitoring	**Trigger**	**Action**
	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 Creek (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

Native Dog Creek, ND1, ND2, WC15, WC12, WC7, LA1 and LA2 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 BCD, DPIE, MEG, Water NSW • Report in the End of Panel Report • Summarise actions and monitoring in AEMR
	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 • Submit letter report to DPIE, MEG and WaterNSW and seek advice on any CMA required. • Implement agreed CMAs as approved (subject to agency 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 • 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	• *Actions as stated for Level 2* • Offer site visit with BCD, DPIE, MEG, WaterNSW • 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 BCD, DPIE, MEG, WaterNSW • Completion of works following approvals and at a time agreed between S32, DPIE, MEG and WaterNSW (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 agencies
• WATER QUALITY		

Wongawilli Creek Wongawilli Ck (FR6) Baseline means: • pH 5.98 • EC 98.8 uS/cm • DO 89.5% **Relevant Performance Measure(s):** • Wongawilli 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 4.45 – EC 154.1 uS/cm – DO 50.5%	• Continue monitoring program • Submit an Impact Report to BCD, DPIE, MEG, WaterNSW • Report in the End of Panel Report • Summarise actions and monitoring in AEMR
	Level 2 * • Two non-consecutive exceedances of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean within six months: – pH 4.45 – EC 154.1 uS/cm – DO 50.5%	• *Actions as stated for Level 1* • Review monitoring frequency • Submit letter report to DPIE, MEG and WaterNSW and seek advice on any CMA required. • Implement agreed CMAs as approved (subject to agency feedback)

Monitoring	Trigger	Action
	Level 3 * • Three exceedances of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean within six months: – pH 4.45 – EC 154.1 uS/cm – DO 50.5%	• *Actions as stated for Level 2* • Offer site visit with BCD, DPIE, MEG, WaterNSW • Implement additional monitoring or increase frequency if required • Review relevant TARP and Management Plan in consultation with key agencies • Develop site CMA (subject to agency feedback). This may include: – Limestone emplacement to raise pH where it is appropriate to do so • Completion of works following approvals and at a time agreed between S32, DPIE, MEG and WaterNSW (i.e. may be after mining induced movements and impacts are complete), including monitoring and reporting on success
	Exceeding Prediction • Mining results in two consecutive exceedances or three exceedances of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean within six months: – 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
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 within six months: – pH 3.60 – EC 185.8 uS/cm – DO 40.1%	• Continue monitoring program • Submit an Impact Report to BCD, DPIE, MEG, WaterNSW • Report in the End of Panel Report • Summarise actions and monitoring in AEMR
	• Two non-consecutive exceedances of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean within six months: – pH 3.60 – EC 185.8 uS/cm – DO 40.1%	• *Actions as stated for Level 1* • Review monitoring frequency • Submit letter report to DPIE, MEG and WaterNSW and seek advice on any CMA required. • Implement agreed CMAs as approved (subject to agency feedback)

Monitoring	Trigger	Action
	***Level 3** ** • Three exceedances of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean within six months: – pH 3.60 – EC 185.8 uS/cm – DO 40.1%	• *Actions as stated for Level 2* • Offer site visit with BCD, DPIE, MEG, WaterNSW • Implement additional monitoring or increase frequency if required • Review relevant TARP and Management Plan in consultation with key agencies • 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 agency feedback). This may include: – Limestone emplacement to raise pH where it is appropriate to do so • Completion of works following approvals and at a time agreed between S32, DPIE, MEG and WaterNSW (i.e. may be after mining induced movements and impacts are complete), including monitoring and reporting on success
	Exceeding Prediction • Mining results in two consecutive exceedances or three exceedances of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean within six months: – 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

Monitoring	Trigger	Action
Lake Avon Lake Avon tributary (LA4_S1) Baseline means: • pH 5.38 • EC 90.8 uS/cm • DO 89.9% **Relevant Performance Measure(s):** • Avon Dam - negligible reduction in the quality of surface water inflows to Avon Dam	***Level 1*** * • One exceedance of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean within six months: – pH 4.90 – EC 129.8 uS/cm – DO 69.5%	• Continue monitoring program • Submit an Impact Report to BCD, DPIE, MEG, WaterNSW • Report in the End of Panel Report • Summarise actions and monitoring in AEMR
	Level 2 * • Two non-consecutive exceedances of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean within six months: – pH 4.90 – EC 129.8 uS/cm – DO 69.5%	• *Actions as stated for Level 1* • Review monitoring frequency • Submit letter report to DPIE, MEG and WaterNSW and seek advice on any CMA required. • Implement agreed CMAs as approved (subject to agency feedback)
	Level 3 * • Three exceedances of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean within six months: – pH 4.90 – EC 129.8 uS/cm – DO 69.5%	• *Actions as stated for Level 2* • Offer site visit with BCD, DPIE, MEG, WaterNSW • Implement additional monitoring or increase frequency if required • Review relevant TARP and Management Plan in consultation with key agencies • 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 agency 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 S32, DPIE, MEG and WaterNSW (i.e. may be after mining induced movements and impacts are complete), including monitoring and reporting on success
	Exceeding Prediction	• *Actions as stated for Level 3*

Monitoring	Trigger	Action
	• Mining results in two consecutive exceedances or three exceedances of the ±3 standard deviation level (positive for EC, negative for pH and DO) from the baseline mean within six months: – pH 4.90 – EC 129.8 uS/cm – DO 69.5%	• 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		
Wongawilli Creek and Donalds Castle Creek **Relevant Performance Measure(s):** • Wongawilli Creek - minor environmental consequences • Donalds Castle Creek - minor environmental consequences	***Level 1*** * • Single pool on a subject creek is observed as dry	• Continue monitoring program • Carry out Water Flow Assessment Method D. • Submit letter report to DPIE, MEG, Water NSW • Report in the End of Panel Report • Summarise actions and monitoring in AEMR
	Level 2 * • Single pool on a subject creek is observed as dry in consecutive monitoring events • Two or more pools on a subject creek as observed as dry in a single monitoring period	• *Actions as stated for Level 1* • Review monitoring frequency • Submit letter report to DPIE, MEG and WaterNSW and seek advice on any CMA required. • Implement agreed CMAs as approved (subject to agency 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* • Offer site visit with BCD, DPIE, MEG, WaterNSW • Implement additional monitoring or increase frequency if required • Review relevant TARP and Management Plan in consultation with key agencies • Develop site CMA (subject to agency feedback). This may include: Grouting of rockbar and bedrock base of any significant pool where it is appropriate to do so in consultation with BCD, DPIE, MEG, WaterNSW • Completion of works following approvals and at a time agreed between S32, DPIE, MEG and WaterNSW (i.e. may be after mining induced movements and impacts are complete), including monitoring and reporting on success
	Exceeding Prediction	• *Actions as stated for Level 3* • Investigate reasons for the exceedance

Monitoring	Trigger	Action
	• Fracturing resulting in diversion of flow such that >10% of the pools have water levels lower than baseline period	• 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
SURFACE WATER FLOW		
Wongawilli Creek and Donalds Castle CreekAvon Dam and Cordeaux River **Relevant Performance Measure(s):** • Wongawilli Creek - minor environmental consequences • Donalds Castle Creek - minor environmental consequences • Avon Dam - negligible reduction in the quantity of surface water inflows to Avon Dam[1] • Cordeaux River - negligible reduction in the quantity of surface water inflow to the Cordeaux River at its confluence with Wongawilli Creek[2] **Surface water flow Reference sites**: • Wongawilli Creek - WWU (Wongawilli Creek upstream); • O'Hares Creek at Wedderburn (213200);	***Level 1*** • A) Lower flow than expected (additional 10-15% of days where Q% lower than Reference Q%) • B) 5-10% increase in cease-to-flow frequency beyond natural) • C) Reduction in Q50 (10-15% beyond natural)	• Continue monitoring program. • Submit an Impact Report to BCD, DPIE, DRG, WaterNSW. • Report in the End of Panel Report. • Summarise actions and monitoring in AEMR.
	Level 2 • A) Lower flow than expected (additional 15-20% of days where Q% lower than Reference Q%). • B) 10-20% increase in cease-to-flow frequency (beyond natural) • C) 15-20% reduction in Q50 (beyond natural) • D) Observation that the subject Creek has ceased to flow at spatially consecutive monitoring sites.	• *Actions as stated for Level 1* • Review monitoring frequency. • D) ➔ carry out Water Flow Assessment Method D. • Submit letter report to DPIE, MEG and WaterNSW and seek advice on anyCMA required. • Implement agreed CMAs as approved (subject to agency feedback).
	Level 3 • A) Lower flow than expected (additional >20% of days where Q% lower than Reference Q%) • B) >20% increase in cease-to-flow frequency (beyond natural) • C) >20% reduction in Q50 (beyond natural)	• *Actions as stated for Level 2* • Offer site visit with BCD, DPIE, MEG, WaterNSW. • Implement additional monitoring or increase frequency if required. • Develop site CMA (subject to agency feedback). This may include: grouting of rockbar and bedrock base of any significant pool where it is appropriate to do so in consultation with BCD, DPIE, MEG, WaterNSW.

[1] Surface water inflows calculation = [Impacts at gauged catchments (LA1 + LA2 + LA3 + LA4 + LA6+ NDT1 + ND2) + estimated impacts at ungauged but undermined catchments (e.g. LA5)] / [total inflow to LA].
[2] Flow reduction as determined from measured at flow gauging station WWL_A.

• (other such sites, if necessary, include Woronora River 2132101 and Bomaderry Creek 215016) NB. This section of the TARP contains four Water Flow Assessment Methods, labelled A, B, C and D, which are specified in detail in Watershed HydroGeo (2019). Hydrological changes are assessed by comparing pre- and post-mining observed flows from impact or assessment sites to flow data from the reference sites. *Natural variability ('NV') will be defined as the 'average' change at the selected reference sites. Triggers may occur when the apparent impact at a site (NV + x% change) could be less than maximum observed variability at one of the reference sites.*		• Completion of works following approvals and at a time agreed between S32, DPIE, MEG and WaterNSW (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 agencies.
	Exceeding Prediction Measured surface water flow reduction, based on Assessment Methods C, D, to be compared against predictions made in contemporary groundwater modelling conducted to the satisfaction of the Secretary to assess whether effects that cannot be explained by natural variability "exceed prediction".	• *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.
Tributaries of Wongawilli Creek and Donalds Castle Creek and other affected watercourses not subject to performance measures **Surface water flow Reference sites:** • Wongawilli Creek - WWU (Wongawilli Creek upstream); • O'Hares Creek and Wedderburn (213200); • (other such sites, if necessary, include Woronora River 2132101 and Bomaderry Creek 215016) NB. This section of the TARP contains four Water Flow Assessment Methods, labelled A, B, C and D, which are specified in detail in Watershed HydroGeo (2019).	***Level 1*** • A) Lower flow than expected (additional 10-20% of days where Q% lower than Reference Q%) • B) 5-10% increase in cease-to-flow frequency (beyond natural) • C) 10-20% reduction in Q50 (beyond natural)	• Continue monitoring program. • Submit an Impact Report to BCD, DPIE, MEG, WaterNSW. • Report in the End of Panel Report. • Summarise actions and monitoring in AEMR.
	Level 2 • A) Lower flow than expected (additional 20-30% of days where Q% lower than Reference Q%) • B) 10-20% increase in cease-to-flow frequency (beyond natural) • C) 20-30% reduction in Q50 (beyond natural)	• *Actions as stated for Level 1* • Review monitoring frequency. • Submit letter report to DPIE, MEG and WaterNSW and seek advice on anyCMA required. • Implement agreed CMAs as approved (subject to agency feedback).

Hydrological changes are assessed by comparing pre- and post-mining observed flows from impact or assessment sites to flow data from the reference sites. *Natural variability ('NV') will be defined as the 'average' change at the selected reference sites. Triggers may occur when the apparent impact at a site (NV + x% change) could be less than maximum observed variability at one of the reference sites.*	***Level 3*** • A) Lower flow than expected (additional >30% of days where Q% lower than Reference Q%) • B) >20% increase in cease-to-flow frequency (beyond natural) • C) >30% reduction in Q50 (beyond natural)	• *Actions as stated for Level 2* • Offer site visit with BCD, DPIE, MEG, WaterNSW. • Implement additional monitoring or increase frequency if required • Develop site CMA (subject to agency feedback). This may include: grouting of rockbar and bedrock base of any significant pool where it is appropriate to do so in consultation with BCD, DPIE, MEG, WaterNSW. • Completion of works following approvals and at a time agreed between S32, DPIE, DRG and WaterNSW (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 agencies.
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 BCD, DPIE, MEG, WaterNSW. • 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 • Submit letter report to DPIE, MEG and WaterNSW and seek advice on anyCMA required. • Implement agreed CMAs as approved (subject to agency feedback)
	Level 3 * • Reduction in aquatic habitat for >2 years following the active subsidence period	• *Actions as stated for Level 2* • Offer site visit with BCD, DPIE, MEG, WaterNSW. • Implement additional monitoring or increase frequency if required • Review relevant TARP and Management Plan in consultation with key agencies • Develop site CMA (subject to agency feedback). This may include: grouting of rockbar and bedrock base of any significant pool where it is appropriate to do so in consultation with BCD, DPIE, MEG, WaterNSW. • Completion of works following approvals and at a time agreed between S32, DPIE, DRG and WaterNSW (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 • Avon Dam tributary – 1 site • Native Dog tributary – 1 site	***Level 1 **** • Reduction in habitat for 1 year	• Continue monitoring program. • Submit an Impact Report to BCD, DPIE, MEG, WaterNSW. • 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 • Submit letter report to DPIE, MEG and WaterNSW and seek advice on any CMA required. • Implement agreed CMAs as approved (subject to agency feedback)
	Level 3 * • Reduction in habitat for > 2 years following the active subsidence period	• *Actions as stated for Level 2* • Offer site visit with BCD, DPIE, MEG, WaterNSW. • Implement additional monitoring or increase frequency if required • Review relevant TARP and Management Plan in consultation with key agencies • Develop site CMA (subject to agency feedback). This may include: grouting of rockbar and bedrock base of any significant pool where it is appropriate to do so in consultation with BCD, DPIE, MEG, WaterNSW. • Completion of works following approvals and at a time agreed between S32, DPIE, DRG and WaterNSW (i.e. may be after mining induced movements and impacts are complete), including monitoring and reporting on success.