



DA3B LONGWALL 11 END OF PANEL LANDSCAPE REPORT

MARCH 2016





Executive Summary

This report summarises the observed and measured subsidence effects on landscape features resulting from the extraction of Dendrobium Longwall 11.

Longwall 11 is the third panel to be extracted from Dendrobium Area 3B. Extraction began on the 18th of February 2015 and was completed on the 26th of January 2016.

The Illawarra Coal Environmental Field Team (ICEFT) conducts detailed monitoring and inspections on landscape features including swamps, watercourses, rock outcrops, key landscape features and the general area within Dendrobium Area 3B. This monitoring is conducted in accordance with the Dendrobium Area 3B Subsidence Management Plan (SMP), Dendrobium Area 3B Watercourse Impact, Monitoring, Management and Contingency Plan (WIMMCP) (October 2015), Dendrobium Subsidence, Landscape Monitoring and Management Plan (November 2012) and the Dendrobium Area 3B Swamp, Impact, Monitoring, Management and Contingency Plan (SIMMCP) (October 2015). Impacts to landscape features were incorporated into the monitoring program as they were identified. The WIMMCP, SIMMCP and Landscape Trigger Action Response Plans (TARPs) form the basis of the impact assessments in this report.

Monitoring of water levels, water flow and water quality were also conducted by specialist consultants.

A total of eleven surface impacts were identified by the ICEFT. Nine of these impacts were observed on fire roads or access tracks, and two were observed within a watercourse (WC21).

The Dendrobium Area 3B mine plan was modified to reduce the potential for impacts to Wongawilli Creek. No impacts have been identified in Wongawilli Creek as a result of Longwall 11 extraction. Additionally, iron staining present in the Wongawilli Creek tributary WC21 has not been detected downstream in Wongawilli Creek.

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Abbreviations

CMA – Corrective Management Action

DPE - Department of Planning and Environment

DRE - Department of Trade and Investment, Division of Resources and Energy

EoP – End of Panel

ICEFT – Illawarra Coal Environmental Field Team

OEH - Office of Environment and Heritage

SCA – Sydney Catchment Authority (now Water NSW)

SIMMCP – Swamp Impact, Monitoring, Management and Contingency Plan

SLMMP – Subsidence Landscape Monitoring and Management Plan

SMP – Subsidence Management Plan

TARP – Trigger Action Response Plan

WIMMCP – Watercourse Impact, Monitoring, Management and Contingency Plan

1. Introduction

This report has been prepared for the Dendrobium Area 3B Longwall 11 End of Panel Report (EoP Report). The monitoring programs and the Triggers reached in relation to subsidence from Longwall 11 are outlined in this report.

Longwall 11 is the third longwall in Dendrobium Area 3B. Extraction began on the 18th of February 2015 and was completed on the 26th of January 2016.

Monitoring and inspections were carried out in accordance with the following:

- SIMMCP (Revision 1.1 to 1.5)
- WIMMCP (Revision 1.1 to 1.5)
- Dendrobium Area 3B SMP, Volume 2 – Table 1.1 – Dendrobium Landscape Key Monitoring Sites (November 2012)

The abovementioned Management Plans identify monitoring required for landscape features including watercourses, swamps, rock outcrops, cliff-lines and steep slopes as well as man-made features.

The TARPs set out in the above documents provide the various actions required for subsidence impacts. The SIMMCP and WIMMCP and associated TARPs were updated during the extraction of the previous longwalls, Longwalls 9 and 10.

For all observed impacts associated with Longwall 11, the appropriate TARPs were applied and actions implemented. The “Surface Impacts” and “TARP Trigger Observations” sections of this report provide a summary of all impacts and triggers observed during Longwall 11 extraction. Detailed impact reports are provided as an attachment to the Longwall 11 EoP Report. Eleven surface impacts were recorded by the ICEFT in the general area undermined by Longwall 11. TARP triggers regarding shallow groundwater in Swamp 5 were also reported during the extraction of Longwall 11.

Impacts and triggers are assessed by specialists where required and these assessments are included as attachments to the Longwall 11 EoP Report.

2. Overview of Monitoring Program

Monitoring was conducted for landscapes in the zone of influence of Longwall 11 during baseline, active mining and post-mining periods. Baseline inspections were conducted until the longwall was within 400m of each feature. From that point weekly inspections of each feature were conducted until the longwall was 400m past the feature. Post-mining inspections continue as outlined in the relevant Management Plans or as required. Figure 2.1 displays monitoring sites associated with Longwall 11 and Area 3B.

2.1. Surface Monitoring for Longwall 11

An overview of the monitoring is provided in Appendix A, Table 1. Observations and measurements of water levels, water flow rates, water quality and key landscape features were conducted by the ICEFT and a hydrological consultant. This monitoring regime included targeted sites within swamps, watercourses, steep slopes, cliff-lines and other landscape features.

Monitoring sites associated with Longwall 11 are provided in Appendix A, Table 1.

2.2. Reference Site Monitoring

Reference sites are monitored as required by the TARPs. Sites monitored during Longwall 11 extraction are listed in Appendix A. Photos 1 to 4 show the most recent inspection for the reference sites Swamp 15A, Swamp 2, Sandy Creek and site NDC1 on Native Dog Creek. During extraction of Longwall 11, installation of additional reference swamp sites was undertaken. Refer to Appendix A, Table 1 for a summary of reference swamps monitored.



Photo 1: Swamp 15A Site 03 vegetation. Taken on 29/01/2016.



Photo 2: Swamp 2 Site 01 vegetation. Taken on 15/02/2016.



Photo 3: Sandy Creek Pool 23 looking downstream. Taken on 23/09/2015.



Photo 4: Site NDC1 on Native Dog Creek looking downstream. Taken on 13/11/2015.

2.3. TARP Overview

In accordance with the Area 3B SMP approvals, the SIMMCP and WIMMCP (and Environmental Management Plan) were revised during the extraction of the previous longwalls, Longwalls 9 and 10. Key government agencies including Department of Trade and Investment, Division of Resources and Energy (DRE), Department of Planning and Environment (DPE), Water NSW (previously known as SCA) and Office of Environment and Heritage (OEH) were consulted during this process. This revision included the TARP's which address Performance Measures specified in the approval conditions.

Impacts to surface features observed during Longwall 11 extraction were reported under the most recent version of the TARPs. Table 2-1 lists the date range of Area 3B TARP's.

Table 2-1: Management Plan and TARP Dates Summary

Aspect	Management Plan	TARP Date Range
Swamps	Swamp Impact, Monitoring, Management and Contingency Plan (October 2013)	10/10/2013 – 03/06/2014
	Swamp Impact, Monitoring, Management and Contingency Plan (June 2014)	04/06/2014 – 11/10/2015
	Swamp Impact, Monitoring, Management and Contingency Plan (October 2015)	12/10/2015 - Present
Watercourse	Watercourse Impact, Monitoring, Management and Contingency Plan (December 2013)	19/12/2013 – 03/06/2014
	Watercourse Impact, Monitoring, Management and Contingency Plan (June 2014)	04/06/2014 – 11/10/2015
	Swamp Impact, Monitoring, Management and Contingency Plan (October 2015)	12/10/2015 - Present
Landscape	Dendrobium Area 3B Subsidence Management Plan (SMP), Volume 2 – Table 1.2 Dendrobium Landscape Impacts, Triggers and Response (November 2012)	12/11/2012 – Present

2.4. Landscape Monitoring Summary

In accordance with the Area 3B SMP approvals, landscape features within 400m of the longwall face were monitored at monthly intervals. A total of 20 landscape sites (SLMMP Photo Points) were monitored before and during the Longwall 11 extraction period and are summarised in Table 2-2 below. For a detailed description of Longwall 11 impacts to landscape features refer to the relevant impact reports provided as an attachment to the Longwall 11 EoP Report. Figure 3.1 displays the location of the observed impacts.

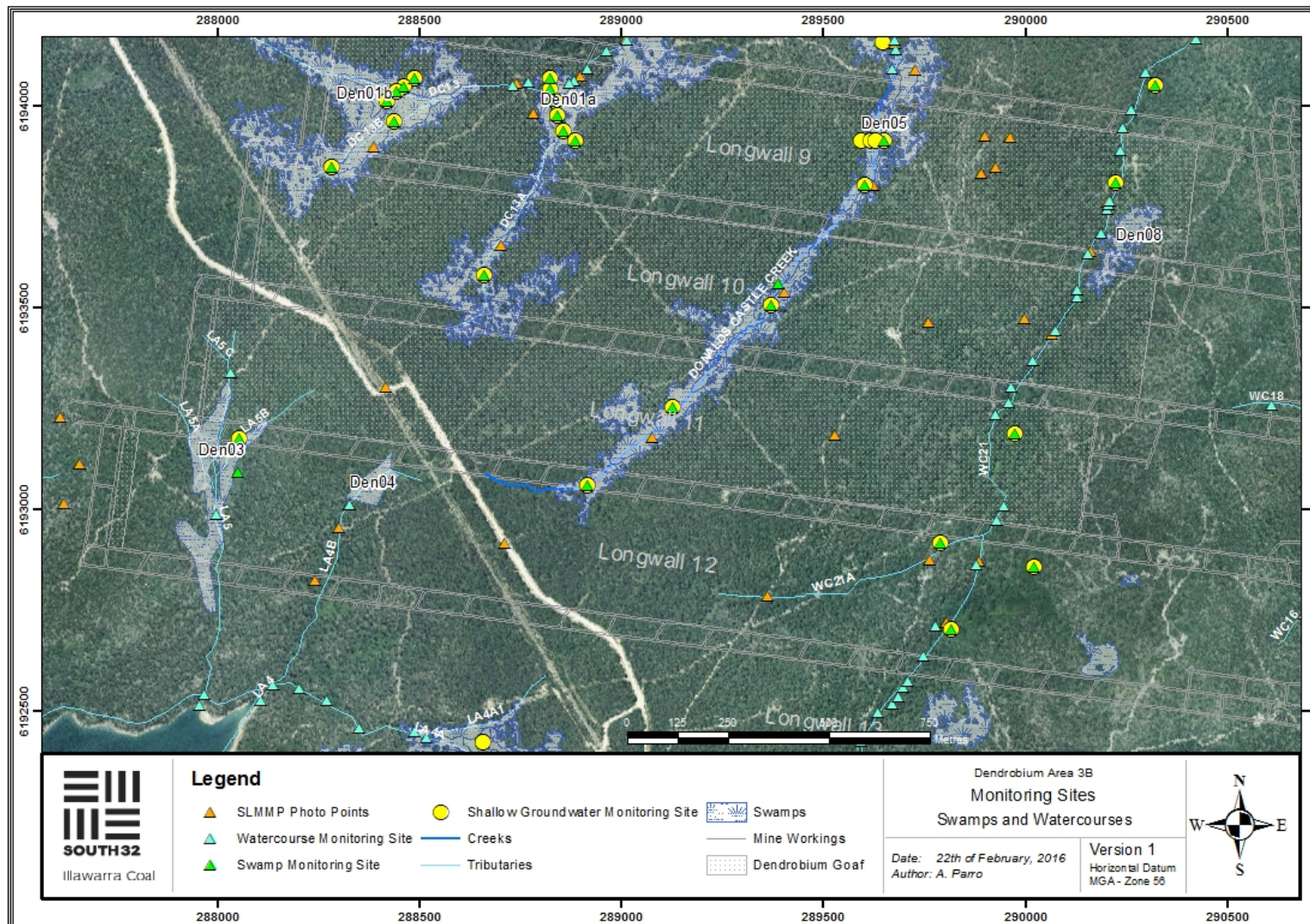


Figure 2.1: Location of Monitoring sites in Dendrobium Area 3B

Table 2-2: Summary of Longwall 11 Landscape Monitoring Sites.

Site Name	Easting	Northing	Description
Access Tracks			
FR6A-slmp-Pt1	288414	6193305	Surface cracking and uplift on FR6A on each side of the monitoring site during LW11 extraction (impacts DA3B_LW11_001 & 002).
FR6A-slmp-Pt2	288710	6192918	No impacts identified.
AT6000-slmp-Pt1	289360	6192787	No impacts identified.
AT6000-slmp-Pt2	289527	6193186	A zone of surface cracking identified 50m south of site during extraction of Longwall 11 (impact DA3B_LW11_007).
Cliffs and Steep Slopes			
A3b-SS1-slmp-Pt1	289998	6193473	No impacts identified.
A3b-SS3-slmp-Pt1	287609	6193229	No impacts identified.
Ab3-SS3-slmp-Pt2	287656	6193113	No impacts identified.
A3b-SS3-slmp-Pt3	287618	6193015	No impacts identified.
A3b-SS4-slmp-Pt1 a	288240	6192825	No impacts identified.
A3b-SS5-slmp-Pt1	289761	6193464	Rock fracture north of monitoring site during extraction of LW10 (Impact DA3B_LW10_004). No further impacts as a result of Longwall 11.
Swamps			
S05-slmp-Pt3	289402	6193539	No impacts identified.
S05-slmp-Pt4	289075	6193179	No impacts identified.
S10-slmp-Pt1	289806	6192722	No impacts identified.
S01a-slmp-Pt2	288702	6193655	No impacts identified.
Watercourses			
WC21-Pt4	290161	6193641	No impacts identified.
WC21-Pt5	290065	6193435	Multiple fractures identified in downstream section of Rockbar 24 during Longwall 10 extraction (Impact DA3B_LW10_020). No further impacts during Longwall 11 extraction.
WC21-Pt6	289886	6192874	No impacts identified.
WC21a-slmp-Pt1	289762	6192875	No impacts identified.
LA4b-slmp-Pt1	288326	6193013	No impacts identified.
LA4b-slmp-Pt2	288300	6192957	No impacts identified.

3. Surface Impacts

3.1. Summary of Impacts

Eleven new impacts were identified during the extraction of Longwall 11. These impacts have been labelled as “DA3B_LW11_001” to “DA3B_LW11_011”. The impacts are summarised in Table 3-1. For a detailed description of these impacts refer to the relevant impact reports provided as an attachment to the Longwall 11 EoP Report. Figure 3.1 provides the location of the observed impacts.

3.2. Impacts to Natural Features

Subsidence includes vertical and horizontal movement of the land surface, which can result in surface and subsurface cracking, buckling, dilation and tilting. These effects can impact watercourses (e.g. hydrology and water quality), swamps (e.g. hydrology and ecological

function) and the landscape in general (e.g. surface cracks which can lead to erosion and rock falls).

Potential mine subsidence impacts within Area 3B are discussed in the Dendrobium Area 3B SMP, WIMMCP and SIMMCP. Predicted impacts are outlined in the tables provided in Appendix A; Table 2.

An overview of impacts observed during the extraction of Longwall 11 is provided in the following sections. For specific details on the impacts listed in Table 3-1, refer to the relevant impact reports (attached separately to the Longwall 11 EoP Report).

3.2.1. Fracturing

Fractures observed during the extraction of Longwall 11 were assessed against the relevant TARP (for landscape, swamp or watercourse) and assigned a trigger value (Level 1, Level 2, Level 3 or exceedance of performance measure where applicable). Trigger values for fractures were determined based on characteristics such as:

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

First and Second Order Streams

Four first and second order streams were monitored as part of the Longwall 11 monitoring program; LA5, LA4B, DC13 and WC21. Surface cracking and rock fracturing was observed in tributary WC21 within the zone of influence for Longwall 10. These impacts were assessed under the TARP's in the WIMMCP (October 2015) and Table 1.2 of Dendrobium Area 3B SMP, Volume 2 (November 2012).

Two TARP Level 1 rock fractures have been observed in WC21- DA3B_LW11_008 (Photos 5 and 6) and DA3B_LW11_010 (Photos 7 and 8). In accordance with the TARPs these fractures are consistent with a Level 1 impact being:

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

Fracturing and Rock fall

- There were no impacts involving fracturing and rock fall during the extraction of Longwall 11. Inspections of the landscape will continue in order to identify impacts from future longwalls.

Table 3-1: Longwall 11 Surface Impacts

Site ID	Easting	Northing	Description	Features Affected	Identification Date	Impact Level	TARP's Used	Refer to Impact Report/s Dated
DA3B_LW11_001	288499	6193268	A soil crack with uplift across Fire Road 6A with associated smaller cracking.	FR6A	1/06/2015	Level 2	Dendrobium Area 3B SMP Volume 2 – Table 2, TARP dated 12/11/2012	2/06/2015
DA3B_LW11_002	288353	6193334	A single soil crack with some uplift across Fire Road 6A.	FR6A	1/06/2015	Level 2	Dendrobium Area 3B SMP Volume 2 – Table 2, TARP dated 12/11/2012	2/06/2015
DA3B_LW11_003	288632	6193249	A zone of soil cracking approx 5m x 3m identified on a seismic track to the east of Fire Road 6A.	Seismic Track	24/06/2015	Level 1	Dendrobium Area 3B SMP Volume 2 – Table 2, TARP dated 12/11/2012	25/06/2015
DA3B_LW11_004	289224	6193221	A soil crack on a seismic track adjacent Swamp 5 next to Access Track 6000.	Seismic Track	21/08/2015	Level 1	Dendrobium Area 3B SMP Volume 2 – Table 2, TARP dated 12/11/2012	24/08/2015
DA3B_LW11_005	289353	6193130	A soil crack on a seismic track adjacent Swamp 5 next to Access Track 6000.	Seismic Track	19/09/2015	Level 1	Dendrobium Area 3B SMP Volume 2 – Table 2, TARP dated 12/11/2012	21/09/2015
DA3B_LW11_006	289383	6193112	A soil crack on a seismic track adjacent Swamp 5 next to Access Track 6000.	Seismic Track	24/09/2015	Level 1	Dendrobium Area 3B SMP Volume 2 – Table 2, TARP dated 12/11/2012	24/09/2015
DA3B_LW11_007	289502	6193103	A zone of soil cracking along a 50m section of Access Track 6000.	FR6000	Initial: 10/12/2015 Update: 4/02/2016	Level 2	Dendrobium Area 3B SMP Volume 2 – Table 2, TARP dated 12/11/2012	11/12/2015, 5/02/2016
DA3B_LW11_008	289918	6193219	Multiple fractures on a rockbar across a 30m section of WC21.	WC21	14/01/2016	Level 2	WIMMCP TARP dated 12/10/2015	15/01/2016
DA3B_LW11_009	289830	6192993	A zone of soil cracking along a section of seismic track adjacent to WC21.	Seismic Track	14/01/2016	Level 1	Dendrobium Area 3B SMP Volume 2 – Table 2, TARP dated 12/11/2012	15/01/2016
DA3B_LW11_010	289965	6193303	Rock fracture on WC21_RB27.	WC21	11/02/2016	Level 1	WIMMCP TARP dated 12/10/2015	12/02/2016
DA3B_LW11_011	290147	6193066	A soil crack on a seismic line east of WC21.	Seismic Track	26/02/2016	Level 1	Dendrobium Area 3B SMP Volume 2 – Table 2, TARP dated 12/11/2012	26/02/2016

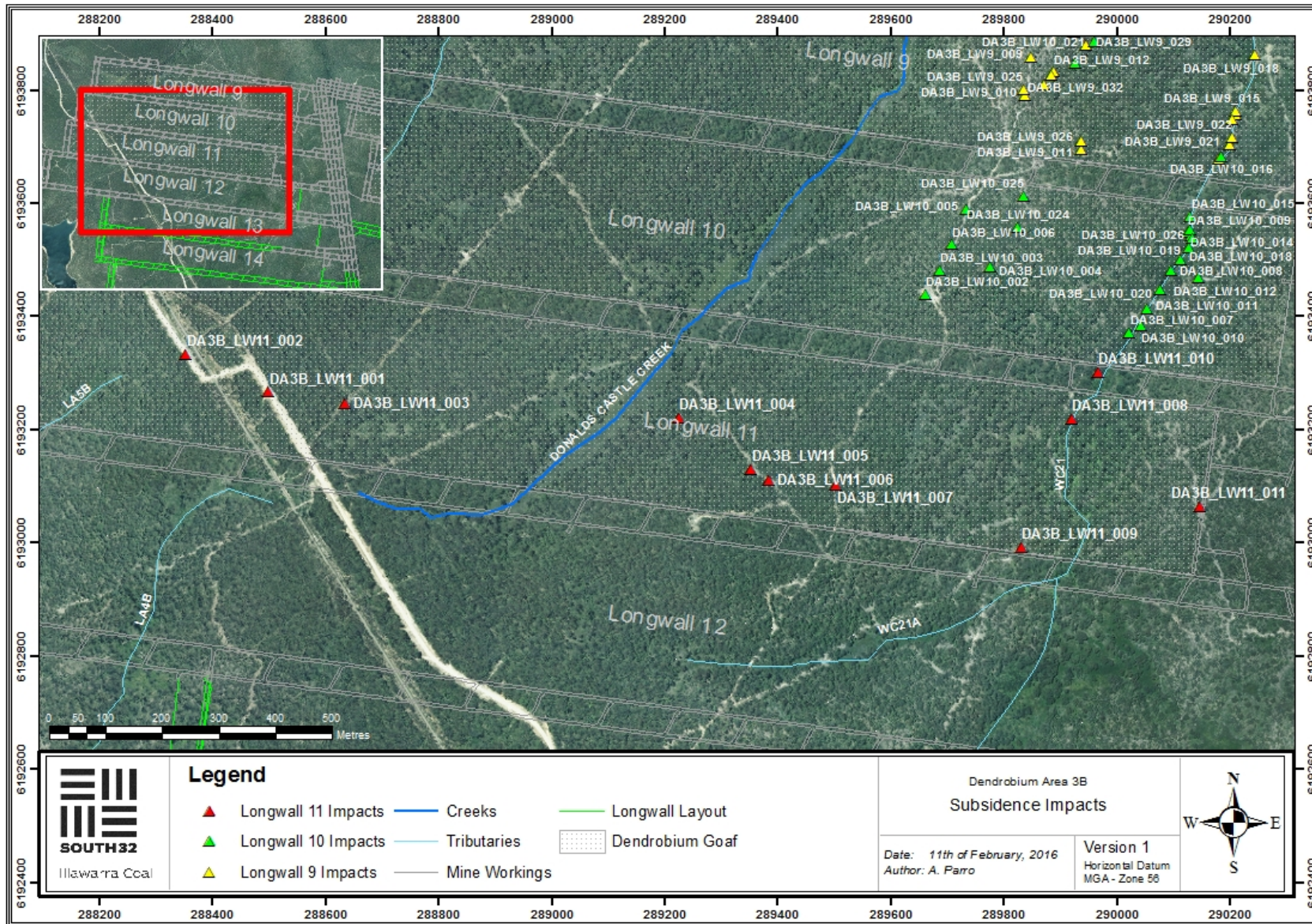


Figure 3.1: Dendrobium Area 3B Impacts



Photo 5: DA3B_LW11_008- Rock fracture, looking upstream along WC21. Taken on 14/01/2016.



Photo 6: DA3B_LW11_008- Rock fracture, looking along WC21. Taken on 14/01/2016.



Photo 7: DA3B_LW11_010- Rock fracture, looking upstream along WC21. Taken on 11/02/2016.



Photo 8: DA3B_LW11_010- Rock fracture and uplift, looking across stream along WC21. Taken on 11/02/2016.

3.3. Impacts to Man-made Features

3.3.1. Fracturing

Eight impacts have been identified on access tracks within the Longwall 11 mining area. These impacts consist of multiple soil cracks on seismic trails, Fire Road 6A and Access Track 6000.

Six surface cracks identified during the extraction of Longwall 11 were identified as Level 1 impacts in the TARP as defined in the Dendrobium Area 3B SMP, Volume 2 (November 2012). Impact DA3B_LW11_003 was identified to the west of Swamp 5 and consists of a zone of soil cracking approximately 5m long by 3m wide, the largest crack is 1.9m with a depth of approximately 0.015m to 0.03m (Photo 9). Three soil cracking impacts; DA3B_LW11_004, 005 and 006, were identified on an access track between Swamp 5 and Access Track 6000 (Figure 3.1). The largest crack on this access track measured 4.0m long, with a maximum width of 0.03m and depth of 0.08m (Photos 10 and 11). Impact DA3B_LW11_009 was identified as a zone of soil cracking across a seismic track that runs alongside WC21, the largest crack is 2.7m long and 0.01m wide (Photo 12). Additional soil cracking was identified on a seismic track above the eastern edge of Longwall 11, east of WC21, consisting of surface cracks totalling a length of 2.5m with a maximum width of 0.04m and depth of 0.30m, DA3B_LW11_011.

These cracks are a Level 1 impact according to the Dendrobium Landscape Impacts, Triggers and Response Plan (Appendix A. Table 2), 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.



Photo 9: DA3B_LW11_003- Soil crack, looking across seismic track. Taken on 24/06/2015.



Photo 10: DA3B_LW11_005- Soil crack, looking along seismic track. Taken on 19/09/15.



Photo 11: DA3B_LW11_005- Soil crack, looking across seismic track. Taken on 19/09/15.



Photo 12: DA3B_LW11_009- Soil Cracking, looking across seismic track. Taken on 14/01/2016

Three surface cracks on access tracks identified during the extraction of Longwall 11 were identified as Level 2 impacts in the TARP as defined in the Dendrobium Area 3B SMP, Volume 2 (November 2012). Two of these cracks, identified on Fire Road 6A; Impact DA3B_LW11_001 and 002, were up to 25m and 20m long respectively, continuing beneath vegetation on either side of the Fire Road with up to 0.050m of uplift and small associated cracks up to 0.020m wide (Photo 13 to 16). Impact DA3B_LW11_007 on Access Track 6000, initially reported as a Level 1 Impact on the 11th of December 2015, was found to have additional cracking and slumping of soil cracks on an inspection on the 3rd of February 2016 and updated to a Level 2 impact. The longest continual soil crack in the zone is 8m long, 0.1m wide and 0.25m deep (Photo 17). Two soil holes were identified along a discontinuous soil crack, the largest being 0.45m wide, 1m long and approximately 1m deep (Photo18).

These cracks are a Level 2 impact according to the Dendrobium Landscape Impacts, Triggers and Response Plan (Appendix A. Table 2), specifically:

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



Photo 13: DA3B_LW11_001- Soil crack across Fire Road 6A. Uplift on the southern side of crack is only slightly evident in the photo. Taken on 1/06/2015.



Photo 14: DA3B_LW11_001- Uplift on southern side of crack. Taken on 1/06/2015.



Photo 15: DA3B_LW11_002- Soil crack across Fire Road 6A. Uplift evident on the northern side of crack, more pronounced to the east of Fire Road 6A. Taken on 1/06/2015.



Photo 16: DA3B_LW11_002- Eastern end of soil crack. Taken on 1/06/2015.



Photo 17: DA3B_LW11_007 Extension - soil crack, looking south along Access Track 6000 (04/02/16).



Photo 18: DA3B_LW11_007 Extension – eroded hole and discontinuous soil cracking looking north along Access Track 6000 (04/02/16).

4. Update for Previous Mining Areas

Post-mining inspections are carried out in accordance with the approved Management Plans. Photos 19 to 38 provide a comparative summary of post-mining monitoring for Dendrobium Area 3A.



Photo 19: S15b_S01 looking at swamp vegetation. Taken on 28/12/2012.



Photo 20: S15b_S01 looking at swamp vegetation. Taken on 23/02/2016.



Photo 21: S15b_S04 looking at swamp vegetation. Taken on 17/12/2012.



Photo 22: S15b_S04 looking at swamp vegetation. Taken on 23/02/2016.



Photo 23: SC10C_Pool 7 looking upstream.
Taken on 28/12/2012.



Photo 24: SC10C_Pool 7 looking upstream.
Taken on 23/02/2016.



Photo 25: SC10C_Pool 11a looking upstream.
Taken on 28/12/2012.



Photo 26: SC10C_Pool 11a looking upstream.
Taken on 23/02/2016.



Photo 27: S16_S03 looking at swamp
vegetation. Taken on 22/12/2011.



Photo 28: S16_S03 looking at swamp
vegetation. Taken on 23/02/2016.



Photo 29: S16_S05 looking at swamp vegetation. Taken on 17/11/2011.



Photo 30: S16_S05 looking at swamp vegetation. Taken on 23/02/2016.



Photo 31: WC17_Pool 12 looking downstream. Taken on 12/11/2012.



Photo 32: WC17_Pool 12 looking downstream. Taken on 27/02/2015.



Photo 33: WC17_Pool 6 looking upstream. Taken on 12/10/2012.



Photo 34: WC17_Pool 6 looking upstream. Taken on 11/05/2015.



Photo 35: S12_S02 looking at swamp vegetation. Taken on 11/12/2012.



Photo 36: S12_S02 looking at swamp vegetation. Taken on 30/01/2015.



Photo 37: S12_S04 looking at swamp vegetation. Taken on 11/12/2012.



Photo 38: S12_S04 looking at swamp vegetation. Taken on 30/01/2016.

5. TARP Trigger Observations

5.1. Shallow Groundwater

Shallow groundwater in swamps is monitored in accordance with the TARPs set out in the SIMMCP (October, 2015). Changes to groundwater are reported when measurements of water level drop below baseline levels or when rates of recession exceed those recorded during baseline periods. For further details refer to the relevant impact reports.

Swamps 1a and 1b

Fourteen groundwater monitoring sites have been installed in Swamps 1a and 1b. Of these fourteen sites, eleven have been undermined by Longwall 9 and one by Longwall 10. No sites were undermined by Longwall 11. Eight of the boreholes have recorded post-mining water levels lower than baseline levels and six cases where post-mining water level recession rates exceeded baseline rates. No further groundwater effects attributed to the extraction of Longwall 11 have been recorded.

Swamp 3

Due to the relatively small size of Swamp 3, only one groundwater monitoring site has been installed. Since Longwall 11 passed under the site, the post-mining rate of water level recession has exceeded the fastest rate recorded before mining at the equivalent horizon. Water level has not dropped below the lowest level recorded during the baseline period. A more detailed analysis is provided in the relevant impact report dated 28th of May 2015.

As only one groundwater monitoring site is installed in Swamp 3, exceedance of water level recession in comparison to baseline levels is a Level 3 Trigger according to the Dendrobium Swamp TARP (Appendix A, Table 2), specifically:

- 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.

Management strategies have been initiated according to the SIMMCP TARP Table (Appendix A, Table 2).

Swamp 5

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

During extraction of Longwall 11 groundwater levels at borehole 05_01 dropped below the lowest levels recorded during the baseline period, and the post-mining rate of water recession has exceeded the rate recorded during the baseline period. At borehole 05_05 the post-mining rate of water recession has exceeded the rate recorded before mining.

Two out of the six shallow boreholes within Swamp 5 have recorded a trigger for water level. Six out of the six shallow boreholes within Swamp 5 have recorded a trigger level for rate of recession. Swamp 5 is at a Level 3 Trigger (see report dated 19/08/2015) according to the Dendrobium Swamp TARP (Appendix A, Table 2), specifically:

- 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.

Swamp 8

Borehole 08_01 is located adjacent to Swamp 8 and was undermined by Longwall 11 on the 6th of January 2016. Since being undermined groundwater level has been recorded as dry, below the lowest level recorded during the baseline period (Figure 5.1). Borehole 08_01 recorded a rate of recession exceeding the rate before mining of Longwall 10.

Dendrobium Area 3b
Piezometer 08_01

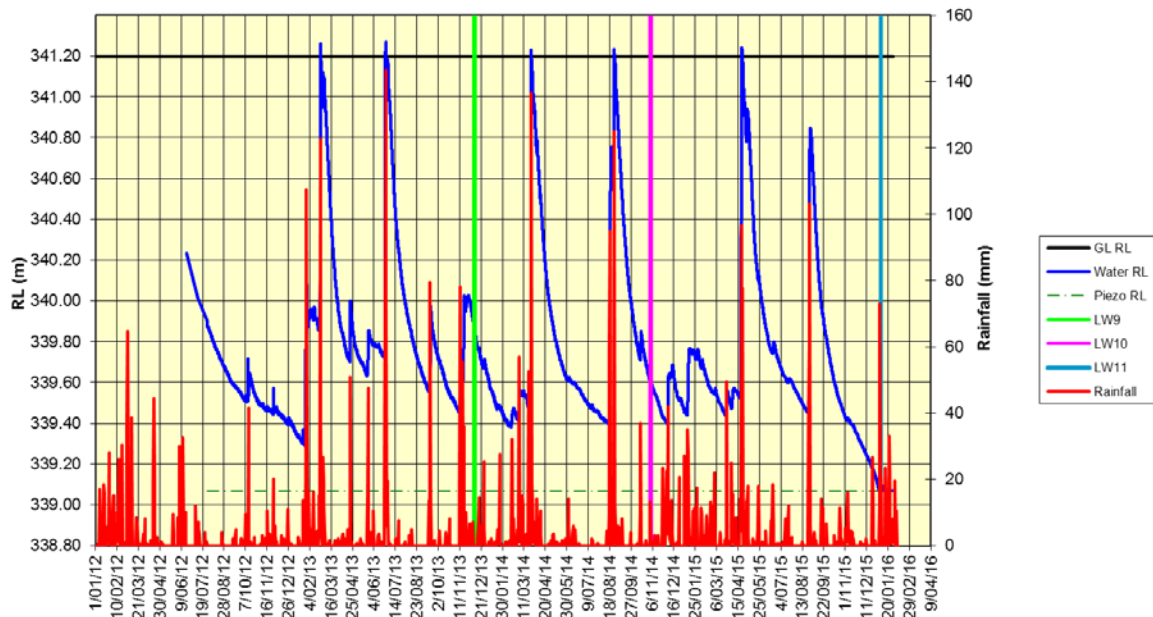


Figure 5.1: Groundwater levels measured borehole site 08_01.

5.2. Soil Moisture

The piezometric monitoring directed at shallow groundwater levels is supplemented with monitoring of soil moisture profiles. Soil moisture probes have been installed in swamp and monitor to a depth of 1m. Most swamp-site soil moisture profiles are monitored using a single in-situ soil moisture measurement at 100mm increments, however key monitoring sites in Swamps 5, 11 and Reference Swamps 14 and 87 have been installed with continuous loggers, measuring soil moisture at 200mm increments (to 1m) at half-hourly or hourly increments. The equipment uses frequency-domain reflectometry (FDR) technology to measure the relative intensity of a generated pulse along a waveguide and relates it to soil moisture content using an equivalent circuit as a reference. Soil moisture is recorded in units of millimetres of H₂O around the 100mm radius of the sensor using a raw count calibrated to obtain absolute volumetric soil water content, then averaged to result in an average moisture count through the soil profile.

Swamp 5

Four soil moisture profiles are monitored in Swamp 5. At some sites baseline data is limited to less than 6 months before mining due to the timing of requests for additional monitoring from Government. Sites S05_S02 and S05_S08 were undermined by Longwall 10 and during extraction of Longwall 11 soil moisture levels dropped below baseline levels. Following extraction of Longwall 11 soil moisture at sites S05_S01 and S05_S05 also dropped to a level lower than recorded during the baseline period (Figures 5.2 and 5.3). For further details refer to relevant impact reports dated 12th of October 2015 and 19th of February 2016. Soil moisture at all four sites has responded to rainfall and has fluctuated between baseline and below baseline levels since being undermined. Swamp 5 is now at a

Level 3 Trigger according to the Dendrobium Swamp TARP (Appendix A, Table 2), specifically:

- Soil moisture level lower than baseline level at >80% of monitoring sites (within 400m of mining) within a swamp (in comparison to reference swamps).

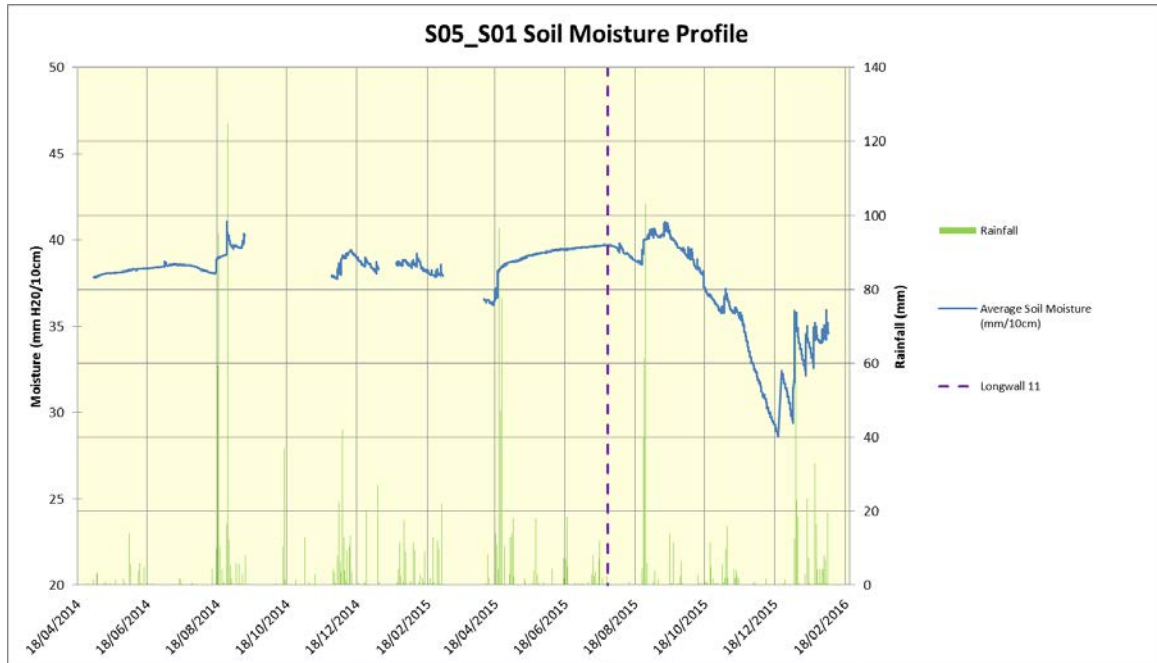


Figure 5.2: Soil moisture levels recorded at S05_S01.

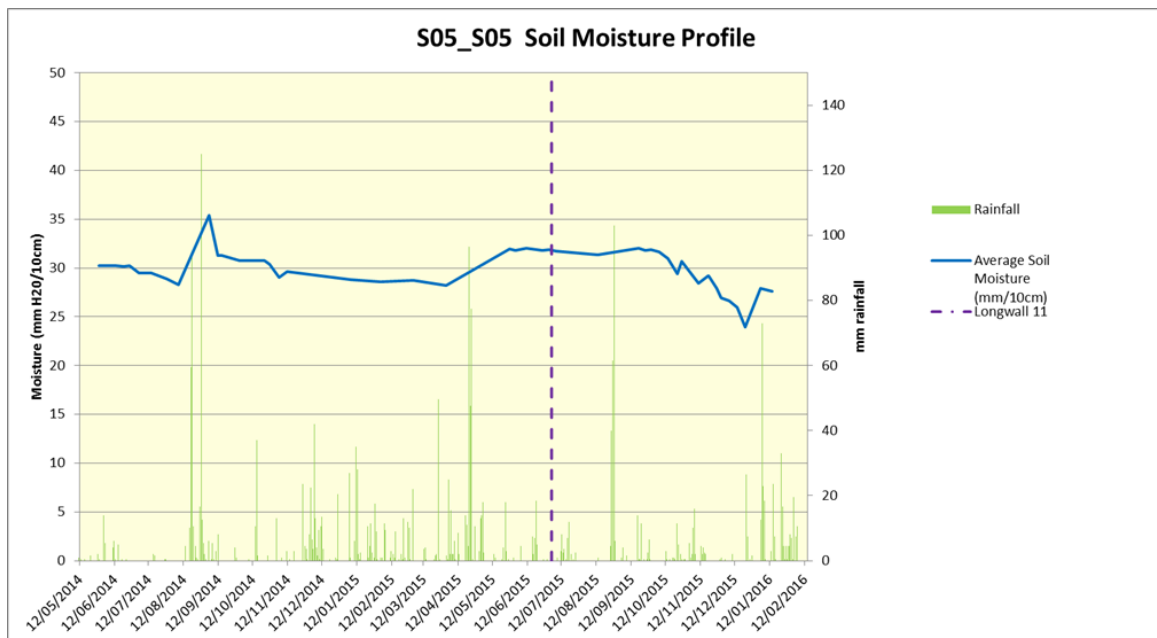


Figure 1.3: Soil moisture levels at S05_S05.

Swamp 8

One soil moisture profile is monitored adjacent to Wongawilli tributary WC21. S08_S05 has not been undermined by Longwall 11 but is within 400m and the total soil moisture level has dropped below those recorded in the baseline period. Soil moisture levels have fluctuated in response to rainfall (Figure 5.4).

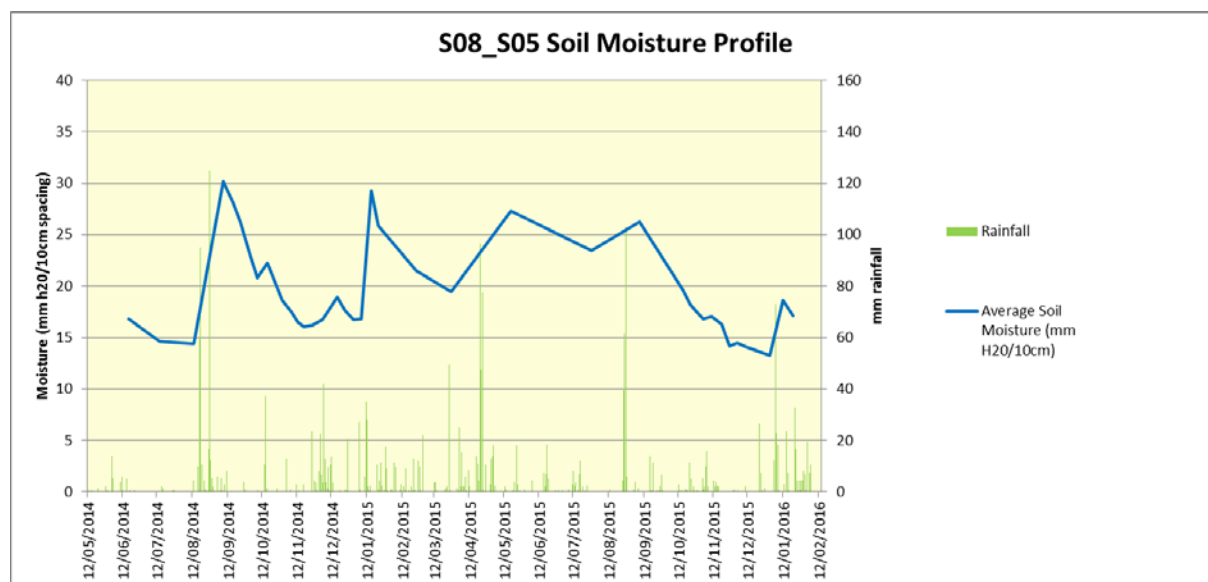


Figure 5.4: Soil moisture levels at S08_S05.

6. Recommendations for Future Monitoring

Recommendations for future monitoring in Dendrobium Area 3B, particularly concerning Longwall 11, are outlined in Table 6-1. These recommendations are based on monitoring commitments in the Dendrobium Area 3B SMP, WIMMCP and SIMMCP and the proximity of sites to future longwalls.

Table 6-16-1: Recommendations for future monitoring.

ASPECT	MONITORING SITES ASSOCIATED WITH LONGWALL 11	MONITORING REQUENCY	RECOMMENDED FUTURE MONITORING
Watercourses	Observational, Photo Point and Water Monitoring		
	<ul style="list-style-type: none"> Wongawilli Creek Donalds Castle Creeks WC21 DC13 LA5 Swamps 1a, 1b, 3, 5 and 8 	<ul style="list-style-type: none"> SLMMP Sites: pre and post mining, monthly when longwall is within 400m of monitoring site Monthly 2 years pre and post mining, weekly when longwall is within 400m of monitoring site 	<ul style="list-style-type: none"> Wongawilli Creek – Continue as required Donalds Castle Creek – Continue as required WC21 – Continue as required with additional upstream sites DC13 – Continue as required Swamps 5, 1a, 1b, 8, and 13 – Continue as required LA5 – Continue as required Swamp 3, 4 and 11 – Target sites within the subsidence zone of Longwall 12.
	Water Quality		

	<ul style="list-style-type: none"> • WWU1 (Wongawilli Creek headwaters) • WWU4 (Wongawilli Creek upstream) • WC Pool 49 (Wongawilli Creek adjacent to LW15) • WWM1 (Wongawilli Creek adjacent to LW12) • WWM2 (Wongawilli Creek adjacent to LW11) • WWM3 (Wongawilli Creek downstream of LW9) • WWL2 (Wongawilli Creek downstream) • WC21S1 (Wongawilli Creek tributary downstream of mining) • WC21 Pool 30 (Wongawilli Creek tributaries over mining) • WC15S1 (Wongawilli Creek tributary downstream of mining) <p>Lake Avon</p> <ul style="list-style-type: none"> • LA4_S1, LA4_S2, LA5_S1, LA5_S2 <p>Donalds Castle Creek:</p> <ul style="list-style-type: none"> • DCU3 (Donalds Castle Creek lower) • DCL3 (Donalds Castle Creek @ Cordeaux River) • DCS2 (Donalds Castle Creek downstream of mining) • DC13S1 (Donalds Castle Creek tributary downstream of mining) 	<ul style="list-style-type: none"> • Monthly monitoring during and post mining for two years until required 	<ul style="list-style-type: none"> • Continue water quality sample sites as required by the SMP
Swamps			
	<ul style="list-style-type: none"> • Swamps 01a, 01b, 03, 04, 05, 08, and 13 	<ul style="list-style-type: none"> • Pre and post mining for two years, monthly when longwall is within 400m of monitoring site 	<ul style="list-style-type: none"> • Swamps 1a, 3, 4, 5, 8, 10, 11 and 13- Continue as required by the SMP
Shallow Groundwater Level			
	<ul style="list-style-type: none"> • Swamp 01A: 01a_01, 01a_02, 01a_03, 01a_04, 01a_04i, 01a_04ii, 01a_04iii, 01a_04iv, 01a_04v • Swamp 01B: 01b_01, 01b_02, 01b_02i, 01b_02ii, 01b_02iii, 01b_02iv, 01b_03 • Swamp 3: 03_01. • Swamp 05: 05_01, 05_02, 05_03, 05_03i, 05_03ii, 05_03iii, 05_04, 05_05, 05_06 • Swamp 08: 08_01, 08_02, 08_03, 08_04, 08_05, 08_06 • Swamp 10: 10_01 	<p>For open hole sites:</p> <ul style="list-style-type: none"> • Monthly monitoring pre, during and post mining for two years to be removed annually • Reference sites 6 monthly <p>For instrumented sites:</p> <ul style="list-style-type: none"> • Automatic groundwater level monitoring , during and post mining (4 hour interval or similar) • Monitoring post mining for five years to be reviewed annually 	<ul style="list-style-type: none"> • Swamp 01A: 01a_01, 01a_02, 01a_03, 01a_04, 01a_04i, 01a_04ii, 01a_04iii, 01a_04iv, 01a_04v • Swamp 01B: 01b_01, 01b_02, 01b_02i, 01b_02ii, 01b_02iii, 01b_02iv, 01b_03 • Swamp 3: 03_01. • Swamp 05: 05_01, 05_02, 05_03, 05_03i, 05_03ii, 05_03iii, 05_04, 05_05, 05_06 • Swamp 08: 08_01, 08_02, 08_03, 08_04, 08_05, 08_06 • Swamp 10: 10_01 • Swamp 11: S11-HI, S11-H2, S11-H3 – continue as required • Swamp 13: 13_01 – continue as required
Soil Moisture			
	<ul style="list-style-type: none"> • Swamp 05: S05_S01, S05_S02, S05_S03, S05_S03i, S05_S03ii, S05_S03iii, S05_S04, S05_S05, S05_S08 • Swamp 08: S08_S01, S08_S02, S08_S03, S08_S04, S08_S05, S08_S06 	<ul style="list-style-type: none"> • 6 monthly baseline and reference site monitoring • Weekly monitoring when longwall is within 400m of swamp • 6 monthly monitoring for 2 years post mining 	<ul style="list-style-type: none"> • Swamp 05: S05_S01, S05_S02, S05_S03, S05_S03i, S05_S03ii, S05_S03iii, S05_S04, S05_S05, S05_S08 • Swamp 08: S08_S01, S08_S02, S08_S03, S08_S04, S08_S05, S08_S06 • Swamp 11: S11_S01, S11_S02, S11_S05 • Swamp 13: S13_S01, S13_S02, S13_S03

			<ul style="list-style-type: none"> •Swamp 14: 14_01, 14_02 •Swamp 23: 23_01, 23_02 •Swamp 35A: 35a_01 •Swamp 35B: 35b_01 <p>Reference Sites:</p> <ul style="list-style-type: none"> •Swamp 2: S02_S01 •Swamp 7: S07_S05, S07_S06 •Swamp 15A: S15a_S01, S15a_Piezo, S15a_S04, S15a_S06 •Swamp 22: 22_01, 22_02 •Swamp 24: S24_S01 Swamp 25: S25_S01 •Swamp 33: S033_S01, S033_S03 •Swamp 84: S84_S02 •Swamp 85: S85_S01, S85_S02 •Swamp 86: S86_S01, S86_S02 •Swamp 87: S87_S01, S87_S02 • Swamp 88: S88_S01, S88_S02
Landscape	Targeted Sites		
	<p>Cliffs No clifflines associated with Longwall 10</p> <p>Fire Trails Fire road N.6A (Across Longwalls 10-18)</p>	<ul style="list-style-type: none"> • Baseline monitoring campaign prior to monitoring • Monthly monitoring during any subsidence period • Monitoring to continue 6 monthly for 2 years following the completion of mining 	<p>Cliffs No clifflines associated with Longwall 12</p> <p>Fire Trails Fire Road No.6A (across LWs 10-18) - Continue as required by the SMP</p>
Inspection of Active Mining Area – Landscape Features, Vegetation, Watercourses			
	<p>All mapped cliff, steep slopes, watercourse, swamp and fire trail sites in subsidence area</p> <p>General observation of active mining areas</p>	<ul style="list-style-type: none"> • Weekly monitoring when longwall extraction is within 400m of feature 	<p>Continue monitoring of all mapped cliffs, steep slopes, watercourse, swamp and fire trail sites in subsidence area</p> <p>Continue general observation of active mining areas</p>

Appendix A: Table 1- Overview of surface monitoring for Longwall 11.

ASPECT	MONITORING SITE	MONITORING FREQUENCY	MONITORED SITES ASSOCIATED WITH LONGWALL 11
Watercourse	Observational, Photo Point and Water Monitoring		
	<p>Impact Sites:</p> <ul style="list-style-type: none"> • Native Dog, Wongawilli and Donalds Castle Creeks, WC21, WC15, LA4, DC13, LA5, ND1, WC6, WC7, WC8, WC9, WC12, WC16 and WC18 • Swamps 5, 10, 11, 13, 14, 23, 35a, 35b, 1a, 1b, 8, 3 and 4 <p>Reference Sites:</p> <ul style="list-style-type: none"> • Wongawilli Creek, Sandy Creek, LC7B, WC11, SC9A, SC10A, NDC1, DC10 and D10 • Swamps 2, 7, 15a, 22, 24, 25, 33, 84, 85, 86, 87 and 88 	<ul style="list-style-type: none"> • Monthly 2 years pre and post mining, weekly when longwall is within 400m of monitoring site • Reference sites 6 monthly • SLMMP Sites: Pre and post mining, monthly when longwall is within 400m of monitoring site 	<ul style="list-style-type: none"> • Wongawilli Creek • Donalds Castle Creek • WC21 • DC13 • LA5 • Swamps 1a, 1b, 3, 4, 5 8, 10
	<p>Water Quality</p> <p>Wongawilli Creek</p> <ul style="list-style-type: none"> • WWU1 (Wongawilli Creek headwaters) • WWU4 (Wongawilli Creek upstream) • WC Pool 49 (Wongawilli Creek adjacent to LW15) • WC_Pool 46 (Wongawilli Creek adjacent to LW12) • WWM2 (Wongawilli Creek adjacent to LW11) • WC_Pool 43b (Wongawilli Creek downstream of LW9) • Wongawilli Ck (FR6) (Wongawilli Creek downstream) • WC21_Pool 5 (Wongawilli Creek tributary downstream of mining) • WC21 Pools 30 and 53 (Wongawilli Creek tributaries over mining) • WC15_Pool 9 (Wongawilli Creek tributary downstream of mining) <p>Lake Avon</p> <ul style="list-style-type: none"> • LA4_S1, LA4_S2, LA5_S1, LA5_S2, LA3 Pool 4, LA2 Pool 5 and LA_1 (Lake Avon tributaries downstream of mining) • NDC4 (Native Dog Creek downstream of mining) • NDC1 (Native Dog Creek upstream of Area 3B) <p>Donalds Castle Creek</p> <ul style="list-style-type: none"> • Donalds Castle Ck (FR6) (Donalds Castle Creek lower) • DCL3 (Donalds Castle Creek @ Cordeaux River) • DC_Pool 22 (Donalds Castle Creek downstream of mining) • DC13_Pool 2b (Donalds Castle Creek tributary downstream of mining) 	<ul style="list-style-type: none"> • Monthly monitoring pre, during and post mining for two years 	<p>Wongawilli Creek</p> <ul style="list-style-type: none"> • WWU1 • WWU4 • WC Pool 49 • WC_Pool 46 • WWM2 • WC_Pool 43b • Wongawilli Ck (FR6) downstream) • WC21_Pool 5 • WC21 Pools 30 and 53 • WC15_Pool 9 <p>Lake Avon</p> <ul style="list-style-type: none"> • LA4_S1, LA4_S2, LA5_S1, LA5_S2, LA3 Pool 4, LA2 Pool 5 and LA_1 • NDC4 • NDC1 <p>Donalds Castle Creek</p> <ul style="list-style-type: none"> • Donalds Castle Ck • DCL3 • DC_Pool 22 • DC13_Pool 2b
Swamps	Observational, Photo Point and Water Monitoring		
	<p>Impact Sites:</p> <ul style="list-style-type: none"> • Swamps 01A, 01B, 03, 04, 05, 08, 10, 11, 13, 14, 23, 35A and 35B <p>Reference Sites:</p> <ul style="list-style-type: none"> • Swamps 2, 7, 15a, 22, 24, 25, 33, 84, 85, 86, 87 and 88 	<ul style="list-style-type: none"> • Pre and post mining for 2 years, monthly when longwall is within 400m of monitoring site • Weekly inspection and pool water levels when 	<ul style="list-style-type: none"> • Swamps 1a, 1b, 3, 4, 5 8, 10

	<p>longwall is within 400m of monitoring site <ul style="list-style-type: none"> Reference sites 6 monthly </p> <hr/> <p>Erosion Monitoring</p> <p>Impact Sites: <ul style="list-style-type: none"> Swamps 01A, 01B, 03, 04, 05, 08, 10, 11, 13, 14, 23, 35A and 35B </p> <p>Reference Sites: <ul style="list-style-type: none"> Swamps 2, 7, 15A, 22, 24, 25, 33, 84, 85, 86, 87 and 88 </p> <hr/> <p>Shallow Groundwater Level</p> <p>Impact Sites: <ul style="list-style-type: none"> Swamp 01A: 01a_01, 01a_02, 01a_03, 01a_04, 01a_04i, 01a_04ii, 01a_04iii, 01a_04iv, 01a_04v Swamp 01B: 01b_01, 01b_02, 01b_02i, 01b_02ii, 01b_02iii, 01b_02iv, 01b_03 Swamp 03: 03_01 Swamp 04: (thin soil profile) Swamp 05: 05_01, 05_02, 05_03, 05_03i, 05_03ii, 05_03iii, 05_04, 05_05, 05_06 Swamp 08: 08_01, 08_02, 08_03, 08_04, 08_05, 08_06 Swamp 10: 10_01 Swamp 11: S11-H1, S11-H2, S11-H3 Swamp 13: 13_01 Swamp 14: 14_01, 14_02 Swamp 23: 23_01, 23_02 Swamp 35A: 35A_01 Swamp 35B: 35B_01 <p>Note: Swamp 4 is too shallow for a piezometer to be installed. Piezometers to be installed in Swamps 14, 23, 35A and 35B prior to mining</p> <p>Reference Sites: <ul style="list-style-type: none"> Swamp 2: 02_01 Swamp 7: 07_05, 07_06 Swamp 15A: 15a_02, 15a_03, 15a_04, 15a_06, 15a_07, 15a_08, 15a_09, 15a_11, 15a_12, 15a_15 Swamp 22: 22_01, 22_02 Swamp 24: 24_01 Swamp 25: 25_01 Swamp 33: 33_01, 33_03 Swamp 84: 84_02 Swamp 85: 85_01, 85_02 </p> <p>For open hole sites: <ul style="list-style-type: none"> Monthly monitoring pre, during and post mining for two years to be reviewed annually Reference sites 6 monthly </p> <p>For instrumented sites: <ul style="list-style-type: none"> Automatic groundwater level monitoring pre, during and post mining (4 hour interval or similar) Monitoring post mining for five years to be reviewed annually </p> <p>ALS base surveys were completed in December 2005, with a verification base survey performed in 2013, immediately prior to the commencement of Longwall 9 extraction Ground based surveys to be completed for each longwall after each longwall or to define any new erosions identified by ALS survey</p> <ul style="list-style-type: none"> Swamps 1a, 1b, 3, 4, 5 8, 10 </p>
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	<ul style="list-style-type: none"> • Swamp 86: 86_01, 86_02 • Swamp 87: 87_01, 87_02 • Swamp 88: 88_01, 88_02 		
	Soil Moisture		
	<p>Impact Sites:</p> <ul style="list-style-type: none"> • Swamp 03: (thin soil profile) • Swamp 04: (thin soil profile) • Swamp 05: S05_S01, S05_S02, S05_S05, S05_S08 • Swamp 08: S08_S05 • Swamp 11: S11_S01, S11_S02, S11_S05 • Swamp 13: S13_S01, S13_S02, S13_S03 • Swamp 14: 14_01, 14_02 • Swamp 23: 23_01, 23_02 • Swamp 35A: 35a_01 • Swamp 35B: 35b_01 <p>Reference Sites:</p> <ul style="list-style-type: none"> • Swamp 2: S02_S01 • Swamp 7: S07_S05, S07_S06 • Swamp 15A: S15a_S01, S15a_Piezo, S15a_S04, S15a_S06 • Swamp 22: 22_01, 22_02 • Swamp 24: S24_S01 • Swamp 25: S25_S01 • Swamp 33: S033_S01, S033_S03 • Swamp 84: S84_S02 • Swamp 85: S85_S01, S85_S02 • Swamp 86: S86_S01, S86_S02 • Swamp 87: S87_S01, S87_S02 • Swamp 88: S88_S01, S88_S02 	<p>For manually measured sites:</p> <ul style="list-style-type: none"> • Monthly monitoring for 2 years baseline and post mining and 6 monthly reference site • Weekly monitoring when longwall is within 400m of monitoring site <p>For instrumented sites:</p> <ul style="list-style-type: none"> • Automatic soil moisture monitoring pre, during and post • Monitoring post mining for five years to be reviewed annually 	
Landscape	Targeted sites		
	<p>Cliffs</p> <ul style="list-style-type: none"> • DA3-CF19 (E LW13) • DA3-CF20 (E LW13) • DA3-CF21 (E LW13) • DA3-CF22 (E LW13) • DA3-CF23 (E LW13) • DA3-CF25 (E LW17) • DA3-CF26 (E LW17) • DA3-CF41 (E LW18) • DA3-CF42 (E LW18) • DA3-CF43 (E LW18) <p>Watercourses/Swamps Refer to DA3B Watercourses/Swamps Impact Monitoring Management Contingency Plan/s</p> <p>Fire Trails</p>	<ul style="list-style-type: none"> • Baseline monitoring campaign prior to mining • monthly monitoring during any subsidence period • Monitoring to continue 6 monthly for 2 years following the completion of mining 	<p>Cliffs No clifflines associated with Longwall 10</p> <p>Fire Trails Fire Road No.6A (across LWs 10-18)</p>

	<ul style="list-style-type: none"> • Fire Road No.6A (across LWs 10-18) • Fire Road No.6N (across LW14) • Fire Road No.6Q (across LW 15, 16 and 17) 			
Inspection of Active Mining Area - Landscape Features, Vegetation, Watercourses				
	<table border="0" style="width: 100%;"> <tr> <td data-bbox="360 193 1115 327"> <ul style="list-style-type: none"> • All mapped cliff, steep slopes, watercourse, swamp and fire trail sites in subsidence area • General observation of active mining areas </td> <td data-bbox="1115 193 1637 327"> <ul style="list-style-type: none"> • Weekly monitoring when longwall extraction is within 400m of feature </td> <td data-bbox="1637 193 2098 327"> <ul style="list-style-type: none"> • All mapped cliff, steep slopes, watercourse, swamp and fire trail sites in subsidence area • General observation of active mining areas </td> </tr> </table>	<ul style="list-style-type: none"> • All mapped cliff, steep slopes, watercourse, swamp and fire trail sites in subsidence area • General observation of active mining areas 	<ul style="list-style-type: none"> • Weekly monitoring when longwall extraction is within 400m of feature 	<ul style="list-style-type: none"> • All mapped cliff, steep slopes, watercourse, swamp and fire trail sites in subsidence area • General observation of active mining areas
<ul style="list-style-type: none"> • All mapped cliff, steep slopes, watercourse, swamp and fire trail sites in subsidence area • General observation of active mining areas 	<ul style="list-style-type: none"> • Weekly monitoring when longwall extraction is within 400m of feature 	<ul style="list-style-type: none"> • All mapped cliff, steep slopes, watercourse, swamp and fire trail sites in subsidence area • General observation of active mining areas 		

Appendix A: Table 2- Area 3B Impacts, TARPs & Performance Measures – Longwall 11 End of Panel Report

Performance Measure	Potential Impacts	Exceeding Prediction	TARP Trigger Level	Observed Impacts	Additional Comments
WATERCOURSES					
<p>Wongawilli Creek & Donalds Castle Creek</p> <p><i>Area 3B SMP Approval:</i> Minor environmental consequences including:</p> <ul style="list-style-type: none"> • <i>minor</i> fracturing, gas release and iron staining; and • <i>minor</i> impacts on water flows, water levels and water quality. <p><i>Dendrobium Modified Development Consent:</i></p> <ul style="list-style-type: none"> • Operations shall not cause subsidence impacts at Wongawilli Creek other than “minor impacts” (such as minor fracturing, gas release, iron staining and minor impacts on water flows, water levels and 	<p>Minor environmental consequences including: minor fracturing, gas release and iron staining; and minor impacts on water flows, water levels and water quality</p>	<p><u>Observational</u></p> <ul style="list-style-type: none"> • Fracturing within Wongawilli Creek and/or Donalds Castle Creek resulting in diversion of flow such that >10% of the pools (in Wongawilli Creek or Donalds Castle Creek) have water levels lower than baseline period • Measured surface water flow reduction in Wongawilli Creek and/or Donalds Castle Creek at its confluence with Cordeaux River that is greater than predicted by the groundwater model (to the satisfaction of the Director General - Condition 13 of the SMP) that cannot be attributed to natural variation • Structural integrity of the 	<p><u>Observational</u> Level 1</p> <ul style="list-style-type: none"> • 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 	<p>No Level 1 impacts observed</p>	<p>No observed impacts to Wongawilli Creek or Donalds Castle Creek during extraction of Longwall 11.</p>

Performance Measure	Potential Impacts	Exceeding Prediction	TARP Trigger Level	Observed Impacts	Additional Comments
<p>water quality);</p> <ul style="list-style-type: none"> • Operations will not result in reduction (other than negligible reduction) in the quality or quantity of surface water or groundwater inflows to Lake Cordeaux or Lake Avon or surface water inflow to the Cordeaux River at its confluence with Wongawilli Creek. 		<p>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</p> <ul style="list-style-type: none"> • Gas release results in vegetation dieback that does not revegetate • Gas release results in mortality of threatened species or ongoing loss of aquatic habitat • Iron staining and associated increases in dissolved iron resulting from the mining is observed in water at Wongawilli Creek downstream monitoring site WONGAWILLI CK (FR6) • Iron staining and associated increases in dissolved iron resulting from the mining is observed in water at the Donalds Castle Creek downstream monitoring site Donalds Castle Ck (FR6) 	<p>Level 2</p> <ul style="list-style-type: none"> • 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 	No Level 2 impacts observed	
			<p>Level 3</p> <ul style="list-style-type: none"> • 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 	No Level 3 impacts observed	

Performance Measure	Potential Impacts	Exceeding Prediction	TARP Trigger Level	Observed Impacts	Additional Comments
			habitat • Observable increase in iron staining within the mining area continues more than 600m from the longwall		
		<u>Pool Water Level</u> Fracturing resulting in diversion of flow such that >10% of the pools have water levels lower than baseline period	<u>Pool Water Level</u> Level 1 • Fracturing not resulting in diversion of flow	No Level 1 impacts observed	
			Level 2 • Fracturing resulting in diversion of flow	No Level 2 impacts observed	
			Level 3 • Fracturing resulting in diversion of flow such that <10% of the pools have water levels lower than baseline period	No Level 3 impacts observed	

Performance Measure	Potential Impacts	Exceeding Prediction	TARP Trigger Level	Observed Impacts	Additional Comments
	<p>Drainage lines</p> <ul style="list-style-type: none"> • Changes in the natural gradient and stream alignment • Changes in the levels of ponding, flooding and scouring of the banks • Surface fracturing • Surface water diversion • Induction of ferruginous springs <p><i>N.B. Not linked specifically to a performance measure</i></p>	<ul style="list-style-type: none"> • Structural integrity of the bedrock base of any significant pool or controlling rockbar cannot be restored i.e. pool water level within the pool after CMAs continues to be lower than baseline period • Gas release results in vegetation dieback that does not revegetate • Gas release results in mortality of threatened species or ongoing loss of aquatic habitat • Iron staining and associated increases in dissolved iron resulting from the mining is observed in water at Wongawilli Creek downstream monitoring site Wongawilli CK (FR6) 	<p>Level 1</p> <ul style="list-style-type: none"> • 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 	<ul style="list-style-type: none"> • Impact DA3B_LW11_010 - Rock fractures on WC21_Rockbar 27 with associated hairline cracks and uplift, displaced rock fragment. 	<p>See Impact Report dated 11/02/2016</p>

Performance Measure	Potential Impacts	<i>Exceeding Prediction</i>	TARP Trigger Level	Observed Impacts	Additional Comments
		<ul style="list-style-type: none"> • 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) 	<p>Level 2</p> <ul style="list-style-type: none"> • 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 	<ul style="list-style-type: none"> • Impact DA3B_LW11_008 – A 30m fracture zone in WC21, on a rockbar upstream of Pool 30 resulting in observable loss of surface water or erosion. Multiple fractures up to 2m long, 0.03m wide and a depth of 0.3m (max). 	<p>See Impact Report dated 15/01/2016</p>

Performance Measure	Potential Impacts	Exceeding Prediction	TARP Trigger Level	Observed Impacts	Additional Comments
			<p>Level 3</p> <ul style="list-style-type: none"> • 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 	No Level 3 impacts observed	
SWAMPS					
	<p>Falls in surface or near-surface groundwater levels in swamps.</p> <p><i>N.B not linked specifically to a performance measure and would not be considered a breach if predictions were exceeded.</i></p>		<p>Level 1</p> <p>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).</p>	<ul style="list-style-type: none"> • Swamp 5: Groundwater levels at 2 out of 6 boreholes have dropped to below those seen in the baseline period. 	<p>As reported in the LW 10 EoP Report; groundwater levels lower than baseline, and recession rates lower than baseline measured in monitoring sites for Swamps 1a and 1b attributed to LW 9/10 extraction. See report dated 18/12/15</p>

Performance Measure	Potential Impacts	Exceeding Prediction	TARP Trigger Level	Observed Impacts	Additional Comments
			<p>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.</p>	No new Level 2 impacts observed.	As reported in the LW 10 EoP Report; groundwater levels lower than baseline, and recession rates lower than baseline measured in >50% of monitoring sites for Swamps 1a and 1b attributed to LW 9/10 extraction.
			<p>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.</p>	<ul style="list-style-type: none"> • Swamp 5: Groundwater reduction rates exceed those before the baseline period at 6 out of 6 boreholes. 	
	<p>Falls in soil moisture levels in swamps.</p> <p><i>N.B. Not linked specifically to a performance measure and would not be considered a breach if predictions were exceeded.</i></p>		<p>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).</p>		

Performance Measure	Potential Impacts	Exceeding Prediction	TARP Trigger Level	Observed Impacts	Additional Comments
			<p>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)</p>		
			<p>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).</p>	<ul style="list-style-type: none"> • Swamp 5: 4 out of 4 soil moisture sites have recorded moisture levels lower than baseline. 	Soil moisture levels at all sites continue to fluctuate in accordance with rain events. See Impact Report dated 19/02/2016
LANDSCAPE					
	<p>The cliffs located in the SMP Area are all located outside the extents of the proposed longwalls, at minimum distances of 30 m to 460 m at the closest points. It is possible therefore that some small isolated rock falls could occur along the cliffs as a result of the extraction of the proposed longwalls. It is not expected however, that, any large scale cliff instabilities would occur based on previous experience.</p> <p>Impacts to steep slopes due to mining induced subsidence are most likely to occur in the form of surface cracks. Experience indicates that the likelihood of large-scale down-slope movements is extremely low due to the high depth of</p>		<p>Level 1</p> <ul style="list-style-type: none"> • 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 	<ul style="list-style-type: none"> • DA3B_LW11_003 – Soil crack on seismic track west of Swamp 5 • DA3B_LW11_004 - Soil crack on seismic track east of Swamp 5 • DA3B_LW11_005 - Soil crack on seismic track east of Swamp 5 • DA3B_LW11_006 - Soil crack on seismic track east of Swamp 5 • DA3B_LW11_007 – Soil crack on AT6000- (upgraded to Level 2) • DA3B_LW11_009 - Soil crack on seismic track west of WC21. • DA3B_LW11_011 - Soil crack on seismic track east of WC21. 	Soil cracks stabilised and expected to infill through natural processes. Refer to relevant impact reports dated 25/06/2015, 24/08/2015, 21/09/2015, 24/09/2015, 11/12/2015, 05/02/2016 and 26/02/1016

Performance Measure	Potential Impacts	Exceeding Prediction	TARP Trigger Level	Observed Impacts	Additional Comments
	<p>cover within the SMP Area. If tension cracks do develop it is possible that soil erosion may occur if the cracks are left untreated. Some remediation may therefore be required.</p>		<p>naturally stabilise without CMA and within the period of monitoring</p>		
			<p>Level 2</p> <ul style="list-style-type: none"> • 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 	<ul style="list-style-type: none"> • DA3B_LW11_001 - Soil crack on FR6A 25m long with uplift. • DA3B_LW11_002 - Soil crack on FR6A 20m long with uplift. • DA3B_LW11_007 - Soil cracking on AT6000 upgraded to a Level 2 impact 	<p>Impact DA3B_LW11_007 revised to a Level 2 as it had the potential to impede traffic, impact has since been infilled for safe vehicular access. See Impact Report dated 2/06/2015</p>

Performance Measure	Potential Impacts	Exceeding Prediction	TARP Trigger Level	Observed Impacts	Additional Comments
			<p>the period of monitoring, or is located in a sensitive area e.g. swamps, creek, lake shore, and may result in increased sediment transport to Cordeaux Dam, or has been previously identified as Level 1, but is not likely to naturally stabilise within the monitoring period</p>		
			<p>Level 3</p> <ul style="list-style-type: none"> • 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 	NA	No Level 3 Landscape Impacts observed.

References

- Illawarra Coal, 2015. *Swamp Impact, Monitoring, Management and Contingency Plan*, Revision 1.4, June 2015. Approved 29/06/15 (T&I) and 10/07/2015 (DPE).
- Illawarra Coal, 2015. *Watercourse Impact, Monitoring, Management and Contingency Plan*, Revision 1.4, May 2015. Approved 29/06/15 (T&I) and 10/07/2015 (DPE).
- BHP Billiton Illawarra Coal, 20125. *Dendrobium Area 3B Subsidence Monitoring Plan*, Volume 1 and 2.