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Attention: Billy Agland

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Dear Billy,

LONGWALL 18 END OF PANEL REPORT AQUATIC FLORA AND FAUNA REVIEW

Introduction

South 32 Illawarra Metallurgical Coal (South32) extracts coal using longwall mining techniques from the Dendrobium Coal Mine, situated approximately 15 km to 20 km west of Wollongong. Consent for the mine, granted in November 2001, allows extraction from three longwall domains, known as Areas DA1, DA2 and DA3. DA3, situated to the east of Lake Avon, is currently being mined. A modification to the mine layout of DA3, approved in December 2008, allowed the mine to be expanded, with Area 3 divided into three smaller domains, DA3A, DA3B and DA3C. Longwalls in DA3B have been extracted as follows:

- > Longwall 9 commenced 9 February 2013; completed on 2 June 2014;
- > Longwall 10 commenced 21 January 2014; completed 20 January 2015;
- > Longwall 11 commenced 18 February 2015; completed 26 January 2016;
- > Longwall 12 commenced 22 February 2016, completed 31 January 2017;
- > Longwall 13 commenced 3 March 2017, completed on 19 April 2018;
- > Longwall 14 commenced 22 May 2018, completed 26 February 2019;
- > Longwall 15 commenced 4 April 2019, completed 22 January 2020;
- > Longwall 16 commenced 25 February, completed 4 November 2020;
- > Longwall 17 commenced 12 December 2020, completed 13 October 2021; and,
- > Longwall 18 commenced 2 December 2021, completed 17 May 2022.

Cardno NSW/ACT now Stantec (Cardno) was commissioned by South32 to undertake a review of the status of aquatic flora and fauna in relation to the extraction of Longwall 18 to support the End of Panel reporting. Cardno has been undertaking ongoing monitoring of watercourses within the DA3B mining area including the perennial Wongawilli Creek, Donalds Castle Creek and several associated first and second order ephemeral / intermittent tributaries. The overall objective of the monitoring is to determine whether the extent and nature of observed impacts, primarily subsidence-induced fracturing of bedrock, flow diversion and loss of aquatic habitat, if any, are consistent with the predictions made in the Aquatic Flora and Fauna Assessment (AFFA) (Cardno Ecology Lab 2012) and Subsidence Management Plan (SMP) (BHPBIC 2012) for DA3B. This review includes:

- > An overview of the management of aquatic flora and fauna including monitoring proposed and undertaken;

- > Review of observed impacts to aquatic habitat, flora and fauna from South32 impact reports and a comparison with those predicted in the SMP; and,
- > Recommendations for any Corrective Management Actions (CMA) and future aquatic flora and fauna monitoring.

This review focuses on any physical and water quality impacts to watercourses overlaying and within 400 m (i.e., have potential to be impacted based on previous observations of mining impacts in the dendrobium mine area) of Longwall 18 and any associated potential impacts to aquatic habitat and biota that may have occurred during extraction of Longwall 18. These are Lake Avon Tributary LA2, Native Dog Creek and Native Dog tributaries ND1, ND2, ND1A, ND1B and ND1C. The aquatic ecology impact assessment is based on the findings of ongoing field surveys in these watercourses by the Illawarra Metallurgical Coal Environmental Field Team (IMCEFT) and on Cardno's experience of undertaking monitoring and assessment of aquatic habitat and biota in the Dendrobium Mine Area.

During extraction of Longwall 18, water quality impacts were observed in tributary LA4, which is outside of the 400 m boundary of Longwall 18. These impacts have not been attributed to Longwall 18. Nevertheless, they are included in this review. The potential impacts to aquatic ecology attributed to extraction of Longwall 18 are also placed in context of the cumulative impacts to aquatic ecology experienced in the Dendrobium Mine. A full assessment of impacts due to extraction of all longwalls in DA3B will be provided in the latest biennial monitoring report (Cardno 2022a). Any impacts to swamps and amphibians are considered by other specialist consultants.

Aquatic Ecology Management and Monitoring

The monitoring requirements recommended in the AFFA for DA3B and included in the SMP for DA3B incorporates a Before, After, Control, Impact (BACI) sampling design. The program monitors 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 for DA3B as a measure of aquatic health:

- > Aquatic habitat condition - using a modified version of the Riparian, Channel and Environmental Inventory method (RCE) (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.

It was recommended that monitoring in DA3B be undertaken once every two years (Cardno Ecology Lab, 2012).

Table 1-1 summarises the monitoring that has been completed in DA3B in line with the AFFA and SMP. Baseline surveys were undertaken in DA3B in 2010 and 2011 (Cardno Ecology Lab 2011), followed by the during-extraction monitoring in 2013 (Cardno Ecology Lab 2014), 2015 (Cardno 2016), 2017 (Cardno 2018), 2019 (Cardno 2020a) and 2021 (Cardno 2022a). Additional monitoring was undertaken in DA3B in 2011 to support the AFFA, including more extensive fish surveys in WC21 and during the 2014 investigations in DA3A (Cardno Ecology Lab 2015). The AFFA also included a literature review on the physical setting, aquatic habitat, water quality, aquatic macroinvertebrates, fish, threatened species, populations and ecological communities in DA3B.

South32 undertake weekly monitoring of landscape and natural features in DA3B when within 400 m of the active longwall, and monthly thereafter. This includes monitoring during extraction of DA3B longwalls to identify any fracturing, pool water level reduction, changes in flow and water quality in Wongawilli Creek, Donalds Castle Creek, Lake Avon, and their tributaries.

The SMP includes the following triggers as part of the Trigger Action Response Plans (TARPs) relating to aquatic ecology:

- > Level 1 – Reduction in aquatic habitat for 1 year;
- > Level 2 – Reduction in aquatic habitat for 2 years following the active subsidence period (i.e., when a longwall is within 400 m of a feature, such as a creek, is completed); and
- > Level 3 – Reduction in aquatic habitat for >2 years or complete loss of habitat following the active subsidence period.

Table 1-1 Monitoring undertaken for DA3B longwalls in line with the DA3B SMP Requirements and Recommendation in Cardno Ecology Lab (2012)

Report	Survey Date	Sampling Component
Baseline Monitoring		
Dendrobium Areas 3A and 3B. Aquatic Ecology Monitoring 2008 to 2013 (Cardno Ecology Lab 2014)	Mar / May / Sep / Nov 2010	Habitat assessment, fish, macroinvertebrates, water quality
	Apr / Jun / Sep / Oct 2011	
During Extraction Monitoring		
Dendrobium Areas 3A and B. Aquatic Ecology Monitoring 2008 to 2013 (Cardno Ecology Lab 2014)	Apr / Jun / Sep / Nov 2013	Habitat assessment, fish, macroinvertebrates, water quality
Dendrobium Area 3A Aquatic Ecology Monitoring 2008 to 2014 (Cardno Ecology Lab 2015)	Throughout 2014	Observations of mining impacts and effects on aquatic habitat in WC21 in 2014 that were attributed to extraction of Longwalls 9 and 10, undertaken as part of DA3A monitoring fieldwork
Dendrobium Area 3B Aquatic Ecology 2010 to 2015 (Cardno 2016)	May / Jun / Oct / Nov 2015	Habitat assessment, fish, macroinvertebrates, water quality
Dendrobium Area 3B Aquatic Ecology 2010 to 2017 (Cardno 2018)	Apr / May / Oct / Nov 2017	Habitat assessment, fish, macroinvertebrates, water quality
Dendrobium Area 3B Aquatic Ecology 2010 to 2019 (Cardno 2020a)	May / Jun / Oct / Nov 2019	Habitat assessment, fish, macroinvertebrates, water quality
Dendrobium Area 3B Aquatic Ecology 2010 to 2021 (Cardno 2022a)	Apr / May / Sep / Oct 2021	Habitat assessment, fish, macroinvertebrates, water quality

These trigger specific management actions aim to minimise any further impacts to the aquatic environment, and include requirements for further monitoring, reporting, application of corrective management actions (CMAs), such as grouting and repair of fractures, and notification of relevant stakeholders, as required.

Predicted and Observed Impacts

Physical and Water Quality Mining Impacts

Details of the mining related impacts identified in watercourses by IMCEFT (South32 2022) during extraction of Longwall 18 are provided in **Table 1-2**. No physical or water quality impacts were observed in watercourses above or within 400 m of Longwall 18. Three water quality impacts were identified in Lake Avon tributary LA4, which overlays Longwalls 12 and 13 (HGEO 2022). Results reached the TARP trigger for pH, Dissolved Oxygen and Electrical Conductivity (**Table 1-3**). These changes in water quality were observed at the end of 2021. these impacts are not attributed to extraction of Longwall 18. LA4 was impacted following the commencement of Longwalls 12 and 13, with rock fracturing and subsequent flow diversion observed here.

More recently on 8 June 2022, pool water loss was observed in pool ND1C_Pool 2 on NDC1 (South32 2022b). This pool is located directly above Longwall 18 and was mined underneath on 1 April 2022. The pool was found to be dry for the first time since monitoring began in September 2020. No fracturing was observed in the pool or tributary. Also, although not attributed to Longwall 18, LA2 monitoring sites that were mined beneath by Longwall 16 and 17 (LA2 Pool 24, Pool 25 and Pool 32) had no water present during the June inspection despite recent rainfall. LA2 has previously experienced fracturing and flow diversions associated with extraction of Longwall 17. Following the completed extraction of Longwall 18, some pooling was observed further downstream in LA2 and low flow was evident entering Lake Avon.

Localised iron staining was observed in LA3 on 18 August 2022. LA3 is above Longwalls 15 and 16 and the iron staining here was not attributed to extraction of Longwall 18. Iron staining was also observed in Wongawilli Creek, WC21, LA5 and SC10C, though these were first observed prior to commencement of extraction of Longwall 18 (HGEO 2022). No elevations in concentrations of metals were attributed to extraction of Longwall 18 (HGEO 2022).

Table 1-2 Mining related impacts observed in watercourses by IMCEFT during extraction of DA3B Longwall 18

Site ID	Impact Type	Watercourse	Identification	Description	Trigger Level
LA4_S1	Water Quality Trigger	LA4	17/12/2021	Trigger for dissolved oxygen	1
LA4_S1	Water Quality Trigger	LA4	17/12/2021	Trigger for pH	Exceeds Predictions
LA4_S1	Water Quality Trigger	LA4	17/12/2021	Trigger for electrical conductivity.	Exceeds Predictions

Table 1-3 Measures of water quality at LA4_S1 on Lake Avon tributary LA4 recorded by IMCEFT

Measure	18/11/21	17/12/21	Tarp Level
pH (pH units)	4.11	4.01	< 4.90
DO (% Sat.)	86.4	67.6	< 69.5
EC (µS/cm)	172	160	< 130

Impacts on Aquatic Habitat and Biota

The assessment of impacts to aquatic habitat and biota due to the physical and water quality impacts observed by South32 and described above are summarised in **Table 1-4**. The findings are compared with the impacts to aquatic habitat and biota predicted to occur in the AFFA for DA3B (Cardno Ecology Lab 2012). These predictions were based on the maximum predicted subsidence parameters for the sections of Wongawilli Creek, Donalds Castle Creek and tributaries that flow through the DA3B SMP Area, their predicted impacts on the physical and water chemistry characteristics of the waterways (MSEC 2011), and the assessment of potential impacts on surface water quality (Ecoengineers 2011).

Given that no mining induced physical or water quality impacts attributed to Longwall 18 have been observed in watercourses overlying or within 400 m of Longwall 18 (LA2, Native Dog Creek, ND1, ND2, ND1A, ND1B and ND1C), associated impacts to aquatic habitat or biota due to Longwall 18 extraction are not expected to have occurred. Physical and water quality impacts identified in LA2 and LA4, however, indicate ongoing impacts to aquatic habitat and biota in this watercourse unrelated to Longwall 18. Previous physical mining impacts resulting in fracturing, flow diversions and pool drainage were first observed in LA4 following extraction of Longwall 14 (Cardno 2019) and in LA2 following extraction of Longwall 17. This is expected to be associated with some reduction in the amount of ephemeral aquatic habitat. Although severe at the scale of individual pools and tributaries, based on the abundance of first and second order stream habitat in the local area, in isolation these impacts are considered relatively minor in the context of the Metropolitan Catchment Special Area.

Although not directly associated with extraction of Longwall 18, the changes in water quality identified in LA4 are unlikely to result in significant impacts to aquatic biota. Although reductions in pH in LA4 were below the lower ANZECC Default Trigger Values (DTV) for pH (pH 6.5) (ANZECC/ARMCANZ 2000), this was also the case during the baseline period. The elevated EC recorded in LA4 did not exceed the upper DTV (350 µS/cm). Also, although the reduction in DO was below the lower DTV (90 % saturation), the mean DO recorded during the baseline period (67.6 % saturation) was also below the DTV. Thus, water quality in this area of the Dendrobium Mine is natural variable and often outside default water quality guidelines. Given these changes were also short term, and the ephemeral nature of LA4 being associated with limited aquatic habitat, this does not suggest observed changes in water quality in this watercourse would result in significant impacts to aquatic habitat or biota. Similarly, the localised iron staining in the ephemeral LA3 would not result in significant impacts to aquatic ecology.

The cumulative impact to tributaries due to extraction of longwalls in DA3B and the wider Metropolitan Catchment should, however, be considered. Mapping by IMCEFT indicates that approximately 38.6 km of the total 716 km length of watercourse habitat located directly above longwall mining (Cardno 2022b). This could result in loss of flow and reduction in pool water level. It is noted that a large proportion of this is expected to be ephemeral and intermittent first and second order watercourses that provide more limited habitat for aquatic biota compared with larger and more permanent watercourses such as Wongawilli Creek. Nevertheless, these watercourses would still provide habitat and connectivity for some species at times of high rainfall. Given these tributaries are ephemeral, and thus, provide disconnected habitat irrespective of mining, any further reduction in connectivity associated with flow diversions would not be expected to result in significant impacts to aquatic habitat and biota. It is also expected that that connectivity would occur during high rainfall events.

Table 1-4 Predicted and observed impacts to aquatic ecology associated with Longwall 18.

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 18.
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 400 metres 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 or upslope 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 18, and thus no suggestion of impacts occurring to aquatic habitat and biota. No changes to existing Iron straining or water quality triggers observed in Wongawilli Creek.
Donalds Castle Creek and Tributaries (as appropriate to each longwall)			
Ponding, flooding and scouring of stream banks due 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 stream banks in highly localised areas along the tributaries. 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 to tilt but will be difficult to detect because of the large variability in natural flows within these ephemeral systems.	No impacts observed due to tilt.
Fracturing of bedrock and diversion of surface flows	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 underlying strata and drainage of pools may occur, particularly during low flows. It is unlikely, that this would result in a significant impact on the overall quantity or 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, or tributaries of these creeks during extraction of Longwall 18. Some reductions in pool water levels in ND1C and LA2. Changes to water quality observed in LA4 and iron staining in LA3 are not expected to have resulted in significant impact to aquatic biota or habitat. The reductions in pool water levels in NDC1 and LA2 would have negligible impacts to aquatic habitat and biota at the scale of the Native Dog Creek and Lake Avon catchments

It is very unlikely that the threatened Macquarie perch previously identified downstream in Wongawilli Creek has been put at risk by extraction in DA3B. Macquarie perch has been recorded in Dendrobium Area 3 in the mid to lower reaches of Wongawilli Creek, including pools just upstream and downstream of the Fire Road 6 crossing (Cardno 2018 and references therein). However, this species was not identified further upstream in Wongawilli Creek. This was despite extensive sampling here as part of this and previous surveys in Wongawilli Creek for the DA3B monitoring program. It is possible that this species is unable to pass the natural barrier in the form of a cascade / waterfall present a few hundred metres upstream of the Fire Road 6 crossing, at least not in any appreciable numbers. Macquarie perch would be very unlikely to occur in LA4 or in tributaries overlaying Longwall 18 due to the absence of suitable habitat otherwise provided by large permanent pools.

It is difficult to quantify the additional impact to aquatic habitat and biota in DA3B due to extraction of individual longwalls. The water quality triggers observed in LA4 during extraction of Longwall 18, occurred over 1.7 km away, have not been attributed directly to extraction of Longwall 18, and occurred following several other mining related impacts during extraction of previous DA3B longwalls. However, it is probable that Longwall 18 extraction has increased the existing impacts to water levels and flow associated groundwater depressurisation in DA3B. Physical mining impacts that have occurred can be associated with

individual longwalls or a cumulative effect of several longwalls. In such cases, it is difficult to determine if aquatic ecology impacts are due to a delayed response following extraction of earlier longwalls, a cumulative effect of extracting multiple longwalls, or a combination of mining impacts with prevailing environmental conditions e.g., prolonged reduced rainfall periods.

Aquatic Ecology TARP

Table 1-5 compares observed impacts to aquatic ecology with the aquatic ecology TARP levels to determine if any have been triggered and what management actions associated with extraction of Longwall 18 and previous longwalls may be appropriate, if any. These TARPS are applicable to watercourses where aquatic ecology monitoring sites are located (Wongawilli Creek, Donalds Castle Creek, and WC21). For Site X1 on Donalds Castle Creek, the active subsidence period ended on 24 October 2013 when Longwall 9 was more than 400 m away from this site. It is noted that the TARP triggers here relate to mining of the domain as a whole, rather than individual longwalls. Thus, the reduction in aquatic habitat observed at these sites constitute a Level 3 Trigger. Actions for a Level 3 Trigger include notification of stakeholders and the development and implementation of CMAs. Longwall 18 is not within the Donalds Castle Creek or WC21 catchments. Extraction of this longwall is not expected to have affected the availability of aquatic habitat in these creeks. The reductions in pool water levels and aquatic habitat in Wongawilli Creek during 2018 occurred for less than 1 year and did not constitute a trigger.

Table 1-5 TARP triggers and current status in Wongawilli Creek and Donalds Castle Creek

TARP	Donalds Castle Creek	WC21	Wongawilli Creek
Level 1 – Reduction in aquatic habitat for 1 year	Triggered: September 2014	Triggered: December 2014	Not triggered
Level 2 – Reduction in aquatic habitat for 2 years following the active subsidence period (i.e., when a longwall within 400 m of a feature, such as a creek, is completed)	Triggered: 24 October 2015	Triggered: 20 January 2017	Not triggered
Level 3 – Reduction in aquatic habitat for >2 years or complete loss of habitat following the active subsidence period	Triggered: During 2017 Aquatic Ecology Surveys (Cardno 2018)	Triggered: During 2017 Aquatic Ecology Surveys (Cardno 2018)	Not triggered

Conclusion and Recommendations

No physical or water quality impacts to watercourses in DA3B have been attributed to extraction of Longwall 18. The water quality triggers in LA4 represent relatively minimal impacts to aquatic habitat and biota. In any case, these occurred over 1.7 km to the north of Longwall 18 and have not been attributed to extraction of this longwall. At this stage, no specific actions associated with Longwall 18 or LA4 are recommended.

It would be expected that extraction of Longwall 18 would have contributed to mining induced groundwater depressurisation in DA3B (HGEO 2022). Physical mining impacts, reduction in availability of aquatic habitat and assumed loss of some associated aquatic biota in tributaries overlying and within 400 m of Longwall 18 may also have occurred but have not yet been observed. Such impacts could result in a greater potential for and severity of any future similar reductions in pool water levels and flow in tributaries and Wongawilli Creek. It is noted that previous reductions in flow observed in Wongawilli Creek have been within predictions. No aquatic ecology TARPs have been triggered with respect to Wongawilli Creek. Level 3 triggers were in place for WC21 and Donalds Castle Creek prior to extraction of Longwall 18 and remain in place.

It is recommended that further during- and post-mining aquatic ecology monitoring is completed in DA3B in Wongawilli Creek and WC21 in line with the AFFA and SMP. South32 should continue to monitor watercourses (as required by the SMP) that have been affected by Area 3B longwalls. The findings of these will be used to assess whether TARPs will subsequently be triggered.

Yours sincerely,



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