DENDROBIUM
LONGWALL 19A

OCTOBER 2023

LONGWALL 19A

SWAMP IMPACT, MONITORING, MANAGEMENT AND CONTINGENCY PLAN

Table of Contents

Tables

Figures

Appendices

Review History

REVISION	DESCRIPTION OF CHANGES	DATE	APPROVED BY
A	New Document-DRAFT	September 2023	GB
B	Amended to include Agency feedback	October 2023	GB
C	Amended to include further Agency feedback	October 2023	GB

Prepared By:

Illawarra Metallurgical Coal
Port Kembla Coal Terminal
Port Kembla Road, Inner Harbour
PORT KEMBLA NSW 2502

Persons involved in the development and review of this document include:

NAME & TITLE/COMPANY	QUALIFICATIONS	EXP. (YRS)	AREA OF EXPERTISE
Illawarra Metallurgical Coal			
Billy Agland Specialist Environment	BSc (Env)	6.5	Environment and Subsidence
Josh Carlon Coordinator Environment	BSc	15	Environment and Subsidence
Linda Zanotto Principal Approvals	BEng (Envi), CEnvP (IA, REAP)	20	Impact Assessment, Environmental Management and Planning
Gary Brassington Manager Approvals	BAppSc	30	Environment and Subsidence
Technical Experts			
Will Minchin Watershed Hydrogeo	MEngSci, BE (Enviro) (Hons)	20	Hydrogeology
Stuart Brown HGEO	PhD (Geology), MSc (Hydrogeology)	25	Hydrogeology
Luke Stone Niche-EH	MRes, BEnvSc	7	Aquatic and Terrestrial Ecology

1 INTRODUCTION

1.1 Project Background

Illawarra Metallurgical Coal (IMC) operates the underground Dendrobium Mine, located in the Southern Coalfield of New South Wales. Longwalls from the Wongawilli Seam have been mined in Areas 1, 2, 3A, 3B and 3C.

IMC was granted Development Consent by the NSW Minister for Planning for the Dendrobium Project on 20 November 2001. In 2007, IMC proposed to modify its underground coal mining operations and the NSW Department of Planning advised that the application for the modified Area 3 required a modification to the original consent. The application followed the process of s75W of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and required the submission of a comprehensive Environmental Assessment (Cardno 2007). The Environmental Assessment (EA) described the environmental consequences likely from cracking and diversion of surface water as a result of the proposed mining. These impacts included diversion of flow, lowering of aquifers, changes to habitat for threatened species as well as other impacts and environmental consequences.

On 8 December 2008, the Minister for Planning approved a modification to DA_60-03-2001 for Dendrobium Underground Coal Mine and associated surface facilities and infrastructure under Section 75W of the EP&A Act.

Schedule 3, Condition 7 of the Development Consent requires the development of a Subsidence Management Plan (SMP) for approval prior to carrying out mining operations that could cause subsidence in Areas 3A, 3B and 3C.

A SMP application for Longwall 19A in Area 3A was submitted to the Department in December 2022. On 16 June 2023, the application was referred to the Independent Expert Advisory Panel for Mining (the Panel) to provide advice on the SMP, specifically in relation to the proposed setback distance of the longwall from Swamp 15a. The SMP application proposed that Longwall 19A be setback a distance of 61 m from Swamp 15a. This setback distance was based on historic analysis of Dendrobium coastal upland swamps (Watershed Hydrogeo, 2019) which found that rapid drawdown to levels lower than pre-mining levels in the water tables in colluvial sediments had not been observed in swamps further than 60 m from a longwall panel. Recent monitoring reports suggest that some mining induced hydrological changes may occur within swamps further than 60 m from longwalls.

Swamp 15a is a large upland coastal swamp located to the east, southeast and south of Longwall 19A. The swamp's controlling rockbar is a 12 m waterfall at the north-eastern downstream end of the swamp. Condition 5 of Schedule 3 of the Development Consent applies to Swamp 15a:

> *The Applicant must ensure that subsidence does not cause erosion of the surface or changes in ecosystem functionality of Swamp 15a and that the structural integrity of its controlling rock-bar is maintained or restored, to the satisfaction of the Secretary.*

The Panel advised that adaptive management is not suitable for managing the risks of impacts to ecosystem functionality of Swamp 15a because:

- There are no real time performance indicators suitable for pre-empting impending mining-induced changes in ecosystem functionality of a swamp.
- The time lag between cause and impact on ecosystem functionality is too long for identifying the need to implement preventative measures (responses) during active mining in time for them to be effective.
- Swamp soil moisture, groundwater dependent community and species change that are the basis for current TARPs for Swamp 15a ecosystem functionality can, themselves be irreversible impacts of mining.

On this basis, the Panel concluded that the only feasible option for practising adaptive management is an appropriate setback distance from Swamp 15a.

The Longwall 19A SMP was approved by the Planning Secretary on 11 August 2023. Condition 7 of Schedule 3 requires that Longwall 19A be setback at least 120 metres to the west of Swamp 15a.

Condition 14 of Schedule 3 of the SMP Approval requires a Swamp Impact Monitoring, Management and Contingency Plan (SIMMCP) for Longwall 19A to be submitted to the Secretary by 1 October 2023. Performance measures for Swamps 15a and 148 are stipulated in Condition 8 of Schedule 3 of the SMP Approval.

1.2 Scope

The SIMMCP has been prepared to comply with the Dendrobium Development Consent and the Longwall 19A SMP Approval in respect to swamp management, specifically for Swamps 15a and Swamp 148 within the Study Area. All other swamps within the study area are addressed in the Longwall 19 SIMMCP.

The Dendrobium Development Consent requires a SIMMCP subject to Schedule 3, Condition 6 as provided below.

> 6. Prior to carrying out any underground mining operations that could cause subsidence in either Area 3A, Area 3B or Area 3C, the Applicant must prepare a Swamp Impact Monitoring, Management and Contingency Plan to the satisfaction of the Secretary. Each such Plan must:
>
> (a) demonstrate how the subsidence impact limits in condition 5 are to be met;
>
> (b) include a monitoring program and reporting mechanisms to enable close and ongoing review by the Department and Resources Regulator of the subsidence effects and impacts (individual and cumulative) of each Area 3A Longwall on Swamp 15a;
>
> (c) include a general monitoring and reporting program addressing surface water levels, near surface groundwater levels, water quality, surface slope and gradient, erodibility, flora and ecosystem function;
>
> (d) include a management plan for avoiding, minimising, mitigating and remediating impacts on swamps, which includes a tabular contingency plan (based on the Trigger Action Response Plan structure) focusing on measures for remediating both predicted and unpredicted impacts;
>
> (e) address headwater and valley infill swamps separately and address each swamp individually;
>
> (f) be prepared in consultation with BCS, WaterNSW and Resources Regulator;
>
> (g) incorporate means of updating the plan based on experience gained as mining progresses;
>
> (h) be approved prior to the carrying out of any underground mining operations that could cause subsidence impacts on swamps in the relevant Area; and
>
> (i) be implemented to the satisfaction of the Secretary.

The Longwall 19A SMP Approval requires a SIMMCP for Longwall 19A subject to Schedule 3, Condition 14 as provided below.

> **Longwall 19A SIMMCP**
>
> 14. The Applicant must submit a SIMMCP for Longwall 19A to the Secretary by 1 October 2023. The SIMMCP must:
>
> (a) be prepared by a suitably qualified and experienced person/s;
>
> (b) be prepared in consultation with BCD and WaterNSW;
>
> (c) include TARPs which contain quantitative triggers to provide for achievement of the relevant performance measures set out in Table 1; and
>
> (d) address the recommendations contained in the advice of the Independent Expert Advisory Panel for Mining dated 1 August 2023;
>
> The Applicant must not commence longwall extraction of Longwall 19A until the SIMMCP is approved by the Secretary.
>
> The Applicant must implement the approved Longwall 19A SIMMCP

1.3 Study Area

The Study Area is defined as the surface area that could be affected by the mining of the proposed Longwall 19A (**Figure 1-1**). The extent of the Study Area has been calculated by combining the areas bounded by the following limits:

- The 35° angle of draw line from the extents of the proposed Longwall 19A;

- The predicted limit of vertical subsidence, taken as the 20 mm subsidence contour, resulting from the extraction of the proposed longwall; and
- The natural features located within 600 m of the extent of the Longwall 19A mining area, in accordance with Schedule 3, Condition 8(d) of the Development Consent.

The depth of cover to the Wongawilli Seam directly above the proposed longwalls is:

- Longwall 19A – between 290 m and 360 m.

The predicted limit of vertical subsidence, taken as the predicted total 20 mm subsidence contour, has been determined using the calibrated Incremental Profile Method (IPM), which is described in reports MSEC1082 (MSEC 2020) and MSEC1234 (MSEC 2022). The predicted incremental 20 mm subsidence contour extends beyond the 35° angle of draw above the existing Longwalls 6 to 8. Elsewhere, the contour is located inside the angle of draw.

This SIMMCP applies to Swamps 15a and 148 as specific performance measures are applicable to these swamps under Condition 8 of Schedule 3 of the Longwall 19A SMP Approval. Swamp 15a performance measures are also defined in the Dendrobium Development Consent (Schedule 3, Conditions 5, 6a and 6b).

Other swamps located in the Study Area include Swamps 12, 34, 96, 15b and 15c. These swamps are addressed within the Longwall 19 SIMMCP as they are located within the Longwall 19 Study Area. No specific performance measures apply to these swamps under the Longwall 19A SMP Approval.

A number of smaller swamps or swamp-like vegetation are scattered throughout the Study Area. These small patches of swamp like vegetation are often too small to map as discrete swamps and occur in small areas of impeded drainage that contain a mix of plant species common to the upland swamps and fringing eucalypt woodlands of the region. These patches of vegetation have not been identified in the existing swamp mapping of the Study Area (**Figure 1-1**) and field observations indicate that these patches of vegetation occur randomly in the landscape and are not typically restrained by sandstone rock bars. Further, these vegetation patches do not occur in valley floors and therefore are not likely to be subject to valley closure movements resulting from longwall extraction (Niche 2012).

1.4 Objectives

The objectives of this SIMMCP are to identify and monitor features and characteristics of Swamps 15a and 148 within the Study Area (**Figure 1-1**) and to provide Trigger Action Response Plans containing quantitative performance indicators and management actions for achievement of relevant performance measures. The SIMMCP also provides additional monitoring of Swamps within the Area 3A mining domain. This Longwall 19A SIMMCP is intended to operate in parallel with the Area 3A SIMMCP (approved 28 June 2010) and Longwall 19 SIMMCP (approved 11 March 2021).

1.5 Consultation

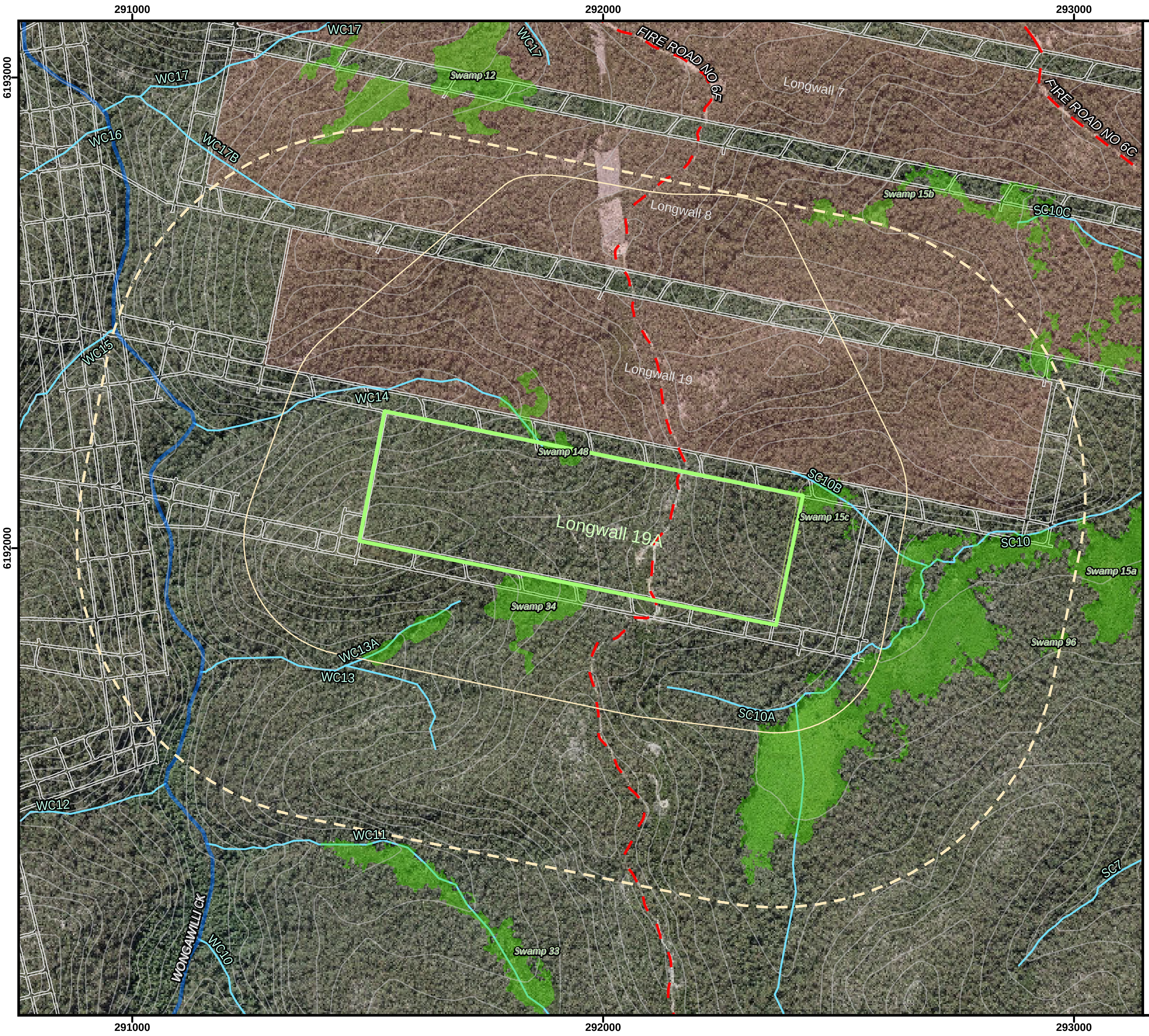
The Dendrobium SIMMCPs and other Management Plans have been developed by IMC in consultation with:

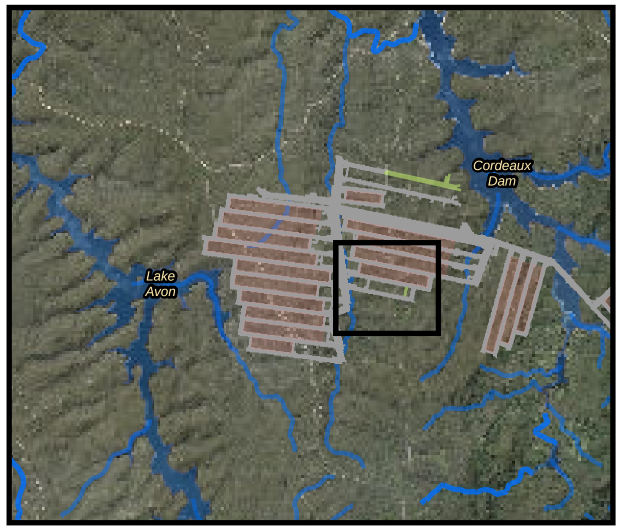
- The NSW Department of Planning and Environment (DPE);
- the Biodiversity Conservation Division of DPE (BCD),
- Resources Regulator; and
- WaterNSW.

The SIMMCP and other relevant documentation are available on the IMC website (Schedule 8, Condition 11).

DENDROBIUM LONGWALL 19A Overview

Figure 1-1





Date: September, 2023

Version 1
Horizontal Datum
GDA2020 - Zone 56

Meters
0 250 500

2 PLAN REQUIREMENTS

Extraction of coal from Longwall 19A will be in accordance with the conditions set out in the Dendrobium Development Consent, SMP approvals and conditions attached to relevant mining leases.

Baseline studies have been completed within the Study Area and surrounds to record biophysical characteristics. Monitoring is conducted in the area potentially affected by subsidence. The baseline studies have identified monitoring sites in these areas based on the Before After Control Impact (BACI) design criteria.

A comprehensive monitoring program which details the monitoring to be undertaken for swamps is provided in **Appendix A: Table 1.1**.

A summary of swamp monitoring for Swamps 15a and 148 is provided in the following sections. In the event that monitoring reveals impacts greater than performance measures identified in Trigger Action Response Plans (TARPs), modifications to the project and mitigation measures including remediation and/or offsets or other appropriate actions determined in consultation with the consent authority will be implemented. The monitoring locations will be reviewed as required and can be modified (with agreement) accordingly.

2.1 Dendrobium Development Consent DA60-03-2001

The Dendrobium Underground Coal Mine (DA 60-03-2001) modification was approved under Section 75W of the EP&A Act on 8 December 2008, which granted approval over Dendrobium Area 3 (comprised of 3A, 3B and 3C). **Table 2-1** lists the Conditions of Consent relevant to the SIMMCP and where the conditions are addressed.

Table 2-1 Dendrobium Development Consent

Dendrobium Development Consent Condition	Relevant SIMMCP Section
Condition 5 – Schedule 3 The Applicant must ensure that subsidence does not cause erosion of the surface or changes in ecosystem functionality of Swamp 15a and that the structural integrity of its controlling rock-bar is maintained or restored, to the satisfaction of the Secretary.	Section 5
Condition 6 – Schedule 3 Prior to carrying out any underground mining operations that could cause subsidence in either Area 3A, Area 3B or Area 3C, the Applicant must prepare a Swamp Impact Monitoring, Management and Contingency Plan to the satisfaction of the Secretary. Each such Plan must:	
(a) demonstrate how the subsidence impact limits in condition 5 are to be met;	Section 6
(b) include a monitoring program and reporting mechanisms to enable close and ongoing review by the Department and Resources Regulator of the subsidence effects and impacts (individual and cumulative) of each Area 3A Longwall on Swamp 15a;	Section 3
(c) include a general monitoring and reporting program addressing surface water levels, near surface groundwater levels, water quality, surface slope and gradient, erodibility, flora and ecosystem function;	Section 3 and Appendix A
(d) include a management plan for avoiding, minimising, mitigating and remediating impacts on swamps, which includes a tabular contingency plan (based on the Trigger Action Response Plan structure) focusing on measures for remediating both predicted and unpredicted impacts;	Section 6 and Appendix A
(e) address headwater and valley infill swamps separately and address each swamp individually;	Section 5

Dendrobium Development Consent Condition	Relevant SIMMCP Section
(f) be prepared in consultation with BCS, WaterNSW and Resources Regulator;	Section 1.5
(g) incorporate means of updating the plan based on experience gained as mining progresses;	Section 7
(h) be approved prior to the carrying out of any underground mining operations that could cause subsidence impacts on swamps in the relevant Area; and	Section 1.4
(i) be implemented to the satisfaction of the Secretary.	

2.2 Longwall 19A Subsidence Management Plan

The Longwall 19A SMP was approved by the Planning Secretary on 11 August 2023.

In accordance with Condition 7 of Schedule 3 of the Longwall 19A SMP Approval, Longwall 19A is set back 121 metres to the west of Swamp 15a, requiring a shortening of the longwall by 142 metres.

The Longwall 19A SMP performance measures for Swamps 15a and 148 are stipulated in Condition 8 of Schedule 3 and are provided in Table 2-2 below. These performance measures have been used in the development of TARPs associated with Swamps 15a and 148 presented in **Appendix A**.

Table 2-2: Subsidence Impact Performance Measures – Swamps

Swamps	
Swamp 15a	Negligible environmental consequences including: • negligible erosion of the surface of the swamp; • negligible change in the size of the swamp; • negligible change in the ecosystem functionality of the swamp; • negligible change to the composition or distribution of species within the swamp; or • maintenance or restoration of the structural integrity of rockbar SC10-RB15A
Swamp 148	Minor environmental consequences including: • minor erosion of the surface of the swamp; • minor change in the size of the swamp; • minor change in the ecosystem functionality of the swamp; • minor change to the composition or distribution of species within the swamp; or • maintenance or restoration of the structural integrity of rockbar base of any significant permanent pool or controlling rockbar within the swamp.

Table 2-3 lists the Conditions of the Approval relevant to preparing the Longwall 19A SIMMCP and where the conditions are addressed.

Table 2-3: Longwall 19A SMP Approval

Longwall 19A SMP Approval	Relevant SIMMCP Section
Condition 14 – Schedule 3 The Applicant must submit a SIMMCP for Longwall 19A to the Secretary by 1 October 2023. The SIMMCP must:	
(a) be prepared by a suitably qualified and experienced person/s; (b) be prepared in consultation with BCD and WaterNSW;	Review History (p. iv) Section 1.5

Longwall 19A SMP Approval	Relevant SIMMCP Section
(c) include TARPs which contain quantitative triggers to provide for achievement of the relevant performance measures set out in Table 1; and	Appendix A
(d) address the recommendations contained in the advice of the Independent Expert Advisory Panel for Mining dated 1 August 2023;	Section 2.2.1
The Applicant must not commence longwall extraction of Longwall 19A until the SIMMCP is approved by the Secretary.	Section 1
The Applicant must implement the approved Longwall 19A SIMMCP.	Section 8

2.2.1 Condition 14(d), Schedule 3 – IEAPM Recommendations

In accordance with Condition 14(d), Schedule 3 of the Longwall 19A SMP Approval, this SIMMCP has been prepared to address recommendations contained in the advice of the Panel dated 1 August 2023 in relation to potential impacts to Swamp 15a. Table 2-4 details how the recommendations have been addressed.

Table 2-4 IEAPM (2023) Recommendations

IEAPM Recommendation	Response
1. In order to avoid changes in ecosystem functionality, the setback distance of LW19A from Swamp 15a should be in excess of 120 m. There is insufficient information available to the Panel to recommend at upper bound for setback distance	Longwall 19A has been shortened by 142 m to enable the longwall to be setback >120 metres to the west of Swamp 15a.
2. The definition of Ecosystem Functionality is outdated and inadequate and should be revised to accommodate all processes (such as swamp hydrology) that are essential for swamps and their dependent ecosystems	There are many definitions of "ecosystem functionality" in use in the scientific community, however, in 2013 the now DPE advised their performance measure relating to ecosystem functionality for the Dendrobium Consent was general in intent; basically the swamp will remain a swamp. This discussion was recorded in meeting minutes dated 5 June 2013 and stated in subsequent approved SMPs and SIMMCPs since 2013. The Panel's advice for Longwall 19A substantially conflicts with this guidance. Further discussions with DPE as a result of the Panel's most recent advice dated 1 August 2023 call for an updated definition and therefore revised performance measures for ecosystem functionality. Performance indicators for ecosystem functionality proposed in this SIMMCP now include hydrological changes within the swamp including measures for dry periods, groundwater recession rate for shallow groundwater, as well as median pool levels and duration of dry periods for surface pools. These indicators include a recovery based temporal component in parallel and vegetation change as a result of Longwall 19A mining induced hydrological changes.
3. The performance indicators for assessing compliance with Performance Measures related to the ecosystem functionality of a swamp should include perched groundwater levels in the swamp, in	Performance indicators for ecosystem functionality proposed in this SIMMCP now include hydrological changes within the swamp including measures for dry periods, groundwater recession rate for shallow groundwater, as well as median pool levels and duration of dry periods for surface pools.

IEAPM Recommendation	Response
addition to those related to swamp size, species and vegetation communities	These indicators include a recovery based temporal component and vegetation change as a result of Longwall 19A mining induced hydrological changes. Reporting triggers and performance indicators are included in Tables 1.2 and 1.3 of Appendix A.
4. An observable change to perched groundwater level at any site in Swamp 15a due to mining should be treated as a change to ecosystem functionality	Shallow groundwater level has been included as a performance indicator within the Longwall 19A TARP (Table 1.2 of Appendix A) for ecosystem functionality of Swamp 15a. The groundwater measure includes a recovery based temporal component and vegetation change as a result of Longwall 19A mining induced hydrological changes. This is to allow for any temporary affects to be distinguished from permanent changes in Swamp 15a as a result of Longwall 19A.
5. Performance indicators for pool water levels should be proposed for selected pools, with TARPs including provision for assessing if remediation is warranted and feasible to prevent changes to the swamp ecosystem functionality	Reduced pool water levels have been included as a Performance Indicator for SC10 Pools 23, 26a and 29 within the Longwall 19A TARP (Table 1.2 of Appendix A) for Ecosystem Functionality of Swamp 15a. Provision for assessing if remediation is warranted and feasible to prevent changes to ecosystem functionality is included as a management strategy within the TARP. Furthermore, fracturing resulting in increased cease-to-flow or dry pool days at rockbar SC10-RB15A (Pool 15) which cannot be restored via CMAs is included as a performance indicator for the “Maintenance or restoration of the structural integrity of rockbar SC10-RB15A” performance measure for Swamp 15a.
6. The locations of the proposed pool water level, shallow groundwater and deep groundwater monitoring sites that are included in the SIMMCP should, prior to approval of the LW19A SMP, be independently reviewed for adequacy to detect the nature and magnitude of any mining-induced change.	The Longwall 19A SMP and SIMMCP are updates of previous plans which have undergone substantial peer review by Government agencies and the Panel. The Longwall 19A SMP was submitted to DPE in October 2022 and there have been several rounds of review and response with Government agencies. DPE referred the application to the Panel for review. An extensive groundwater monitoring network is in place to monitor the effects of Longwall 19A. This monitoring program was revised and extended to include additional monitoring sites (noted in response to item #8 below) during which time technical experts and the DPE reviewed the draft prior to release to other agencies for review. Feedback from agencies and technical experts has been included and therefore, this monitoring program is considered sufficient to detect the nature and magnitude of mining-induced change.
7. The Department should encourage proponents to ensure longer baseline periods to assess potential impacts and ensure that longer monitoring periods occur post-mining (and post End of Panel reporting) to further evaluate performance indicator trends and to confirm whether there are long-term mining-induced impacts	Monitoring and reporting are conducted in line with approved SMPs. This recommendation for the DPE is noted.

IEAPM Recommendation	Response
8. The South32 monitoring program for Swamp 15a should include: a. Continued and expanded monitoring of shallow groundwater in the swamp across Swamp 15a to be able to assess compliance with the Condition 5. b. Monitoring of groundwater in the underlying sandstone adjacent to the western edge of Swamp 15a given that VWP 1888 will be destroyed once the longwall commences. A nested standpipe location monitoring shallow and deeper aquifers in the Hawkesbury Sandstone west of the swamp at an accessible location is required to confirm whether there is any emerging evidence of connected cracking or further depressurisation impacting these aquifers.	a. Four additional instrumented shallow groundwater level monitoring sites have been included across Swamp 15a: 15a_06, 15a_08, 15a_09 and 15a_11. These have been included in the Longwall 19A monitoring program and shown on the LW19A SIMMCP Environmental Monitoring Plan in Appendix A. There are also six existing shallow groundwater level monitoring sites within Swamp 15a. Monitoring data from the ten monitoring sites within Swamp 15a will enable assessment of compliance with Condition 5 of the Development Consent. b. There are two HBSS groundwater level monitoring sites – S1888 and S1907 included in the Longwall 19A monitoring program and shown on the Draft LW19A SIMMCP Environmental Monitoring Plan (Appendix A) that will be used to determine whether there is any emerging evidence of connected cracking or further depressurisation impacting the aquifer. With the reduced length of Longwall 19A it is unlikely that VMP 1888 will be damaged by subsidence. Should the monitoring site be damaged, any replacement of VMP 1888 can only be installed following the completion of mining and subsidence movements at the point of the installation.
9. Dendrobium Mine should be required to prepare six monthly reports, or suite of reports, that detail monitoring data and analysis relevant to assessing subsidence effects, impacts and environmental consequences	Impact reports are regularly submitted as required in the TARP (Appendix A). Condition 19 of Schedule 3 of the Longwall 19A SMP Approval requires four monthly reporting.
10. The SIMMPC for LW19 and LW19A should be revised and reissued	This document.
11. In future, in circumstances where the location of a longwall installation roadway determines the setback distance from a feature that requires a degree of protection from mining-induced impacts, approval conditions should require that within three months prior to commencing the drivage of the installation roadway, the appropriateness of the planned location of the installation roadway is to be confirmed/reaffirmed by undertaking a review of all relevant monitoring data to the satisfaction of the Department Secretary	This recommendation for the DPE is noted.

2.3 Leases and Licences

The following licences and permits may be applicable to IMC's operations in the Study Area:

- Dendrobium Mining Lease as shown in **Table 2-2**;

- Environmental Protection Licence 3241 which applies to the Dendrobium Mine. A copy of the licence can be accessed at the EPA website via the following link http://www.environment.nsw.gov.au/poeo;
- Relevant Occupational Health and Safety approvals; and
- Any additional leases, licences or approvals resulting from the Dendrobium Development Consent.

Table 2-5 Dendrobium Leases

Mining Lease - Document Number	Issue Date	Expiry Date/ Anniversary Date
CCL 768	7 May 1998	7 September 2026

3 MONITORING

The Swamp Monitoring Program and Trigger Action Response Plans (**Appendix A**) have been prepared specifically to address performance measures for Swamps 15a and 148. Other swamps within the Longwall 19A study area are addressed in the Longwall 19 SIMMCP which remains in force.

Swamp monitoring sites will be installed ahead of mining to achieve at least 2-years baseline data (subject to timing and approval timeframes of any request to install additional monitoring). Monitoring is generally conducted through the mining period and for 2-years following active subsidence. Where performance measures require more than 2 years of post-mining monitoring, this will be undertaken. Monitoring sites established for Swamp 15a and 148 are shown on **Figure 3-8**. Swamp monitoring and reference sites associated with Swamps 15a and 148 are presented in **Appendix B**.

3.1 Area 3A Swamps

Coastal Upland Swamps are endemic to the eastern part of the Sydney Basin and listed as an endangered ecological community under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, and the NSW *Biodiversity Conservation Act 2016*. Upland Swamps are commonly known as vegetated freshwater wetlands occurring in shallow basins located in low hills or mountains. They occur in either low sloped headwater tributary valleys (headwater swamps) that are characteristically derived from colluvial sand eroded from the ridgelines or along the riparian zone of the creeks (valley infill swamps) within the headwater valleys. Swamp vegetation is highly variable, ranging from open graminoid (grassy) heaths and sedgelands to fernlands and scrubs (Threatened Species Scientific Committee (TSSC), 2014).

There are four swamps that have been identified wholly or partially within the Longwall 19A Study Area based on the 35 degree angle of draw. There are three additional swamps that are located wholly or partially within the Study Area based on the 600 m boundary. The swamps within the 600 m Study Area are identified in **Table 3-1** and shown on **Figure 1-1**. The Longwall 19A SIMMCP applies to Swamps 15a and 148. The other five swamps located within the Study Area (Swamps 12, 15b, 15c, 34 and 96) are addressed in the approved Longwall 19 SIMMCP.

Table 3-1 Summary of swamps within the Longwall 19A Study Area

Swamp ID[1]	Total Area (Ha)	Position	Vegetation Communities	Minimum Distance from Longwall (m)
Swamp 15a	17.38	Valley Infill	Banksia Thicket, Tea-tree thicket, Sedgeland Heath	121
Swamp 148	0.86	Headwater	Banksia Thicket	0 (22% of swamp directly above LW19A and previously impacted by LW19)
Swamp 12	5.37	Headwater	Banksia Thicket	590
Swamp 15b	4.96	Valley Infill	Banksia Thicket, Tea-tree thicket, Sedgeland Heath	538
Swamp 15c	0.65	Headwater	Banksia Thicket	0 (4% of swamp directly above LW19A and previously impacted by LW19)
Swamp 34	2.58	Headwater / Valley Infill	Banksia Thicket, Tea-tree thicket, Mallee Heath	0 (0.2% of swamp directly above LW19A)
Swamp 96	0.17	Headwater	Banksia Thicket	547

3.1.1 Swamp 15a

Swamp 15a is a large complex swamp that covers an area of 17.4 hectares with pools observed within or on edges of the swamp. The swamp follows the alignment of watercourse SC10. Most of the swamp is on the gently sloping parts of the eastern side of the SC10 valley floor, which is located on the opposite side of Longwall 19A. Swamp 15a contributes significantly to biodiversity values given its size, complexity and available pooling habitat which is known to support a large population of Littlejohn's Tree Frog within areas of this swamp and associated drainage lines and pools. Sub-communities associated with Swamp 15a include Banksia Thicket, Sedgeland-Heath Complex (Cyperoid Heath), Sedgeland-Heath Complex (Restoid Heath) and Tea-tree Thicket. Longwall 19A has been setback >120 metres from Swamp 15a so that 0% of the swamp is within 120 m of extraction.

3.1.2 Swamp 148

Swamp 148 is a small simple swamp with a single sub-community located adjacent to WC14. The swamp sub-community is Banksia Thicket which tends to be a drier swamp type. This swamp has been partially mined beneath by Longwall 19 and the southern area of this swamp is located directly above Longwall 19A.

3.1.3 Reference Swamps

The monitoring design is structured around the BACI concept: Before, After, Control and Impact. Predicted impact areas are compared with control areas and measurements taken both before and after an impact event (longwall mining) occurs. Where measurable impacts occur, comparisons of before and after data should reveal changes at an impact site after mining. Reference or controls sites remain unimpacted before and after mining, where the mining plan evolves and has the potential to impact on a previous reference swamp, this will be updated to reflect the on-ground works (e.g. the data that was previously listed as control is now listed as pre-mining Impact data (Before) and is no longer included in the analysis as a control). Where both reference and impact sites change in a similar manner, observed changes may be due to other wider-ranging factors such as rainfall.

Impacted areas are those within the 400 m risk management zone (RMZ) which are sensitive to valley closure, uplifts, strains, and fracturing. This is in accordance with recommendations of the Department of Planning (2008).

[1] This SIMMCP applies to Swamps 15a and 148 only. All other swamps listed are included in Longwall 19 SIMMCP.

The Impact sites are referred to as pre-impact (Before) prior to mining activity, until the closest point of secondary extraction is located within the RMZ of the site. This allows for baseline (Before) data to be collected at each potential impact site. Once the point of secondary extraction is located within a RMZ the site is then referred to as post-impact but not yet mined beneath, this allows for the potential of observing any indirect impacts that have been predicted. Given that any observed impacts to natural features become most evident after the natural feature is mined beneath, the date the site has been mined beneath has also been considered in the assessment and analysis of trends over time. At this point the sites are referred to as post-impact and mined beneath.

Reference swamps have been selected in consideration of the following criteria:

- Distance from longwalls – outside 400 m risk management zone;
- Size of swamp;
- Suitable subcommunities comparable to impacted swamps;
- Not to be impacted by mining within foreseeable future;
- Swamp also used as a control for groundwater monitoring;
- Proximity to drainage features;
- Valley infill/headwater swamps;
- Natural disturbances (e.g. fire); and
- Rainfall patterns.

Reference swamps (**Figure 3-2**) within each of the mining domains are generally monitored for a minimum of two years prior to mining to gather baseline data. There are some Upland Swamps and creeks that will remain in the RMZ, as they are not planned to be mined beneath.

The reference swamps for Dendrobium Longwall 19A monitoring include Swamps 7, 22, 24, 25, 33, 84, 85, 86, 87 and 88. Swamp 7 will become an impact site following extraction of Longwalls 22 and 23.

A table that includes details of swamp monitoring sites (impact and reference) associated with Swamp 15a and 148 is provided in **Appendix B**.

3.2 Dendrobium Survey Monitoring Program

Survey monitoring techniques will be employed at upland swamps and watercourses throughout the Study Area to measure subsidence movements. Additionally, regional 3D Global Navigation Satellite System (GNSS) marks will be placed at strategic positions throughout the Study Area to monitor absolute surface movements.

Pending site access and approval, survey monitoring lines will be established across a selection of watercourses and upland swamps within the 20 mm predicted subsidence contour. The monitoring lines will target controlling rockbars and steps. Additionally, survey monitoring lines will be installed across the Wongawilli Creek valley to measure closure (or opening) of the valley. Installation of additional Wongawilli Creek monitoring lines will be subject to site access and any other constraints.

Watercourse and upland swamp monitoring lines will employ a series of marks along a transect at nominally 20 m intervals. If practical, upland swamp transects will be related to a GNSS control network to provide absolute 3D movements in addition to level, tilt and strain changes.

Nominal accuracy will be +/- 5 mm relative between marks and +/- 20 mm for horizontal and vertical accuracy if the swamp is related to a GNSS control network. Survey closure lines across the Wongawilli Creek valley will be measured for closure only; nominal accuracy will be +/- 5 mm.

Survey monitoring sites will be chosen for suitability and detailed in the Dendrobium Survey Monitoring Program. Baseline monitoring will be conducted prior to active subsidence.

3.3 Observational Monitoring

IMC has conducted ongoing monitoring of watercourses and swamps in the Dendrobium area since 2001. Swamp monitoring sites within the area surrounding Longwall 19A is shown in **Figure 3-1**. Water Quality and observational monitoring is shown in **Figure 3-4**. This monitoring builds upon the understanding of processes within the watercourses, along with identifying and assessing any episodic or temporal changes.

This monitoring (along with other monitoring programs described in the WIMMCP) is consistent with (in part) Condition 4 Schedule 3 "*include a general monitoring and reporting program addressing surface water levels, water flows, water quality, surface slope and gradient, erodibility, aquatic flora and fauna (including Macquarie Perch, any other threatened aquatic species and their habitats) and ecosystem function*".

The IMC Environmental Field Team is continuing to undertake structured monitoring assessments, including:

- Water: location, volume and flow characteristics;
- Significant features: rockbars, pools and flow channels;
- Vegetation: location, species and observed health; and
- Sediment: composition, depth and moisture.

Monitoring sites and frequencies related to Swamps 15a and 148 are provided in **Appendix A; Table 1.1**. Every effort is made to install additional monitoring sites within the Study Area ahead of longwall mining to achieve 2 years baseline data (subject to timing and approval timeframes of any request to install additional monitoring). Proposed monitoring sites are subject to minor locality changes due to field inspections which determine the suitability of the site.

Observations of any surface water and vegetation health for prominent species are undertaken. Where surface water is present within a swamp or a watercourse the data collected includes water quality parameters (using a monitoring probe) and water levels from installed benchmarks established at the pool (**Figure 3-3**). Observations of any surface flow are also made during monitoring.

This data is used to compare differences in site conditions of swamps and watercourses before and after mining. Sites that will not be mined under are also monitored to provide a comparison of sites mined under and sites not mined under during different climatic conditions.

3.4 Water Quality and Chemistry

Monitoring undertaken by IMC since 2003 (**Figure 3-4**) includes water quality monitoring of parameters such as pH, Electrical Conductivity (EC), Dissolved Oxygen (DO), Oxygen Reduction Potential (ORP) and temperature. monitoring sites where these parameters are sampled are indicated as water chemistry sites.

Water quality is also monitored for analytes including DOC, Na, K, Ca, Mg, Filt. SO4, Cl, T. Alk., Total Fe, Mn, Al, Filt. Cu, Ni, Zn, Si. Water samples are retrieved from the monitoring sites and analytes are tested in a laboratory. Monitoring sites where water samples are taken for laboratory testing are indicated as water chemistry sites.

The key field parameters of DO, pH, EC and ORP for monitoring sites within the Study Area will be analysed to identify any changes in water quality resulting from the mining. Pools and streams away from mining are monitored to allow for a comparison against sites not influenced by mining. Pools will be measured at weekly intervals during active subsidence and monthly before and following mining. The monitoring of water chemistry provides a sensitive means of detecting and providing quantitative assessment of effects in the early stages of streambed fracturing or induction of ferruginous springs. Assessment of water quality data will be supported by geochemical modelling using PHREEQC, where applicable (Parkhurst and Appelo 1999).

Water quality monitoring is detailed in the Longwall 19 and 19A WIMMCP.

3.5 Groundwater

A Groundwater Assessment is provided in Attachment B of the SMP (Watershed HydroGeo 2022), which assesses the cumulative impacts of both Longwalls 19 and 19A. An existing groundwater monitoring program is in place for Dendrobium, which includes the Study Area (**Figure 3-5**). The Dendrobium Long Term Groundwater Monitoring Program is available in Appendix B of the WIMMCP.

Groundwater monitoring is undertaken in:

- Surficial and shallow systems associated with upland swamps and the weathered near-surface bedrock.
- Consolidated rock strata comprising the deeper Hawkesbury Sandstone, the underlying Narrabeen Group and Illawarra Coal Measures.

Pre-mining and post-mining monitoring holes have been installed within Area 3 to investigate and monitor the highly connected fracture network above the goaf and the upwards migration of the phreatic surface.

Monitoring pore pressures at Dendrobium Mine uses vibrating wire piezometers installed at different depths within the same borehole, thereby creating a vertical array which can be used for 3D mapping and analysis of the pore pressure regime (IEP 2019a).

Before and after mining piezometers are routinely installed along the centreline of longwall panels to identify the maximum groundwater effects and the height of depressurisation within the subsidence zone.

3.6 Surface Water Flow and Pool Water Level

Existing surface water flow gauges and data loggers are installed at SC10 flow monitoring site downstream from Swamp 15a (**Figure 3-6**). Water level data loggers are also installed at stream flow monitoring sites (**Figure 3-6**) and other select pools along with manual benchmark water level monitoring sites (**Figure 3-3)**. Data has been collected since 2003 and has been compiled within monitoring and field inspection reports, EoP Reports and regular impact update reports. Pool water level and flow monitoring sites have been established in Swamp 15a for monitoring before, during and after mining (see WIMMCP for details).

3.7 Near-Surface Groundwater and Soil Moisture

The surface area above Dendrobium Area 3A is characterised by a series of drainage basins separated by steep ridges. The drainage basins drain to Wongawilli Creek, Sandy Creek and directly into Lake Cordeaux.

Monitoring of shallow groundwater levels allows for the indirect measurement of water storage and transmission parameters within the saturated part of hill-slope/upland swamp complexes. Shallow groundwater piezometers have been installed in Swamps 15a and 148 (**Figure 3-1** and Figure 3-8), with an additional three proposed sites now instrumented with shallow groundwater level monitoring within Swamp 15a as part of this SIMMCP.

Within Area 3B long-term piezometer records are available for Swamp 11 as well as additional sites installed since 2011 (**Figure 3-2**). Currently 27 swamps over Dendrobium mining area are instrumented with groundwater level loggers. Swamps 2 (Donalds Castle Creek), 7 (LC5 Lake Cordeaux tributary), 22, 24, 25, 33 (WC11), 84 (SC9), 85 (DC10), 86 (AR19), 87 and 88 (Gallahers Creek) have been selected as reference monitoring sites. This data is used to compare differences in shallow groundwater levels within swamps, streams and hill-slope aquifers before and after mining. Sites that will not be mined under are also monitored to provide a comparison of sites mined under and not mined under during different climatic conditions.

Groundwater monitoring bores (and other monitoring) is provided in **Figure 3-5**.

The piezometric monitoring directed at shallow groundwater levels is supplemented with monitoring of soil moisture profiles up to 1.2 m (**Figure 3-1**). Key monitoring sites have been installed with loggers to provide a continuous soil moisture record.

The shallow groundwater piezometers and soil moisture probe data is compared with the Cumulative Monthly Rainfall Residuals (a key parameter for interpreting temporal soil and shallow groundwater data). Comparisons of the Cumulative Monthly Rainfall Residuals against mean monthly water heads in shallow groundwater piezometers and soil moisture profiles will take into account the known distribution of rainfall isohyets (contours of equal annual precipitation) in the local region (these being denser and less smooth closer to the Illawarra Escarpment and much wider proceeding northwest).

Several climate stations are available for analysis and modelling in Dendrobium Area 3A with the most appropriate data taking into account proximity, length of record and data quality (**Figure 3-4**).

A comprehensive array of multi-level piezometers have been installed on the centreline of panels at Dendrobium Mine to monitor pore pressure changes associated with subsidence. These monitoring holes include at least five transducers per borehole with installation at least 2 years prior to mining, in line with the recommendations of the IEP (2019a). Where these monitoring sites are damaged as a result of undermining, they are reinstalled after subsidence movements cease. Daily monitoring of local rainfall and mine water ingress from overlying and surrounding strata, and separation of rainfall correlated inflows for base flow volumetric analyses is also undertaken (IEP 2019 a and b).

3.8 Pools and Controlling Rockbars

Dendrobium Mine lies in the southern part of the Permo-Triassic Sydney Basin. The geology mainly comprises sedimentary sandstones, shales and claystones, which have been intruded by igneous sills.

The sandstone units vary in thickness from a few metres to as much as 120 m. The major sandstone units are interbedded with other rocks and, though shales and claystones are quite extensive in places, the sandstone predominates.

The major sedimentary units at Dendrobium are, from the top down:

- The Hawkesbury Sandstone.
- The Narrabeen Group (including the Bulgo Sandstone).
- The Eckersley Formation.

Extensive geomorphological mapping has been completed for a large portion of Dendrobium Area 3, including the location of significant features in the watercourses (**Figure 3-7**).

The eastern area is broadly sited on a plateau dissected by a number of relatively shallow sub-catchments draining either into Cordeaux River via Wongawilli Creek or Donalds Castle Creek or five un-named 1st and 2nd order streams draining directly to the southern end of Lake Avon.

The largest watercourse within the Study Area is Wongawilli Creek (**Figure 1-1**), which is located between Areas 3A and 3B. The headwaters of Wongawilli Creek are located along a drainage divide separating surface runoff and shallow groundwater outflow runoff from Native Dog Creek and Lake Avon to the west. Sandy Creek is a third order perennial stream with a small baseflow which is located to the east of Longwall 19A. Sandy Creek flows into Lake Cordeaux and has a number of 1st and 2nd order tributaries reporting flows.

The geomorphology of tributary sub-catchments in Area 3A is typically characterised by upland plateau and a series of 'benches' comprised of catenary hill-slopes and swamps enclosed in roughly crescent-shaped cliff lines.

The upstream southern end of the catchment consists of a ridge containing a thin sandy soil profile accumulated on a generally dome shaped outcrop. This outcrop exhibits pronounced removal of the sandstone's kaolinite clay cement and is typically white and friable (Hazelton and Tille 1990).

Drainage is to the north east and south west down slopes, with little evidence of surface drainage channels. This is consistent with headwater hill-slope aquifer zones and overland sheet flow during extreme rainfall events.

Wongawilli, Sandy and Donalds Castle Creeks are perennial flowing streams with small base flows and increased flows for short periods of time after each significant rain event.

Beds of the creeks are typically formed within Bulgo Sandstone, which overlies the Stanwell Park Claystone; however, there are sections of the headwaters of these creeks which are formed within the Hawkesbury Sandstone.

Three distinct channel types may be recognised in the main channel uplands, and in the tributaries of Sandy and Wongawilli Creeks:

- Narrow indistinct channels associated with low sedge/heath type vegetation cover and a relatively thick sandy riparian soil profile. The streambed consists of weathered bedrock and/or sandy materials. This is the situation in which valley infill swamps may be found.
- Rock rockbars of variable width which are usually smooth except for minor depressions on joint planes and occasional potholes. These platforms normally grade to a thinly vegetated sandy soil on both sides and usually exhibit the effects of chemical deposition of hydrated iron oxides. This deposition ranges from a slight colouration of the surface strata to intense replacement of the rock fabric.
- Channels that are erosive into cross-bedded sandstone and exhibit a rough riffle like surface usually with accumulations of boulders and other sediments. These channels are usually bounded by solid rock outcrop.

A number of semi-permanent pools may be found within the channels of these drainage lines and creeks. The mechanisms of pool stability are variable and uniquely depend on local stratigraphy, structure and gradient. Pools range from:

- Water accumulations in depression of an impermeable bedrock shelf (analogous to a bathtub) that is fed by direct precipitation, seepage or flood events; to
- Pools within eroded sections of sandy sediment and a free water surface that is dependent on surface flows and the local groundwater regime for stability.

Pools within unconsolidated (sandy) sediments are in a state of equilibrium between water in (from a higher part of the phreatic groundwater surface either upstream or laterally) and water out (flowing down the phreatic surface).

Most bedrock pools and riffle complexes rely on equilibrium between excess water in compared to water out. If the water inflow is less than the outflow, then the pool water level declines. The nature of this equilibrium is ultimately dependent on the position of the pool on the overall stream gradient. Many pools in the streams naturally develop at rockbars and at sediment and debris accumulations.

Rockbars and pools of Wongawilli Creeks within the 600 m Study Area boundary (**Figure 3-7**) were mapped in February 2020 by IMCEFT. All mapped rockbar controlled pools in Sandy and Wongawilli Creeks are significant permanent pools.

3.9 Erodibility

Most of the surface of Area 3A has been identified as highly weathered Hawkesbury Sandstone outcrops and Sandstone-derived soils. This soil landscape has been identified to have high to extreme erosion susceptibilities to concentrated flows. This results in potential flow on effects to slope stability and erosion from any cracking resulting from subsidence (Ecoengineers 2012). Landscape monitoring of slopes is undertaken in the Study Area to identify any erosion of the surface (Appendix 5 of the Longwall 19A SMP).

The extensive survey program will be continued for Swamps 15a and 148, which includes relative and absolute horizontal and vertical movements. Additional sites will be added to the monitoring program prior to subsidence movements impacting the sites if required.

Due to terrain, vegetation and access restrictions, the primary method of identifying any erosion over the Study Area will be Airborne Laser Scanning (ALS). This technique has proven to be successful in generating topographic models of subsidence over entire longwall and mining domains and will also provide identification of any erosion. The maximum areas, length and depth of erosion will be measured by standard survey methods.

Base surveys over Area 3A using ALS were completed in December 2005. A verification base survey will be conducted prior to the commencement of mining of the proposed longwall. Subsidence landscape models using the same methodology after the completion of subsidence at each longwall will provide a new (subsided) baseline surface dataset. For a period of up to ten years after mining repeat ALS datasets and surface modelling will be completed to identify new or increases in existing erosion. Erosion will be quantified by comparison of the immediate post subsidence landscape model with the long-term monitoring model. Targeted ALS scans will be completed where erosion is observed via the observational and landscape monitoring programs or after significant events such as bushfire and flooding.

The nominal accuracy of ALS derived subsidence contours is in the order of +/- 0.10 m and effective algorithms have been developed to allow the use of ground strike data only within the assessment. This effectively allows the analysis to see through vegetation to the ground surface.

General observational inspections of the mining area will be undertaken at regular intervals, during active subsidence. In addition to erosion, these observations aim to identify any surface cracking, surface water loss, soil moisture changes, vegetation condition changes, and slope and gradient changes.

3.10 Flora and Fauna

Terrestrial flora and vegetation communities in the Study Area are described in the Terrestrial Ecology Assessment for Longwall 19A (Niche 2022). Aquatic flora and fauna in the Study Area are described in the Aquatic Ecology Assessment (Cardno 2022).

An aquatic ecology monitoring program has been established by Cardno for Area 3. The monitoring program includes sites within Donalds Castle, Sandy and Wongawilli Creeks.

Annual Reporting (Biosis 2016, Biosis 2017, Biosis 2018, Biosis 2019, Niche 2021 and Niche 2022) documents the ecological monitoring program undertaken within Dendrobium Areas 2, 3A and 3B. Subsidence related impacts following mining in these areas include lowering of shallow groundwater in uplands swamps and loss or alteration in the quality of pool water for first and second order streams.

A monitoring program designed to detect potential impacts to ecology from subsidence has been implemented for Area 3. As recommended by the IEP (2019a), the monitoring program is based on a BACI design with sampling undertaken at impact and control locations prior to the commencement of extraction, during extraction and after extraction. The existing monitoring program uses a BACI approach in the data analysis to identify whether there has been any change in lifestage detection pre-post impact, or between the control and impact sites. Identification of habitat loss due to potential mining induced change (e.g. pool water loss due to bedrock fracturing, or flocculant) is also completed to identify impacts.

Over two years of baseline data is available for the Study Area and includes stream/pond/frog population data. This data indicates that the habitat in this area is relatively undisturbed. There is sufficient baseline data to enable the detection of changes to ecology associated with mining related impacts. Three frog monitoring transects are associated with Swamp 15A: SC10(1), SC10(2), SC10C. These have been monitored since 2005.

Monitoring of Swamps 15a and 148 focuses on flora, fauna and swamp size and is measured via the following attributes:

- The size of the swamps based on the area of groundwater dependent communities contributing to the swamps;

- The composition and distribution of species within the swamps measured by a change in Total Species Richness (TSR) and species composition over time (Swamp 15a only)[2];
- Water quality, including pH, DO, ORP, temperature, turbidity and EC; and
- Frog monitoring –frog surveys using standardised transects focussing on Littlejohn's Tree Frog and Giant Burrowing Frog (Swamp 15a only).

Standardised transects in potential breeding habitat for the threatened frog species Littlejohn's tree frog and Giant burrowing frog have been established in Dendrobium Area 3A. These repeatable surveys enable direct comparison of the numbers of individuals recorded at each site from one year to the next.

Monitoring is also undertaken away from mining to act as control sites for the mining versus non-mining comparative assessment. Although there has been mining upstream of Site SC8, data to date has shown no obvious trending decline in detection, recording an average of 3 Adults, 5 Eggmass and 166 Tadpoles per survey which is within the range recorded at other Control (reference) sites.

Along each transect the monitoring includes: counts of frogs, an assessment of pools being used for breeding as well as counts of tadpoles and egg masses. This will enable a quantitative as well as qualitative assessment of breeding habitat for these species prior to, during and after mining.

Observations of the sites, photo points and pool water level data will also be collected as part of the frog and observational monitoring programs. Locations where significant changes have been observed (e.g. drainage of pools) will be mapped, documented and reported.

3.10.1 Swamp Size

Detailed mapping of the boundaries of the swamps and vegetation sub-communities has been undertaken for Swamps 12, 15a, 15b, 15c, 34, 95, 96, 146, 147 and 148 (**Figure 3-1**). Reference swamps have previously been mapped, including Swamp 7, 22, 24, 25, 33, 84, 85, 86, 87 and 88. (**Figure 3-2**). These swamps were selected based on size, similar vegetation sub-communities, geographic proximity and a lack of previous mining near them.

The detailed mapping included the use of LiDAR data to indicate the location and extent of upland swamp boundaries followed by ground-truthing of these boundaries and the vegetation sub-communities. LiDAR surveys are captured following completion of each longwall.

This mapping will allow for detailed comparison of the size of upland swamps following mining, as well as detailed comparison of the extent of sub-communities within upland swamps over time. Mapping will be replicated following mining and on an ongoing basis for the life of the mine or as agreed by the Secretary. This will allow direct comparison of changes in the size of upland swamps as well as the distribution of vegetation sub-communities within upland swamps.

Any change in the total area of a swamp will be compared to its pre-mining area and any change in area of reference swamps.

3.10.2 Flora - Composition and Distribution of Species

Control sites have been established at Gallahers Creek Swamp (Swamp 88), Fire Trail 15e Swamp (Swamp 87), Fire Trail 6x Swamp (Swamp 86), Swamp 22 and Swamp 33.

Three 15 m transects consisting of thirty 0.5 m by 0.5 m quadrats have been established in Swamp 15a. The monitoring will record:

- Presence of all species within each quadrat;
- Observations of dieback or changes in community structure; and
- Photo point monitoring at each transect.

Data from other monitoring programs (such as groundwater and observational data) in both mining sites and reference sites will be used to assist in the determination and reporting of any impacts identified by the quantitative vegetation monitoring.

[2] For the purposes of the program, Swamp 15a has been divided into two areas (Swamp 15a(1) and Swamp 15a(2) since 2009. A total of 18 years of monitoring data has been collected at Swamp 15a(1) and 14 years at Swamp 15a(2).

The selection of monitoring sites has been determined by specialists in the ecology of upland swamps based on a multi-criteria analysis. Criteria used to determine locations include:

- The location of the swamp in relation to longwall layout;
- Predicted subsidence, including vertical movements, tilts and strains;
- Location of vegetation sub-communities within the upland swamp, particularly those hypothesised to be most susceptible to changes in groundwater;
- Ensuring a representative sample of vegetation sub-communities in the monitoring program;
- Availability of reference sites; and
- Access requirements and workplace health and safety.

A particular focus has been placed on those vegetation sub-communities expected to undergo the greatest change. Tea-tree Thickets and Cyperoid Heath are considered to be more susceptible to change given their dependency on groundwater, followed by Sedgeland, Restoid Heath and finally Banksia Thicket.

Data will be analysed according to the BACI design applied in the existing ecological monitoring program. The analysis provides a statistical comparison of impact and control sites with the aim to identify, understand and manage any mining impacts through the implementation of a quantitative assessment against the relevant TARPs. Exploratory data analysis is conducted by creating boxplots of TSR at all swamps over the period of monitoring to determine any visually detectable yearly trend in TSR between swamp types (impact or control), and any difference in TSR before and after impacts. A complete analysis of all one, two, three, four and five yearly comparisons is undertaken across the entire historical dataset. The mean TSR of all two-consecutive-year pairs at impact swamps is contrasted against the mean TSR of all Control swamp data from prior to the impact. Where applicable, a BACI style analysis is completed, whereby differences in group means before impact between the control and impact swamps, and after impact, are tested to explore whether they are different from zero (0). If only a single year of before-impact monitoring is available, a control-impact analysis is completed, whereby differences in group means after impact at the Control and Impact swamp is tested to explore whether they were different from 0.

A model-based approach is used when dealing with the complex multivariate species assemblage data. Multivariate presence-absence models are fitted using the 'manyglm' function in the 'mvabund' package in program R. These models fit multiple presence-absence models to each detected species, correcting for the correlation between species (thus violating an assumption of standard Generalised Linear Models (GLMs) using generalized estimating equations (GEEs). Analysis of variance (ANOVA) are used to formally test the significance of explanatory variables (i.e., 'Mining Status'). Separate models are fitted to data collected at each swamp. If 'Mining Status' is found to be statistically significant, univariate tests are completed to determine which species were driving the change in flora community composition.

A complete analysis is undertaken across the entire historical dataset. Data are subset into two-consecutive year periods and analysed within a multivariate framework to determine if species composition differed between the two-year period after impact, compared to species composition prior to impact. For example, if a swamp was impacted in 2013, species composition in 2013 and 2014 at the impact swamp is compared to the species composition prior to the impact. This is then repeated for 2014-2015, 2015-2016, 2017-2018, 2018-2019, 2019-2020, 2020-2021, 2021-2022 and onwards. Three- and four-yearly comparisons are also undertaken.

3.10.3 Fauna

Seven-part tests concluded that the Area 3 mining operations would likely cause a significant impact to local populations of Littlejohn's Tree Frog, Giant Burrowing Frog, Red-crowned Toadlet, Stuttering Frog (Mixophyes balbus) and Giant Dragonfly (Petalura gigantean) (Biosis 2007). The possible mechanisms of subsidence and physical effects of subsidence were determined to have a direct impact on known and potential habitat for the threatened fauna, which included waterways, upland swamps, riparian vegetation, ridge lines and rock overhangs.

Standardised transects in potential breeding habitat for the threatened frog species Littlejohn's tree frog and Giant burrowing frog have been established in Swamp 15a. These repeatable surveys enable direct comparison of the numbers of individuals recorded at each site from one year to the next. The sites have been established within creeks associated with and/or downstream of swamps and focus on features susceptible to impacts e.g. breeding pools.

Creeks DC13, DC(1), WC21, LA4A, ND1 and WC15 are monitored as a part of the Dendrobium Area 3B monitoring program, with additional monitoring commencing in other streams two years prior to mining. Monitoring is also undertaken away from mining to act as control sites for the mining versus non-mining comparative assessment. Although there has been mining upstream of Sites SC6, SC8 and NDC, data to date indicates there are strong numbers of frogs in these areas for monitoring purposes.

Baseline surveys commenced in winter 2013 and included counts of frogs along each transect, an assessment of pools being used for breeding and counts of tadpoles and egg masses in each pool. This will enable a quantitative as well as qualitative assessment of breeding habitat for these species prior to, during and after mining.

Observations of the sites, photo points and pool water level data will also be collected as part of the frog and observational monitoring programs. Locations where significant changes have been observed (e.g. drainage of pools) will be mapped, documented and reported.

IMC continues to fund and support research into a regional understanding of the context and cumulative impact of the Dendrobium Mine on populations of Little John’s Treefrog and Giant Dragonfly.

3.11 Ecosystem Functionality

The upland swamps in the Study Area fit the description of Coastal Upland Swamps in the Sydney Basin Bioregion, which has been listed as an EEC under the BC Act (Niche 2020; Niche 2022). Specifically, the Banksia Thicket, Tea-tree Thicket and Sedgeland-heath Complex are considered part of the Coastal Upland Swamp EEC as defined by the NSW Scientific Committee’s 2012 determination.

At the Agency Consultation Workshop 27 May 2013 there was discussion about the definition of ‘ecosystem functionality’ in relation to subsidence impact performance measures for swamps. The term ‘ecosystem functionality’ is included in Table 1 of Condition 13 of the SMP Approval. The term is not included in the definitions of the Approval.

At the workshop it was stated that BCD disagrees with the definition of ecosystem function included in the Plans as they consider it is too simplistic and does not cover shallow groundwater levels. DPE advised the intent of the performance measure relating to ecosystem functionality for swamps was more general in intent; basically, the swamp will remain a swamp.

The outcome of the workshop was for IMC to propose a definition in the next version of the SIMMCP which was approved in subsequent SIMMCPs. Up to this point, ecosystem function of swamps was measured by the size of the groundwater dependent communities contributing to the swamps. Specifically, any changes in the proportion of Banksia Thicket, Tea-tree Thicket and Sedgeland-heath Complex within the monitored swamps. However, recent advice from the Panel (2023) concludes that the definition of “ecosystem functionality” warrants updating. The Panel considers the definition used in previous SIMMCPs to be “*outdated and inadequate and should be revised to accommodate all processes (such as swamp hydrology) that are essential for swamps and their dependent ecosystems.*”

The LW19A SIMMCP has been updated to address a broader definition of ecosystem functionality as recommended by the Panel. In addition to the size of groundwater dependent communities within a swamp, ecosystem functionality for Swamp 15a is measured by Longwall 19A induced hydrological changes including falls in surface or near-surface groundwater levels, falls in soil moisture levels and reduced pool water levels in SC10 compared with baseline and reference sites.

Ecosystem functionality of Swamp 148 is measured by Longwall 19A induced hydrological changes (shallow groundwater) that result in vegetation dieback. Lack of baseline data for Swamp 148 precludes the use of similar measures to that for Swamp 15a.

3.12 Reporting

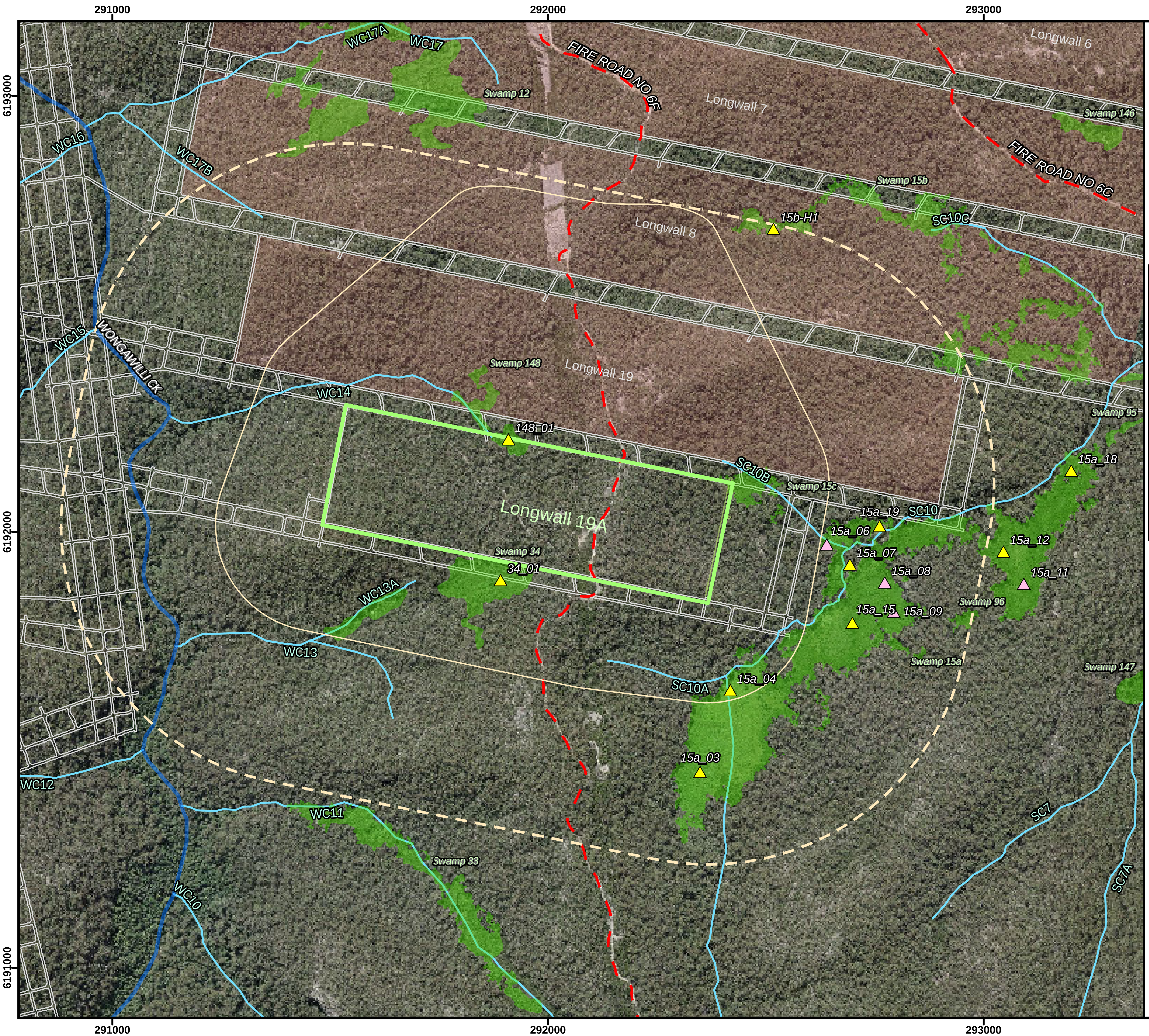
Trigger and Impact Reporting will be undertaken in accordance with the TARP in Appendix A.

Summary reports are required to be submitted to the Secretary four months from commencement of Longwall 19A and every 4 months thereafter under Condition 19 of the Longwall 19A SMP Approval. This regular reporting is required to include details of monitoring results, an assessment of compliance with performance measures, outcomes of any investigations into exceedances and reported Level 2 and 3 TARP Triggers and actions taken.

EoP Reports are prepared in accordance with Condition 9, Schedule 3 of the Dendrobium Development Consent. Results from the monitoring program are included in the EoP Report and in the AR. These reports detail the outcomes of monitoring undertaken; provide results of visual inspections and determine whether performance indicators have been exceeded.

Monitoring results will be reviewed monthly by the IMC Subsidence Management Committee. However, if the findings of monitoring are deemed to warrant an immediate response, the Principal Approvals will initiate the requirements of the TARPs shown as **Appendix A**.

Monitoring results are included in the Annual Reporting requirement under Condition 5 Schedule 8 in accordance with the Dendrobium Development Consent and are made publicly available in accordance with Condition 11, Schedule 8.

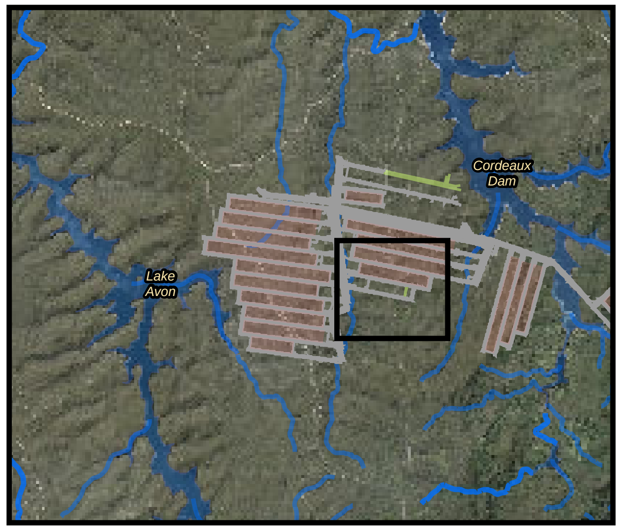


DENDROBIUM LONGWALL 19A Swamp Monitoring

Figure 3-1

SOUTH32

- Shallow Groundwater Site
- Shallow Groundwater and Soil Moisture Site
- Study Area (35 deg Angle of Draw)
- Study Area (600m boundary)
- Longwall 19A
- Existing Mine Workings
- Approved Mine Layout
- Dendrobium Goaf
- Fire Roads
- Swamp
- Rivers
- Creeks
- Tributaries



Date: September, 2023

Version 1

Horizontal Datum

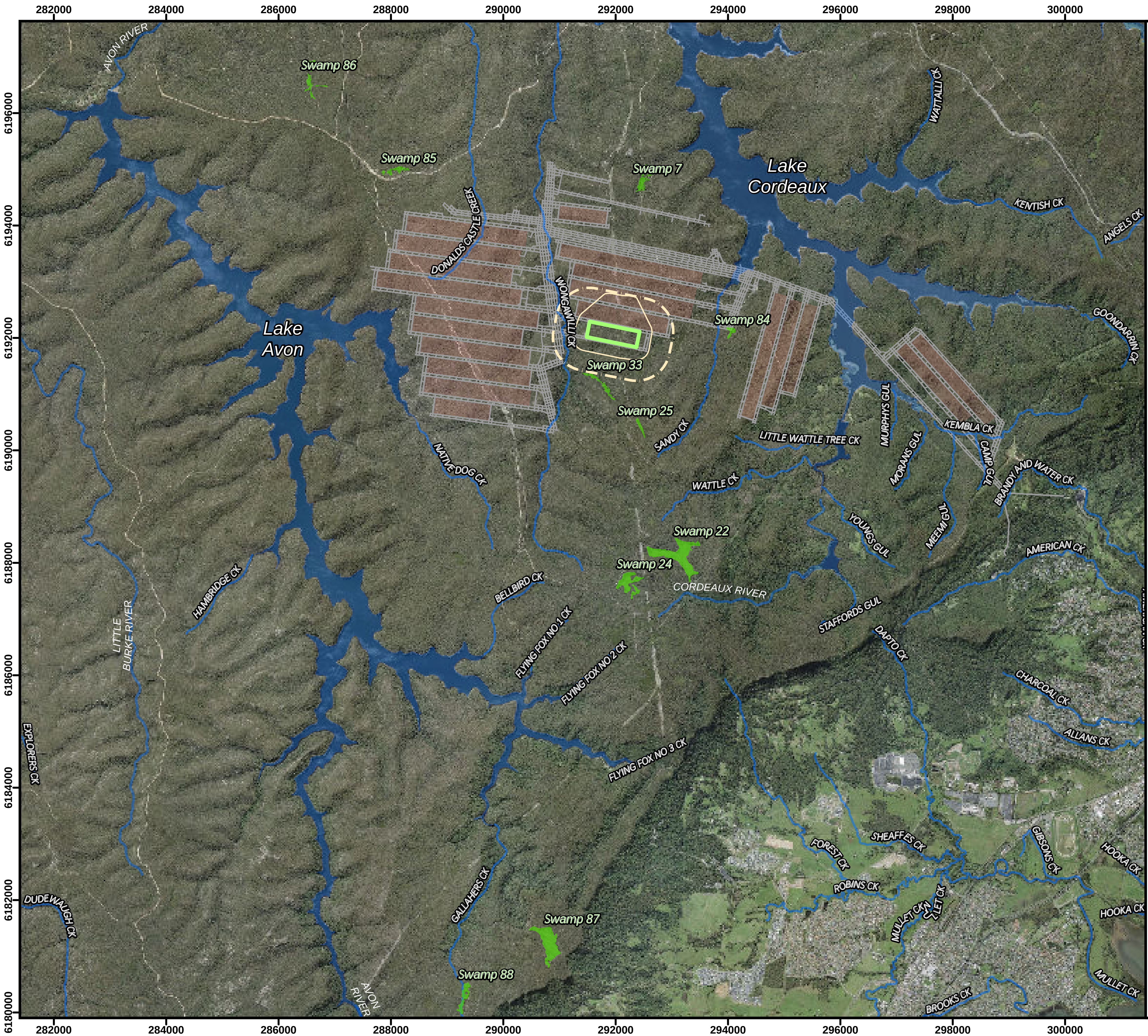
GDA2020 - Zone 56

Meters

0 250 500

DENDROBIUM
LONGWALLS 19A
Reference Swamps

Figure **3-2**

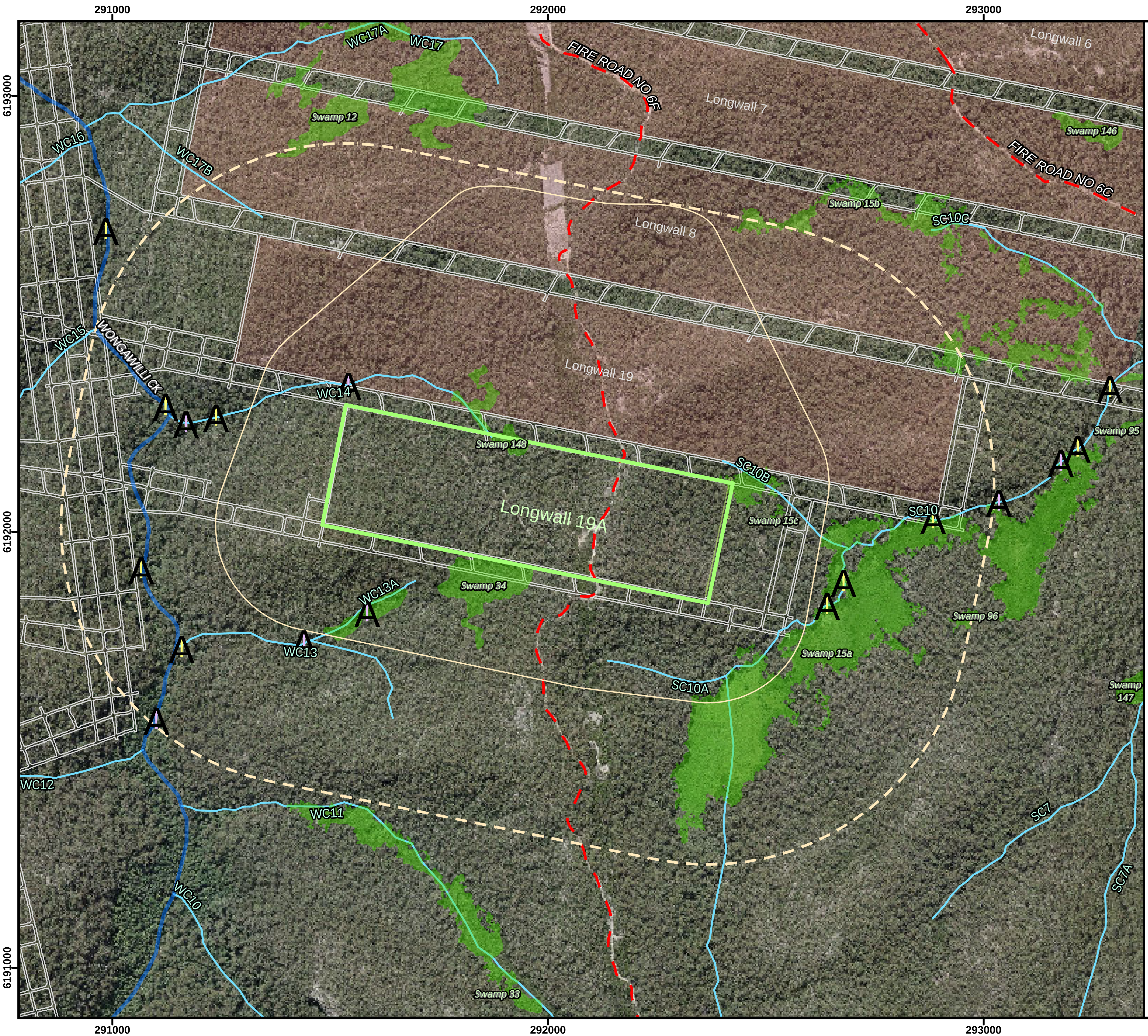


Legend
Longwall 19A
Study Area (35 deg Angle of Draw)
Study Area (600m boundary)
Reference Swamps
Creeks and Rivers
Existing Mine Workings
Dendrobium Goaf

Date: September, 2023

Version 1
Horizontal Datum
MGA - Zone 56

Meters
0 2,500 5,000

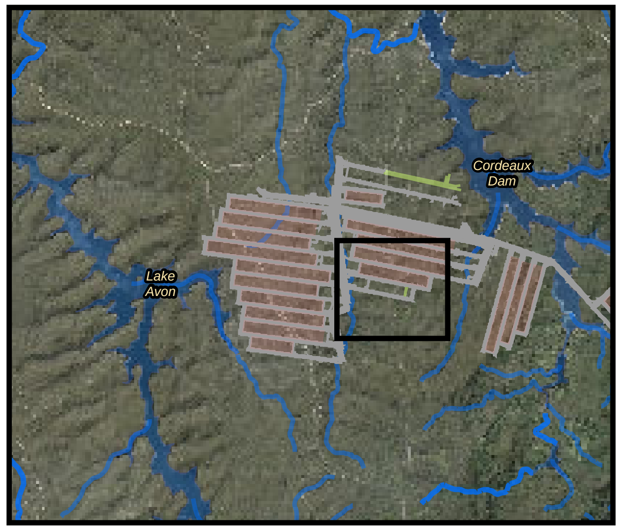


DENDROBIUM LONGWALL 19A Water Level Monitoring

Figure 3-3

SOUTH32

- Water Level Manual Benchmark
- Water Level Logger
- Study Area (35 deg Angle of Draw)
- Study Area (600m boundary)
- Longwall 19A
- Existing Mine Workings
- Approved Mine Layout
- Dendrobium Goaf
- Fire Roads
- Swamp
- Rivers
- Creeks
- Tributaries



Date: September, 2023

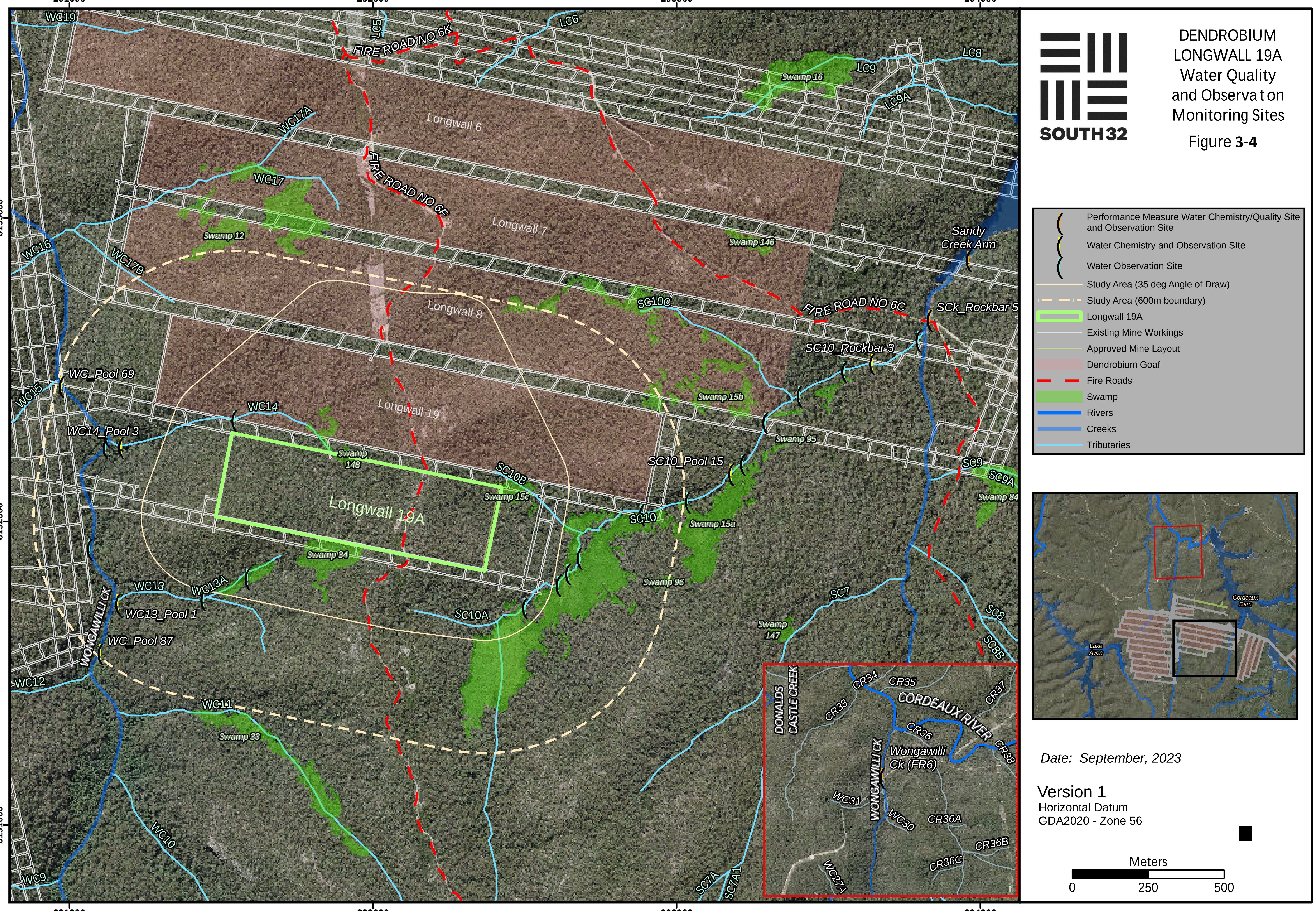
Version 1

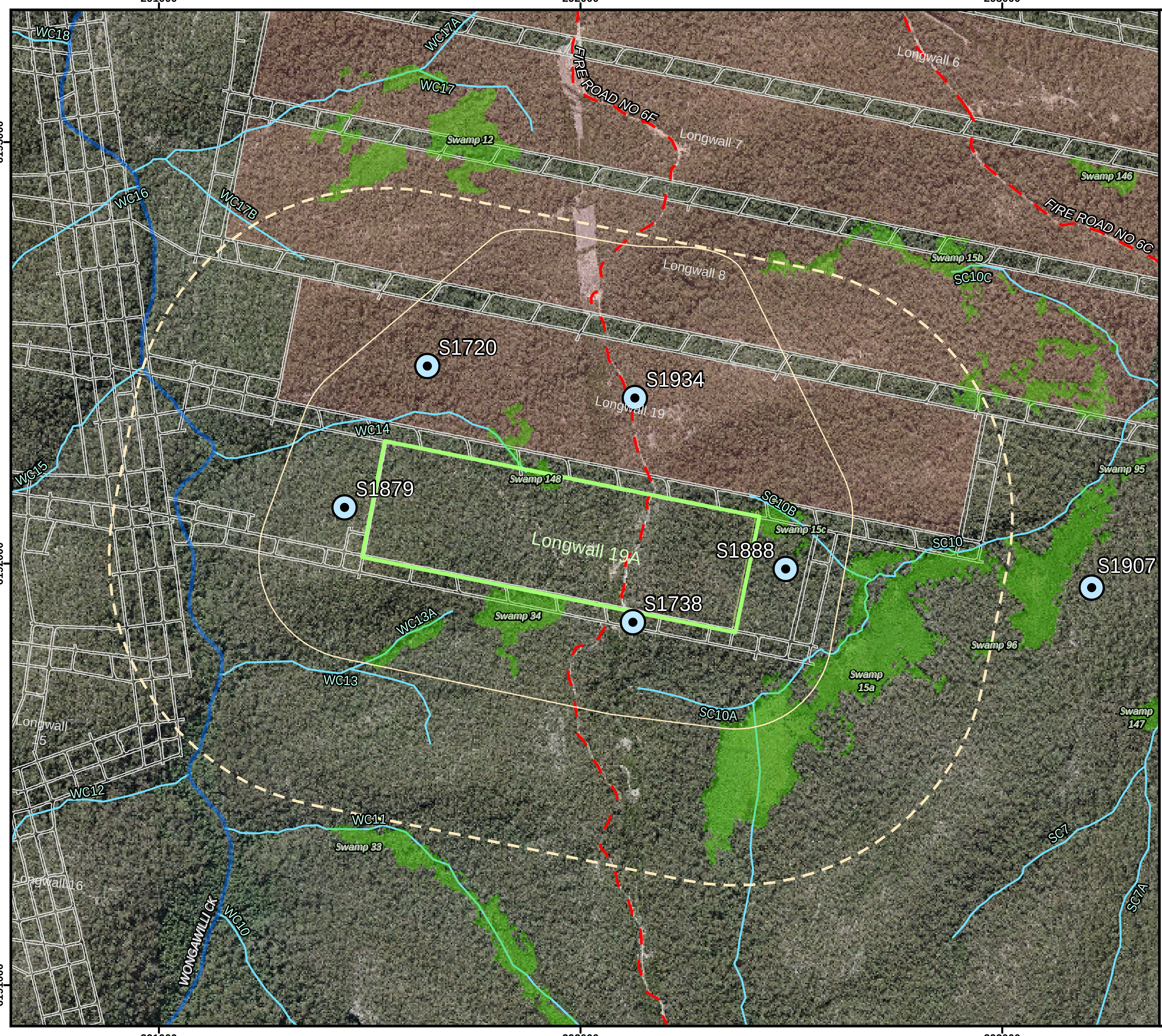
Horizontal Datum

GDA2020 - Zone 56

Meters

0 250 500


DENDROBIUM
LONGWALL 19A
Water Quality
and Observat on
Monitoring Sites
Figure 3-4
SOUTH32
Performance Measure Water Chemistry/Quality Site and Observation Site
Water Chemistry and Observation SIte
Water Observation Site
Study Area (35 deg Angle of Draw)
Study Area (600m boundary)
Longwall 19A
Existing Mine Workings
Approved Mine Layout
Dendrobium Goaf
Fire Roads
Swamp
Rivers
Creeks
Tributaries
Date: September, 2023
Version 1
Horizontal Datum
GDA2020 - Zone 56
Meters
0
250
500
291000
292000
293000
294000
6193000
6192000
6191000
Longwall 6
Longwall 7
Longwall 8
Longwall 19
Longwall 19A
FIRE ROAD NO 6K
FIRE ROAD NO 6F
FIRE ROAD NO 6C
Sandy Creek Arm
SCk_Rockbar 5
SC10_Rockbar 3
SC10_Pool 15
SC10C
SC10B
SC10A
SC10
SC9
SC9A
SC7
SC8
SC8B
SC7A
SC7A1
WC19
WC17A
WC17
WC17B
WC16
WC15
WC_Pool 69
WC14
WC14_Pool 3
WC13
WC13A
WC13_Pool 1
WC_Pool 87
WC12
WC11
WC10
WC9
WONGAWILLI CK
LC5
LC6
LC8
LC9
LC9A
Swamp 16
Swamp 12
Swamp 146
Swamp 15b
Swamp 95
Swamp 148
Swamp 15c
Swamp 15a
Swamp 34
Swamp 96
Swamp 147
Swamp 84
Swamp 33
DONALDS CASTLE CREEK
CR33
CR34
CR35
CR36
CR37
CR38
CORDEAUX RIVER
Wongawilli Ck (FR6)
WONGAWILLI CK
WC31
WC30
CR36A
CR36B
CR36C
WC27A
Cordeaux Dam
Lake Avon



DENDROBIUM LONGWALL 19A Groundwater Monitoring Sites

Figure 3-5

SOUTH32

Groundwater Monitoring
Study Area (35 deg Angle of Draw)
Study Area (600m boundary)
Longwall 19A
Existing Mine Workings
Approved Mine Layout
Dendrobium Goaf
Fire Roads
Swamp
Rivers
Creeks
Tributaries

Date: September, 2023

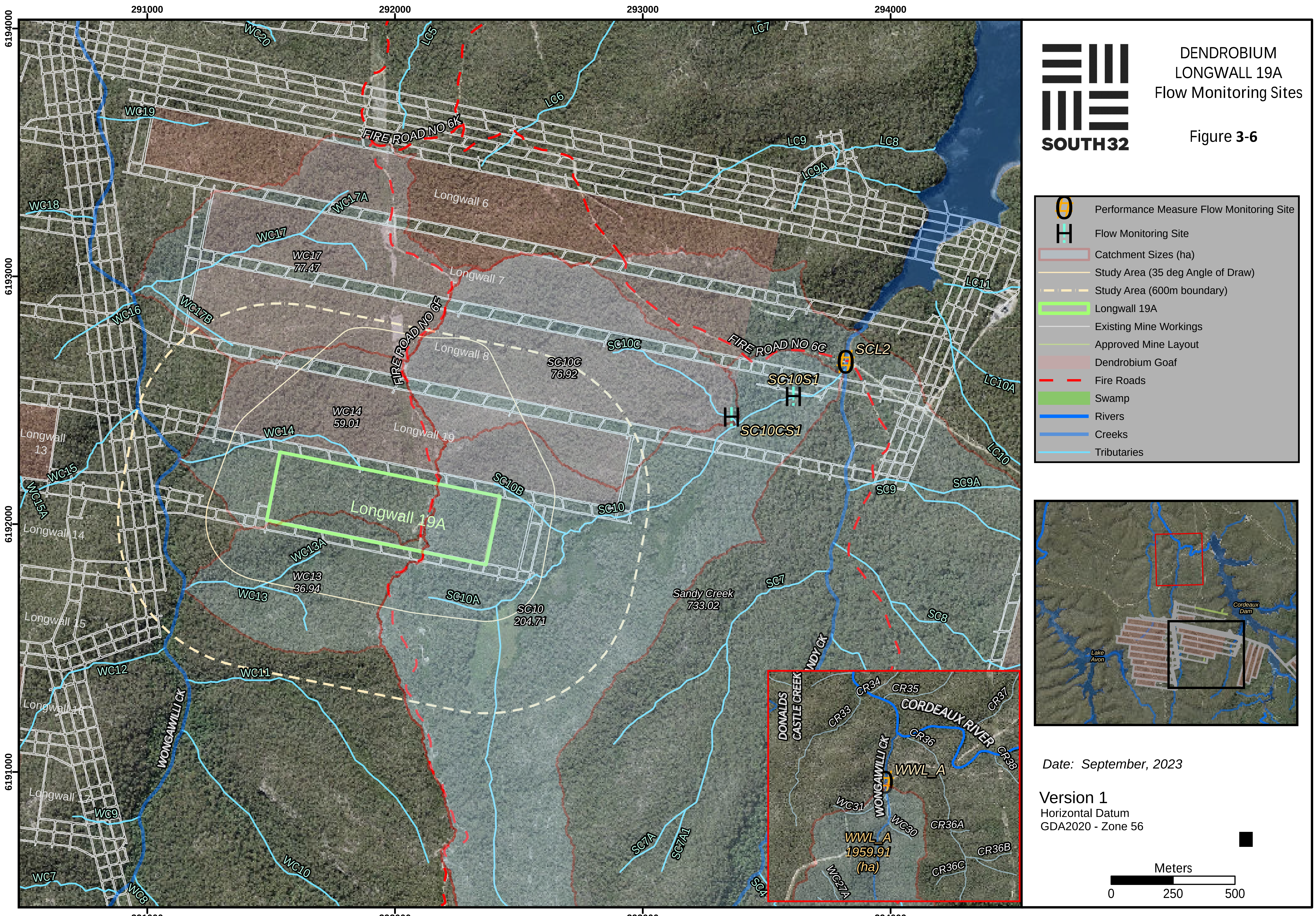
Version 1

Horizontal Datum

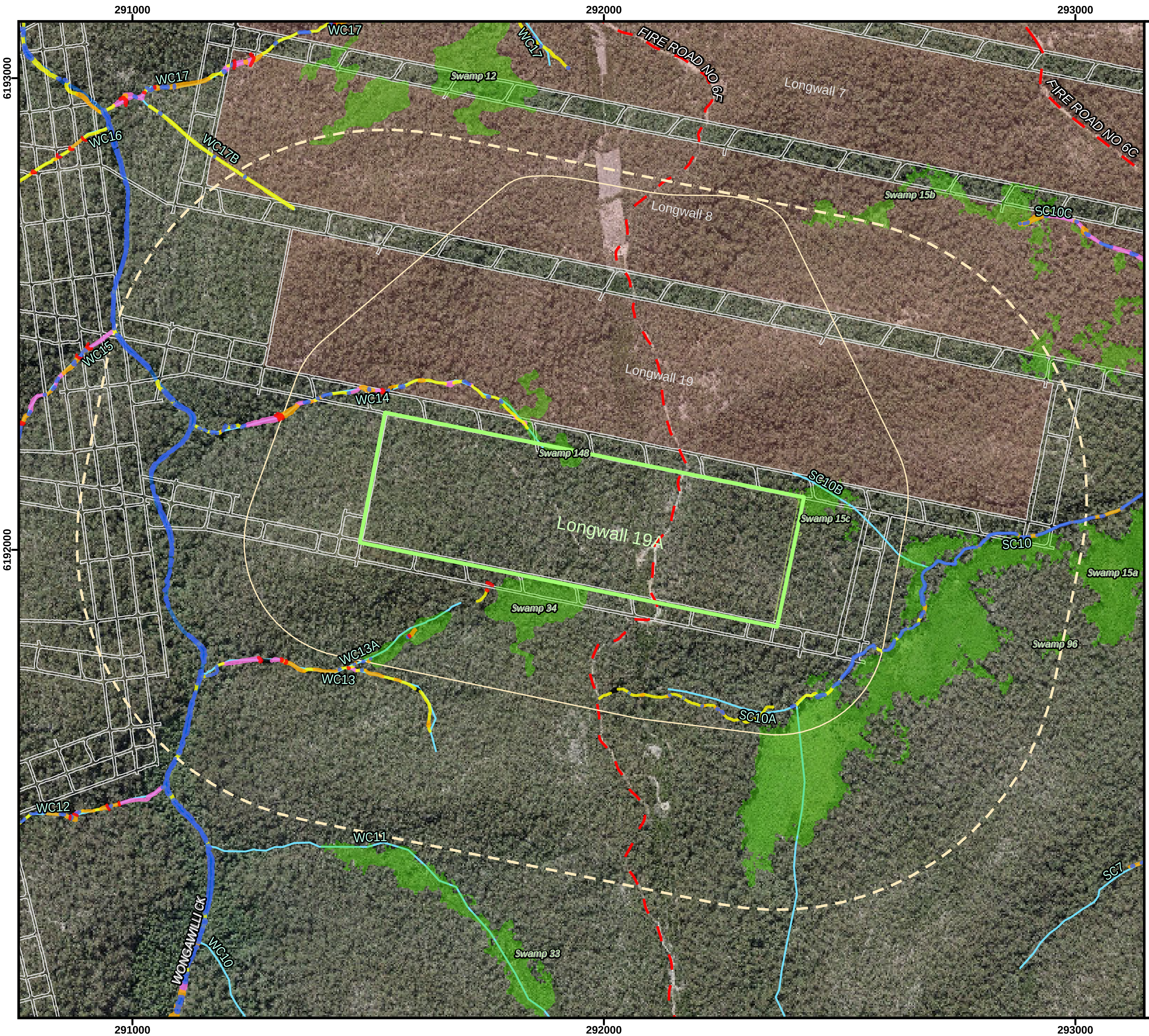
GDA2020 - Zone 56

Meters

0 250 500



SOUTH32
DENDROBIUM
LONGWALL 19A
Flow Monitoring Sites
Figure 3-6
Performance Measure Flow Monitoring Site
Flow Monitoring Site
Catchment Sizes (ha)
Study Area (35 deg Angle of Draw)
Study Area (600m boundary)
Longwall 19A
Existing Mine Workings
Approved Mine Layout
Dendrobium Goaf
Fire Roads
Swamp
Rivers
Creeks
Tributaries
Date: September, 2023
Version 1
Horizontal Datum
GDA2020 - Zone 56
Meters
0
250
500
291000
292000
293000
294000
6194000
6193000
6192000
6191000
Longwall 6
Longwall 7
Longwall 8
Longwall 19
Longwall 19A
Longwall 13
Longwall 14
Longwall 15
FIRE ROAD NO 6K
FIRE ROAD NO 6F
FIRE ROAD NO 6C
SCL2
SC10S1
SC10CS1
WC17
77.47
WC14
59.01
WC13
36.94
SC10C
76.92
SC10
204.71
Sandy Creek
733.02
WONGAWILLI CK
CORDEAUX RIVER
DONALDS CASTLE CREEK
WWL_A
WWL_A
1959.91
(ha)
Lake Avon
Cordeaux Dam



DENDROBIUM LONGWALL 19A Geomorphology

Figure 3-7

Stream Mapping Geomorphology

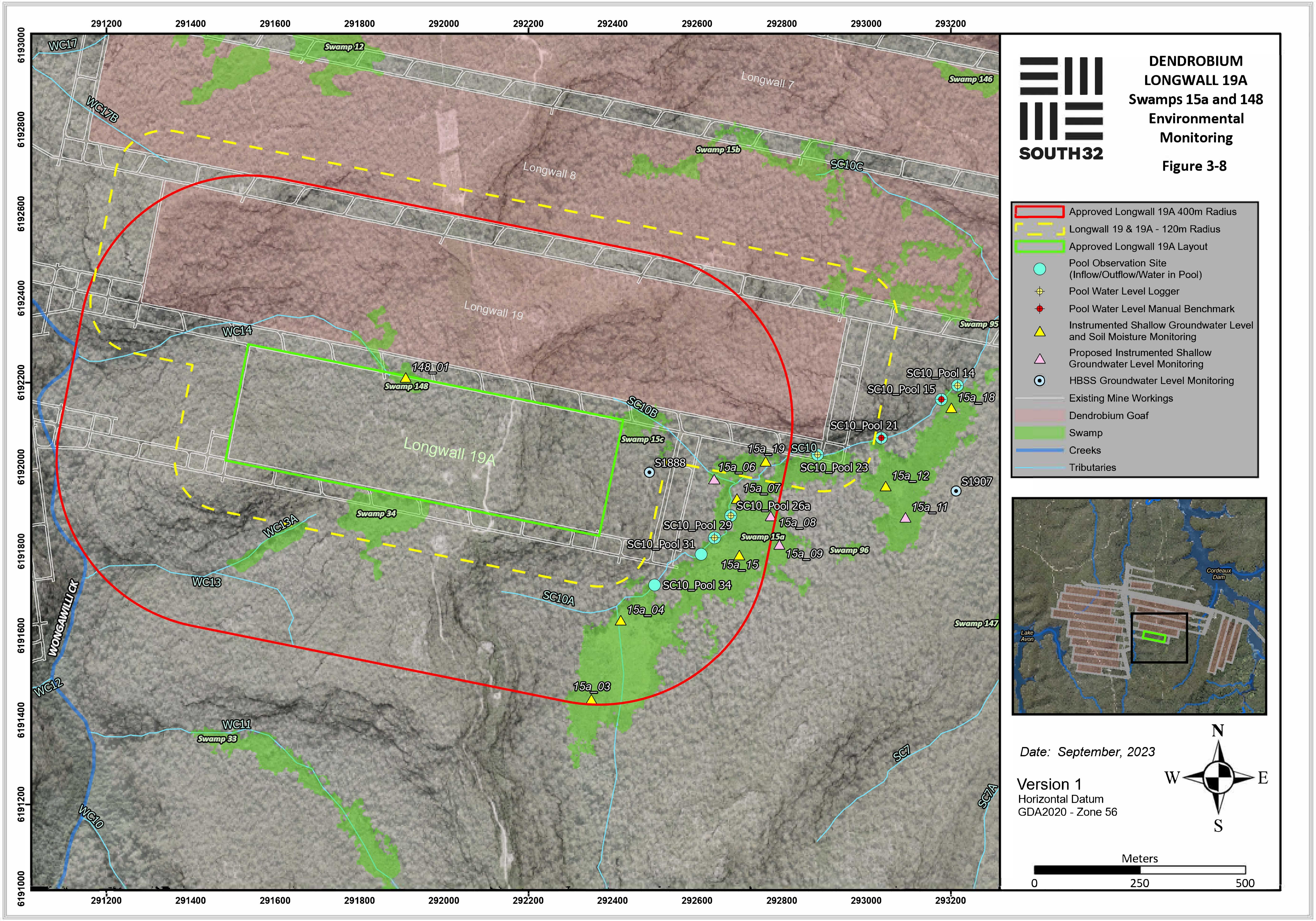
- Step/Waterfall
- Pool
- Rockbar
- Channel
- Boulder Field
- Cascade
- Study Area (35 deg Angle of Draw)
- Study Area (600m boundary)
- Longwall 19A
- Existing Mine Workings
- Approved Mine Layout
- Dendrobium Goaf
- Fire Roads
- Swamp
- Rivers
- Creeks
- Tributaries

Date: September, 2023

Version 1

Horizontal Datum

GDA2020 - Zone 56


DENDROBIUM LONGWALL 19A Swamps 15a and 148 Environmental Monitoring
Figure 3-8
SOUTH32
Approved Longwall 19A 400m Radius
Longwall 19 & 19A - 120m Radius
Approved Longwall 19A Layout
Pool Observation Site (Inflow/Outflow/Water in Pool)
Pool Water Level Logger
Pool Water Level Manual Benchmark
Instrumented Shallow Groundwater Level and Soil Moisture Monitoring
Proposed Instrumented Shallow Groundwater Level Monitoring
HBSS Groundwater Level Monitoring
Existing Mine Workings
Dendrobium Goaf
Swamp
Creeks
Tributaries
Date: September, 2023
Version 1
Horizontal Datum GDA2020 - Zone 56
Meters
0
250
500
N
S
E
W
Longwall 7
Longwall 8
Longwall 19
Longwall 19A
Swamp 12
Swamp 146
Swamp 15b
Swamp 95
Swamp 148
Swamp 15c
Swamp 34
Swamp 15a
Swamp 96
Swamp 147
Swamp 33
WC17
WC17B
WC14
WC13A
WC13
WC12
WC11
WC10
WONGAWILLI CK
SC10C
SC10B
SC10A
SC10
SC7
SC7A
148_01
S1888
S1907
15a_19
15a_06
15a_07
15a_08
15a_09
15a_15
15a_04
15a_03
15a_12
15a_11
15a_18
SC10_Pool 14
SC10_Pool 15
SC10_Pool 21
SC10_Pool 23
SC10_Pool 26a
SC10_Pool 29
SC10_Pool 31
SC10_Pool 34
Cordeaux Dam
Lake Avon
291200
291400
291600
291800
292000
292200
292400
292600
292800
293000
293200
6193000
6192800
6192600
6192400
6192200
6192000
6191800
6191600
6191400
6191200
6191000

4 PERFORMANCE MEASURES AND INDICATORS

Performance measures and indicators have been derived from the Dendrobium Development Consent and Longwall 19A SMP Approval. These performance measures will be applied to the extraction of Longwall 19A. These performance measures are presented in **Table 4-1**.

Table 4-1 Subsidence impact performance measures

Dendrobium Development Consent
Condition 5 – Schedule 3 • Operations must not cause erosion of the surface or changes in ecosystem functionality of Swamp 15a and that the structural integrity of its controlling rockbar is maintained or restored, to the satisfaction of the Secretary.
Longwall 19A SMP Approval Conditions
Condition 8 – Schedule 3 The Applicant must ensure that the development does not cause any exceedance of the performance measures below, to the satisfaction of the Secretary. *Swamp 15a* Negligible environmental consequences including: • negligible erosion of the surface of the swamp; • negligible change in the size of the swamp; • negligible change in the ecosystem functionality of the swamp; • negligible change to the composition or distribution of species within the swamp; and • maintenance or restoration of the structural integrity of rockbar SC10-RB15A. *Swamp 148* Minor environmental consequences including: • minor erosion of the surface of the swamp; • minor change in the size of the swamp; • minor change in the ecosystem functionality of the swamp; • minor change to the composition or distribution of species within the swamp; and • maintenance or restoration of the structural integrity of rockbar base of any significant permanent pool or controlling rockbar within the swamp.

A detailed list of performance measures, reporting triggers and performance indicators are included in the TARPs in **Appendix A: Tables 1.2 and 1.3**.

4.1 Impact Mechanisms

Subsidence is an unavoidable consequence of longwall mining and includes vertical and horizontal movement of the land surface. Subsidence effects include surface and sub-surface cracking, buckling, dilation and tilting. These effects can result in changes to the hydrology of watercourses.

Changes to watercourse hydrology and water quality can result in environmental consequences. The likelihood and timing of these consequences relate to the size and duration of the effect. The potential consequences of mining on groundwater and surface water in the Special Areas are (IEP 2019a):

- Groundwater depressurisation
  - The creation of an excavation below the water table can affect groundwater in a number of basic ways. In all cases, because the fluid pressure in an excavation is much lower than that of the fluid that originally occupied the space, a flow system is established with the excavation acting as a sink into which surrounding groundwater flows. The rate of flow and observed extent of depressurisation depend on the hydrogeological properties of

the rock mass. If the excavated area is sufficiently large, the spatial extent and rate of flow into the sink can be enhanced by the formation of fractures.

- Surface water diversions
  - Diversions into a shallow, localised fracture network, where loss of flow from a surface water is likely to return to the system at some point downstream, which based on observations of the SCI (2008) may vary from 20 m for specific rockbars to more than 200 m.
- Surface water permanent losses
  - Diversions into deeper, dilated shear surfaces on bedding planes, where these form a conduit for lateral water flow, which may or may not report to the same catchment (i.e. it may become a permanent loss).
- Groundwater depressurisation
  - Groundwater within the Hawkesbury Sandstone and Narrabeen Group as well as the Permian coal measures is recharged from rainfall and water bodies where the lithologies occur at outcrop, as well as potential downward leakage from overlying strata (Hydrosimulations 2018).
- Water quality
  - Water quality within watercourses is affected by numerous factors including runoff from swamps and interactions between bedrock and water, with fracturing of bedrock due to mining causing local water quality impacts.

The environmental consequences which could relate to changes in hydrology and water quality include:

- Species composition change and/or changes in vegetation communities.
- Loss of aquatic ecology and/or changes in aquatic habitat resulting from a reduction of surface water quality and/or flows and standing pools.
- Water-borne inputs to Lake Avon, Lake Cordeaux and Cordeaux River such as erosive export of fine sands and clays and/or ferruginous precipitates.
- Reduced inflows into Lake Avon, Lake Cordeaux and Cordeaux River.

An overview of the potential impacts and consequences of mining on swamps, surface flows and storages is presented in **Table 4-2**.

Table 4-2 Summary of subsidence effects, impacts and consequences for surface flows, storages and swamp hydrology (IEP 2019b)

Subsidence effects	Impacts	Consequences
• Tensile cracking, tensile, compressive or shear movement of joint and bedding plane • Fracturing of sandstone blocks • Buckling and localised upsidence in the stream bed below the swamp • Tilting of bedrock	• Cracking of rock bars • Lowered water tables and soil moisture • Potential erosion and scouring • Altered water chemistry e.g. enhanced release of iron • Change to the size of swamps	• Loss of surface flow and storage through leakage • Loss of baseflow generation including from swamps • Vulnerability of swamps to fire and further erosion and reduction in baseflow generation capacity • Increased loads of contaminants to water storages

Changes to swamp hydrology can result in environmental consequences, particularly drying of swamps. The likelihood and timing of these consequences relate to the size and duration of the effect. The possible impacts of the drying of swamps due to mining-induced changes in hydrology include (IEP 2019b):

- reduction of soil moisture levels and loss of cohesiveness of the swamp sediments

- enhanced risk of channelization and consequent susceptibility to erosion of swamp sediments, with potential water quality implications
- decline of groundwater-dependent plant species and consequent changes in vegetation structure
- decline of groundwater-dependent fauna including macroinvertebrates and stygofauna
- oxidation of peaty sediments resulting in increased hydrophobicity, lower water-holding capacity and potential changes in nutrient status and cycling
- increased risk of erosion, which may lead to gully formation.
- swamps have less resilience to bushfires which, in turn, can lead to an increased susceptibility to erosion and loss of baseflow (NSW Threatened Species Scientific Committee, 2012).

4.2 Potential for Connectivity to the Mine Workings

The fracture zone above a longwall panel comprises in-situ material lying immediately above the caved zone which have sagged downwards and consequently suffered significant bending, fracturing, joint opening and bed separation (Singh and Kendorski, 1981; Forster, 1995). Where the panel width-to-depth ratio is high and the depth of cover is shallow, the fracture zone would extend from the seam to the surface. Where the panel width-to-depth ratio is low, and where the depth of cover is high, the fracture zone would not extend from the seam to the surface.

The possible height of the fracture zone above the longwall panel is dependent upon the angle of break, the width of the panel, the thickness of seam extracted and the spanning capacity of a competent stratum at the top of the fracture zone (MSEC 2012). Based on mining geometry, the height of the fracture zone equals the panel width, minus the span, divided by twice the tangent of the angle of break.

It should be noted that the height of the fracture zone should be viewed in the context of fracturing only and should not necessarily be directly associated with an increase in vertical permeability. There are numerous models for the height of fracturing and height of depressurisation. A review of these matters was conducted for the Bulli Seam Operations Project Response to PAC deliberations (Hebblewhite 2010).

The Regional Groundwater Models at Dendrobium uses site specific data to determine the height of depressurisation.

Dendrobium monitors in excess of 1,000 piezometers in ~100 boreholes (including a comprehensive array of piezometers above the centreline of longwall goafs) and has analysed many thousands of samples for field parameters, laboratory analysis, algae and isotopes.

The results of water analysis and the interpretation of the height of connective fracturing was peer reviewed by Parson Brinckerhoff (2012). The peer review states that "*the use of standard hydrogeochemical tools clearly demonstrated the geochemical difference between water from the Wongawilli Coal Seam and goaf, and the overlying sandstone formations and surface water from Lake Cordeaux*". Although the report acknowledged limitations of the available data, this review is based on one of the most comprehensive datasets available in the Southern Coalfield.

In January 2015 SRK Consulting conducted a detailed independent review of the Dendrobium water chemistry data to:

- Assess the level of detail, quality of science, depth and technical appropriateness of the water chemistry data.
- Evaluate associated interpretations in relation to underground operations of Dendrobium Mine, with a specific focus on how these address the question of hydraulic connectivity between the mined areas and the reservoirs.

Based on the review SRK concluded that the observed geochemical trends are not consistent with a high degree of hydraulic connectivity between the underground workings and the surface water bodies.

As reported in Coffey (2012) most of the change in aquifer properties occurs within the collapsed zone. Changes in aquifer properties above the collapsed zone are less severe and largely restricted to increases in storability. Groundwater drawdown due to sudden storativity increases will ultimately impact the surface, either directly (as seepage from watercourses or lakes to satisfy the drawdown), or by intercepting baseflow.

Predictions of fracture zone dimensions above longwall panels for Dendrobium (MSEC 2012 and Coffey 2012) refer to geotechnical fracturing behaviour and are not necessarily directly related to groundwater responses resulting from increased vertical permeability.

Parson Brinckerhoff and IMC have completed testing to characterise the pre- and post-mining permeability above Longwall 9, the first longwall in a new domain, not affected by previous mining. After Longwall 9 mined under the site it was tested to quantify the change to vertical and horizontal permeability of the strata, including the Bulgo and Hawkesbury Sandstones and the Bald Hill Claystone. The testing involved core, packer and borehole interference testing, groundwater flow and tracer testing.

Mining of Longwall 9 resulted in a significant increase in subsurface fracturing compared with pre-mining. Down-hole camera surveys identified a number of open horizontal and inclined fractures with apertures of several centimetres. Groundwater ingress was noted at several open fractures.

Most post-mining test bores showed decreases in groundwater level and strong downward hydraulic gradients, particularly in the lower Bulgo Sandstone. Significantly however, groundwater levels in the shallow Hawkesbury Sandstone remained perched at the study site.

Horizontal hydraulic conductivity increased between one to three orders of magnitude due to mine subsidence and strata fracturing. Increases in hydraulic conductivity are observed in every geological unit but are greatest below the base of the Hawkesbury Sandstone.

In contrast to pre-mining testing in which no breakthrough was observed, horizontal tracer testing after the passage of Longwall 9 resulted in breakthrough in about 40 minutes. This indicates a bulk hydraulic conductivity in the order of 10 m/day; at least two orders of magnitude higher than pre-mining conditions.

No breakthrough in tracer was observed in either the pre-mining or the post-mining tests of the Bald Hill Claystone and this indicates that the vertical conductance at the research site was below the detection limit of the test, estimated to be approximately 0.7 m/day.

Activated carbon samplers deployed in streams adjacent to the research site detected no breakthrough of tracer and therefore there is no evidence of preferential flow paths either existing or induced between the research site and adjacent streams.

Sampling of water from the underground mine detected no breakthrough of tracer and therefore there is no evidence of preferential flow paths induced between the research site and the workings.

Although current observations do not allow a precise definition of the height of intense fracturing using any criteria (and the boundaries are gradational in any case), most evidence suggests that the zone of most intense and vertically connected fracturing in Area 3B extends into the Bulgo Sandstone.

Estimates for the height of fracturing above a longwall panel at Dendrobium based on published methods range from 122 m to 357 m. This range in estimates is large and presents a challenge to those wishing to model hydrogeological impacts of mining on a regional scale based on mine site data.

The pre- and post-mining investigations carried out in this research study provide important constraints on the extent of mining related disturbance and its effect on groundwater systems.

A review of methods for estimating the height of fracturing above longwall panels at Dendrobium Mine was commissioned by DPE and carried out by geotechnical consultants Pells Sullivan Meynink (PSM). The PSM report was made available to South32 on 7 September 2017.

Recommendations by PSM regarding additional monitoring and research to add to our understanding of the catchment are generally supported and many of these have been acted on.

The IEP (2019b) Part 2 Report further considered mining operations within the special areas and reiterated its earlier position stated in IEP (2019a*):*

The Panel has given detailed consideration to the equations in the Part 1 Report and concluded that it cannot endorse either at this point in time. For a range of reasons, neither or either may ultimately prove to be sufficiently reliable. It recommended erring on the side of caution and deferring to the Tammetta equation until:

1. *field investigations quantify the height of complete drainage at Metropolitan and Dendrobium mines; and/or*
2. *geomechanical modelling of rock fracturing and fluid flow are shown to be sufficiently reliable for informing the calibration of groundwater models at mine sites in the catchment.*

The Regional Groundwater Model for Dendrobium Mine has been revised to consider the findings of the PSM report and IEP Reports (2019a), including the use of the Tammetta model and modelling connectivity to the surface. HydroSimulations state that regardless of the method used to assess fracturing, they believe the current groundwater modelling approach is sound.

In accordance with Schedule 3, Condition 19(c) of the Area 3B SMP Approval, height of connective fracturing investigations across longwalls in Area 3B are undertaken and reported to the Department prior to each longwall extraction. The most recent report, Hebblewhite (2020) states:

… comments and conclusions are drawn in relation to the overall concept of height of depressurisation, and the status of predictive models:

- *…*
- *… mining-induced impacts are occurring above all panels throughout the overburden sequence, through to, or very close to the surface in all cases. This includes increased defect/fracture impacts; significant increases in permeability; and reduction to near-zero pressure head throughout the strata.*
- *There is some evidence of very localised retained groundwater in perched aquifers at some locations, and at different vertical horizons, but these are not extensive.*
- *On the basis of this evidence, it is reasonable to conclude that the height of depressurisation is close to, or equal to the total depth of overburden above the working coal seam, i.e. extending to the surface in each instance.*
- *In spite of the reduced longwall panel width in Area 3A (LW6 and LW7), the height of depressurisation has still effectively extended to the surface, albeit with a reduced strata fracture density above the mined panels. It is likely that a more significant panel width reduction and or mining height reduction would be necessary to cause a significant reduction in height of depressurisation in this particular mining region.*
- *The lack of significant differential in height of depressurisation with the reduced panel widths means that the range of the dataset available to assist with developing an improved prediction model remains inconsistent, and insufficient to enable any further model development based on empirical methods.*
- *There is strong evidence at all locations of significant depressurisation occurring ahead of under-mining, due to the effect of adjacent mining panels, and earlier mining development. These effects are evident at most of the strata horizons, extending towards the surface.*
- *… the Tammetta model is clearly the most appropriate one to continue using in the future. It provides a reasonably accurate prediction – given the variability of factors such as depth across any particular panel.*

4.3 Potential for Fracturing Beneath the Swamps

Based on the predicted systematic and non-systematic subsidence movements (MSEC 2020 and MSEC 2022) the bedrock below the swamps and any significant permanent pools within the swamps are likely to fracture as a consequence of subsidence induced strains. The predicted strains decrease where the surface is not directly mined beneath, and generally reduce with distance from the longwall panel.

Surface flows captured by any surface subsidence fracture network resulting from valley related movements which do not connect to a deeper aquifer or the mine workings will re-emerge further downstream. This prediction is based on an assessment of the depth of valley closure induced vertical fracturing from the surface and measurements of water balance during the modelled periods of recessional, baseflow and small storm unit hydrograph periods downstream of mining areas.

The depth of fracturing in the "surface zone" above a longwall panel is addressed in the Bulli Seam Operations Environmental Assessment: Section 5.2.1, Appendix A, Appendix B and Appendix C as well as in the Response to Submissions and Response to the NSW Planning Assessment Commission. The BSO Independent Peer Review of strata deformation provided by Professor Bruce Hebblewhite concurs with the concept of the "surface zone" fracture network related to down-slope or valley movements. Several studies have determined the depth of these vertical fracture networks are restricted to approximately 15 m to 20 m below the surface.

The depth and other attributes of the surface fracture zone have been comprehensively determined using the following instruments and techniques:

- Calliper logging;
- Straddle packer permeability testing;
- Overcore stress measurements;
- Core logging and geotechnical testing;
- Geophysical testing;
- Water level monitoring;
- Borehole cameras;
- Subsidence, extensometer monitoring and shear deformation monitoring;

- Stress change and fracture logging;
- Permeability testing and falling head tests; and
- Mapping of pressured air drilling fines.

The following sites have been comprehensively investigated to demonstrate the dimensions of the “surface fracture zone”:

- Two rockbars on the Waratah Rivulet; and
- Four rockbars on Georges River.

Monitoring from Dendrobium Mine indicates the surface fracture network over the goaf connects to or is concurrent with the fracture network which propagates from the seam to the surface. In this instance the diversion of surface flow to deep strata or the mine relates to vertical permeability increases associated with this fracturing.

Prior to any remediation works within the Study Area that target surface/shallow fracture networks, the depth of the fracturing will be characterised by standard techniques such as drilling, down hole cameras and calliper measurements. The hydraulic conductance of these fracture networks will also be determined prior to implementing any rehabilitation.

Swamps that have been mined under commonly display hydrological changes shortly following the passage of the longwall beneath the monitoring site. An assessment of hydrological change at Upland Swamps was carried out at Dendrobium by Watershed HydroGeo (2019), updated (Watershed HydroGeo, 2021) and again recently (Watershed Hydrogeo, 2023) to include data to June 2023 and sites in Areas 2, 3A, 3B and 3C. The most recent study updated the empirical model of impact to swamp piezometers based on the assessments of water levels and recession rates around existing mining. The study identified that approximately 85-95% of Upland Swamp piezometers within 70 metres [of mining] are likely to exhibit a response to mining, and that there is overwhelming evidence that the probability of an impact declines with distance from the goaf. Four main zones were identified from the data:

A. Above the goaf – Almost certain (97% chance) of being impacted;
B. Within 75 m of the goaf – Highly likely (85-95% chance) of being impacted;
C. 75-120 m from the goaf – 40% chance of being impacted; and
D. >120 m from the goaf – Unaffected (0% chance of being impacted)

Furthermore, there is likely a difference between the distance to which groundwater effects propagate from the long edge compared to from the short edge, however there is insufficient quantitative data to be definitive in regard to shallow groundwater response.

4.4 Potential for Erosion Within the Swamps

Tilting, cracking, desiccation and/or changes in vegetation health could result in concentration of runoff and erosion which intern could alter water distribution in the swamp. Changes to swamp hydrology can result in environmental consequences. The likelihood and timing of these consequences relate to the size and duration of the effect. The possible impacts of the drying of swamps due to mining-induced changes in hydrology include (IEP 2019b):

- reduction of soil moisture levels and loss of cohesiveness of the swamp sediments
- enhanced risk of channelization and consequent susceptibility to erosion of swamp sediments, with potential water quality implications
- decline of groundwater-dependent plant species and consequent changes in vegetation structure
- decline of groundwater-dependent fauna including macroinvertebrates and stygofauna
- oxidation of peaty sediments resulting in increased hydrophobicity, lower water-holding capacity and potential changes in nutrient status and cycling
- increased risk of erosion, which may lead to gully formation.
- swamps have less resilience to bushfires which, in turn, can lead to an increased susceptibility to erosion and loss of baseflow (NSW Threatened Species Scientific Committee, 2012).

Subsidence predictions were carried out to assess the potential impacts of longwall mining in the Longwall 19A Study Area. The assessment indicated that the levels of impact on the natural features were likely to be similar to the impacts observed within Area 3A and Area 3B to date, including the reduction in the potential for impacts where mining is setback from surface features (see Section 4.3 where hydrological impacts have not been observed at distances greater than 120m). A summary of the maximum predicted values of subsidence, tilt and strain at the swamps is provided in **Section 5**.

Where a swamp is directly mined under, tilting of sufficient magnitude could change the catchment area of a swamp or re-concentrate runoff leading to scour and erosion, potentially reducing the water flowing onto a swamp or allowing water to escape from the swamp margins. These effects could be observed within the whole swamp or alter water distribution in parts of the swamp, thus favouring some flora species associations over others.

Changes in gradients predicted to occur following mining are shown in **Section 5**. These changes have been considered in relation to the likelihood of change in drainage line alignment by MSEC (2022). The assessment takes into account the nature of the drainage channel and whether the predicted tilt is significant when compared to the existing slopes.

Landscape monitoring commenced in 2004 for Dendrobium Area 1. This monitoring program has been continued and updated throughout the mining period for Areas 2, 3A and 3B. The monitoring includes inspections of swamps at regular intervals prior to mining, during active subsidence and following the completion of subsidence movements. In addition to erosion (increased incision and/or widening), these observations target any surface cracking, surface water loss, soil moisture changes, vegetation condition changes, slope and gradient changes, the condition of rock-bars and peat condition.

The observed impacts on natural features above Longwalls 1 – 15 have been generally consistent with those predicted in the assessments undertaken prior to mining.

In Area 3B, one surface impact (cracking) has been observed in swamps. To date there has been no instance of erosion resulting from this cracking. No erosion of the surface of the swamps as a result of mining observed to date. For Area 3B to completion of Longwall 14, 154 surface impacts have been identified. Many of these are very minor impacts and of very limited environmental consequence. For example, 91% of the cracking identified at the surface has a width of less than 100 mm. To date there has been no instance of erosion resulting from this cracking (Illawarra Coal 2018).

Swamp 18 is a swamp that some have reported to be impacted by mining. An important observation of Tomkins and Humphreys (2006) is that in 1951, Swamp 18 was more extensive and included a continuous, intact swampy unit infilling the valley of Native Dog Creek for several hundred meters downstream of the main body of the swamp to link with Swamp 19. Furthermore, the gully erosion of the lower extension of the swamp had commenced before 1951 and had reached the main body of Swamp 18 by 1990, well before underground coal mining in this area.

In 2003 approximately 450 m of gully erosion was identified in Swamps 1A and 1B and the associated stream before any mining influence in the area. These case studies demonstrate that erosion within swamps can be active without any influence of mining.

4.5 Potential for Vegetation Changes Within the Swamps

Where there are changes to swamp hydrology that are large and persistent there is likely to be a vegetation response. Swamp vegetation is likely to be relatively resilient to short term changes in groundwater level and soil moisture, demonstrated by the persistence of the swamp vegetation communities during extended periods of drought. For this reason, any response to changes in swamp hydrology are likely to be over the medium to longer time period as the vegetation equilibrates to the new hydrological regime. Vegetation change may be observed in the rates of species composition change and/or changes in vegetation communities over and above what is measured in nearby swamps due to natural variation.

Flora monitoring in swamps includes collection of data on species abundance within thirty 0.5 m x 0.5 m quadrats along a 15 m transect. Data is also collected from a number of control sites, to allow comparison both pre- and post-mining with control sites as a part of a Before – After - Control – Impact (BACI) experimental design.

Eleven years of post-mining monitoring is available for Dendrobium Area 2 and Dendrobium Area 3A and four to nine years in Dendrobium Area 3B. Monitoring includes a minimum of two years baseline surveys for pre-impact sites within Area 2 and Area 3. Monitoring of control sites has been occurring for up to 14 years.

Caution is urged when interpreting the results of the swamp size and ecosystem functionality LiDAR monitoring given that a number of factors unrelated to mining-induced impacts may drive some of the observed decreases in swamp size and extent of groundwater dependent sub-communities. Changes in swamp size and extent of groundwater dependent communities observed at each swamp may be the result of responses to natural phenomena such as recent and long-term climate conditions, fire patterns and stochastic events (e.g. storm damage).

Monitoring is continuing to further define any vegetation changes likely to result from reduced groundwater levels.

The IEP Report (2019b) recognised that improvements in monitoring data supported by a substantial body of research has improved understanding of the impacts and consequences of longwall mining for swamps. The report also established that longwall mining directly under swamps in the Southern Coalfield can result in significant changes to swamp hydrology and redirection of surface runoff which currently appear to be irreversible. Additionally, the IEP Report (2019b) concluded:

- Impacts on swamps and on the streams exiting from them are evident, however currently there is no strong evidence to date of consequences of swamp impacts on catchment-scale water supplies.
- When shallow groundwater levels in a swamp decline, soil moisture levels also decline, with a lag time of weeks or months.
- Quantifying the consequences of changes for flows in exit streams requires the development of water balance models of the swamps.
- Mining-induced changes to upland swamp vegetation communities are still not able to be differentiated from natural changes.
- Vegetation change assessment does not provide a clear and timely measure of possible changes in ecosystem functionality of the upland swamps. While changes in methodology, such as using targeted obligate swamp-dependent species (either plants or animals) may improve assessment, the decadal nature of many changes remains.

4.6 Potential for changes to Ecosystem Functionality

Recent impact reports for swamps in Dendrobium Area 3 suggested that mining induced hydrological changes may occur further than 60 m from a longwall panel. The SMP application for Longwall 19A was referred to the Panel in June 2023 to provide advice specifically in relation to maintaining the ecosystem functionality of Swamp 15a. Primary conclusions of this advice in relation to ecosystem functionality included:

- The definition of ecosystem functionality devised in 2013 and adopted in the Swamp Impact, Monitoring, Management and Contingency Plan (SIMMCP) for Longwalls 19 and 19A (and some other previous longwalls) neither reflects the universal definition of the term that has prevailed for at least the last three decades (and, hence, at the time when it was written into the Consent Conditions for Dendrobium Mine) nor general informed usage of the term.
- In particular, the established definitions of ecosystem functionality allude to physical processes, a key aspect of which is the swamp soil hydrology; a parameter that is not reflected in the definition of ecosystem functionality in the SIMMCP.
- Since a change in swamp hydrology at any monitoring site reflects a wider hydrological change, the area of which may be large but unmeasured, a change to the hydrology at any site should be regarded as indicating a change in swamp ecosystem functionality.
- Any observed changes to the hydrology at any site in Swamp15a are a reflection of a wider hydrological impact, the area of which may be large but undetectable due to the sparseness of shallow groundwater monitoring sites. This cannot be fully resolved by adding more monitoring sites.
- If the Dendrobium-centric definition of ecosystem functionality continues to prevail, it is incomplete and warrants updating.
- In respect to advice presented in the SMP for LW19 that rapid drawdown to levels lower than pre-mining levels and increased rate of recession (drainage) in the water tables in colluvial sediments of swamps had not been observed at Dendrobium Mine to that point in time in swamps further than 60 m from a longwall panel, the Panel concludes on the basis of its assessment of recent Impact Reports relating to Swamp 35b, Swamp 144 and Swamp 15a as well as hydrological and other data, that this is no longer the case. Observations of this behaviour have since been recorded at distances close to 120 m from the edges of longwall panels.
- Based on the Panel's assessment of information currently available to it, the Panel is of the opinion that that a setback distance of at least 120 m is the minimum distance required to protect the ecosystem functionality of Swamp 15a from being impacted by depressurisation or drainage of shallow groundwater. Still, this may not prove sufficient.
- Fundamentally, the TARPs incorporated into the SIMMCP are not suitable for managing the risk of impacts to the ecosystem functionality of Swamp 15a because:
    - There are no real time performance indicators suitable for pre-empting impending mining-induced changes in the ecosystem functionality of a swamp.

  - The time lag between cause and impact on ecosystem functionality is too long for identifying the need to implement preventative measures (responses) during active mining in time for them to be effective.
  - Swamp soil moisture, groundwater dependent community and species changes that are the basis for current TARPs for Swamp 15a ecosystem functionality can, themselves, be irreversible impacts of mining.
- For the above reasons, options for adopting effective, TARP driven, adaptive management during extraction of a longwall panel are virtually non-existent when it comes to managing the risk of impacts to the ecosystem functionality of swamps, including Swamp 15a.
- For Swamp 15a, the only feasible option for practising adaptive management is the selection prior to the commencement of extraction of each longwall panel, of an appropriate setback distance based on field experience; setback distance from Swamp 15a is the critical (essential) primary control in the case of LW19A.

The Longwall 19A SMP Approval includes a condition requiring that Longwall 19A is set back at least 120 metres to the west of Swamp 15a. Condition 8 of Schedule 3 include performance measures for Swamp 15a and Swamp 148. Condition 14 of Schedule 3 requires a SIMMCP to be submitted for Longwall 19A which includes TARPs containing quantitative triggers and addresses recommendations contained in the advice of the Panel dated 1 August 2023.

The Longwall 19A Swamp Monitoring Program and TARP have been revised in consultation with DPE, WaterNSW and BCD. The revision includes the addition of mining-induced hydrological changes in Swamp 15a as a measure of changes to ecosystem functionality including:

- Falls in surface or near-surface groundwater levels;
- Falls in soil moisture levels; and
- Reduced pool water levels.

Reporting trigger levels are included in the TARP to provide a rapid assessment that indicate an immediate change that can be reported to key stakeholders within a few days of the identified change. Reporting triggers do not indicate an exceedance of a performance measure. Reporting triggers increase in severity from Level 1 to 3 and are used to trigger reporting, response and/or management action.

Performance indicators are quantifiable measures used to assess whether the performance measure has been exceeded.

The Longwall 19A Swamp Monitoring Program and TARP has been prepared to specifically address performance measures for Swamp 15a and 148. The monitoring program and TARP are presented in **Appendix A**.

4.7 Achievement of Performance Measures

Due to the inclusion of BACI designed monitoring programs related to long-term monitoring parameters there is some uncertainty related to the achievement of long-term performance measures. However, mining has been occurring for a number of years beneath swamps and this allows an opportunity to do some relatively simple back analysis of impacts to these features over the long-term. This approach has the disadvantage of a relatively simple experimental design whereby only obvious changes as a result of the mining are likely to be identified.

Subsidence predictions for swamps in historic mining areas were reviewed as part of the Bulli Seam Project Environmental Assessment (Resource Strategies 2009).

Field investigations were carried out in these swamps to assess impacts and consequences from various levels of back-predicted levels of subsidence movement. This data was used to inform the assessment of risk of impacts and environmental consequences for the Bulli Seam Operation Project. A summary of the review findings is provided below.

Back predictions have been undertaken for 34 swamps previously subject to subsidence in the Southern Coalfield. The back predictions indicate that six of these swamps would have been subject to closure values of greater than 200 mm, namely:

- Swamp STC-S4 (221mm predicted closure) at West Cliff;
- Swamp STC-S1c (276mm predicted closure) at West Cliff;
- Swamp STC-S1a (278mm predicted closure) at West Cliff;
- Swamp 12 (335mm predicted closure) at Dendrobium;
- Swamp STC-S1b (461mm predicted closure) at West Cliff; and
- Swamp STC-S2 (542mm predicted closure) at West Cliff.

Site inspections have been conducted of the swamps listed above. An additional ten swamps predicted to have been previously subject to less than 200mm valley closure were also inspected.

The inspection methods included walking the length of the swamp and recording observations of any significant environmental impacts or consequences, for example:

- Significant subsidence-induced buckling or cracking.
- Any significant erosion or scour.
- Significant vegetation dieback on a broad scale.
- Significant desiccation of vegetation or peat materials on a broad scale.

It is recognised that there are limitations associated with the assessment. As stated above, the assessment is based on back predictions of subsidence effects, as opposed to observed (i.e. monitored) subsidence effects. However, these back predictions are being compared with predictions using the same methodology for analysis at Dendrobium, thus ensuring consistency within the comparative assessment.

Evidence of cracking and minor erosion was observed during the site inspections; however, no evidence of significant environmental consequences was observed.

Observational monitoring of upland swamps on the Woronora Plateau has been conducted by IMC since 2003. The results of this observational monitoring are in the report Understanding Swamp Conditions (BHPBIC 2010).

The report identifies any morphological, geological, hydrological and/or botanical changes observed in the swamps since inspections were initiated in winter 2003. Data is collected and analysed in such a way to identify and record any episodic or temporal changes to these swamp features.

Data is collected with the use of field instruments and through visual inspections of the dominant features within each swamp. The monitoring includes location and extent of any surface water or moisture, the health and location of vegetation, sediment and peat distributions and depths, as well as any cracking, erosion or sedimentation. Observation sites are recorded and plotted on plans with relevant comments.

A total of 28 swamps were visited and inspected between October 2010 and November 2010. A field sheet and plan with defined “Swamp Characteristics” were used to collect the data. Field officers visit each swamp and photograph and record data at various accessible sites. Data collection methodologies are consistent with previous swamp inspections. Swamp characteristics photographed and recorded include:

- Water: Location, volume and flow characteristics.
- Vegetation: Location, species, height and observed health.
- Sediment: Composition, depth and moisture.

The data is used to compare the conditions of sites in swamps before and after mining and under different climatic conditions. Data is also used to outline differences in swamp conditions due to geological and morphological conditions.

5 PREDICTED IMPACTS TO UPLAND SWAMPS

Subsidence has the potential to impact swamps overlying the proposed longwall due to either transient or relatively permanent changes in porosity and permeability of a swamp or hillslope aquifer. Underlying sandstone substrate is likely to fracture as a result of the maximum predicted differential subsidence movements. The likelihood of these impacts occurring reduces where mining is setback from surface features (see Section 4.3 where hydrological impacts have not been observed at distances greater than 120m).

If a swamp overlies a longwall panel it may undergo temporary extensional "face line" cracking (perpendicular to the long axis of the panel) as the panel retreats, followed by re-compression as the maximum subsidence occurs.

In addition, a swamp overlaying the longwall panel may also undergo both longer term extensional "rib line" cracking (parallel to the long axis of the panel) along the outer edge and compression within the central portion of the subsidence trough.

Non-conventional movements can also occur, and have occurred, in the NSW Coalfields as a result of, amongst other things, anomalous movements, valley closure and downslope movements. MSEC1034 (2019) analysed the effects of surface lineaments on the measured ground movements at Dendrobium Area 3B based on the measured LiDAR contours. No interactions or anomalous movements were found in between the surface lineaments and the subsidence movement. Many of the swamps are located in the bases of drainage lines and, therefore, could experience valley and slope related movements. The predicted valley related movements are provided in MSEC (2022).

Conventional closures result from sagging curvature; these predictions are provided separately to the valley related closures, as the associated conventional strains are distributed across the longwalls, as opposed to the valley related compressive strains, which are concentrated in the valley bases. Generally, the valley related closures and conventional closures are orientated obliquely to each other.

Where mining induced movements were sufficient to result in fracturing, these would be visible at the surface where the bedrock is exposed, or where the thickness of the overlying sediment is relatively shallow.

In accordance with the findings of the Southern Coalfield Inquiry and IEP (2019a):

- **Subsidence effects** are defined as the deformation of ground mass such as horizontal and vertical movement, curvature and strains.
- **Subsidence impacts** are the physical changes to the ground that are caused by subsidence effects, such as tensile and sheer cracking and buckling of strata.
- **Environmental consequences** are then identified, for example, as a loss of surface water flows and standing pools.

5.1 Description of Upland Swamps Within the Study Area

There are four swamps that have been identified wholly or partially within the Study Area based on the 35° angle of draw line. There are three additional swamps that are located wholly or partially within the Study Area based on the 600 m boundary.

Swamp 148 is partially located above Longwall 19 and the proposed Longwall 19A. Small parts of Swamps 15a are located above the maingate of Longwall 19 and is 121 m away from Longwall 19A at its closest point. The remaining swamps are located outside the extents of the proposed longwall. A summary of the swamps located within the Study Area based on the 600 m boundary is provided in Table 3-1. The upland swamps can be categorised into two types, the valley infill swamps that form within the drainage lines, and headwater swamps that form within relatively low sloped areas of weathered Hawkesbury Sandstone where hillslope aquifers exist. Further details are provided in Section 3.1.

5.2 Subsidence Predictions

A summary of the maximum predicted total vertical subsidence, tilt and curvatures for Swamps 15a and 148 is provided in **Table 5-2**. The values are the maximum predicted cumulative subsidence effects, within 20 m of the mapped extents of each of the swamps within the Study Area, due to the mining of Longwalls 6 to 8; and Longwalls 19 and 19A.

Table 5-1 Maximum predicted total vertical subsidence, tilt and curvatures for Swamps 15a and 148

Swamp	Maximum predicted total vertical subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (km^{-1})	Maximum predicted total sagging curvature (km^{-1})
15a	<20	<0.5	<0.01	<0.01
148	3250	35	0.90	0.70

Swamps 15a and 148 are located near the bases of drainage lines SC10, and WC14, respectively. These swamps could experience valley related effects due to the extraction of Longwall 19 and the proposed Longwall 19A.

A summary of the maximum predicted total upsidence and closure for Swamps 15a and 148 is provided in **Table 5-3**. The values are the maximum predicted cumulative valley related effects due to the mining of Longwalls 6 to 8; and Longwalls 19 and 19A. As described in Section 4.7, site inspections have been conducted of swamps previously subject to predicted valley closure of between 221mm and 542mm. Evidence of cracking and minor erosion was observed during the site inspections; however, no evidence of significant environmental consequences was observed.

Table 5-2 Maximum predicted total upsidence and closure for the swamps

Swamp	Maximum predicted total upsidence (mm)	Maximum predicted total closure (mm)
15a	125	210
148	225	325

5.3 Impact Assessment

5.3.1 Potential for changes in surface water flows due to the mining-induced tilts

Mining can potentially affect surface water flows through swamps, if the mining-induced tilts are much greater than the natural gradients, potentially resulting in increased levels of ponding or scouring, or affecting the distribution of the water within the swamps.

The maximum predicted total tilts for Swamps 15a and 148 is presented in **Table 5-2**.

Swamps 15a and 148 are located near the bases of drainage lines SC10 and WC14, respectively. There are no predicted substantial reductions or reversals of stream grade along these drainage lines nor within the extents of the swamps. Similarly, there are no substantial changes for the other swamps within the Study Area.

There are small reductions in grades along drainage line WC14, upstream of the chain pillars and the edges of the mining area. There is potential for minor and localised increased ponding in this location, due to the mining-induced tilt, and therefore upstream of Swamp 148.

It is considered unlikely, that there would be adverse changes in the levels of ponding or scouring for the swamps within the Study Area based on the predicted vertical subsidence and tilt (MSEC 2022).

5.3.2 Potential for cracking in Upland Swamps and fracturing of bedrock

Fracturing of the bedrock has been observed in the past, as a result of longwall mining, where the tensile strains have been greater than approximately 0.5 mm/m or where the compressive strains have been greater than approximately 2 mm/m.

Swamp 148 is partially located above the tailgate of the proposed Longwall 19A and partially located above the existing Longwall 19. The maximum predicted total compressive strain for this swamp due to the valley-related effects are in the order of 10 mm/m to 20 mm/m. It is likely, therefore, that fracturing would occur in the bedrock beneath this swamp, predominately in areas located above and adjacent to the mining area.

The typical fracture widths in the bedrock beneath Swamp 148 could be similar to the surface deformations previously observed, soil crack and rock fracture widths were generally observed to be less than 50 mm (i.e. 78 % of the cases) (MSEC 2022). However, the widths of the surface deformations were between 50 mm and 150 mm in 15 % of cases, between 150 mm and 300 mm in 5 % of cases and greater than 300 mm in 2 % of cases. Fracturing would only be visible at the surface where the bedrock is exposed, or where the thickness of the overlying soil is relatively shallow.

Swamp148 is located above the mining area and is predicted to experience upsidence of 175 mm to 350 mm. These valley-related effects could result in the dilation of the strata beneath this swamp. It has been previously observed that the depth of fracturing and dilation of the uppermost bedrock, resulting from valley-related movements, is generally in the order of 10 m to 15 m (Mills 2003, Mills 2007, and Mills and Huuskes 2004).

The dilated strata beneath the drainage lines upstream of Swamp 148 could result in the diversion of some surface water flows beneath part of this swamp where they are located directly above the mining area. The drainage line upstream of this swamp flows during and shortly after rainfall events. Where there is no connective fracturing to any deeper storage, it is likely that surface water flows will re-emerge at the limits of fracturing and dilation.

Potential for cracking beneath the base of Swamp 15a and an assessment of impacts of such cracking is discussed in Section 5.3.2.1.

5.3.2.1 Swamp 15a

Fracturing of the bedrock has been observed in the past, as a result of longwall mining, where the compressive strains have been greater than approximately 2 mm/m. It is likely, therefore, that fracturing would occur in the bedrock beneath Swamp 15a due to the cumulative subsidence movements of LW19 and LW19A. The fracturing would occur predominately where the swamp is located closest to the mining area, such as the area adjacent to Longwall 19 which is setback from Swamp 15a by 22m.

Fracture widths in the order of 20 mm to 50 mm have been observed due to valley closure effects at similar distances from longwall mining. It would be expected that the additional fractures due to the mining of LW19A would be towards the lower end of this range as this longwall is located further from the swamp compared to the existing LW19. It is possible that a series of smaller fractures, rather than one single fracture, could develop in the bedrock (MSEC, 2023b). However, as described in Sections 4.3 and 5.3.3, hydrological impacts within swamps have not been observed at distances greater than 120m from mining.

5.3.3 Potential changes to Upland Swamp Hydrology

Swamps that have been mined beneath commonly display hydrological changes shortly following the passage of the longwall beneath the monitoring site. Hydrographs of piezometers at affected locations may show one or more of the following:

- A decrease in the average shallow groundwater elevation;
- A decrease in the duration of saturation of the swamp sediments following a significant rainfall event; or
- A change in the shape of saturation peak and recession curves in response to significant rainfall events.

An assessment of shallow groundwater impacts due to mining at Dendrobium was carried out by Watershed Hydrogeo in 2019 and updated in 2021 and more recently in 2023 to include data to June 2023 and sites in Areas 2, 3A, 3B and 3C. The most recent study updated the empirical model of impact to swamp piezometers based on the assessments of water levels and recession rates around existing mining. The study identified that approximately 85-95% of Upland Swamp piezometers within 70 metres [of mining] are likely to exhibit a response to mining, and that there is overwhelming evidence that the probability of an impact declines with distance from the goaf. Four main zones were identified from the data:

A. Above the goaf – Almost certain (97% chance) of being impacted;

B. Within 75 m of the goaf – Highly likely (85-95% chance) of being impacted;

C. 75-120 m from the goaf – 40% chance of being impacted; and

D. >120 m from the goaf – Unaffected (0% chance of being impacted)

Furthermore, there is likely a difference between the distance to which groundwater effects propagate from the long edge compared to from the short edge, however there is insufficient quantitative data to be definitive in regard to shallow groundwater response.

Observations at the Springvale Mine in the Western Coalfield show that hydrological impacts can occur in swamps overlying connected geological structures (faults or other lineaments) at distances greater than 1200 m from the longwall (Galvin *et al*., 2016). The same effect is not apparent at Dendrobium. Recent studies have identified no anomalous subsidence specifically related to mapped lineaments (MSEC, 2020), and no hydrological impacts at swamp piezometers located near mapped lineaments that are greater than 120 m from the goaf (Watershed Hydrogeo, 2023).

The hydrological changes are most likely due to the development of surface fracturing and bedding plane openings in the sandstone substrate of the swamp and/or a rock-bar at the swamp outlet. The formation of fractures in the substrate may change the swamp from a perched system to a connected system. The impact on the swamp will be dependent on the head difference between the swamp sediments and the sandstone substrate. Where the hydraulic gradient is downwards (into the sandstone, which is common) then the fracturing will lead to greater flows of water from the swamp and a decline in average swamp groundwater levels. It is not yet known whether the hydrological characteristics recover to some degree as fractures are filled with fine sediments and on-going monitoring is required to assess longer-term impacts (HGEO 2020).

The locations of mapped swamp vegetation communities relative to the planned longwalls are shown in Figure 3 of Niche (2022). Swamps located within 600 m of the planned longwalls are listed in **Table 5-4**, with a qualitative assessment of the likelihood that the shallow groundwater regime will be affected by subsidence related ground movements associated with Longwalls 19 and Longwall 19A (as described above). The likelihood is based on observations at swamps in Area 3B during and after longwall extraction (e.g. HGEO, 2021; Watershed Hydrogeo, 2021) and predictions of subsidence related to longwall extraction and other ground movement related to valley closure (MSEC 2022).

Table 5-3 Summary of predicted impacts to upland swamps (HGEO 2022 and 2023)

Swamp	Total Swamp Area (ha)	Upland Swamp Vegetation Communities	Likelihood of Shallow Groundwater Effects
15a	18.0	Banksia Thicket, Sedgeland-Heath Complex (Cyperoid Heath), Sedgeland-Heath Complex (Restioid Heath), Tea-tree Thicket	Previously affected by Longwall 19. Effects from Longwall 19A drawdown of the regional groundwater table is possible where < 400 m from longwall. Rapid drawdown of groundwater due to surface fracturing greater than 120m from mining is unlikely. There is overwhelming evidence that the probability of an impact declines with distance from the goaf. Data shows that where piezometers are setback >120 m from the goaf at Dendrobium Mine there is a 0% chance of being impacted (HGEO, 2023).
148	0.86	Banksia Thicket	Previously mined under by Longwall 19. Likely further effects within 120 m of Longwall 19A.

There has been no recorded hydrological change more than 120 metres from the edge of a longwall at Dendrobium as assessed and compared to reference sites to date. Swamp TARP triggers reported in impact reports during the extraction of a longwall are assessed and reported in End of Panel reports. Table 5-4 predicts for Swamp 15a, “rapid drawdown due to surface fracturing greater than 120 m from mining is unlikely (HGEO, 2023).” The performance measure of ‘negligible’ change due to the mining of Longwall 19A is achievable due to the 120 m set back of the longwall from the closest point of Swamp 15a.

Table 5-4 indicates there are likely to be further effects to Swamp 148 within 120 m of Longwall 19A. It is noted that Condition 8, Schedule 3 of the Longwall 19A SMP Approval allows performance measures for Swamp 148 to be met “either by avoidance, mitigation, remediation or offset.” Should the performance measure of ‘minor’ change be exceeded, remediation or other appropriate actions will be determined and implemented in consultation with key agencies, and where remediation is not feasible, a suitable biodiversity offset would be provided.

Based on the assessments provided in the Longwall 19A SIMMCP it is predicted that the performance measures/indicators for Swamps 15a and 148 can be met.

5.3.4 Potential impacts on Upland Swamp Ecology

Vegetation communities which are not dependent on groundwater are unlikely to be impacted by subsidence due to underground mining (Niche 2020).

Groundwater dependent and riparian vegetation may experience some floristic changes in response to changed groundwater conditions, as a result of subsidence (Niche 2020).

Riparian vegetation may be potentially impacted by subsidence through water diversion or cracking of bedrock. Impacts to riparian vegetation associated with the Project are predicted to be minor in occurrence, being localised if they occurred (Niche 2020). There is overwhelming evidence that the probability of a hydrological impact within a swamp decline with distance from the goaf. Data shows that where piezometers are setbacks >120 m from the goaf at Dendrobium Mine there is a 0% chance of being impacted (HGEO, 2023).

An assessment of the potential ecological impacts of subsidence on Upland Swamps was completed by Niche (2020) and Niche (2022) which is summarised below (**Table 5-5)**. Based on the assessments provided in the Longwall 19A SIMMCP it is predicted that the performance measures/indicators for Swamps 15a and 148 can be met.

5.3.4.1 Potential Impacts to Threatened Flora

Eleven threatened flora species have been determined to have a moderate to high likelihood of occurring within the Study Area. However, a limited number have potential habitat likely to be impacted by subsidence (Niche 2020).

Four species (*Epacris purpurascens var. purpurascens, Pultenaea aristata, Cryptostylis hunteriana* and *Leucopogon exolasius*) are considered to have habitat within the Study Area that may be potentially impacted by subsidence. Each of these species has potential habitat within upland swamps or creek line vegetation communities, however none of these species are reliant on such habitat and occur throughout a range of other habitats within the Study Area.

5.3.4.2 Potential Impacts to Fauna

Subsidence may have a direct impact on known and potential habitat for threatened fauna such as watercourses, upland swamps, riparian vegetation, rock overhangs, rocky outcrops, cliffs and crevices.

Woodland and forest habitat types make up the majority of the Study Area. These habitat types which are not dependent on groundwater are unlikely to be impacted by subsidence. Microhabitat features such as tree hollows and exfoliating bark are also unlikely to be impacted (Niche 2020 and Niche 2022).

5.3.4.3 Potential Impacts to Threatened Fauna

Fifty-six threatened fauna were considered during likelihood of occurrence assessment. Thirty-nine of these species were determined to have a moderate or high likelihood of occurrence within the Study Area. Subsidence impacts from the proposed longwall are likely to be negligible for the majority of these species (Niche 2020 and Niche 2022). Nine threatened species are considered to be potentially impacted by subsidence impacts resulting from the proposal (Niche 2020 and Niche 2022).

An assessment of potential impacts from the current proposal, for each of the identified threatened species likely to be impacted, is provided in the Longwall 19A Terrestrial Ecology Assessment (Niche 2022).

Table 5-4 Ecological impact predictions for Swamps 15a and 148 (Niche 2022 and Niche 2023)

Swamp	Swamp characteristics	Position	Subsidence predictions (MSEC 2022)	Conclusion
15a	Large complex swamp with pools observed within or on edges of swamp. Swamp follows alignment of watercourse SC10	Partially above the maingate of Longwall 19; within angle of draw of Longwall 19A. Feeding tributary (SC10) within angle of draw.	Fracturing could occur beneath Swamp 15a near the valley base and where it is located closest to the proposed longwall. It is possible that a series of smaller fractures, rather than one single fracture could develop in the bedrock. Predicted upsidence could result in the dilation of the strata beneath this swamp. The dilated strata beneath the drainage lines could result in the diversion of some surface water flows beneath parts of the swamp where they are located adjacent to the proposed longwall. Where there is no connective fracturing to any deeper storage, it is likely that surface water flows will re-emerge at the limits of fracturing and dilation. Swamp 15a, is located near the base of drainage lines SC10. This swamp could experience valley related effects due to the extraction of the longwalls in DA3A. The potential for fracturing of the downstream controlling rockbar for Swamp 15a due to the mining of Longwall 19, resulting in reduction in standing water level based on current rainfall and surface water flow, is in the order of 13 %. Impacts to the controlling rockbar have not occurred as a result of Longwall 19 extraction.	Ecological impacts including changes in vegetation and threatened species habitat (predominantly for Littlejohn's Tree Frog) are possible where hydrological impacts occur. There is overwhelming evidence that the probability of a hydrological impact within a swamp decline with distance from the goaf. Data shows that where piezometers are setbacks >120 m from the goaf at Dendrobium Mine there is a 0% chance of being impacted (HGEO, 2023).. A large population of Littlejohn's Tree Frog is known to occur within areas of this swamp and associated drainage lines and pools. Breeding habitat for this population may be impacted through reductions in water retention from pools should fracturing occur.
148	Small simple swamp, Adjacent to WC14.	Directly above Longwalls 19 and 19A.	Fracturing of the bedrock could occur beneath Swamp 148 where it is located above and adjacent to the proposed longwall. The swamp has layers of organic soil and, in most cases, cracking would not be visible at the surface within the swamp, except where the bedrock is shallow or exposed. The dilated strata beneath the drainage lines could result in the diversion of some surface water flows beneath parts of the swamp where they are located above and adjacent to the proposed longwall. Where there is no connective fracturing to any deeper storage, it is likely that surface water flows will re-emerge at the limits of fracturing and dilation. There are no predicted reversals of stream grade along drainage lines nor within the extent of the swamp due to subsidence induced tilt.	Possible ecological impacts including changes in vegetation and threatened species habitat. Areas may trend towards Fringing Eucalypt Forest if changes are long-term.

6 MANAGEMENT AND CONTINGENCY PLAN

A summary of the avoidance, minimising, mitigation and remediation measures proposed for Swamps 15a and 148 are provided below.

6.1 Objectives

The aims and objectives of this Plan include:

- Avoiding and minimising impacts to significant environmental values where possible.
- Implementing TARPs and reporting to identify, assess and respond to changes and/or impacts to swamps.
- Carrying out mitigation and remediation works in a manner that protects to the greatest practicable extent the environmental values of the area.
- Implementing environmental offsets where applicable.
- Monitoring and reporting effectiveness of the SIMMCP.

To achieve these aims, monitoring, management, mitigation, remediation and offsetting has been incorporated into the mining activity proposed by IMC.

6.2 Trigger Action Response Plan

The TARPs relate to identifying, reporting, assessing and responding to changes and potential impacts to Swamps 15a and 148 (including impacts greater than predicted) from impacts due to the mining of Longwall 19A. These TARPs have been prepared using knowledge gained from previous mining in other areas of Dendrobium, advice from the Panel (2023) and in consultation with DPE, WaterNSW and BCD. The TARPs for any Longwall 19A changes and potential impacts to Swamps 15a and 148 are included in **Appendix A**. For impacts due to mining on Swamps 12, 15b, 15c, 34 and 96, which are within the 600 m Longwall 19A Study Area, the previously approved Dendrobium Area 3A SIMMCP TARPs for Longwall 19 (11 March 2021) will be applied.

The TARPs represent actions (including reporting) to be taken upon reaching each defined trigger level. If required, a Corrective Management Action (CMA) is developed in consultation with stakeholders in order to manage an observed impact in accordance with relevant approvals. The SIMMCP provides a basis for the design and implementation of any mitigation and remediation. Generic CMAs will be developed as required, in consultation with WaterNSW, to provide for a prompt response to a specific impact that requires a specific CMA. If appropriate these discussions will consider whether pre-approvals for the CMA can be obtained where immediate implementation is required.

Monitoring of environmental aspects (Figure 3-8) provides key data when determining any requirement for a CMA, including mitigation or rehabilitation. The triggers are based on comparison of baseline and impact monitoring results. Specific triggers will continue to be reviewed and developed in consultation with key stakeholders as the impact monitoring phase matures. Where required the triggers will be reviewed and changes proposed in impact assessment reports provided to government agencies or in EoP Reports. Any changes to the triggers would require approval of DPE.

Level 1 TARPs typically relate to the routine impacts from mining and/or natural (non-mining) variability in the monitoring data. TARP level 1 impacts are reported to key stakeholders via a variety or mechanisms, including an Impact Update Report provided to Government Agencies.

Level 2 and 3 TARPs result in further investigations and reporting by appropriately qualified people. Impact assessment reports may include:

- Study scope and objectives;
- Consideration of relevant aspect from this Plan;
- Analysis of trends and assessment of any impacts compared to prediction;
- Root cause analysis of any change or impact;
- Assessment of the need for contingent measures and management options;
- Any recommended changes to this Plan; and

- Appropriate consultation.

The Level 2 and 3 TARPs may require the development of site specific CMAs which include:

- A description of the impact to be managed;
- Results of specific investigations;
- Aims and objections for any corrective actions;
- Specific actions required to mitigate/manage and timeframes for implementation;
- Environmental offsetting;
- Roles and responsibilities;
- Gaining appropriate approvals from landholders and government agencies; and
- Reporting, consultation and communication.

Performance indicators provide a measure for the exceedance of the performance measures. Where a performance indicator is exceeded, actions detailed in Section 6.4 will be undertaken.

6.3 Avoiding and Minimising

Mine layouts for Dendrobium Area 3A have been developed using IMC's Integrated Mine Planning Process (IMPP). This process considers mining and surface impacts when designing mine layouts.

IMC has assessed mining layout options for Dendrobium Area 3A against the following criteria:

- Extent, duration and nature of any community, social and environmental impacts;
- Coal customer requirements;
- Roadway development and longwall continuity;
- Mine services such as ventilation;
- Recovery of the resource for the business and the State; and
- Gas drainage, geological and geotechnical issues.

Several layout alternatives for Area 3A were assessed by IMC using a multi-disciplinary team including environment, community, mining and exploration expertise. These included variations in the number of longwalls and orientations, lengths, and setbacks of the longwalls from key surface features. These options were reviewed, analysed and modified until an optimised longwall layout in Area 3A was achieved.

Area 3A is part of the overall mining schedule for Dendrobium Mine and has previously been mined, with Longwall 8 extracted in December 2012. A return to Area 3A to extract Longwall 19 (completed in March 2023) and the proposed Longwall 19A has been designed to flow on from Areas 3B and 3C to provide a continuous mining operation.

SMP Approval for Longwall 19A was granted 11 August 2023. The proposed set back from Swamp 15a was 61 m. The SMP approval conditions require that Longwall 19A be set back at least 120 m from Swamp 15a.

There are a number of surface and subsurface constraints within the vicinity of Area 3A including major surface water features such as Cordeaux Reservoir, Sandy Creek, Wongawilli Creek; and a number of geological constraints such as dykes, faults, and particularly the Dendrobium Nepheline Syenite Intrusion, which has intruded into the Wongawilli Seam to the southeast of Longwall 19A. The process of developing the layout for Area 3A has considered predicted impacts on natural features and aimed to minimise these impacts within geological and other mining constraints.

No contingent mining areas containing Wongawilli Seam Coal resources with the possibility for extraction are available to IMC.

The layouts at Dendrobium Mine have been modified to reduce the potential for impacts to surface features. Changes to a mine layout have significant flow-on impacts to mine planning and scheduling as well as economic viability. These issues need to be taken into account when optimising mine layouts. The process adopted in designing the Dendrobium Area 3A mine layout incorporated the hierarchy of avoid/minimise/mitigate as requested by the DPE and BCD. Mine plan changes result in significant business and economic impact, including:

- Reduction in coal extracted;
- Reduction in royalties to the State;
- Additional costs to the business;
- Risks to longwall production due to additional roadway development requirements; and
- Constraints on blending which can disrupt the supply of coal to meet customer requirements.

The mining layout of the proposed longwall is designed to avoid Wongawilli Creek and the Nepheline Syenite Intrusion. A summary of the geology of Longwall 19A is available in Attachment G of the SMP.

Wongawilli Creek is located to the west of the proposed Longwall 19A. The thalweg (i.e. base or centreline) of Wongawilli Creek is located at a minimum distance of 390 m west of the finishing end of Longwall 19A, at its closest point. The minimum distances between the thalweg of the creek and the completed longwalls are 110 m for Longwall 6 in Area 3A and 290 m for Longwall 9 in Area 3B.

6.4 Mitigation and Rehabilitation

If the performance measures in the Development Consent are not met, then following consultation with BCD, WaterNSW and DRG, the Secretary of DPE may issue a direction in writing to undertake actions or measures to mitigate or remediate subsidence impacts and/or associated environmental consequences. The direction must be implemented in accordance with its terms and requirements, in consultation with the Secretary and affected agencies.

As indicated in Schedule 2, Conditions 1 and 14 of the Development Consent, the mitigation and rehabilitation described in this Plan is required for the development and an integral component of the proposed mining activity. To the extent these activities are required for the development approved under the Dendrobium Mine Development Consent no other licence under the then *Threatened Species Conservation Act 1995* (TSC Act) (repealed by the *Biodiversity Conservation Act 2016*) is required in respect of those activities.

At the time of grant of the Dendrobium Development Consent there was no requirement for concurrence in respect of threatened species or ecological communities. The requirement for concurrence was, at that time, governed by section 79B of the EPA Act. At the time of grant of the Dendrobium Consent there was a requirement for consultation with the Minister administering the then TSC Act and this consultation was undertaken.

6.4.1 Sealing of Rock Fractures

Where the bedrock base of any significant permanent pool or controlling rockbar within swamps are impacted from subsidence and where there is limited ability for these fractures to seal naturally they will be sealed with an appropriate and approved cementitious (or alternative) grout. Grouting will be focused where fractures result in diversion of flow from pools or through the controlling rockbar. Significant success has been achieved in the remediation of the Georges River where four West Cliff longwalls directly mined under the river and pool water level loss was observed.

A number of grouts are available for use including cement and Poly-urethane Resin (PUR), with various additives. These grouts can be used with or without fillers such as clean sand. Grouts can be mixed on-site and injected into a fracture network or placed by hand. Hand placed and injection grouting of large fractures were successfully implemented in the Georges River near Appin.

Such operations do have the potential to result in additional environmental impacts and are carefully planned to avoid any contamination. Mixing areas will be restricted to cleared seismic lines or other open areas wherever possible. Bunds are used to contain any local spillage at mixing points. Temporary cofferdams can be built downstream of the grouting operations to collect any spillage or excess grouting materials for disposal off-site. The selection of grouting materials is based on demonstrated effectiveness and ensuring that there is no significant impact to water quality or ecology.

6.4.2 Injection Grouting

Injection grouting involves the delivery of grout through holes drilled into the bedrock targeted for rehabilitation. A variety of grouts and filler materials can be injected to fill the voids in the fractured strata intercepted by the drill holes. The intention of this grouting is to achieve a low permeability ‘layer’ below any affected pool as well as the full depth of any controlling rockbar.

Where alluvial materials overlie sandstone, grouts may be injected through grout rods to seal voids in or under the soil or peat material. This technique was successfully used at Pool 16 in the Georges River to rehabilitate surface flow by-pass to Pool 17. In this case 1-2 m of loose sediment was grouted through using purpose built grouting pipes.

Grouting holes are drilled in a pattern, usually commencing at a grid spacing of 1 m x 1 m to 2 m x 2 m. The most efficient way to drill the holes taking into account potential environmental impact is by using handheld drills. The drills are powered by compressed air which is distributed to the work area from a compressor. The necessary equipment will be sited on cleared seismic lines or other clear areas wherever possible with hoses run out to target areas.

Grout is delivered from a small tank into the ground via mechanical packers installed at the surface. All equipment can be transported with vehicles capable of travelling on tracks similar to seismic lines. If necessary, equipment or materials can be flown to nearby tracks or open spaces by a helicopter. Helicopter staging has previously occurred from Cordeaux Mine where there is appropriate logistical support. The grout is mixed and pumped according to a grout design. A grout of high viscosity will be used if vertical fracturing is believed to be present since it has a shorter setting time. A low viscosity grout will be used if cross-linking is noted during grouting. Once the grout has been installed the packers are removed and the area cleaned.

After sufficient time for the product to set the area may be in-filled with additional grouting holes that target areas of significant grout take from the previous pass. The grouting program can normally be completed with hand held equipment. Wherever possible the setup and mixing areas will be restricted to cleared seismic lines and other open areas. Bunds are used to contain any local spillage at mixing points.

Grouting volumes and locations are recorded and high-volume areas identified. Once the grout take in the area is reduced and the material has set, the grouted section of the pool is isolated and tested with local or imported clean water. The rate at which the water drains is measured and compared to pre-grouting results. The grouting process is iterative; relying on monitoring of grout injection quantities, grout backpressures and measurements of water holding capacity. In the Georges River, the majority of pools were sealed with two to three grout passes.

If flow diversion through a swamp rockbar occurs it may be more appropriate to implement alternative grouting techniques such as a deeper grout curtain which can be delivered via directional drilling technologies.

Grouting should preferentially be undertaken at the completion of subsidence movements in the area to reduce the risk of the area being re-impacted. **Figure 6-1** shows grouting operations in progress within the Georges River.

(a) Drilling into the bedrock

(b) Grout pump station setup

(c) Injecting grout into bedrock via a specially designed packer system

Figure 6-1 Rockbar Grouting In The Georges River

6.4.3 Erosion Control

The types of erosion which could manifest within swamps are sheet, rill, gully, tunnel and stream channel.

These types of erosion will be monitored in swamps in the mining area as well as in reference swamps not in the mining area. The types and magnitude of any erosion identified in swamps in the mining area will be compared to any erosion away from the mining area.

Erosion can create preferred flow paths and where this erosion creates a topographic low point within a swamp it could act to dewater the swamp sediments. To arrest this type of erosion, ‘coir log dams’ are installed at knick points, channelised flow paths and/or at the inception of tunnel/void spaces (**Figure 6-2**). The square coir logs used for the construction of these small dams were developed specifically for swamp rehabilitation and have been successfully used during a number of swamp rehabilitation programs of recent years in the Blue Mountains and Snowy Mountains.

Figure 6-2 Square Coir Logs For Knick Point Control

As the coir log dams silt up they are regularly added to by the placement of additional layers of logs until the pooled water behind the ‘dams’ is at or above the level of the bank of the eroded channel, or the peat bed of the swamp. The coir logs are held in place by 50 x 50mm wooden tree stakes and bound together with wire (**Figure 6-3**).

The coir log dam slows the flows in the eroding drainage line such that the drainage line will silt up and water in the swamp will once again flow through the swamp rather than being concentrated in the eroding channel.

Figure 6-3 Installation of Square Coir Logs

The most important aspect of these coir dams is the positioning of the first layer of coir logs. A trench is cut into the swamp soil so the first layer sits on the underlying substrate or so the top of the first coir log is at ground level (**Figure 6-4**).

Figure 6-4 Trenching & Positioning of the First Layer of Coir Logs and Construction of a Small Dam in an Eroding Swamp Channel

The coir log dams are constructed at intervals down the eroding channel, the intervals being calculated on the depth of erosion and predicted peak flows and added to until the pooled water behind the 'dams' is at or above the level of the bank of the erosion. At this point the stream becomes, once again, a net water contributor to the swamp and not a net drainer of water from the swamp. Where increased filtering of flows is required the coir logs are wrapped in fibre matting (**Figure 6-5**).

Figure 6-5 Small Coir Log Dams with Fibre Matting

6.4.4 Water Spreading

Where sheet and rill erosion forms, these processes can reduce vegetation on the surface and/or be a precursor to the formation of gully and stream channel erosion. Treatment of these areas can prevent the formation of channels and maintain swamp moisture. The treatment proposed includes water spreading techniques, involving long lengths of coir logs and hessian 'sausages' linked together across the contour such that water flow builds up behind them and slowly seeps through the water spreaders (**Figure 6-6**). Where required the water spreaders would be installed in shallow trenches within the swamp and along the higher margins.

Figure 6-6 Round Coir Logs Installed to Spread Water

Erosion control and water spreading involves soft-engineering materials that will contribute to and function as part of the swamp system but will eventually degrade (biodegradable) and become integrated into the soil of the swamps. This approach is ecologically sustainable in that all the materials used can breakdown and become part of the organic component of the swamp. This also removes the requirement for any post-rehabilitation removal of structures or materials.

6.4.5 Alternative Remediation Approaches

IMC has successfully implemented a subsidence rehabilitation program in the Georges River where there were impacts associated with mining directly under streams. This rehabilitation focused on grouting of mining induced fractures and strata dilation to reinstate the structural integrity and water holding capacity of the bedrock. Metropolitan Colliery is currently undertaking work aimed at rehabilitating areas impacted by subsidence using PUR and other grouting materials. IMC is consulting with Metropolitan Colliery in relation to these technologies. Should rehabilitation be necessary in the Study Area, the best option available at the time of the rehabilitation work will be identified and with appropriate approval, implemented by IMC.

Cracking due to subsidence will tend to seal as the natural processes of erosion and deposition act on them. The characteristics of the surface materials and the prevailing erosion and depositional processes of a specific area will determine the rate of infill of cracks and sealing of any fracture network.

6.4.6 Monitoring Remediation Success

Baseline studies have been completed within the Study Area in order to record biophysical characteristics of the mining area. Monitoring is conducted in the area potentially affected by subsidence from the Longwall 19A extraction as well as areas away from mining to act as control sites. The studies in these areas are based on the BACI design criteria.

A comprehensive swamp monitoring program is in place for swamps identified in this SIMMCP. A summary of swamp monitoring within the Study Area is provided in **Section 3**. In the event that monitoring reveals impacts greater than what is authorised by the approval, modifications to the project, mitigation measures including remediation, offsets, or other appropriate actions determined in consultation with the consent authority will be implemented.

The monitoring program would remain in place prior to, during and following the implementation of any mitigation measures in the Study Area.

The monitoring program is based on a BACI design with sampling undertaken at impact and control locations prior to the commencement of mitigation, during mitigation and after the completion of the mitigation actions. The monitoring locations/points for Swamps 15a and 148 will be reviewed as required and can be modified (with agreement) accordingly.

Data will be analysed according to the BACI design. Statistical analyses between control, impact and mitigation sites will be used to determine whether there are statistically significant differences between these sites. This analysis will assist in determining the success of any mitigation or natural reduction of mining impacts over time.

Observation data will also be collected as part of the monitoring program and be used to provide contextual information to the above assessment approach. Monitoring data and observations will be mapped, documented and reported.

The water levels of all significant permanent pools within swamps will be monitored prior to and during mining. These pool water levels will provide a direct comparison of pre-mining and post mining conditions within the pool. Where rehabilitation activities are required to restore the structural integrity of the bedrock base of any significant permanent pool or controlling rockbar, the pool water level will also be monitored after the CMAs are implemented. The rehabilitation will be successful if the measured pool water levels after a rainfall recharge event are re-established to pre-mining conditions. The rainfall recharge event is required to fill the pool so that the success of the CMA can be tested. A rainfall recharge event is where the watercourse flows into the significant permanent pool to such an extent that it is filled.

6.5 Biodiversity Offset Strategy

Where impacts are greater than predicted or not within approved levels, compensatory measures will be considered. Any compensatory measure will consider the level of impact requiring compensation, the compensatory measures available and the practicality and cost of implementing the measure.

Subject to Condition 14 of Schedule 3 of the Development Consent:

- The Applicant shall provide suitable offsets for loss of water quality or loss of water flows to WaterNSW storages, clearing and other ground disturbance (including cliff falls) caused by its mining operations and/or surface activities within the mining area, unless otherwise addressed by the conditions of this consent, to the satisfaction of the Secretary. These offsets must:
  (a) be submitted to the Secretary for approval by 30 April 2009;
  (b) be prepared in consultation with WaterNSW;
  (c) provide measures that result in a beneficial effect on water quality, water quantity, aquatic ecosystems and/or ecological integrity of WaterNSW's Special Areas or water catchments.

IMC transferred 33 ha of land adjacent to the Cataract River to WaterNSW to meet the above condition. A biodiversity offset strategy has been developed in consultation with BCS and WaterNSW for the approval of the Secretary of DPE. The Secretary DPE approved the Strategic Biodiversity Offset in accordance with Condition 15 of Schedule 2 of the Development Consent for the Dendrobium Coal Mine 16 December 2016. The Secretary also expressed satisfaction that the Strategy fulfils the requirements of the SMP for Area 3B and 3C.

Condition 9 and 10 of Schedule 3 of the Longwall 19A SMP Approval requires the environmental consequences from the development in all affected upland swamps to be offset and preparation of a Biodiversity Offset Strategy (in prep).

6.6 Research

To assist in further understanding the impacts of subsidence and rehabilitation of swamps IMC will undertake research to the satisfaction of the Secretary. The research is directed to improving the prediction, assessment, remediation and/or avoidance of subsidence impacts and environmental consequences to swamps.

The program of research will continue through the mining of Longwall 19A and be adaptive to results as the program is implemented. The research will be conducted as provided by a Swamp Rehabilitation Research Program. This Program will:

- be prepared in consultation with BCD, WaterNSW and DRG;
- be submitted by 31 October 2013 to the Secretary for approval;

- investigate methods to rehabilitate swamps subject to subsidence impacts and environmental consequences within Area 3A and 3B, with the aim of restoring groundwater levels and groundwater recharge response behaviour to pre-mining levels;
- establish a field trial (for a 5 year duration or longer) for rehabilitation techniques at a swamp or swamps that have been impacted by subsidence;
- provide for the expenditure of at least $3.5 million over this period; and
- include a schedule of subsequent trials, development of work plans and ongoing reporting.

Condition 18 of Schedule 3 of the Longwall 19A SMP Approval requires IMC to report to the Secretary on its Swamp Rehabilitation and Research Program every 6 months.

6.7 Contingency and Response Plan

In the event the TARP performance indicators are considered to have been exceeded, or are likely to be exceeded, IMC will implement a Contingency Plan to manage any unpredicted impacts and their consequences. This contingency and response plan is applicable for Swamps 15a and 148.

This would involve the following actions:

- Identify and record the event.
- Notify Government agencies and specialists as soon as practicable.
- Conduct site visits with stakeholders as required.
- Contract specialists to investigate and report on changes identified.
- Provide incident report to relevant agencies.
- Establish weekly monitoring frequency for the site until stabilised.
- Inform relevant Government agencies of investigation results.
- Develop site CMA in consultation with key stakeholders and seek approvals.
- Implement CMA as agreed with stakeholders following approvals.
- Conduct initial follow up monitoring and reporting following CMA completion.
- Provide any environmental offset required by the Consent.
- Review the SIMMCP in consultation with key Government agencies.
- Report in EoP Report and AR.

A site-specific rehabilitation action plan detailing the location and specific works to be implemented will be prepared following the identification of mining induced swamp degradation that exceeds the performance indicators specified in the TARPs.

The site-specific rehabilitation action plan will be developed in consultation with relevant stakeholders. Authority to access the land to conduct works and implement environmental controls requires approval of WaterNSW.

Appendix A provides a summary of the avoidance, actions, mitigation and contingency measures proposed to manage mining impacts where TARP reporting triggers are exceeded.

7 INCIDENTS, COMPLAINTS, EXCEEDANCES AND NON-CONFORMANCES

7.1 Incidents

IMC will notify DPE and other relevant agencies of any incident associated with Area 3A operations as soon as practicable after IMC becomes aware of the incident. IMC will provide DPE and any relevant agencies with a report on the incident within seven days of confirmation of any event.

7.2 Complaints Handling

IMC will:

- Provide a readily accessible contact point through a 24-hour toll-free Community Call Line (1800 102 210). The number will be displayed prominently on IMC sites in a position visible by the public as well as on publications provided to the local community.
- Respond to complaints in accordance with the IMC Handling Community Complaints, Enquiries and Disputes.
- Maintain good communication lines between the community and IMC.
- Keep a register of any complaints, including the details of the complaint with information such as:
  - Time and date.
  - Person receiving the complaint.
  - Complainant’s name and phone number.
  - Description of the complaint and where complaint relates to.
  - Details of any response where appropriate.
  - Details of any corrective actions.

7.3 Non-Conformance Protocol

The requirement to comply with all approvals, plans and procedures is the responsibility of all personnel (staff and contractors) employed on or in association with Dendrobium Mine operations. Regular inspections, internal audits and initiation of any remediation/rectification work in relation to this Plan will be undertaken by the Principal Approvals.

Non-conformities, corrective actions and preventative actions are managed in accordance with the following process:

- Identification and recording of non-conformance and/or non-compliance.
- Evaluation of the non-conformance and/or non-compliance to determine specific corrective and preventative actions.
- Corrective and preventative actions to be assigned to the responsible person.
- Management review of corrective actions to ensure the status and effectiveness of the actions.

An Annual Review will be undertaken to assess IMC’s compliance with all conditions of the Dendrobium Development Consent, Mining Leases and other approvals and licenses.

An independent environmental audit will be undertaken in accordance with Schedule 8, Condition 6 to review the adequacy of strategies, plans or programs under these approvals and if appropriate, recommend actions to improve environmental performance. The independent environmental audit will be undertaken by a suitably qualified, experienced and independent team of experts whose appointment has been endorsed by the Secretary of DPE.

8 PLAN ADMINISTRATION

This SIMMCP will be administered in accordance with the requirements of the Dendrobium Environmental Management System (EMS) and the Dendrobium Development Consent conditions. A summary of the administrative requirements is provided below.

8.1 Roles and Responsibilities

Statutory obligations applicable to Dendrobium Mine operations are identified and managed via an online compliance management system (TICKIT). The online system can be accessed by the responsible IMC managers from the link below.

https://illawarracoal.tod.net.au/login.

The overall responsibility for the implementation of this SIMMCP resides with the Approvals Manager who shall be the SIMMCP's authorising officer.

Responsibilities for environmental management in Dendrobium Area 3 and the implementation of the SIMMCP include:

Approvals Manager

- Ensure that the requisite personnel and equipment are provided to enable this SIMMCP to be implemented effectively.
- Authorise the SIMMCP.

Principal Approvals

- To document any approved changes to the SIMMCP.
- Provide regular updates to IMC on the results of the SIMMCP.
- Arrange information forums for key stakeholders as required.
- Prepare any report and maintain records required by the SIMMCP.
- Organise and participate in assessment meetings called to review mining impacts.
- Respond to any queries or complaints made by members of the public in relation to aspects of the SIMMCP.
- Organise audits and reviews of the SIMMCP.
- Address any identified non-conformances, assess improvement ideas and implement if appropriate.
- Arrange implementation of any agreed actions, responses or remedial measures.
- Ensure surveys required by this SIMMCP are conducted and record details of instances where circumstances prevent these from taking place.

Coordinator Environment

- Instruct suitable person(s) in the required standards for inspections, recording and reporting and be satisfied that these standards are maintained.
- Investigate significant subsidence impacts.
- Identify and report any non-conformances with the SIMMCP.
- Participate in assessment meetings to review subsidence impacts.
- Bring to the attention of the Principal Approvals any findings indicating an immediate response may be warranted.
- Bring to the attention of the Principal Approvals any non-conformances identified with the Plan provisions or ideas aimed at improving the SIMMCP.

Survey Team Coordinator

- Collate survey data and present in an acceptable form for review at assessment meetings.

- Bring to the attention of the Principal Approvals any findings indicating an immediate response may be warranted.
- Bring to the attention of the Principal Approvals any non-conformances identified with the Plan provisions or ideas aimed at improving the SIMMCP.

Technical Experts

- Conduct the roles assigned to them in a competent and timely manner to the satisfaction of the Approvals Manager and provide expert opinion.

Person(s) Performing Inspections

- Inform the Coordinator Environment of any non-conformances identified with the Plan, or ideas aimed at improving the SIMMCP.
- Conduct inspections in a safe manner.

8.2 Resources Required

The Approvals Manager provides resources sufficient to implement this SIMMCP.

Equipment will be needed for the TARP provisions of this SIMMCP. Where this equipment is of a specialised nature, it will be provided by the supplier of the relevant service. All equipment is to be appropriately maintained, calibrated and serviced as required in operations manuals.

The Approvals Manager shall ensure personnel and equipment are provided as required to allow the provisions of this Plan to be implemented.

8.3 Training

All staff and contractors working on IMC sites are required to complete the IMC training program which includes:

- An initial site induction (including all relevant aspects of environment, health, safety and community).
- Safe Work Method Statements and Job Safety Analyses Toolbox Talks and pre-shift communications.
- On-going job specific training and re-training (where required).

It is the responsibility of the Approvals Manager to ensure that all persons and organisations having responsibilities under this SIMMCP are trained and understand their responsibilities.

The person(s) performing regular inspections shall be under the supervision of the Coordinator Environment and be trained in observation, measurement and reporting. The Coordinator Environment shall be satisfied that the person(s) performing the inspections are capable of meeting and maintaining this standard.

8.4 Record Keeping and Control

Environmental Records are maintained in accordance with the IMC document control requirements.

IMC document control requirements include:

- Documents are approved for adequacy by authorised personnel prior to use.
- Obsolete documents are promptly removed from circulation.
- Documents are reissued, or made available, to relevant persons in a timely fashion after changes have been made and the authorisation process is complete.

The SIMMCP and other relevant documentation will be made available on the IMC website.

8.5 Management Plan Review

A comprehensive review of the objectives and targets associated with the Dendrobium Area 3 operations is undertaken on an annual basis via the planning process. These reviews, which include involvement from senior management and other key site personnel, assess the performance of the mine over the previous year and develop goals and targets for the following period.

An annual review of the environmental performance of Dendrobium Area 3 operations will also be undertaken in accordance with Condition 5, Schedule 8. More specifically this SIMMCP will be subject to review (and revision if necessary, to the satisfaction of the Secretary) following:

- The submission of an annual review under Condition 5 Schedule 8.
- The submission of an incident report under Condition 3 Schedule 8.
- The submission of an audit report under Condition 6 Schedule 8.
- Any modification to the conditions of the Dendrobium Development Consent.

If deficiencies in the EMS and/or SIMMCP are identified in the interim period, the plans will be modified as required. This process has been designed to ensure that all environmental documentation continues to meet current environmental requirements, including changes in technology and operational practice, and the expectations of stakeholders.

9 REFERENCES AND SUPPORTING DOCUMENTATION

ACARP, 2009. Damage Criteria and Practical Solutions for Protecting River Channels. Project Number C12016. Ken Mills SCT May 2009.

Axys, 2022. Review of Dendrobium Longwall 19A Subsidence Management Plan, Risk Assessment Report. AR3536 (Revision 3) September 2022.

BHP Billiton Illawarra Coal, 2006. Georges River Report: Assessment of Georges River Remediation Longwalls 5A1-4. November 2006.

BHP Billiton Illawarra Coal, 2011. Understanding Swamp Conditions - Field Inspection Report - September 2010 to November 2010. BHP Billiton Illawarra Coal, April, 2011.

Biosis Research 2007. Dendrobium Area 3 Species Impact Statement, Prepared for BHP Billiton Illawarra Coal, Biosis Research Pty Ltd.

Biosis Research 2007. Dendrobium Coal Mine and Elouera Colliery Flora and Fauna Environmental Management Program, Annual Monitoring Report – Spring 2003 to Winter 2006, Biosis Research Pty Ltd.

Biosis Research, 2009. Revision of the Dendrobium Coal Mine Flora and Fauna Monitoring Program. February 2009.

Biosis Research, 2012(a). Elouera and Dendrobium Ecological Monitoring Program. Annual Monitoring Report Financial Year 2010/2011. August 2012.

Biosis Research, 2012(b). Swamp 15b TARP Assessment – Ecology. Ref:15462, 10 October 2012.

Biosis, 2014. Dendrobium Ecological Monitoring Program, Annual Report for 2012/2013 Financial Year. February 2014. Prepared for Illawarra Coal.

Biosis, 2015. Dendrobium Terrestrial Ecology Monitoring Program, Annual Report for 2014. September 2015. Prepared for Illawarra Coal.

Biosis, 2019. Dendrobium Areas 2, 3A and 3B: Terrestrial Ecology Monitoring Program Annual Report 2018, Final Report, Prepared for Illawarra Coal, 21 June 2019.

Boughton W, 2004. The Australian water balance model. Environ Model Softw 19:943–956. doi: doi:10.1016/j.envsoft.2003.10.007.

Cardno, 2020. Aquatic Flora and Fauna Review, Longwall 19 Subsidence Management Plan. AWE200141. March 2020.

Cardno, 2022. Aquatic Flora and Fauna Assessment. Longwall 19A Subsidence Management Plan. NE30130, September 2022.

Cardno, 2018. Dendrobium Area 3B Aquatic Ecology Monitoring 2010 to 2017. 8 December 2019.

Cardno Ecology Lab, 2012. Aquatic Flora and Fauna Assessment. Prepared for BHPBIC, February 2012.

Cardno Ecology Lab, 2012. Swamp 15b and SC10C Aquatic Flora and Fauna Review. Ref: NA49913032, 5 October 2012.

Cardno Ecology Lab, 2013. Dendrobium Area 3A Aquatic Ecology Monitoring 2008-2012. Job Number: EL1112073 Prepared for BHP Billiton – Illawarra Coal, February 2013.

Cardno Ecology Lab, 2013. Review of Sandy Creek Pools Aquatic Flora and Fauna. 25 February 2013.

Cardno Ecology Lab, 2013. SC10C Level 3 Aquatic Ecology Trigger Assessment. 11 June 2013.

Cardno Ecology Lab, 2015. Dendrobium Area 3A Aquatic Ecology Monitoring 2008 to 2014. 30 March 2015.

Cardno Forbes Rigby, 2007. Landscape Impact Assessment and Monitoring Site Optimisation. Prepared for BHPBIC.

Cardno Forbes Rigby, 2007. Area 3A Subsidence Management Plan Longwalls 6 to 10. Prepared for BHPBIC.

Cardno Forbes Rigby, 2007. Dendrobium Area 3 Environmental Assessment. Prepared for BHPBIC.

Chafer, C., Noonan, M and Macnaught, E. 2004. The Post-Fire Measurement of Fire Severity and Intensity in the Christmas 2001 Sydney Wildfires. International Journal of Wildland Fire Vol. 13; pp. 227-240.

Chiew, F, Wang, Q. J., McConachy, F., James, R., Wright, W, and deHoedt, G. 2002. Evapotranspiration Maps for Australia. Hydrology and Water Resources Symposium, Melbourne, 20-23 May, 2002, Institution of Engineers, Australia.

Coffey, 2012. Groundwater Study Area 3B Dendrobium Coal Mine: Numerical Modelling. GEOTLCOV24507AA-AB2 2 October 2012.

Ditton, S., and Merrick, N.P. 2014. A new sub-surface fracture height prediction model for longwall mines in the NSW coalfields. Paper presented at the Australian Earth Science Convention, Newcastle, NSW.

Doherty, J. 2010. PEST: Model-Independent Parameter Estimation User Manual (5th ed.): Watermark Numerical Computing, Brisbane, Queensland, Australia.

EarthTech Engineering Pty Ltd, 2005. Thresholds for Swamp Stability. Prepared for BHPBIC, January 2005.

The Ecology Lab, 2007. Dendrobium Area 3 Assessment of Mine Subsidence Impacts on Aquatic Habitat and Biota. October 2007.

Ecoengineers, 2006. Assessment of Surface Water Chemical Effects of Mining by Elouera Colliery. January - December 2005. February 2006.

Ecoengineers, 2006. Assessment of Catchment Hydrological Effects by Mining by Elouera Colliery Stage 1: Establishment of a Practical and Theoretical Framework. August 2006.

EcoEngineers, 2007. Surface Water Quality and Hydrology Assessment to Support SMP Application for Dendrobium Area 3.

EcoEngineers, 2010. End of Panel Surface and Shallow Groundwater Impacts Assessment Dendrobium Area 2 Longwall 5. Document Reference No. 2010/01A. April 2010.

Ecoengineers, 2012. Surface Water Quality and Hydrological Assessment: Dendrobium Area 3B Subsidence Management Plan Surface and Shallow Groundwater Assessment.

Ecoengineers, 2012. Level 2 TARP Independent Review and Recommendations Swamp 15b Dendrobium Area 3A. 25 September 2012.

Ecoengineers, 2013. Level 3 TARP Independent Review and Recommendations Sandy Creek Catchment Pool 7 (Dendrobium Area 3A). 12 February 2013.

Ecoengineers, 2013. Level 2 TARP Specialist Review and Recommendations Donalds Castle Creek. 22 May 2013.

Ecoengineers, 2014. End of Panel Surface and Shallow Groundwater Impacts Assessment, Dendrobium Area 3B Longwall 9. June 2014.

Ecoengineers, 2015. End of Panel Surface and Shallow Groundwater Impacts Assessment, Dendrobium Area 3B Longwall 10. February 2015.

Eco Logical Australia, 2004. The Impacts of Longwall Mining on the Upper Georges River Catchment: Report to Total Environment Centre, 2004.

Forster, 1995. Impact of Underground Mining on the Hydrogeological Regime, Central Coast NSW. Engineering Geology of the Newcastle-Gosford Region. Australian Geomechanics Society. Newcastle, February 1995.

GHD, 2007. Dendrobium Area 3A Predicted Hydrogeologic Performance. Report for BHP Billiton, Illawarra Coal. November 2007.

GSS Environmental, 2013. Baseline and Pre-Mining Land Capability Survey. Dendrobium Mine, Area 3B. February 2013.

Hazelton P.A. and Tille P.J. 1990. Soil Landscapes of the Wollongong-Port Hacking 1:100,000 Sheet map and report, Soil Conservation Service of NSW, Sydney.

Hebblewhite, 2010. BHP Billiton Illawarra Coal: Bulli Seam Operations Project – Independent Review. 31 March 2010.

Helensburgh Coal Pty Ltd, 2007. Submission to: Independent Expert Panel - Inquiry into NSW Southern Coalfield July 2007, Helensburgh Coal Pty Ltd.

Heritage Computing, 2009. Dendrobium Colliery Groundwater Assessment: Mine Inflow Review, Conceptualisation and Preliminary Groundwater Modelling. Merrick, N.P., Heritage Computing Report HC2009/2, February 2009.

Heritage Computing, October 2011. Recalibration of the Dendrobium Local Area Groundwater Model after Completion of Longwall 6 (Area 3A). Report prepared for Illawarra Coal. Report HC2011/13.

HGEO, 2019. Dendrobium Mine End of Panel Surface Water and Shallow Groundwater Assessment: Longwall 14 (Area 3B), September 2019, Project number: J21474, Report: D19327.

HGEO, 2019. Dendrobium Mine Estimates of seepage from Lake Avon following redrilling of holes at AD3, AD4 and AD8. September 2019. Project number: J21476. Report: D19337.

HGEO 2020. Assessment of surface water flow and quality effects of proposed Dendrobium Longwall 19. J21495, March 2020.

HGEO 2022. Assessment of surface water flow and quality effects of proposed Dendrobium Longwall 19A. J21533, September 2022.

HGEO 2023. Assessment of surface water flow and shallow groundwater effects of proposed Dendrobium Longwall 19A: Revised longwall geometry. D23208, February 2023.

HydroSimulations, 2014. Dendrobium Area 3B Groundwater Model Revision: Swamps, Stream Flows and Shallow Groundwater Sata. Report: HC2014/4 March 2014.

HydroSimulations, 2019. Dendrobium Area 3B Longwall 17 Groundwater Assessment. Report: HC2018 March 2019.

Illawarra Coal, 2014. Longwall 9 End of Panel Report.

Illawarra Coal, 2015. Longwall 10 End of Panel Report.

Illawarra Coal, 2016. Longwall 11 End of Panel Report.

Illawarra Coal, 2017. Longwall 12 End of Panel Report.

Illawarra Coal, 2018. Longwall 13 End of Panel Report.

Illawarra Metallurgical Coal, 2019. Longwall 14 End of Panel Report.

Independent Expert Advisory Panel for Mining, 2023. Advice Re: Dendrobium Coal Mine Longwall 19A Subsidence Management Plan. 1 August 2023.

Independent Expert Panel for Mining in the Catchment, 2019a, Independent Expert Panel for Mining in the Catchment Report: Part 1. Coal Mining Impacts in the Special Areas of the Greater Sydney Water Catchment, Prepared for the NSW Department of Planning, Industry and Environment.

Independent Expert Panel for Mining in the Catchment, 2019b, Independent Expert Panel for Mining in the Catchment Report: Part 2. Coal Mining Impacts in the Special Areas of the Greater Sydney Water Catchment, Prepared for the NSW Department of Planning, Industry and Environment.

Kirchner, J. W. 2009. Catchments as simple dynamical systems: Catchment characterization, rainfall-runoff modelling, and doing hydrology backwards. Res., W02429.

Manly Hydraulics Laboratory, 2006. BHP Billiton Dendrobium Mine Area 2 Subsidence Environmental Management Plan Water Monitoring and Management Program. Prepared for BHPBIC. Version 1.4 January 2006.

McMahon, 2014. Dendrobium Community Consultative Committee Report: Review of Surface Water Study. An independent review of surface water hydrological modelling associated with Illawarra Coal's Dendrobium Area 3, conducted by Emeritus Professor Thomas McMahon, University of Melbourne. 4 June 2014.

MSEC, 2007. Dendrobium Mine Area 3A Longwalls 6 to 10. Report on The Prediction of Subsidence Parameters and the Assessment of Mine Subsidence Impacts on Natural Features and Surface Infrastructure Resulting from the Extraction of proposed Longwalls 6 to 10 in Area 3A at Dendrobium Mine in Support of the SMP and SEMP Applications. September 2007.

MSEC, 2012. Dendrobium Area 3B Subsidence Predictions and Assessments for Natural Features and Surface Infrastructure in Support of the SMP Application.

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, 2017. Dendrobium mine – Area 3B. The Effects of the Proposed Modified Commencing Ends of Longwalls 15 to 18 in Area 3B at Dendrobium Mine on the Subsidence Predictions and Impact Assessments. MSEC914 August 2017.

MSEC, 2018. Dendrobium – Longwalls 17 and 18. Subsidence Predictions and Impact Assessments for the Natural and Built Features due to the Extraction of Longwalls 17 and 18 in Area 3B at Dendrobium Mine. MSEC992 November 2018.

MSEC, 2019. Report on the effects of surface lineaments on the measured ground movements at Dendrobium Area 3B based on the measured LiDAR contours. Report No. MSEC1034.

MSEC, 2020. Dendrobium – Longwall 19 Subsidence Predictions and Impact Assessments for the Natural and Built Features due to the Extraction of the Proposed Longwall 19 in Area 3A at Dendrobium Mine. MSEC1082 March 2019.

MSEC, 2022. Dendrobium – Longwall 19A Subsidence Predictions and Impact Assessments for the Natural and Built Features due to the Extraction of the Proposed Longwall 19A in Area 3A at Dendrobium Mine. MSEC1234, September 2022.

MSEC, 2023a. Dendrobium – Area 3A – Longwall 19A – Subsidence Management Plan Addendum to Report No. MSEC1234 (Rev. B), March 2023.

MSEC, 2023b. Dendrobium Mine – Area 3A – Modified commencing end of LW19A, Updated predicted subsidence effects for Swamp 15a. MSEC1384, October 2023.

Niche Environment and Heritage, 2012. Terrestrial Ecological Assessment. Prepared for BHP Billiton Illawarra Coal. February 2012.

Niche, 2020. Dendrobium Longwall 19 Terrestrial Ecological Assessment - Accompanying Document to Dendrobium Longwall 19 Subsidence Management Plan. Prepared for South32 Illawarra Metallurgical Coal, March 2020.

Niche, 2022. Dendrobium Longwall 19A Terrestrial Ecological Assessment - Accompanying Document to Dendrobium Longwall 19A Subsidence Management Plan. Prepared for South32 Illawarra Metallurgical Coal, September 2022.

Niche, 2023. Dendrobium Area 3A Longwall 19A – Terrestrial Ecology Assessment Addendum (Niche Ref 7167). March 2023.

NPWS, 2003. The Native Vegetation of the Woronora, O'Hares and Metropolitan Catchments. Central Conservation Programs and Planning Division NSW National Parks and Wildlife Service; August 2003.

NSW Threatened Species Scientific Committee, 2012. Coastal Upland Swamp in the Sydney Basin Bioregion - endangered ecological community listing. NSW Scientific Committee - final determination.

OEC, 2001. Environmental Impact Statement Dendrobium Coal Project. Olsen Environmental Consulting, Figtree, N.S.W.

Parkhurst. D.L., and Appelo, C.A.J. 2012. Description of Input and Examples for PHREEQC Version 3 – A Computer Program for Speciation, Batch-Reaction, One- Dimensional Transport and Inverse Geochemical Calculations. US Department of Interior/US Geological Survey.

Parson Brinckerhoff, 2012. Independent Review of Dendrobium Area 2 and 3A Hydrochemical Data. August 20012.

Parsons Brinckerhoff, 2015. Connected fracturing above longwall mining operations, Part 2: Post-longwall investigation. For BHP Billiton Illawarra Coal. Document number 2172268F-WAT-REP-002 RevB. 6 March 2015.

Petersen, 1992. The RCE: a Riparian, Channel, and Environmental Inventory for small streams in the agricultural landscape. Freshwater Biology Vol 27, Issue 2, April 1992.

Resource Strategies, 2009. Bulli Seam Operations Environmental Assessment. Report in support of an application for the continued operations of the Appin and West Cliff Mines.

Singh & Kendorski, 1981. Strata Disturbance Prediction for Mining Beneath Surface Water and Waste Impoundments, Proc. First Conference on Ground Control in Mining, West Virginia University, PP 76-89.

SLR, 2020. Dendrobium Area 3A Longwall 19 Groundwater Assessment. Report: 665.10009-R02_v2.0. F. January 2020.

Tammetta, P. (2013). Estimation of the height of complete groundwater drainage above mined longwall panels. Groundwater, 51(5), 723-734.

Tomkins, K.M. and Humphries, G.S. 2006. Technical report 2: Upland Swamp development and erosion on the Woronora Plateau during the Holocene. January 2006. Sydney Catchment Authority – Macquarie Collaborative Research Project.

Tozer, M. et el 2002. Native Vegetation Maps of the Cumberland Plain Western Sydney. NSW National Parks and Wildlife Service 2002.

Waddington, A.A. and Kay, D.R. 2001. Research into the Impacts of Mine Subsidence on the Strata and Hydrology of River Valleys and Development of Management Guidelines for Undermining Cliffs. Gorges and River Systems. Final Report on ACARP Research Project C8005, March 2001.

Waddington, A.A. and Kay, D.R. 2002. Management Information handbook on the Undermining of Cliffs, Gorges and River Systems. ACARP Research Projects Nos. C8005 and C9067, September 2002.

Watershed HydroGeo, 2018. Analysis of low flow and pool levels on Wongawilli Creek. Report r003i2, October 2018.

Watershed HydroGeo, 2019. Discussion of Surface Water Flow TARPs. Report r011i5, December 2019.

Watershed HydroGeo, 2021. Update to geographic review of mining effects on Upland Swamps at the Dendrobium Mine, 2021

Watershed HydroGeo, 2023. Update to geographic review of mining effects on Upland Swamps at the Dendrobium Mine (data to June 2023). Report R053c, September 2023.

Zhang, L. Dawes, W.R. and Walker, G.R. 1999. Predicting the effect of Vegetation Changes on Catchment Average Water Balance. Technical Report No. 99/12, Cooperative Research Centre for Catchment Hydrology.

Appendix A – Swamp Monitoring and Trigger Action Response Plan

Appendix A: Longwall 19A Swamp Monitoring Program and Trigger Action Response Plan

Swamp monitoring sites will be installed ahead of mining to achieve at least 2-years baseline data (subject to timing and approval timeframes of any request to install additional monitoring). Monitoring is generally conducted through the mining period and for 2-years following active subsidence. Where performance measures require more than 2 years of post-mining monitoring, this will be undertaken.

The Longwall 19A Swamp Monitoring Program and Trigger Action Response Plans have been prepared specifically to address performance measures for Swamps 15a and 148. Other swamps within the Longwall 19A study area are addressed in the Longwall 19 SIMMCP which remains in force.

Table 1.1 – Dendrobium Area 3A Longwall 19A Swamp Monitoring Program

Monitoring Site		Site Type	Monitoring Frequency	Parameters
OBSERVATIONAL, PHOTO POINT AND WATER MONITORING				
Area 3A	Longwall 19A-Swamps 15A and 148 *Reference Sites* Swamps 7[(1)], 22, 24, 25, 33, 84, 85, 86, 87 and 88	Observation and photo point monitoring: Sites based on risk Swamps Pools and rockbars Steep slopes and rock outcrops Previously observed impacts that warrant follow-up inspection Mining area	Pre and post mining for 2 years, monthly when longwall is within 400 m of monitoring site Weekly inspection and pool water levels when longwall is within 400 m of monitoring site Reference sites 6-monthly	Visual signs of impacts to swamps and drainage lines (i.e. cracking, vegetation changes, increased erosion, changes in water colour, soil moisture etc.) determined by comparing baseline photos with photos during the mining period Key water quality parameters in pools within and downstream of swamps analysed to identify any changes resulting from mining
EROSION MONITORING				
Area 3A	Longwall 19A-Swamps 15A and 148	Airborne Laser Scanning/LiDAR Surveyed cross-sections, areas and lengths	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 erosion identified by ALS survey	Raw ground strike ALS data will be contoured with a 0.2 m interval after the completion of subsidence at each longwall to provide a new (subsided) baseline surface dataset. For a period of up to ten years after mining repeat ALS datasets and surface modelling will be completed to assess for new or increases in existing erosion. The maximum area/length and depth of any erosion identified by ALS will be measured by standard survey methods
SHALLOW GROUNDWATER LEVEL				
AREA 3A	Longwall 19A Study Area Swamps Swamp 15A: 15a_03, 15a_04, 15a_07[(2)], 15a_12, 15a_15, 15a_18 and 15a_19. Additional sites proposed: 15a_06, 15a_08, 15a_09, 15a_11. Swamp 148: 148_01	Monitoring bore drilled into the soil profile	For open hole sites: Monthly monitoring pre, during and post mining for two years to be reviewed annually Reference sites 6 monthly For instrumented sites: Automatic groundwater level monitoring pre, during and post mining (1-hour interval or similar) Monitoring post mining for five years to be reviewed annually	Piezometric and dip meter monitoring of shallow groundwater level
SOIL MOISTURE				

Area 3A	Swamp 15A: 15a_03, 15a_04, 15a_07[2], 15a_12, 15a_15, 15a_18 and 15a_19 Swamp 148: 148_01	Monitoring bore drilled into the soil profile	Automatic soil moisture monitoring pre, during and post Monitoring post mining for five years to be reviewed annually	Installed dielectric soil moisture sites down to a maximum of 1.2 m to measure deep soil moisture at various depths down-profile
SANDSTONE GROUNDWATER				
AREA 3A	The following 'sandstone' monitoring bores to be monitored: • S1888 – west of Swamp 15a, close to Longwall 19A. • S1907 – east of Swamp 15a.	• Logged groundwater level in the Hawkesbury Sandstone (HBSS)	• Groundwater level logged at least 6-hourly	Piezometric monitoring of shallow groundwater level
POOL LEVELS				
AREA 3A	**Swamp 15A (SC10)** Logged water levels[3]: • SC10_Pool 23 • SC10_Pool 26a • SC10_Pool 29 Manual water level benchmark: • SC10_Pool 21 Visual observation sites: • SC10_Pool 14 • SC10_Pool 15 • SC10_Pool 21 • SC10_Pool 23 • SC10_Pool 26a • SC10_Pool 29 • SC10_Pool 31 • SC10_Pool 34	• Water level logger at pools where install of instrumentation permits • Manual benchmark • Visual observations	• Hourly water levels for logged sites • Manual benchmarks and visual observations- monthly prior to and after mining; weekly during mining	• Logged and manual levels- water level relative to an installed benchmark • Manual water level measurement- distance from installed benchmark to water level • Visual observations- Pool Inflow and Outflow status; 'Water in Pool' observations
TERRESTRIAL FLORA – COMPOSITION AND DISTRIBUTION OF SPECIES				
AREA 3A	Swamp 15A	Swamp vegetation transects	A baseline monitoring campaign prior to mining during spring Annual post-mining in spring for two years or as otherwise required General observation of active mining areas during all other monitoring	15 m transects consisting of thirty 0.5 m x 0.5 m quadrats. The monitoring records: • Presence of species within each quadrat; • Observations of dieback or changes in community structure; and • Photo point monitoring at each transect
TERRESTRIAL FLORA – SWAMP SIZE				

Area 3A	Swamp 15A and 148	Size of the groundwater dependent communities (Banksia Thicket, Tea-tree Thicket and Sedgeland-heath Complex) and the total size of the swamps	Baseline mapping prior to mining with repeat mapping after each longwall or as determined by observational monitoring i.e. if dieback or invasion of non-swamp species is observed. If no longwall extraction was occurring for an extended period, annual LiDAR surveys would be undertaken.	Detailed mapping including the use of LiDAR data to indicate the location and extent of upland swamp boundaries. Ground-truthing of these boundaries and the vegetation sub-communities will be undertaken if subsequent LiDAR data shows swamp boundary movements
TERRESTRIAL FAUNA – THREATENED FROG SPECIES				
AREA 3A	Swamp 15A	Frog monitoring	Surveys are undertaken in winter each year to target active breeding periods (these can be variable depending on prevailing conditions) To address recommendation from Niche (2019), rainfall or hydrometric trigger values for surveys will be developed for surveys to allow for greater consistency between years which would aid in comparison of results (pre- versus post-mining and impact versus control). To address recommendation from Niche (2019), a baseline survey focussed on tadpole survey for Littlejohn's Tree Frog has been undertaken.	For swamps frog surveys are conducted along associated creeks with a focus on features susceptible to impacts e.g. breeding pools. Potential breeding habitat for Littlejohn's Tree Frog and Giant Burrowing Frog will be targeted. Standardised transects have been established to record numbers of individuals recorded at each site from one year to the next. Tadpole counts will also be undertaken as part of the breeding habitat monitoring transects. These transects are surveyed by walking down the creekline and counting all amphibians seen or heard on either side of the line

[(1)]Reference site for Area 3A; impact site when mining commences in Area 3C

[(2)]S15a_07 is not located within Swamp 15a and is therefore not included in the reporting triggers or performance indicators in Table 1.2

[(3)]SC10_Pool 14 is monitored for logged water level however is not included in the reporting triggers or performance indicators in Table 1.2 due to being located >400m from Longwall 19A

Table 1.2 - Dendrobium Longwall 19A Swamp TARP – Swamp 15a

Performance Measure	Potential Impacts	Reporting Trigger	Trigger Response	Performance Indicator
EROSION				
Negligible erosion of the surface of the swamp	Gully erosion or similar	***Level 1*** The increase in length of erosion within the 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.	• Continue monitoring program • Submit impact report to key stakeholders • Report in the End of Panel Report • Summarise actions and monitoring in Annual Review	Mining results in the total length of erosion within the 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%**).
		Level 2 The increase in length of erosion within the 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.	• *Actions as stated for Level 1* • Review monitoring frequency • Seek expert and agency advice on any CMA required • Implement agreed CMAs as approved (subject to agency feedback) e.g. implement temporary erosion control (e.g., knickpoint control, coir logs)	
		Level 3 The increase in length of erosion within the 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.	• *Actions as stated for Level 2* • Offer site visit with key stakeholders • Implement additional monitoring or increase frequency if required • Develop any additional CMA required in consultation with key stakeholders • Completion of works following approvals and at a time agreed between S32 and key stakeholders including monitoring and reporting on success	
ECOSYSTEM FUNCTION				
Negligible change in the size of the swamp	LW19A induced hydrological changes in Swamp 15A result in decline in size of groundwater dependent communities	***Level 1*** A decline in the extent of an upland swamp (combined area of groundwater dependent communities), greater than observed in the Control Group, and exceeding the standard error (SE) of the Control Group.	• Continue monitoring program • Submit impact report to key stakeholders • Report in the End of Panel Report • Summarise actions and monitoring in Annual Review	LW19A induced hydrological changes in Swamp 15A result in 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.
		Level 2 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 SE of the Control Group.	• *Actions as stated for Level 1* • Review monitoring frequency • Undertake ground-truthing of swamp boundaries and the vegetation sub-communities • Seek expert and agency advice on any CMA required • Implement agreed CMAs as approved (subject to agency feedback)	

Performance Measure	Potential Impacts	Reporting Trigger	Trigger Response	Performance Indicator
		Level 3 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.	• *Actions as stated for Level 2* • Offer site visit with key stakeholders • Develop any additional CMA required in consultation with key stakeholders • Completion of works following approvals and at a time agreed between S32 and key stakeholders including monitoring and reporting on success	
ECOSYSTEM FUNCTION				
Negligible change in the ecosystem functionality of the swamp	LW19A induced hydrological changes in Swamp 15A result in falls in surface or near-surface groundwater levels in the swamp at shallow groundwater sites 15a_03, 15a_04, 15a_12, 15a_15, 15a_18, 15a_19, 15a_06, 15a_08, 15a_09, 15a_11 LW19A induced hydrological changes in Swamp 15A result in falls in soil moisture levels in the swamp at soil moisture sites 15a_03, 15a_04, 15a_12, 15a_15, 15a_18, 15a_19 LW19A induced hydrological changes in Swamp 15A result in reduced pool water levels in SC10 at surface pools 23, 26a and 29	***Level 1*** Post-mining median rate of shallow groundwater or pool level recession[1] is higher than the **80^{th} percentile** rate of recession during the baseline period; or 5-10% increase in the period of time a borehole/pool is dry compared to baseline and reference sites at any monitored groundwater or pool level sites within the swamp.	• Continue monitoring program • Submit impact report to key stakeholders • Report in the End of Panel Report • Summarise actions and monitoring in Annual Review	LW19A induced hydrological changes within Swamp 15A at more than 2 shallow groundwater sites (15a_03, 15a_04, 15a_12, 15a_15, 15a_18, 15a_19, 15a_06, 15a_08, 15a_09, 15a_11) and/or at more than 2 surface pools (SC10 Pools 23, 26a and 29) result in: • Post-mining recession[1] rate for shallow groundwater or pool water level exceeds the 95^{th} percentile rate during the baseline period; or • >20% increase in the period of time a borehole/pool is dry compared to baseline and reference sites, Where the post-mining assessment is carried out over a year of average (or above) rainfall[2] and the same thresholds are not exceeded at reference sites.
		Level 2 Groundwater or soil moisture or pool level lower than baseline level at any monitoring site within the swamp; or Post-mining median rate of shallow groundwater or pool level recession[1] is higher than the **90^{th} percentile** rate of recession during the baseline period; or 10-20% increase in the period of time a borehole/pool is dry compared to baseline and reference sites at any monitored groundwater or pool level sites within the swamp.	• *Actions as stated for Level 1* • Review monitoring frequency • Undertake ecological survey • Seek expert and agency advice on any CMA required • Implement agreed CMAs as approved (subject to agency feedback)	
		Level 3 Post-mining median rate of shallow groundwater or pool level recession[1] is higher than the **95^{th} percentile** rate of recession during the baseline period; or >20% increase in the period of time a borehole/pool is dry compared to baseline and reference sites at any monitored groundwater or pool level sites within the swamp.	• *Actions as stated for Level 2* • Offer site visit with key stakeholders • Develop any additional CMA in consultation with key stakeholders • Implement any additional CMAs as approved • Consider additional vegetation management actions (e.g., water spreading, seeding/planting, weeding) in consultation with key stakeholders • Completion of works following approvals and at a time agreed between S32 and key stakeholders including monitoring and reporting on success	

[1] Recession rate is calculated over a three-day period from daily median water levels. Excludes water levels measured within 2 days of recorded rain at Dendrobium

[2] Average rainfall = (based on IMC Centroid rainfall data)

Performance Measure	Potential Impacts	Reporting Trigger	Trigger Response	Performance Indicator
ECOSYSTEM FUNCTION				
Negligible change to the composition or distribution of species within the swamp	LW19A induced hydrological changes in Swamp 15A result in a decline in species richness, distribution, composition and diversity	***Level 1*** A statistically significant difference (decline) in TSR or species composition as part of a Before-After-Control-Impact approach in any year. The change will be tested at a statistically significant level of 5% (p=≤0.05);	• Continue monitoring program • Submit impact report to key stakeholders • Report in the End of Panel Report • Summarise actions and monitoring in Annual Review	LW19A induced hydrological changes within Swamp 15A results in a statistically significant difference (decline) in TSR or species composition as part of a Before-After-Control-Impact approach over four consecutive years (e.g. impact detected in each of 2023-2024, 2024-2025, 2025-2026 and 2026-2027 impact years. The change over four consecutive years will be tested at a statistically significant level of 5% (p=≤0.05).
		Level 2 A statistically significant difference (decline) in TSR or species composition as part of a Before-After-Control-Impact approach over two consecutive years (e.g. impact detected in each of 2023-2024 and again 2024-2025 impact years). The change over two consecutive years will be tested at a statistically significant level of 5% (p=≤0.05).	• *Actions as stated for Level 1* • Review monitoring frequency • Seek expert and agency advice on any CMA required • Implement agreed CMAs as approved (subject to agency feedback)	
		Level 3 A statistically significant difference (decline) in TSR or species composition as part of a Before-After-Control-Impact approach over three consecutive years (e.g. impact detected in each of 2023-2024, 2024-2025 and 2025-2026 impact years). The change over three consecutive years will be tested at a statistically significant level of 5% (p=≤0.05).	• *Actions as stated for Level 2* • Offer site visit with key stakeholders • Develop any additional CMA in consultation with key stakeholders. This may include additional vegetation management actions (e.g., water spreading, seeding/planting, weeding) • Completion of works following approvals and at a time agreed between S32 and key stakeholders including monitoring and reporting on success	
STRUCTURAL INTEGRITY OF CONTROLLING ROCKBAR				
Maintenance or restoration of the structural integrity of rockbar SC10-RB15A	Subsidence impacts (i.e. cracking) on bedrock base of rockbar Loss of surface water	***Level 1*** Increase in number of cease-to-flow days observed at Rockbar SC10-RB15A (Pool 15) when compared to baseline	• Continue monitoring program • Submit impact report to key stakeholders • Report in the End of Panel Report • Summarise actions and monitoring in Annual Review	Fracturing resulting in increased cease-to-flow or dry pool days at rockbar SC10-RB15A (Pool 15) which cannot be restored via CMAs.
		Level 2 Increase in number of dry pool days observed at Rockbar SC10-RB15A (Pool 15) when compared to baseline	• *Actions as stated for Level 1* • Review monitoring frequency • Seek expert and agency advice on any CMA required • Implement agreed CMAs as approved (subject to agency feedback)	
		Level 3 Fracturing observed at rockbar SC10-RB15A	• *Actions as stated for Level 2* • Offer site visit with key stakeholders • Develop any additional CMA required in consultation with key stakeholders. This may include grouting of rockbar and bedrock base or any significant pool where appropriate.	

Performance Measure	Potential Impacts	Reporting Trigger	Trigger Response	Performance Indicator
			• Completion of works following approvals and at a time agreed between S32 and key stakeholders including monitoring and reporting on success	

Table 1.3 - Dendrobium Longwall 19A Swamp TARP – Swamp 148

Performance Measure	Potential Impacts	Reporting Trigger	Trigger Response	Performance Indicator
EROSION				
Minor erosion of the surface of the swamp	Gully erosion or similar	***Level 1*** The increase in length of erosion within the swamp (compared to its pre-mining length) is **3%** 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.	• Continue monitoring program • Submit impact report to key stakeholders • Report in the End of Panel Report • Summarise actions and monitoring in Annual Review	Mining results in the total length of erosion within a swamp (compared to its pre-mining length) to increase **>10%** of the length or area of the swamp compared to any increase in total erosion length in a reference swamp (i.e. 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 **>10%**).
		Level 2 The increase in length of erosion within the swamp (compared to its pre-mining length) is **5%** 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.	• *Actions as stated for Level 1* • Review monitoring frequency • Seek expert and agency advice on any CMA required e.g. implement temporary erosion control, knickpoint control, coir logs • Implement agreed CMAs as approved (subject to agency feedback)	
		Level 3 The increase in length of erosion within a swamp (compared to its pre-mining length) is **9%** 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.	• *Actions as stated for Level 2* • Offer site visit with key stakeholders • Implement additional monitoring or increase frequency if required • Develop any additional CMA required in consultation with key stakeholders • Completion of works following approvals and at a time agreed between S32 and key stakeholders including monitoring and reporting on success	
ECOSYSTEM FUNCTION				
Minor change in the size of the swamp **Minor** change to the composition or distribution of species within the swamp	LW19A induced hydrological changes in Swamp 148 result in decline in size of groundwater dependent communities	***Level 1*** 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.	• Continue monitoring program • Submit impact report to key stakeholders • Report in the End of Panel Report • Summarise actions and monitoring in Annual Review	LW19A induced hydrological changes in Swamp 148 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.
		Level 2 A trending decline in the extent of an upland swamp (combined area of groundwater dependent communities) for three consecutive monitoring periods,	• *Actions as stated for Level 1* • Review monitoring frequency • Undertake ground-truthing of swamp boundaries and the vegetation sub-communities	

Performance Measure	Potential Impacts	Reporting Trigger	Trigger Response	Performance Indicator
		greater than observed in the Control Group, and exceeding the SE of the Control Group.	•	
		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.	• *Actions as stated for Level 2* • Offer site visit with key stakeholders •	
ECOSYSTEM FUNCTION				
Minor changes in the ecosystem functionality of the swamp	LW19A induced hydrological changes in Swamp 148 result in falls in surface or near-surface groundwater levels in the swamp LW19A induced hydrological changes in Swamp 148 result in falls in soil moisture levels in the swamp	***Level 1*** Rate of groundwater level recession exceeds rate of groundwater level recession by 20% during baseline period at any monitoring site within the swamp (measured as average mm/day during the recession curve and where the 95%ile of pre- and post-mining recession rates are used for comparison); or 5-10% increase in period of time a borehole/pool is dry compared to baseline at any monitored groundwater level site within the swamp.	• Continue monitoring program • Submit impact report to key stakeholders • Report in the End of Panel Report • Summarise actions and monitoring in Annual Review	LW19A induced hydrological changes within Swamp 148 (shallow groundwater) results in piezometer remaining dry and does not recover following the completion of mining and following a year of average (or above) rainfall[1].
		Level 2 Groundwater or soil moisture level lower than baseline level at any monitoring site within the swamp; or Rate of groundwater level recession exceeds rate of groundwater level recession by >20 to 50% during baseline period any monitoring site within the swamp (measured as average mm/day during the recession curve and where the 95%ile of pre- and post-mining recession rates are used for comparison); or 10-20% increase in period of time a borehole/pool is dry compared to baseline at any monitored groundwater level site within the swamp.	• *Actions as stated for Level 1* • Review monitoring frequency • Undertake ecological survey •	
		Level 3 Rate of groundwater level recession exceeds rate of groundwater level recession by >50 to 100% during baseline period at any monitoring site within the swamp (measured as average mm/day during the recession curve and where the 95%ile of pre- and post-mining recession rates are used for comparison); or	• *Actions as stated for Level 2* • Offer site visit with key stakeholders •	

Performance Measure	Potential Impacts	Reporting Trigger	Trigger Response	Performance Indicator
		>20% increase in period of time a borehole/pool is dry compared to baseline at any monitored groundwater level site within the swamp.		
STRUCTURAL INTEGRITY OF CONTROLLING ROCKBAR				
Maintenance or restoration of the structural integrity of rockbar base of any significant permanent pool or controlling rockbar within the swamp	Subsidence impacts (i.e. cracking) on bedrock base or controlling rockbar Loss of surface water in permanent pools	***Level 1*** Fracturing to rockbar base of any significant permanent pool or controlling rockbar within the swamp	• Continue monitoring program • Submit impact report to key stakeholders • Report in the End of Panel Report • Summarise actions and monitoring in Annual Review	Fracturing resulting in increased cease-to-flow or dry pool days at controlling rockbar within the swamp which cannot be restored via CMAs.
		Level 2 Fracturing to rockbar base of any significant permanent pool or controlling rockbar within the swamp results in cease-to-flow	• *Actions as stated for Level 1* • Review monitoring frequency •	
		Level 3 Fracturing to rockbar base of any significant permanent pool or controlling rockbar within the swamp results in dry pool	• *Actions as stated for Level 2* • Offer site visit with key stakeholders •	

Note: Key Stakeholders/Agencies include the following and their successor agencies:

- Department of Planning and Environment (DPE)
- Biodiversity and Conservation Division (BCD)
- Resources Regulator
- WaterNSW

Appendix B – Swamp 15a and 148 Monitoring and Reference Sites

Appendix B - Swamp 15a and 148 Monitoring and Reference Sites (Data as at 18 October 2023)

Monitoring Site ID	Data Type	Area	Monitoring Start Date	Monitoring Completion Date	Longwall	Easting	Northing	Comments
148_01	Groundwater level	Dendrobium Area 3a	30/08/2021	ongoing	Not mined beneath	291905.0	6192218.0	Proposed by IMC
15a_03	Groundwater level	Dendrobium Area 3a	19/07/2012	ongoing	Not mined beneath	292349.4	6191452.5	Proposed by IMC
15a_04	Groundwater level	Dendrobium Area 3a	22/06/2021	ongoing	Not mined beneath	292418.9	6191639.9	Proposed by IMC
15a_06	Groundwater level	Dendrobium Area 3a	19/07/2012	ongoing	Not mined beneath	292640.2	6191974.3	Proposed by IMC
15a_07	Groundwater level	Dendrobium Area 3a	19/07/2012	ongoing	Not mined beneath	292693.4	6191928.4	Proposed by IMC
15a_08	Groundwater level	Dendrobium Area 3a	12/09/2023	ongoing	Not mined beneath	292773.4	6191887.0	Proposed by IMC as part of consultation with DPE in August/Sept 2023.
15a_09	Groundwater level	Dendrobium Area 3a	12/09/2023	ongoing	Not mined beneath	292793.9	6191819.5	Proposed by IMC as part of consultation with DPE in August/Sept 2023.
15a_11	Groundwater level	Dendrobium Area 3a	15/09/2023	ongoing	Not mined beneath	293092.6	6191883.8	Proposed by IMC as part of consultation with DPE in August/Sept 2023.
15a_12	Groundwater level	Dendrobium Area 3a	1/07/2021	ongoing	Not mined beneath	293045.7	6191957.9	Proposed by IMC
15a_15	Groundwater level	Dendrobium Area 3a	29/06/2021	ongoing	Not mined beneath	292699.0	6191794.3	Proposed by IMC
15a_18	Groundwater level	Dendrobium Area 3a	19/07/2012	ongoing	Not mined beneath	293201.4	6192143.5	Proposed by IMC

Monitoring Site ID	Data Type	Area	Monitoring Start Date	Monitoring Completion Date	Longwall	Easting	Northing	Comments
15a_19	Groundwater level	Dendrobium Area 3a	8/06/2022	ongoing	Not mined beneath	292761.5	6192016.4	Recommended by Specialist
34_01	Groundwater level	Dendrobium Area 3a	30/08/2021	ongoing	Not mined beneath	281891.0	6191891.0	Proposed by IMC
S148_01	Soil Moisture	Dendrobium Area 3a	27/05/2021	ongoing	Not mined beneath	291905.0	6192218.0	Proposed by IMC
S15a_03	Soil Moisture	Dendrobium Area 3a	6/11/2021	ongoing	Not mined beneath	292349.4	6191452.5	Proposed by IMC
S15a_04	Soil Moisture	Dendrobium Area 3a	13/09/2021	ongoing	Not mined beneath	292418.9	6191639.9	Proposed by IMC
S15a_07	Soil Moisture	Dendrobium Area 3a	16/08/2021	ongoing	Not mined beneath	292693.4	6191928.4	Proposed by IMC

Monitoring Site ID	Data Type	Area	Monitoring Start Date	Monitoring Completion Date	Longwall	Easting	Northing	Comments
S15a_12	Soil Moisture	Dendrobium Area 3a	13/09/2021	ongoing	Not mined beneath	293045.7	6191957.9	Proposed by IMC
S15a_15	Soil Moisture	Dendrobium Area 3a	13/09/2021	ongoing	Not mined beneath	292699.0	6191794.3	Proposed by IMC
S15a_18	Soil Moisture	Dendrobium Area 3a	16/08/2021	ongoing	Not mined beneath	293201.4	6192143.5	Proposed by IMC
S15a_19	Soil Moisture	Dendrobium Area 3a	27/03/2022	ongoing	Not mined beneath	292761.5	6192016.4	Recommended by Specialist
S34_01	Soil Moisture	Dendrobium Area 3a	24/05/2021	ongoing	Not mined beneath	281891.0	6191891.0	
SC10_Pool_11	Pool Level	Dendrobium Area 3a	8/06/2022	ongoing	Not mined beneath	293290.0	6192330.0	Proposed by IMC as part of consultation with DPE in August/Sept 2023.
SC10_Pool_14	Pool Level	Dendrobium Area 3a	8/06/2022	ongoing	Not mined beneath	293216.0	6192194.0	Proposed by IMC as part of consultation with DPE in August/Sept 2023.

Monitoring Site ID	Data Type	Area	Monitoring Start Date	Monitoring Completion Date	Longwall	Easting	Northing	Comments
SC10_Pool_23	Pool Level	Dendrobium Area 3a	9/06/2022	ongoing	Not mined beneath	292884.0	6192029.0	Proposed by IMC as part of consultation with DPE in August/Sept 2023.
SC10_Pool_26a	Pool Level	Dendrobium Area 3a	9/06/2022	ongoing	Not mined beneath	292680.0	6191881.0	Proposed by IMC as part of consultation with DPE in August/Sept 2023.
SC10_Pool_29	Pool Level	Dendrobium Area 3a	31/08/2023	ongoing	Not mined beneath	292640.0	6191833.0	Proposed by IMC as part of consultation with DPE in August/Sept 2023.
02_01	Groundwater level	Reference Swamps	29/06/2012	ongoing	Not mined beneath	289477.0	6194981.0	
22_01	Groundwater level	Reference Swamps	11/08/2015	ongoing	Not mined beneath	292800.0	6188138.0	Proposed by IMC
22_02	Groundwater level	Reference Swamps	11/08/2015	ongoing	Not mined beneath	293186.0	6188170.0	Proposed by IMC
24_01	Groundwater level	Reference Swamps	10/11/2022	ongoing	Not mined beneath	292208.0	6187666.0	
25_01	Groundwater level	Reference Swamps	30/07/2009	ongoing	Not mined beneath	292451.0	6190414.0	Proposed by IMC
33_01	Groundwater level	Reference Swamps	13/08/2015	ongoing	Not mined beneath	291948.0	6190939.0	Proposed by IMC
33_03	Groundwater level	Reference Swamps	13/08/2015	ongoing	Not mined beneath	291669.0	6191270.0	Proposed by IMC
84_01	Groundwater level	Reference Swamps	3/07/2015	ongoing	Not mined beneath	294101.0	6192112.0	Proposed by IMC
85_01	Groundwater level	Reference Swamps	26/06/2015	ongoing	Not mined beneath	288040.0	6195000.0	Proposed by IMC
85_02	Groundwater level	Reference Swamps	26/06/2015	ongoing	Not mined beneath	288141.0	6195011.0	Proposed by IMC
85_03	Groundwater level	Reference Swamps	26/05/2017	ongoing	Not mined beneath	288222.0	6195022.0	
86_01	Groundwater level	Reference Swamps	26/06/2015	ongoing	Not mined beneath	286625.0	6196839.0	Proposed by IMC
86_02	Groundwater level	Reference Swamps	26/06/2015	ongoing	Not mined beneath	286536.0	6196553.0	Proposed by IMC

Monitoring Site ID	Data Type	Area	Monitoring Start Date	Monitoring Completion Date	Longwall	Easting	Northing	Comments
86_03	Groundwater level	Reference Swamps	15/06/2017	ongoing	Not mined beneath	286535.0	6196653.0	
87_01	Groundwater level	Reference Swamps	8/07/2015	ongoing	Not mined beneath	290859.0	6180953.0	Proposed by IMC
87_02	Groundwater level	Reference Swamps	8/07/2015	ongoing	Not mined beneath	290881.0	6181182.0	Proposed by IMC
88_01	Groundwater level	Reference Swamps	8/07/2015	ongoing	Not mined beneath	289221.0	6180109.0	Proposed by IMC
88_02	Groundwater level	Reference Swamps	24/08/2015	ongoing	Not mined beneath	289368.0	6180463.0	Proposed by IMC
S02_01	Soil Moisture	Reference Swamps	20/10/2020	ongoing	Not mined beneath	289477.0	6194981.0	Proposed by IMC
S22_01	Soil Moisture	Reference Swamps	15/07/2018	ongoing	Not mined beneath	292800.0	6188138.0	Proposed by IMC
S24_01	Soil Moisture	Reference Swamps	13/12/2022	ongoing	Not mined beneath	292208.0	6187666.0	Proposed by IMC
S25_01	Soil Moisture	Reference Swamps	3/04/2023	ongoing	Not mined beneath	292451.0	6190414.0	
S33_01	Soil Moisture	Reference Swamps	30/06/2023	ongoing	Not mined beneath	291948.0	6190939.0	Proposed by IMC
S33_03	Soil Moisture	Reference Swamps	30/06/2023	ongoing	Not mined beneath	291669.0	6191270.0	Proposed by IMC
S84_01	Soil Moisture	Reference Swamps	5/07/2023	ongoing	Not mined beneath	294101.0	6192112.0	Proposed by IMC
S85_01	Soil Moisture	Reference Swamps	7/07/2023	ongoing	Not mined beneath	288040.0	6195000.0	Proposed by IMC
S85_02	Soil Moisture	Reference Swamps	7/07/2023	ongoing	Not mined beneath	288141.0	6195011.0	Proposed by IMC
S85_03	Soil Moisture	Reference Swamps	14/07/2017	ongoing	Not mined beneath	288222.0	6195022.0	
S86_01	Soil Moisture	Reference Swamps	22/09/2023	ongoing	Not mined beneath	286625.0	6196839.0	Proposed by IMC
S86_02	Soil Moisture	Reference Swamps	22/09/2023	ongoing	Not mined beneath	286536.0	6196553.0	Proposed by IMC

Monitoring Site ID	Data Type	Area	Monitoring Start Date	Monitoring Completion Date	Longwall	Easting	Northing	Comments
S86_03	Soil Moisture	Reference Swamps	24/07/2017	ongoing	Not mined beneath	286535.0	6196653.0	
S87_01	Soil Moisture	Reference Swamps	7/03/2023	ongoing	Not mined beneath	290859.0	6180953.0	Proposed by IMC
S87_02	Soil Moisture	Reference Swamps	8/05/2016	ongoing	Not mined beneath	290881.0	6181182.0	
S88_01	Soil Moisture	Reference Swamps	7/03/2023	ongoing	Not mined beneath	289221.0	6180109.0	Proposed by IMC
S88_02	Soil Moisture	Reference Swamps	25/11/2022	ongoing	Not mined beneath	289368.0	6180463.0	Proposed by IMC