METROPOLITAN COAL LONGWALLS 311-316

BIODIVERSITY MANAGEMENT PLAN




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METROPOLITAN COAL

LONGWALLS 311-316

BIODIVERSITY MANAGEMENT PLAN

Revision Status Register

Section/Page/ Annexure	**Revision Number**	**Amendment/Addition**	**Distribution**	**DPHI Approval Date**
All	BMP-R01-A	Original	DPHI, BCS, DPI - Fisheries	-
All	BMP-R01-B	Updated to reflect amendments to the Longwalls 311-316 longwall layout and to address agency comments	DPHI, BCS, DPI - Fisheries	-
All	BMP-R01-C	Updated to reflect Longwall 311 Approval	DPHI	-

November 2024

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1 INTRODUCTION

The Metropolitan Colliery (Metropolitan Coal Mine) is owned and operated by Metropolitan Collieries Pty Ltd (Metropolitan Coal), which is a wholly owned subsidiary of Peabody Energy Australia Pty Ltd (Peabody). The Metropolitan Coal Mine is located adjacent to the township of Helensburgh (Figure 1), approximately 30 kilometres (km) north of Wollongong in New South Wales (NSW).

Metropolitan Coal was granted approval for the Metropolitan Coal Project (the Project) under section 75J of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) on 22 June 2009. A copy of the Project Approval is available on the Peabody website (http://www.peabodyenergy.com).

The Project comprises the continuation, upgrade and extension of underground coal mining operations (Longwalls 20-27 and Longwalls 301-317) and surface facilities at Metropolitan Coal. Longwalls 311-316 are situated to the west of Longwalls 301-310 and define the next mining sub-domain within the Project underground mining area (Figure 2). Longwall 317 will be subject to future Extraction Plans.

1.1 PURPOSE AND SCOPE

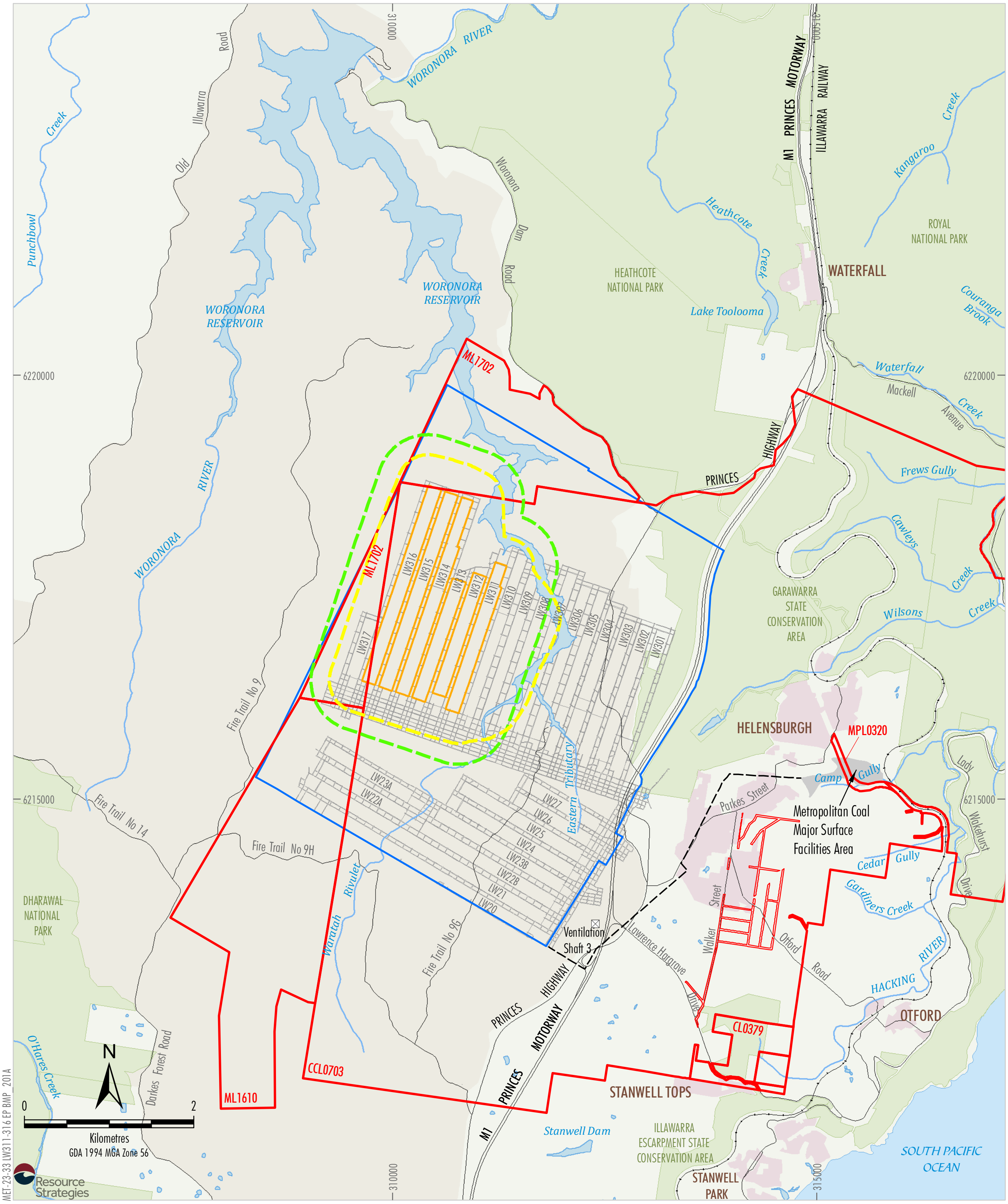
In accordance with Condition 6(f), Schedule 3 of the Project Approval, this Biodiversity Management Plan (BMP) has been prepared as a component of the Metropolitan Coal Longwalls 311-316 Extraction Plan to manage the potential environmental consequences of the Extraction Plan on aquatic and terrestrial flora and fauna, with a specific focus on swamps.

The relationship of this BMP to the Metropolitan Coal Environmental Management Structure and to the Metropolitan Coal Longwalls 311-316 Extraction Plan is shown on Figure 3.

This BMP includes post-mining monitoring and management of aquatic and terrestrial flora and fauna for Longwalls 20-22, 23-27, 301-303, 304, 305-307 and 308-310, subject to the previously approved Metropolitan Coal Longwalls 305-307 BMP. Consistent with the recommended approach in the NSW Department of Planning and Environment (DPE) (now known as the Department of Planning, Housing and Infrastructure[1] [DPHI]) (2022) *Extraction Plan Guideline*, the Longwalls 308-310 BMP will be superseded by this document following the completion of Longwall 307.

In accordance with Condition 6, Schedule 3 of the Project Approval, this BMP has been prepared by Metropolitan Coal, with assistance from Ecoplanning Pty Ltd (Ecoplanning), Bio-Analysis Pty Ltd (Bio-Analysis), ATC Williams Pty Ltd (ATC Williams), SLR Consulting Australia Pty Ltd (SLR) and Mine Subsidence Engineering Consultants (MSEC).

[1] The former Department of Planning and Environment (DPE) was renamed to the Department of Planning, Housing and Infrastructure (DPHI) on 1 January 2024. References to DPE have been retained throughout the remainder of this document.



LEGEND

- Mining Lease Boundary
- Woronora Special Area
- Railway
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 311-316 Secondary Extraction
- Longwalls 311-316 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 311-316 Secondary Extraction
- Existing Underground Access Drive (Main Drift)

Source: Land and Property Information (2015); Department of Industry (2015); Metropolitan Coal (2023); MSEC (2024)

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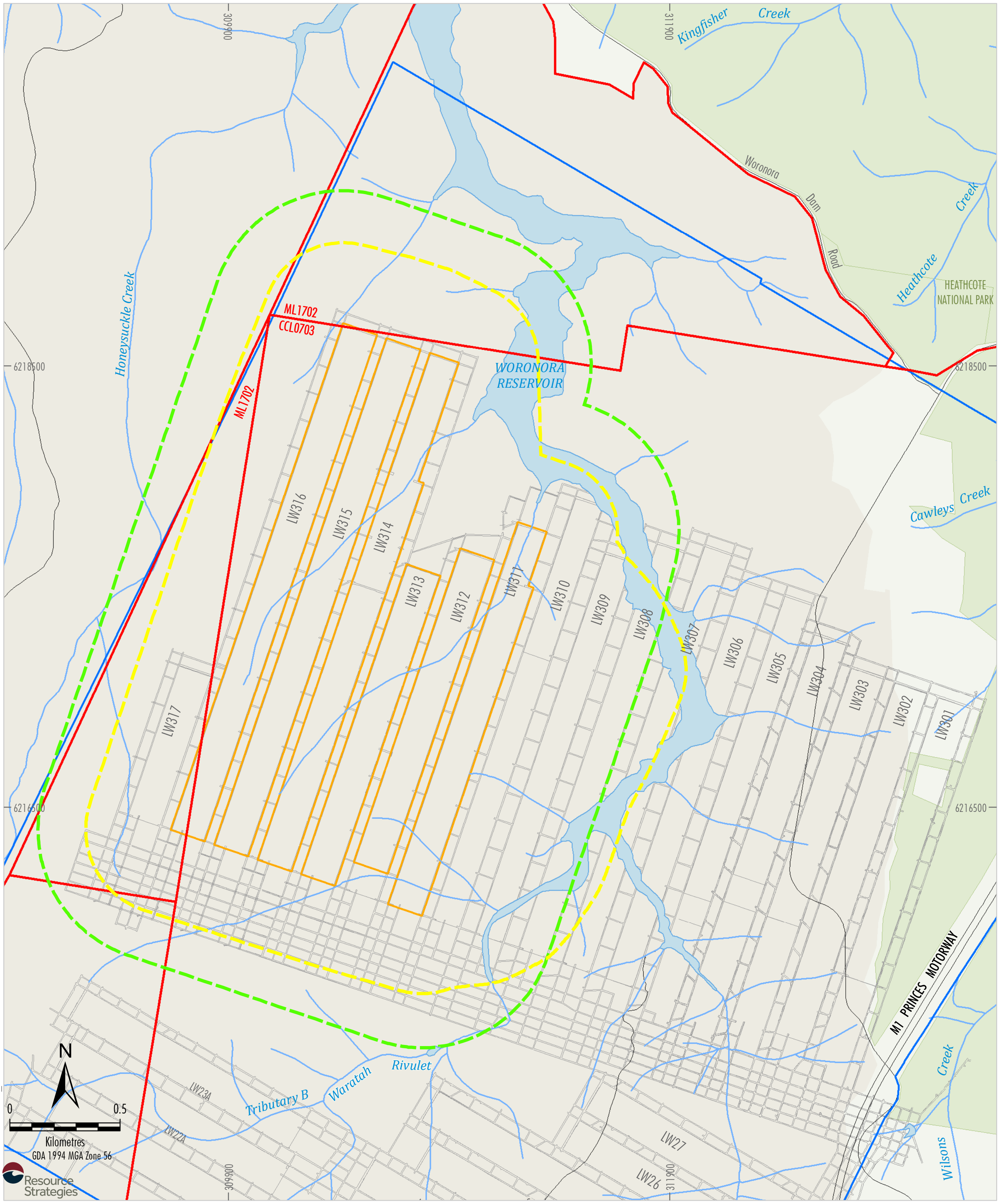
Longwalls 311-316 and Project Underground Mining Area

Figure 1



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Source: Land and Property Information (2015); Department of Industry (2015); Metropolitan Coal (2023); MSEC (2024)

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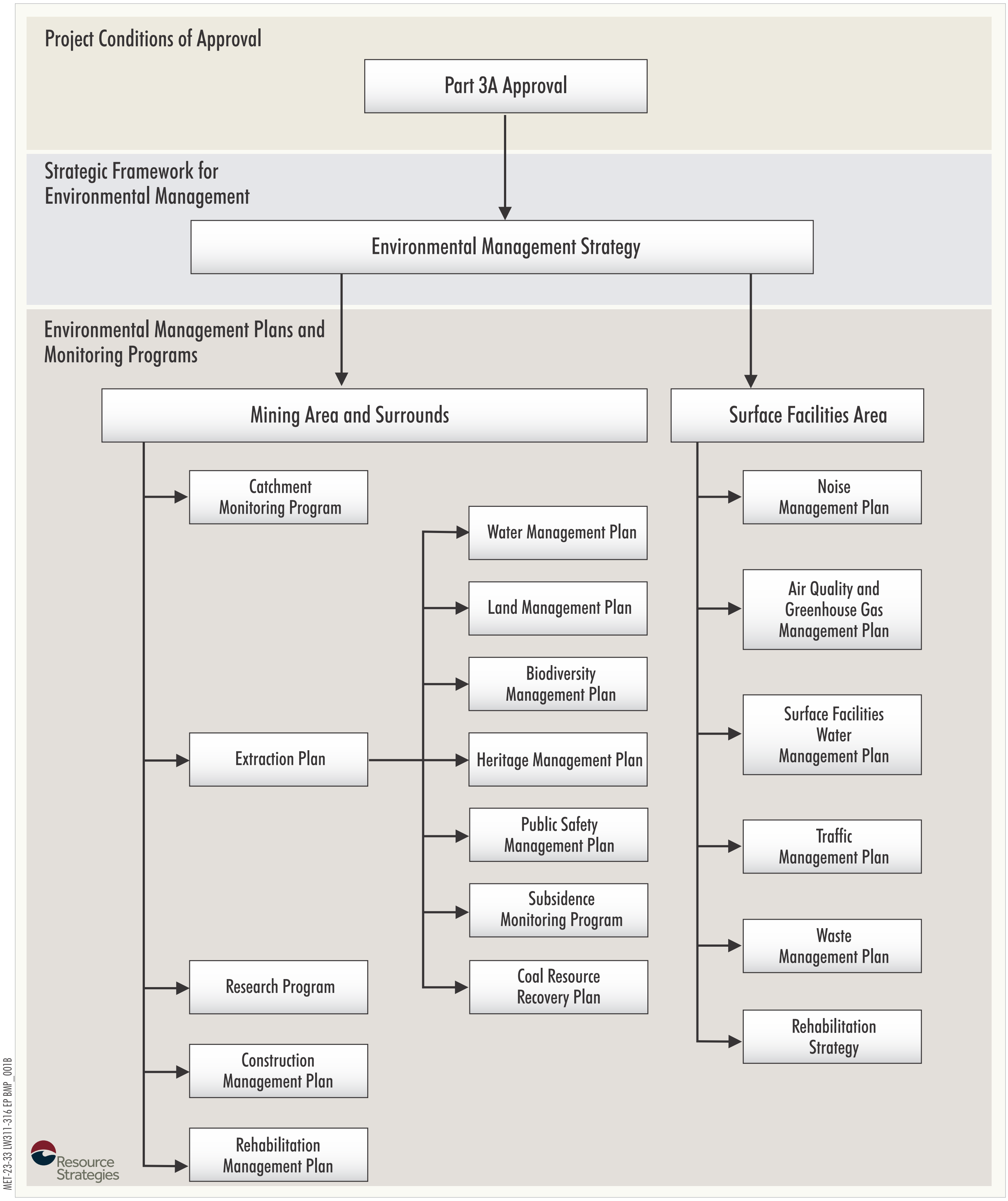
Longwalls 311-316 Layout

Figure 2



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Environmental Management Structure

Figure 3

1.2 STRUCTURE OF THE BIODIVERSITY MANAGEMENT PLAN

The remainder of the BMP is structured as follows:

Section 2:	Describes the review and update of the BMP.
Section 3:	Outlines the statutory requirements applicable to the BMP.
Section 4:	Provides a summary of the water, land and biodiversity management information obtained since Project Approval.
Section 5:	Provides a revised assessment of the potential subsidence impacts and environmental consequences for Longwalls 311-316.
Section 6:	Details the performance measures and indicators that will be used to assess the Project.
Section 7:	Details the available baseline data.
Section 8:	Describes the monitoring programs and provides the detailed Trigger Action Response Plans (TARPs).
Section 9:	Describes the management measures that will be implemented.
Section 10:	Provides a Contingency Plan to manage any unpredicted impacts and their consequences.
Section 11:	Describes the program to collect baseline data for future Extraction Plans.
Section 12:	Describes the annual review and improvement of environmental performance.
Section 13:	Outlines the management and reporting of incidents.
Section 14:	Outlines the management and reporting of complaints.
Section 15:	Outlines the management and reporting of non-compliances with statutory requirements.
Section 16:	Lists the references cited in this BMP.

2 BIODIVERSITY MANAGEMENT PLAN REVIEW AND UPDATE

In accordance with Condition 4, Schedule 7 of the Project Approval, this BMP will be reviewed within three months of the submission of:

- an audit under Condition 8, Schedule 7;
- an incident report under Condition 6, Schedule 7;
- an annual review under Condition 3, Schedule 7; and

if necessary, revised to the satisfaction of the Director-General (now Secretary) of the DPE to ensure the BMP is updated on a regular basis and to incorporate any recommended measures to improve environmental performance.

The BMP will also be reviewed within three months of approval of any Project modification and if necessary, revised to the satisfaction of the DPE.

The revision status of this BMP is indicated on the title page of each copy. The distribution register for controlled copies of the BMP is described in Section 2.1.

2.1 DISTRIBUTION REGISTER

In accordance with Condition 10, Schedule 7 of the Project Approval 'Access to Information', Metropolitan Coal will make the BMP publicly available on the Peabody website.

Metropolitan Coal recognises that various regulators have different distribution requirements, both in relation to whom documents should be sent and in what format.

An Environmental Management Plan and Monitoring Program Distribution Register has been established in consultation with the relevant agencies and infrastructure owners that indicates:

- to whom the Metropolitan Coal plans and programs, such as the BMP, will be distributed;
- the format (i.e. electronic or hard copy) of distribution; and
- the format of revision notification.

Metropolitan Coal will make the Distribution Register publicly available on the Peabody website. Metropolitan Coal will be responsible for maintaining the Distribution Register and for ensuring that the notification of revisions is sent by email or post as appropriate.

In addition, Metropolitan Coal employees with local computer network access will be able to view the controlled electronic version of this BMP on the Metropolitan Coal local area network. Metropolitan Coal will not be responsible for maintaining uncontrolled copies beyond ensuring the most recent version is maintained on Metropolitan Coal's computer system and the Peabody website.

3 STATUTORY REQUIREMENTS

Metropolitan Coal's statutory obligations are contained in:

(i) the conditions of the Project Approval;

(ii) relevant licences and permits, including conditions attached to mining leases; and

(iii) other relevant legislation.

These are described below.

3.1 ENVIRONMENTAL PLANNING & ASSESSMENT ACT APPROVAL

Condition 6(f), Schedule 3 of the Project Approval requires the preparation of a BMP as a component of Extraction Plan(s) for second workings. Condition 6(f), Schedule 3 states:

> ***SECOND WORKINGS***
>
> ***Extraction Plan***
>
> *6. The Proponent shall prepare and implement an Extraction Plan for all second workings in the mining area to the satisfaction of the Director-General. This plan must:*
>
> *…*
>
> *(f) include a:*
>
> *…*
>
> - *Biodiversity Management Plan, which has been prepared in consultation with OEH[2] and DRE (Fisheries)[3], to manage the potential environmental consequences of the Extraction Plan on aquatic and terrestrial flora and fauna, with a specific focus on swamps;*

In addition, Condition 2, Schedule 7 and Condition 7, Schedule 3 of the Project Approval outline management plan requirements that are applicable to the preparation of the BMP. Table 1 indicates where each component of the conditions is addressed within this BMP.

2 The NSW Office of Environment and Heritage (OEH) is now the Department of Planning and Environment – Biodiversity, Conservation and Science Directorate (BCS).

3 The Division of Resources and Energy (DRE) - Fisheries is now the Department of Primary Industries (DPI) - Fisheries.

Table 1
Management Plan Requirements

Project Approval Condition	BMP Section
Condition 2, Schedule 7	
2. The Proponent shall ensure that the management plans required under this approval are prepared in accordance with any relevant guidelines, and include:	
a) detailed baseline data;	Section 7
b) a description of:	
• the relevant statutory requirements (including any relevant approval, licence or lease conditions);	Section 3
• any relevant limits or performance measures/criteria;	Section 6
• the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the project or any management measures;	Section 6
c) a description of the measures that would be implemented to comply with the relevant statutory requirements, limits, or performance measures/criteria;	Sections 6, 8, 9 and 10
d) a program to monitor and report on the:	Sections 8, 9 and 12
• impacts and environmental performance of the project;	
• effectiveness of any management measures (see c above);	
e) a contingency plan to manage any unpredicted impacts and their consequences;	Section 10
f) a program to investigate and implement ways to improve the environmental performance of the project over time;	Sections 8 and 12
g) a protocol for managing and reporting any;	
• incidents;	Section 13
• complaints;	Section 14
• non-compliances with statutory requirements; and	Section 15
• exceedances of the impact assessment criteria and/or performance criteria; and	Section 10
h) a protocol for periodic review of the plan.	Sections 2 and 12
Condition 7, Schedule 3	
7. In addition to the standard requirements for management plans (see condition 2 of schedule 7), the Proponent shall ensure that the management plans required under condition 6(f) above include:	
a) a program to collect sufficient baseline data for future Extraction Plans;	Section 11
b) a revised assessment of the potential environmental consequences of the Extraction Plan, incorporating any relevant information that has been obtained since this approval;	Sections 4 and 5
c) a detailed description of the measures that would be implemented to remediate predicted impacts; and	Section 9
d) a contingency plan that expressly provides for adaptive management.	Section 10

3.2 LICENCES, PERMITS AND LEASES

In addition to the Project Approval, all activities at or in association with the Metropolitan Coal Mine will be undertaken in accordance with the following licences, permits and leases which have been issued or are pending issue:

- The conditions of mining leases issued by the NSW Division of Resources and Geoscience (DRG) (now Mining, Exploration and Geoscience [MEG]), under the NSW *Mining Act 1992* (e.g. Consolidated Coal Lease [CCL] 703, Mining Lease [ML] 1610, ML 1702, Coal Lease 379 and Mining Purpose Lease 320).
- The conditions of Environment Protection Licence (EPL) No. 767 issued by the NSW Environment Protection Authority (EPA) under the NSW *Protection of the Environment Operations Act 1997*. Revision of the EPL will be required prior to the commencement of Metropolitan Coal activities that differ from those currently licensed.
- The prescribed conditions of specific surface access leases within CCL 703 for the installation of surface facilities as required.
- Water Access Licences (WALs) issued by the NSW Department of Industry – Water (now DPE – Water) under the NSW *Water Management Act 2000,* including WAL 36475 under the *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2023* and WAL 25410 under the *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources 2023.*
- Mining and workplace health and safety related approvals granted by the Resources Regulator and WorkCover NSW.
- Supplementary approvals obtained from WaterNSW for surface activities within the Woronora Special Area (e.g. fire road maintenance activities).

3.3 OTHER LEGISLATION

Metropolitan Coal will conduct the Project consistent with the Project Approval and any other legislation that is applicable to an approved Part 3A Project under the EP&A Act.

The following Acts may be applicable to the conduct of the Project (Helensburgh Coal Pty Ltd [HCPL], 2008)[4]:

- *Biodiversity Conservation Act 2016* (BC Act)*;*
- *Biosecurity Act 2015;*
- *Contaminated Land Management Act 1997;*
- *Crown Land Management Act 2016;*
- *Dams Safety Act 2015;*
- *Dangerous Goods (Road and Rail Transport) Act 2008;*
- *Energy and Utilities Administration Act 1987;*
- *Fisheries Management Act 1994;*
- *Mining Act 1992;*
- *National Parks and Wildlife Act 1974;*

4 The list of potentially applicable Acts has been updated to reflect changes to the Acts that were in force at the time of submission of the Metropolitan Coal Project Environmental Assessment (Project EA) (HCPL, 2008).

- *Protection of the Environment Operations Act 1997;*
- *Rail Safety (Adoption of National Law) Act 2012;*
- *Roads Act 1993;*
- *Water Act 1912;*
- *Water Management Act 2000;*
- *Water NSW Act 2014;*
- *Work Health and Safety Act 2011;* and
- *Work Health and Safety (Mines and Petroleum Sites) Act 2013.*

Relevant licences or approvals required under these Acts will be obtained as required.

4 RELEVANT INFORMATION OBTAINED SINCE PROJECT APPROVAL

Sections 4.1 to 4.2 summarise the water, land and biodiversity management information obtained since Project Approval, respectively.

4.1 RELEVANT WATER MANAGEMENT INFORMATION OBTAINED SINCE PROJECT APPROVAL

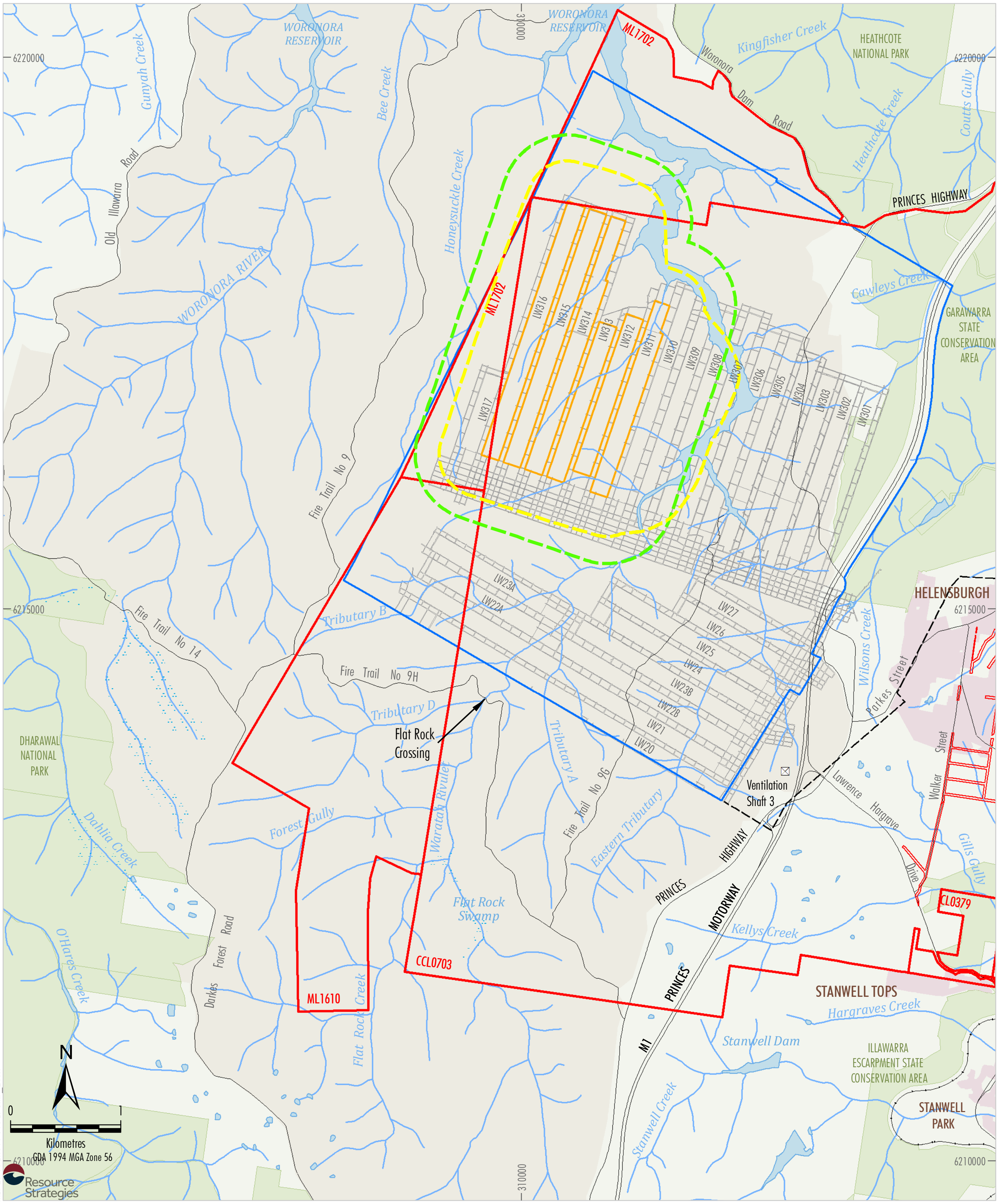
The Metropolitan Coal Water Management Plans were prepared to manage the potential environmental consequences of the Metropolitan Coal Extraction Plans on water resources and watercourses in accordance with Condition 6, Schedule 3 of the Project Approval.

4.1.1 Surface Water

Streams occurring within 600 metres (m) of Longwalls 20-22, 23-27, 301-303, 304, 305-307 and/or 308-310 secondary extraction include the Waratah Rivulet and its tributaries (such as Tributary A and B), the Eastern Tributary and its tributaries, and small first and second order streams including those that drain into the Woronora Reservoir (Figure 4).

The Waratah Rivulet and Eastern Tributary are the subject of Project performance measures, as described in Section 6. The locations of pools on the Waratah Rivulet and the Eastern Tributary are shown on Figure 5. The Preferred Project Report (HCPL, 2009) indicated that valley closure values of greater than 200 millimetres (mm) were predicted for a number of pools/rock bars on the Waratah Rivulet, Eastern Tributary and other streams. 'Negligible consequence' for a watercourse was considered by the Project Approval to mean, *'no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining, and minimal gas releases'*, and was assumed to be achieved in circumstances where predicted valley closure was less than 200 mm. Subsidence impacts to a number of pools on the Eastern Tributary occurred during the mining of Longwalls 26 and 27 at predicted valley closure values of less than 200 mm.

Subsidence impacts to a number of pools on the Eastern Tributary occurred during the mining of Longwalls 26 and 27 at predicted valley closure values of less than 200 mm.



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- Longwalls 311-316 Secondary Extraction
- Longwalls 311-316 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 311-316 Secondary Extraction
- Existing Underground Access Drive (Main Drift)

Source: Land and Property Information (2015); Department of Industry (2015); Metropolitan Coal (2023); MSEC (2024)

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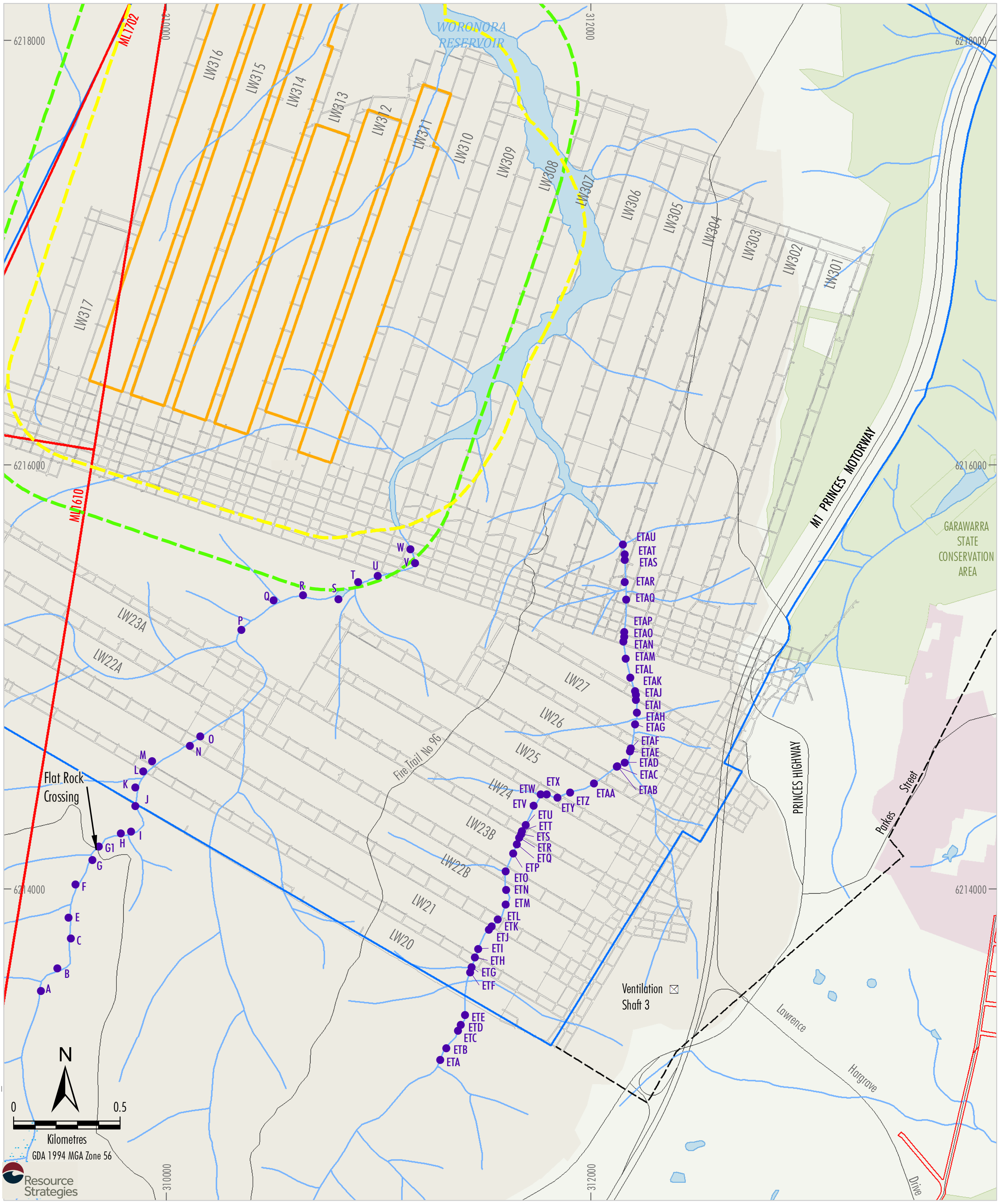
Streams within the Project Underground Mining Area and Surrounds

Figure 4



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- Existing Underground Access Drive (Main Drift)
- Pool

Note: The streams are based on mapping by the Lands Department (2006). More detailed and accurate mapping of the streams is provided in Water Management Plan Appendices 1 to 4.

Source: Land and Property Information (2015); Department of Industry (2015); Metropolitan Coal (2023); MSEC (2024)

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Waratah Rivulet and Eastern Tributary Pools

Figure 5

The Independent Expert Panel for Mining in the Catchment (IEPMC)[5] Initial Report recommended that the concept of restricting predicted valley closure to a maximum of 200 mm to avoid significant environmental consequences be revised for watercourses (IEPMC, 2018). Metropolitan Coal agreed that the 200 mm valley closure concept required revision in relation to the Eastern Tributary, noting that the unexpected impacts are particular to the Eastern Tributary and not the Waratah Rivulet. Restricting total predicted valley closure to 200 mm has been a successful design tool for mining in the vicinity of the Waratah Rivulet.

The negligible environmental consequences performance measure for watercourses as described above applied specifically for the Waratah Rivulet along the portion of the '*Waratah Rivulet between the full supply level of the Woronora Reservoir and the maingate of Longwall 23 (upstream of Pool P)'.* This section of the Waratah Rivulet includes Pool P to Rock Bar W, located to the south-east of Longwalls 311-316.

The restriction of predicted valley closure to 200 mm has been a successful design tool on the Waratah Rivulet, with no impacts to pools and rock bars along the Waratah Rivulet at predicted total valley closure of less than 200 mm. Pool P to Rock Bar W have not exceeded the negligible environmental consequence performance measure for the Waratah Rivulet. Predicted total valley closure for Pool P to Rock Bar W was less than 200 mm for the extraction of Longwalls 20-27, 301-303, 304, 305-307 and did not increase for Longwalls 308-310.

Pool A to Pool O (a total of 16 pools) are located upstream of Pool P, and are therefore not subject to the Waratah Rivulet negligible environmental impact performance measure. It is noted that the majority of these pools were predicted to experience maximum predicted total closure of greater than 200 mm. However, of these pools, only two (Pools G1 and N) have experienced subsidence impacts that would have resulted in an exceedance of the negligible environmental impact performance measure. Impacts that have occurred at these pools have been the result of mining directly beneath the Waratah Rivulet or in close proximity (< 100 m) to the rock bars, at predicted total valley closure greater than 200 mm.

Although subsidence impacts were observed at a number of pools on the Eastern Tributary at predicted total valley closure values of less than 200 mm during the mining of Longwalls 26 and 27, restricting predicted total valley closure to 200 mm is no longer applied for the Eastern Tributary.

A geotechnical study of the Waratah Rivulet investigated the geological characteristics of the stream bed, with the aim of identifying any characteristics that would make the Waratah Rivulet more susceptible to subsidence movements (similar to the Eastern Tributary). The study focussed on Pool P to Rock Bar W on the Waratah Rivulet, and compared these sites to Pool ETAM on the Eastern Tributary, which has experienced subsidence movements due to historical mining.

The geotechnical study identified a thick unit (approximately 25 m) of thinly bedded sandstone along the Eastern Tributary at the location of Pool ETAM. The thinly bedded sandstone is considered to be of lower strength, and more weathered than adjoining thickly bedded sandstone units and therefore more prone to impact from valley closure movements. In addition, a higher frequency of seam level faults and surface lineaments have been identified in the vicinity of the Eastern Tributary. The thinly bedded units identified along the along Waratah Rivulet were limited to less than 5 m thickness and the frequency of seam level faults and surface lineaments was considerably less.

5 The IEPMC was established in November 2017 by the NSW Government to provide expert advice to the DPIE on the impact of mining activities in the Greater Sydney Water Catchment Special Areas, with a particular focus on risks to the quantity of water in the catchment.

Based on the results of the assessment, the geological features identified along the Eastern Tributary are considered to be unique, compared to the Waratah Rivulet. The Eastern Tributary is therefore more likely to be susceptible to subsidence movements. Restricting valley closure to 200 mm therefore continues to be an appropriate design tool for the Waratah Rivulet. Further discussion on the subsidence predictions and 200 mm valley closure design tool for Longwalls 311-316 is provided in the Longwalls 311-316 Water Management Plan.

Metropolitan Coal developed a monitoring and adaptive management approach to the mining of Longwall 303 towards the Eastern Tributary. As Longwall 303 mined towards the Eastern Tributary, Metropolitan Coal used a TARP designed to monitor valley closure movements on the Eastern Tributary. The Eastern Tributary Valley Closure TARP has been successfully implemented by Metropolitan Coal for Longwalls 303, 304 and 305. The Waratah Rivulet is monitored by the same Global Navigation Satellite System (GNSS) valley closure monitoring methods used for the Eastern Tributary with consideration of the 200 mm valley closure design tool (as described in the Longwalls 308-310 Extraction Plan).

Pool Water Levels and Surface Water Flow

Visual inspections and photographic surveys have been conducted of the Waratah Rivulet, Eastern Tributary, Tributary A and Tributary B in accordance with the Metropolitan Coal Water Management Plans.

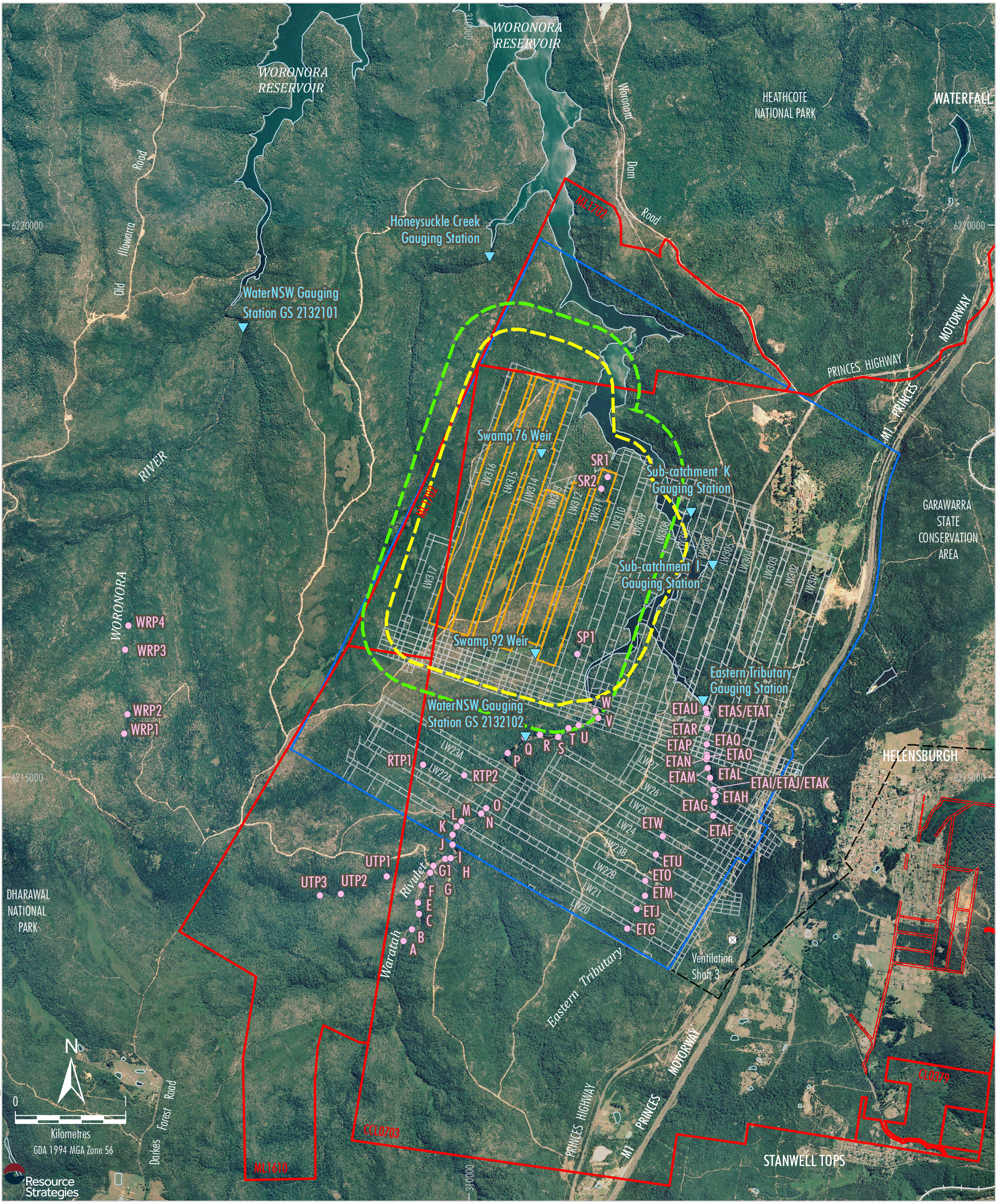
Water levels in pools on the Waratah Rivulet (Pools A, B, C, E, F, G, G1, H, I, J, K, L, M, N, O, P, Q, R, S, T, U, V and W) have either been manually monitored on a daily basis or monitored using a continuous water level sensor and logger (Figure 6). A number of pools on the Eastern Tributary (Pools ETG, ETJ, ETM, ETO, ETU, ETW, ETAF, ETAG, ETAH, ETAI/ETAJ/ETAK[6], ETAL, ETAM, ETAN, ETAO, ETAP, ETAQ ETAR, ETAS/ETAT[7] and ETAU), Tributary P (SP1), Tributary R (SR1 and SR2), Tributary B (Pools RTP1 and RTP2) and Woronora River (Pools WRP1, WRP2, WRP3 and WRP4) have also been monitored using a continuous water level sensor and logger (Figure 6).

The stream inspections, pool water level monitoring and surface water flow monitoring have identified subsidence impacts and environmental consequences consistent with those described in the Metropolitan Coal Project Environmental Assessment (Project EA) (HCPL, 2008), Preferred Project Report, and Metropolitan Coal Water Management Plans. These documents identified that the key potential subsidence impacts in relation to pool water levels and surface water flow would include:

- The magnitudes of the predicted systematic and/or valley related movements are likely to result in some fracturing and dilation of the underlying strata of streams above and immediately adjacent to the longwalls.
- Cracking and dilation of bedrock are likely to result in the localised diversion of a portion of the surface flow through either:
  - **diversion into subterranean flows**, where water travels via new mining induced fractures and opened natural joints in the bedrock into near-surface dilated strata beneath the bedrock, ultimately re-emerging at the surface downstream; or
  - **leakage through rock bars**, where the rate of leakage from pools through rock bars to the downstream reaches of the stream is increased by new mining induced fractures.

6 Only small rock bars separate Pools ETAI, ETAJ and ETAK. Pools join to become the one large pool. Pool ETAK is controlled by a rock bar. The water level meter situated in Pool ETAI is considered to be representative of the water level in Pools ETAJ and ETAK.

7 Due to the nature of rock bar ETAS, Pool ETAS and Pool ETAT typically sit at the same level. The water level meter situated in Pool ETAT is considered to be representative of the water level in Pool ETAS.



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- 600 m from Longwalls 311-316 Secondary Extraction
- Existing Underground Access Drive (Main Drift)
- Gauging Station
- Pool Water Level Site

Source: Land and Property Information (2015); Date of Aerial Photography 1998; Department of Industry (2015); Metropolitan Coal (2023); MSEC (2024)

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Surface Water Quantity Sites

Figure 6

The key potential environmental consequences in relation to pool water levels and surface water flow included:

- Changes in stream flows as a result of fracturing of bedrock and the consequent diversion of a portion of the total stream flow as underflow. The effects of underflow would be localised to the subsidence affected reaches of streams. Underflows would be most noticeable during periods of low flow and would depend on the frequency of no flow periods, while the effects on the frequency and magnitude of high flows would be negligible.
- Changes in pool water levels and in-stream connectivity - underflow has been observed to result in lower water levels in pools as they become hydraulically connected with the fracture network. During prolonged dry periods when flows recede to low levels, the number of instances where loss of flow continuity between pools occurs increases with a greater proportion of the flow being conveyed entirely in the subsurface fracture network.
- Negligible impacts on water quantity to the Woronora Reservoir.

Prior to the commencement of Longwall 20, the water levels in pools upstream of Flat Rock Crossing (i.e. Pools A to G) (Figure 5) on the Waratah Rivulet had been impacted by mine subsidence. Since the commencement of Longwall 20, two additional pools on the Waratah Rivulet have been impacted by mine subsidence (i.e. fallen below their cease to flow levels and not as a result of climatic conditions, namely, Pool G1 in March 2011 and Pool N in September 2012[8]) (Figure 5). To date, stream remediation activities on the Waratah Rivulet have been conducted by Metropolitan Coal at Pools A, F and G. Mining has not resulted in the diversion of flows or change to the natural drainage behaviour of pools downstream of the maingate of Longwall 23 (i.e. Pools P to W) (Figure 5).

In 2021, Hydro Engineering & Consulting (2021) assessed the effectiveness of pool remediation measures for restoring the water holding capacity of pools on the Waratah Rivulet. Hydro Engineering & Consulting (2021) found that for Pools G1 and N, the water level recessionary behaviour post-remediation was consistent with pre-impact behaviour, and that for Pools B, C, E, F and G, water levels during low flow conditions were consistent with the water levels of similar, un-impacted pools. For Pool A, recorded water levels during low flow conditions were not consistent with the water levels of similar, unimpacted pools.

Since 2012, sections of Tributary B have been mostly dry (in the vicinity of site RTP1) (Figure 6) with no surface flow. Pool RTP2 on Tributary B regularly falls below its cease to flow level, however generally overflows during and following rainfall events.

Up until December 2016, the water levels/drainage behaviour of pools on the Eastern Tributary between the full supply level of the Woronora Reservoir and the Longwall 26 maingate were consistent with predictions. In the Longwalls 20-22 Extraction Plan Subsidence Assessment, it was recognised that fracturing resulting in surface flow diversion could be observed at a site where the predicted total closure is less than 200 mm, although none had been observed to date. The report also noted that reference to the 200 mm predicted total closure value should be viewed as an indication of low probability (10 percent [%]) of impact rather than certainty. In the Longwalls 23-27 Extraction Plan Subsidence Assessment, additional case studies were added to the pool impact model, including cases where loss of pool water levels had occurred at less than 200 mm predicted total closure. Similar to the previous database for Longwalls 20-22, the updated database showed that based on a maximum predicted total closure of 200 mm, the proportion of pools that experienced loss of pool water levels was around 10%.

8 To date (September 2023), Pool N has overflowed its rock bar since December 2014, with the exception of relatively short periods. Pools on the Woronora River also stopped flowing within the same periods. Monitoring of Pool N will continue to be conducted.

In December 2016 and January 2017, a number of pools on the Eastern Tributary with predicted closure values of less than 200 mm experienced loss of pool water levels. This resulted in the exceedance of the negligible environmental consequences performance measure for the Eastern Tributary in relation to diversion of flows and drainage behaviour (Eastern Tributary Incident). Downstream of the Longwall 26 maingate, mine subsidence has resulted in the diversion of flows or change to the natural drainage behaviour of Pools ETAG to ETAR (Figure 5). Mining has not resulted in the diversion of flows or change to the natural drainage behaviour of Pools ETAS, ETAT and ETAU (Figure 5).

The Longwalls 303, 304 and 305-307 Eastern Tributary Valley Closure TARPs were designed to minimise the risk that mining of Longwalls 303, 304 and 305-307 would result in the exceedance of the Eastern Tributary performance measure, being negligible environmental consequences. Consistent with the TARP, the decision to cease mining of Longwall 303, 304 and 305 was made at a very low magnitude of valley closure. High accuracy closure measurements taken directly on the rock bar or valley floor demonstrated that total rock bar closure was less than 2 mm throughout the mining process and strains on the rock bar were less than 0.5 millimetres per metre (mm/m), (i.e. in the order of survey accuracy). The Eastern Tributary Valley Closure TARP has been successfully implemented by Metropolitan Coal for Longwalls 303, 304 and 305.

The Waratah Rivulet Valley Closure TARP was designed to minimise the risk that the mining of Longwalls 308-310 would result in exceedance of the Waratah Rivulet Exceedance Measure, being negligible environmental consequences. The intent of the Waratah Rivulet Valley Closure TARP is to identify the initial development of valley closure prior to an impact occurring. The adaptive management approach is based on Metropolitan Coal conducting GNSS monitoring of the Waratah Rivulet to detect mining-induced effects and ceasing mining prior unacceptable or adverse impacts on the Waratah Rivulet. The monitoring provides the earliest possible indicator for development of valley closure. The development of valley closure is recognised as the dominant mechanism that results in impact to a rock bar.

Woronora Reservoir Inflows

For the Project EA, a comprehensive analysis of stream flow data and data on the yield behaviour of Woronora Reservoir indicated that past mining at Metropolitan Coal had no discernible effect on the inflow to, or yield from, the reservoir.

Surface water flow monitoring has been conducted at the Waratah Rivulet, Woronora River and O'Hares Creek gauging stations since the commencement of Longwall 20 in 2010 (Figure 6). As documented in the original model in the Project EA, the Waratah Rivulet catchment model is capable of reliably identifying a loss of 1 megalitre per day (ML/day). One (1) ML/day meets the definition of 'negligible' (being small and unimportant, such as not to be worth considering) on the basis that it is a small component of overall inflows – it represents about 1.4% of annual average inflow to the reservoir; and is small compared to changes in inflows caused by changes in climate and catchment conditions. It is also noted that 1 ML/day is well above the reduction in catchment yield that is actually predicted.

The surface water flow monitoring data obtained from the Eastern Tributary gauging station has also been assessed. The results indicate that flow at the Eastern Tributary gauging station has been continuous and that it has been generally consistent with, or above, model predictions. This indicates that flows reaching the Woronora Reservoir have not been reduced by mining.

Surface water flow monitoring indicates there is no evidence of a loss of flow from the Waratah Rivulet or Eastern Tributary reaching the Woronora Reservoir.

The gauging stations installed in sub-catchments I and K as a component of the Woronora Reservoir Impact Strategy are discussed in Section 4.1.3.

Gauging stations have also been installed immediately downstream of Swamp 76 (Swamp 76 Flume) and Swamp 92 (Swamp 92 Flume). The gauging stations were installed in November 2020 to enable record of baseline flow data prior to the commencement of mining of Longwalls 311-316. The gauging station data would be analysed post commencement of mining of Longwalls 311-316 to aid in the assessment of potential impacts to Swamp 76 and Swamp 92.

Iron Staining

Hawkesbury Sandstone is the main geological feature of the Woronora River catchment within the Woronora Plateau (The University of Queensland, 2016a). The sandstone is held together by cements, most commonly carbonate, which contains iron (The University of Queensland, 2016a). Iron staining occurs naturally in the Waratah Rivulet and Eastern Tributary and other streams on the Woronora Plateau.

As described in the Southern Coalfield Panel Report (Department of Planning, 2008) and the NSW Planning Assessment Commission's Report for the Metropolitan Coal Project (NSW Planning Assessment Commission, 2009), under certain conditions, the cracking of stream beds and underlying strata has the potential to result in changes in water quality, particularly ferruginous springs and/or development of iron bacterial mats. Experience at Metropolitan Coal prior to Project Approval indicated that areas of the substratum can be covered by iron flocculent material for several hundred metres downstream of mine subsidence fractures.

Metropolitan Coal has monitored the extent of iron staining through visual and photographic surveys and assessed the extent of iron staining against the subsidence impact performance measures as follows:

- Negligible environmental consequences (that is, no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining, and minimal gas releases) on the Waratah Rivulet between the full supply level of the Woronora Reservoir and the maingate of Longwall 23 (upstream of Pool P).
- Negligible environmental consequences over at least 70% of the stream length (that is, no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining, and minimal gas releases) on the Eastern Tributary between the full supply level of the Woronora Reservoir and the maingate of Longwall 26.

Monitoring to date indicates the subsidence impact performance measure in relation to iron staining has not been exceeded for the Waratah Rivulet.

In October 2016, Metropolitan Coal reported the exceedance of the *minimal iron staining* component of the Eastern Tributary performance measure (the Eastern Tributary Incident) to the Secretary of the Department of Planning, Industry and Environment (DPIE) and other relevant agencies in accordance with Condition 6, Schedule 7 of the Project Approval and the Metropolitan Coal Longwalls 23-27 Water Management Plan Contingency Plan. Inspection results of fresh iron staining/flocculent within the performance measure reach indicates the extent of iron staining/flocculent has varied over time since the exceedance (Metropolitan Coal, 2021).

The iron staining/flocculent is associated with Eastern Tributary water quality impacts, which have occurred in association with the exceedance of the Eastern Tributary watercourse performance measure. Reducing conditions (through water saturation excluding oxygen) has solubilised iron in the groundwater, which has been transferred to surface water through mine-induced cracking. The soluble iron (iron (II) ion, Fe^{2+}), rapidly oxidises to iron (III) Fe^{3+}, and forms insoluble hydrated ferric hydroxide in colloidal (< 0.45 micrometres [μm]) and particulate (> 0.45 μm) forms (The University of Queensland, 2018a). Iron oxidising bacteria can also create oxidised iron precipitate (National Health and Medical Research Council, 2011). The iron floc is a mixture of precipitated iron oxyhydroxide material >0.45 μm size and colloidal material which is < 0.45 μm size. The colloidal material coagulates to give the larger size precipitated material and coats the creek bed rock surfaces (The University of Queensland, 2018a). The iron oxyhydroxide gradually converts to goethite (Yee et al., 2006) which has a darker colour (a dark reddish-brown) and is commonly found in the creek sediment. Goethite staining occurs both naturally and commonly and can be seen in many similar watercourses throughout the Southern Coalfield (Department of Planning, 2009). It is anticipated that the stream remediation activities being conducted on the Eastern Tributary (Section 9.1) will reduce the transfer of iron from the groundwater to the Eastern Tributary.

Gas Releases

Prior to approval of the Project in 2009, no gas releases had been observed along the Waratah Rivulet, Eastern Tributary or other tributaries over the Metropolitan Coal lease, either before or during mining. Notwithstanding, the Project EA, Preferred Project Report and Metropolitan Coal Longwalls 20-22 Water Management Plan recognised there was the potential for gas releases to occur.

Gas releases (often sporadic) have since been observed on occasions over particular periods in Pools A, J, K, L, O, P, S, U and W on the Waratah Rivulet and Pools ETAG, ETAH, ETAI, ETAL and ETAM on the Eastern Tributary (Figure 5). Primarily, the two minor natural gas components that occur in gas releases from mine subsidence are carbon dioxide and methane. Assessments against the subsidence impact performance measure for negligible environmental consequence on the Waratah Rivulet and Eastern Tributary, *minimal gas releases*, to date indicate the performance measure has not been exceeded (Gilbert & Associates, 2014; The University of Queensland, 2014; 2016b; 2017; 2018b; 2018c, 2019a, 2020a – 2020d, 2021a – 2021e).

Changes in Bed Gradients, Scouring and Stream Alignment

The key potential subsidence impacts and environmental consequences in relation to bed gradients, scouring and stream alignment described in the Project EA, Preferred Project Report, and Metropolitan Coal Water Management Plans included:

- Potential changes in bed gradients could occur, however, were anticipated to be small relative to the existing grades.
- An increased potential for scouring of the stream bed and banks (at locations where the predicted tilts considerably increase the natural pre-mining stream gradients). The potential for scouring is greatest in stream sections with alluvial deposits. Since the streambed of the Waratah Rivulet and the Eastern Tributary is predominantly erosion-resistant Hawkesbury Sandstone, scouring was expected to be very low.
- Subsidence fracturing of bedrock has the potential to cause dislodgement of rock fragments during high flow events.
- The potential for changes to stream alignment as a result of mine subsidence effects was considered to be low.

- Minor stream bank erosion, where changes in channel gradients result in increases in flow energy. It would be expected that bank erosion would be relatively minor and comprise a slow retreat of the bank until a new dynamic equilibrium is reached.

The results of the stream inspections have generally been consistent with these predictions. On the Waratah Rivulet (in a section of the stream over Longwall 21) and Eastern Tributary (in a section of the stream over Longwalls 20 and 21) increased ponding from changes in bed gradients has previously resulted in the prolonged inundation of the adjacent riparian vegetation which has resulted in some vegetation dieback on a local scale.

Surface Water Quality

Subsidence impacts on water quality were predicted by the Project EA, Preferred Project Report, and Metropolitan Coal Water Management Plans to be similar to that previously observed at Metropolitan Coal, specifically, transient pulses of iron, manganese and to a lesser extent aluminium, which would likely occur following fresh cracking of the stream bed. Aluminium comes from erosion of rock material whereas iron and manganese arise from dissolution of minerals in sandstone via changes in redox conditions.

Surface water quality has been monitored at a number of sites on Waratah Rivulet, Tributary B, Tributary D, Eastern Tributary, Far Eastern Tributary, Tributary P, Tributary R, Honeysuckle Creek, Bee Creek and Woronora River. Recent trends in the monitoring data for key parameters (pH, electrical conductivity, dissolved iron, dissolved manganese and dissolved aluminium) at the sites listed in Table 2 have been summarised by Hydro Engineering & Consulting (2022). The water quality sites are shown on Figure 7.

Table 2
Stream Water Quality Monitoring Results

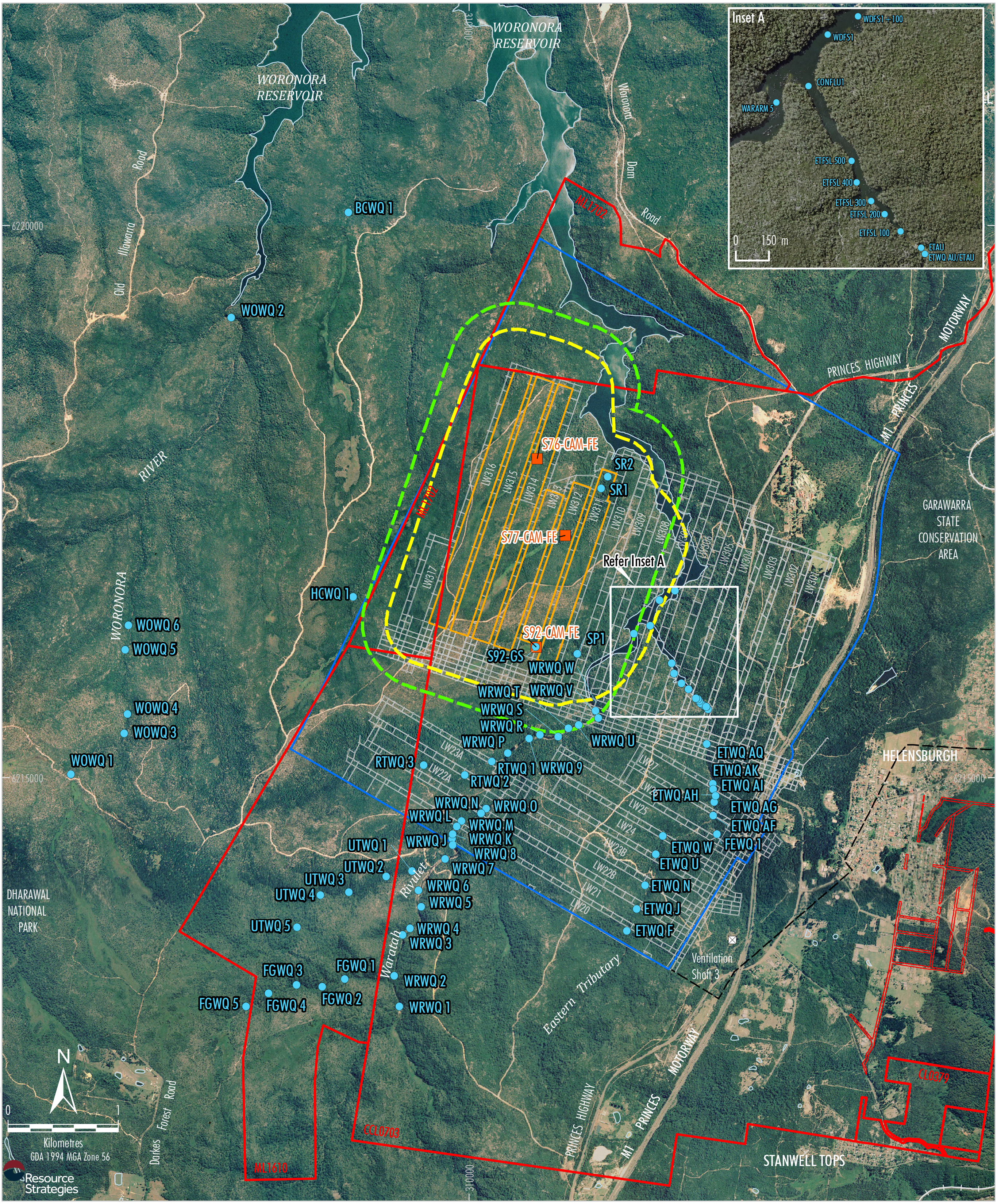
Stream	Monitoring Results to Date*
Waratah Rivulet (sites WRWQ 2, WRWQ 6, WRWQ 8, WRWQ 9, WRWQ M, WRWQ N, WRWQ P, WRWQ R, WRWQ T and WRWQ W)	• Water quality trends for the period of January to December 2022 were variable due to significant rainfall experienced in the first half of 2022, however, the range of constituent values recorded was generally within the range of historical records. • Upstream sites on Waratah Rivulet (sites WRWQ 2 and WRWQ 6) show slightly acidic to near neutral pH values with higher (slightly alkaline) values being recorded at lower to middle and lower reach sites (e.g. at sites WRWQ 8, WRWQ T and WRWQ W). • Electrical conductivity values were generally lower than historical values from January to June 2022 and within the range of historical values from July to December 2022. No historically high electrical conductivity values were recorded from January to December 2022. • Dissolved iron concentrations remained consistent with baseline values at all sites. • Historically high aluminium concentrations recorded at all upper and middle reach sites in May 2022 and at all lower reach sites in March and April 2022 except for WRWQ 9 and WRWQ W. In the second half of 2022, dissolved aluminium concentrations declined at all sites. • Dissolved manganese concentrations at the upper, middle and lower reach sites up to December 2022 have been generally consistent with previously recorded values (0.08 milligrams per litre [mg/L] to 0.30 mg/L). Historically high concentrations were recorded at WRWQ R, WRWQ T and WRWQ W in June 2022 although were less than 0.12 mg/L.

Table 2 (Continued)
Stream Water Quality Monitoring Results

Stream	Monitoring Results to Date*
Woronora River (control sites WOWQ 1[1] and WOWQ 2)	• The pH values recorded at sites on Woronora River have generally been variable, ranging from slightly acidic to slightly alkaline. Slightly acidic conditions were recorded for the period January to December 2022. • Electrical conductivity values at all sites were less than or within range of baseline conditions. Historically low values were recorded mid-2022. • Dissolved iron has been generally low, with concentrations recorded in 2022 within the range of baseline concentrations. • Dissolved manganese concentrations recorded at WOWQ 1 during 2022 were within the range of baseline values. Dissolved manganese concentrations recorded at WOWQ 2 during 2022 were slightly elevated however within the range of historical concentrations. • Dissolved aluminium concentrations recorded at WOWQ 1 during 2022 were within the range of baseline values. Dissolved aluminium concentrations recorded at WOWQ 2 during 2022 were variable however remained within the range of historical concentrations.
Eastern Tributary (sites ETWQ F, ETWQ J, ETWQ N, ETWQ U, ETWQ W, ETWQ AF, ETWQ AH, ETWQ AQ and ETWQ AU)	• The pH values recorded at sampling sites on Eastern Tributary indicate slightly acidic to near neutral pH conditions. • Electrical conductivity values were consistent with historical values during 2022. • Dissolved manganese concentrations were within the range of historical concentrations during 2022. • Dissolved iron concentrations at some Eastern Tributary sites were slightly elevated, however consistent with historical values. • Generally elevated and variable dissolved aluminium concentrations have been recorded at all sites since 2016, with historically high concentrations recorded at ETWQ F in April 2022 and ETWQ N, ETWQ AF and ETWQ AU in March 2022.
Western Tributaries of Woronora Reservoir (sites SP1, SR1 and SR2)	• The pH values recorded at sampling sites SP1, SR1 and SR2 indicate acidic to slightly acidic pH conditions. • Electrical conductivity values have been low, ranging between 68 and 200 microSiemens per centimetre (µS/cm). • Dissolved iron concentrations recorded during the baseline period have remained below 0.36 mg/L. • Dissolved manganese concentrations recorded during the baseline period have remained below 0.065 mg/L. • Dissolved aluminium concentrations recorded during the baseline period have remained below 0.16 mg/L.
Bee Creek, Honeysuckle Creek, Far Eastern Tributary, Tributary B and Tributary D (sites BCWQ 1, HCWQ 1, FEWQ 1, RTWQ 1, and UTWQ 1)	• Slightly acidic pH values have been recorded at sampling sites in Bee Creek and Honeysuckle Creek over the period of record. The pH records for Tributary D indicate slightly acidic to near neutral conditions while pH values recorded at Far Eastern Tributary and Tributary B have trended around pH 7 (near neutral). • Electrical conductivity values less than 600 µS/cm have been recorded at all sites over the period of record, with a generally declining trend in EC values recorded at the majority of sites since 2019. Elevated EC values were recorded at UTWQ 1 in early 2022 however remained below 500 µS/cm. • Dissolved iron concentrations of less than 1 mg/L have been recorded at the majority of sites since 2020. • Dissolved manganese concentrations have typically been low at all sites (less than 1 mg/L). • A decline in dissolved aluminium concentrations was recorded at HCWQ 1 and BCWQ 1 in 2022, in comparison to elevated concentrations recorded during periods of 2018, 2020 and 2021. A historically high dissolved aluminium concentration was recorded at FEWQ 1 in April 2022 although concentrations generally declined over the remainder of 2022.

* Monitoring results to date are up to and including December 2022.

Source: after Hydro Engineering & Consulting (2022).



MET-23-33 LW311-316 EP BMP_206B

LEGEND

- Mining Lease Boundary
- Railway
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 311-316 Secondary Extraction
- Longwalls 311-316 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 311-316 Secondary Extraction
- Existing Underground Access Drive (Main Drift)
- Surface Water Quality Site
- Proposed Iron Staining Camera

Source: Land and Property Information (2015); Date of Aerial Photography 1998; Department of Industry (2015); Metropolitan Coal (2023); MSEC (2024)

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Surface Water Quality Sites

Figure 7

The cracking and dilation of bedrock and associated diversion of surface flow and leakage of water through rock bars at pools which has occurred on the Eastern Tributary (including the reach associated with the exceedance of the Eastern Tributary watercourse performance measure) has resulted in impacts on water quality, in particular increases in dissolved manganese and at times iron. Reducing conditions (through water saturation excluding oxygen) has solubilised iron (and manganese) in the groundwater. The soluble iron and manganese has been transferred to surface water through mine-induced cracking, resulting in increases in iron and manganese concentrations in the Eastern Tributary. The soluble iron (iron (II) ion, Fe^{2+}), rapidly oxidises to iron (III) Fe^{3+}, and forms insoluble hydrated ferric hydroxide in colloidal (< 0.45 µm) and particulate (>0.45 µm) forms (The University of Queensland, 2018a). Manganese remains dissolved in the water column as oxidation at near-neutral pH is slow (Raveendran et al., 2001) and soluble manganese (II ion, Mn^{2+}) is the most stable species (Rayner-Canham, 1996) (The University of Queensland, 2018a). Low levels of manganese, e.g. < 0.1 mg/L exist in the natural creek water. Dissolved manganese is however readily diluted by freshwater flow to low levels when higher creek flows occur.

Assessment of the water quality monitoring results to date by Associate Professor Barry Noller (The University of Queensland, 2018a, 2018d – 2018l; 2019b – 2019d, 2020e – 2020l, 2021f – 2021l) indicate there has been a negligible reduction in the quality of water resources reaching the Woronora Reservoir. Notwithstanding, subsidence impacts on water quality will continue to be monitored. Metropolitan Coal is committed to the remediation of pools on the Eastern Tributary.

Woronora Reservoir Water Quality

The Project EA, Preferred Project Report, and Metropolitan Coal Water Management Plans predicted the Project would not impact on the performance of the Woronora Reservoir and would have a neutral effect on water quality. Water quality monitoring results to date are consistent with the predictions.

Metropolitan Coal sources water quality data for the Woronora Reservoir from WaterNSW in accordance with a data exchange agreement and analyses data for total iron, total aluminium and total manganese from 0 m to 9 m below the reservoir surface.

Since early to mid-2020, an increasing trend in total iron, total aluminium and total manganese has been recorded at sampling location DW01. Similar intermittent increases in the concentrations of iron, aluminium and manganese in the Woronora Reservoir are evident over the period of record, including during the baseline period prior to the start of Longwall 20. The intermittent increases in the concentrations of these constituents are considered related to above average rainfall conditions occurring during these periods.

While there was a more rapid increase in total aluminium in early 2020, recorded concentrations have remained consistent since then. It is noteworthy that similar intermittent increases in concentrations of iron, aluminium and manganese in the Woronora Reservoir are evident over the period of record, including during the baseline period prior to the start of Longwall 20.

The water quality monitoring results to date are consistent with the predictions and indicate there has been a negligible reduction in the water quality of Woronora Reservoir.

4.1.2 Groundwater

The conceptual hydrogeological model supports three distinct groundwater systems, including:

- Perched groundwater system – generally above and independent of the regional groundwater table (typically less than 20 m below the ground surface). Excess rainfall produces a permanent perched water table within swamp sediments and outcropping sandstone that is independent of the regional water table in the Hawkesbury Sandstone. As the swamps are essentially rain-fed, water levels within upland swamps fluctuate seasonally with climatic conditions.
- Shallow groundwater system – the shallow groundwater system (extending typically to less than 100 m below the ground surface) defines a regional water table and is separate from the overlying perched groundwater system.
- Deep groundwater system – although the shallow and deep groundwater systems are connected, low permeability of the Bald Hill Claystone provides a degree of isolation between the Hawkesbury Sandstone (Figure 8) that hosts shallow groundwater and the underlying Bulgo Sandstone and deeper formations that host deep groundwater. The deep groundwater system is typically more than 100 m below the ground surface.

Recharge to the groundwater system is from rainfall and from lateral groundwater flow. Although groundwater levels are sustained by rainfall infiltration, they are controlled by ground surface topography and surface water levels. A local groundwater mound develops beneath elevated sandstone that ultimately discharges to creeks and waterbodies. Loss by evapotranspiration through vegetation where the water table is within a few metres of the ground surface occurs within upland swamps and outcropping sandstone.

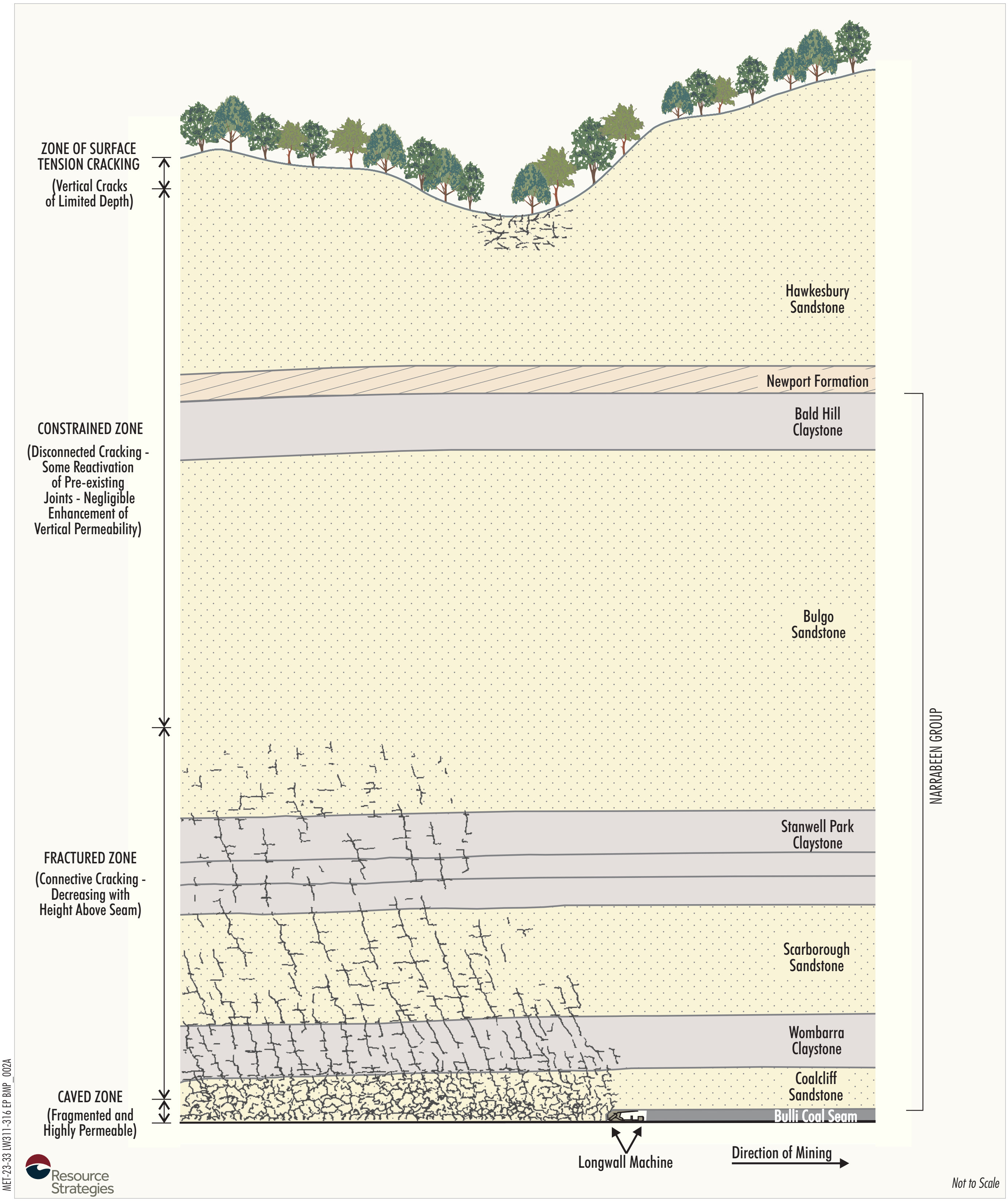
The only recognised economic aquifer in the area is the Hawkesbury Sandstone. The Hawkesbury Sandstone is a low yield aquifer of generally good quality beneath the Woronora Plateau and the Illawarra Plateau. Review of the WaterNSW 'Real-time Data' database (September 2023) indicates no privately owned registered bores, other than those registered by Metropolitan Coal, are located in the vicinity of the 300 series longwalls.

Groundwater Model

A tabulated list of groundwater models developed and used for the Project by HydroAlgorithmics and SLR Consulting is provided in Table 3.

A three-dimensional numerical model of groundwater flow was developed in 2008 for the Project EA. The groundwater model was recalibrated in December 2012 for the Preferred Project Layout by revising the hydraulic conductivities in the Hawkesbury Sandstone and the Bald Hill Claystone. At this time, two extra layers were added to the Hawkesbury Sandstone section to improve resolution of the vertical hydraulic gradient in the shallow groundwater system. The model simulations were based on initial conditions at the end of Longwall 14, consistent with the Project EA assessment (Heritage Computing, 2008). Model outputs have been examined every six months for review of environmental performance.

Transient calibration was undertaken in 2018 to incorporate Metropolitan Coal updates to the geological model. The previously revised model included an update of the topographical surface and geological interfaces, the addition of two model layers below the Bulli Seam and updated estimates of the fractured zone height. A report for the previously revised model was prepared (HydroSimulations, 2018), which was used for the assessment of the Longwall 304 and Longwalls 305-307 Extraction Plans.



Source: After Geosensing Solutions (2008); Heritage Consulting (2008)

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Schematic - Longwall Mining and Subsidence Profile

Figure 8

Table 3
Groundwater Model Tabulation

Date	Groundwater Model	Purpose
2008	MODFLOW 3D [13 layers]	Groundwater assessment of Longwalls 20-44 for the Project EA. Steady-state calibration.
2009	MODFLOW-SURFACT [13 layers]	Recalibration of the regional groundwater model prepared for Longwalls 20 to 44 with advanced software; high-inflow and low-inflow model versions.
2009	MODFLOW-SURFACT [13 layers]	Post-audit of the 3D groundwater model confirmed model performance at three new deep bores.
2012	MODFLOW-SURFACT [15 layers]	Recalibration of Hawkesbury Sandstone vertical head gradients and the addition of two extra layers to the Hawkesbury Sandstone section to improve resolution of the vertical hydraulic gradient in the shallow groundwater system.
2018	MODFLOW-SURFACT [17 layers]	Revised model, which includes an update of the topographical surface and geological interfaces, the addition of two model layers below the Bulli seam and updated estimates of the fractured zone height. Transient calibration.
2020	MODFLOW-USG [17 layers]	Revised model, including the implementation of 'stacked drains' in the groundwater model. Recalibration.

In 2020, and consistent with the recommendations of the Woronora Reservoir Impact Strategy (WRIS) Panel Stage 2 Report (Hebblewhite et al., 2019), the groundwater model was updated to include the incorporation of 'stacked drains' to represent the fractured zone instead of using enhanced hydraulic conductivity and storage properties. A calibration report for the updated model was prepared by SLR Consulting (2020), which has been used for the assessment of Longwalls 301-310 and Longwalls 311-316.

In December 2020, Metropolitan Coal commissioned Dr Justin Bell (JBS&G) to undertake a peer review of the calibration report for the updated model (SLR Consulting, 2020). Although the peer review was focussed around the incorporation of stacked drains, Dr Bell reviewed the complete groundwater model as described in the calibration report. Dr Bell concluded that "*the current approach to the groundwater model is 'fit-for-purpose', as per the definition of the NSW Aquifer Interference Policy"*.

Perched Groundwater Systems (Upland Swamps)

The key potential subsidence impacts and environmental consequences on perched groundwater systems described in the Project EA, Preferred Project Report, and Metropolitan Coal Water Management Plans and BMPs, included:

- Any cracking of the bedrock within upland swamps was expected to be isolated and of a minor nature, due to the relatively low magnitudes of the predicted strains and the relatively high depths of cover.
- Surface cracking resulting from mine subsidence within the upland swamps was not expected to result in an increase in the vertical movement of water from the perched water table into the regional aquifer as the sandstone bedrock is massive in structure and permeability decreases with depth.
- It was expected that any surface cracking that may occur would be superficial in nature (i.e. would be relatively shallow) and would terminate within the unsaturated part of the low permeability sandstone. Any changes in swamp water levels as a result of cracking were expected to be unmeasurable when compared to the scale of seasonal and even individual rainfall event-based changes in swamp groundwater levels.

- Whilst swamp grades vary naturally, the predicted maximum mining-induced tilts were generally orders of magnitude lower than the existing natural grades within the swamps. The predicted tilts would not have any significant effect on the localised or overall gradient of the swamps or the flow of water. Any minor mining-induced tilting of the scale and nature predicted was not expected to significantly increase lateral surface water movements which are small in relation to the other components in the swamp water balance.

No changes to the fundamental surface hydrological processes and upland swamp vegetation were expected within upland swamps.

In relation to impacts of the Project on upland swamps, the NSW Planning Assessment Commission (2009) concluded that the mining parameters were such that:

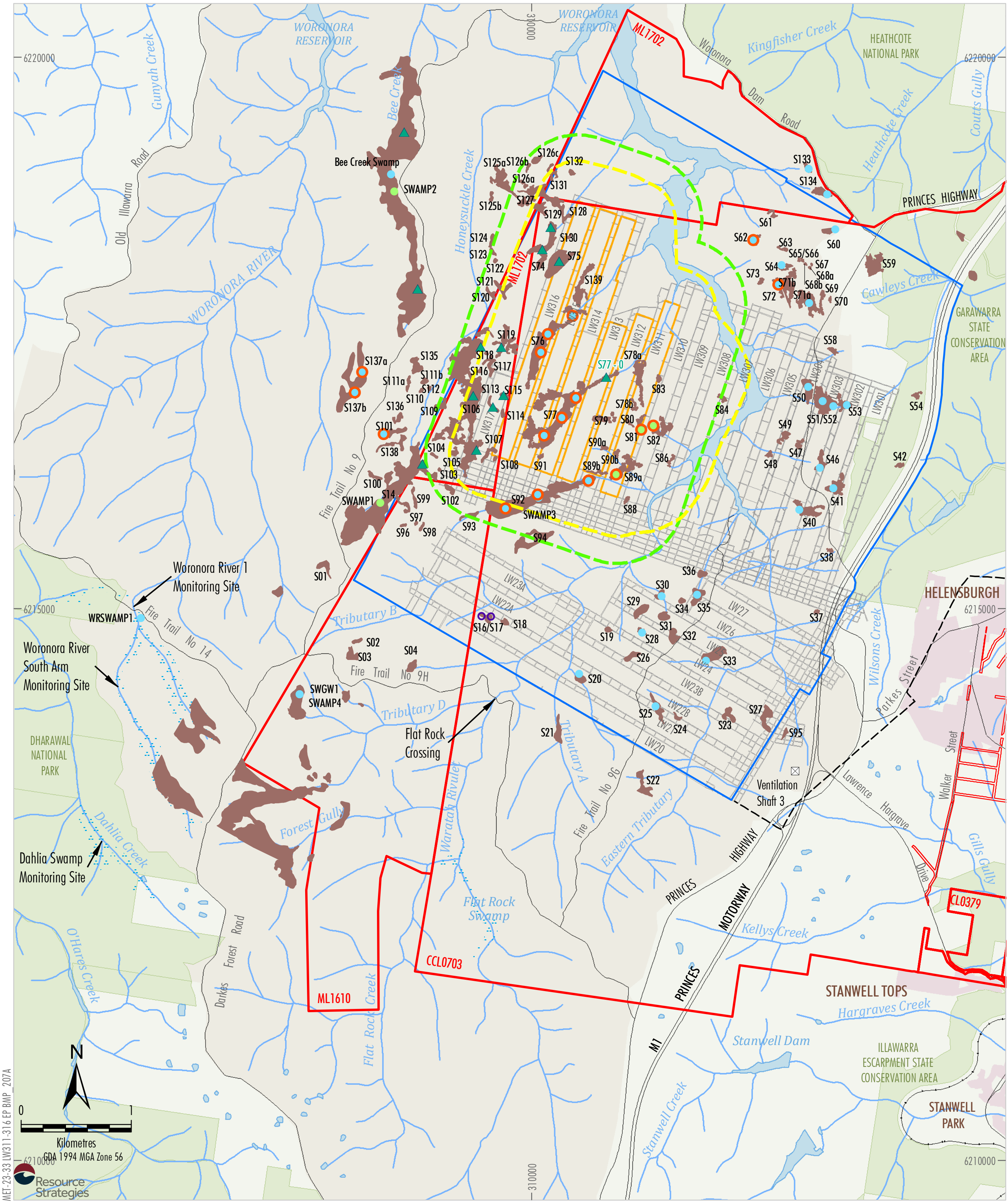
- for most swamps in the Project Area, there was a low risk of negative environmental consequences; and
- that there was a very low risk that a significant number of swamps would suffer such consequences.

Groundwater monitoring of upland swamps has involved the use, where practicable, of paired piezometers, one swamp substrate piezometer (at approximately 1 m depth) and one sandstone piezometer (at a depth of approximately 10 m) (Figure 9). Specifically, paired piezometers have been monitored in Swamps 20 and 25 overlying Longwalls 20-22, Swamps 28, 30, 33 and 35 overlying Longwalls 23-27, Swamps 40, 41, 46, 51, 52 and 53 overlying Longwalls 301-303, Swamp 50 overlying Longwall 304, Swamps 71a and 72 adjacent to Longwalls 305-307, Swamps 62, 64, 82 and 92 adjacent to Longwalls 308-310 and in control Swamps 101, 137a, 137b, Woronora River Swamp 1 and Bee Creek Swamp (Figure 9). At Swamp 20 and control swamp Woronora River Swamp 1, multiple piezometers have been monitored (i.e. one swamp substrate piezometer to a depth of approximately 1 m and two sandstone piezometers to depths of approximately 4 m and 10 m) (Figure 9).

The swamp substrate piezometer represents water levels within the swamp sediments, and the piezometer at approximate depths of 4 m and 10 m allows comparison with the shallow water table in the Hawkesbury Sandstone. Data shows that water levels within the swamps over longwalls are typically perched above those of the local Hawkesbury sandstone groundwater levels and indicates a separate control on swamp water levels. That is, the swamps are primarily surface water fed systems and generally water infiltrates downwards from the swamps to the groundwater.

The substrate water levels in Swamp 20 changed from being permanently saturated to being periodically saturated as a result of the passing of Longwall 21 (Chart 1) (SLR Consulting, 2021). There is a very strong correlation with rainfall trend at Swamp 20 and control swamp Woronora River Swamp 1 over the period of record. As the rate of decline in the two piezometers is similar from 2013, but different in 2012, it is considered that Longwall 21 caused a mining effect at Swamp 20, but the effects were not exacerbated by Longwalls 22-27 (SLR Consulting, 2021).

A mining effect to the substrate water levels of Swamp 28 (overlying Longwall 24) was identified in 2016 based on the incomplete recovery of substrate water levels following rainfall events (Chart 2) (SLR Consulting, 2021). Swamp 28 is considered to have had an impact from mining of Longwall 25, although no effect on swamp substrate water levels occurred when Longwall 24 passed directly beneath the monitoring site (SLR Consulting, 2021).



LEGEND

- Mining Lease Boundary
- Woronora Special Area
- Railway
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 311-316 Secondary Extraction
- Longwalls 311-316 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 311-316 Secondary Extraction
- Existing Underground Access Drive (Main Drift)
- Upland Swamp
- Swamp Substrate and Shallow Groundwater Piezometer
- Swamp Substrate Groundwater Piezometer
- Swamp Shallow Groundwater Piezometer
- Swamp Soil Moisture Probe
- Proposed Future Monitoring Sites

Source: Land and Property Information (2015); Department of Industry (2015); Metropolitan Coal (2023); MSEC (2024); after NPWS (2003), Bangalay Botanical Surveys (2008); Eco Logical Australia (2015; 2016; 2018) and Ecoplanning (2021; 2023)

Note: Shallow Groundwater Piezometers at swamp monitoring site 92-1 is planned for installation by November 2024. Installation would be subject to suitable weather conditions and access to the Woronora Special Area. The future monitoring site locations in Bee Creek are indicative only and subject to change based on site access and swamp field investigations.

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Upland Swamps Groundwater Piezometer Locations

Figure 9

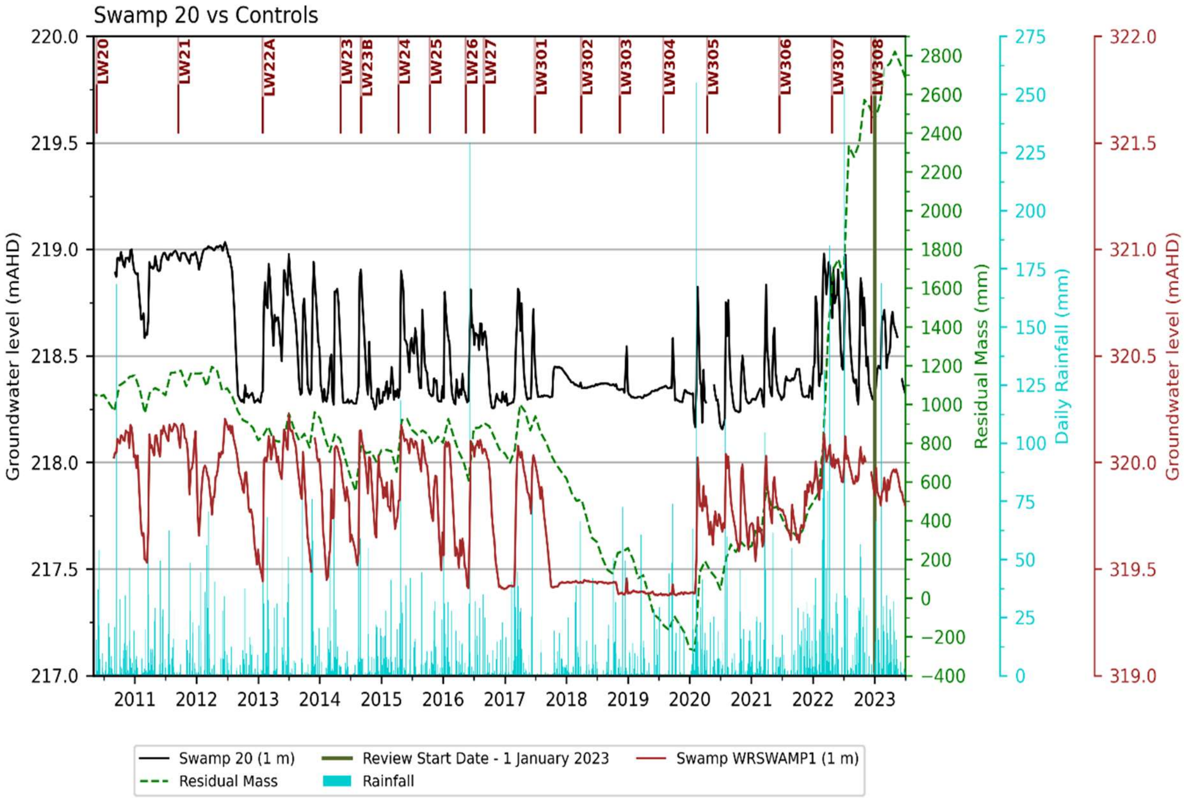

Chart 1 Comparison of Piezometer Responses at Swamp 20 and Woronora River 1 Control Swamp

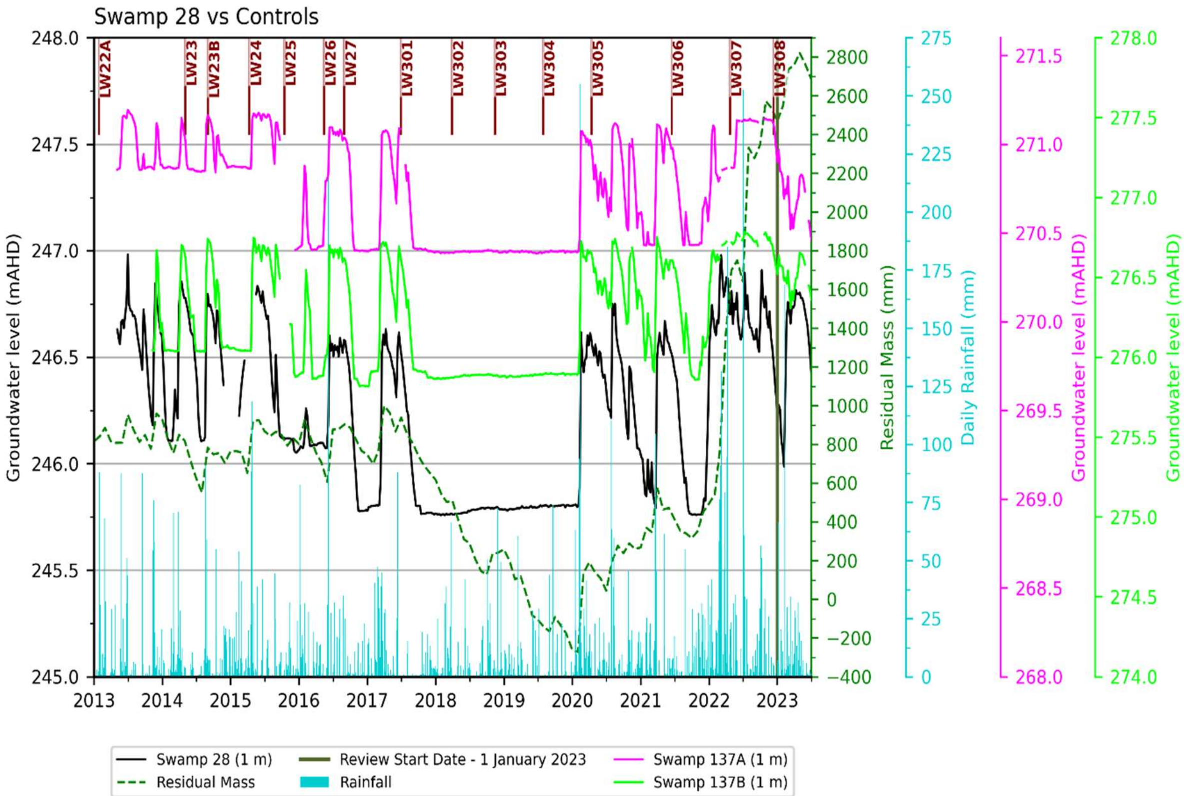

Chart 2 Groundwater Hydrographs at Swamp 28 and Two Control Swamps (137a and 137b)

Analysis of the swamp substrate water levels of Swamps 25, 30, 33, 35, 40, 41, 46, 50, 51, 52, 53, 71a and 72, including comparisons with control swamps and rainfall records, have indicated the drop in swamp water levels (below sensor level) recorded in the swamps that prevailed up to early 2020 were a natural response to reduced rainfall (SLR Consulting, 2021). It should be noted that piezometers measure only free water within swamps substrates and not bound water such as that which occurs within peat.

While the free water lost from Swamp 20 and Swamp 28 was retained in the unsaturated sandstone above the regional water table, the changes in swamp water levels as a result of cracking are measurable when compared to seasonal individual rainfall event-based changes in swamp groundwater levels. There is currently no sign that the vegetation in Swamp 20 is being impacted by the changed hydrological conditions. The vegetation monitoring results from autumn 2017 to autumn 2019 suggest the changes in vegetation occurring in Swamp 28 are significantly different from changes in the control swamps (Eco Logical Australia [Eco Logical], 2018a, 2018b, 2019a, 2019b, 2020a). In spring 2019, the declining trend in the vegetation condition at Swamp 28 stabilised and has remained stable to date (Eco Logical, 2020b, 2021a, 2021b, 2022a, 2022b, 2023).

No adverse impact has been observed on threatened vertebrate species that potentially could be present in swamps, particularly threatened amphibian species. However, since bound water is not currently being measured at these sites, potential adverse impacts on species using swamp substrates cannot be determined.

Consistent with the recommendations of Hydro Engineering & Consulting (2024), flow measuring flumes were installed immediately downstream of Swamps 76 (Swamp 76 Flume) and Swamp 92 (Swamp 92 Flume) in November 2020.

Shallow Groundwater Systems and Inflows to the Woronora Reservoir

The key potential subsidence impacts and environmental consequences on shallow groundwater systems and inflows to the Woronora Reservoir described in the Project EA, Preferred Project Report, and Metropolitan Coal Water Management Plans included:

- Permanent mining-induced changes in the groundwater levels of shallow aquifers in connection with streams and ecosystems at Metropolitan Coal would not occur to any significant degree (i.e. the direction of shallow groundwater system flow [i.e. in the Hawkesbury Sandstone] would not be altered by mining).
- As there is an alternation of thick sandstone/claystone lithologies, there is a constrained zone in the overburden that remains rigid and acts as a barrier which isolates shallow and deep aquifers. At the substantial depths of cover of the Project, there would not be connective cracking from the mined seam to the surface.
- The depressurisation effects described below for the deep groundwater system would not propagate to the Hawkesbury Sandstone where the shallow groundwater system is located. As a result, no measurable impacts on registered bores in the wider Project area and surrounds would be expected.
- There would be negligible loss of groundwater yield to the Woronora Reservoir since groundwater modelling indicated negligible reduction in cumulative average inflows to the Woronora Reservoir. In relation to the potential loss of catchment yield, the NSW Planning Assessment Commission (2009) was of the view that the risk of any significant loss is very low unless a major geological discontinuity is encountered during mining that might provide a direct hydraulic connection between the surface and the mine workings.
- Local surface water quality impacts are expected as a result of enhanced groundwater – surface water interactions (as described for surface water quality above).

The shallow groundwater monitoring results to date are considered to be consistent with the potential subsidence impacts and environmental consequences described in the Project EA, Preferred Project Report, and Metropolitan Coal Water Management Plans.

Depressurisation of the Deep Groundwater System

Immediately above a mined coal seam, rocks collapse into the void created by the removal of coal to form a caved zone and a fractured zone develops above the caved zone (Figure 8). This causes aquifer properties to change (e.g. permeability and porosity) and results in a higher vertical permeability as a result of mining, with some increase also in horizontal permeability over the dimension of a longwall panel.

The key potential subsidence impacts and environmental consequences on the deep groundwater system described in the Project EA, Preferred Project Report, and Metropolitan Coal Water Management Plans, included:

- Based on experience at Metropolitan Coal, substantial depressurisation of the deep aquifers in the fractured zone above the goaf is restricted to a height of less than about 130 m from the top of the goaf, while transient pressure effects have been observed to propagate to a height of about 300 m above the goaf. That is, there is a pronounced increase in vertical hydraulic gradient in the deep groundwater system over the Metropolitan Coal longwalls.
- Above goaf zones there would be substantial changes in fracture porosity and permeability, due to opening up of existing joints, new fractures and bed separation. Permeability increases would have accompanying reductions in lateral hydraulic gradients, with associated changes in groundwater levels and pressures. Pronounced changes in groundwater levels can occur without any significant drainage into a mine, particularly from the less permeable Narrabeen Group sandstones.
- Groundwater discharge to the mined seam would occur from above and below the seam in proportion to local permeabilities. Based on earlier modelling, the water make (i.e. groundwater inflow) was predicted to be in the order of 0.1 ML/day for Longwalls 20-27 and from 0.045 to 0.6 ML/day for Longwalls 301-303. Modelling indicated that the inflow could be up to 0.5 ML/day from the deep groundwater system during mining of Longwall 24 and up to 0.6 ML/day during the mining of Longwall 302[9]. The 2018 groundwater model predicted that inflow for Longwalls 305-307 would be approximately 0.02 ML/day to approximately 0.24 ML/day at the end of Longwall 307[10].
- Due to the substantial depths of cover at the Project, there would not be connective fracturing from the mined seam to the surface. Groundwater modelling for the Project indicates that there is expected to be eventual recovery of deep groundwater system pressures over many decades following the cessation of mining.

The NSW Planning Assessment Commission (2009) concluded that given the considerable depth of mining and the restricted panel width in the Project area, in the absence of geological structures such as faults and igneous intrusions (sills, dykes and diatremes), there was a very high probability that a constrained zone would be associated with the mine layout proposed over the Project area, thereby preventing direct hydraulic connections between mine workings and surface water bodies.

9 Modelling and assessments conducted for Longwalls 20-27 and Longwalls 301-303 were documented in the Metropolitan Coal Longwalls 20-22, 23-27 and 301-303 Extraction Plans.

10 Modelling and assessments conducted for Longwalls 301-307 were documented in the Metropolitan Coal Longwalls 305-307 Extraction Plan.

Previously, two goaf holes drilled at Metropolitan Coal informed the height of connective fracturing (both holes indicating the height is less than 130 m from the top of the goaf). Comparisons of calculated fracture heights using the Ditton model and the Tammetta model have both supported the uppermost fractured layer that has been adopted in previous groundwater modelling for Metropolitan Coal. The Metropolitan Coal longwall widths (narrower than typical Southern Coalfield longwalls), substantial depths of cover (compared to other Southern Coalfield mines) and the alternation of thick sandstone/claystone lithologies, would result in a constrained zone in the overburden that remains rigid and acts as a bridge which isolates shallow and deep aquifers.

Metropolitan Coal conducts weekly inspections of development workings for water accumulation. The mine inspections have not identified any unusual water flows from the goaf, geological structures, or strata generally either prior to, or since, the commencement of Longwall 20.

Multiple structures have been intersected by development workings that are coincident with the Woronora Reservoir directly above the maingates of Longwall 305 (F0027, F0030), Longwall 306 (F0036, F0037), and Longwall 307 and 308 (F0037). These structures were dry at the time of intersection and have continued to remain dry during regular inspections conducted as part of the underground inspection program. Longwall 306, Longwall 307, and Longwall 308 have extracted through F0037 which lies directly beneath the reservoir. Inspections of the F0037 structure both during development and during longwall extraction found that it continued to remain dry. Similar to previously encountered structures, changes to the hydraulic conductivities of F0008, F002. F0027, and F0037 as a result of mining are considered highly unlikely.

Monitoring of the mine water balance (mine water make) is calculated from the difference between total mine inflows and total mine outflows. Given the large fluctuations in daily water usage and the cycle period for water entering the mine and for assessment of environmental performance of the mine, a 20 day average is used by Metropolitan Coal to provide a more reliable estimate of water make. The 20 day average daily mine water make has been below 0.5 ML/day (Charts 3a and 3b). The increased water make during the period April 2011 to July 2011 (Chart 3a) was a result of dewatering of old workings in advance of the 200 Mains Panel (Metropolitan Coal, 2011). From 2 January 2009 to 31 August 2023, the mine water make has averaged 0.02 ML/day, which is less than that predicted by groundwater modelling for the Project. The monitoring results are consistent with the predictions for mine water make.

Continuous groundwater level/pressure monitoring has been conducted at bores 9HGW0 (Longwall 10 post-mining), 9EGW1B, 9FGW1A, 9GGW1-3, 9GGW1-80, 9GGW2B, 9HGW1B, PM02, PM01 (9DGW1B), 9EGW2A[11], 9EGW2-4, PM03, PHGW1B, PHGW2A, 302GW01, TBS02, TBS03, LW305GW (Longwall 305 post-mining), F6GW3A and F6GW4A in accordance with the Metropolitan Coal Water Management Plans. The monitoring results indicate that a hydraulic gradient has been maintained between bores and the floor levels of the nearest streams and a hydraulic gradient exists from bores to the Woronora Reservoir at the level of the regional water table. The monitoring results also support the assessment of no connective cracking between the surface and the mine. The results of the additional groundwater monitoring conducted as a component of the Woronora Reservoir Impact Strategy are discussed in Section 4.1.3.

11 Multi-level piezometer site 9EGW2A experienced failure of some lower level instrumentation. An additional hole was drilled adjacent to 9EGW2A (bore 9EGW2-4) to a depth of 557 m to install new piezometers at the same levels as the failed piezometers in December 2017.

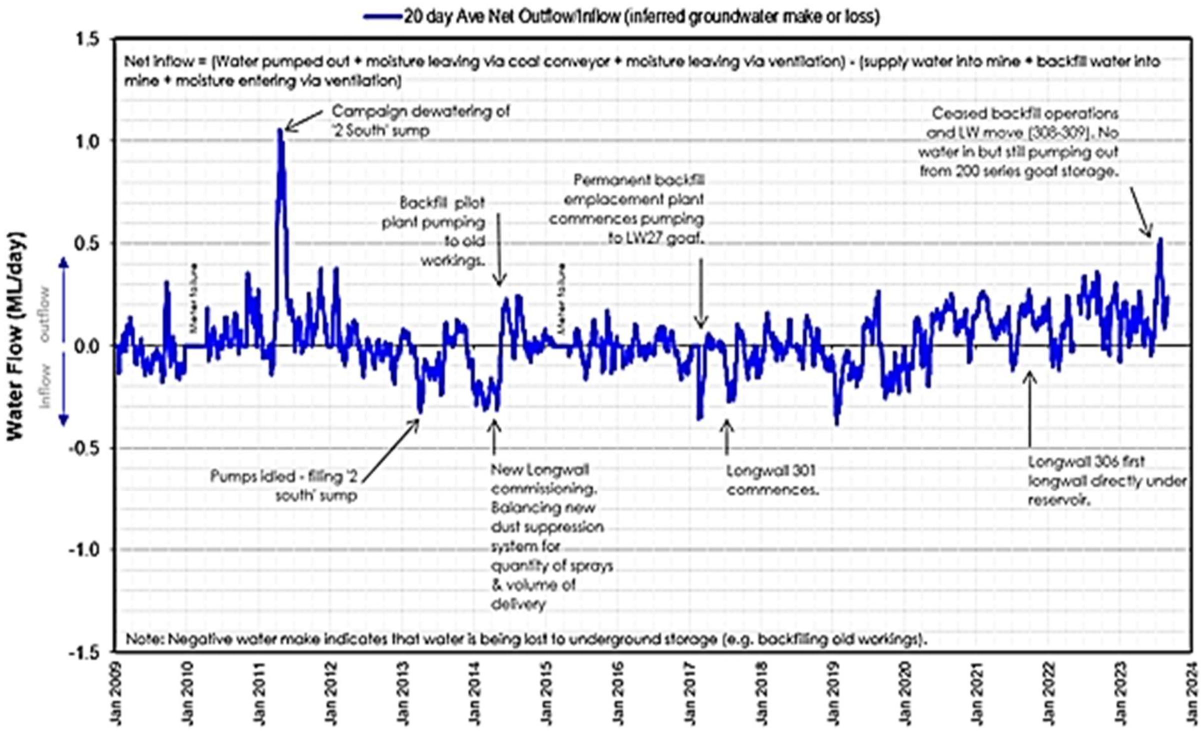

Chart 3a Estimated Daily Mine Water Make, 2009 to August 2023

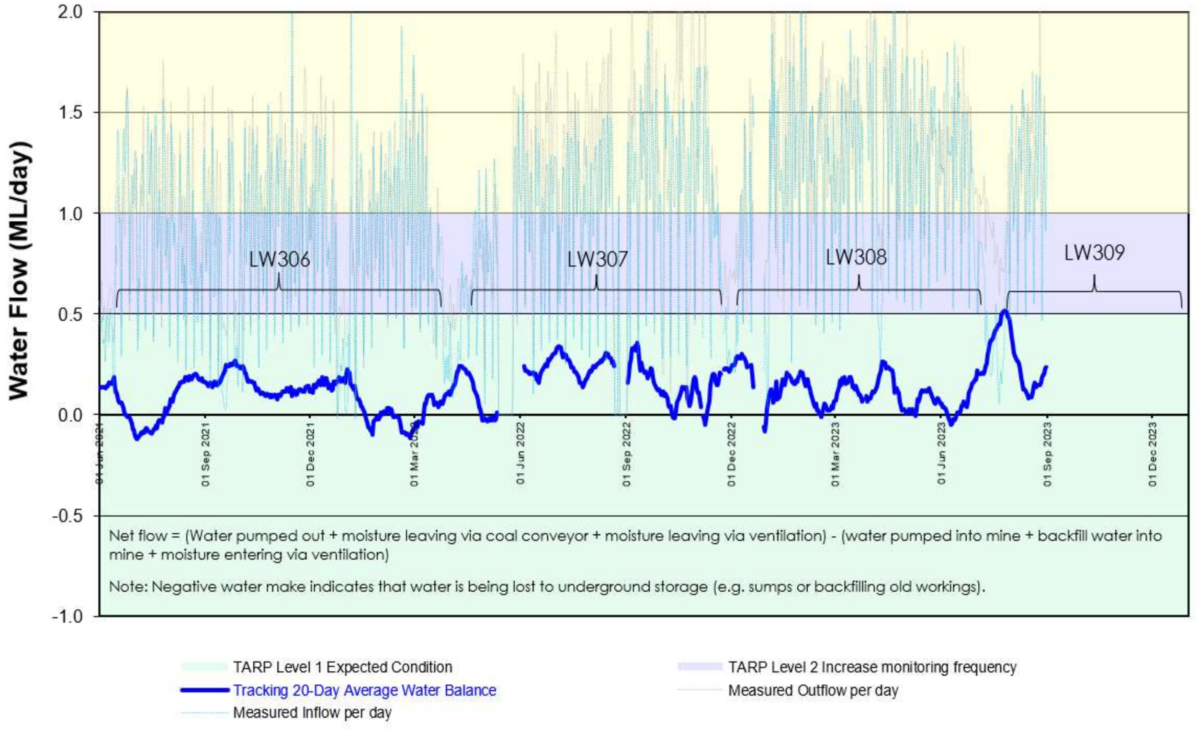

Chart 3b Estimated Daily Mine Water Make, January 2020 to August 2023

In accordance with the Dams Safety NSW prior Approvals for mining within the Woronora Reservoir Notification Area[12], Metropolitan Coal has undertaken sampling programs to investigate the properties of groundwater above and below the Hawkesbury Sandstone and to establish chemical signatures that would indicate mining-induced fracturing through the Bald Hill Claystone, should it occur. The data analysis (to June 2023) shows through statistics, trend diagrams (Piper), time-series plots and ratio plots that although a few sampling sites were grout-impacted, there are sufficient reliable data to show a clear distinction between groundwaters in the upper Hawkesbury Sandstone, lower Hawkesbury Sandstone and upper Bulgo Sandstone, and that there is no evidence of mining-induced leakage across the Bald Hill Claystone.

The groundwater monitoring results are considered to be consistent with the potential subsidence impacts and environmental consequences described in the Project EA, Preferred Project Report, and Metropolitan Coal Water Management Plans.

4.1.3 Woronora Reservoir Impact Strategy

Condition 2 of the Longwalls 301 and 302 approval required Metropolitan Coal to conduct further investigation into potential impacts on the Woronora Reservoir. Metropolitan Coal engaged independent experts to prepare a Woronora Reservoir Impact Strategy to provide a staged plan of action for further investigations and a report into the impacts of mining near the reservoir. Professor Bruce Hebblewhite (B. K. Hebblewhite Consulting), Dr Frans Kalf (Kalf and Associates Pty Ltd) and Emeritus Professor Thomas McMahon (University of Melbourne) were endorsed by the DPIE for the Woronora Reservoir Impact Strategy in May 2017.

The *Woronora Reservoir Strategy Report – Stage 1* (Hebblewhite et al*.,* 2017) was provided by the independent experts to the then Department of Planning and Environment (DP&E) in September 2017. The Stage 1 report included recommendations for further groundwater and surface water investigations and monitoring and was approved by the Secretary for Planning in December 2017.

The *Woronora Reservoir Strategy – Stage 2 Report* (Hebblewhite et al*.,* 2019) was provided by the independent experts to the DPIE in June 2019. The Stage 2 report includes additional recommendations in regard to groundwater and surface water investigations and monitoring, based on further data and analysis arising from the ongoing monitoring programs, including those recommended in the original Stage 1 report.

The Stage 2 report represents the second stage of the Woronora Reservoir Impact Strategy, based on further data and analysis arising from the ongoing monitoring programs, including those recommended in the Stage 1 report.

The surface water and groundwater monitoring locations that have been installed as a component of the Woronora Reservoir Impact Strategy are described in the Longwalls 311-316 Water Management Plan.

The additional monitoring sites and environmental investigations for the Woronora Reservoir Impact Strategy included the installation of two streamflow monitoring stations in sub-catchments I and K to the west of Longwalls 301-303 and the installation of a pluviometer in the vicinity of the northern end of Longwall 307. The Stage 2 report recommended that further analysis of the data obtained from these monitoring sites (that covers at a minimum the initial 12-month period) be conducted. A summary of the outcomes of this assessment is provided below.

12 The Woronora Notification area was amended on 1 July 2022 to an area 1.5 km around the Woronora Dam wall which is outside or beyond the mining lease.

Data collected from the flumes on sub-catchments I and K commenced on 31 May 2018 and 3 June 2018, respectively (the flumes were installed on 17 May 2018 and 16 May 2018, respectively). Secondary extraction from Longwall 302 was occurring at the commencement of monitoring. Sub-catchment I overlies Longwall 301 to Longwall 305 while Sub-Catchment K predominately overlies Longwall 306 and Longwall 307. Sub-Catchment K formed a control for the assessment of potential impacts to streamflow in Sub-Catchment I associated with secondary extraction from Longwall 301 to Longwall 304.

Streamflow monitoring in sub-catchments I and K is proposed to continue up to the completion of Longwall 310.

Assessments of the dry weather recessions recorded at the flumes on sub-catchments I and K show consistent behaviour with time, although the recorded streamflow recession during low flow periods appears to be more rapid at the gauging station on Sub-Catchment K than on Sub-Catchment I. There is no visual indication of a change in recessionary behaviour (i.e. rate of recession) for Sub-Catchment I and no indication from the recorded stage and streamflow data that mining of Longwall 301 to Longwall 305 has impacted streamflow at the Sub-Catchment I gauging station. Additionally, there is no visual indication of a change in recessionary behaviour (i.e. rate of recession) for Sub-Catchment K and no indication from the recorded data that mining of Longwall 306 or Longwall 307 has impacted streamflow at the Sub-Catchment K gauging station (to June 2023), noting the Sub-Catchment K gauging was inundated by backwater from the Woronora Reservoir for periods of 2023. This is consistent with the results of monitoring of the quantity of water resources reaching the Woronora Reservoir for the Waratah Rivulet and Eastern Tributary.

A preliminary water balance of the Woronora Reservoir has been developed as a component of the Woronora Reservoir Impact Strategy. The primary purpose of the water balance analysis was to establish whether the inputs to and outputs from the Woronora Reservoir could be measured sufficiently and accurately to estimate a loss through the bed of the reservoir because of longwall mining being undertaken in the catchment and/or from other activities that may affect the water balance. The issues identified in the water balance suggest that the magnitude of bias and uncertainty in the data used in the analysis is such that it is doubtful that the water balance values provide a satisfactory baseline for assessing the potential loss of reservoir water through the bed and it was recommended that a Stage 2 water balance study be not undertaken.

A number of groundwater monitoring bores and inclinometer monitoring points have also been installed as a component of the Woronora Reservoir Impact Strategy. The results obtained to date are summarised below.

The Stage 2 report recommended groundwater model-derived cross sections be generated to display the pressure head profiles before and after mining specific panels with the zero pressure heads clearly displayed. Representative north-south and east-west cross sections have been prepared for Longwalls 311-316 using the re-calibrated model with stacked drains and are shown in the Metropolitan Coal Water Management Plan.

In December 2019, the WRIS Panel prepared a letter report which provides a summary of the key conclusions from the Stage 1 and Stage 2 reports and considers the IEPMC *Report on Coal Mining Impacts in the Special Areas of the Greater Sydney Water Catchment* (dated 14 October 2019). It also considers feedback from the WRIS Panel's meeting with the DPIE, Water NSW and Metropolitan Coal on 11 November 2019. The key findings of this report were:

1. *Connective fracturing/depressurisation and depressurisation alone extends up to approximately 195 m above the current 163 m wide longwall extraction zone (Figure 1).*
2. *There is virtually no pressure head propagation (i.e. depressurisation), that is pressure head loss, extending upwards beyond about 80 m from the surface and very little above 150 m from the surface (Figure 1). The depressurisation zone below 150m is recovering due to lateral groundwater flow.*
3. *There is no evidence of surface to longwall panel connectivity at the Metropolitan Mine, with inflows averaging 0.01 ML/day between January 2009 and April 2019.*
4. *There is a clear benefit in using narrower panels and wider chain pillars near and beneath the Woronora Reservoir as it substantially reduces subsidence predictions.*
5. *The ratios of 'width of panel' and 'depth of cover' at the Metropolitan Mine proposed for mining under the Woronora Reservoir (0.32 to 0.35) are similar to those used for the previously successful mining conducted with very low inflow reported at the South Bulli Mine and Bellambi West Colliery below the Cataract Reservoir (0.34 to 0.41).*
6. *Mining in the upper reaches of sub-catchment I has not impacted on flows recorded at the flume further downstream, consistent with the results of monitoring of the quantity of water resources reaching the Woronora Reservoir for the Waratah Rivulet and Eastern Tributary.*
7. *Water balance modelling of inputs to and outputs from the Woronora Reservoir indicates that the combined average loss from groundwater outflow under the dam wall and loss through the bed of the Woronora Reservoir is 2.9 ML/day with a 95% uncertainty band between 0.4 ML/day to 5.4 ML/day, in which ungauged inflows to the reservoir and reservoir evaporation are the major contributors to the uncertainty. The 2.9 ML/day equates to 3.6% of the total outputs modelled from the Woronora Reservoir. Taking into account the facts that groundwater outflow under than dam wall could not be adequately modelled, that there are problems in stream gauging a large proportion of the current ungauged area, and there are difficulties in estimating reservoir evaporation, it is recommended that a Stage 2 water balance study be not undertaken.*
8. *Based on the review of available data, analytical predictions and monitoring bore evidence at LW302, together with the use of narrower panels and wider chain pillars beneath the reservoir, the proposed longwall mining is not expected to result in connective cracking between the longwalls and surface or significant inflows from Woronora Reservoir to the mine extraction zone.*
9. *The existing monitoring regime should be continued, together with the additional monitoring recommended above. All monitoring results should be regularly reviewed against predicted values to provide ongoing confidence in the performance of the mining operation and its impacts.*

Metropolitan Coal understands that the WRIS Panel is no longer required to conduct investigations into potential impacts on the Woronora Reservoir and that these investigations will instead be conducted by the Independent Expert Advisory Panel for Mining.

4.2 RELEVANT BIODIVERSITY MANAGEMENT INFORMATION OBTAINED SINCE PROJECT APPROVAL

The Metropolitan Coal Longwalls 308-310 BMP was prepared to manage the potential environmental consequences of the Metropolitan Coal Longwalls 20-22, 23-27, 301-303, 304, 305-307 and 308-310 Extraction Plans on aquatic and terrestrial flora and fauna, with a specific focus on swamps, in accordance with Condition 6, Schedule 3 of the Project Approval.

4.2.1 Upland Swamps

4.2.1.1 Swamp Types

Several types of upland swamps have been defined in the Metropolitan Coal Project underground mining area and surrounds according to the geomorphological settings in which they occur by the Metropolitan Coal BMPs, as follows:

1. Headwater swamps. These are the largest swamp type. They occupy broad, shallow, trough-shaped valleys, usually on first order watercourses at the head of valleys on broad plateaux. They sit on a relatively impermeable, low gradient sandstone base with dispersed seepage flows that encourage the growth of hygrophilic vegetation that in turn traps sediment, thereby increasing the water holding capacity. These swamps usually terminate at points where the watercourse suddenly steepens or drops away at a 'terminal step'. Terminal steps often occur at constrictions in the landscape where two ridges converge, causing a narrowing of the swamp and a concentration of water flows into a central channel.
2. Valley side swamps. Valley side swamps occur on steeper terrain than headwater swamps and are sustained by small horizontal aquifers that seep from the sandstone strata and flow over unbroken outcropping rock masses. These 'swamps' have shallow soils because the gradient usually limits sediment accumulation. They tend to terminate either on a horizontal step in the bedrock, or where broken rock, scree or deeper soil occurs at the base of the outcropping rock.
3. In-valley swamps. In-valley swamps are uncommon and occur on relatively flat sections of more deeply incised second and third order watercourses. Some are thought to develop behind obstructions in the watercourse, such as fallen rocks or log jams that result in a slowing of the water flow and deposition of sediments. Flat Rock Swamp is considered to represent a 'classic' in-valley swamp. Because of their relatively large catchment areas these swamps tend to be wetter than many headwater and valley side swamps.

Although these swamp types may occur discretely in the landscape, they can also occur in the same connected swamp system. For example, large headwater swamps may transition into in-valley swamps at the downstream end. Similarly, valley side swamps may occur around the steeper margins of some headwater swamps.

The terrain over Longwalls 20-27, Longwalls 301-304, Longwalls 305-307 and Longwalls 308-310 is highly dissected with narrow ridges. All the swamps mapped in the Longwalls 20-22, Longwalls 23-27, Longwalls 301-304, Longwalls 305-307 and Longwalls 308-310 mining areas are valley side swamps, with the exception of Swamp 20 which is a small in-valley swamp on a second order stream over Longwall 21 (Figure 9). Swamp 20 (situated in a gently inclined valley over solid bedrock) appears to have developed behind a terminal step, at a geological constriction in a valley, in much the same way as headwater swamps develop.

4.2.1.2 Swamp Characterisation

Swamp characterisation studies were conducted by Cenwest Environmental Services (2010) for the Longwalls 20-22 BMP and Cenwest Environmental Services (2011, 2013a) for the Longwalls 23-27 BMP. These studies have contributed to Metropolitan Coal's understanding of the ecological, hydrological and geomorphic processes of the upland swamps over Longwalls 20-27.

4.2.1.3 Swamp Vegetation Mapping

Bangalay Botanical Surveys (2008) conducted a baseline flora survey and mapped vegetation communities within the Project underground mining area for Longwalls 20-27 and Longwalls 301-317 for the Project EA (HCPL, 2008). Swamps were mapped by Bangalay Botanical Surveys (2008) consistent with vegetation mapping by the NSW National Parks and Wildlife Service (NPWS) (2003) as either vegetation community 3a (Banksia Thicket), 3b (Tea Tree Thicket), 3c (Sedgeland-heath Complex), 3d (Fringing Eucalypt Woodland), or a combination of these communities.

Longwalls 20-27

Swamps mapped by Bangalay Botanical Surveys (2008) located above or immediately adjacent to Longwalls 20-27 include Swamps 16, 17, 18, 19, 20, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35 and 36 (Figure 9).

While Swamp 29 is illustrated on Figure 9 (for consistency with the previous BMPs), field inspections by Eco Logical for the Longwalls 23-27 vegetation monitoring program indicated that it is not a swamp. The vegetation was found to be similar to sandstone heath woodland, being dominated by *Angophora costata, Corymbia gummifera* and *Eucalyptus oblonga,* with an understorey of *Banksia ericifolia, Acacia ulicifolia, Leptospermum trinervium, Kunzea ambigua, Dillwynia retorta* and *Schoenus ericetorum*. Accordingly, Swamp 29 was not considered further in the Metropolitan Coal BMPs.

The vegetation in the remaining swamps (with the exception of Swamp 33) was classified by Bangalay Botanical Surveys (2008) as 'Sedgeland-heath Complex' consistent with vegetation mapping by NPWS (2003). Sedgeland-heath Complex is a mapping unit that amalgamates the Sedgeland, Restioid Heath and Cyperoid Heath vegetation associations identified by Keith and Myerscough (1993). The three communities were condensed by NPWS (2003) because they could not be reliably distinguished by Air Photo Interpretation for community mapping. Swamp 33 was mapped by Bangalay Botanical Surveys as 'Banksia Thicket' consistent with vegetation mapping by NPWS (2003).

Field inspections for the Longwalls 20-22 and Longwalls 23-27 BMPs by Eco Logical indicated that all the swamps over Longwalls 20-27 comprised either Banksia Thicket or Restioid Heath (or a combination of the two), with the exception of Swamp 20 and Swamp 28. Swamp 20 supports Tea Tree Thicket, while Swamp 28 is a Banksia Thicket swamp with the lower portion supporting Tea Tree Thicket.

Three of the vegetation patches mapped as swamps (Swamps 16, 17 and 23), although showing seepage, do not appear to be upland swamps, being more akin to Sandstone Heath Woodland with low tree densities. The vegetation on these patches have species found in upland swamps, mixed with a range of non-swamp species, including *Banksia serrata, Eucalyptus sieberi* and *E. racemosa* in Swamps 16 and 17, and *Angophora hispida* and *Allocasuarina distyla* in the case of Swamp 23. However, Swamp 23 also has a number of characteristic swamp species, including *Sprengelia incarnata, Epacris obtusifolia* and *Pultenaea aristata,* indicating at least some parts of it are quite moist. However, despite this, Swamp 23 is considered to be transitional between swamp and wet heath and somewhat atypical.

Similarly, Swamp 32 and Swamp 34 included elements of the Sandstone-Heath Woodland consistent with descriptions of this community by NPWS (2003).

During the conduct of Longwalls 20-27 upland swamp vegetation monitoring, the swamp boundary of control swamps 101, 111a, 135, 136, 137a, 137b, 138 and Bee Creek Swamp were updated by Eco Logical (as shown on Figure 9).

Longwalls 301-303

Field inspections of upland swamp vegetation mapped by Bangalay Botanical Surveys (2008) in the vicinity of Longwalls 301-303 was conducted by Eco Logical in 2015. The field inspections indicated that the upland swamps were comprised of Banksia Thicket, with the exception of Swamps 58 and 59 which were mapped as a combination of Banksia Thicket and Sedgeland-heath Complex (Eco Logical, 2016). The revised upland swamp mapping was detailed in Eco Logical (2016), which was included as Appendix 2 of the Longwalls 301-303 BMP.

The revised mapping of Swamps 37, 38, 40, 41, 42, 46, 47, 48, 49, 50, 51/52, 53, 54, 58, 59, 69, 70, 71a and 71b by Eco Logical (2016) is shown on Figure 9.

Subsequent to the vegetation mapping, Swamps 46, 51/52, 69, 70, 71a and 71b were subject to WaterNSW hazard reduction burns in 2016 and/or 2017. It is recognised that while these swamps were all mapped as containing Banksia Thicket vegetation, the hazard reduction burns are likely to have affected the vegetation that is now present.

Longwalls 304-310

All of the upland swamps within the 35 degree (°) angle of draw and/or predicted 20 mm subsidence contour for Longwall 304 were included in Eco Logical's field inspections for the Longwalls 301-303 BMP described above.

Field inspections of upland swamp vegetation mapped by Bangalay Botanical Surveys (2008) overlying or proximal to Longwalls 304-310 was conducted by Eco Logical in 2016 and 2017 to confirm the upland swamp vegetation communities present and swamp boundaries. Similar to the revised upland swamp vegetation mapping conducted for Longwalls 301-303, for each upland swamp a description of the vegetation was recorded including the different vegetation strata present, the dominant species and an estimation of percent foliage cover for each stratum to assign vegetation communities described by the NPWS (2003) and Bangalay Botanical Surveys (2008). Final delineation of vegetation community boundaries was undertaken by interpretation of recent aerial photographs. Patterns identified on aerial photographs were related to the field observations and used to delineate the boundaries of vegetation communities. The revised mapping of upland swamp vegetation overlying or proximal to Longwalls 304-310 secondary extraction is detailed in Eco Logical (2018c), which is provided in Appendix 2 of this BMP.

The *NSW Native Vegetation Interim Type Standard* (Sivertsen 2009) requires patches of vegetation to be mapped if the dimensions of the representative polygon on a map sheet are 2 mm x 2 mm or greater (i.e. at a map scale of 1:25,000, patches of vegetation equal to or greater than 0.25 hectares [ha]). However, the revised swamp vegetation mapping boundaries (including those swamps less than 0.25 ha in area) are shown on Figure 9 to document the changes to the previous Bangalay Botanical Surveys (2008) vegetation mapping. It is noted that many of the revised swamp boundaries comprising vegetation characteristic of the upland swamp vegetation communities are very small in size and are unlikely to represent an upland swamp (Appendix 2). For example, Swamp 65/66 (0.11 ha in area), Swamp 67 (0.030 ha in area), Swamp 68a (0.043 ha in area), Swamp 68b (0.034 ha in area). In addition to those listed above, Swamps 61, 63, 73, 83, 86 and 88 are all less than 0.25 ha in area.

In addition to the swamps described above as being subject to hazard reduction burns, Swamps 63, 64, 65/66, 67, 68a and 68b overlying or proximal to Longwalls 305-307 were also subject to hazard reduction burns in October 2016 and August 2017. It is recognised that while these swamps were all re-mapped as containing Banksia Thicket vegetation (Appendix 2), the hazard reduction burns are likely to have affected the vegetation that is now present.

Further to the above, Swamp 84 and Swamp 86 are considered to be marginal upland swamps in that they contain non-swamp vegetation more consistent with sandstone woodland (Appendix 2).

The revised upland swamp mapping and associated vegetation community mapping by Eco Logical (2018c) of Swamps 60, 61, 62, 63, 64, 65/66, 67, 68a, 68b, 72, 81, 82, 83, 84, 86, 88, 89, 133 and 134 is shown on Figure 9.

Longwalls 311-316

Field inspections of upland swamp vegetation mapped by Bangalay Botanical Surveys (2008) overlying or proximal to Longwalls 301-317 secondary extraction were conducted by Ecoplanning in 2019 to confirm the upland swamp vegetation communities present and to check the swamp boundaries.

The field inspections of upland swamps were limited to Swamps 78, 79, 80, 90 and 91 overlying Longwalls 311-315, and the large headwater swamps, namely Swamps 76, 77, 92 and 106 overlying Longwalls 312-317. Similar to the revised upland swamp vegetation mapping conducted for Longwalls 304-310 (Appendix 2), for each upland swamp a description of the vegetation was recorded including the different vegetation strata present, the dominant species and an estimation of percent foliage cover for each stratum to assign vegetation communities described by the NPWS (2003) and Bangalay Botanical Surveys (2008). Final delineation of vegetation community boundaries was undertaken by interpretation of recent aerial photographs. Patterns identified on aerial photographs were related to the field observations and used to delineate the boundaries of vegetation communities. The revised upland swamp mapping is shown on Figure 9 and is detailed in Ecoplanning (2021c) (Appendix 4).

Upland swamps associated with Longwalls 311-316 include the valley side swamps (Swamps 78, 79, 80, 90 and 91) and the three large headwater swamps (Swamps 76, 77 and 92), which occupy broad sandstone plateau areas, typically more common west of the Woronora River (Ecoplanning 2021c). These large headwater swamps generally support a mosaic of different swamp community types with Swamp 92 being the most diverse. Ecoplanning undertook additional field inspections of Swamps 76, 77 and 92 in August 2023 and 2024 to confirm the upland swamp vegetation communities present and to check the swamp boundaries. The revised upland swamp mapping is shown on Figures 9 and is detailed in Ecoplanning (2024) (Appendix C of the Large Swamp Assessment).

4.2.1.4 Upland Swamp Vegetation Monitoring

Upland swamp vegetation monitoring for Longwalls 20-22, Longwalls 23-27, Longwalls 301-304, Longwalls 305-307 and Longwalls 308-310 has included visual, quadrat/transect and/or indicator species monitoring, as described below.

The upland swamp vegetation monitoring programs were designed to comprehensively assess potential vegetation changes at three scales; overall gross changes across the whole swamp, changes at the community level and changes at the level of individual plants. Visual inspections aim to appraise the overall condition of the swamp and to detect any localised changes, described below, that may not be detected by detailed transect, quadrat and individual plant monitoring. The visual inspections provide qualitative information that may lead to further investigation and/or actions.

The fixed vegetation transects and associated quadrats aim to precisely measure changes in vegetation community composition over time in undermined and control swamps, including a two year pre-mining baseline data period. This sampling design follows that of Keith and Myerscough (1993) which is specifically tailored for upland swamp monitoring. The original design of the vegetation monitoring programs included sufficient replication for robust statistical analysis[13,14].

Monitoring of individual plants provides species level data on the health and survival of individual plants in undermined and control swamps. Monitoring is targeted to swamp specialist species that may be prone to any mining-induced changes to swamp hydrology.

Visual Inspections

Visual inspections have been conducted in Swamps 16, 17, 18, 19, 20, 24, 25, 27, 28, 30, 31, 32, 33, 34, 35, 36, 40, 41, 46, 47, 48, 49, 50, 51/52, 53, 58, 61, 62, 63, 64, 69, 70, 71a, 71b, 72, 73, 78, 79, 80, 81, 82, 83, 88, 89, 90, 92 and 94 overlying or adjacent to Longwalls 20-27, Longwalls 301-304, Longwalls 305-307 and/or Longwalls 308-310 to record evidence of potential subsidence impacts and control swamps.

Traverses covering the majority of the extent of the swamp have been conducted to record:

- cracking of exposed bedrock areas and/or swamp sediments;
- areas of increased erosion, particularly along any existing drainage lines;
- any changes in water colour;
- changes in vegetation condition, including areas of stressed[15] vegetation (i.e. plants that demonstrate symptoms of stress) and dead/dying plants that appear unusual; and
- whether the amount of seepage (at the terminal step/over exposed surfaces of the swamp) at the time of inspection appears unusual (relative to recent rainfall).

As many of the Longwalls 301-307 swamps comprise dense Banksia Thicket, it was anticipated that such traverses would be difficult to impractical to monitor at some locations.

Transect and Quadrat Monitoring

Transect and quadrat monitoring is conducted of:

- Banksia Thicket/Restioid Heath vegetation – in Swamps 16, 17, 18, 24 and 25 overlying Longwalls 20-22, Swamps 28 (upper portion), 30, 33, 35 and 94 overlying or adjacent to Longwalls 23-27, Swamps 40, 41, 46, 48, 50, 51/52 and 53 overlying Longwalls 301-304, Swamp 71a overlying or adjacent to Longwalls 305-307, Swamp 62, 64, 78, 79, 80, 81, 82, 89, 90 and 92 overlying or adjacent to Longwalls 308-310 and in control Swamps 101, 111a, 125, 135, 136, 137a, 137b, 138 and Bee Creek Swamp (Figure 9); and
- Tea Tree Thicket vegetation – in Swamp 20 overlying Longwalls 20-22, in the lower portion of Swamp 28 overlying Longwalls 23-27, in the central portion of Swamp 92 overlying Longwalls 308-310 and in control swamps Woronora River 1, Woronora River south arm and Dahlia Swamp (Figure 9).

13 It should be noted that Swamp 46 and Swamp 51/52 were subject to WaterNSW hazard reduction burns resulting in vegetation along transects in these swamps no longer being comparable to the control swamps, and unable to be subject to statistical analysis.

14 The vegetation monitoring program for Longwall 304 was originally designed for Longwalls 304-306.

15 Vegetation that is 'stressed' and vegetation that is dying or has died (senescent). Senescence is the process of ageing including the period leading up to death. It is sometimes difficult to differentiate between the two under field conditions.

Baseline upland swamp vegetation surveys were conducted for Longwalls 20-22 in spring 2009 and autumn 2010[16], for Longwalls 23-27 from spring 2010 to spring 2013[17], for Longwalls 301-303 from spring 2015 to autumn 2017[18], for Longwall 304 from spring 2017 to spring 2018, for Longwalls 305-307 from spring 2015 to autumn 2020[19], and for Longwalls 308-310 from spring 2021 to spring 2022.

The Banksia Thicket/Restioid Heath swamps and Swamp 20 (Tea Tree Thicket) have been monitored with three transects, with the exception of Swamp 28. Swamp 28 is a small valley-side swamp which supports Banksia Thicket in the upper portion of the swamp and Tea Tree Thicket in the lower portion of the swamp. Vegetation within Swamp 28 has been monitored along two transects, one within the Banksia Thicket and one within Tea Tree Thicket vegetation. Tea Tree Thicket control swamps Woronora River 1, Woronora River south arm and Dahlia Swamp have been monitored with a single transect owing to the much larger size of these control swamps.

For the Banksia Thicket/Restioid Heath swamps, assessments have been made on 1 square metre (m^2) quadrats along a transect line every 5 m starting from 0 m. For the Tea Tree Thicket swamps, assessments have been made on 1 m^2 quadrats located upslope of the transect line with one quadrat edge located on the line as a means of avoiding the impacts of vegetation trampling as a result of access into these thickly vegetated swamps. As for Banksia Thicket/Restioid Heath swamps, assessments are made every 5 m starting from 0 m.

The data collected for each quadrat includes:

- vegetation structure;
- dominant species;
- estimated cover and height for each stratum;
- full floristics;
- estimated cover abundance for each species using seven point Braun-Blanquet scale; and

  Modified Braun-Blanquet Scale
  1 = cover less than 5% of site and rare
  2 = cover less than 5% of site and uncommon
  3 = cover of less than 5% and common
  4 = cover of 5-20% of site
  5 = cover of 21-50% of site
  6 = cover of 51-75% of site
  7 = cover of greater than 75%

- condition/health rating for each species in the quadrat:

  Condition Scale
  1 severe damage/dieback
  2 many dead stems
  3 some dead branches
  4 minor damage
  5 healthy

16 Longwall Swamps 16 and 17 (Restioid Heath/Sandstone Heath Woodland) were added to the vegetation monitoring program in autumn 2010.

17 Monitoring of transects/quadrats in control Swamps 101, 111a, 125, Woronora River 1, Woronora River south arm and Dahlia Swamp commenced in spring 2009 and in control Swamps 135, 136, 137a, 137b, 138 and Bee Creek Swamp in spring 2010.

18 Baseline data for upland swamps has been obtained up to, and including, autumn 2017 prior to the commencement of mining and is reported in Eco Logical (2021c).

19 Baseline monitoring commenced in spring 2015 for Swamps 69, 70 and 71a based on the original extraction plan layout. Due to changes in longwall layout and planning, baseline monitoring for Swamps 71b, 72 and 73 only occurred in autumn 2020.

Permanent photo points were established along each transect.

Existing control Swamps 101, 135, 136, 137a, 137b and 138 were selected for comparison with the swamps over Longwalls 311-316. It is noted that some of these control swamps have previously been identified as supporting Sedgeland-heath Complex (Bangalay Botanical Surveys, 2008; Metropolitan Coal, 2014), however, the height and density of the shrub layer of these swamps (in particular *Banksia ericifolia* subsp. *Ericifolia*) has increased with time since fire, and these control swamps now support vegetation comparable to Banksia Thicket as described in NPWS (2003) and Bangalay Botanical Surveys (2008) and similar to that observed in swamps overlying Longwalls 301-304.

Portions of Swamps 46 and 51/52 overlying or adjacent to Longwalls 301-304, Swamps 69, 70, 71a and 71b overlying or adjacent to Longwalls 305-307 and Swamp 64 overlying or adjacent to Longwalls 308-310 were subject to WaterNSW hazard reduction burns in 2016 and/or 2017. In addition, a WaterNSW hazard reduction burn in autumn 2021 impacted some areas of Swamp 33. This has resulted in vegetation along some transects in these swamps no longer being comparable to the control swamps.

Indicator Species Monitoring

Indicator species monitoring has been conducted in Banksia Thicket/Restioid Heath swamps, as follows:

- *Epacris obtusifolia* in Swamps 18, 24 and 25 overlying Longwalls 20-22, in Swamps 19, 30, 33, 35 and 94 overlying or adjacent to Longwalls 23-27, Swamps 40, 51/52[20] and 53 overlying Longwalls 301-304 and in control Swamps 101, 111a, 125, 135, 136, 137a, 137b and 138[21].
- *Sprengelia incarnata* in Swamp 24 overlying Longwalls 20-22, in Swamps 19, 33, 35 and 94 overlying or adjacent to Longwalls 23-27, Swamps 40, 51/52[20] and 53 overlying Longwalls 301-304 and in control Swamps 101, 125, 135, 136, 137a, 137b and 138[21].
- *Pultenaea aristata*[22] in Swamps 18, 24 and 25 overlying Longwalls 20-22, in Swamps 19, 30, 33, 35 and 94 overlying or adjacent to Longwalls 23-27 and in control Swamps 101, 111a, 135, 136, 137a and 138.

Indicator species monitoring of *Banksia robur, Callistemon citrinus* and *Leptospermum juniperinum* has been conducted in the Tea Tree Thicket vegetation of Swamp 20 overlying Longwalls 20-22, of *Banksia robur* and *Callistemon citrinus* in the Tea Tree Thicket vegetation of Swamp 28 overlying Longwalls 23-27, and at the associated control sites (Woronora River 1, Woronora River south arm and Dahlia Swamp).

Baseline indicator species monitoring was conducted in spring 2009 and autumn 2010 for Longwalls 20-22[23], from spring 2010 to spring 2013 for Longwalls 23-27[24], from spring 2015 to autumn 2017 for Longwalls 301-303[21] and from spring 2017 to spring 2018 for Longwall 304.

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20 Subsequent to the autumn 2017 survey and prior to the spring 2017 survey, Swamp 51/52 was subject to WaterNSW hazard reduction burns, resulting in the death of indicator species in Swamp 51/52. As a result, monitoring in Swamp 51/52 was removed from the monitoring program.

21 Individuals of indicator species being monitored within these control swamps for Longwalls 23-27 have not been used for Longwalls 301-303 as a proportion of these individuals within control swamps have already been recorded with severe dieback or are dead. Additional individuals have been tagged as a component of the monitoring program.

22 Insufficient individuals of *Pultenaea aristata* were available in the swamps over Longwalls 301-303 for monitoring.

23 Monitoring of *Pultenaea aristata* in Swamp 24 commenced in autumn 2010.

24 Monitoring of indicator species in control Swamps 101, 111a, 125, Woronora River 1, Woronora River south arm and Dahlia Swamp commenced in spring 2009 and monitoring of indicator species in control Swamps 135, 136, 137a, 137b and 138 commenced in spring 2010.

Twenty tagged individuals of each species have been monitored in the swamps indicated above. Population monitoring data collected includes a condition/health rating (1 – severe damage/dieback, 2 – many dead stems, 3 – some dead branches, 4 – minor damage, 5 – healthy) and a reproductive rating (1 – nil, 2 – sparse [occasional flowers only], 3 – low [under 25% of potential], 4 – moderate [25% to 75%], 5 – high [over 75% of potential flowering]) for each plant.

Monitoring Results to Date

The results of the Longwalls 20-22 and Longwalls 23-27 upland swamp vegetation monitoring programs (up to and including the spring 2022 survey) can be summarised as follows:

- No cracking of exposed bedrock areas or swamp sediments has been observed, other than those recorded during the baseline surveys.
- Areas in which active erosion was observed were all minor and limited to access tracks, drainage lines and areas of bare earth without vegetation cover.
- Swamp surface sediments have been generally damp to wet depending on the size of the swamp, the preceding rainfall and location within the swamp extent. In contrast, swamp surface sediments were wet to saturated, with an abundance of standing water in spring 2022 following a year of extremely high rainfall.
- Iron-stained groundwater seepage has been observed since spring 2012 on the terminal rocky step and/or the small rocky step of Swamp 20. In spring 2022, iron staining of seepage was common across many of the swamps, in particular Swamps 16, 17, 18, 19, 25, 35 and 94. This was often observed in conjunction with a metallic sheen on seepage and standing water. It is noted that this is a natural phenomenon resulting from an abundance of bacteria which feed on the iron-rich ground water which was more prevalent following the extreme rainfall experienced during 2022.
- The vegetation structure, dominant species and estimated cover abundance for each stratum has been variable across all seasons with variations recorded between sites, seasons and strata. No notable changes in vegetation structure, dominant species or estimated cover and abundance which could be attributed to impacts associated with the mining of Longwalls 20-22 or Longwalls 23-27 have been recorded.
- Visual inspections of Restioid Heath/Banksia Thicket swamps between spring 2017 and spring 2019 identified that vegetation at both longwall and control swamps was in poorer condition than in previous years, with yellowing and senescence common and widespread. Dieback throughout this drier period was most evident where soils are shallow, particularly over rocky areas and downslope. Following the increase in rainfall in early 2020, this trend appeared to reverse, with vegetation being observed in a good condition from autumn 2020 to spring 2022. For the Tea Tree Thicket swamps, vegetation of both longwall and control swamps was found to be generally in good condition in spring 2022. Some isolated dieback was recorded throughout most longwall and control swamps. Close monitoring of trends in vegetation will continue to assess the contribution of dry climatic conditions versus mine subsidence impacts.
- Fluctuations in species cover/abundance and condition have been recorded across all sites.
- Analysis of species richness within Restioid Heath/Banksia Thicket and Restioid Heath / Banksia Thicket sites using analysis of variance (ANOVA) did not detect significant differences between longwall and control sites in any season including spring 2020.
- Species richness within individual sites in spring 2022 was within the range of previous seasons at all longwall sites and most control sites, the exception being one control site (Swamp 136) which recorded its lowest species richness since monitoring begun.

- Monitoring of indicator species indicates the observed mortality appears to be driven by natural factors including predation, competition with other vegetation and abiotic factors and not related to longwall mining. The increased mortality of *Banksia robur* at the single Tea Tree Thicket longwall site (Swamp 28) over Longwalls 23-27 has been observed since spring 2013 prior to the commencement of mining Longwalls 23-27 and mine subsidence impacts (as indicated by piezometer data).
- The upland swamp vegetation performance indicator '*The vegetation in upland swamps is not expected to experience changes significantly different to changes in control swamps'* has not been exceeded for any of the monitored Restioid Heath/Banksia Thicket Swamps or Swamp 20 (Tea Tree Thicket vegetation).
- The vegetation performance indicator was exceeded at longwall Tea Tree Thicket Swamp 28 from autumn 2017 to autumn 2019 based on the continual decline in condition of both the understorey and species richness, and the high mortality rate of Banksia robur in comparison to the control sites. Threatened flora and fauna assessments against the biodiversity subsidence impact performance measure, negligible impact on the species, populations or ecological communities were conducted from autumn 2017 to autumn 2019 and concluded that the performance measure has been met. During the spring 2022 survey, there was a slight increase in species richness along the Tea Tree Thicket component of Swamp 28 compared to the previous five surveys.

The revised upland swamp vegetation monitoring program for Longwalls 20-22 and Longwalls 23-27 is described in Section 8.1.

The spring 2017 survey was the first survey undertaken during the mining of Longwalls 301-304. The results of the Longwalls 301-304 upland swamp vegetation monitoring program (up to and including the spring 2022 survey) can be summarised as follows:

- Visual inspections have not identified any cracking of exposed bedrock areas or swamp sediments in longwall swamps as a result of mine subsidence.
- Up until the spring 2022 survey, observations of active erosion in swamps was generally minor and limited to flow paths along existing tracks. In spring 2022, however, moderate erosion was observed in Swamp 50 along the drainage line which runs off the nearby Princes Highway as well as along parts of Transect 3, where sediment has been gouged, roots exposed and plants uprooted, exposing underlying rock in places. This is likely the impacts of heavy runoff from Princes Highway during the extremely high rainfall experienced throughout 2022. Swamp surface sediments in Longwalls 301-304 sites have previously been dry to damp depending on the size of the swamp, the preceding rainfall and location within the swamp extent. In contrast, in spring 2022 swamp surface sediments were wet to saturated in most longwall and control sites, with an abundance of standing water in, following a year of extremely high rainfall.
- Seepage has been recorded in some swamps over most survey seasons. In spring 2022, however, seepage and standing water was abundant and common across all longwall sites. In many cases this was observed in conjunction with a metallic sheen. It is noted that this is a natural phenomenon resulting from an abundance of bacteria which feed on the iron-rich ground water which was more prevalent following the extreme rainfall experienced during 2022.
- Vegetation at both longwall and control sites has generally been in good condition with no unusual areas of vegetation senescence or death observed. Some isolated dieback and senescence of individuals has occurred throughout most longwall and control swamps.

- The vegetation structure commonly found within all longwalls swamps is slightly different to that of the controls, most likely attributable to fire history. The mid layer is taller and denser compared with the mid layer at control sites. Similar to control swamps the mid layer is dominated by *Banksia ericifolia* subsp. *Ericifolia*, *Hakea teretifolia* and *Leptospermum squarrosum* but the cover is generally greater with a generally less diverse ground layer in some areas of these swamps. Floristically, the longwall and control swamps are similar.
- Fluctuations in species cover/abundance and condition were recorded across all sites throughout the baseline monitoring period. For swamps not subject to the WaterNSW hazard reduction burns, no patterns of increasing or decreasing cover/abundance, or declines in vegetation condition, were identified in spring 2022 in relation to individual species across sites or groups of species (i.e. swamp indicator species, generalist species, shrubs, ground covers) within sites. Vegetation in Swamps 46 and 51/52 following hazard reduction burns is distinctly different to all other monitoring swamps.
- Analysis of species richness using ANOVA has not detected significant differences between longwall and control swamps. Data for Swamp 46 and Swamp 51/52, which were subject to hazard reduction burns, are excluded from the analysis. All observed changes in species richness are considered to be within the range of natural fluctuations in response to weather, population dynamics, seasonality of survey and natural disturbances including grazing by fauna species.
- In spring 2022, the proportion of upland swamp indicator species plants which were dead was greater at longwall sites than control sites for *Epacris obtusifolia*, whilst the proportion of dead *Sprengelia incarnata* individuals was greater at control sites, however it is noted that the vast majority of monitored individuals of this species have died. The highest rates of mortality were recorded during the extended dry period from spring 2017 to autumn 2019. Monitoring of swamp substrate water levels in the longwall swamps indicates the dry swamp conditions are natural.
- The upland swamp performance indicator '*The vegetation in upland swamps is not expected to experience changes significantly different to changes in control swamp*s' has not been exceeded.

The revised upland swamp vegetation monitoring program for Longwalls 301-304 is described in Section 8.1.

The results of the Longwalls 305-307 upland swamp vegetation monitoring programs (up to and including the spring 2022 survey) can be summarised as follows:

- Visual inspections have not identified any cracking of exposed bedrock areas or swamp sediments in longwall swamps as a result of mine subsidence.
- Vegetation at both longwall and control sites has generally been in good condition with no unusual areas of vegetation senescence or death observed. Some isolated dieback and senescence of individuals has occurred throughout most longwall and control swamps.
- Swamp surface sediments have previously been recorded ranging from damp to wet, depending on swamp size, location within the swamp, and rainfall directly preceding the survey. In spring 2022, following a year of extremely high rainfall, swamp surface sediments were wet to saturated in all longwall and control sites.
- Seepage and standing water have been recorded at most longwall and control sites throughout the monitoring period. In spring 2022, abundant seepage was recorded in the majority of longwall and control sites. This was generally observed on terminal steps or along transects. A metallic sheen was often observed on seepage and standing, ranging from widespread across the swamp (most control sites) to isolated occurrences within the swamp (some longwall sites).

- The vegetation structure commonly found within the single longwall swamp in which transect/quadrat monitoring is being undertaken (Swamp 71a) is very different to that of the controls, attributable to historical hazard reduction burning[25]. As a result of the hazard reduction burning, no live mid layer vegetation had been recorded for many seasons, with the lower layer vegetation dominated by *Leptospermum squarrosum, Banksia ericifolia* subsp. *Ericifolia* and *Entolasia stricta*. In spring 2022, a differentiated mid layer was beginning to form across the majority of the swamp, dominated by *Banksia ericifolia* subsp. *Ericifolia* and *Leptospermum squarrosum,* the lower layer is now dominated by sedges, in particular *Lepyrodia scariosa, Ptilothrix deusta,* and *Chorizandra cymbaria*.
- Fluctuations in species cover/abundance and condition were recorded across all sites in spring 2022. During recent surveys, no patterns of increasing or decreasing cover/abundance were identified in relation to individuals species across sites or ground of species (i.e. swamp indicator species, generalist species, shrubs, ground covers) within sites. From previous surveys, a small decline in average vegetation condition was recorded in Swamp 71a in spring 2020.
- Since autumn 2018, species richness in longwall Swamp 71a has remained greater than control sites. In spring 2022, species richness was within the range previously recorded across all previous monitoring season for the single longwall site and all control sites. The hazard reduction burning which occurred at Swamp 71a may account for the variability of species richness observed.
- The upland swamp performance indicator '*The vegetation in upland swamps is not expected to experience changes significantly different to changes in control swamp*s' has not been exceeded.

4.2.1.5 Upland Swamp Groundwater Monitoring

Groundwater monitoring of upland swamps is described in Section 4.1.2 above.

4.2.1.6 Assessment of Monitoring Results against Predicted Subsidence Impacts and Environmental Consequences

The key potential subsidence impacts and environmental consequences on perched groundwater systems and upland swamp vegetation described in the Project EA, Preferred Project Report, Metropolitan Coal Water Management Plans and BMPs are described in Section 4.1.2.

In summary, no change to the fundamental surface hydrological processes and upland swamp vegetation were expected within upland swamps; however, Swamp 20 was identified as being most at risk of subsidence impacts as a result of Longwalls 20-27.

Swamp substrate water levels have been assessed against the following upland swamp groundwater performance indicator:

> *Subsidence impacts are not expected to result in measurable changes to swamp groundwater levels when compared to control swamps or seasonal variations in water levels experienced by upland swamps prior to mining*.

The upland swamp groundwater performance indicator has been exceeded at Swamp 20 since 2012. Swamp 20 substrate water levels changed from being permanently saturated to being periodically saturated as a result of the passing of Longwall 21. It is considered that Longwall 21 caused a mining effect at Swamp 20, but the effects were not exacerbated by Longwalls 22-27.

25 Portions of 71a were subject to WaterNSW hazard reduction burns in 2016 and/or 2017.

A mining effect to the substrate water levels of Swamp 28 (overlying Longwall 24) was identified in 2016 based on the incomplete recovery of substrate water levels following rainfall events. Swamp 28 is considered to have an impact from mining of Longwall 25, although no effect on swamp substrate water levels occurred when Longwall 24 passed directly beneath the monitoring site.

While the water lost from Swamp 20 and Swamp 28 was retained in the unsaturated sandstone above the regional water table, the changes in swamp water levels as a result of cracking are measurable when compared to seasonal individual rainfall event based changes in swamp groundwater levels.

Analysis of swamp substrate water levels of Swamps 25, 30, 33 and 35 overlying Longwalls 20-27, Swamps 40, 41, 46, 50, 51, 52 and 53 overlying Longwalls 301-304 and Swamps 71a and 72 overlying or adjacent to Longwalls 305-307 compared with control swamps (Swamps 101, 137a and 137b) and rainfall records have not shown any mining effect. Both control and longwall swamps have responded similarly to reduced rainfall under drought conditions (SLR Consulting, 2021).

To date, the upland swamp vegetation monitoring results indicate that the vegetation in Swamp 20 has not experienced changes significantly different to changes in control swamps. However, it is not possible to predict the long term impacts on the vegetation of Swamp 20 owing to uncertainty about the altered hydrological regime, particularly the extent of cracking, and the potential for natural remediation. The effects on vegetation of reductions in water levels in Swamp 20, if any, may take some years to be expressed in the absence of a catastrophic event such as extreme drought and/or a wildfire. Continued biannual quantitative monitoring is required to reliably determine the impact of subsidence on Swamp 20 vegetation.

Based on the decline in condition of the understorey and species richness, and the high mortality rate of *Banksia robur*, compared to the control swamps, the Tea Tree Thicket component of Swamp 28 is considered to have experienced changes significantly different[26] to the control sites between the autumn 2017 survey and autumn 2019 survey.

Assessments against the biodiversity subsidence impact performance measure, *Negligible impact on threatened species and populations* conducted to date for Swamp 20 and Swamp 28 by FloraSearch (2012, 2013, 2014, 2015, 2016a), Cenwest Environmental Services (2012, 2013b, 2014a, 2015, 2016, 2017, 2019, 2020, 2021a), Eco Logical (2017a) and Ecoplanning (2019a, 2020a, 2021a) have concluded the subsidence impact performance measure has been met.

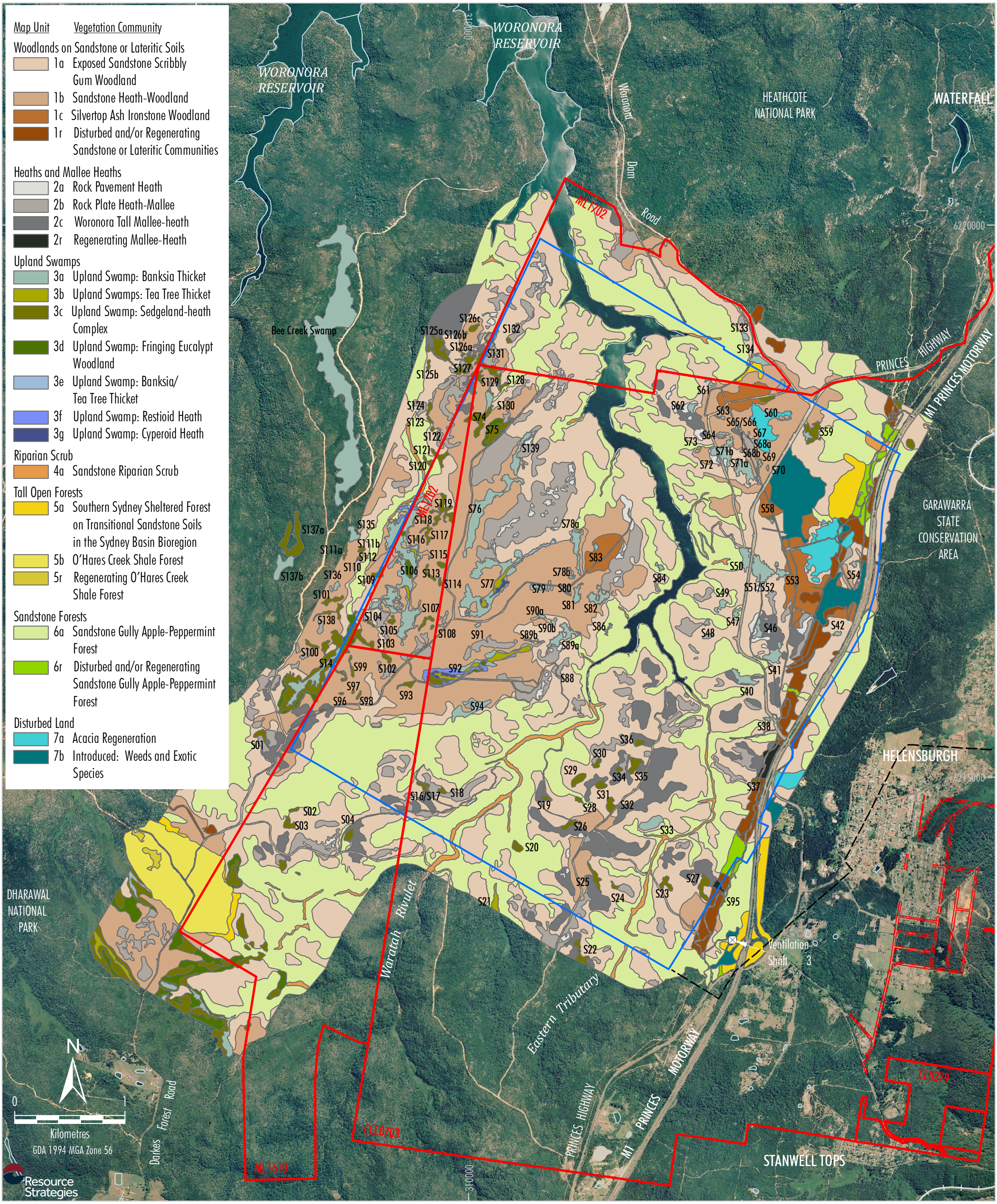
4.2.2 Riparian Vegetation

Riparian vegetation within the Project underground mining area occurs along streams which flow to the Woronora Reservoir, including Waratah Rivulet and the Eastern Tributary, and some of their tributaries. Vegetation mapping within the Project underground mining area is shown on Figure 10. Riparian vegetation includes vegetation mapped as community 4a (Sandstone Riparian Scrub).

4.2.2.1 Riparian Vegetation Mapping

Field inspections of Sandstone Riparian Scrub vegetation mapped by Bangalay Botanical Surveys (2008) on a tributary of the Woronora Reservoir on the lower reaches of the stream that is located above the middle of Longwall 304 were conducted by Eco Logical in 2015. The area mapped by Bangalay Botanical Surveys (2008) as Sandstone Riparian Scrub was found to support Sandstone Gully Apple-Peppermint Forest in the eastern upper portion and Sandstone Riparian Scrub in the western lower portion. The revised vegetation community mapping of this riparian vegetation by Eco Logical is further described in Section 5.4.

26 As there is only one Tea Tree Thicket longwall site for Longwalls 23-27, data for the Tea Tree Thicket component of Swamp 28 is not able to be analysed using ANOVA.



LEGEND

- Mining Lease Boundary
- Railway
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Existing Underground Access Drive (Main Drift)

Note: *The NSW Native Vegetation Interim Type Standard 2009 requires patches of vegetation to be mapped if the dimensions of the representative polygon on a map sheet are 2 mm x 2 mm or greater (i.e. 0.25 hectares or greater at a scale of 1:25,000). Eco Logical Australia conducted field inspections of upland swamp vegetation previously mapped by Bangalay Botanical Surveys (2008) overlying or proximal to Longwalls 301-310 to confirm the upland swamp vegetation communities present and to confirm or update the swamp vegetation boundaries. It is noted that the revised boundaries of a number of upland swamps (Swamps 37, 38, 42, 48, 54, 58, 61, 63, 65/66, 67, 68a, 68b, 70, 73, 83, 86 and 88) are less than 0.25 hectares in area and consistent with NSW vegetation mapping guidelines are not required to be mapped. Notwithstanding, the revised swamp vegetation mapping boundaries (including those swamps less than 0.25 hectares in area) are shown on this figure to document the changes to previous vegetation mapping.*

Source: Land and Property Information (2015); Date of Aerial Photography 1998; Department of Industry (2015); Metropolitan Coal (2023); after NPWS (2003), Bangalay Botanical Surveys (2008); Eco Logical Australia (2015; 2016; 2018) and Ecoplanning (2021; 2023)

Peabody

METROPOLITAN COAL

Mapped Vegetation Communities Within the Project Underground Mining Area and Surrounds

Figure 10

The area of Sandstone Riparian Scrub occurs along a steep and deeply incised drainage line with extensive stream boulders[27]. The vegetation of this area was consistent with the description of Sandstone Riparian Scrub by NPWS (2003) including the following features: a variable canopy commonly including overhanging *Angophora costata* and *Eucalyptus piperita;* a dense shrub layer commonly including *Ceratopetalum apetalum, Callicoma serratifolia, Lomatia myricoides* and *Tristania neriifolia;* and a ground layer dominated by mesic ferns such *as Sticherus flabellatus* var. *flabellatus* and *Gleichenia microphylla*. While the vegetation was closely aligned with the description of Sandstone Riparian Scrub by NPWS (2003), a number of abiotic features typical of the community (and observed along the Waratah Rivulet and Eastern Tributary) were absent including rock pools, rock platforms, sandy banks and sandy alluvial deposits.

4.2.2.2 Riparian Vegetation Monitoring

The riparian vegetation monitoring program includes visual, quadrat/transect and indicator species monitoring of riparian vegetation on the Waratah Rivulet and Eastern Tributary, as described below.

The riparian vegetation monitoring program was designed to comprehensively assess potential vegetation changes at three scales; overall gross changes across the observed streamside section, changes at the community level and changes at the level of individual plants. Visual inspections aim to appraise the overall condition of the riparian zone and to detect any localised changes, described below, that may not be detected by detailed transect, quadrat and individual plant monitoring. The visual inspections provide qualitative information that may lead to further investigation and/or actions.

The fixed vegetation transects and associated quadrats aimed to precisely measure changes in vegetation community composition over time, including a two-year pre-mining baseline data period.

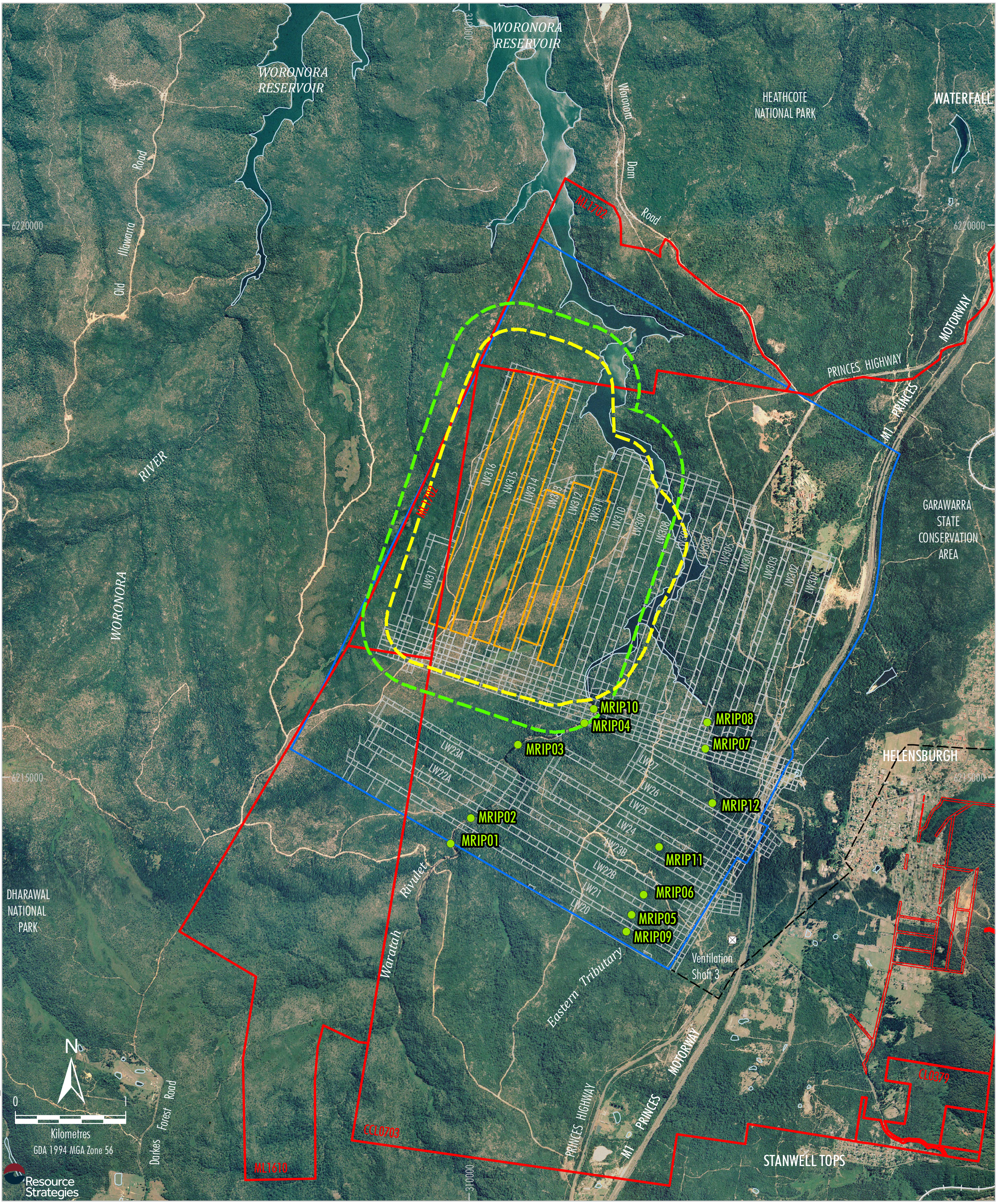
Monitoring of individual plants provides species level data on the health and survival of individual within riparian zone species. Monitoring is targeted to specialist species that depend on the habitats of the riparian zone and may be prone to any mining-induced changes to stream geomorphology.

Visual Inspections

Visual inspections of riparian areas have been conducted biannually in locations adjacent to riparian vegetation monitoring sites (sites MRIP01 to MRIP12) (Figure 11), and areas traversed whilst accessing the monitoring sites, to record evidence of subsidence impacts including:

- areas of new water ponding;
- any cracking or rock displacement; and
- changes in vegetation condition, including areas of stressed vegetation that appear unusual.

27 At the time of inspection by Eco Logical, standing water was largely absent from the drainage line. Due to the steep slope it is expected that standing water would generally be absent and only be present for a short period after rainfall events.



LEGEND

- Mining Lease Boundary
- Railway
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 311-316 Secondary Extraction
- Longwalls 311-316 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 311-316 Secondary Extraction
- Existing Underground Access Drive (Main Drift)

Monitoring Site

- Riparian Vegetation Monitoring Site

Source: Land and Property Information (2015); Date of Aerial Photography 1998; Department of Industry (2015); Metropolitan Coal (2023); MSEC (2024)

Peabody

METROPOLITAN COAL

Riparian Vegetation Monitoring Locations

Figure 11

Transect/Quadrat Monitoring

A permanent quadrat (20 m x 2 m) and permanent transect (50 m x 2 m, i.e. a 30 m extension of each quadrat) have been used to monitor riparian vegetation on the Waratah Rivulet and Eastern Tributary at (Figure 11)[28]:

- sites MRIP01, MRIP02, MRIP05 and MRIP06 overlying Longwalls 20-22;
- sites MRIP11 and MRIP12 overlying Longwalls 23-27; and
- sites MRIP03, MRIP04, MRIP07, MRIP08 and MRIP10 downstream of Longwalls 23-27[29].

The data collected for each quadrat includes:

- vegetation structure;
- dominant species;
- estimated cover and height for each stratum;
- full floristics;
- estimated cover abundance for each species using seven point Braun-Blanquet scale; and

  Modified Braun-Blanquet Scale
  1 = cover less than 5% of site and rare
  2 = cover less than 5% of site and uncommon
  3 = cover of less than 5% and common
  4 = cover of 5-20% of site= cover of 21-50% of site
  5 = cover of 51-75% of site
  6 = cover of greater than 75%
- condition/health rating for each species in the quadrat:

  Condition Scale
  1 severe damage/dieback
  2 many dead stems
  3 some dead branches
  4 minor damage
  5 healthy

Data was collected along each transect during the mining of Longwalls 20-27, including the occurrence of weed species (species and location) and a condition/health rating for each plant along the transect[30].

Permanent photo points were established for each quadrat and along each transect.

Baseline riparian transect/quadrat surveys were conducted biannually from spring 2008 to autumn 2010 at sites MRIP01 to MRIP08 and from spring 2010 to spring 2013 (i.e. prior to the commencement of Longwall 23) at sites MRIP11 and MRIP12.

28 Note that no quadrat or transect monitoring is conducted at sites MRIP09 and MRIP10. These sites were established for the purpose of visual inspections and indicator species monitoring only.

29 Prior to the autumn 2017 vegetation monitoring survey, mine subsidence impacts to pool drainage behaviour were recorded by Metropolitan Coal at sites MRIP07 and MRIP08.

30 Analysis of the transect data indicated the data was highly variable between seasons, which is attributed to the dynamic nature of riparian vegetation associated with variable flooding impacts. As described in the Longwalls 301-303 BMP, this variability was found to reduce the ability of this monitoring technique to detect changes to riparian vegetation associated with potential mining impacts and was discontinued for Longwalls 301-303.

Indicator Species

Three riparian vegetation indicator species have been monitored along Waratah Rivulet and the Eastern Tributary, namely, *Prostanthera linearis*, *Schoenus melanostachys* and *Lomatia myricoides*. Twenty tagged individuals of each species have been monitored at the following sites (Figure 11):

- sites MRIP01, MRIP02, MRIP05, MRIP06 and MRIP09 overlying Longwalls 20-22;
- sites MRIP11 and MRIP12 overlying Longwalls 23-27; and
- sites MRIP03, MRIP04, MRIP07, MRIP08[31] and MRIP10 downstream of Longwalls 23-27.

Population monitoring data collected includes a condition/health rating (1 – severe damage/dieback, 2 – many dead stems, 3 – some dead branches, 4 – minor damage, 5 – healthy) and a reproductive rating (1 – nil, 2 – sparse [occasional flowers only], 3 – low [under 25% of potential], 4 – moderate [25% to 75%], 5 – high [over 75% of potential flowering]) for each plant.

Surveys have been conducted bi-annually in autumn and spring.

Baseline indicator species monitoring was conducted in spring 2009 and autumn 2010 at sites MRIP01 to MRIP10 and from spring 2010 to spring 2013 (i.e. prior to the commencement of Longwall 23) at sites MRIP11 and MRIP12.

Monitoring Results to Date

The results of the riparian vegetation monitoring programs (up to and including the spring 2022 survey) are summarised below.

Vegetation has generally been observed in good condition, with the exception of observed flood impacts including prone vegetation and burial by flood debris. Increased depth and breadth of ponding from subsidence at site MRIP02 on the Waratah Rivulet and between sites MRIP05 and MRIP09 on the Eastern Tributary (Figure 11) has previously resulted in submersion of streamside vegetation causing vegetation dieback. Vegetation dieback was first observed at site MRIP02 in spring 2012 and between sites MRIP09 and MRIP05 in spring 2013.

Vegetation dieback greater than 50 centimetres (cm) from top of bank at site MRIP02 on the Waratah Rivulet and between sites MRIP05 and MRIP09 on the Eastern Tributary has been recorded. It was considered that the most appropriate action was to continue monitoring to determine whether the vegetation recovers in these areas or whether management measures are required, consistent with management measures outlined in the BMPs.

Up until autumn 2017, the amount of dieback had not changed at these sites over time (i.e. the same dead vegetation has been re-recorded on each survey visit and there had been no recovery). It was anticipated that over time a new stream bank would be established that would be colonised in due course by native riparian vegetation adapted to the changed conditions.

[31] Note: Twenty individuals of *Prostanthera linearis* were not available for tagging at site MRIP08.

In spring 2017, site MRIP02 on the Waratah Rivulet and between sites MRIP05 and MRIP09 on the Eastern Tributary were inspected and the vegetation was found to be in an improved condition at sites MRIP02 and MRIP09, where regeneration was observed and dieback was less than 50 cm from top of bank. Vegetation dieback was noted to be greater than 50 cm from top of bank at site MRIP05, extending beyond that recorded previously. In autumn 2018, site inspections of sites MRIP05 and MRIP06 indicated that dieback was greater than 50 cm from the top of the bank, whilst in spring 2018 to spring 2022 survey vegetation within these sites appeared to be improve with regrowth occurring despite impacts due to high water flow.

Assessments against the biodiversity subsidence impact performance measure, *Negligible impact on threatened species and populations* by FloraSearch (2012-2013, 2014, 2015, 2016b), Cenwest Environmental Services (2012-2013, 2014b, 2015, 2016, 2017, 2019), Eco Logical (2017b) and Ecoplanning (2019b) conducted to date for the riparian vegetation dieback at Site MRIP02, and between Sites MRIP05 and MRIP09 have concluded the subsidence impact performance measure has been met.

4.2.2.3 Assessment of Monitoring Results against Predicted Subsidence Impacts and Environmental Consequences

The key potential subsidence impacts and environmental consequences on streams described in the Project EA, Preferred Project Report and Metropolitan Coal Water Management Plans and BMPs are described in Section 4.1.1.

The Project EA, Preferred Project Report and Metropolitan Coal BMPs predicted potential impacts on riparian vegetation, primarily as a result of changes in stream water levels. As described above and in Section 4.1.1, increased ponding from changes in bed gradients has previously resulted in the prolonged inundation of the adjacent riparian vegetation which has resulted in vegetation dieback.

4.2.3 Aquatic Biota and their Habitats

4.2.3.1 Aquatic Ecology Monitoring

The richness and abundance of assemblages of fish recorded by the Project EA aquatic ecology surveys was low. Only two native species were recorded, *viz.* the Long-finned Eel (*Anguilla reinhardtii*) in the Waratah Rivulet and Woronora River, and Australian Smelt (*Retropinna semoni*) in the Woronora Reservoir. The introduced Mosquito Fish (*Gambusia holbrooki*) was recorded in the Woronora Reservoir, Waratah Rivulet and Woronora River.

No threatened fish have been recorded in the Woronora Reservoir, Waratah Rivulet or Woronora River and the dam wall of the Woronora Reservoir is likely to be a major barrier to migration of fish. Further to discussions with the Department of Primary Industries (DPI) – Fisheries during development of the Metropolitan Coal Longwalls 20-22 BMP, fish were not included in the aquatic ecology monitoring programs.

Metropolitan Coal has assessed subsidence impacts and environmental consequences on aquatic habitats in accordance with the Metropolitan Coal Water Management Plans (Section 4.1.1). Surface water monitoring includes monitoring of stream features, surface water flow, pool water levels, surface water quality, iron staining and gas releases. Observations of surface cracking, iron staining and gas releases are also made during the conduct of the aquatic ecology surveys.

The Longwalls 20-22 and Longwalls 23-27 aquatic ecology monitoring programs include the monitoring of aquatic habitat characteristics, water quality, macroinvertebrates and aquatic macrophytes. Consistent with the Project EA, the Longwalls 20-22 and Longwalls 23-27 aquatic ecology monitoring programs were designed to:

- monitor subsidence-induced impacts on aquatic ecology (stream monitoring); and
- monitor the response of aquatic ecosystems to the implementation of future potential stream remediation works (pool monitoring).

The design of the monitoring programs uses a "Beyond BACI"[32] experimental design and focuses on representative sampling within streams and pools in mining areas and in suitable control streams and pools (i.e. not subject to mine subsidence).

Stream Monitoring

Monitoring of aquatic biota has been conducted at a number of sampling and control sites (approximately 100 m long) at the following locations (Figure 12):

- Location WT3 on Waratah Rivulet, Locations ET1, ET3 and ET4 on the Eastern Tributary and Locations B1 and B2 on Tributary B overlying Longwalls 20-27.
- Location WT4 on Waratah Rivulet adjacent to Longwalls 20-27.
- Location WT5 on Waratah Rivulet and Location ET2 on the Eastern Tributary, downstream of Longwalls 20-27.
- Control Locations: WR1 on Woronora River; OC on O'Hares Creek; BC on Bee Creek; and WOT on Woronora Tributary.

The approximate locations of the sampling sites are shown on Figure 12.

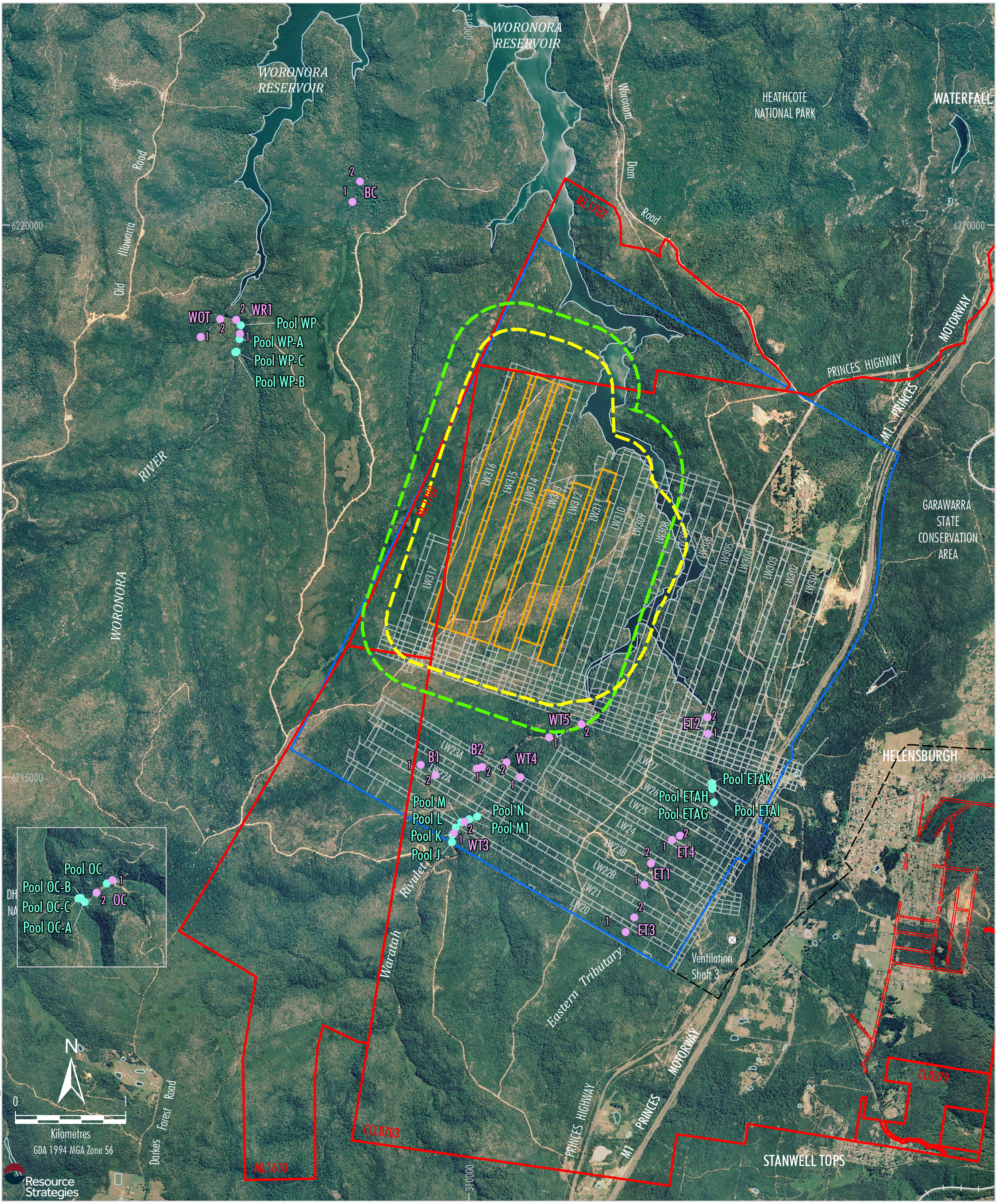
Monitoring of the sampling sites has been conducted biannually in spring (15 September to 15 December) and autumn (15 March to 15 June), consistent with the timing required by the Australian River Assessment System (AUSRIVAS) protocol.

Baseline aquatic ecology surveys of macroinvertebrates and macrophytes were conducted biannually from spring 2008 or spring 2009[33] to autumn 2010 for Longwalls 20-22 stream monitoring at Locations WT3, WT4 and WT5 on Waratah Rivulet, Locations ET1, ET2 and ET3 on the Eastern Tributary, Location B1 on Tributary B, Location WR1 on Woronora River, Location OC on O'Hares Creek, Location BC on Bee Creek and Location WOT on Woronora Tributary (Figure 12). Baseline surveys of macroinvertebrates and macrophytes were conducted prior to the commencement of Longwall 23 (biannually from spring 2009 to spring 2013) for the additional Longwalls 23-27 stream monitoring sites at Location ET4 on the Eastern Tributary and Location B2 on Tributary B (Figure 12).

The monitoring parameters and methods are described in Table 4.

32 BACI (Before-After and Control-Impact) sampling is widely used in investigations of environmental impacts on mean abundance of a population.

33 The sampling of Location ET3 on the Eastern Tributary commenced in spring 2009.



LEGEND

- Mining Lease Boundary
- Railway
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 311-316 Secondary Extraction
- Longwalls 311-316 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 311-316 Secondary Extraction
- Existing Underground Access Drive (Main Drift)

Monitoring

- Pool Aquatic Ecology Sampling Site
- Stream Aquatic Ecology Sampling Site

Source: Land and Property Information (2015); Date of Aerial Photography 1998; Department of Industry (2015); Metropolitan Coal (2023); MSEC (2024)

Peabody

METROPOLITAN COAL

Aquatic Ecology Sampling Locations

Figure 12

Table 4
Stream Monitoring Parameters and Methods

Monitoring Parameter	Monitoring Methods
• Habitat Characteristics	Information on stream characteristics is recorded at each site in accordance with the AUSRIVAS protocol (Turak et al., 2004). Characteristics recorded include a visual assessment of stream width and depth, sequence of pools, runs and riffles (shallow areas with broken water), riparian conditions, signs of disturbance, water quality and percentage cover of the substratum by algae.
• Water Quality	A number of water quality variables are measured at each of the sampling sites prior to undertaking the biological sampling. Measurements of physico-chemical water quality are collected using a submersible data logger. Water quality measurements include electrical conductivity (μS/cm), dissolved oxygen (% Saturation and mg/L, pH, temperature (degrees Celsius [ºC]), turbidity (Neophlemetric Turbidity Units [NTU]) and oxygen reduction potential (millivolts [mV]). Alkalinity is determined in the field using a total alkalinity field kit. To test for total nitrogen (mg/L) and total phosphorus (mg/L), replicate samples are sent to a laboratory. The water quality measurements provide information relevant to water quality at the time of sampling.
• Aquatic Macroinvertebrates	Two methods are used to sample aquatic macroinvertebrates at each site: sampling using the AUSRIVAS protocol and quantitative sampling, as described below.
AUSRIVAS Sampling	To sample assemblages of macroinvertebrates in accordance with the AUSRIVAS protocol (Turak et al., 2004), samples of stream edge habitats are collected using a 250 μm dip net. Edge habitat is defined as areas along stream banks with little or no flow, including alcoves and backwaters, with abundant leaf litter, fine sediment deposits, beds of macrophytes, overhanging banks and areas with trailing vegetation (Turak et al., 2004). At each site (approximately 100 m long), samples are collected over a total length of 10 m, usually in 1 to 2 m sections, ensuring all significant edge sub-habitats within a site (i.e. macrophytes, over-hanging bank and vegetation, leaf-litter, pool rocks, logs) are included in the sample (Turak et al., 2004). The contents of each net sample are placed into a white sorting tray and animals are collected for a minimum period of 30 minutes. Thereafter, removals are carried out in 10 minute periods, up to a total of one hour (Turak et al., 2004). If no new taxa are found within a 10 minute period, removals cease (Turak et al., 2004). The animals collected are placed inside a labelled container and preserved with 70% alcohol. Samples are identified using a stereomicroscope. Taxa are identified to family level with the exception of Acarina (to order), Chironomidae (to sub-family), Nematoda (to phylum), Nemertea (to phylum), Oligochaeta (to class), Ostracoda (to subclass) and Polychaeta (to class). Some families of Anisoptera (dragonfly larvae) are identified to species, as they could potentially include threatened aquatic species.
Quantitative Sampling	Within each site, three replicate macroinvertebrate samples are collected using timed one minute sweeps of all habitats (edge, riffle, pools, etc.), using a 250 μm dip net. For each replicate sample, the contents of the net are placed into white plastic trays filled with fresh water and then placed into pre-labelled plastic sample containers filled with 70% alcohol. In the laboratory, animals are identified to family level with the exception of some families of Anisoptera (dragonfly larvae), which are identified to species, as they could potentially include threatened aquatic species.
• Aquatic Macrophytes	The distribution of floating-attached, submerged and emergent (occurring in-stream and in the riparian zone) macrophytes is estimated along each sampling location by assigning a cover class to each species. The cover classes are: (1) one plant or small patch (i.e few), (2) not common, growing in a few places (i.e. scattered), and (3) widespread (i.e. common). Within each site, an assessment of the aquatic vegetation (i.e. floating-attached, submerged and emergent) is made by estimating the relative abundance (i.e. percentage cover) of aquatic macrophytes within five haphazardly placed 0.25 m^2 quadrats, using a stratified sampling technique.

Pool Monitoring

A number of pools have been monitored historically (up until spring 2019) to assess the response of aquatic ecosystems to the implementation of potential future stream remediation works, namely (Figure 12):

- Larger pools (i.e. > 40 m in length) J, M1 and N on Waratah Rivulet and ETAH on the Eastern Tributary, overlying Longwalls 20-27.
- Smaller pools (i.e. < 40 m in length) K, L and M on Waratah Rivulet and ETAG, ETAI and ETAK on the Eastern Tributary, overlying Longwalls 20-27.
- One larger control pool on Woronora River (Pool WP) and one larger control pool on O'Hares Creek (Pool OC).
- Three smaller control pools on Woronora River (Pools WP-A, WP-B and WP-C) and three smaller control pools on O'Hares Creek (Pools OC-A, OC-B and OC-C).

Monitoring of the sampling sites was conducted biannually in spring (15 September to 15 December) and autumn (15 March to 15 June).

Sampling was conducted at two random sites within the larger pools and at one site within the smaller pools. Within each site in each pool, aquatic macroinvertebrates and macrophytes were sampled using the same quantitative techniques described in Table 4 for stream monitoring. Quantitative estimates of aquatic macrophytes (i.e. emergent, floating attached and/or submerged species of aquatic plants) were collected at one site at each small pool and at two sites at each large pool. In addition, the spatial distribution of floating attached and/or submerged macrophytes (i.e. *Myriophyllum pedunculatum* and *Triglochin procerum*) were also mapped in each pool on each sampling occasion to provide a visual comparison of their distribution through time. AUSRIVAS sampling techniques were not used for pool monitoring.

Baseline aquatic ecology surveys of macroinvertebrates and macrophytes were conducted biannually from spring 2008 or spring 2009[34] to autumn 2010 for Longwalls 20-22 pool monitoring at Pools J, K, L, M, M1 and N on Waratah Rivulet, Pools WP, WP-A, WP-B and WP-C on the Woronora River and Pools OC, OC-A, OC-B and OC-C on O'Hares Creek (Figure 12). Baseline surveys were also conducted prior to the commencement of Longwall 23 (biannually from spring 2009 to spring 2013) for Longwalls 23-27 pool monitoring at Pools ETAG, ETAH, ETAI and ETAK on the Eastern Tributary for comparison with Pools WP, WP-A, WP-B and WP-C on the Woronora River and Pools OC, OC-A, OC-B and OC-C on O'Hares Creek (Figure 12).

Monitoring Results to Date

The results of the Longwalls 20-22 and Longwalls 23-27 aquatic ecology monitoring programs (up to and including the spring 2022 survey) are summarised below.

Multivariate and univariate statistical procedures[35] are used to test whether there is evidence of significant change in aquatic macroinvertebrate and macrophyte indicators at selected locations and pools within areas subject to mining activities, in relation to Control (i.e. not subject to mining) locations or pools, before- versus after-commencement of mining.

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[34] The sampling of larger pools N on Waratah Rivulet, WP on Woronora River and OC on O'Hares Creek commenced in spring 2008. The sampling of larger pools J and M1 on Waratah Rivulet, and smaller pools K, L and M on Waratah Rivulet, WP-A to WP-C on Woronora River and OC-A to OC-C on O'Hares Creek commenced in spring 2009.

[35] Permutational Multivariate Analyses of Variance [PERMANOVA] and Plymouth Routines in Multivariate Ecological research [PRIMER] software packages.

Multivariate methods allow comparisons of two (or more) samples based on the degree to which these samples share particular species, at comparable levels of abundance (Clarke and Warwick, 1994). Principal Coordinates Analyses are used to present a graphical representation of relationships among samples. Similarity of percentages (SIMPER) are used to determine those taxa primarily responsible for the observed similarities (or dissimilarities) (Clarke, 1993).

Univariate analyses are used to examine the total number of taxa, total abundance and abundances of the most important taxonomic groups identified from the samples.

Stream Monitoring

To date (to spring 2022), multivariate analyses of the Longwalls 20-22 stream monitoring data have not detected significant changes in assemblages of aquatic macroinvertebrates or macrophytes at Locations ET1, ET2 and ET3 on the Eastern Tributary and at Locations WT3, WT4 and WT5 on the Waratah Rivulet before-versus-after mining, in relation to the control locations.

Univariate analyses have detected:

- a significant change in mean numbers of the freshwater shrimp family, Atyidae, at Location ET1 within the after-mining period in spring 2015, autumn 2022 and spring 2022, in relation to the control locations;
- a significant change in mean numbers of Atyidae at Location ET2 within the after-mining period in spring 2015, autumn 2021, spring 2021 and autumn 2022 but not in spring 2022, in relation to the control locations;
- a significant change in mean diversity of aquatic macroinvertebrates at Location WT3 within the after period in spring 2016, autumn 2018 and subsequent surveys; and
- a significant decline in mean abundance of Atyidae at WT3 within the after-period in spring 2021, autumn 2022 and spring 2022.

Multivariate analyses of the Longwalls 23-27 stream monitoring data have detected:

- a significant before-versus-after mining change in the structure of the aquatic macroinvertebrate assemblage at Location ET2 since spring 2019;
- a significant before-versus-after mining change in the structure of assemblages of macrophytes at Location ET1 since spring 2019; and
- a significant change in the structure of assemblages of macrophytes at Location ET2 within the after period since autumn 2021.

Univariate analyses of the Longwalls 23-27 stream monitoring data indicate:

- a significant decrease in mean numbers of the freshwater shrimp family, Atyidae, within the after-mining period between autumn 2016 and autumn 2018, autumn 2020, spring 2020, autumn 2021 and spring 2021, but not subsequently (i.e., autumn and spring 2022) at Location ET2;
- a significant change in mean diversity of macroinvertebrates at Location ET4 between autumn 2018 and spring 2022; and
- a significant change in mean numbers of Atyidae in relation to control locations in autumn 2016, spring 2018, spring 2019 and autumn 2020 at Location ET4, but not subsequently.

A considerable drop in water level was noted in a large pool at Location B1 on Tributary B in spring 2012. By autumn 2013, the pool had almost completely emptied and there was no surface flow along the study reach due to subsidence associated with mining of the Longwalls 20-22 underground mining area. Quantitative sampling of aquatic macroinvertebrates has not been carried out at Location B1 on Tributary B in spring 2013, or since spring 2014 due to insufficient habitat available for sampling.

Past analyses examining patterns of change in the assemblage of aquatic macroinvertebrates and key components at Location B1 on Tributary B in relation to control locations found evidence of impacts related to mining activities within the Longwalls 20-22 underground mining area. Analyses indicate that the assemblage of macrophytes at Location B1 have experienced a degree of environmental stress since spring 2012 as a result of mining activities within the Longwalls 20-22 underground mining area.

Since spring 2016, subsidence associated with extraction of Longwalls 23-27 appears to have impacted aquatic indicators at Location B2. These impacts include evidence of a reduction in availability and quality of aquatic habitat and significant changes in numbers of Leptophlebiidae and Atyidae. To date, no changes to aquatic macrophyte indicators have been evident.

The aquatic ecology subsidence impact performance indicator: *The aquatic macroinvertebrate and macrophyte assemblages in streams are not expected to experience long-term impacts as a result of mine subsidence* has been exceeded at Location B1 and Location B2 on Tributary B. Assessments have also been made against the biodiversity subsidence impact performance measure, *Negligible impact on threatened species, populations, or ecological communities.* The assessments against the biodiversity performance measure have been conducted in relation to threatened terrestrial flora and fauna; there are no threatened aquatic fauna or flora known, or considered likely to occur (Eco Logical, 2017b; Cenwest Environmental Services, 2017) and both concluded that the subsidence impact performance measure has been met.

<u>Pool Monitoring</u>

Monitoring of large and small pools on the Waratah Rivulet (large pools J, M1 and N; small pools K, L and M) and Eastern Tributary (large pool ETAH; small pools ETAG, ETAI and ETAK) (i.e. the pool monitoring) was established to monitor the response of aquatic ecosystems to the implementation of future potential stream remediation works.

Up until the most recent survey (i.e., spring 2019), Pools J, K, L, M and M1 on the Waratah Rivulet had not been impacted by mine subsidence (Figure 12). Pool N was impacted by mine subsidence in September 2012, however has overflowed its rock bar since December 2014, with the exception of January/February 2017 and within the period January to May 2018 (Metropolitan Coal, 2021).

Multivariate data analyses for Pools J, K, L, M1, M and N on the Waratah Rivulet have found no evidence to suggest that assemblages of aquatic macroinvertebrates or macrophytes have changed significantly before- vs after-mining of the Longwalls 20-22 mining area in relation to the control pools.

Univariate analyses of data collected in pools on the Waratah Rivulet between spring 2008 and spring 2019 found:

- a significant increase in mean diversity of macroinvertebrates in Pool J (from autumn 2015 to autumn 2017) and Pool M1 (from autumn 2015 to autumn 2018) within the after-mining period in relation to the control pools;
- mean cover of macrophytes appears to have decreased significantly at Pool M1 in relation to the control pools, and the diversity of macrophytes at Pool M1 has become significantly more variable in relation to control pools, within the after-mining period since autumn 2016;

- the diversity of macrophytes appears to have decreased significantly at Pool N within the after period (since autumn 2016); and
- mean diversity of aquatic macroinvertebrates in Pools K, L and M has changed significantly in relation to the control locations since autumn 2015 as a result of a small increase in diversity in the Waratah Rivulet pools within the after-mining period, but little change within the control pools.

In December 2016 and January 2017, a number of pools on the Eastern Tributary downstream of the Longwall 26 maingate (including Pools ETAG, ETAH, ETAI and ETAK) experienced loss of pool water levels as a result of mine subsidence. This resulted in the negligible environmental consequences performance measure for the Eastern Tributary watercourse being exceeded in relation to the diversion of flows and drainage behaviour component. Stream remediation has been triggered for the Eastern Tributary.

4.2.3.2 Assessment of Monitoring Results against Predicted Subsidence Impacts and Environmental Consequences

The key potential subsidence impacts and environmental consequences for streams described in the Project EA, Preferred Project Report and Metropolitan Coal BMPs are described in Section 4.1.1.

Potential environmental consequences include impacts on aquatic habitats (e.g. alteration of hydrology, pool habitat, in-stream connectivity and water quality), and on biodiversity (e.g. aquatic macrophytes, macroinvertebrates, fish and riparian vegetation).

In summary, the key potential environmental consequences described in the Project EA, Preferred Project Report, and Metropolitan Coal BMPs include:

- Changes in stream flows as a result of fracturing of bedrock and the consequent diversion of a portion of the total stream flow as underflow. The effects of underflow would be most noticeable during periods of low flow and on the frequency of no flow, while the effects on the frequency and magnitude of high flows would likely be negligible.
- Changes in pool water levels and in-stream connectivity – underflow has been observed to result in lower water levels in pools as they become hydraulically connected with the fracture network. During prolonged dry periods when flows recede to low levels, the number of instances where loss of flow continuity between pools occurs increases with a greater proportion of these lower flows being conveyed entirely in the subsurface fracture network.
- Impacts on water quality following cracking of the stream bed that can reduce the quality of habitat for aquatic biota (e.g. generation of iron flocculent material).
- Minor stream bank erosion, where changes in channel gradients result in increases in flow energy.
- Impacts on aquatic macrophyte plants (e.g. as a result of changes in hydrology described above) resulting in exposure and desiccation or smothering of plants by iron flocculent material. Aquatic macrophytes have evolved reproductive strategies to cope with the variable nature of flow in streams and wetlands within Australia. Obligate water plants generally require permanent water; however, they can recolonise once water becomes available again.
- Localised impacts on aquatic macroinvertebrates (as a result of the changes in aquatic habitat/hydrology described above). The Project is unlikely to have any significant long-term impacts on assemblages of macroinvertebrates.
- The conveyance of surface water flows to sub-surface fractures in the area affected by subsidence has the potential to reduce available habitat for fish (e.g. aquatic macrophytes, pools) and connectivity among sections of the stream channel, impeding fish passage.

The results of aquatic ecology monitoring for Longwalls 20-22 and Longwalls 23-27 are considered to be consistent with the potential subsidence impacts and environmental consequences described in the Project EA, Preferred Project Report and the Metropolitan Coal Water Management Plans and BMPs. However, the subsidence impacts on Locations C1 and C2 on the Eastern Tributary, and Pools K, L, M, M1 and N on the Waratah Rivulet, have triggered assessments against the biodiversity subsidence impact performance measure, *Negligible impact on threatened species, populations, or ecological communities*. Threatened flora and fauna assessments prepared by Ecoplanning (2020b, 2021b) and Cenwest Environmental Services (2020, 2021a) have concluded that the subsidence impact performance measures have been met.

Subsidence impacts on Tributary B have resulted in no surface flow along the stream in the vicinity of Location B1 for an extended period of time. This change in aquatic habitat/hydrology has resulted in long term impacts to the aquatic macroinvertebrate assemblage at this location (Location B1) and downstream at Location B2. Assessments have been made against the biodiversity subsidence impact performance measure, *Negligible impact on threatened species, populations or ecological communities*, by Eco Logical (2017b) and Cenwest Environmental Services (2017) and concluded the subsidence impact performance measure has been met.

4.2.4 Terrestrial Fauna and their Habitats

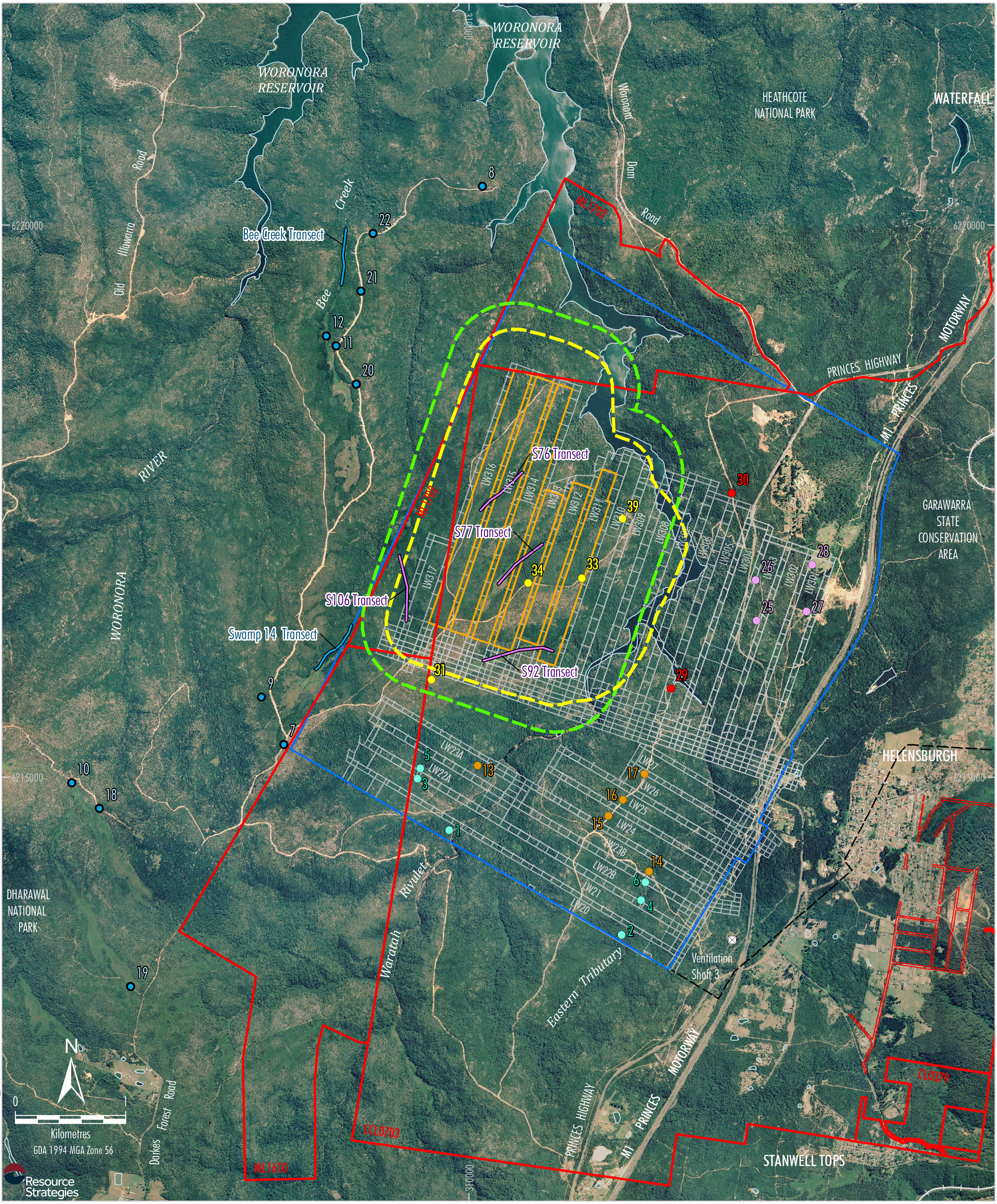
Amphibians were selected as the appropriate representative of terrestrial vertebrate fauna because they were/are widespread across the Project area at the time of monitoring program design, including three threatened species that are sensitive to changes in surface hydrology, and because this group is represented by at least 14 species that appear to have viable populations.

Amphibian monitoring programs have been implemented annually in spring/summer for Longwalls 20-22 (2009 – 2022), Longwalls 23-27 (2010 – 2022), Longwalls 301-307 (2015 – 2022) Longwalls 308-317 (2019 – 2022). Fifteen amphibian species have been monitored including three threatened species: the Giant Burrowing Frog (*Heleioporus australiacus*), Red-crowned Toadlet (*Pseudophryne australis*) and Littlejohn's Tree Frog (*Litoria littlejohni*).

Six test sites overlying Longwalls 20-22 (sites 1-6), five test sites overlying Longwalls 23-27 (sites 13-17), eight test sites overlying Longwalls 301-307 (sites 23-30) and eleven control sites (sites 7-12 and 18-22) are surveyed annually in spring/summer (i.e. October to February) during suitable weather conditions. Nine additional sites were added to the amphibian monitoring program in spring/summer 2019, located in the vicinity of Longwalls 308-317 (sites 31 to 39). Two six-day survey periods are utilised for each spring/summer survey, typically over the periods October to December and January to February. Separation of the two survey events optimises the likelihood of observing breeding events. In some years the second survey has occurred as late as March/April due to the absence of suitable survey conditions.

Each site is surveyed once during a standard 30 minute general area day search (early morning and late afternoon) supplemented by an evening 30 minute search/playback session using hand-held spotlights and head lamps.

Four additional sites were surveyed in spring/summer 2023 (i.e. one site within each of Swamps 76 and 77 and two sites located within Swamp 92), overlying Longwalls 311-316. Baseline monitoring was undertaken at each site on two occasions during suitable weather conditions. On each sampling occasion, each site was surveyed once during a standard 30 minute general area day search, supplemented by deployment of a song-meter at each site for a minimum of 1 night. Searches for Giant Dragonfly (*Patalura gigantea*) was also carried out.



MET-23-33 LW311-316 EP BMP_212C

LEGEND

- Mining Lease Boundary
- Railway
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 311-316 Secondary Extraction
- Longwalls 311-316 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 311-316 Secondary Extraction
- Existing Underground Access Drive (Main Drift)

Monitoring Sites

- Longwalls 20-22 Amphibian Monitoring Site
- Longwalls 23-27 Amphibian Monitoring Site
- Longwalls 301-303 Amphibian Monitoring Site
- Longwalls 305-307 Amphibian Monitoring Site
- Longwalls 308-317 Amphibian Monitoring Site
- Longwalls 311-316 Amphibian Monitoring Transect
- Control Site
- Control Transect

Note: Swamp 76 and 106 would be used as a control swamp until such time that subsidence effects are greater than negligible (to be determined by MSEC), at which time, it would become a test (impact) site

Source: Land and Property Information (2015); Date of Aerial Photography 1998; Department of Industry (2015); Metropolitan Coal (2023); MSEC (2024)

Peabody

METROPOLITAN COAL

Amphibian Monitoring Locations

Figure 13

The control sites for Longwalls 301-307 and Longwalls 308-317 consist of the eleven existing sites associated with Longwalls 20-22 and Longwalls 23-27. The approximate locations of the monitoring sites are shown on Figure 13. Site selection was biased towards optimising the detection of the two threatened species, the Giant Burrowing Frog and Red-crowned Toadlet at the commencement of the monitoring program.

Species are assigned to the following relative abundance categories for tadpole and adult stages:

- 0 = no sightings;
- 1 = one sighting of adult or tadpole stage;
- UC = uncommon (i.e. 2 to 10 individuals), adult or tadpole stage;
- MC = moderately common (i.e. 11 to 20 individuals), adult or tadpole stage;
- C = common (i.e. 21 to 40 individuals), adult or tadpole stage; and
- A = abundant (> 40 individuals), adult or tadpole stage.

Baseline monitoring was conducted in spring/summer 2009 and 2010 for Longwalls 20-22, in spring/summer 2010 to 2013 for Longwalls 23-27 and in spring/summer 2015 and 2016 for Longwalls 301-303, with two additional survey sites added during the spring/summer 2018 survey. Baseline monitoring for Longwalls 308-317 was conducted in spring/summer 2019.

The Littlejohn's Tree Frog was recorded for the first time during the spring/summer 2016 survey at site 24 during baseline monitoring for Longwalls 301-307. Metropolitan Coal commissioned a targeted survey for the Littlejohn's Tree Frog to be carried out in August or September 2017 when adult calling was likely to be at its peak under wet conditions to determine the status of the species within the Project area. However, the dry weather conditions experienced in August and September 2017 did not provide suitable weather conditions for the conduct of the targeted survey and the survey was postponed until 2018.

The spring/summer 2017 amphibian survey recorded the Littlejohn's Tree Frog at control sites 10 and 18 and test site 24.

The dry weather conditions in 2018 meant the targeted survey described above was not able to be conducted until late October to early November 2018, following rain. The survey was not able to be completed as the catchment was closed due to fire risk. The survey recorded the Littlejohn's Tree Frog at control sites 7 and 18, and at test site 13 (Figure 13).

The spring/summer 2018 amphibian survey recorded the Littlejohn's Tree Frog at control sites 10 and 21 (Figure 13). No evidence of breeding has been observed at all test and control sites for this species during surveys to date.

Subsidence impacts have been observed at a number of test sites including stream flow diversion to subterranean flows under low flow conditions, in-stream rock cracking, loss of pool numbers and/or persistence under low flow conditions, and iron staining/bacterial mats.

The data gathered since 2009 is non-normally distributed and characterised by significant occurrences of zero data. Such data require non-normal analysis to determine if potential adverse impacts are significant at the 95% confidence level. Poisson regression analysis has been used to analyse the amphibian survey results. The four datasets (Longwalls 20-22, 23-27, 301-307 and 308-317) have been analysed together to increase the resolution of the analysis.

Data gathered from 2009 – 2021, indicated no adverse impact from mining had been detected for the amphibian assemblage at the 95% confidence level based on abundance and diversity measures for Longwalls 20-22, 23-27, 301-307 and 308-317, including the Giant Burrowing Frog, the Red-crowned Toadlet and Littlejohn's Tree Frog.

The spring/summer 2022 amphibian surveys determined that there are significant differences between test and control sites at the 95% confidence level for Longwalls 20-22, 23-27, 301-307 and 308-317. Thus, the performance indicator had been exceeded.

The performance indicator refers to the amphibian assemblage (17 amphibian populations) as a whole. Hence whilst an exceedance has been observed, it is not possible to determine which species have been impacted by mining, nor can it be determined if the three threatened species have been adversely impacted. It is possible that the 2022 analysis finding is an aberration (Cenwest, 2024). Cenwest (2024) recommends that the 2023 amphibian monitoring data is collected and analysed before determining a response (if any). The 2023 field work is not yet completed, and the analysis is likely to be completed later in 2024. If the adverse findings in this report are repeated than this would likely confirm the 2022 analysis.

It is understood that BCS has conducted threatened amphibian surveys during 2023 and 2024 in the Longwalls 311-316 area and surrounds (including Honeysuckle Creek) (BCS, 2024). While the specific details of the survey efforts and extent is not provided in BCS (2024), Littlejohn's Tree Frog was identified and Red-crowned Toadlet were identified within the Longwalls 311-316 35° angle of draw and/or 20 mm subsidence contour. A number of records of Giant Burrowing Frog and a Littlejohn's Tree Frog were also recorded along Honeysuckle Creek to the west of the Longwalls 311-316 35° angle of draw and/or 20 mm subsidence contour (i.e. outside of the impact area of the Longwalls 311-316 Extraction Plan).

Furthermore, it is understood that BCS has conducted Giant Dragonfly surveys recently in the Longwalls 311-316 area and surrounds (including Honeysuckle Creek). While there are no details of the survey efforts and extent is not provided in BCS (2024), recent data from these surveys (available on the BioNet database), indicates that Giant Dragonfly has been identified via eDNA analysis downstream of Swamp 14 (within Honeysuckle Creek) on 30 April 2024. The location of the water sample (and upstream catchment) is not within 600 m of Longwalls 311-316 and, therefore, would not be subject to any subsidence effects/impacts.

4.2.4.1 Assessment of Monitoring Results against Predicted Subsidence Impacts and Environmental Consequences

A Poisson regression analysis has been used to analyse the amphibian survey results obtained to spring/summer 2022. The monitoring results are consistent with the predictions described in the Project EA, Preferred Project Report, and Metropolitan Coal BMPs, specifically, that it is unlikely that any vertebrate population would be put at risk by the Project.

4.2.5 Threatened Flora and Fauna

A number of threatened flora and fauna species listed under the NSW *Biodiversity Conservation Act 2016* (BC Act) or Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) are known to occur, or have the potential to occur within the Project underground mining area or surrounds.

Appendix 1 shows the Threatened Flora and Fauna Species Records. Figure 1-1 in Appendix 1 shows the location of threatened flora recorded by Bangalay Botanical Surveys (2008), FloraSearch (2008; 2009) and Eco Logical (2010 – 2018) in the Project underground mining area and surrounds. Figure 1-2 in Appendix 1 shows the location of threatened fauna recorded by Western Research Institute and Biosphere Environmental Consultants (2008) and Cenwest Environmental Services (2008 – 2018) in the Project underground mining area and surrounds. No threatened aquatic biota listed under the *Fisheries Management Act 1994*, BC Act or EPBC Act has been recorded within the Project underground mining area or in the Woronora Reservoir.

In relation to threatened flora and fauna, the Project was considered unlikely to have a significant effect on threatened flora or fauna (Appendix G of the Project EA). No endangered flora or fauna populations that were listed under the *Threatened Species Conservation Act* 1995 (TSC Act) at the time of Project Approval occur within the Project underground mining area or surrounds. Endangered Ecological Communities (EECs) listed under the TSC Act at the time of Project Approval and identified as occurring in the Project underground mining area or surrounds includes the Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC (Map Unit 5a) and the O'Hares Creek Shale Forest EEC (Map Units 5b and 5r) (Figure 10).

Coastal Upland Swamp in the Sydney Basin Bioregion was listed as an EEC under the TSC Act in March 2012 which post-dates the Project Approval. The predicted impacts to this community were assessed in the Project EA and subsequently approved by the Project Approval in 2009.

A research program, *Conservation of the Eastern Ground Parrot on the Woronora Plateau*, funded by Metropolitan Coal was conducted by the OEH. The research program involved a targeted survey for the Eastern Ground Parrot (*Pezoporus wallicus wallicus)* (classified as Vulnerable under the BC Act) and the establishment of a network of bio-acoustic monitoring stations (35 sites) in 2013. A total of 588 days and approximately 3,000 hours of data were recorded from the stations, however, no Eastern Ground Parrots were detected. Spot checks of recordings from a range of sites, confirmed the recogniser was performing accurately (i.e. no Eastern Ground Parrot calls).

The results of the research program were considered by OEH to indicate that Eastern ground Parrots are not likely to be resident on the Woronora Plateau. The occasional records of single parrots on the Woronora Plateau in the past ten years suggest isolated birds are dispersing through the area and are not part of a larger resident population[36].

[36] This description is based on OEH's reporting to Metropolitan Coal on the status of the research program for inclusion in the *Metropolitan Coal 2014 Annual Review and Annual Environmental Management Report/Rehabilitation Report* (Metropolitan Coal, 2015).

5 REVISED ASSESSMENT OF POTENTIAL ENVIRONMENTAL CONSEQUENCES

5.1 LONGWALLS 311-316 EXTRACTION LAYOUT

Longwalls 311-316 and the area of land within 600 m of Longwalls 311-316 secondary extraction are shown on Figures 1 and 2. Longwall extraction will occur from north to south. The layout of Longwalls 311-316 includes 163 m and 138 m panel widths (void) and 45 m and 70 m pillar widths (solid). As the mine progresses west of the reservoir it will transition to 163 m panel widths, with 138 m panel widths remaining at the northern commencing ends beneath the reservoir.

The provisional extraction schedule for Longwalls 311-316 is provided in Table 5.

Table 5
Provisional Extraction Schedule

Longwall	Estimated Start Date	Estimated Duration	Estimated Completion Date
Longwall 311	October 2024	8 Months	June 2025
Longwall 312	July 2025	6 Months	December 2025
Longwall 313	January 2026	5 Months	June 2026
Longwall 314	August 2026	9 Months	June 2027
Longwall 315	July 2027	8 Months	March 2028
Longwall 316	April 2028	8 Months	December 2028

The total cumulative predicted subsidence effects, subsidence impacts and/or environmental consequences at the completion of the Project are considered in the Project EA and Preferred Project Report, and the cumulative subsidence effects, subsidence impacts and environmental consequences will be assessed in future Extraction Plans.

5.2 ENVIRONMENTAL RISK ASSESSMENT

An Environmental Risk Assessment (ERA) was conducted for four of the key component plans of the Metropolitan Coal Longwalls 311-316 Extraction Plan[37] *viz.* Water Management Plan, Land Management Plan, Heritage Management Plan and this BMP to give appropriate consideration to risk assessment and risk management in accordance with the DPE (2022) *Extraction Plan Guideline*.

The suitably qualified and experienced experts endorsed by the Secretary of the DPE for the preparation of the Metropolitan Coal Longwalls 311-316 Extraction Plan participated in the ERA[38]. The ERA process involved the key steps described below.

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37 A risk assessment has been undertaken separately in relation to the Metropolitan Coal Longwalls 311-316 Public Safety Management Plan.

38 Participants included Mr Peter DeBono (MSEC, Subsidence and Land), Ms Ines Epari (SLR Consulting, Groundwater), Mr Anthony Marszalek and Dr Camilla West (ATC Williams, Surface Water), Associate Professor Barry Noller (The University of Queensland, Surface Water Quality), Dr Sharon Cummins (Bio-Analysis, Aquatic Fauna), Ms Elizabeth Norris (Ecoplanning, Flora), Mr Jamie Reeves (Niche Environment and Heritage, Heritage), Mr Jon Degotardi (Metropolitan Coal), Mr Stephen Love (Metropolitan Coal), Mr Nicolas Tucker (Metropolitan Coal), Mr Jamie Warwick (Resource Strategies) and Ms Harper Mulloy (Resource Strategies) and Ms Abigail Ashford (Resource Strategies).

Review of Relevant Documentation and Risk Identification

In preparation for the ERA workshop, the ERA participants reviewed a number of documents relevant to the risk assessment. This included (but was not limited to):

- The 2008 *Environmental Risk Analysis* (SP Solutions, 2008) conducted for the Project EA (Appendix O of the Project EA).
- The Preferred Project Report (HCPL, 2009). During the NSW Government's assessment phase of the Project EA, and in recognition of concerns raised by key stakeholders during the formal Planning Assessment Commission (PAC) assessment process, HCPL considered it appropriate to reduce the proposed extent of the original Project longwall mining area (i.e. Longwalls 20-44). This reduction in the extent of longwall mining resulted in a significant reduction to the extent of potential subsidence effects to the Waratah Rivulet and the Eastern Tributary and a reduction in the consequential potential environmental impacts.
- The Longwalls 308-310 Environmental Risk Assessment Report (Risk Mentor, 2021) (which included consideration of the Longwalls 301-303, Longwall 304, Longwalls 305-307 and Longwalls 308-310 Environmental Risk Assessment Reports).
- Figures showing the Longwalls 311-316 layout in relation to key surface features.
- Subsidence predictions for Longwalls 311-316 (including subsidence contours, Eastern Tributary, Waratah Rivulet, Woronora Reservoir, other streams, cliff sites, upland swamps and Aboriginal heritage sites).

The participants were asked to identify any additional (specific) issues/risks and/or changes to previously assessed levels of risk in preparation for the ERA workshop.

ERA Workshop

The ERA workshop for Longwalls 311-316 was conducted on 18 August 2023, with some participants attending via video conferencing and others attending in person at the Metropolitan Coal Mine. The ERA workshop was facilitated by an independent specialist, Dr Peter Standish of Risk Mentor and conducted in accordance with Australian Standard/New Zealand Standard ISO 31000: *2009 Risk Management – Principles and Guidelines.*

The general consensus of the workshop participants was the additional (specific) issues/risks identified for Longwalls 311-316 were broadly assessed and ranked as part of the 2008 Environmental Risk Analysis, Longwalls 301-303, Longwall 304, Longwalls 305-307 and/or Longwalls 308-310 ERAs. However, additional (specific) issues were identified by the workshop participants relevant to Longwalls 311-316. Each of the issues/risks were explained systematically by the relevant workshop participants and each carefully reviewed.

Loss scenarios for the key potential environmental issues were identified for upland swamps, aquatic biota, threatened amphibians, Waratah Rivulet and the Woronora Reservoir. The risk rankings are within the "low-medium" range and consequently the potential outcomes can be integrated into the existing management systems for effective review and monitoring.

ERA Report Review

All ERA participants were asked to review the draft Longwalls 311-316 ERA report that was prepared to summarise the outcomes of the risk assessment. Participants' comments were incorporated into the final Risk Mentor (2023) report.

This BMP has been prepared to provide for effective management of the identified subsidence risks.

5.3 UPLAND SWAMPS

Upland swamps located within 600 m of Longwalls 311-316 secondary extraction are shown on Figure 14a. Thirty-nine (39) upland swamps[39] are located within the Longwalls 311-316 35° angle of draw and/or predicted 20 mm subsidence contour (Swamps 74, 75, 76, 77, 78a, 78b, 79, 80, 81, 82, 83, 84, 86, 88, 89a, 89b, 90a, 90b, 91, 92, 105, 106, 107, 108, 113, 114, 115, 116, 117, 118, 119, 121, 127 128, 129, 130, 131, 132 and 139), and an additional fifteen swamps (Swamps 14, 93, 94, 102, 103, 104, 109, 120, 122, 123, 124, 125a, 126a, 126b and 126c) are located within 600 m of Longwalls 311-316 (Figure 14a).

5.3.1 Revised Subsidence Predictions

The maximum predicted subsidence parameters for swamps located within the Longwalls 311-316 35° angle of draw and/or predicted 20 mm subsidence contour have been prepared by MSEC (2024). Table 6 compares the revised subsidence predictions for the Longwalls 311-316 Extraction Plan layout with the subsidence predictions for the Preferred Project Layout at the completion of Longwall 316.

The maximum subsidence predictions for swamps for the Longwalls 311-316 Extraction Plan layout indicate (Tables 6 and 7):

- Maximum predicted average tilt[40] of greater than 5.0 mm/m in Swamps 88, 89a, 89b, 91 and 92 (the remaining 33 swamps have predicted tilts of 4.5 mm/m or less). A maximum predicted average tilt of 5.0 mm/m was predicted for the Preferred Project Layout after Longwall 316.
- Maximum predicted hogging curvature[41] for the 39 swamps ranges from < 0.01 to 0.06 km^{-1} (corresponding conventional tensile strains range from < 0.5 to 1.0 mm/m). A maximum predicted hogging curvature of 0.05 km^{-1} and maximum predicted conventional tensile strain of 1.0 mm/m were predicted for the Preferred Project Layout after Longwall 316.
- Maximum predicted sagging curvature[41] for the 39 swamps ranges from < 0.01 to 0.08 km^{-1} (corresponding conventional compressive strains range from < 0.5 to 1.0 mm/m). A maximum predicted sagging curvature of 0.08 km^{-1} and maximum predicted conventional compressive strain of 1.5 mm/m were predicted for the Preferred Project Layout after Longwall 316.
- A few swamps could experience valley closure[42] movements as a result of their position in the landscape (i.e. those near to drainage lines). Valley closure movements at these swamps range from less than 20 mm to 325 mm, and the associated valley closure strains at these swamps are less than or equal to 11 mm/m.

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39 Following a review of the swamp vegetation mapping, swamp extents have been revised (including splitting of swamps into multiple individual sub-swamps).

40 Tilt is the change in the slope of the ground as a result of differential subsidence, and is calculated as the change in subsidence between two points divided by the distance between those points.

41 Curvature is the second derivative of subsidence, the rate of change of tilt and is calculated as the change in tilt between two adjacent sections of the tilt profile divided by average length of those sections.

42 Closure is the reduction in the horizontal distance between the valley sides.

Table 6
Revised Maximum Subsidence Predictions for Upland Swamps – Subsidence, Tilt and Curvature

Swamp[1]	Maximum Predicted							
	Subsidence[2] (mm)		Tilt[3] (mm/m)		Hogging Curvature[4] (km^{-1})		Sagging Curvature[4] (km^{-1})	
	PPL (LW316)[5]	EPL (LW316)[6]	PPL (LW316)[5]	EPL (LW316)[6]	PPL (LW316)[5]	EPL (LW316)[6]	PPL (LW316)[5]	EPL (LW316)[6]
S74	40	150	< 0.5	1.5	< 0.01	0.02	< 0.01	< 0.01
S75	175	750	2.0	4.5	0.03	0.04	< 0.01	0.04
S76	975	1250	4.5	3.5	0.04	0.04	0.07	0.04
S77	1150	1450	2.5	4.0	0.04	0.04	0.07	0.04
S78a	1100	1450	3.5	2.0	0.05	0.04	0.07	0.05
S78b	1050	1450	3.5	2.0	0.05	0.04	0.08	0.05
S79	1150	1500	1.5	1.5	0.04	0.04	0.07	0.05
S80	1050	1450	3.5	2.0	0.05	0.03	0.08	0.05
S81	825	1450	2.5	2.0	0.05	0.03	0.06	0.05
S82	600	1300	1.5	3.0	0.04	0.04	0.06	0.05
S83	825	1350	2.5	2.0	0.05	0.03	0.06	0.02
S84	475	700	1.0	1.0	0.04	0.01	0.06	0.02
S86	500	925	1.5	2.0	0.04	0.02	0.06	0.05
S88	450	475	2.5	5.5	0.02	0.06	0.05	0.02
S89a	825	1450	3.0	6.5	0.05	0.03	0.06	0.06
S89b	1050	1200	3.5	6.5	0.05	0.03	0.08	0.04
S90a	1050	1500	1.0	1.5	0.03	0.04	0.08	0.05
S90b	1000	1450	3.5	1.5	0.05	0.03	0.07	0.05
S91	1100	1050	2.0	6.0	0.03	0.02	0.04	0.04
S92	1000	975	5.0	7.0	0.04	0.06	0.07	0.04
S105	< 20	< 20	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01
S106	175	50	2.0	0.5	0.03	< 0.01	< 0.01	< 0.01
S107	600	150	4.0	2.0	0.04	0.02	0.03	< 0.01
S108	550	100	3.5	1.5	< 0.01	0.01	0.03	< 0.01

Table 6 (Continued)
Revised Maximum Subsidence Predictions for Upland Swamps – Subsidence, Tilt and Curvature

Swamp[1]	Maximum Predicted							
	Subsidence[2] (mm)		Tilt[3] (mm/m)		Hogging Curvature[4] (km^{-1})		Sagging Curvature[4] (km^{-1})	
	PPL (LW316)[5]	EPL (LW316)[6]	PPL (LW316)[5]	EPL (LW316)[6]	PPL (LW316)[5]	EPL (LW316)[6]	PPL (LW316)[5]	EPL (LW316)[6]
S113	225	175	2.0	2.0	0.03	0.02	< 0.01	< 0.01
S114	450	325	4.5	3.0	0.05	0.02	< 0.01	< 0.01
S115	300	275	3.5	2.5	0.05	0.02	< 0.01	< 0.01
S116	20	< 20	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01
S117	50	30	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01
S118	< 20	< 20	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01
S119	125	150	1.0	1.5	< 0.01	0.02	< 0.01	< 0.01
S121	< 20	< 20	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01
S127	< 20	< 20	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01
S128	30	250	< 0.5	3.0	< 0.01	0.03	< 0.01	< 0.01
S129	< 20	40	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01
S130	60	525	0.5	4.0	< 0.01	0.03	< 0.01	0.03
S131	< 20	<20	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01
S132	< 20	<20	< 0.5	<0.5	< 0.01	<0.01	< 0.01	< 0.01
S139	950	1150	2.5	4.0	0.04	0.04	0.07	0.08

Source: after MSEC (2024). mm = millimetres; mm/m= millimetres per metre; km^{-1} =1/kilometres

Swamps overlying Longwalls 311-316.

1 Swamps within the Longwalls 311-316 35° angle of draw and/or predicted 20 mm subsidence contour.

2 Subsidence refers to vertical displacements of the ground.

3 Tilt is the change in the slope of the ground as a result of differential subsidence, and is calculated as the change in subsidence between two points divided by the distance between those points.

4 Curvature is the second derivative of subsidence, the rate of change of tilt and is calculated as the change in tilt between two adjacent sections of the tilt profile divided by average length of those sections.

5 PPL (LW316) – after completion of Longwall 316 of the Preferred Project Layout.

6 EPL (LW316) – after completion of Longwall 316 of the Extraction Plan Layout (i.e. Longwalls 311-316 subject of this BMP).

Table 7
Revised Maximum Subsidence Predictions for Upland Swamps – Tensile and Compressive Strain, Upsidence and Closure

Swamp[1]	Maximum Predicted							
	Conventional Tensile Strain[2] (mm/m)		Conventional Compressive Strain[2] (mm/m)		Upsidence[3] (mm)		Closure[4] (mm)	
	PPL (LW316)[5]	EPL (LW316)[6]	PPL (LW316)[5]	EPL (LW316)[6]	PPL (LW316)[5]	EPL (LW316)[6]	PPL (LW316)[5]	EPL (LW316)[6]
S74	< 0.5	< 0.5	< 0.5	< 0.5	-	-	-	-
S75	< 0.5	1.0	< 0.5	1.0	-	-	-	-
S76	1.0	1.0	1.5	1.0	200	150	125	125
S77	1.0	0.5	1.5	0.5	325	325	325	325
S78a	1.0	1.0	1.5	1.0	-	-	-	-
S78b	1.0	1.0	1.5	1.0	-	-	-	-
S79	1.0	1.0	1.5	1.0	-	-	-	-
S80	1.0	<0.5	1.5	1.0	-	-	-	-
S81	1.0	1.0	1.0	1.0	50	70	40	40
S82	1.0	1.0	1.0	1.0	225	250	175	200
S83	1.0	< 0.5	1.0	< 0.5	-	-	-	-
S84	1.0	< 0.5	1.0	< 0.5	-	-	-	-
S86	1.0	< 0.5	1.0	1.0	-	-	-	-
S88	< 0.5	1.0	1.0	< 0.5	-	-	-	-
S89a	1.0	< 0.5	1.0	1.0	-	-	-	-
S89b	1.0	< 0.5	1.5	1.0	-	-	-	-
S90a	< 0.5	1.0	1.5	1.0	40	60	30	30
S90b	1.0	< 0.5	1.5	1.0	50	40	30	30
S91	< 0.5	< 0.5	1.0	1.0	-	-	-	-
S92	1.0	1.0	1.5	1.0	200	225	125	100
S105	< 0.5	< 0.5	< 0.5	< 0.5	-	-	-	-
S106	< 0.5	< 0.5	< 0.5	< 0.5	< 20	< 20	< 20	< 20
S107	1.0	< 0.5	1.0	< 0.5	-	-	-	-
S108	< 0.5	< 0.5	< 0.5	< 0.5	-	-	-	-

Table 7 (Continued)
Revised Maximum Subsidence Predictions for Upland Swamps – Tensile and Compressive Strain, Upsidence and Closure

Swamp[1]	Maximum Predicted							
	Conventional Tensile Strain[2] (mm/m)		Conventional Compressive Strain[2] (mm/m)		Upsidence[3] (mm)		Closure[4] (mm)	
	PPL (LW316)[5]	EPL (LW316)[6]	PPL (LW316)[5]	EPL (LW316)[6]	PPL (LW316)[5]	EPL (LW316)[6]	PPL (LW316)[5]	EPL (LW316)[6]
S113	< 0.5	< 0.5	< 0.5	< 0.5	-	-	-	-
S114	1.0	< 0.5	< 0.5	< 0.5	-	-	-	-
S115	1.0	< 0.5	< 0.5	< 0.5	-	-	-	-
S116	< 0.5	< 0.5	< 0.5	< 0.5	-	-	-	-
S117	< 0.5	< 0.5	< 0.5	< 0.5	-	-	-	-
S118	< 0.5	< 0.5	< 0.5	< 0.5	-	-	-	-
S119	< 0.5	< 0.5	< 0.5	< 0.5	-	-	-	-
S121	< 0.5	< 0.5	< 0.5	< 0.5	-	-	-	-
S127	< 0.5	< 0.5	< 0.5	< 0.5	-	-	-	-
S128	< 0.5	< 0.5	< 0.5	< 0.5	-	-	-	-
S129	< 0.5	< 0.5	< 0.5	< 0.5	-	-	-	-
S130	< 0.5	< 0.5	< 0.5	< 0.5	-	-	-	-
S131	< 0.5	< 0.5	< 0.5	< 0.5	-	-	-	-
S132	< 0.5	< 0.5	< 0.5	< 0.5	-	-	-	-
S139	1.0	1.0	1.5	1.5	-	-	-	-

Source: after MSEC (2024). mm = millimetres; mm/m= millimetres per metre; km^{-1} =1/kilometres

Swamps overlying Longwalls 311-316.

1 Swamps within the Longwalls 311-316 35° angle of draw and/or predicted 20 mm subsidence contour.

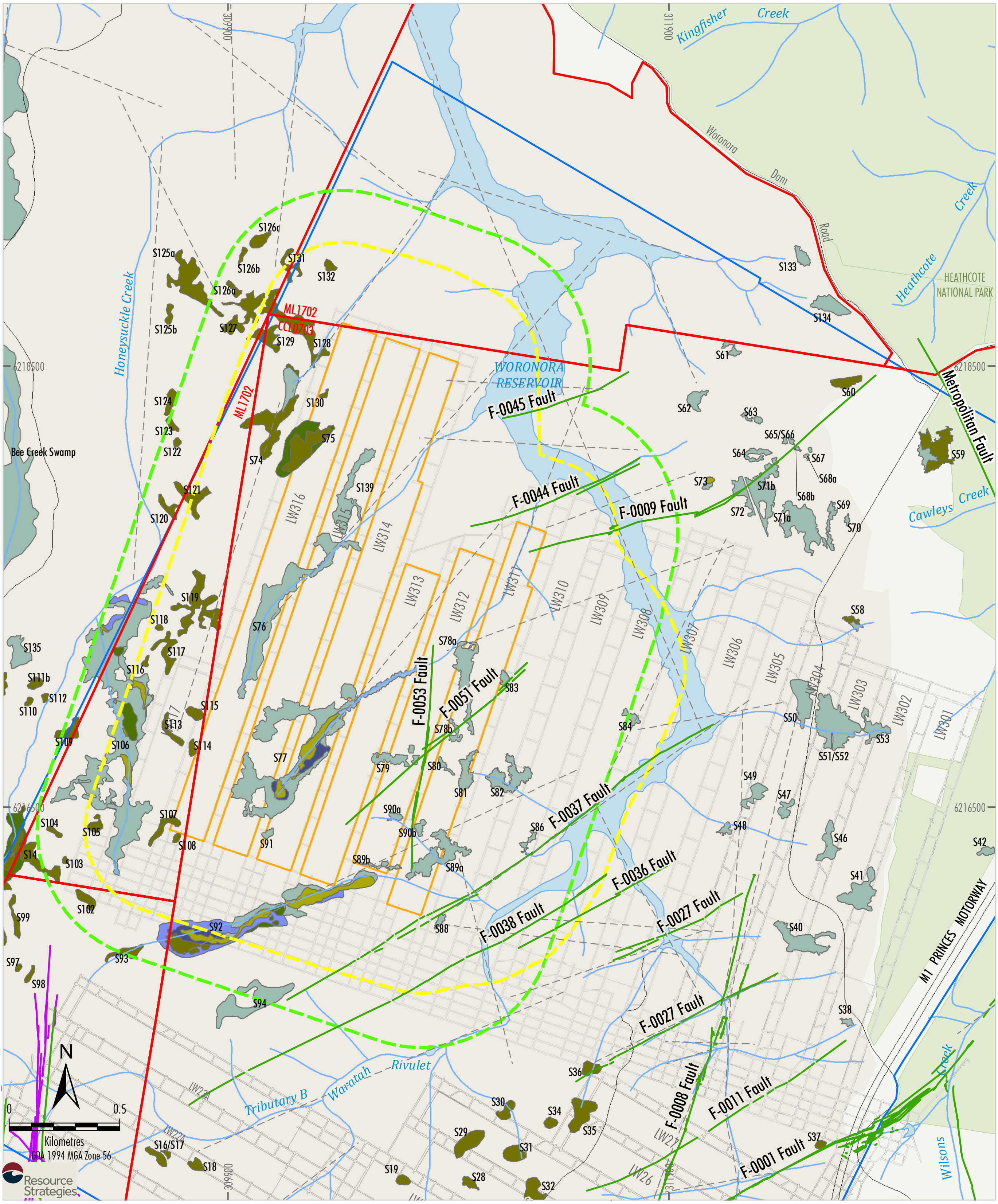
2 Conventional strain based on 15 times curvature. Strain is the relative differential horizontal movements of the ground. Tensile strains occur where the distance between two points increases and compressive strains occur when the distance between two points decreases.

3 Upsidence is the reduced subsidence, or the relative uplift within a valley which results from the dilation or buckling of near surface strata at or near the base of the valley.

4 Closure is the reduction in the horizontal distance between the valley sides.

5 PPL (LW316) – after completion of Longwall 316 of the Preferred Project Layout.

6 EPL (LW316) – after completion of Longwall 316 of the Extraction Plan Layout (i.e. Longwalls 311-316 subject of this BMP).



LEGEND

- Mining Lease Boundary
- Woronora Special Area
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 311-316 Secondary Extraction
- Longwalls 311-316 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 311-316 Secondary Extraction
- Faults (of note or greater than 1 km strike)
- Dykes
- Lineament

Map Unit	Vegetation Community
	3a - Upland Swamp: Banksia Thicket
	3b - Upland Swamps: Tea Tree Thicket
	3c - Upland Swamp: Sedgeland-heath Complex
	3d - Upland Swamp: Fringing Eucalypt Woodland
	3e - Upland Swamp: Banksia / Tea Tree Thicket
	3f - Upland Swamp: Restioid Heath
	3g - Upland Swamp: Cyperoid Heath

Note: 1. *The NSW Native Vegetation Interim Type Standard 2009 requires patches of vegetation to be mapped if the dimensions of the representative polygon on a map sheet are 2 mm x 2 mm or greater (i.e. 0.25 hectares or greater at a scale of 1:25,000). Eco Logical Australia conducted field inspections of upland swamp vegetation previously mapped by Bangalay Botanical Surveys (2008) overlying or proximal to Longwalls 301-310 to confirm the upland swamp vegetation communities present and to confirm or update the swamp vegetation boundaries. It is noted that the revised boundaries of a number of upland swamps (Swamps 37, 38, 42, 48, 54, 58, 61, 63, 65/66, 67, 68a, 68b, 70, 73, 83, 86 and 88) are less than 0.25 hectares in area and consistent with NSW vegetation mapping guidelines are not required to be mapped. Notwithstanding, the revised swamp vegetation mapping boundaries (including those swamps less than 0.25 hectares in area) are shown on this figure to document the changes to previous vegetation mapping.*

Source: Land and Property Information (2015); Department of Industry (2015); Metropolitan Coal (2023); MSEC (2024); after NPWS (2003), Bangalay Botanical Surveys (2008); Eco Logical Australia (2015; 2016; 2018) and Ecoplanning (2021; 2023)

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Upland Swamps over Longwalls 311-316 and Surrounds

Figure 14a

5.3.2 Revised Assessment of Potential Subsidence Impacts and Environmental Consequences

The potential subsidence impacts and environmental consequences to upland swamps described in the Project EA and Preferred Project Report (as described in Section 4.1.2) have been reviewed in consideration of the information obtained since Project approval and the revised subsidence predictions. There is potential for surface cracking from mine subsidence to result in impacts to swamp substrate water levels and upland swamp vegetation; however, based on the experience at Metropolitan Coal to date (described in Sections 4.1.2 and 4.2.1), it is considered unlikely that a significant number of swamps within the Project underground mining area would suffer such consequences.

The Independent Expert Scientific Committee's (IESC's) *Advice to decision maker on coal mining – Further advice on impacts to swamps* (24 July 2015) (IESC advice) and IEPMC (2018) Initial Report contend that areas containing lineaments may experience greater than normal subsidence. Surface lineaments are linear features in the surface landscape, preferentially eroded, that may be the surface expression of an underlying geological structure, fault or dyke or simply a result of surface joint sets.

The IEPMC (2018) Initial Report indicates that in recent years it has been identified in the Western Coalfield that surface subsidence, groundwater and surface water responses to longwall mining can be significantly modified in the vicinity of lineaments. Further to advice from the IEPMC, the DP&E requested that specific regard be given in the Longwall 304 Extraction Plan to the potential impacts of mining near and under lineaments on swamps. Metropolitan Coal has also considered the potential impacts of mining near and under lineaments on swamps for this BMP.

Lineaments and faults mapped by Metropolitan Coal proximal to swamps within 600 m of Longwalls 311-316 are shown on Figure 14a. Figure 14a indicates that there is no distinct correlation between lineaments and swamp locations; it is probable that lineaments are not causative for swamp formation at Metropolitan. The lineaments mapped adjacent to Swamp 40 and Swamp 41 do not correspond with any underground faults (mapped at the coal seam) adjacent to the swamps. Longwall 301 passed Swamp 41 in December 2017, Longwall 302 passed Swamps 41 and 40 in July 2018 and Longwall 303 was completed in May 2019.

A lineament that runs north-south across Longwalls 20-27 extends to the south-western edge of Swamp 50 over Longwall 304. Over Longwalls 20-27 and through Longwall 304, this lineament is associated with an underground fault (F0008). It is noted that the lineament does not continue through, or to the north of, Swamp 50 (Figure 14a). Longwalls 20-27 and Longwall 304 mined through this fault structure and did not intercept water (i.e. the fault did not act as a conduit at depth).

The potential for hydraulic connectivity via lineaments to impact adversely on upland swamps as a result of the mining of Longwalls 311-316 is considered highly unlikely.

5.3.3 Large Swamp Assessment

The Metropolitan PAC Report identified three large upland-swamps (herein referred to as swamps), Swamps 76, 77 and 92 (collectively referred to as the 'Large Swamps') as "*being of special concern because their lower ends are in valleys with moderate longitudinal slopes and the EA described them as terminating at rock bars. These factors could conceivably see an increased vulnerability to the effects of valley closure and upsidence*".

The Metropolitan PAC Report also states (page 87):

> *The Panel is also of the view that at least three of the swamps identified as being exposed to non-conventional subsidence impacts should be the focus of further attention before undermining is allowed to proceed. These are swamps S76, S77 and S92.*

The recommendations made in the Metropolitan PAC Report were reflected in Condition 4, Schedule 3 of Project Approval (08_0149):

> 4. *The proponent shall not undermine Swamps 76, 77 and 92 without the written approval of the Director – General. In seeking this approval, the Proponent shall submit the following information with the relevant Extraction Plan (see condition 6 below):*
>   a) *a comprehensive environmental assessment of the:*
>   - *potential subsidence impacts and environmental consequences of the proposed Extraction Plan;*
>   - *potential risks of adverse environmental consequences; and*
>   - *options for managing these risks:*
>
>   b) *a description of the proposed performance measures and indicators for these swamps; and*
>
>   c) *a description of the measures that would be implemented to manage the potential environmental consequences of the Extraction Plan on these swamps (to be included in the Biodiversity Management Plan – see condition 6(f) below), and comply with the proposed performance measures and indicators.*

Swamps 76, 77 and 92 are proposed to be undermined as a part of secondary extraction of Longwalls 311-316 (Figure 14b).

In accordance with the Project Approval, Metropolitan Coal has prepared a Large Swamp Assessment with the assistance of Ecoplanning, ATC Williams, SLR Consulting and MSEC. A Large Swamp Assessment (Metropolitan Coal, 2024) has also been prepared in consideration of the several recommendations set out in Section 9.4.2 of the Metropolitan PAC Report.

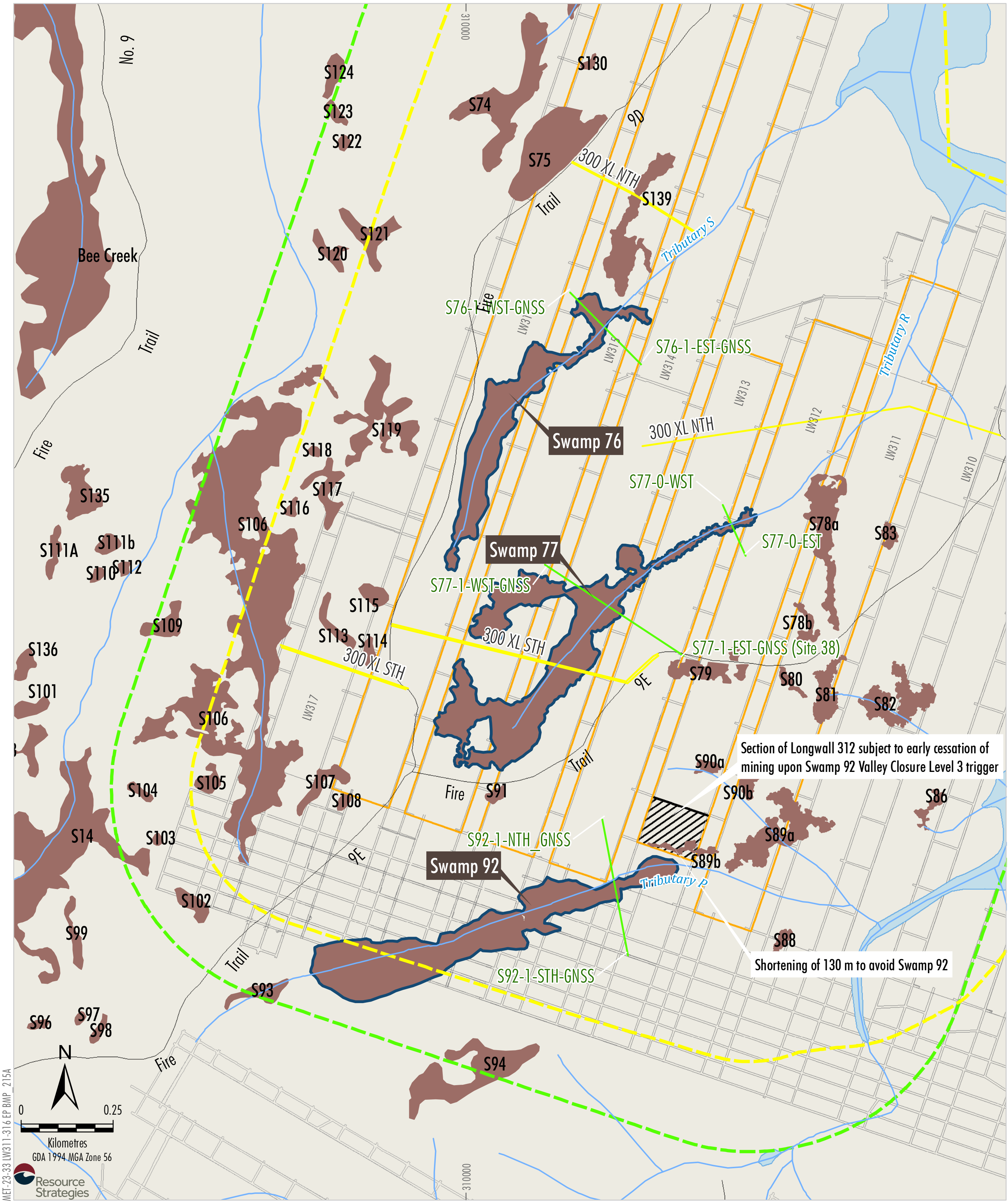
5.4 RIPARIAN ZONE AND AQUATIC BIOTA AND THEIR HABITATS

Riparian vegetation and habitats for aquatic biota occur along streams which flow to the Woronora Reservoir (including the Waratah Rivulet and Eastern Tributary), and some of their tributaries (Figure 10).

Vegetation mapping within 600 m of Longwalls 311-316 secondary extraction is shown on Figure 15. Riparian vegetation includes vegetation mapped as community 4a (Sandstone Riparian Scrub).

5.4.1 Revised Subsidence Predictions

The subsidence predictions for Longwalls 311-316 in relation to streams have been prepared by MSEC (2024).



LEGEND

- Woronora Special Area
- Longwalls 311-316 Secondary Extraction
- Longwalls 311-316 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 311-316 Secondary Extraction
- Upland Swamp
- Large Swamp Boundary
- GNSS Monitoring Line
- Valley Closure Monitoring Line

Source: Land and Property Information (2015); Department of Industry (2015); Metropolitan Coal (2023); MSEC (2024); after NPWS (2003), Bangalay Botanical Surveys (2008); Eco Logical Australia (2015; 2016; 2018) and Ecoplanning (2023)

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Location of Large Swamps 76, 77 and 92

Figure 14b

Waratah Rivulet

The Waratah Rivulet flows to the north-east and into the full supply level of the Woronora Reservoir, approximately 550 m to the south-east of Longwall 311-316 (Figures 1 and 2). The predicted profiles of subsidence, upsidence and closure along the Waratah Rivulet (to the full supply level of the Woronora Reservoir), resulting from the extraction of Longwalls 311-316, are shown on Figure 16 (MSEC, 2024).

The maximum predicted values of total upsidence and closure for the Waratah Rivulet, after Longwall 310 and resulting from the extraction of Longwalls 311-316, is provided in Table 8 (MSEC, 2024). The values are the predicted maxima within the Longwalls 311-316 35° angle of draw and/or predicted 20 mm subsidence contour.

The maximum predicted subsidence parameters for the Waratah Rivulet, based on the Extraction Plan Layout, are similar to or less than the maxima predicted based on the Preferred Project Layout.

The maximum predicted total upsidence for the Waratah Rivulet is 125 mm and the maximum predicted total closure on the Waratah Rivulet resulting from the extraction of Longwalls 311-316 is 175 mm (MSEC, 2024).

At distances of over 550 m from Longwalls 311 to 316, the Waratah Rivulet is located outside the Study Area and is not expected to experience measurable conventional vertical subsidence, tilts, curvatures, and strains (i.e. no greater than survey accuracy).

Table 8
Maximum Predicted Upsidence and Closure for the Waratah Rivulet Resulting from Longwalls 311-316 Extraction

Longwall	Maximum Predicted (to the full supply level of the Woronora Reservoir)	
	Upsidence[1] (mm)	Closure[2] (mm)
After LW310	100	175
After LW311	125	175
After LW312	125	175
After LW313	125	175
After LW314	125	175
After LW315	125	175
After LW316	125	175

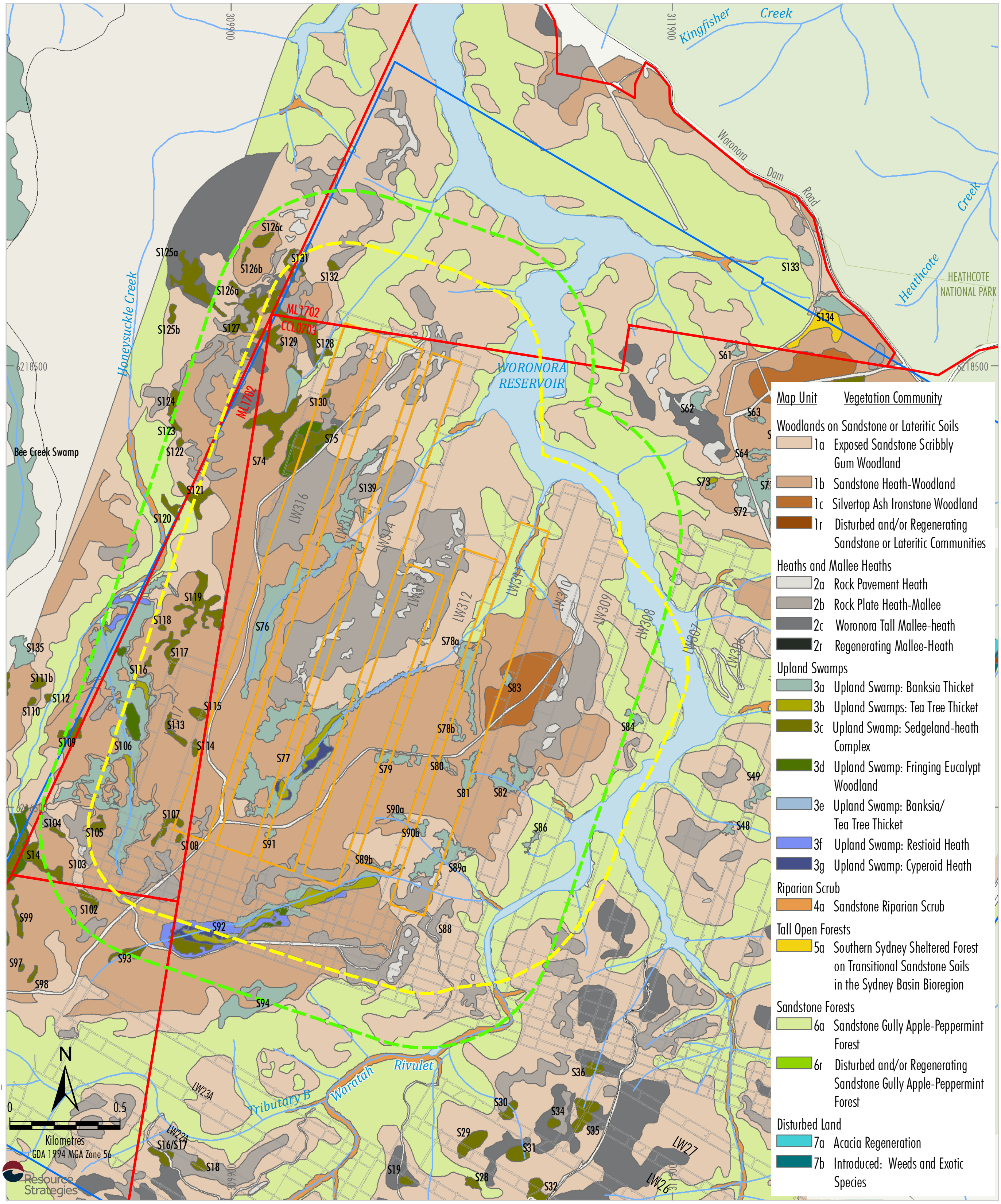
Source: after MSEC (2024).

mm = millimetres; mm/m= millimetres per metre; km^{-1} =1/kilometres

1 Upsidence is the reduced subsidence, or the relative uplift within a valley which results from the dilation or buckling of near surface strata at or near the base of the valley.

2 Closure is the reduction in the horizontal distance between the valley sides.

The maximum predicted valley closure for the rock bars/boulder field downstream of Pool P, resulting from Longwalls 311-316 is provided in Table 9. Rock bars T, U and V are located within the Longwalls 311-316 35° angle of draw and/or predicted 20 mm subsidence contour.



LEGEND

- Mining Lease Boundary
- Woronora Special Area
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 311-316 Secondary Extraction
- Longwalls 311-316 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 311-316 Secondary Extraction

Note: The NSW Native Vegetation Interim Type Standard 2009 requires patches of vegetation to be mapped if the dimensions of the representative polygon on a map sheet are 2 mm x 2 mm or greater (i.e. 0.25 hectares or greater at a scale of 1:25,000). Eco Logical Australia conducted field inspections of upland swamp vegetation previously mapped by Bangalay Botanical Surveys (2008) overlying or proximal to Longwalls 301-310 to confirm the upland swamp vegetation communities present and to confirm or update the swamp vegetation boundaries. It is noted that the revised boundaries of a number of upland swamps (Swamps 37, 38, 42, 48, 54, 58, 61, 63, 65/66, 67, 68a, 68b, 70, 73, 83, 86 and 88) are less than 0.25 hectares in area and consistent with NSW vegetation mapping guidelines are not required to be mapped. Notwithstanding, the revised swamp vegetation mapping boundaries (including those swamps less than 0.25 hectares in area) are shown on this figure to document the changes to previous vegetation mapping.

Source: Land and Property Information (2015); Department of Industry (2015); Metropolitan Coal (2023); MSEC (2024); after NPWS (2003), Bangalay Botanical Surveys (2008); Eco Logical Australia (2015; 2016; 2018) and Ecoplanning (2021; 2023)

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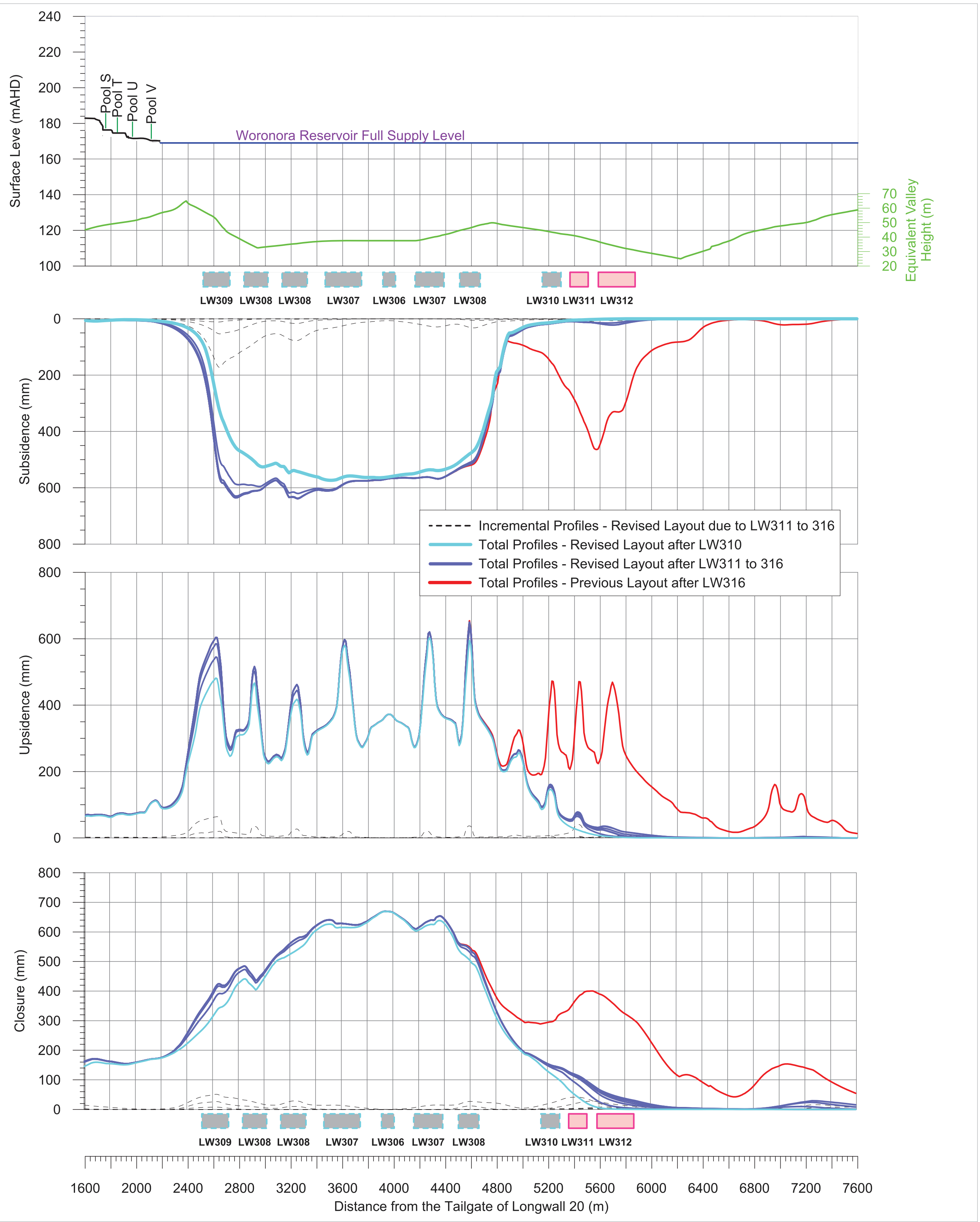
Longwalls 311-316 Vegetation Mapping

Figure 15



MET-23-33 LW311-316 EP BMP_003B

Source: MSEC (2024)

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Predicted Profiles of Subsidence, Upsidence and Closure along the Waratah Rivulet and Woronora Reservoir due to Longwalls 311-316

Figure 16

Table 9
Maximum Predicted Total Closure at Rock Bars/Boulder Field Along the Waratah Rivulet

Longwall	Maximum Predicted Total Closure (mm)					
	RB-P	RB-Q	RB-R	RB-S	RB-T	RB-V
After LW310	125	125	150	150	150	175
After LW311	150	150	175	175	150	175
After LW312	150	150	175	175	150	175
After LW313	150	150	175	175	150	175
After LW314	150	150	175	175	150	175
After LW315	150	150	175	175	150	175
After LW316	150	150	175	175	150	175

Source: after MSEC (2024)
mm = millimetres

Table 9 indicates that there is negligible additional predicted closure at the rock bars further upstream from the full supply level of the Woronora Reservoir (MSEC, 2024).

A comparison of the maximum predicted closure for the rock bars, resulting from the Extraction Plan Layout of Longwalls 311-316, with those based on the Preferred Project Layout is provided in Table 10.

Table 10
Comparison of Maximum Predicted Closure for the Waratah Rivulet Rock Bars Based on the Preferred Project Layout and the Extraction Plan Layout

Layout	Maximum Predicted Total Closure (mm)					
	RB-P	RB-Q	RB-R	RB-S	RB-T	RB-V
Preferred Project Layout (after LW316)	150	150	175	175	200	225
Extraction Plan Layout	150	150	175	175	150	175

Source: after MSEC (2024)
mm = millimetres

The maximum predicted closure for the rock bars downstream of Pool P, based on the Extraction Plan Layout, are less than the maxima predicted based on the Preferred Project Layout at Rock Bars T and V and the maximum predicted closure is the same at Rock Bars P, Q, R and S (MSEC, 2024).

Eastern Tributary

The Eastern Tributary flows in an approximate south to north direction into the full supply level of the Woronora Reservoir approximately 1.4 km (at the full supply level) to the east of Longwall 311.

Being 1.4 km or more east of Longwall 311, the Eastern Tributary is not predicted to experience measurable valley related movements and conventional subsidence movements during the extraction of Longwalls 311-316.

The Eastern Tributary has been managed using an adaptive management approach during the extraction of Longwalls 308 to 309 with a comprehensive monitoring program about Rock Bar ETAU. The monitoring program will continue during the extraction of Longwall 310. Following a review of monitoring data after the completion of Longwall 310, the need for further monitoring of Rock Bar ETAU will be determined.

Woronora Reservoir

The Woronora Reservoir full supply level is located above the commencing ends of Longwalls 311-316. The area of the Woronora Reservoir full supply level immediately downstream of the Waratah Rivulet and Eastern Tributary is referred to as an inundation area. When the Woronora Reservoir is at full capacity, this area is flooded. When the water level is below the full supply level, portions of the inundation area form temporary pools above exposed rock bars.

The predicted profiles of vertical subsidence, upsidence and closure for the Woronora Reservoir full supply level, resulting from the extraction of Longwalls 311-316, are shown on Figure 16 (for the alignment of the Waratah Rivulet) and Figures 17a, 17b and 17c (for the alignment of Tributary P, Tributary R and Tributary S, respectively).

A summary of the maximum predicted values of total subsidence, tilt, curvature, upsidence and closure for the Woronora Reservoir full supply level, after Longwall 310 and resulting from the extraction of Longwalls 311-316 is provided in Table 11. The values are the predicted maxima within the 35° angle of draw and/or predicted 20 mm subsidence contour for Longwalls 311-316.

The maximum predicted conventional tilt for the Woronora Reservoir full supply level is 4.0 mm/m (i.e. 0.4%, or 1 in 250). The maximum predicted conventional curvatures are 0.04 km^{-1} hogging and 0.03 km^{-1} sagging, which equate to minimum radii of curvature of 25 km and 33 km, respectively (MSEC, 2024). The predicted conventional strains for the Woronora Reservoir full supply level (based on 15 times the curvature) are < 1.0 mm/m tensile and compressive (MSEC, 2024).

Table 11
Maximum Predicted Subsidence, Tilt, Curvature, Upsidence and Closure for the Woronora Reservoir Resulting from Longwalls 310-316 Extraction

Longwall	Maximum Predicted					
	Subsidence (mm)	Tilt (mm/m)	Hogging Curvature (km^{-1})	Sagging Curvature (km^{-1})	Upsidence (mm)	Closure (mm)
After LW310	575	2.5	0.02	0.03	600	675
After LW311	625	3.5	0.04	0.03	625	675
After LW312	625	4	0.04	0.03	650	675
After LW313	650	4	0.04	0.03	650	675
After LW314	650	4	0.04	0.03	650	675
After LW315	650	4	0.04	0.03	650	675
After LW316	650	4	0.04	0.03	650	675

Source: after MSEC (2024).

mm = millimetres; mm/m= millimetres per metre; km^{-1} =1/kilometres

A comparison of the maximum predicted vertical subsidence, upsidence and closure for the Woronora Reservoir full supply level resulting from the Extraction Plan Layout of Longwalls 311-316, with those based on the Preferred Project Layout after Longwall 316, is provided in Table 12.

The revised maximum predicted upsidence and closure for the Woronora Reservoir full supply level, are less than the maxima for the Preferred Project Layout (MSEC, 2024). The maximum predicted subsidence is greater than the maxima for the Preferred Project Layout (MSEC, 2024). The greater predicted vertical subsidence is the result of Incremental Profile Model model calibration (MSEC, 2024). The maximum predicted total closure on the Woronora Reservoir full supply level resulting from the extraction of Longwalls 311-316 is 825 mm (Table 12).

Table 12
Comparison of Maximum Predicted Conventional Subsidence Parameters for the Woronora Reservoir Based on the Preferred Project Layout and the Extraction Plan Layout

Layout	Maximum Predicted Total Conventional		
	Subsidence (mm)	Upsidence (mm)	Closure (mm)
Preferred Project Layout (after LW316)	475	800	825
Extraction Plan Layout	650	650	675

Source: after MSEC (2024).
mm = millimetres

The maximum predicted closure based on the Extraction Plan Layout is less than the maximum predicted based on the Preferred Project Layout.

Other Drainage Lines/Streams

There are a number of other tributaries also located within the Longwalls 311-316 35° angle of draw and/or predicted 20 mm subsidence contour (Figure 2). These streams consist of shallow drainage lines from the topographical high points, forming streams where valley heights increase and drain into the Woronora Reservoir. The streams are located above Longwalls 311-316, and could experience the full range of predicted subsidence movements, with maximum predicted closure up to 675 mm (MSEC, 2024).

Three larger tributaries are located within the Longwalls 311-316 35° angle of draw and/or predicted 20 mm subsidence contour (Figure 14b). These tributaries are identified as Tributary P (through Swamp 92), Tributary R (through Swamp 77) and Tributary S (through Swamp 76). The predicted profiles of subsidence, upsidence and closure through Swamps 76, 77 and 92 resulting from the extraction of Longwalls 311-316, are shown on Figure 17a, Figure 17b and Figure 17c, respectively.

5.4.2 Revised Assessment of Potential Subsidence Impacts and Environmental Consequences

The maximum predicted subsidence parameters for the Waratah Rivulet, based on the Extraction Plan Layout, are similar to or less than the maxima predicted based on the Preferred Project Layout.

MET-23-33 LW311-316 EP BMP_004B

Source: MSEC (2024)

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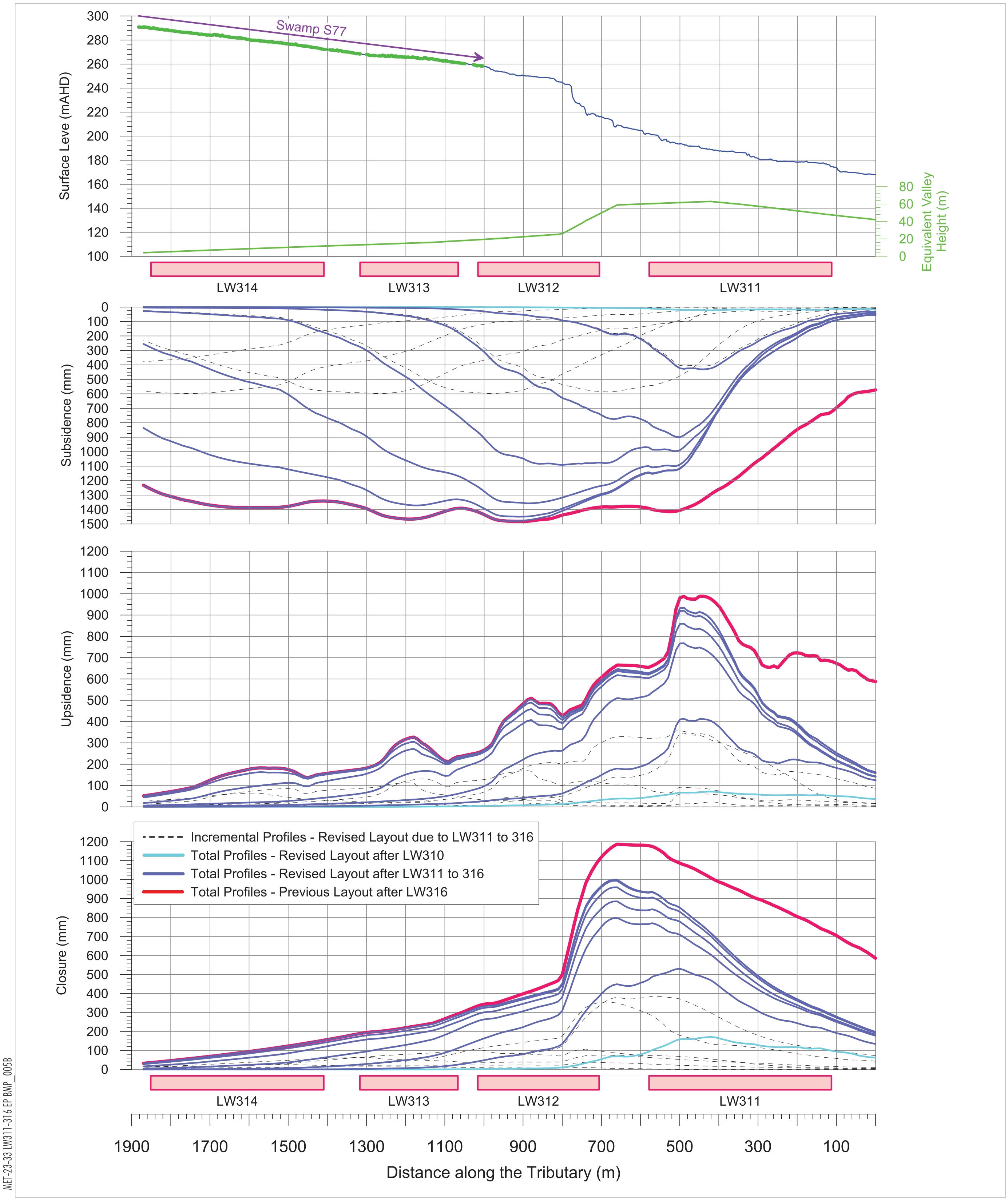
Predicted Profiles of Subsidence, Upsidence and Closure along Tributary P due to Longwalls 311-316

Figure 17a



Source: MSEC (2024)

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Predicted Profiles of Subsidence, Upsidence and Closure along Tributary R due to Longwalls 311-316

Figure 17b

MET-23-33 LW311-316 EP BMP_006B

Source: MSEC (2024)

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Predicted Profiles of Subsidence, Upsidence and Closure along Tributary S due to Longwalls 311-316

Figure 17c

Previous assessments of stream impacts at Metropolitan Coal have used a relationship between predicted total closure at rock bars and proportion of impacted pools for streams in the Southern Coalfield. The relationship identified approximately 10% of pools were impacted at a predicted total valley closure of up to 200 mm (MSEC, 2024). Impacts to some pools along the Eastern Tributary resulting from the extraction of Longwall 27, have occurred at predicted values of total valley closure of less than 200 mm resulting in a higher proportion of impacted pools at lower magnitudes of predicted total valley closure. As a result of the observed impacts to the Eastern Tributary, the finishing ends of Longwalls 303, 304 and 305 were set back to minimise predicted valley closure at the Eastern Tributary. As described in Section 4.1, Metropolitan Coal has established a comprehensive monitoring and adaptive management program to identify subsidence related movements at the Eastern Tributary to minimise the risk of further exceedance of the Eastern Tributary performance measure. The Eastern Tributary Valley Closure TARP has been successfully implemented by Metropolitan Coal for Longwalls 303, 304, 305, 306, 307 and 308. The same monitoring and adaptive management program will be used for the extraction of Longwalls 309 and 310 (as described in the Longwalls 308-310 Extraction Plan).

As discussed in Section 4.1.1, the restriction of predicted total valley closure to 200 mm has been a successful design tool for complying with the negligible environmental consequence performance measure on the Waratah Rivulet. Furthermore, the geotechnical study of the Waratah Rivulet (detailed in Section 4.1.1) concluded that the geological features identified along the Eastern Tributary are considered to be unique, compared to the Waratah Rivulet. The Eastern Tributary is therefore more likely to be susceptible to subsidence movements. Restricting valley closure to 200 mm therefore continues to be an appropriate design tool for the Waratah Rivulet.

Given that the maximum predicted closure for the rock bars downstream of Pool P, based on the Extraction Plan Layout, are less than or equal to the maxima predicted based on the Preferred Project Layout, and that the maximum predicted total valley closure for the rock bars downstream of Pool P is 200 mm (Table 9), the potential subsidence impacts and environmental consequences described in the Project EA, Preferred Project Report, and Metropolitan Coal Water Management Plans in relation to the Waratah Rivulet continue to be applicable for Longwalls 311-316.

Further to advice from the IEPMC, and at the request of the DPIE, specific regard was given in the Longwall 304 Extraction Plan to the potential impacts of mining near and under lineaments on surface water features, including waterfalls. A similar assessment has been conducted for the Longwalls 311-316 Extraction Plan[43].

Lineaments and faults mapped by Metropolitan Coal in close proximity to streams within 600 m of Longwalls 311-316 are shown on Figure 14a. The lineament that runs north-south across Longwalls 20-27 extends over Longwall 304. Over Longwalls 20-27, this lineament is associated with an underground fault (F-008) and this fault partially extends over Longwall 304. Longwalls 20-27 mined through this fault structure and did not intercept water (i.e. the fault did not act as a conduit at depth).

A lineament that aligns with the Eastern Tributary at the waterfall located at the downstream end of Rock Bar ETAU (Figure 14a) is aligned with a 20 mm wide minor strike-slip fault, F-0021, which has zero vertical displacement. No moisture has been evident at seam level where it crosses the 300 mains or in the Longwall 303 maingate. WaterNSW representatives were shown this particular strike-slip fault, along with F-0008 during an underground inspection on 19 March 2019[44]. WaterNSW representatives concurred that the faults are not readily apparent without the assistance of Metropolitan Coal's geologist.

43 The risk assessment conducted for potential impacts of mining effects on geological features on the quantity of water resources to the reservoir is discussed in Section 5.3. The risk assessment conducted for potential impacts of mining effects on geological features on surface water resources, including waterfalls is discussed in the Longwalls 311-316 Water Management Plan.

44 WaterNSW representatives on the underground visit included Ms Fiona Smith (Executive Manager, Water and Catchment Protection) and Mr Peter Dupen (Manager, Mining).

It is considered likely that Fault F-0008 and Fault F-0021, would have similar characteristics and behave in a similar manner to that experienced by mine extraction and development to date. Similar to the assessment for Longwall 304, hydraulic connectivity via lineaments to the waterfall at Rock Bar ETAU on the Eastern Tributary is considered to be highly unlikely as a result of the extraction of Longwalls 311-316.

A strike slip fault, F0037, with zero vertical displacement, has been mapped in the gate roads and the three longwalls extracted through this feature, being Longwalls 306, 307 and 308. The associated surface linear is aligned with the Waratah Rivulet arm of Woronora Reservoir. Similar to previous experience of mining through these features no moisture has been evident from F0037 structure in the seam. The Longwalls 311-316 Geological Features Risk Assessment participants were shown images of F0037 during longwall extraction with the structure displaying dry and dusty conditions.

F0009 is a normal fault with a displacement of 0 m to 18 m located north of Longwall 308 and with a south-west strike bisecting Longwall 309 and diminishing to 0 m displacement at Longwall 310. The displacement of F0009 combined with coal quality north of the structure led to an economic decision to reposition the Longwall 308 and 309 face line from the Preferred Project Layout to the Extraction Plan Layout. Longwall 310 is anticipated to be able to ramp through the structure.

A detailed seismic assessment of F0009 was commissioned to determine the vertical extent of the structure with multiple dedicated seismic lines installed to provide a suitable resolution throughout the stratigraphy. The Velseis (2018) report concluded:

> *The large normal fault F0009 can be seen to impact the Bulli Seam only, and there is no evidence from available seismic data that this normal fault extends to the shallower Bald Hill Claystone level in the stratigraphy*

From the detailed seismic report, the fault is not vertically extensive, residing at depth about the Illawarra Coal Measures. Whilst not vertically extensive, horizontally the structure extends north-west away from the extraction area towards the Metropolitan Fault. From the point where F0009 bisects Longwall 309 to the Metropolitan fault, the horizontal distance is approximately 1.5 km.

To demonstrate the structure poses negligible effects to the groundwater systems, a surface to seam borehole (2020EX02) was approved and installed in 2020. This hole, located along strike, approximately 700 m north-west of the intercept with Longwall 310, was designed to measure the horizontal permeability characteristics of F0009 by coring through the structure at depth. An assessment of the permeability characteristics found (Golder Associates Pty Ltd, 2020):

> *Hydraulic conductivities measured across the fault were comparable to those recorded for the unfractured host rock… there is negligible variance in horizontal flow characteristics associated with the fault measured at this location.*

Detailed surface mapping has not identified any associated surface linear with F0009. The Longwalls 311-316 Geological Features Risk Assessment participants were shown images of F0009 during development mining with the structure displaying dry and dusty conditions and a tight unbroken contact with the surrounding rock. Given the available data, it is highly unlikely that this feature would provide hydraulic connectivity either vertically or horizontally as a result of the extraction of Longwalls 311-316, similar to previous experiences of mining through other structures such as F0008, F0021, F0027 and F0037. The risk posed by F0009 was carefully considered and reviewed during the Longwalls 311-316 Geological Features Risk Assessment, with the continuation of a control to visual monitor F0009 for signs of moisture and further delineation to occur on roadway advancement (similar to controls previously used for structures passed through by mining).

The maximum predicted subsidence parameters for the Woronora Reservoir full supply level, based on the Extraction Plan Layout, are less than the maxima predicted based on the Preferred Project Layout.

The potential impacts on the Woronora Reservoir, based on the Extraction Plan Layout, therefore, are predicted to be consistent with or less than those assessed based on the Preferred Project Layout (including cracking at the base of valleys and fracturing and dilation of the underlying strata when the reservoir level is lower than the full supply level). Further, it is noted that Longwall 306 undermined the Woronora Reservoir in September 2021, and Metropolitan Coal did not identify abnormal water flow from the goaf, geological structure, or the strata generally.

The first and second order streams located above Longwalls 311-316 (Figure 2) could experience the full range of predicted subsidence movements. The potential subsidence impacts and environmental consequences for these streams, based on the Extraction Plan Layout, are consistent with those assessed for the Preferred Project Layout that are described in Section 4.1.

5.5 SLOPES AND RIDGETOPS

Vegetation communities mapped on slopes and ridgetops within 600 m of Longwalls 311-316 secondary extraction include woodlands on sandstone or lateritic soils (vegetation communities 1a, 1b and 1c), heaths and mallee heaths (vegetation communities 2a, 2b and 2c), sandstone forests (vegetation community 6a) (Figure 15).

Figure 18 shows the location of the cliffs and associated overhangs, steep slopes, and land in general that occur within 600 m of Longwalls 311-316 secondary extraction and wider Project underground mining area in accordance with the Metropolitan Coal Longwalls 311-316 Land Management Plan.

5.5.1 Revised Subsidence Predictions

The subsidence predictions for slopes and ridgetops have been prepared by MSEC (2024) for the Longwalls 311-316 Extraction Plan layout.

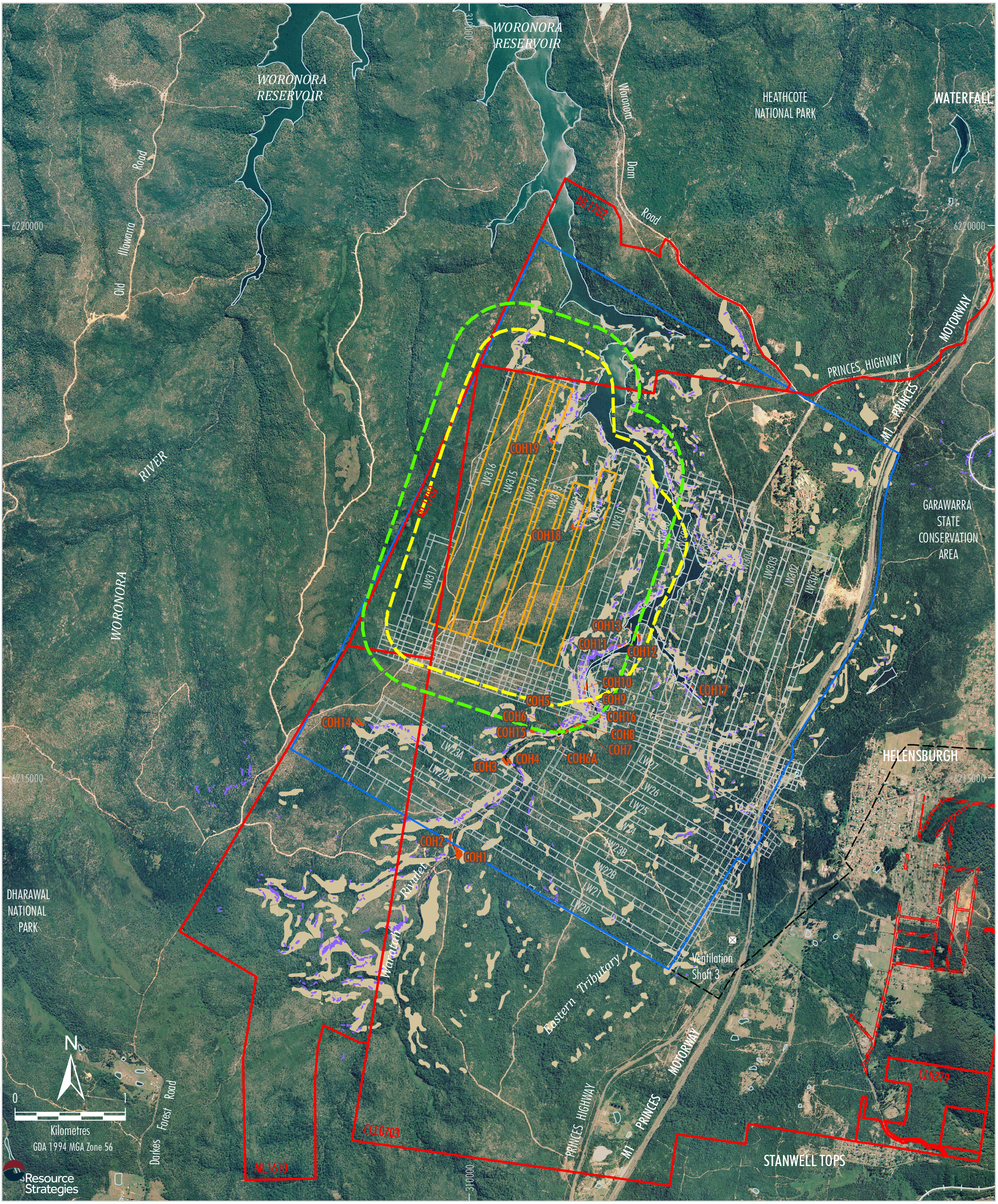
Six cliff and overhang sites (sites COH10, COH11, COH12, COH13, COH18 and COH19) have been identified within the 35° angle of draw and/or predicted 20 mm subsidence contour of Longwalls 311-316 (Figure 18). An additional four cliff and overhang sites (sites COH5, COH7, COH8 and COH9) are located within the 600 m contour for Longwalls 311-316 (Figure 18). There are no cliff and overhang sites located above directly above Longwalls 311 to 316.

COH18 is located above Longwall 312 and COH19 is located above Longwall 314. COH11, COH12 and COH13 are located above previously extracted Longwalls 307 and 308 (Figure 18).

Table 13 compares the predicted subsidence parameters for the Longwalls 311-316 Extraction Plan with those for the Preferred Project Layout (at the completion of Longwall 316).

The maximum predicted vertical subsidence for the cliffs based on the Extraction Plan Layout is less than the maxima predicted based on the Preferred Project Layout at one sites and greater than the Preferred Project Layout at five sites (Table 13). The maximum predicted tilt for the cliffs based on the Extraction Plan Layout is less than or similar at three sites and greater than the Preferred Project Layout at three sites (Table 13).

The maximum predicted hogging curvature and sagging curvature based on the Extraction Plan Layout are less than or the similar to the maxima predicted based on the Preferred Project Layout, with the exception of hogging curvature at Cliffs COH11 and COH18, which is slightly higher (Table 13). Whilst hogging curvature increases at COH11 and COH18 as a result of the Extraction Plan Layout, the maximum predicted conventional hogging curvature for cliffs, based on the Extraction Plan Layout, (0.04 km^{-1}) is similar to the maxima based on the Preferred Project Layout after Longwall 316 (MSEC, 2024).



LEGEND

- Mining Lease Boundary
- Railway
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 311-316 Secondary Extraction
- Longwalls 311-316 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 311-316 Secondary Extraction
- Existing Underground Access Drive (Main Drift)
- Cliffs and Overhangs
- Steep Slopes (Project Approval)
- Steep Slopes (Project Environmental Assessment)

Source: Land and Property Information (2015); Date of Aerial Photography 1998; Department of Industry (2015); Metropolitan Coal (2023); MSEC (2024)

Peabody

METROPOLITAN COAL

Cliffs and Overhangs, Steep Slopes and Land in General within the Project Underground Mining Area and Surrounds

Figure 18

Table 13
Revised Subsidence Predictions for Cliffs and Overhangs

Cliff Site	Maximum Predicted Total Conventional Subsidence (mm)[1]		Maximum Predicted Total Conventional Tilt (mm/m)[2]		Maximum Predicted Total Conventional Hogging Curvature (km^{-1})[3]		Maximum Predicted Total Conventional Sagging Curvature (km^{-1})[3]	
	PPL	**EPL**	**PPL**	**EPL**	**PPL**	**EPL**	**PPL**	**EPL**
COH10	200	150	2.0	1.5	0.02	0.02	0.02	< 0.01
COH11	475	650	< 0.5	1.0	0.01	0.02	0.04	0.02
COH12	475	625	1.0	0.5	0.02	0.01	0.06	0.03
COH13	450	600	0.5	1.0	0.04	0.03	0.02	0.01
COH18	1100	1450	1.5	1.5	0.03	0.04	0.04	0.03
COH19	525	1150	1.0	2.5	0.04	0.04	0.06	0.05

Source: after MSEC (2024).

1 Subsidence refers to vertical displacements of the ground.

2 Tilt is the change in the slope of the ground as a result of differential subsidence, and is calculated as the change in subsidence between two points divided by the distance between those points.

3 Curvature is the second derivative of subsidence, the rate of change of tilt, and is calculated as the change in tilt between two adjacent sections of the tilt profile divided by average length of those sections.

PPL = After completion of Longwall 316 of the Preferred Project Layout.

EPL = After completion of Longwall 316 of the Extraction Plan Layout.

mm = millimetres

mm/m= millimetres per metre

km^{-1} =1/kilometres

5.5.2 Revised Assessment of Potential Subsidence Impacts and Environmental Consequences

The potential for impacts on the cliffs and overhangs, based on the Extraction Plan Layout, are similar to those based on the Preferred Project Layout. Based on comparisons with other mines in the Southern Coalfield where cliff lines have been undermined, the lengths of potential cliff instabilities are expected to be less than 3% of the lengths of these cliffs (MSEC, 2024). Although isolated rock falls have been observed over solid coal outside the extracted goaf areas of longwall mining in the Southern Coalfield, there have been no recorded cliff instabilities outside the extracted goaf areas of longwall mining in the Southern Coalfield. It is possible that isolated rock falls could occur as a result of the extraction of the proposed longwalls. It is not expected, however, that any large cliff instabilities would occur outside the longwall footprints as a result of the extraction of the longwalls (MSEC, 2024).

The potential impacts on steep slopes and land in general, for the Extraction Plan Layout, are the same as those assessed for the Preferred Project Layout, specifically, surface tension cracking of sandstone and rock falls, particularly where rock ledges are marginally stable.

The subsidence predictions and impact assessment for the Extraction Plan Layout do not change the assessment of environmental consequences on slope and ridgetop vegetation and terrestrial fauna habitats provided in the Project EA and Preferred Project Report:

- The magnitude of expected surface cracking is considered too small to influence the hydrological processes in the slope and ridgetop areas and is unlikely to have any biologically significant effect on the soil moisture regime that sustains the existing vegetation.

- Rock falls occur naturally in the slope and ridgetop areas, however subsidence has the potential to further reduce the stability of features and thereby increase the incidence of rock fall. Impacts to vegetation from rock falls are expected to be isolated and small. The potential impacts on terrestrial fauna are described in Section 5.6.

5.6 TERRESTRIAL FAUNA AND THEIR HABITATS

Terrestrial fauna habitats include the habitat types discussed in Section 5.3 (upland swamps), Section 5.4 (riparian zone and aquatic biota and their habitats) and Section 5.5 (slopes and ridgetops).

5.6.1 Revised Subsidence Predictions

The subsidence predictions for the Extraction Plan Layout for upland swamps, riparian vegetation and aquatic habitats, and slopes/ridgetops are discussed in Sections 5.3 to 5.5, respectively.

5.6.2 Revised Assessment of Potential Subsidence Impacts and Environmental Consequences

Sections 5.3 to 5.5 describe the revised subsidence predictions for the Extraction Plan Layout for terrestrial fauna habitats (i.e. upland swamps, riparian vegetation and aquatic habitats, and slopes/ridgetops).

The subsidence impact assessment for the Extraction Plan Layout does not change the assessment of environmental consequences on terrestrial fauna and their habitats provided in the Project EA and Preferred Project Report. In summary, the key potential environmental consequences include:

- The potential for surface cracks within some upland swamps and impacts on surface hydrological processes and/or upland swamp vegetation (such as those observed in Swamp 20 and Swamp 28) however, it is considered unlikely that any vertebrate population would be put at risk.
- Localised and limited impacts on riparian vegetation, which may reduce the habitat resources available to terrestrial fauna in the riparian zone. However, the nature of the impacts on riparian habitat is unlikely to significantly impact this habitat type or any terrestrial fauna species.
- The potential for surface cracking to form areas capable of ‘trapping’ some ground dwelling fauna (e.g. frogs and reptiles) in the same way that pitfall traps operate. The size and extent of surface cracking is expected to be minor. Any impacts on vertebrate fauna due to surface cracking are likely to be relatively minor and very unlikely to result in an impact that would threaten the viability of any vertebrate species population.
- The potential for a reduction in terrestrial fauna habitat resources (e.g. roost sites for bats, nest sites for birds, and shelter for reptiles and some amphibian species) as a result of rock falls, or the loss of individuals in a few cases, either by entrapment or direct fatal rock fall. It is predicted that the incidence of rock falls would be low.
- The potential for a reduction in water level in pools (in the inundation area of the Woronora Reservoir and first and second order tributaries) as they become hydraulically connected with the fracture network, reduced continuity of flow between affected pools during dry weather and changes in water quality leading to changes in fauna habitats. Metropolitan Coal has established a comprehensive monitoring and adaptive management program for the Eastern Tributary to avoid the diversion of flows/changes in the natural drainage behaviour of Pools ETAS/ETAT and ETAU on the Eastern Tributary.

6 PERFORMANCE MEASURES AND INDICATORS

The Project Approval requires Metropolitan Coal not to exceed the subsidence impact performance measures outlined in Table 1 of Condition 1, Schedule 3.

Two subsidence impact performance measures are specified in Table 1 of Condition 1, Schedule 3 in relation to biodiversity:

Table 1: Subsidence Impact Performance Measures

Biodiversity	
Threatened species, populations, or ecological communities	*Negligible impact*
Swamps 76, 77 and 92	*Set through condition 4 below*

In relation to the subsidence impact performance measure for Swamps 76, 77 and 92, set through condition 4 below states:

The Proponent shall not undermine Swamps 76, 77 and 92 without the written approval of the Director-General. Ln seeking this approval, the Proponent shall submit the following information with the relevant Extraction Plan (see condition 6 below):

(a) a comprehensive environmental assessment of the:

- *potential subsidence impacts and environmental consequences of the proposed Extraction Plan;*
- *potential risks of adverse environmental consequences; and.*
- *options for managing these risks;*

(b) a description of the proposed performance measures and indicators for these swamps; and

(c) a description of the measures that would be implemented to manage the potential environmental consequences of the Extraction Plan on these swamps (to be included in the Biodiversity Management Plan – see condition 6(f) below), and comply with the proposed performance measures and indicators.

The performance measures and indicators for the Large Swamps are described below.

In relation to the subsidence impact performance measure for threatened species, populations or ecological communities, *negligible* is defined in the Project Approval as *small and unimportant, such as to be not worth considering.*

Metropolitan Coal will also assess the Project against the following biodiversity performance indicators to monitor environmental performance consistent with the TARPs detailed in Section 8.7:

The vegetation in upland swamps is not expected to experience changes significantly different to vegetation in control swamps.

Subsidence impacts are not expected to result in measurable changes to swamp groundwater levels when compared to control swamps or seasonal variations in water levels experienced by upland swamps prior to mining.

Impacts to riparian vegetation are expected to be localised and limited in extent, similar to the impacts previously experienced at Metropolitan Coal.

The aquatic macroinvertebrate and macrophyte assemblages in streams are not expected to experience long-term impacts as a result of mine subsidence.

The amphibian assemblage is not expected to experience changes significantly different to the amphibian assemblage at control sites [for Longwalls 20-27 and 301-310].

The threatened amphibian abundance is not expected to experience a decline compared to previous years, due to groundwater substrate or pool water level impacts, significantly different to the threatened amphibian abundance trends at control sites. [for Longwalls 311-316].

If data analysis indicates a biodiversity performance indicator has been exceeded, Metropolitan Coal will initiate an assessment against the performance measure and consider the need for management measures (Section 9).

Other subsidence impact performance measures (Table 1 of Condition 1, Schedule 3) of relevance to the BMP include:

Table 1: Subsidence Impact Performance Measures

Water Resources	
Catchment yield to the Woronora Reservoir	*Negligible reduction to the quality or quantity of water resources reaching the Woronora Reservoir* *No connective cracking between the surface and the mine*
Woronora Reservoir	*Negligible leakage from the Woronora Reservoir* *Negligible reduction in the water quality of Woronora Reservoir*
Watercourses	
Waratah Rivulet between the full supply level of the Woronora Reservoir and the maingate of Longwall 23 (upstream of Pool P)	*Negligible environmental consequences (that is, no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining, and minimal gas releases)*
Eastern Tributary between the full supply level of the Woronora Reservoir and the maingate of Longwall 26	*Negligible environmental consequences over at least 70% of the stream length (that is no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining and minimal gas releases)*
Land	
Cliffs	*Less than 3% of the total length of cliffs (and associated overhangs) within the mining area experience mining-induced rock fall*

Other performance indicators of relevance to the BMP include those detailed in the Metropolitan Coal Longwalls 311-316 Water Management Plan and Metropolitan Coal Longwalls 311-316 Land Management Plan.

If data analysis indicates a water resource, watercourse or land performance indicator has been exceeded, Metropolitan Coal will initiate an assessment against the relevant water resource, watercourse or land performance measure and consider the need for management measures. If a water resource, watercourse or land performance measure is considered to have been exceeded, the relevant Contingency Plan will be implemented and Metropolitan Coal will initiate an assessment against the biodiversity performance measure.

Section 8 describes the monitoring that will be conducted to assess the Project against the biodiversity performance indicators and subsidence impact performance measure for threatened species, populations and ecological communities. The monitoring program includes monitoring of:

- upland swamps (Sections 8.1 and 8.2);
- riparian vegetation (Section 8.3);
- slopes and ridgetops (Section 8.4);
- aquatic biota and their habitats (Section 8.5); and
- terrestrial fauna and their habitats (Section 8.6).

Section 8.7 provides the detailed TARPs to assess the biodiversity subsidence impact performance indicators and measures.

7 BASELINE DATA

In accordance with Condition 2, Schedule 7 of the Project Approval, this section outlines the biodiversity baseline information and data available for Longwalls 311-316.

The Longwalls 311-316 biodiversity monitoring program is described in Section 8.

7.1 UPLAND SWAMPS

7.1.1 Swamp Types

As described in Section 4.2.1, several types of upland swamps have been defined within the Metropolitan Coal Project underground mining area and surrounds according to the geomorphological settings in which they occur, namely, headwater swamps, valley side swamps and in-valley swamps.

Similar to the Longwalls 301-304, 305-307 and 308-310 mining area, the terrain over Longwalls 311-316 is highly dissected with narrow ridges. All swamps mapped in the Longwalls 311-316 mining area are a mixture of valley side swamps and headwater swamps (Figure 14).

7.1.2 Swamp Vegetation Mapping

Field inspections of upland swamp vegetation mapped by Bangalay Botanical Surveys (2008) in the vicinity of Longwalls 301-303 were conducted by Eco Logical in 2015. The revised upland swamp mapping is shown on Figures 9 and 14a and was detailed in Eco Logical (2016) (provided as Appendix 2 of the Longwalls 301-303 BMP).

Field inspections of upland swamp vegetation mapped by Bangalay Botanical Surveys (2008) overlying or proximal to Longwalls 304-310 secondary extraction were conducted by Eco Logical in 2016 and 2017 to confirm the upland swamp vegetation communities present and to check the swamp boundaries. The revised upland swamp mapping is shown on Figures 9 and 14a and was detailed in Eco Logical (2018c) (Appendix 2).

Field inspections of upland swamp vegetation mapped by Bangalay Botanical Surveys (2008) overlying or proximal to Longwalls 301-317 secondary extraction were conducted by Ecoplanning in 2019 to confirm the upland swamp vegetation communities present and to check the swamp boundaries. The revised upland swamp mapping is shown on Figures 9 and 14a and is detailed in Ecoplanning (2021c) (Appendix 4).

The field inspections of upland swamps undertaken by Ecoplanning in 2019 were limited to Swamps 78, 79, 80, 90 and 91 overlying Longwalls 311-315, and the large headwater swamps, namely Swamps 76, 77, 92 and 106 overlying Longwalls 312-317. Similar to the revised upland swamp vegetation mapping conducted for Longwalls 304-310 (Appendix 2), for each upland swamp a description of the vegetation was recorded including the different vegetation strata present, the dominant species and an estimation of percent foliage cover for each stratum to assign vegetation communities described by the NPWS (2003) and Bangalay Botanical Surveys (2008). Final delineation of vegetation community boundaries was undertaken by interpretation of recent aerial photographs. Patterns identified on aerial photographs were related to the field observations and used to delineate the boundaries of vegetation communities. The revised upland swamp mapping is shown on Figures 9 and is detailed in Ecoplanning (2021c) (Appendix 4).

In addition to the swamps described above, Ecoplanning undertook additional field inspections of Swamps 76, 77 and 92 in 2023 to confirm the upland swamp vegetation communities present and to check the swamp boundaries. The revised upland swamp mapping is shown on Figure 9 and is detailed in Ecoplanning (2024) (Appendix C of the Large Swamp Assessment).

Upland swamps associated with Longwalls 311-316 include the valley side swamps (Swamps 78, 79, 80, 90 and 91) and the three large headwater swamps (Swamps 76, 77 and 92), which occupy broad sandstone plateau areas, typically more common west of the Woronora River (Ecoplanning 2021c). These large headwater swamps generally support a mosaic of different swamp community types with Swamp 92 being the most diverse (Figures 9, 14a and 14b).

As described in Section 4.2.1.4, swamps in the vicinity of Longwalls 311-316 were subject to WaterNSW hazard reduction burns in 2016 and/or 2017 (namely, Swamps 63, 64, 65, 66, 67, 68a, 68b, 71a and 71b). It is recognised that while these swamps were all mapped as containing Banksia Thicket vegetation (Appendix 2), the hazard reduction burns are likely to have affected the vegetation communities that are now present.

7.1.3 Swamp Vegetation Data

As described in Section 4.2.1.4, a number of swamps proximal to Longwalls 311-316 have been monitored for Longwalls 301-304, Longwalls 305-307 or Longwalls 308-310. This includes transect/quadrat monitoring at Swamps 78, 79, 80, 81, 82, 89, 90 and 92 (Figure 14a).

Visual inspections of swamps proximal to Longwalls 311-316 have also been conducted biannually (i.e. in spring and autumn) as a component of the Longwalls 23-27, Longwalls 301-304, Longwalls 305-307 or Longwalls 308-310 upland swamp vegetation monitoring program, namely swamps 62, 78, 79, 80, 81, 82, 83, 88, 89, 90, 92 and 94 (Figure 14a), including:

- for Swamp 94, as a part of the Longwalls 23-27 upland swamp vegetation monitoring program since spring 2010;
- for Swamps 62, 78, 79, 80, 81, 82, 83, 88, 89, 90 and 92 as a part of the Longwalls 308-310 upland swamp vegetation monitoring program, since spring 2021 (Figure 14a).

Baseline visual inspections have been conducted biannually (i.e. in spring and autumn) since autumn 2023 at Swamps 76 and 77 and since spring 2021 at Swamps 78, 79, 80, 81, 82, 89, 90 and 92 above Longwalls 311-316 and within the 35° angle of draw and/or predicted 20 mm subsidence contour.

Transect and quadrat data has been obtained for swamps proximal to Longwalls 311-316 biannually (i.e. in spring and autumn) as a component of other longwall series upland swamp vegetation monitoring program, including:

- for Swamp 94, as a part of the Longwalls 23-27 upland swamp vegetation monitoring program since spring 2010; and
- for Swamps 62, 78, 79, 80, 81, 82, 89, 90, and 92 as a part of the Longwalls 308-310 upland swamp vegetation monitoring program since spring 2021 (Figures 9 and 14a).

Baseline transect and quadrat data for Longwalls 311-316 have been obtained biannually (i.e. in spring and autumn) for Swamps 78, 79, 80, 81, 82, 89, 90 and 92 since spring 2021 and for Swamps 76 and 77 since autumn 2023, consistent with the methods used for Longwalls 20-22, Longwalls 23-27, Longwalls 301-303, Longwall 304, Longwalls 305-307 and Longwalls 308-310 upland swamp vegetation monitoring programs.

Baseline visual inspections will be conducted for Swamps 74, 75, 119, 128, 139 and 106 from 2025 onwards.

7.1.4 Swamp Groundwater Data

Paired piezometers (i.e. one swamp substrate piezometer [at approximately 1 m depth] and one sandstone piezometer [at a depth of approximately 10 m]) were installed in Swamps 60, 62, 64, 72, 133 and 134 in October 2018 (prior to the shortening of the commencing ends of Longwalls 305-307) (Figure 9).

Further, Metropolitan Coal completed Surface Works Assessment Forms for the proposed installation of upland swamp piezometers in Swamps 76, 77, 81, 82, 89 and 92 (Figure 9), which were submitted to the DPIE in early 2020. DPIE subsequently approved these works and piezometers were installed in all of these upland swamps in November 2020.

In early 2024, Metropolitan Coal installed additional 10 m piezometers in Swamps 77-1 and 77-3 where monitoring previously housed a substrate piezometer only. Prior to commencing Longwall 311 (and where access, weather and ground conditions permit), Metropolitan Coal plans to install additional 10 m piezometers in Swamps 76 and 92 at the locations currently housing a substrate piezometer only (i.e. at sites 76-1, 76-3, 92-1 and 92-3). As of October 2024, the 10 m piezometer at S92-1 has not been installed due to unsuitable ground conditions.

Metropolitan Coal will seek to install monitoring equipment (subject to access, weather and ground conditions) at sites 106-1, 106-2, 106-3, S14, S74, S75, S113, S115, S119, Bee Creek Swamp-1 and Bee Creek Swamp-2.

Consistent with the previous extraction plans, piezometers are not proposed to be installed in smaller swamps. A number of the smaller swamps are also difficult and unsafe to access.

7.1.5 Swamp Moisture Probes

Metropolitan Coal installed soil moisture probes (linked to a datalogger) at various depth intervals to monitor the vertical profile of soil moisture in the swamp substrate of Swamps 62, 72, 76, 77, 81, 82, 89, 92, 101, 137a and 137b (Figure 9).

7.2 RIPARIAN VEGETATION

Visual, transect/quadrat and indicator species monitoring has been conducted for the Eastern Tributary and Waratah Rivulet riparian vegetation for Longwalls 20-22 and Longwalls 23-27 as described in Section 4.2.2.

Site MRIP10 and MRIP04 on the Waratah Rivulet are located within 600 m of Longwalls 311-316 (Figure 11).

No additional monitoring sites have been established in relation to Longwalls 301-303, 304, 305-307, 308-310 or 311-316.

7.3 SLOPES AND RIDGETOPS

Six cliff and overhang sites (namely COH10, COH11, COH12, COH13, COH18 and COH19) are located within the 35° angle of draw and/or predicted 20 mm subsidence contour for Longwalls 311-316.

Detailed baseline recording for four cliffs and overhang sites located within the Longwalls 311-316 35°angle of draw and/or predicted 20 mm subsidence contours (COH10, COH11, COH12 and COH13) has been conducted and is included in Appendix B. Baseline recording of the remaining two cliffs, COH18 and COH19, within the 35° angle of draw and/or predicted 20 mm subsidence contour will be carried out prior to the commencement of Longwall 311.

The data obtained includes:

- photographic records of the cliff and overhang;
- sketches of the overhang; and
- mapping of the approximate location of the cliff/overhang face and the rear extent of the overhang/undercut.

The baseline record is provided in the Longwalls 311-316 Land Management Plan.

No surface tension cracks as a result of previous mining have been observed within the 35° angle of draw and/or predicted 20 mm subsidence contour of Longwalls 311-316 to date (i.e. at the time of BMP development).

7.4 AQUATIC BIOTA AND THEIR HABITATS

The Eastern Tributary and Waratah Rivulet flow in a northerly direction into the full supply level of the Woronora Reservoir within the 35° angle of draw and/or predicted 20 mm subsidence contour for Longwalls 311-316 (Figure 2). Prior to the commencement of Longwall 20, MSEC compiled a comprehensive survey and photographic record of the Eastern Tributary (from the east-west headings to the Woronora Reservoir full supply level) and the Waratah Rivulet (from Flat Rock Crossing to the Woronora Reservoir full supply level). The detailed mapping and photographic record of the Eastern Tributary and Waratah Rivulet are provided in the Metropolitan Coal Longwalls 311-316 Water Management Plan.

Baseline surface water data (e.g. surface water flow, pool water levels and water quality) are also available for the Eastern Tributary and Waratah Rivulet at the sites shown on Figures 6 and 7 and as described in the Metropolitan Coal Longwalls 311-316 Water Management Plan.

As described in Section 5.4.1, small first and second order streams are located within the 35° angle of draw and/or predicted 20 mm subsidence contour for Longwalls 311-316 (Figures 2 and 4). These streams consist of shallow drainage lines from the topographical high point above Longwalls 301-304 and Longwalls 308-310, forming streams where valley heights increase and drain into the Woronora Reservoir.

Hydro Engineering & Consulting conducted a visual inspection and photographic survey of streams in the vicinity of Longwalls 304-310 (not previously inspected for Longwalls 301-303) in April 2018 (Hydro Engineering & Consulting, 2019). The visual inspection and photographic survey report is provided in Appendix 3.

Monitoring of macroinvertebrates and macrophytes has been conducted at sites on the Eastern Tributary and Waratah Rivulet for Longwalls 20-22 and Longwalls 23-27 as described in Section 4.2.3. Aquatic ecology monitoring Location WT5 on the Waratah Rivulet is situated within 600 m of Longwalls 311-316 (Figure 12).

No additional monitoring sites have been established in relation to Longwalls 301-303, 304, 305-307, 308-310 or 311-316.

7.5 TERRESTRIAL FAUNA AND THEIR HABITATS

Baseline data are available for terrestrial fauna habitats, i.e. upland swamps, riparian vegetation, slopes and ridgetops, and aquatic habitats, as described in Sections 7.1 to 7.4, respectively.

Amphibians were selected as the appropriate representative of terrestrial vertebrate fauna because they were/are widespread across the Project area at the time of monitoring program design, and included two threatened species that are sensitive to changes in surface hydrology. This group is represented by at least 14 species that appear to have viable populations. Amphibian monitoring has been conducted for Longwalls 20-22, 301-307 and Longwalls 308-317 as described in Section 4.2.4 and shown on Figure 13.

Two amphibian monitoring sites (sites 32 and 39) have been established proximal to Longwalls 308-310 (Figure 13). Monitoring of these sites commenced in spring/summer 2019. Four additional amphibian monitoring sites (i.e. one site within each of Swamp 76, 77 and two sites within Swamp 92) have been established within the Longwalls 311-316 mining area (Figure 13). Monitoring of these sites commenced in spring/summer 2023. No additional control sites were required to ensure a continually robust experimental design.

A total of 39 amphibian survey sites have been established, including 28 test sites overlying or adjacent to Longwalls 20-317 to monitor amphibian species, with a focus on the habitats of the Giant Burrowing Frog, Red-crowned Toadlet and Littlejohn's Tree Frog.

Baseline surveys were undertaken by Ecological Consultants Australia in late 2023 and early 2024 in Swamps 76, 77 and 92. Surveys were conducted on 25 October 2023, 22 November 2023 and 5 January 2024. A total of four Song Meter Micro bird and wildlife audio recorders (Faunatech) were installed on the 22 November 2023, one at Swamps 76 and 77 and two at Swamp 92.

Further baseline surveys for threatened amphibians will continue in the Longwalls 311-316 area in late 2024/early 2025 along Tributaries P, R and S. During the further baseline amphibian surveys, searches would be conditioned to identify potential breeding pools for threatened amphibians. If a breeding pool is identified, pool water level monitoring equipment will be installed in the relevant pool.

Additional targeted baseline surveys for the Giant Dragonfly in Swamps 76, 77 and 92 and Eastern Ground Parrot within Swamp 92 will be conducted during the Summer 2024 period. Giant Dragonfly surveys would target exuviae in wetter sections of the Large Swamps. If detected during baseline surveys, regular monitoring for the Giant Dragonfly and/or Eastern Ground Parrot would be conducted and incorporated into an updated BMP. Should the baseline surveys not identify these species in the Longwalls 311-316 Extraction Plan Study Area, Metropolitan Coal will not conduct regular monitoring. If established, monitoring programs would target key lifecycle stages of the species (e.g. key emergence period between December and January for Giant Dragonfly).

8 MONITORING PROGRAM

Subsidence parameters will be measured in accordance with the Longwalls 311-316 Subsidence Monitoring Program (Figure 3). In summary, surveys will be conducted to measure subsidence movements in three dimensions using a total station survey instrument. Subsidence movements will be measured along subsidence lines that have been positioned across the general landscape.

The Longwalls 311-316 Water Management Plan describes the monitoring and adaptive management approach that will be implemented to monitor subsidence effects on the Waratah Rivulet.

A monitoring program will be implemented to monitor the impacts and environmental performance of the Project on aquatic and terrestrial flora and fauna during the mining of Longwalls 311-316. The monitoring program is described in Sections 8.1 to 8.6 and will be implemented at the commencement of Longwall 311 extraction. The monitoring program includes monitoring for Longwalls 311-316, as well as the post-mining monitoring to be implemented for Longwalls 20-22, Longwalls 23-27, Longwalls 301-303, Longwall 304, Longwalls 305-307 and Longwalls 308-310[45]. As described in Section 1.1, the Metropolitan Coal Longwalls 308-310 BMP will be superseded by this document following the completion of Longwall 310 consistent with the recommended approach in the DPE (2022) *Extraction Plan Guideline*.

Section 8.7 provides detailed TARPs to assess the biodiversity subsidence impact performance indicators and measures. The Longwalls 311-316 Water Management Plan provides a detailed TARP to assess subsidence effects on the Waratah Rivulet during the mining of Longwalls 311, 312, 313, 314, 315 and 316.

As described in Section 2, this BMP will be reviewed within three months of the submission of an Annual Review, and revised where appropriate, to the satisfaction of the Secretary of the DPE.

8.1 UPLAND SWAMP VEGETATION MONITORING

Visual Inspections

Visual inspections will continue to be conducted of Swamps 16, 17, 18, 19, 20, 24, 25, 28, 30, 31, 32, 33, 34, 35, 36 and 94 overlying or adjacent to Longwalls 20-27 to record evidence of potential subsidence impacts. Some of these swamps are also subject to biannual transect/quadrat and/or indicator species monitoring (as described below). None of these swamps are located within the Longwalls 311-316 35° angle of draw and/or predicted 20 mm subsidence contour (Figure 9).

Visual inspections will continue to be conducted of Swamps 40, 41, 46, 47, 48, 49, 50, 51/52, 53 and 58 overlying or adjacent to Longwalls 301-304, Swamps 69, 70, 71a, 71b, 72 and 73 overlying or adjacent to Longwalls 305-307 and Swamps 61, 62, 63, 64, 78, 79, 80, 81, 82, 83, 88, 89, 90 and 92 overlying or adjacent to Longwalls 308-310, to record evidence of potential subsidence impacts (Figures 9 and 14a).

Visual inspections will be conducted of Swamps 74, 75, 76, 77, 92, 106, 119, 128 and 139 (Figure 9), located within the Longwalls 311-316 35° angle of draw and/or predicted 20 mm subsidence contour.

Visual inspections will also continue to be conducted in control Swamps 101, 111a, 125, 135, 136, 137a, 137b, 138, Bee Creek Swamp, Woronora River 1, Woronora River south arm and Dahlia Swamp (Figure 9).

[45] The Metropolitan Coal Longwall 305-307 BMP will be implemented until the commencement of Longwall 308.

Traverses over the swamps will be conducted biannually in autumn and spring for swamps overlying or adjacent to Longwalls 301-317 and every third year in autumn and spring for swamps overlying or adjacent to Longwalls 20-27, to record:

- cracking of exposed bedrock areas and/or swamp substrate;
- areas of increased erosion, particularly along any existing drainage line;
- any changes in water colour, particularly evidence of iron precipitation;
- changes in vegetation condition, including areas of stressed vegetation (i.e. plants that demonstrate symptoms of stress) and dead/dying plants that appear unusual; and
- whether the amount of seepage (at the terminal step/over exposed surfaces of the swamp) at the time of inspection appears unusual (relative to recent rainfall).

Photographs of any cracking, erosion, water colour changes and stressed vegetation will be taken, concurrently with a description of the nature and extent of the observations, and appropriate global positioning system (GPS) readings. If changes in vegetation condition are observed in a swamp that are not similar to that in control swamp(s), the extent of change will be noted, and where practicable, mapped. Seepage will be documented by photographs of flow over exposed surfaces, e.g. terminal step.

The visual inspections will assess the changes in the observed physical condition of the swamps over time.

Visual inspections are to be conducted every third year (in both autumn and spring) for swamps associated with Longwalls 20-27. Other monitoring for the 300-series would occur in autumn and spring each year.

Transect/Quadrat Monitoring

Transect and quadrat monitoring will be conducted every third year in autumn and spring in Swamps 28, 30, 33, 35 and 94 overlying or adjacent to Longwalls 23-27 and biannually in control Swamps 101, 135, 136, 137a, 137b, 138, Bee Creek Swamp, Woronora River south arm and Dahlia Swamp (Figure 9) consistent with the monitoring methods described in Section 4.2.1.4. None of these swamps are located within the Longwalls 311-316 35° angle of draw and/or predicted 20 mm subsidence contour.

Previous transect/quadrat monitoring of swamps overlying or adjacent to Longwalls 20-22 has been discontinued as of autumn 2022. This is due to the stability of vegetation condition, as reflected by species richness, observed in most swamps over the seven years since the completion of mining of Longwalls 20-22. Species richness has been stable at five of the six Longwall 20-22 upland swamp sites, with peaks and troughs reflecting climatic and seasonal changes (e.g. peaks during wetter seasons prior to 2017, troughs observed during prolonged dry period from spring 2017 to spring 2019 and higher species richness during spring compared to autumn survey). The exception is Swamp 28 where long term decline in species richness has been observed since spring 2016. It is likely this is an effect of canopy thickening with time since fire, which results in localised loss of ground layer species, which contribute the majority of species richness. A similar dynamic is observed in the control site, Swamp 101. Visual inspections of these swamps will continue to monitor for any obvious changes to vegetation condition.

Transect and quadrat monitoring will also continue to be conducted in Swamps 40, 41, 46, 48, 50, 51/52 and 53 overlying or adjacent to Longwalls 301-304, Swamp 71a adjacent to Longwalls 305-307 and Swamps 62, 64, 78, 79, 80, 81, 82, 83, 89, 90 and 9 overlying or adjacent to Longwalls 308-310 (Figures 9 and 14a).

Transect and quadrat monitoring will be conducted in Swamps 76 and 77 within the 35° angle of draw and/or predicted 20 mm subsidence contour of Longwalls 311-316 (Figures 9 and 14a).

Transect and quadrat monitoring will also be conducted in control Swamps 101, 135, 136, 137a, 137b and 138 (Figures 9 and 14a) biannually consistent with the monitoring methods described in Section 4.2.1.4.

As described in Section 4.2.1.4, portions of Swamp 46, Swamp 51/52, Swamp 71a and Swamp 64, 52 were subject to WaterNSW hazard reduction burns after the autumn 2017 survey (baseline) and before the spring 2017 survey.

The data collected for each quadrat will continue to include:

- vegetation structure;
- dominant species;
- estimated cover and height for each stratum;
- full floristics;
- estimated cover abundance for each species using seven point Braun-Blanquet scale; and

  Modified Braun-Blanquet Scale
  1 = cover less than 5% of site and rare
  2 = cover less than 5% of site and uncommon
  3 = cover of less than 5% and common
  4 = cover of 5-20% of site
  5 = cover of 21-50% of site
  6 = cover of 51-75% of site
  7 = cover of greater than 75%
- condition/health rating for each species in the quadrat:

  Condition Scale
  1 severe damage/dieback
  2 many dead stems
  3 some dead branches
  4 minor damage
  5 healthy

Analysis of the quadrat/transect data will be conducted on a six-monthly basis.

Drone Survey

Consistent with the recommendations in Independent Expert Advisory Panel for Mining (IEAPM) (2023a), Metropolitan Coal will investigate the inclusion of drone surveys as part of the regular monitoring for Large Swamps 76, 77 and 92. The inclusion of drones as part of the regular monitoring would assist with identifying changes to vegetation across the entire swamp on a year-to-year basis (while avoiding potential impacts to vegetation associated with more extensive ground surveys).

Indicator Species Monitoring

Population monitoring will continue to be conducted for Longwalls 20-22 during the extraction of Longwalls 311-316, specifically, 20 tagged individuals of:

- *Epacris obtusifolia* in each of Swamps 18 and 24 (longwall swamps) and control Swamps 101, 111a and 125.

Three indicator species characteristic of the Tea Tree Thicket vegetation namely, *Banksia robur, Callistemon citrinus* and *Leptospermum juniperinum* will also continue to be monitored in Swamp 20 and at associated control sites (Woronora River 1, Woronora River south arm and Dahlia Swamp). The 20 tagged individuals will continue to be monitored in each swamp.

Population monitoring will also continue to be conducted for Longwalls 23-27 during the extraction of Longwalls 311-316, specifically, 20 tagged individuals of:

- *Epacris obtusifolia* in each of Swamps 35 and 94 (longwall swamps) and control Swamps 101, 111a, 125, 137a, 137b and 138; and
- *Callistemon citrinus* in Swamp 28 (longwall swamp) and control Swamps Woronora River 1, Woronora River south arm and Dahlia Swamp.

Population monitoring will also continue to be conducted for Longwalls 301-304 during the extraction of Longwalls 311-316, specifically, 20 tagged individuals of[46]:

- *Epacris obtusifolia* will be monitored in each of Swamps 40 and 53 (longwall swamps) and control Swamps 101, 136 and 137a.

Population monitoring for Longwalls 20-22, 23-27 and 301-304 will continue to be conducted in the abovementioned swamps using the methods described in Section 4.2.1.4. Population monitoring data collected will include:

- condition/health rating for each plant; and

  Condition Scale

  1 severe damage/dieback
  2 many dead stems
  3 some dead branches
  4 minor damage
  5 healthy

- reproductive rating:

  Reproductive Rating

  1 nil
  2 sparse (occasional flowers only)
  3 low (under 25 percent of potential)
  4 moderate (25 to 75 percent)
  5 high (over 75 percent of potential flowering)

Surveys will be conducted biannually in autumn and spring.

Analysis of the indicator species data will be conducted on a six-monthly basis.

46 Insufficient individuals of *Pultenaea aristata* were available in the swamps over Longwalls 301-303 for monitoring.

8.2 UPLAND SWAMP GROUNDWATER MONITORING

The approach taken to the development of the upland swamp groundwater monitoring program is described in Section 7.1.4 in relation to the collection of baseline data. Groundwater monitoring of upland swamps has included the monitoring of paired piezometers (i.e. one swamp substrate piezometer to a depth of approximately 1 m and one sandstone piezometer to a depth of approximately 10 m).

Upland swamp groundwater monitoring will continue to be conducted in Swamps 20 and 25 for Longwalls 20-22, Swamps 28, 30, 33 and 35 for Longwalls 23-27, Swamps 40, 41, 46, 51, 52 and 53 for Longwalls 301-303, Swamp 50 for Longwall 304, Swamps 71a and 72 for Longwalls 305-307, Swamps 62 and 64 for Longwalls 308-310 and in control Swamps 101, 137a, 137b, Bee Creek Swamp and Woronora River 1 (WRSWAMP 1) (Figure 9).

Upland swamp groundwater monitoring will be conducted in Swamps 74, 75, 76, 77, 78, 79, 80, 81, 83, 89, 90, 91, 92, 1106, 113, 115 and 119 for Longwalls 311-316 (Figure 9).

In 2020, the piezometer monitoring was augmented by soil moisture monitoring probes in Swamps 62, 72, 76, 77, 81, 89 and 92, as well as in control Swamps 101, 137a and 137b. The probes are measuring soil moisture in 10 cm intervals at each site.

Table 14A in Section 8.7 details the data analysis that will be conducted to assess the upland swamp substrate groundwater monitoring results against the upland swamp groundwater performance indicator (null hypothesis), *Subsidence impacts are not expected to result in measurable changes to swamp groundwater levels when compared to control swamps or seasonal variations in water levels experienced by upland swamps prior to mining*, consistent with the previously approved upland swamp groundwater monitoring program.

In early 2024, Metropolitan Coal installed additional 10 m piezometers in Swamps 77-1 and 77-3 where monitoring previously housed a substrate piezometer only. Prior to commencing Longwall 311 (and where access, weather and ground conditions permit), Metropolitan Coal has installed additional 10 m piezometers in Swamps 76 and 92 at the locations currently housing a substrate piezometer only (i.e. at sites 76-1, 76-3, and 92-3). The piezometer at Swamp 92 (92-1) will be installed as soon as possible subject to suitable weather and access.

The following GNSS valley closure monitoring pairs will be established across the valleys at the downstream groundwater monitoring sites within the Large Swamps:

- S92-1-STH-GNSS.
- S92-1-NTH-GNSS.
- S77-1-EST-GNSS.
- S77-1-WST-GNSS.
- S76-1-EST-GNSS.
- S76-1-WST-GNSS.

Metropolitan is investigating a potential location for a new substrate-only monitoring site at the downstream end of Swamp 77 (S77-0). Metropolitan has paired a set of valley closure monitoring units across this groundwater site, designated as follows:

- S77-0-EST-GNSS.
- S77-0-WST-GNSS.

8.3 RIPARIAN VEGETATION

Riparian areas along the Waratah Rivulet and Eastern Tributary will continue to be monitored at sites MRIP01 to MRIP12[47] established previously for Longwalls 20-22 and/or Longwalls 23-27 (Figure 11). Sites MRIP01, MRIP02, MRIP05, MRIP06 and MRIP09 are situated over Longwalls 20-22 and sites MRIP11 and MRIP12 are situated over Longwalls 23-27. Sites MRIP03, MRIP04 and MRIP10 are situated downstream of Longwall 23A on the Waratah Rivulet. Sites MRIP07 and MRIP08 are situated on the Eastern Tributary downstream of Longwalls 23-27.

No additional riparian monitoring sites have been established for Longwalls 301-303, 304, 305-307, 308-310 or 311-316.

Visual Inspections

Visual inspections of riparian areas will continue to be conducted in locations adjacent to riparian vegetation monitoring sites (sites MRIP01 to MRIP12), and areas traversed whilst accessing the monitoring sites during the mining of Longwalls 311-316 to record evidence of subsidence impacts including:

- areas of new water ponding;
- any cracking or rock displacement; and
- changes in vegetation condition, including areas of stressed vegetation that appear unusual.

Photographs of any new water ponding, cracking/rock displacement and stressed vegetation will be taken, concurrently with a description of the nature and extent of the observations, and appropriate GPS readings. Flora species that have been subject to vegetation dieback will be noted. The visual inspections will be conducted biannually in autumn and spring.

The visual inspections will assess the changes in the observed physical condition of the riparian zone over time (Table 16 in Section 8.7).

Quadrat Monitoring

The existing permanent quadrat (20 m x 2 m) will continue to be used to monitor riparian vegetation at (Figure 11):

- sites MRIP01, MRIP02, MRIP05 and MRIP06 overlying Longwalls 20-22;
- sites MRIP11 and MRIP12 overlying Longwalls 23-27;
- sites MRIP03, MRIP04 and MRIP10 downstream of Longwall 23A; and
- sites MRIP07 and MRIP08 downstream of Longwalls 23-27.

The data collected for each quadrat will include:

- vegetation structure;
- dominant species;
- estimated cover and height for each stratum;
- full floristics;

47 Sites MRIP01, MRIP02, MRIP03, MRIP04 and MRIP10 are situated in the vicinity of pools J, N, Q, U and W, respectively on the Waratah Rivulet. Sites MRIP05, MRIP06, MRIP07, MRIP08, MRIP09, MRIP11 and MRIP12 are situated in the vicinity of pools ETJ, ETM, ETAQ, ETAS, ETF, ETV and ETAG, respectively, on the Eastern Tributary.

- estimated cover abundance for each species using seven point Braun-Blanquet scale; and

  Modified Braun-Blanquet Scale

  1 = cover less than 5% of site and rare
  2 = cover less than 5% of site and uncommon
  3 = cover of less than 5% and common
  4 = cover of 5-20% of site
  5 = cover of 21-50% of site
  6 = cover of 51-75% of site
  7 = cover of greater than 75%

- condition/health rating for each species in the quadrat:

  Condition Scale

  1 severe damage/dieback
  2 many dead stems
  3 some dead branches
  4 minor damage
  5 healthy

Permanent photo points have been established for each quadrat.

Surveys of the quadrats will continue to be conducted biannually in autumn and spring.

The monitoring conducted at quadrats along the streams will inform the assessment of vegetation dieback for the assessment against the riparian vegetation performance indicator, *Impacts to riparian vegetation are expected to be localised and limited in extent, similar to the impacts previously experienced at Metropolitan Coal*.

Indicator Species Monitoring

Three indicator species will continue to be monitored within the riparian vegetation of Waratah Rivulet and the Eastern Tributary, namely, *Prostanthera linearis*, *Schoenus melanostachys* and *Lomatia myricoides*. The existing tagged individuals[48] will continue to be monitored at:

- sites MRIP01, MRIP05, MRIP06 and MRIP09 overlying Longwalls 20-22;
- sites MRIP11 and MRIP12 overlying Longwalls 23-27;
- sites MRIP03 and MRIP10 downstream of Longwall 23A; and
- sites MRIP07 and MRIP08[49] downstream of Longwalls 23-27.

The indicator species, *Lomatia myricoides,* will continue to be monitored at the site MRIP02 overlying Longwalls 20-22. The indicator species *Schoenus melanostachys* and *Lomatia myricoides* will continue to be monitored at the site MRIP04 downstream of Longwall 23A.

48 Twenty individuals were selected and tagged for monitoring at the commencement of the Longwalls 20-22 and Longwalls 23-27 programs.

49 Note: Twenty individuals of *Prostanthera linearis* were not available for tagging at site MRIP08.

Population monitoring data collected includes:

- condition/health rating for each plant; and

  Condition Scale
  1 severe damage/dieback
  2 many dead stems
  3 some dead branches
  4 minor damage
  5 healthy

- reproductive rating:

  Reproductive Rating
  1 nil
  2 sparse (occasional flowers only)
  3 low (under 25 percent of potential)
  4 moderate (25 to 75 percent)
  5 high (over 75 percent of potential flowering)

Surveys will be conducted biannually in autumn and spring.

The monitoring conducted of indicator species along the streams will inform the assessment of vegetation dieback for the assessment against the riparian vegetation performance indicator, *Impacts to riparian vegetation are expected to be localised and limited in extent, similar to the impacts previously experienced at Metropolitan Coal*.

8.4 SLOPES AND RIDGETOPS

Potential subsidence impacts and environmental consequences on cliffs and overhangs, steep slopes, and land in general will be monitored in accordance with the Metropolitan Coal Longwalls 311-316 Land Management Plan, a summary of which is provided in Sections 8.4.1 and 8.4.2. As described in Section 5, subsidence impacts on cliffs and overhangs, steep slopes, and land in general have the potential to result in environmental consequences to aquatic and terrestrial biota and their habitats.

8.4.1 Cliffs and Overhangs

Following the completion of Longwall 27 extraction, cliff sites COH1, COH2, COH3, COH4, COH5, COH6, COH6A, COH7, COH8, COH9, COH10, COH14, COH15 and COH16 (Figure 18) were inspected to record any additional subsidence impacts (e.g. cliff instabilities and cracking) to those previously recorded. The visual inspections did not record any additional subsidence impacts.

Visual inspections of site COH17 were conducted monthly when mining of Longwalls 303, 304 and 305 was within 400 m of the site, and again following their completion. The visual inspections did not record any subsidence impacts.

A visual inspection for subsidence impacts at cliff and overhang sites COH11, COH12, COH13, COH16 and COH17 were conducted following the completion of Longwall 305. The visual inspections did not record any subsidence impacts.

In accordance with the Longwalls 308-310 Land Management Plan, visual inspections for subsidence impacts on cliff sites COH9, COH10, COH11, COH12, COH13 and COH16 will be conducted monthly when the extraction of Longwall 308, Longwall 309 and Longwall 310 is within 400 m of the site and again following the completion of each longwall.

Visual inspections for subsidence impacts for Longwalls 311-313 will be conducted at sites COH10, COH11, COH12, COH13, COH18 and COH19:

- prior to the commencement of Longwall 311 extraction;
- monthly at cliff site(s) located within 400 m of longwall extraction; and
- within three months of the completion of Longwall 311, Longwall 312 and Longwall 313 at all identified sites (i.e. sites COH10, COH11, COH12, COH13, COH18 and COH19) and within three months of the completion of Longwall 314, Longwall 315 and Longwall 316 at sites COH18 and COH19.

Additional visual observations of subsidence impacts will be conducted during routine works and sampling by Metropolitan Coal and its contractors. In the event subsidence impacts are identified on cliff and overhang sites, the following details will be noted and/or photographed:

- the date of the inspection;
- the location of longwall extraction (i.e. the longwall chainage);
- the location of the cliff instability (i.e. freshly exposed rock face and debris scattered around the base of the cliff or overhang) relative to the cliff face or overhang;
- the nature and extent of the cliff instability (including an estimate of volume);
- the length of the cliff instability;
- other relevant aspects such as water seepage (which can indicate weaknesses in the rock);
- whether any actions are required (for example, implementation of appropriate safety controls, review of public safety etc.); and
- any other relevant information.

The information obtained will be recorded in the Land Management Plan – Subsidence Impact Register and reported in accordance with the Project Approval conditions.

The information obtained will be used to assess the potential environmental consequences of the subsidence impact on flora, fauna and/or their habitats. Specific details that will be noted and/or photographed to assess the potential environmental consequences of the subsidence impact include:

- the nature and extent of impacts on the aesthetic values of the land feature;
- any areas of erosion or sedimentation arising from mining activities;
- the co-ordinates of the subsidence impact to assess impacts on known Aboriginal heritage sites;
- nature and extent of impacts on potential flora and fauna habitats;
- evidence of impacts on terrestrial fauna (e.g. observed fauna mortality); and
- any impacts on the serviceability of fire trails/vehicular tracks and/or stream crossings.

Metropolitan Coal will document the assessment of potential environmental consequences in the Land Management Plan – Subsidence Impact Register Assessment Form.

8.4.2 Steep Slopes and Land in General

In accordance with the Longwalls 311-316 Land Management Plan, visual inspections for subsidence impacts on steep slopes and land in general within 600 m of Longwalls 20-27 and Longwalls 301-310 extraction will be conducted by Metropolitan Coal and its contractors during catchment visits, sampling and routine works conducted in the catchment.

In the event subsidence impacts are identified within 600 m of Longwalls 20-27, Longwalls 301-304, Longwalls 305-307 or Longwalls 308-310 (that were not previously recorded during the mining of Longwalls 20-27, Longwalls 301-304, Longwalls 305-307 or Longwalls 308-310), or within 600 m of Longwalls 311-316, the following details will be noted and/or photographed:

- the location, approximate dimensions (length, width and depth), and orientation of surface tension cracks;
- the location of the surface tension crack in relation to fire trails or vehicular tracks;
- the location and approximate dimensions of rock falls (e.g. rock ledges);
- whether any actions are required (for example, implementation of appropriate safety controls, review of public safety etc.); and
- any other relevant information.

The date of the observation, details of the observer and the location of longwall extraction will also be documented. The information obtained will be recorded in the Land Management Plan – Subsidence Impact Register and reported in accordance with the Project Approval conditions.

The information obtained will be used to assess the potential environmental consequences of the subsidence impact on flora, fauna and/or their habitats. Specific details that will be noted and/or photographed to assess the potential environmental consequences of the subsidence impact include:

- any areas of erosion or sedimentation arising from mining activities;
- nature and extent of impacts on potential flora and fauna habitats; and
- evidence of impacts on terrestrial fauna (e.g. observed fauna mortality).

Metropolitan Coal will document the assessment of potential environmental consequences in the Land Management Plan – Subsidence Impact Register Assessment Form.

8.5 AQUATIC BIOTA AND THEIR HABITATS

Metropolitan Coal will assess the subsidence impacts and environmental consequences on surface water resources and watercourses (aquatic habitats) in accordance with the Metropolitan Coal Longwalls 311-316 Water Management Plan (Figure 3 and Section 6).

As indicated in Section 7.4, no additional aquatic ecology monitoring sites have been established in relation to Longwalls 301-303, 304, 305-307, 308-310 or 311-316. Existing monitoring Location WT5 on the Waratah Rivulet is situated within 600 m of Longwalls 311-316 (Figure 12).

Consistent with the Project EA, the aquatic ecology monitoring programs previously established for Longwalls 20-22 and Longwalls 23-27 were designed to:

- monitor subsidence-induced impacts on aquatic ecology (stream monitoring); and
- monitor the response of aquatic ecosystems to the implementation of future potential stream remediation works (pool monitoring).

The design of the monitoring programs uses a “Beyond BACI” experimental design and focuses on representative sampling within streams and pools in mining areas and in suitable control streams and pools (i.e. not subject to mine subsidence).

The aquatic ecology monitoring programs include the monitoring of aquatic habitat characteristics, water quality, macroinvertebrates and aquatic macrophytes. Observations of surface cracking, iron staining and gas releases will also be made during the conduct of the aquatic ecology surveys.

Stream Monitoring

Monitoring of aquatic biota will continue to be conducted (if sufficient aquatic habitat is available for sampling) at two sampling sites (approximately 100 m long) at the following stream sampling locations:

- Location WT3 on Waratah Rivulet and Locations ET1, ET3 and ET4 on the Eastern Tributary overlying Longwalls 20-27.
- Location WT4 on Waratah Rivulet adjacent to Longwalls 20-27.
- Location WT5 on Waratah Rivulet and Location ET2 on the Eastern Tributary, downstream of Longwalls 20-27.
- Control Locations: WR1 on Woronora River and OC on O’Hares Creek.

The approximate locations of the sampling sites are shown on Figure 12.

Monitoring of the sampling sites on the Waratah Rivulet, Eastern Tributary, Woronora River and O’Hares Creek will be conducted biannually in spring (15 September to 15 December) and autumn (15 March to 15 June), consistent with the timing required by the AUSRIVAS protocol.

The monitoring parameters and methods are described in Table 4 (in Section 4.2.3).

Table 17 in Section 8.7 details the data analysis that will be conducted to assess the monitoring results against the aquatic ecology performance indicator:

> *The aquatic macroinvertebrate and macrophyte assemblages in streams are not expected to experience long-term impacts as a result of mine subsidence.*

Pool Monitoring

As described in Section 4.2.3, Pools ETAG, ETAH, ETAI and ETAK on the Eastern Tributary monitored by the previous pool monitoring program were impacted by mine subsidence in late 2016 or early 2017. Since that time, Pools ETAG, ETAH, ETAI and ETAK have often been dry or contained insufficient aquatic habitat for sampling as a result of the mine subsidence impacts. Within the performance measure reach of the Eastern Tributary, Metropolitan Coal have conducted stream remediation activities at Pools ETAH, ETAI, ETAJ and ETAK. As described in Section 9.1, Metropolitan Coal conducts stream remediation activities on the Eastern Tributary in accordance with the Metropolitan Coal Stream Remediation Plan.

Monitoring of Pools ETAG and ETAH will recommence subsequent to the conduct of stream remediation activities at Pool ETAH and will be conducted bi-annually[50]. Monitoring of Pools ETAI and ETAK will recommence subsequent to the conduct of stream remediation activities at Pool ETAK and will be conducted bi-annually[51]. The sampling of pools will be conducted consistent with the parameters and methods described for pool monitoring in Section 4.2.3, in spring (15 September to 15 December) and autumn (15 March to 15 June).

The relevant control pools on the Woronora River (larger Pool WP and/or smaller Pools WP-A, WP-B and WP-C) and O'Hares Creek (larger Pool OC and/or smaller Pools OC-A, OC-B and OC-C) will be monitored bi-annually when sampling of the pools described above recommences.

8.6 TERRESTRIAL FAUNA AND THEIR HABITATS

Terrestrial fauna habitats (upland swamps, riparian vegetation, slopes and ridgetops, and aquatic habitats/streams) will be monitored as described in Sections 8.1 to 8.5, respectively. Observations of any surface cracking and loss of flow in streams will also be noted at amphibian monitoring sites during the conducting of the amphibian surveys.

Amphibians were selected as the appropriate representative of terrestrial vertebrate fauna because they are widespread across the study area, including three threatened species that are sensitive to changes in surface hydrology, and because this group is represented by at least 14 species that appear to have viable populations.

Longwalls 20-27 and 301-310 Amphibian Monitoring Programs

The objective of the Longwalls 20-27 and 301-310 monitoring programs is to determine if longwall mining adversely impacts amphibian species as expressed in the null hypothesis:

> *The amphibian assemblage is not expected to experience changes significantly different to the amphibian assemblage at control sites.*

The Longwalls 301-310 amphibian monitoring program described in Section 4.2.4 will continue during the mining of Longwalls 311-316 to monitor amphibian species, with a focus on the habitats of the Giant Burrowing Frog, Red-crowned Toadlet and Littlejohn's Tree Frog associated with tributaries.

The Longwalls 301-310 amphibian monitoring program includes six test sites (sites 25 to 30). The control sites for Longwalls 301-307 consist of the 11 sites associated with Longwalls 20-22 (sites 7 to12) and Longwalls 23-27 (sites 18 to 22). Additional sites were added to the amphibian monitoring program in spring/summer 2019, located in the vicinity of Longwalls 308-310 (sites 31, 33, 34 and 39). The approximate locations of the monitoring sites are shown on Figure 13.

A total of 32 amphibian survey sites have been established for Longwalls 20-27 and Longwalls 301-310 (including 21 test sites overlying or adjacent to longwalls) to monitor amphibian species, with a focus on the habitats of the Giant Burrowing Frog, Red-crowned Toadlet and Littlejohn's Tree Frog. The monitoring program includes some sites that are located within the Longwalls 311-316 area.

The monitoring sites will be surveyed annually in spring/summer (i.e. October to February) during suitable weather conditions. As described in Section 4.2.4, occasionally the survey period has been extended to early autumn, because of lack of rain in the spring/summer period. It is possible that future survey periods are also delayed to coincide with suitable weather conditions.

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50 Monitoring will commence after the first stream remediation campaign at Pool ETAH has been completed (i.e. once the stream remediation activities have moved from the site).

51 Monitoring will commence after the first stream remediation campaign at Pool ETAK has been conducted (i.e. once the stream remediation activities have moved from the site).

Each site is surveyed once during a standard 30 minute general area day search (early morning and late afternoon) supplemented by an evening 30 minute search/playback session using handheld spotlights and head lamps. Song meters may be used at swamps to supplement searches.

Species will be assigned to the following relative abundance categories for tadpole and adult stages:

- 0 = no sightings;
- 1 = one sighting of adult or tadpole stage;
- UC = uncommon (i.e. 2 to 10 individuals), adult or tadpole stage;
- MC = moderately common (i.e. 11 to 20 individuals), adult or tadpole stage;
- C = common (i.e. 21 to 40 individuals), adult or tadpole stage; and
- A = abundant (>40 individuals), adult or tadpole stage.

Poisson regression analysis will be used to analyse the amphibian survey results. The ongoing analyses can only be undertaken by pooling all data gathered from all longwalls since 2011.

Longwalls 311-316 Amphibian Monitoring Program

Additional baseline amphibian surveys targeting the three threatened species (Littlejohn's Tree Frog, Giant Burrowing Frog and Red-crowned Toadlet) in S76, S77 and S92 will be completed in late 2024 and early 2025. The proposed amphibian monitoring program for the Large Swamps (S76, S77 and S92) is described in Table 18 (Section 8.7).

The following key amphibian monitoring and assessment methods are proposed for the Large Swamps:

- Threatened species-specific amphibian monitoring and TARP.
- Year-on-year comparison between threatened species relative abundance along set transects within and downstream of the Large Swamps.
- Consideration of potential groundwater and/or surface water level impacts when assessing performance against the Performance Indicator and comparison of threatened species abundance in the Large Swamps versus control sites.
- 120 minute aural-visual surveys per 500-metre of transect (subject to suitable access/weather).
- Monitoring would target the collection of data to assess changes in threatened amphibian species (including tadpoles) abundance.
- Nocturnal aural-visual surveys would be conducted along monitoring transects.
- Consideration of swamp substrate water levels, pool water levels and quality at potential breeding locations (as identified during the baseline surveys).

The amphibian monitoring will be conducted along 500 m transects located within three impact sites at Swamp 76, 77 and 92 (Figure 13). Four control transects at Swamps 14, 76, 106 and Bee Creek Swamp will also be used to test the performance indicator.

The data collected will then undergo a multivariate analysis to determine the impacts on the abundance of the threatened amphibian species (refer to Table 18 below).

During the further baseline amphibian surveys to be conducted in late 2024/early 2025 for threatened amphibians along Tributaries P, R and S, baseline conditions (pool and surface water levels) of the threatened species habitats will also be surveyed and potential breeding pools will be targeted. If a breeding pool is identified, pool water level monitoring equipment will be installed in the relevant pool. Furthermore, the Amphibian TARP (Table 18) will be revised to account for changes in the breeding pool water levels.

8.7 TRIGGER ACTION RESPONSE PLANS AND ASSESSMENT AGAINST PERFORMANCE INDICATORS AND MEASURES

The results of the monitoring program described in Sections 8.1 to 8.6 will be used to assess the Project against the performance indicators and performance measures using the TARPs detailed in Tables 14A to 18.

If data analysis indicates a biodiversity performance indicator has been exceeded, an assessment will be made against the biodiversity performance measure and the need for management measures will be considered (Section 9).

The key assessment considerations that will be taken into account when assessing the biodiversity performance measure are outlined in Table 19. Threatened species, populations and ecological communities include those listed under the TSC Act, EPBC Act or *Fisheries Management Act 1994* at the time of Project Approval (i.e. the lists current as at 22 June 2009).

If the biodiversity performance measure is considered likely to have been exceeded, the Contingency Plan will be implemented (Section 10). Metropolitan Coal will implement suitable contingency measures (Section 10) and continue to monitor (Section 8).

Technical Committee

A Technical Committee, comprising industry and technical representatives, will be established to review the monitoring data in accordance with the Large Swamp Groundwater TARP (Table 14B) and Large Swamp Valley Closure TARP (Table 15). The purpose of the Technical Committee is to provide frequent oversight of monitoring data analysis and environmental performance to inform ongoing management decisions. Meetings would commence once valley closure is measured above 50 mm at the Large Swamps. The Technical Committee's reports and advice would be used to inform mine planning decisions for the current longwall and subsequent longwalls planned to be mined. The frequency of data analysis, meetings and reporting is provided in Tables 14B and 15.

In the event the results are at TARP Level 3 status, the Technical Committee will meet on a fortnightly basis to review available data. The Technical Committee will provide key outcomes to DPHI and WaterNSW of the Level 3 status within 24 hours of the meeting. Following the provision of the Technical Committee key outcomes report, the Metropolitan Coal General Manager will determine the appropriate actions in consideration of the advice from the Technical Committee, which may include (but not be limited to):

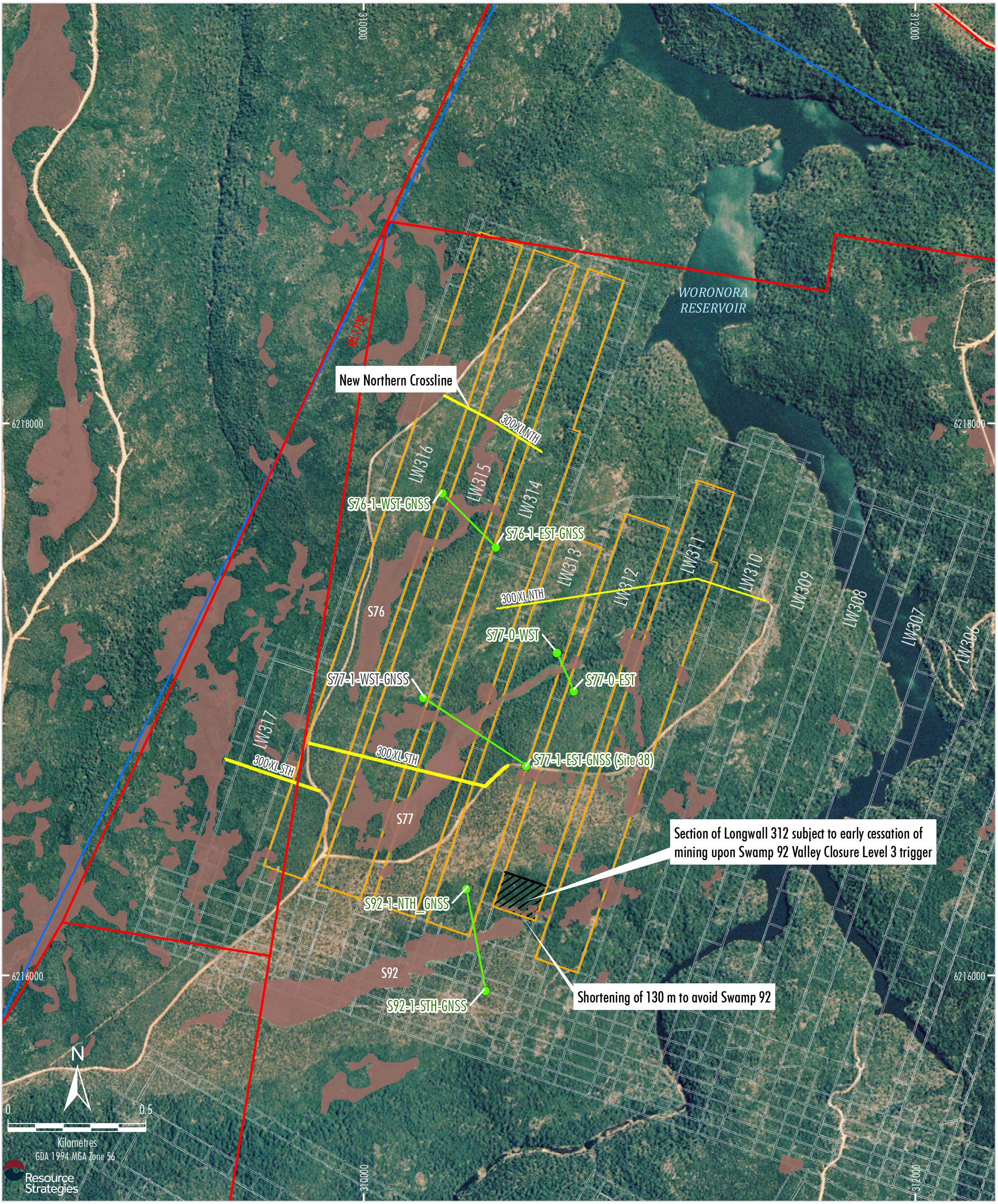
- Temporary cessation of the active longwall to consider all relevant data and/or collect additional data before making further decisions.
- Making amendments to the current and/or future longwall(s) geometry to reduce subsidence effects on the Large Swamps (e.g. stepping around a section of the Large Swamp).
- Ceasing mining in the current longwall (i.e. sterilising the coal in the remaining longwall).

Further details on the operation of the Technical Committee are provided in Table 14B and 15.

In addition to providing TARPs for review, Metropolitan Coal will provide monthly and/or fortnightly reports to the Technical Committee which will include analysis of groundwater levels in the Hawkesbury Sandstone for piezometers in the Large Swamps, surrounding deeper groundwater bores, pool water level and quality data on relevant tributaries.

Metropolitan Coal commits to halting Longwall 312 operations, including cessation of the panel mid-pillar if necessary, should the Valley Closure TARP for Swamp 92 at any stage move into Level 3 during the extraction of Longwall 312 (Figure 19).

Figure 19 shows the indicative subsidence monitoring for the Large Swamps.



LEGEND

- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 311-316 Secondary Extraction
- Upland Swamp
- Valley Closure Monitoring Site
- GNSS Monitoring Line
- Valley Closure Monitoring Line

Source: Land and Property Information (2015); Department of Industry (2015); Metropolitan Coal (2023); MSEC (2024)

Peabody

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Indicative Subsidence Monitoring for the Large Swamps

Figure 19

Table 14A
Trigger Action Response Plan – Upland Swamp Groundwater Monitoring

Performance Measure	Performance Indicator	Monitoring Sites	Parameters	Frequency/ Sample Size	Analysis Methodology[1]	Error Types	Baseline[2]		Significance Levels/ Triggers[3, 4]		Action/Response
Negligible impact on Threatened Species, Populations, or Ecological Communities	*Subsidence impacts are not expected to result in measurable changes to swamp groundwater levels when compared to control swamps or seasonal variations in water levels experienced by upland swamps prior to mining*[5]	• Swamp 25 overlying Longwalls (LW) 20-22. • Swamps 30, 33 and 35 overlying LW23-27. • Swamps 40, 41, 46, 51, 52 and 53 overlying LW301-303. • Swamp 50 overlying LW304. • Swamps 71a and 72 adjacent to LW305-307. • Swamps 62 and 82 within the 35° angle of draw and/or predicted 20 mm subsidence contour of LW308-310. • Swamps 74, 75, 81, 89, 106, 113, 115 and 119 within the 35° angle of draw and/or predicted 20 mm subsidence contour of LW311-316. • Control Swamps 101, 137a,137b, 106[7], 76[7], 14 and Bee Creek Swamp.	Groundwater levels.	Continuous water level monitoring with data logger, downloaded monthly.	Analysis of swamp substrate groundwater levels, annually, within one month of download for swamps overlying LW20-27. Analysis of swamp substrate groundwater levels, six monthly, within one month of download for swamps overlying or adjacent to LW301-316.	Data logger precision and download error.	<u>LW20–27 Swamps</u>[3] • Swamp 25, baseline minimum substrate water level = 270.61 metres Relative Level (m RL) • Swamp 30, baseline minimum substrate water level = 234.97 m RL • Swamp 33, baseline minimum substrate water level = 240.46 m RL • Swamp 35, baseline minimum substrate water level = 254.94 m RL <u>LW301-303 Swamps</u>[3] • Swamp 40, baseline minimum substrate water level = 230.81 m RL • Swamp 41, baseline minimum substrate water level = 277.88 m RL • Swamp 46, baseline minimum substrate water level = 281.20 m RL • Swamp 51, baseline minimum substrate water level = 273.39 m RL • Swamp 52, baseline minimum substrate water level = 281.94 m RL • Swamp 53, baseline minimum substrate water level = 293.23 m RL <u>LW304 Swamps</u>[3] • Swamp 50, baseline minimum substrate water level = 265.58 m RL <u>LW305-307 Swamps</u>[3] • Swamp 71a, baseline minimum substrate water level = 275.51 m RL • Swamp 72, baseline minimum substrate water level = 263.11 m RL	<u>LW308-310 Swamps</u>[3] • Swamp 62, baseline minimum substrate water level = 263.72 m RL • Swamp 82, baseline minimum substrate water level = 256.10 m RL <u>LW311-316 Swamps</u>[3] • Swamp 89, baseline minimum substrate water level = 262.61 m RL • Swamp 74, 75, 81, 89, 106, 113, 115 and 119, baseline minimum to be determined and set in annual reporting	Level 1	Data analysis for LW20-27 swamps indicates: - the seven day moving average for Swamps 25, 30, 33 and 35 is at or above the minimum established for the swamp's full length of record; Data analysis for LW301-316 swamps indicates: - the seven day moving average for Swamps 40, 41, 46, 50, 51, 52, 53, 62, 71a, 72, 74, 75, 81, 82, 89, 106, 113, 115 and 119 is at or above the minimum established for the swamp's full length of record.	Continue monitoring. Six monthly analysis and annual reporting for Swamps overlying or adjacent to LW301-316. Bi-annual analysis and reporting for Swamps overlying or adjacent to LW20-27.
									Level 2[6]	Data analysis for LW20-27 swamps indicates: - the seven day moving average for Swamps 25, 30, 33 and 35 is below the minimum established for the swamp's full length of record; and - semi-quantitative comparisons with control swamps and rainfall record indicates that dry swamp conditions are natural. Data analysis for LW301-316 swamps indicates: - the seven day moving average for Swamps 40, 41, 46, 50, 51, 52, 53, 62, 71a, 72, 74, 75, 81, 82, 89, 106, 113, 115 and 119 is below the minimum established for the swamp's full length of record; and - semi-quantitative comparisons with control swamps and rainfall record indicates that dry swamp conditions are natural.	Increase the frequency of data analysis to quarterly (until such time that data analysis indicates a return to Level 1). Annual reporting for all Swamps at Level 2.
									Level 3[6]	Data analysis for LW20-27 swamps indicates: - the seven day moving average for Swamps 25, 30, 33 and 35 is below the minimum established for the swamp's full length of record; and - semi-quantitative comparisons with control swamps and rainfall record indicates that dry swamp conditions are not natural. Data analysis for LW301-316 swamps indicates: - the seven day moving average for Swamps 40, 41, 46, 50, 51, 52, 53, 62, 71a, 72, 74, 75, 81, 82, 89, 106, 113, 115 and 119 is below the minimum established for the swamp's full length of record; and - semi-quantitative comparisons with control swamps and rainfall record indicates that dry swamp conditions are not natural.	Increase the frequency of data analysis to quarterly (until such time that data analysis indicates a return to Level 1). Complete assessment against the performance measure for threatened species. Consider the need for management measures, in accordance with Sections 9 and 10.

1 Metropolitan Coal will continue to implement the Upland Swamp Groundwater Monitoring TARP for a period of up to 10 years after completion of longwall extraction at suitable locations.

2 The baseline minimum substrate water level represents the pre-subsidence logger elevation at time of installation. Post-subsidence substrate water levels are determined by measuring the water level above the logger such that any changes in relative saturation can be determined.

3 The 'full length of record' will be determined prior to subsidence effects occurring at swamps. Interim triggers have been assigned for the dataset up to 30 November 2023. Should the minima change until the LW311 to 316 are starting, these minima can be corrected accordingly and reported in the Annual Review.

4 Consistent with the OEH (2016) *Addendum to NSW Biodiversity Offsets Policy for Major Projects: Upland swamps impacted by longwall mining subsidence*, the Level 2 and 3 triggers include semi-quantitative analysis of swamp substrate groundwater levels in comparison to control swamps. The semi-quantitative analysis includes analysis of the rate of recession from high to low water levels and analysis of rates of recovery from low to high water levels, compared to control swamps. The TARP method complies with the tenor of the OEH (2016) proposed analysis of recession rates.

5 This performance indicator has been exceeded at Swamp 20 since 2012 and at Swamp 28 since 2016. Swamp water levels at Swamp 20 and Swamp 28 will continue to be analysed on a six monthly basis and assessments against the performance measure will be conducted every second year.

6 This trigger level response also includes providing an investigation memo with potential causes of limit exceedances to DPHI as well as preparing monthly updated graphs (water level and soil moisture) and issuing to DPHI until level returns to Level 1.

7 Swamp 76 and 106 would be used as a control swamp until such time that subsidence effects are greater than negligible (to be determined by MSEC), at which time, it would become a test (impact) site.

Table 14B
Trigger Action Response Plan – Large Swamps Groundwater Monitoring

Performance Measure	Performance Indicator	Monitoring Sites	Parameters	Frequency/ Sample Size	Analysis Methodology[1]	Error Types	Baseline[2]	Significance Levels/ Triggers[3, 4, 5, 6]		Action/Response
Negligible impact on Threatened Species, Populations, or Ecological Communities.	*Subsidence impacts are not expected to result in measurable changes to swamp groundwater levels when compared to control swamps or seasonal variations in water levels experienced by upland swamps prior to mining.*	• Site 76-1, 76-2 and 76-3 in Swamp 76. • Site 77-1, 77-2 and 77-3 in Swamp 77. • Site 92-1, 92-2 and 92-3 in Swamp 92. • Control Swamps 101, 137a and 137b. • Control Swamps 76[7], 14, 106[7] and Bee Creek Swamp.	Groundwater levels.	Continuous water level monitoring with data logger, downloaded monthly.	Analysis of swamp substrate groundwater levels, six monthly (or as specified in the action/response column), within one month of download.	Data logger precision and download error.	• Swamp 76-1, baseline minimum substrate water level = 266.72 m RL • Swamp 76-2, baseline minimum substrate water level = 280.27 m RL • Swamp 76-3, baseline minimum substrate water level = 282.46 m RL • Swamp 77-1, baseline minimum substrate water level = 273.49 m RL • Swamp 77-2, baseline minimum substrate water level = 281.87 m RL • Swamp 77-3, baseline minimum substrate water level = 296.23 m RL • Swamp 92-1, baseline minimum substrate water level = 278.61 m RL • Swamp 92-2, baseline minimum substrate water level = 293.11 m RL • Swamp 92-3, baseline minimum substrate water level = 303.23 m RL	Level 1	Data analysis indicates the seven-day moving average for Swamps 76, 77 and 92 is at or above the minimum established for the swamp's full length of record.	Continue monitoring. Six monthly reporting for Large Swamps.
								Level 2	Data analysis indicates: - the seven-day moving average for Swamps 76, 77 and 92 is below the minimum established for the swamp's full length of record; and - semi-quantitative comparisons with control swamps and rainfall record indicates that dry swamp conditions are natural.	Increase the frequency of data analysis to quarterly (until such time that data analysis indicates a return to Level 1). Quarterly reporting to the Technical Committee. Provide an investigation memo with potential causes of limit exceedances to the Technical Committee.
								Level 3	Data analysis indicates: - the seven-day moving average for Swamps 76, 77 and 92 is below the minimum established for the swamp's full length of record; and - semi-quantitative comparisons with control swamps and rainfall record indicates that dry swamp conditions are not natural.	Increase the frequency of data analysis to monthly (until such time that data analysis indicates a return to Level 2). Provide an investigation memo with potential causes of limit exceedances to the Technical Committee. Complete assessment against the performance measure for threatened species. Metropolitan Coal General Manager will determine the appropriate actions in consideration of the advice from the Technical Committee including management measures detailed in Sections 9 and 10.

1 Metropolitan Coal will continue to implement the Upland Swamp Groundwater Monitoring TARP for a period of up to 10 years after completion of longwall extraction at suitable locations.

2 The baseline minimum substrate water level represents the pre-subsidence logger elevation at time of installation. Post-subsidence substrate water levels are determined by measuring the water level above the logger such that any changes in relative saturation can be determined. Baseline minimum water levels are based on the available period of data and logger installation depth. Lower groundwater levels may have occurred prior to logger installation.

3 The 'full length of record' will be determined prior to subsidence effects occurring at swamps. Interim triggers have been assigned for the dataset up to 30 November 2023. Should the minima change until the LW311 to 316 are starting, these minima can be corrected accordingly and reported in the Annual Review.

4 Consistent with the OEH (2016) *Addendum to NSW Biodiversity Offsets Policy for Major Projects: Upland swamps* impacted by longwall mining subsidence, the Level 2 and 3 triggers include semi-quantitative analysis of swamp substrate groundwater levels in comparison to control swamps. The semi-quantitative analysis includes analysis of the rate of recession from high to low water levels and analysis of rates of recovery from low to high water levels, compared to control swamps. The TARP method complies with the tenor of the OEH (2016) proposed analysis of recession rates.

5 Following completion of Longwall 311, Metropolitan Coal would submit the trigger to the Technical Committee prior to commencing Longwall 312 for review and approval. Approval of the triggers by the Technical Committee is not intended to prevent Metropolitan Coal from commencing secondary extraction of Longwall 312.

6 An exceedance of a trigger level at any one swamp monitoring site constitutes a trigger for the relevant swamp, requiring the Action/Response described for that trigger to be actioned.

7 Swamp 76 and 106 would be used as a control swamp until such time that subsidence effects are greater than negligible (to be determined by MSEC), at which time, it would become a test (impact) site.

Table 15
Trigger Action Response Plan - Large Swamps Valley Closure Monitoring[1]

Performance Measure	Performance Indicator	Monitoring Sites[2]	Parameters	Frequency/ Sample Size	Analysis Methodology	Error Types	Baseline	Significance Level	Triggers / Thresholds	Action/Response	Reporting
Negligible impact on Threatened Species, Populations, or Ecological Communities	*That the specified upland coastal swamps 76, 77 and 92 are not expected to experience valley closure greater than predicted for the Preferred Project Layout.* *S76 = 125 mm* *S77 = 325 mm* *S92 = 125 mm*	• GNSS Units 76-1-Est and 76-1-Wst across Swamp 76; • GNSS Units 77-1-Est and 77-1-Wst across Swamp 77; and • GNSS Units 92-1-Nth and 92-1-Sth, across Swamp 92.	• Absolute 3D movement of paired GNSS units measuring total valley closure. • Visual inspections.	• Paired GNSS units plotting real time absolute position data with daily telemetry of mean 3D movement.	• Use of Total Valley Closure[3] as an indicator for the potential development of shallow surface cracking. • Visual assessment for evidence of subsidence cracking or new Fe staining of the swamp streams over time. Other data that may be considered by the Technical Committee (TC) (where available): • Groundwater monitoring data in the swamp. • Soil moisture data in the swamp. • Deeper groundwater monitoring data for sites proximal to the swamp. • Water quality sampling for changes to chemistry including rising Fe, Mg or Al content. Indicative of possible shallow cracking. • Surface water flow data associated with the swamp. • Vegetation monitoring results. • Visual inspection results.	• GNSS accuracy ±5 mm horizontal and ±10 mm vertical. • Solar storms producing ionospheric interference[4] bending the path of GNSS radio waves, temporary anomaly in data set lasting a handful of days. • Subjective nature of visual observations.	• Pre-mining surface position. • Visual photographic record of stream 25 m downstream of each swamp.	Level 1	Data analysis indicates the measured valley closure is no greater than (i.e. closure is less than what would be expected to cause cracking): • Swamp 76 – ≤50 mm. • Swamp 77 – ≤50 mm. • Swamp 92 – ≤50 mm.	Continue monthly GNSS data download and distribution of results to the TC.	Monthly report on closure data to TC.
								Level 2	Data analysis indicates that the measured valley closure is greater than the Level 1 threshold and no greater than the predicted valley closure values for the Preferred Project Layout: • Swamp 76 – >50 mm and ≤125 mm. • Swamp 77 – >50 mm and ≤325 mm. • Swamp 92 – >50 mm and ≤125 mm. The valley closure monitoring system is being used as a high accuracy measure that active subsidence is occurring with consideration that any effects of this subsidence may start to become visible in the swamp groundwater monitoring system. This will prompt a closer and more frequent inspection of the groundwater monitoring data for evidence of change.	TC to review available GNSS data and undertake analysis and discern trends in valley closure data that may be increasing, decreasing or steady state. TC to predominantly consider hydrological factors for the Large Swamps including: • Swamp groundwater monitoring data for trends against the Swamp Groundwater TARP thresholds. • Control swamp groundwater data to discern possible climatic effects. • Swamp water flow gauge data. • Swamp water quality data for signs of increasing mineral content (where available and subject to suitable access). • Visual inspection (subject to suitable access) for signs of subsidence effects (e.g. cracking, iron staining). TC frequency of meetings are monthly at Level 2, however the TC has the discretion to determine the appropriate frequency based on observed rate of subsidence and/or observed changes to groundwater levels.	Monthly reporting of closure and groundwater data to TC. Following each TC meeting the Key Outcomes are to be provided to DPHI & WaterNSW within 48 hours of meeting. TC to review performance of this TARP and recommend any additional measures and/or monitoring to DPHI.
								Level 3	Data analysis indicates that valley closure is greater than the predicted valley closure for the Preferred Project Layout: • Swamp 76 – >125 mm. • Swamp 77 – >325 mm. • Swamp 92 – >125 mm. Greater than subsidence prediction is not necessarily indicative of cracking having occurred, rather it indicates an elevated risk of it occurring.	Metropolitan Coal will cease mining of Longwall 312, if the valley closure at the Swamp 92 GNSS units reaches TARP Level 3 during the mining of Longwall 312. Increase GNSS download frequency and distribution to fortnightly (*or greater as determined by TC*). Increase TC review frequency to fortnightly and in addition to Level 2 considerations, consider the following: • Deep groundwater level data at surrounding groundwater bores. • Initiate assessment against the performance measure. • Determine the need for extraction changes (e.g. pausing extraction to determine next steps). • Consider the need for management measures, in accordance with Sections 9 and 10.	Fortnightly reporting of closure and groundwater data to TC. TC to provide key outcomes to DPHI and WaterNSW within 24 hours of meeting.

[1] Swamps 76, 77 and 92 will be monitored for total closure (cumulative value) as measured from the commencement of Longwall 311 to the completion of Longwall 316. Where valley closure has stabilised, (i.e. closure has reduced to below the order of accuracy of an GNSS instrument pair of 10 mm [each unit being ±5 mm] measured over the extraction of one longwall) closure will be deemed to have ceased.

[2] GNSS Monitoring sites for three Large Swamps as depicted in the Subsidence Monitoring Program. Control swamps are outside the mining extent and assumed to have no mining based ground movement.

[3] Valley closure has been used to indicate the potential for shallow cracking to develop in tributaries. Swamps 76, 77 and 92 are not rockbar controlled, rather they are valley infill swamps controlled by shallow gradient of the terrain.

[4] GNSS radio signals travel from the satellite to the receiver on the ground, passing through the Earth's ionosphere. The charged plasma of the ionosphere bends the path of the GNSS radio signal similar to the way a lens bends the path of light. In the absence of space weather, GNSS systems compensate for the "average" or "quiet" ionosphere, using a model to calculate its effect on the accuracy of the positioning information. But when the ionosphere is disturbed by a space weather event, the models are no longer accurate and the receivers are unable to calculate an accurate position based on the satellites overhead. For this reason, when values are close to threshold triggers, measurements over seven consecutive epochs (days) should be considered to minimise potential impact of solar activity on short term dataset when near a threshold value.

Table 16
Trigger Action Response Plan – Riparian Vegetation Monitoring

Performance Measure	Performance Indicator	Monitoring Sites	Parameters	Frequency/ Sample Size	Analysis Methodology	Error Types	Baseline	Significance Levels/ Triggers		Action/Response
Negligible impact on Threatened Species, Populations, or Ecological Communities	*Impacts to riparian vegetation are expected to be localised and limited in extent, similar to the impacts previously experienced at Metropolitan Coal*	Locations adjacent to riparian vegetation monitoring sites (MRIP01 to MRIP12) and areas traversed whilst accessing the monitoring sites: • sites MRIP01, MRIP02, MRIP05, MRIP06 and MRIP09 overlying Longwalls (LW) 20-22; • sites MRIP11 and MRIP12 overlying LW23-27; • sites MRIP07 and MRIP08 downstream of LW23-27; and • control sites MRIP03, MRIP04 and MRIP10 downstream of LW23A.	The extent of vegetation subject to vegetation dieback.	Biannually, in autumn and spring.	Assessment of the extent of riparian vegetation dieback.	Subjective nature of visual observations.	No dieback of riparian vegetation prior to the commencement of LW20 as a result of mining. Dieback of riparian vegetation greater than 50 cm from the top of bank identified at site MRIP02 on the Waratah Rivulet and between sites MRIP05 and MRIP09 on the Eastern Tributary as a result of mine subsidence up to and including the spring 2020 survey.	Level 1	No dieback of riparian vegetation as a result of mine subsidence.	Continue monitoring. Six monthly analysis and annual reporting.
								Level 2	Vegetation monitoring: - does not identify an increase in the extent of vegetation dieback at site MRIP02 on the Waratah Rivulet and between sites MRIP05 and MRIP09 on the Eastern Tributary compared to that observed up to and including the spring 2022 vegetation survey; and - does not identify vegetation dieback greater than 50 cm from the top of bank at sites MRIP01, MRIP06, MRIP07, MRIP08, MRIP11 or MRIP12, as a result of mine subsidence.	Consider recent stream features mapping results and pool water level monitoring data. Consider extent of erosion associated with areas of vegetation dieback and whether management measures are required. Six monthly analysis and annual reporting.
								Level 3	Vegetation monitoring: - identifies an increase in the extent of vegetation dieback at site MRIP02 on the Waratah Rivulet and between sites MRIP05 and MRIP09 on the Eastern Tributary compared to that observed up to and including the spring 2022 vegetation survey; and of riparian vegetation as a result of mine - identifies vegetation dieback greater than 50 cm from the top of bank at sites MRIP01, MRIP06, MRIP07, MRIP08, MRIP11 or MRIP12, as a result of mine subsidence.	Consider recent stream features mapping results and pool water level monitoring data. Initiate assessment against the performance measure[1]. Consider the need for management measures, in accordance with Sections 9 and 10.

[1] Threatened species, populations and ecological communities include those listed under the TSC Act, EPBC Act or *Fisheries Management Act 1994* at the time of Project Approval (i.e. the lists current as at 22 June 2009).

Table 17
Trigger Action Response Plan – Monitoring of Aquatic Biota, Stream Monitoring

Performance Measure	Performance Indicator	Monitoring Sites	Parameters	Frequency/ Sample Size	Analysis Methodology	Error Types	Baseline	Significance Levels/ Triggers		Action/Response
Negligible impact on Threatened Species, Populations, or Ecological Communities	*The aquatic macroinvertebrate and macrophyte assemblages in streams are not expected to experience long-term impacts as a result of mine subsidence.*	Two sampling sites (approximately 100 m in length) at the following locations: • Location WT3 on Waratah Rivulet and Locations ET1, ET3 and ET4 on the Eastern Tributary overlying Longwalls (LW) 20-27. • Location WT4 on Waratah Rivulet adjacent to LW20-27. • Location WT5 on the Waratah Rivulet and Location ET2 on the Eastern Tributary, downstream of LW20-27. • Control Locations: WR1 on Woronora River; and OC on O'Hares Creek.	• Aquatic macroinvertebrates. • Aquatic macrophytes.	Biannually, in autumn and spring.	• Analysis of macroinvertebrate and macrophyte multivariate[1] and univariate[2] data using PERMANOVA to test the null hypothesis of no significant change in relation to control places, bi-annually following completion of survey.	Statistical significance levels. Significant = $P < 0.05$	• LW20-22 stream sites, as detailed in the LW20-22 aquatic ecology monitoring reports for the spring 2008 to autumn 2010 surveys[3]. • LW23-27 stream sites, as detailed in the LW23-27 aquatic ecology monitoring reports for the spring 2009 to spring 2013 surveys[4].	Level 1	Data analysis indicates no significant changes in relation to control places pre-mining[6] compared to post-extraction[7] occur in the aquatic macroinvertebrate and/or macrophyte assemblages at Locations WT3, WT4 or WT5 on the Waratah Rivulet or Locations ET1, ET2, ET3 or ET4 on the Eastern Tributary during the mining of LW311-316.	Continue monitoring. Six monthly analysis and annual reporting.
								Level 2	Data analysis indicates significant (not long-term[8]), changes in relation to control places pre-mining[6] compared to post-extraction[7] occur in the aquatic macroinvertebrate and/or macrophyte assemblages at Locations WT3, WT4 or WT5 on the Waratah Rivulet or Locations ET1, ET2, ET3 or ET4 on the Eastern Tributary during the mining of LW311-316.	Consider recent stream features mapping results and pool water level monitoring data. Consider status/progress of stream remediation activities. Six monthly analysis and annual reporting.
								Level 3	Data analysis indicates significant long-term changes[8] in relation to control places pre-mining[6] compared to post-extraction[7] occur in the aquatic macroinvertebrate and/or macrophyte assemblages at Locations WT3, WT4 or WT5 on the Waratah Rivulet or Locations ET1, ET2, ET3 or ET4 on the Eastern Tributary during the mining of LW311-316.	Initiate assessment against the performance measure[9]. Consider the need for management measures, in accordance with Sections 9 and 10.

1 Multivariate Analysis: comparisons of two (or more) samples based on the degree to which these samples share particular species, at comparable levels of abundance.

2 Univariate Analysis: comparison of individual variables (e.g. total number of taxa, total abundance, abundances of individual taxa).

3 Cummins, S. P., Roberts, D. E. (2009a; 2009b; 2010a; 2010b). Aquatic Ecology Monitoring: Metropolitan Coal Longwalls 20-22 Spring 2008 to Autumn 2010 Survey Reports. Prepared for Metropolitan Coal Pty Ltd. BIO-ANALYSIS: Marine, Estuarine & Freshwater Ecology.

4 Cummins, S. P., Roberts, D. E. (2010a; 2010b; 2011; 2012a; 2012b; 2012c; 2013a; 2013b, 2014). Aquatic Ecology Monitoring: Metropolitan Coal Longwalls 23-27 Spring 2009 to Spring 2013 Survey Reports. Prepared for Metropolitan Coal Pty Ltd. BIO-ANALYSIS: Marine, Estuarine & Freshwater Ecology.

6 Pre-mining data is as follows: sites WT3 and ET1 (spring 2008 to autumn 2010); site ET3 (spring 2009 to autumn 2010); site ET4 (spring 2009 to spring 2013); site ET2 (will be assessed for two periods: spring 2008 to autumn 2010 [i.e. pre-mining of Longwalls 20-22] and spring 2009 to spring 2013 [i.e. pre-mining of Longwalls 23-27]).

7 Post-extraction data is represented as follows: sites WT3 and ET1 (from spring 2010 on); site ET3 (from spring 2010 on); site ET4 (from autumn 2014 on); site ET2 (will be assessed for two periods: spring 2010 on [Longwalls 20-22] and autumn 2014 on [Longwalls 23-27]).

8 Long-term changes to the macroinvertebrate and macrophyte assemblages are considered to be significant changes that are persistent (over time) and resulting from mining.

9 Threatened species, populations and ecological communities include those listed under the TSC Act, EPBC Act or *Fisheries Management Act 1994* at the time of Project Approval (i.e. the lists current as at 22 June 2009).

Table 18
Trigger Action Response Plan – Large Swamp Amphibian Monitoring

Performance Measure	Performance Indicator	Monitoring Sites	Parameters	Frequency/ Sample Size	Analysis Methodology	Error Types	Baseline	Significance Levels/ Triggers		Action/Response
Negligible impact on Threatened Species, Populations, or Ecological Communities	*The threatened amphibian abundance is not expected to experience a decline compared to previous years, due to groundwater substrate or pool water level impacts, significantly different to the threatened amphibian abundance trends at control sites.*	• Transects Sites S76, S77 and S92. • Control Transects Sites S14, S106[1], Bee Creek Swamp, and S76[1].	• Threatened amphibian species relative abundance. • Non-threatened amphibian species relative abundance (for consideration in any performance measure assessment). • Species richness (diversity) to be monitored (for consideration in any performance measure assessment).	• Biannual monitoring to target the peak breeding period of threatened amphibian species (two sampling seasons; spring and summer, subject to access). • Three impact sites, and four control sites; with fixed 500 m transects. • Monitoring will consist of aural-visual surveys for a duration 120 minutes per 500 m transect. • An Acoustic recorder will be deployed at each impact and control site during spring monitoring and collected during summer monitoring. The acoustic data will be subsequently analysed for threatened species calls.	Analysis using multivariate analysis[2].	The multivariate analysis can determine impacts on the amphibian assemblage at the 95% confidence level.	2024 surveys completed along Transects Sites S76, S77 and S92 and control sites.	Level 1	Monitoring indicates threatened amphibian populations (relative abundance[3]) are stable and habitat parameters are predominantly within a reasonable range of baseline data at impact sites and/or control sites (supported by multiple lines of evidence and statistical analyses).	Continue monitoring. Six monthly analysis and annual reporting.
								Level 2a	Monitoring indicates threatened amphibian populations (relative abundance) have declined significantly below baseline values[4] which has not been observed at the control sites for one sampling season.	Actions/responses as stated in Level 1. Undertake an investigation of quantitative and/or qualitative monitoring data to assess the cause and determine if differences are mining-related or are in the response to environmental conditions (e.g. drought) within the catchment. Analysis of amphibian monitoring data against other related environmental data (e.g. groundwater, surface water and subsidence monitoring data) and visual observation data. Investigate whether any surface water TARP indicators have been triggered. Any significant differences detected that are not attributable to mining impacts (e.g. are a result of environmental conditions or stochastic events) are to be considered normal conditions and reported as Level 1 to the Technical Committee. Where a significant difference is determined as a result of mining, the Metropolitan Coal General Manager will determine the appropriate actions in consideration of the advice from the Technical Committee including management measures detailed in Sections 9 and 10 and/or any relevant swamp contingency plan where relevant. The need to undertake additional or more frequent monitoring should be considered by the ecologist and Technical Committee.
								Level 2b	Monitoring indicates threatened amphibian populations (relative abundance) have declined significantly below baseline values[4] over two consecutive sampling seasons at impact sites, that, following investigation, is attributed to mining impacts (e.g. similar trends not observed at control sites).	Actions/responses as stated in Level 2a. Investigate whether additional monitoring and analyses can be conducted in relation to the threatened amphibian species (e.g. establish acoustic recorders for Littlejohn's Tree Frog). Consider increased monitoring intensity (e.g. increase duration/intensity of transect surveys). Complete a multiple lines of evidence assessment and report to the Technical Committee and DHPI with proposed remediation measures. Implement any relevant swamp contingency plan where relevant. Review Biodiversity Management Plan and modify if necessary.
								Level 3	Monitoring indicates threatened amphibian populations (relative abundance) have declined significantly below baseline values[4], over three consecutive sampling seasons post-mining that, following investigation, is attributed to mining impacts (e.g. mining-related groundwater or surface water impacts in the relevant swamp/tributary that is not occurring at control sites).	Actions/responses as stated in Level 2b. Increase monitoring and review of data frequency for sites where Level 3 has been reached and at other relevant sites. Complete assessment against the performance measure using a multiple lines of evidence approach. Report to Technical Committee and DHPI. Metropolitan Coal General Manager will determine the appropriate actions in consideration of the advice from the Technical Committee including management measures detailed in Sections 9 and 10. Where appropriate contingency measures or remediation cannot be implemented to address an impact, Metropolitan Coal would provide a suitable offset to compensate for the impact to the satisfaction of the Secretary of Planning.

1 Swamp 76 and 106 would be used as a control swamp until such time that subsidence effects are greater than negligible (to be determined by MSEC), at which time, it would become a test (impact) site.

2 Multivariate statistical analyses have been performed to test whether there is a difference between threatened frog assemblages at future control and impact (using the baseline data). The non-significant interaction (P-value of >/= 0.05) between Control/Impact sites indicates that established future Control and Impact sites are suitable for mining and post-mining monitoring purposes, as they support similar threatened amphibian assemblages (taxa and numbers of individuals), and similar microhabitats.

3 Relative species abundance is a component of biodiversity and is a measure of how common or rare a species is relative to other species in a defined location or community.

4 Determined by Before-After-Control-Impact (BACI) interaction analyses. Significantly below baseline values is defined when the result of the analysis equates to a P-value less than or equal to 0.05 for BACI groups. The detection of a significant interaction between Before/After and Control/Impact indicates the mining activity influences threatened amphibian assemblages. All detected threatened amphibian species are to be recorded during monitoring surveys. The amphibian data will be subject to statistical hypothesis testing. Species abundance is population metrics used to assess threatened amphibian populations in the locality.

Table 19
Key Assessment Considerations for Assessing Negligible Impact on Threatened Species, Populations and Ecological Communities

Negligible Impact on:	Key Assessment Considerations
Threatened species	1. What is the nature of the environmental consequence (e.g. the potential for adverse impacts on upland swamps, riparian vegetation, slopes and ridgetops or aquatic habitats)? 2. What are the potential factors that may have contributed to the environmental consequence (e.g. the degree of subsidence effects, ineffective management measures or prevailing climatic conditions)? 3. Which threatened species have the potential to be impacted? 4. What are the potential impacts on the lifecycle of the potential threatened species (e.g. foraging, breeding/reproduction, nesting, shelter and movement/dispersal)? 5. What are the potential impacts on the habitat of the potential threatened species (e.g. area affected)? 6. Has the habitat connectivity of the threatened species been affected? 7. What actions, if any, are most appropriate to mitigate the impacts and/or to minimise future impacts?
Threatened populations	1. What is the nature of the environmental consequence (e.g. the potential for adverse impacts on upland swamps, riparian vegetation, slopes and ridgetops or aquatic habitats)? 2. What are the potential factors that may have contributed to the environmental consequence (e.g. the degree of subsidence effects, ineffective management measures or prevailing climatic conditions)? 3. Are there any threatened populations that have the potential to be impacted? 4. What are the potential impacts on the lifecycle of the threatened population? 5. What are the potential impacts on the habitat of the threatened population (e.g. area affected)? 6. Has the habitat connectivity of the threatened population been affected? 7. What actions, if any, are most appropriate to mitigate the impacts and/or to minimise future impacts?
Threatened Ecological Communities	1. Can any subsidence impacts (e.g. surface cracking, subsidence-induced erosion) be observed within the occurrence of the Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion EEC situated to the north-east of Longwall 304? 2. If yes, over what area has been affected? 3. What are the potential environmental consequences of the change in subsidence effects? 4. What actions, if any, are most appropriate to mitigate the impacts and/or to minimise future impacts?

8.8 MONITORING PROGRAM REVIEW

Each of the ongoing monitoring programs described in this BMP will be reviewed at the completion of Longwall 311, Longwall 312, Longwall 313, Longwall 314, Longwall 315 and Longwall 316, and thereafter at the completion of each future longwall. The review will include consideration of changes to the monitoring programs, including site locations, parameters measured and the frequency of measurement based on the data obtained to date and the planned future mining activities. Any proposed changes to the monitoring programs will be undertaken in consultation with the BCS and DPI – Fisheries, and to the satisfaction of the DPE.

9 MANAGEMENT MEASURES

This section describes the management measures that will be implemented to remediate impacts, including subsidence impacts and impacts associated with surface activities in the underground mining area and surrounds. Management measures will be implemented, as appropriate, to comply with the relevant statutory requirements and the subsidence impact performance measure.

Systematic and/or valley related movements associated with the Project have the potential to result in fracturing and dilation of the underlying strata of streams above and immediately adjacent to the longwalls. Cracking and dilation of bedrock may result in the localised diversion of a portion of the surface flow into subterranean flows or leakage from pools. Stream remediation measures required to be implemented on the Waratah Rivulet and Eastern Tributary are described in Section 9.1.

Other potential subsidence impacts and associated management measures such as stream bank erosion, ponding of stream bank vegetation, cliff falls and surface tension cracks, and swamp remediation measures are described in Section 9.2.

Vegetation clearance management measures are described in Section 9.3.1.

Metropolitan Coal personnel and contractors will be required to access the underground mining area and surrounds to conduct a range of surface activities including various monitoring, exploration, construction and remediation/rehabilitation activities. Management measures will be implemented to minimise the potential for impacts of such activities on flora and fauna, and their habitats. These measures are described in Section 9.4.

Follow-up inspections will be conducted to assess the effectiveness of implemented management measures and the requirement for any additional management measures.

Management measures will be reported in the Annual Review (Section 12).

9.1 STREAM REMEDIATION

In accordance with Condition 1, Schedule 6 of the Project Approval, Metropolitan Coal is required to achieve the rehabilitation objective: *Restore surface flow and pool holding capacity as soon as reasonably practicable* for (Figure 4):

- Waratah Rivulet, between the downstream edge of Flat Rock Swamp and the full supply level of the Woronora Reservoir; and
- Eastern Tributary, between the full supply level of the Woronora Reservoir and the maingate of Longwall 26.

Prior to the commencement of Longwall 20, the water levels in pools upstream of Flat Rock Crossing (i.e. Pools A to G, Figure 5) on the Waratah Rivulet had been impacted by mine subsidence (i.e. the pool water level had fallen below the cease to flow level). Since the commencement of Longwall 20, two additional pools on the Waratah Rivulet have been impacted by mine subsidence (i.e. fallen below their cease to flow levels, namely, Pool G1 in 2011 and Pool N in September 2012) (Figure 5). Stream remediation activities on the Waratah Rivulet have been conducted at Pools A, F and G (at the time of BMP development) (Figure 5).

As described in Section 6, the Project Approval required Metropolitan Coal to have negligible environmental consequences over at least 70% of the stream length on the Eastern Tributary between the full supply level of the Woronora Reservoir and the maingate of Longwall 26.

Monitoring conducted in accordance with the Metropolitan Coal Longwalls 23-27 Water Management Plan identified that the Eastern Tributary watercourse performance measure was exceeded in relation to *minimal iron staining* and *no diversion of flows, no change in the natural drainage behaviour of pools*. The exceedance of the Eastern Tributary watercourse performance measure (referred to as the Eastern Tributary Incident) was reported to the DP&E and other relevant agencies in October 2016.

Metropolitan Coal provided the DP&E with a proposed course of action in relation to the exceedance of the Eastern Tributary subsidence impact performance measure, focused on the implementation of stream remediation measures.

In accordance with Condition 1, Schedule 6 of the Project Approval, Metropolitan Coal is required to restore surface flow and pool holding capacity on the Eastern Tributary between the full supply level of the Woronora Reservoir and the maingate of Longwall 26.

The drainage behaviour of 12 pools on the Eastern Tributary (Pools ETAG to ETAR) were impacted by mine subsidence during the mining of Longwalls 23-27. The drainage behaviour of Pools ETAS, ETAT and ETAU on the Eastern Tributary have not been impacted.

Within the performance measure reach of the Eastern Tributary, Metropolitan Coal have conducted stream remediation activities at pools ETAH, ETAI, ETAJ and ETAK.

From July to September 2019, Metropolitan Coal conducted stream remediation on the Eastern Tributary at Pool ETO (immediately upstream of the Fire Road 9J crossing and upstream of the Longwall 26 maingate). Permeability testing has confirmed a significant reduction in hydraulic conductivity of Rock Bar ETO and both pool level data and visual observations have confirmed that pool holding capacity has been restored and water is flowing over the rock bar for significantly longer periods post remediation.

Metropolitan Coal will continue to conduct stream remediation works in accordance with the Metropolitan Coal Stream Remediation Plan. The Metropolitan Coal Stream Remediation Plan was approved by the DPIE on 1 November 2019, and is included as Appendix 6 of the Metropolitan Coal Water Management Plan.

Section 8.5 describes the monitoring that will be conducted to monitor the response of aquatic biota to the implementation of stream remediation works.

9.2 OTHER SUBSIDENCE IMPACT MANAGEMENT MEASURES

9.2.1 Stream Bank Erosion

Visual inspections (particularly along Waratah Rivulet and the Eastern Tributary) will be conducted to identify any areas subject to excessive erosion and sedimentation. Where visual observations indicate the potential for excessive erosion or sediment migration, specific mitigation measures will be employed. Potential management measures include:

- filling of cracks and minor erosion holes in the bed or banks of watercourses;
- installation of sediment fences downslope of subsidence-induced erosion areas;
- stabilisation of erosion areas using rock or other appropriate materials;
- stabilisation of banks subject to soil slumping; and
- implementation of vegetation management measures.

These management measures will be implemented in accordance with the Metropolitan Coal Longwalls 311-316 Water Management Plan.

To date, limited erosion and sedimentation has been identified. Sediment controls (coir logs and sandbags) have been used at previous stream remediation sites Pools A and F for erosion control.

There is potential for the riparian areas that have been subject to increased ponding as a result of subsidence to result in stream bank erosion. The potential for excessive erosion and sedimentation will be monitored at these locations. However, it is anticipated that a new stream bank will be established that will be colonised in due course by native vegetation adapted to the new conditions.

9.2.2 Vegetation

Potential management measures for impacts on vegetation include the implementation of weed control measures (e.g. mechanical removal or the application of approved herbicides), the planting of endemic plant species and brush matting, should monitoring indicate the need.

Weed management measures in the Woronora Special Area will be conducted in consultation with WaterNSW.

Any active planting program will utilise flora species characteristic of the particular vegetation community in that area and will utilise seed collected from the Woronora Special Area. Consultation will be undertaken with the DPE and BCS for any proposed revegetation works associated with subsidence impacts (e.g. impacts to riparian vegetation).

To date, brush matting has been used at stream remediation sites in conjunction with locally collected vegetative material to encourage the regeneration of native vegetation.

9.2.3 Cliff Falls

Cliff and overhang sites COH10, COH11, COH12, COH13, COH18 and COH19 will be monitored to record evidence of potential subsidence impacts in accordance with the Metropolitan Coal Longwalls 311-316 Land Management Plan. The monitoring results will be used to assess the potential environmental consequences of the recorded subsidence impact and identify management measures, where appropriate.

In relation to impacts on aquatic or terrestrial flora, fauna, or their habitats, potential management measures include:

- the implementation of erosion and sediment control measures (e.g. the installation of sediment fences downslope of erosion areas, the stabilisation of erosion areas using rock or other appropriate materials); and
- stabilisation techniques (e.g. installation of artificial rock support, installation of standing supports, or scaling/dislodgement/removal of remaining loose rock).

The implementation of management measures will be considered with regard to the specific circumstances of the subsidence impact (e.g. the location, nature and extent of the impact) and the assessment of the environmental consequences in accordance with the Metropolitan Coal Longwalls 311-316 Land Management Plan.

9.2.4 Surface Tension Cracks

As described in Section 8.4, visual inspections for surface tension cracks will be conducted by Metropolitan Coal and its contractors as part of routine works conducted in the catchment in accordance with the Metropolitan Coal Longwalls 311-316 Land Management Plan.

Metropolitan Coal will use the subsidence impact monitoring results to assess the potential environmental consequences of the recorded subsidence impact, including the nature and extent of impacts on flora and fauna habitats and evidence of impacts on terrestrial fauna (e.g. observed fauna mortality). The implementation of management measures will be considered with regard to the specific circumstances of the subsidence impact (e.g. the location, nature and extent of the impact) and the assessment of the environmental consequence.

Potential management measures include the permanent filling of the surface tension crack. Consistent with the Metropolitan Coal Longwalls 311-316 Land Management Plan, WaterNSW will be consulted in the event Metropolitan Coal propose to in-fill any surface tension cracks in the Woronora Special Area.

9.2.5 Swamp Remediation Measures

In the event remediation measures are proposed to be implemented in an upland swamp, Metropolitan Coal will prepare a swamp remediation plan for the swamp in consultation with the DPE, BCS, WaterNSW, DPI – Fisheries and Resources Regulator.

Potential remediation measures for impacts on upland swamps that could be used or are being investigated, include:

- installation of coir log dams (i.e. erosion control structures) at any knick points in a swamp;
- use of surface water spreading techniques, involving long lengths of coir logs and hessian ‘sausages’ linked together across a swamp contour such that water flow builds up behind them and slowly seeps through the water spreaders to maintain swamp moisture; and
- injection grouting of rock substrate where fracturing has occurred.

A summary of these techniques is provided below. Installation of the erosion control works can be undertaken promptly as the need arises and installed within a few weeks.

Knick Point Control

Coir log dams can be installed at knick points (e.g. areas of erosion or scour) if detected during monitoring. Coir logs trap sediment by slowing water and allowing particulate matter to settle and for slow repair to occur. A shallow, narrow trench is cut into the swamp soils such that the first layer of coir logs sits on the underlying substrate or the top of the first coir log is at ground level. The coir logs are held in place by wooden stakes and bound together with wire (Good et al., unpublished in BHPIC, 2009). The small coir log dams are constructed at intervals down the erosion channel.

Where increased filtering of flows is required, the coir logs can be wrapped in jute fibre matting. Coir log dams have been successfully used during a number of swamp rehabilitation programs in recent years in the Blue Mountains and Snowy Mountains. The soft-engineering materials used eventually degrade (totally biodegradable) and become integrated into the soil/organic matter complex of the swamps (Good et al., unpublished in BHPIC, 2009).

Water Spreading

The maintenance of the swamp moisture regime can also be enhanced by additional 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 then slowly seeps through the water spreaders (Good et al., unpublished in BHPIC, 2009). The logs can be positioned as required within shallow trenches within a swamp. The soft-engineering materials eventually degrades (totally biodegradable) and becomes integrated into the soil/organic matter complex of the swamps (*ibid.*).

Injection Grouting

Where piezometer data indicate that a fracture has developed under a swamp leading to the potential/actual drying of a swamp substrate, then injection grouting to repair the fracture may be a possibility. If the rock fractures are very narrow, then self-healing may occur via transport of sediments. In cases where self-healing cannot occur because of fracture characteristics, then the use of grouting may be a possibility. The major issues are: (1) identifying the location and scale of the rock fracture, (2) injecting grout to seal the fracture network, and (3) implementing (1) and (2) with minimal impacts on the swamp in question. A variety of inert grouts and filler materials can be injected to fill the voids in the fractured strata intercepted by the drill holes, thereby preventing water loss from an impacted swamp.

9.2.6 Additional Monitoring

Where a performance indicator and/or measure has been exceeded, it may be appropriate to conduct additional monitoring (e.g. increase the frequency of monitoring or the parameters monitored) or conduct additional test work.

9.3 SURFACE DISTURBANCE

The Metropolitan Coal Construction Management Plan describes the management measures that will be implemented for surface construction works (excluding remediation or rehabilitation works) in the Woronora Special Area. The Metropolitan Coal Stream Remediation Plan and Metropolitan Coal Rehabilitation Management Plan describe the management measures that will be implemented for remediation and rehabilitation works. Management measures include those described in Sections 9.3.1 and 9.3.2 below.

9.3.1 Vegetation Clearance/Habitat Disturbance

Vegetation clearance activities may be required for ongoing surface exploration activities, the upgrade and extension of surface infrastructure, access tracks, environmental monitoring and management activities, stream restoration activities and other mine-related surface activities.

The environmental management of vegetation clearance sites will include:

- Detailed site inspections to identify the specific flora characteristics of the areas proposed to be disturbed.
- Identification of areas in which specific surface works involving vegetation clearance will be avoided or limited (e.g. within swamps, EECs and areas where threatened flora species are present).
- Final site selection and works design so as to minimise the amount of vegetation clearance required.
- Identification of management measures to minimise impacts on flora, prior to, during and/or following the completion of the surface works including natural regeneration and/or rehabilitation measures.

9.3.2 Weed Management

Weed management will be implemented to limit the spread and colonisation of noxious and environmental weeds, where weeds are found to occur in areas subject to mine-related surface activities.

Weed management will include:

- Limiting activities that cause soil disturbance.
- The inspection of vehicles and mechanical equipment brought to the site to avoid importation of foreign material and organic matter.
- Inspections of mine-related surface disturbance areas to identify areas requiring weed management measures to be implemented.
- Implementation of weed management measures (e.g. mechanical removal and application of approved herbicides in authorised areas). Prior to the use of any chemical controls, the chemicals will be approved by the relevant landholder and the Material Safety Data Sheet for the chemical obtained prior to spraying. The implementation of measures that favour the restoration of native vegetation (where appropriate) is also considered an effective method of weed management.
- Follow-up inspections to assess the effectiveness of the weed management measures implemented and the requirement for any additional management measures.
- Consultation with WaterNSW and other relevant land holders in relation to weed management activities.

The weed management activities will be reported in the Annual Review (Section 12).

9.4 OTHER MANAGEMENT MEASURES

9.4.1 Bushfire Hazard

Fire awareness and fire safety training will be included in the induction of all Metropolitan Coal personnel and contractors required to access the Woronora Special Area to reduce the risk of bushfire.

9.4.2 Introduced Pests

Vegetation clearance associated with the Project (e.g. for access tracks) has the potential to increase the occurrence of vertebrate pest species. In accordance with the Metropolitan Coal Construction Management Plan, surface construction works will occupy only small areas of the surface, will involve minimal clearance and disturbed areas will be allowed to naturally regenerate from the soil seed bank when no longer needed. Active planting may be undertaken in areas where natural regeneration is not considered to be progressing.

Management measures for introduced pests will include:

- Maintenance of a clean, rubbish-free environment in order to discourage scavenging and reduce the potential for colonisation of these areas by non-endemic fauna. Employees and contractors will not be permitted to take domestic pets into the Woronora Special Area.
- Reporting sightings of vertebrate pest species to WaterNSW, and the BCS for inclusion in the Atlas of NSW Wildlife in order for the distribution and abundance of the vertebrate pests to be better understood. This is particularly relevant to Feral Deer.
- Subject to consultation with WaterNSW, implementation of pest control measures where observations indicate the need (e.g. the control of Feral Cats and Foxes, or the destruction of rabbit burrows).
- The inclusion of general vertebrate pest awareness in Metropolitan Coal inductions, particularly for staff and contractors accessing the Woronora Special Area.

- Ongoing consultation with WaterNSW and the BCS in relation to the management of vertebrate pest species.

Pest management activities will be reported in the Annual Review (Section 12).

9.4.3 Infection of Native Plants by *Phytophthora cinnamomic*

Measures for the management of *P. cinnamomic* have been developed in consideration of *Management of Phytophthora cinnamomic for Biodiversity Conservation in Australia* (Commonwealth Department of the Environment and Heritage, 2006). Management measures that will be implemented to minimise the potential for the introduction or spread of *P. cinnamomic* include:

- restricting the movement of vehicles to formed tracks and pre-existing roads, where practicable;
- limiting activities that cause soil disturbance; and
- encouraging natural regeneration in areas requiring revegetation.

Measures that will be implemented in the event infestation areas are identified include:

- limiting access to infestation areas;
- limiting access to un-infested areas following entry to infested sites;
- development of hygiene protocols (e.g. clean footwear, equipment, vehicles and/or hygiene stations) to access known infestation areas; and
- the inclusion of *P. cinnamomic* general awareness and procedure information in Metropolitan Coal personnel and contractor inductions, particularly for those requiring access to identified infestation areas.

9.4.4 Amphibian Chytrid Fungus

Personnel conducting amphibian surveys in the Waratah Rivulet and Woronora River catchments, including movement between these two catchments, will be required to observe the following hygiene protocols in accordance with the *Hygiene Protocols for the Control of Disease in Frogs* (NPWS, 2001):

- The thorough cleaning and disinfecting of footwear.
- The thorough cleaning and disinfecting of equipment (such as nets, callipers, headlamps and waders).
- Restricting the movement of vehicles to formed tracks and pre-existing roads, where practicable.
- In the event the amphibian *Chytrid* fungus is known to be present at a site, that site would be the last site surveyed/sampled, where practicable.

10 CONTINGENCY PLAN

In the event the subsidence impact biodiversity performance measure for threatened species, populations or ecological communities detailed in Section 6 is considered to have been exceeded, Metropolitan Coal will implement the following Contingency Plan:

- the exceedance will be reported to the Technical Services Manager and/or the Environment & Community Superintendent within 24 hours.
- the Technical Services Manager and/or the Environment & Community Superintendent will report the likely exceedance to the General Manager as soon as practicable after becoming aware of the exceedance.
- Metropolitan Coal will report the likely exceedance of the biodiversity performance measure to the DPE, BCS and DPI – Fisheries as soon as practicable after Metropolitan Coal becomes aware of the exceedance.
- Metropolitan Coal will identify an appropriate course of action with respect to the identified impact(s), in consultation with specialists and relevant agencies, as necessary. For example:
  - proposed contingency measures;
  - a program to review the effectiveness of the contingency measures; and
  - consideration of adaptive management under circumstances where a water resource or watercourse performance measure detailed in Table 1 of the Project Approval has been exceeded.

Contingency measures will be developed in consideration of the specific circumstances of the exceedance and the assessment of environmental consequences. Potential contingency measures include management measures described in this BMP, the Metropolitan Coal Longwalls 311-316 Land Management Plan and Metropolitan Coal Longwalls 311-316 Water Management Plan.

- Metropolitan Coal will submit the proposed course of action to the DPE for approval.
- Metropolitan Coal will implement the approved course of action to the satisfaction of the DPE.

In accordance with Condition 6, Schedule 6 of the Project Approval, Metropolitan Coal will provide a suitable offset to compensate for the impact to the satisfaction of the Secretary of the DPE if either the contingency measures implemented by Metropolitan Coal have failed to remediate the impact or the Secretary of the DPE determines that it is not reasonable or feasible to remediate the impact.

Since the March 2024 version of the Longwalls 311-316 Extraction Plan, Metropolitan Coal has shortened Longwall 312 by 130 m to avoid undermining Swamp 92. Metropolitan Coal will prepare a site-specific contingency plan with supporting commentary on the remediation process and methods for Swamp 77 and provide to the DPHI.

11 FUTURE EXTRACTION PLANS AND INVESTIGATIONS

Metropolitan Coal is required to collected baseline data for the next Extraction Plan in accordance with Condition 7, Schedule 3 of the Project Approval. However, the currently approved Longwall 317 is too short to economically mine and, therefore, Metropolitan Coal is seeking to modify the Project Approval to extend Longwall 317 and add a new Longwall 318. Metropolitan Coal will collect baseline data for upland swamps, riparian vegetation, slopes and ridgetops, aquatic biota and their habitats, and terrestrial fauna and their habitats as part of the Modification process to inform the impact assessment and for use in future Extraction Plans.

Metropolitan Coal will also address recommendations made by the Independent Expert Advisory Panel for Mining that are relevant to the monitoring and management of biodiversity as part of this Extraction Plan.

A summary of the additional monitoring, data collection and investigations is provided below.

11.1 UPLAND SWAMPS

Vegetation Community Mapping and Swamp Extent

Baseline vegetation mapping and swamp extent data will be collected in 2024 and 2025 as part of the Modification application. Following the baseline surveys and assessment, regular monitoring will be conducted at relevant swamps. To establish a suitable baseline for swamps in the Modification area.

11.2 RIPARIAN VEGETATION

No significant streams (i.e. streams which are third order or higher) are located over Longwalls 311-317. The Waratah Rivulet is located to the south of Longwalls 308-312. The collection of baseline data and establishment of regular monitoring along Honeysuckle Creek would be considered as part of the Modification application process.

11.3 AQUATIC BIOTA AND THEIR HABITATS

The collection of baseline data and establishment of regular monitoring along Honeysuckle Creek would be considered as part of the Modification application process.

11.4 TERRESTRIAL FAUNA AND THEIR HABITATS

The collection of baseline data and establishment of regular monitoring for terrestrial fauna and their habitats will be considered as part of the Modification application process.

12 ANNUAL REVIEW AND IMPROVEMENT OF ENVIRONMENTAL PERFORMANCE

In accordance with Condition 3, Schedule 7 of the Project Approval, Metropolitan Coal will conduct an Annual Review of the environmental performance of the Project by the end of March each year.

The Annual Review will specifically address the environmental performance of the BMP and will:

- describe the works that were carried out in the past calendar year, and the works that are proposed to be carried out over the current calendar year;
- include a comprehensive review of the monitoring results and complaints records of the Project over the past year, including a comparison of these results against the:
  - relevant statutory requirements, limits or performance measures/criteria;
  - monitoring results of previous years; and
  - relevant predictions in the Project EA, Preferred Project Report and Extraction Plan;
- identify any non-compliance over the last year, and describe what actions were (or are being) taken to ensure compliance;
- identify any trends in the monitoring data over the life of the Project;
- provide a review, and where necessary updates to, the conceptual models for the large swamps in consideration of relevant new monitoring data and latest available vegetation mapping;
- identify any discrepancies between the predicted and actual impacts of the Project, and analyse the potential cause of any significant discrepancies; and
- describe what measures will be implemented over the next year to improve the environmental performance of the Project.

The Annual Review will also review the current monitoring programs, including if and when cessation of some monitoring activities is appropriate.

As described in Section 2, this BMP will be reviewed within three months of the submission of an Annual Review, and revised where appropriate.

13 INCIDENTS

An incident is defined as a set of circumstances that causes or threatens to cause material harm to the environment, and/or breaches or exceeds the limits or performance measures/criteria in the Project Approval.

The reporting of incidents will be conducted in accordance with Condition 6, Schedule 7 of the Project Approval. Metropolitan Coal will notify the Secretary of the DPE and any other relevant agencies of any incident associated with the Project as soon as practicable after Metropolitan Coal becomes aware of the incident. Within seven days of the date of the incident, Metropolitan Coal will provide the Secretary and any relevant agencies with a detailed report on the incident.

14 COMPLAINTS

A protocol for the managing and reporting of complaints has been developed as a component of Metropolitan Coal's Environmental Management Strategy and is described below.

The Environment & Community Superintendent is responsible for maintaining a system for recording complaints.

Metropolitan Coal will maintain public signage advertising the telephone number on which environmental complaints can be made. The Environment & Community Superintendent is responsible for ensuring that the currency and effectiveness of the service is maintained. Notifications of complaints received are to be provided as quickly as practicable to the Environment & Community Superintendent.

Complaints and enquiries do not have to be received via the telephone line and may be received in any other form. Any complaint or enquiry relating to environmental management or performance is to be relayed to the Environment & Community Superintendent as soon as practicable. All employees are responsible for ensuring the prompt relaying of complaints. All complaints will be recorded in a complaints register.

For each complaint, the following information will be recorded in the complaints register:

- date and time of complaint;
- method by which the complaint was made;
- personal details of the complainant which were provided by the complainant or, if no such details were provided, a note to that effect;
- nature of the complaint;
- the action(s) taken by Metropolitan Coal in relation to the complaint, including any follow-up contact with the complainant; and
- if no action was taken by Metropolitan Coal, the reason why no action was taken.

The Environment & Community Superintendent is responsible for ensuring that all complaints are appropriately investigated, actioned and that information is fed back to the complainant, unless requested to the contrary.

In accordance with Condition 10, Schedule 7 of the Project Approval, the complaints register will be made publicly available on the Peabody website and updated on a monthly basis. A summary of complaints received and actions taken will be presented to the Community Consultative Committee as part of the operational performance review.

15 NON-COMPLIANCES WITH STATUTORY REQUIREMENTS

A protocol for the managing and reporting of non-compliances with statutory requirements has been developed as a component of Metropolitan Coal's Environmental Management Strategy (Figure 3) and is described below.

Compliance with all approvals, plans and procedures will be the responsibility of all personnel (staff and contractors) employed on or in association with Metropolitan Coal, and will be developed through promotion of Metropolitan Coal ownership under the direction of the General Manager.

The Technical Services Manager and/or Environment & Community Superintendent will undertake regular inspections, internal audits and initiate directions identifying any remediation/rectification work required, and areas of actual or potential non-compliance.

As described in Section 13, Metropolitan Coal will notify the Secretary of the DPE and any other relevant agencies of any incident associated with Metropolitan Coal as soon as practicable after Metropolitan Coal becomes aware of the incident. Within seven days of the date of the incident, Metropolitan Coal will provide the Secretary of the DPE and any relevant agencies with a detailed report on the incident.

A review of Metropolitan Coal's compliance with all conditions of the Project Approval, mining leases and all other approvals and licences will be undertaken prior to (and included within) each Annual Review. The Annual Review will be made publicly available on the Peabody website.

Additionally, in accordance with Condition 8, Schedule 7 of the Project Approval, an independent environmental audit was undertaken by the end of December 2011, and is undertaken a minimum of once every three years thereafter. A copy of the audit report will be submitted to the Secretary of the DPE and made publicly available on the Peabody website. The independent audit will be undertaken by an appropriately qualified, experienced and independent team of experts whose appointment has been endorsed by the Secretary of the DPE.

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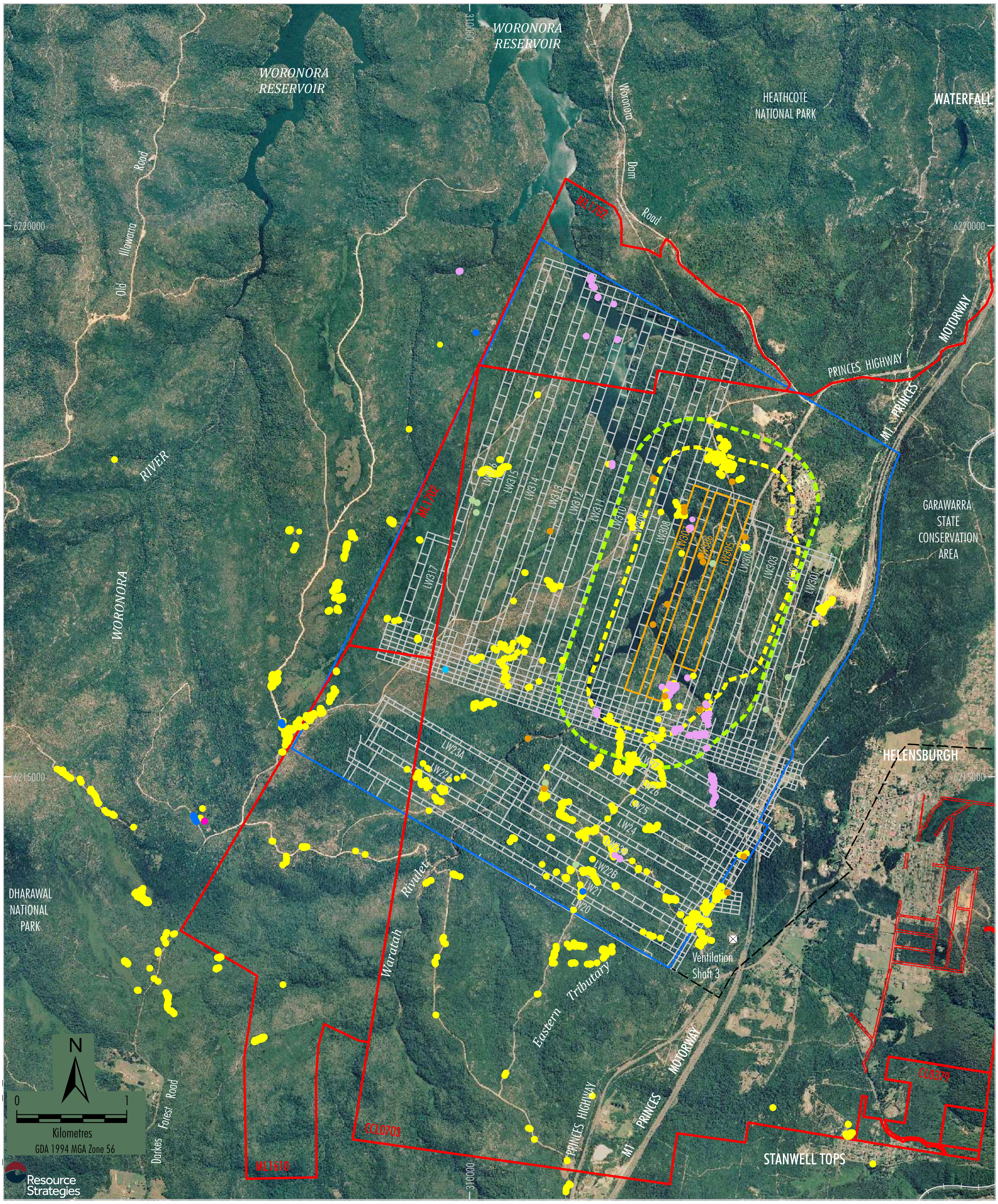
APPENDIX 1

THREATENED FLORA AND FAUNA SPECIES RECORDS



MET-19-19_305-309 EP BMP_A1_201B

LEGEND

- Mining Lease Boundary
- Railway
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 305-307 Secondary Extraction
- Longwalls 305-307 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 305-307 Secondary Extraction
- Existing Underground Access Drive (Main Drift)

Confirmed Threatened Species

- *Astrotricha crassifolia*
- *Acacia bynoeana*
- *Acacia baueri* subsp. *aspera*
- *Melaleuca deanei*
- *Pultenaea aristata*
- *Cryptostylis hunteriana*

Potential (Unconfirmed) Threatened Species

- *Epacris purpurascens* var. *purpurascens*
- *Leucopogon exolasius*

Notes 1. Includes threatened species records up to and including the Autumn 2018 surveys.
2. Each symbol is indicative of a specific location rather than the number of individuals of each species.

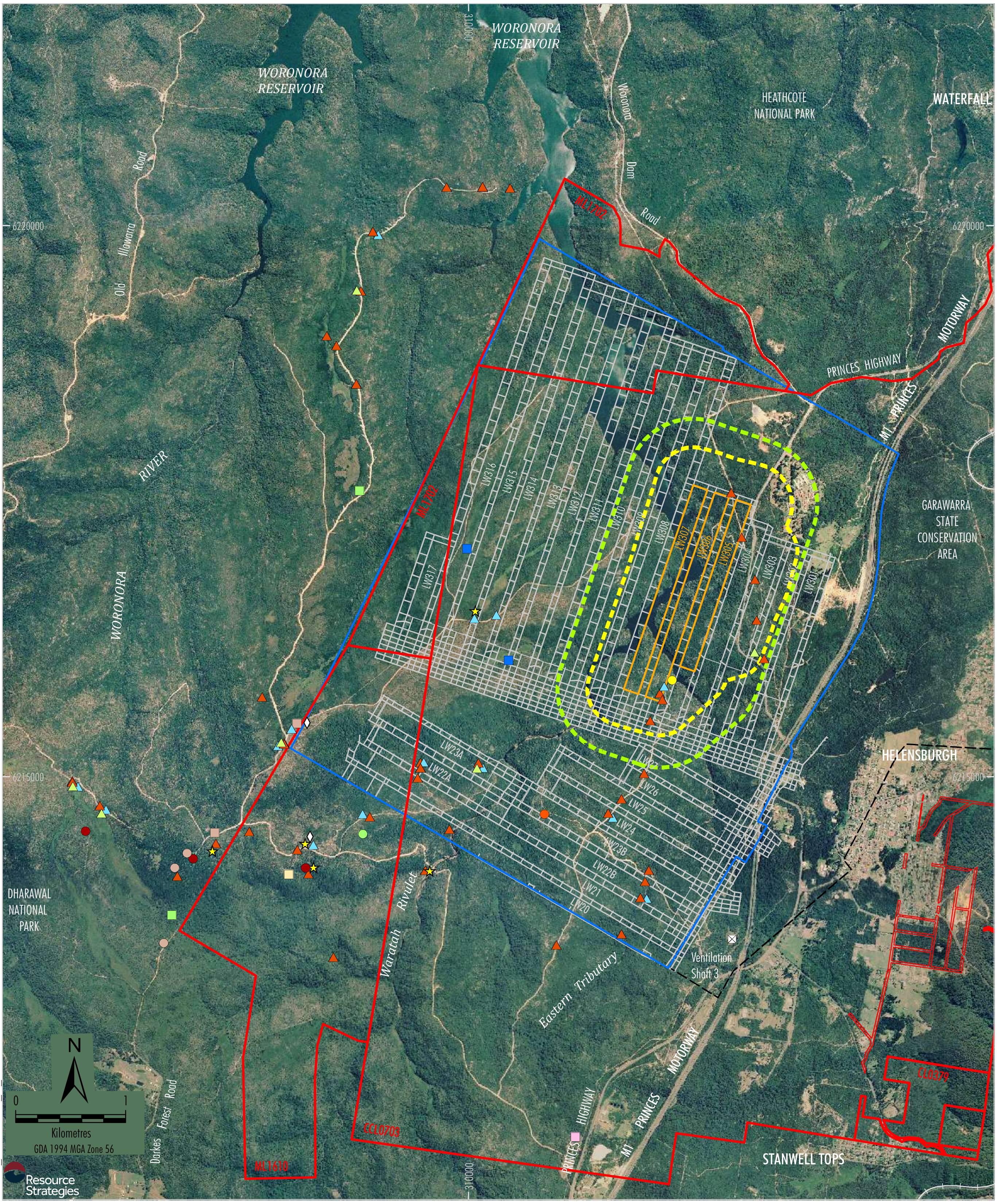
Source: Land and Property Information (2015); Date of Aerial Photography 1998; Department of Industry (2015); Metropolitan Coal (2019); MSEC (2019); Threatened species recorded by Bangalay Botanical Surveys (2008); FloraSearch (2008, 2009); Eco Logical (2010-2018)

Peabody

METROPOLITAN COAL

Threatened Flora Recorded During Metropolitan Coal Surveys

Figure 1-1



LEGEND

- Mining Lease Boundary
- Railway
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Longwalls 305-307 Secondary Extraction
- Longwalls 305-307 35° Angle of Draw and/or Predicted 20 mm Subsidence Contour
- 600 m from Longwalls 305-307 Secondary Extraction
- Existing Underground Access Drive (Main Drift)

Threatened Fauna

- Giant Burrowing Frog
- Littlejohn's Tree Frog
- Red-crowned Toadlet
- Grey Falcon
- Square-tailed Kite
- Black-necked Stork
- Eastern Ground Parrot
- Turquoise Parrot
- Grey-headed Flying Fox
- Large-footed Myotis
- Squirrel Glider
- Eastern Pygmy-possum
- Eastern Bentwing Bat
- Broad-headed Snake
- Diggings that could potentially belong to the threatened Southern Brown Bandicoot or Long-nosed Potoroo, or the Protected Long-nosed Bandicoot

Source: Land and Property Information (2015); Date of Aerial Photography 1998; Department of Industry (2015); Metropolitan Coal (2019); MSEC (2019); Threatened Species recorded by Western Research Institute and Biosphere Environmental Consultants (2008); Cenwest Environmental Services (2008-2019)

Notes: 1. Includes threatened species records up to March 2019.
2. Each symbol is indicative of a specific location rather than the number of individuals of each species.

Peabody

METROPOLITAN COAL

Threatened Fauna Recorded During Metropolitan Coal Surveys

Figure 1-2

APPENDIX 2

REVISED LONGWALLS 304-310 UPLAND SWAMP VEGETATION MAPPING

Revised Longwalls 304-310 Upland Swamp Vegetation Mapping

Prepared for
Metropolitan Coal




DOCUMENT TRACKING

Item	Detail
Project Name	Longwalls 304-310 Upland Swamp Vegetation Mapping
Project Number	16SUT-4772
Project Manager	Elizabeth Norris (02) 8536 8686 Level 3, Suite 2 668 – 672 Old Princes Highway Sutherland NSW 2232
Prepared by	Brian Towle, Elizabeth Norris and Suzanne Eacott
Reviewed by	Elizabeth Norris
Approved by	Elizabeth Norris
Status	Final
Version Number	2
Last saved on	11 February 2019
Cover photo	Upland swamps overlying Longwalls 304-306, Elizabeth Norris and Brian Towle, July 2016

This report should be cited as 'Eco Logical Australia 2018. *Longwalls 304-310 Upland Swamp Vegetation Mapping*. Prepared for Metropolitan Coal.'

ACKNOWLEDGEMENTS

This document has been prepared by Eco Logical Australia Pty Ltd with support from Resource Strategies.

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1 Introduction

Metropolitan Coal was granted approval (08_0149) for the Metropolitan Coal Project in accordance with Section 75J of the *Environmental Planning and Assessment Act, 1979* on 22 June 2009. In accordance with Project Approval Condition 6, Schedule 3, an Extraction Plan is to be prepared for all second workings which includes a Biodiversity Management Plan to manage the potential environmental consequences of the Extraction Plan on aquatic and terrestrial flora and fauna, with a specific focus on swamps. The term 'swamps' in this report is used to refer to all vegetation communities identified as forming the Upland Swamps Complex, as described by New South Wales (NSW) National Parks and Wildlife Services (NPWS 2003).

This report has been prepared to update previous vegetation mapping of upland swamps overlying or proximal to Longwalls 304-310, and to inform the preparation of future Biodiversity Management Plans. Specifically, the aims of this report are to:

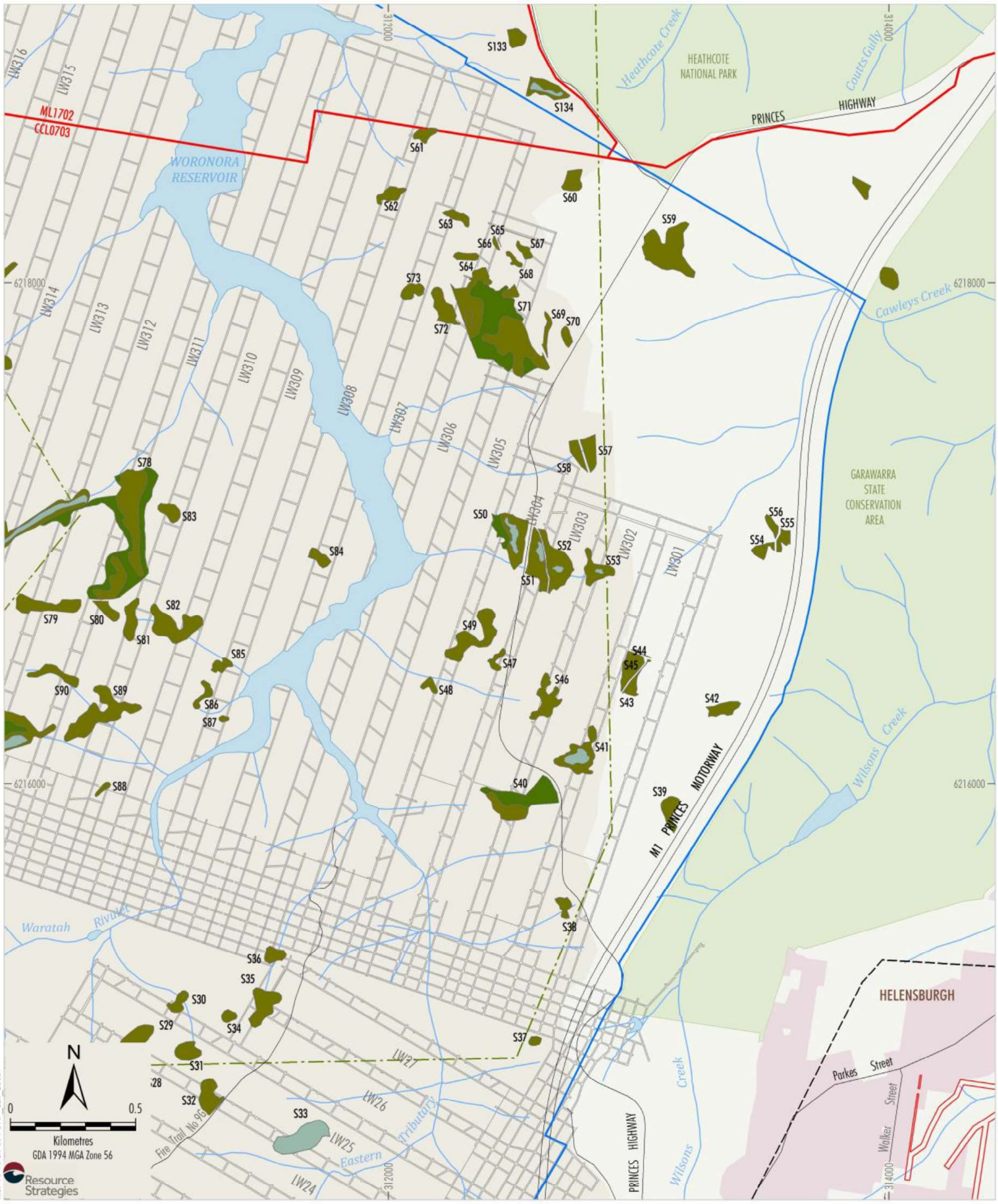
- Validate existing mapping of upland swamp vegetation overlying or proximal to Longwalls 304-310, and where appropriate update vegetation mapping.
- Document any revisions to the existing vegetation mapping.
- Document the vegetation characteristics of each swamp.
- Conduct searches for indicator species within the swamps to inform potential vegetation monitoring.

2 Bangalay Botanical Surveys (2008) Vegetation Mapping

Bangalay Botanical Surveys (2008) conducted a baseline flora survey and mapped vegetation communities within the Project underground mining area for the Metropolitan Coal Project Environmental Assessment (Helensburgh Coal Pty Ltd 2008).

Swamps were mapped by Bangalay Botanical Surveys (2008) consistent with vegetation mapping by the NSW National Parks and Wildlife Service (NPWS) (2003) as either vegetation community 3a (Banksia Thicket), 3b (Tea Tree Thicket), 3c (Sedgeland-heath Complex), 3d (Fringing Eucalypt Woodland), or a combination of these communities.

The Bangalay Botanical Surveys (2008) mapping of upland swamps overlying or proximal to Longwalls 304-310 is shown on Figure 1.



LEGEND

- Mining Lease Boundary
- Woronora Special Area
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Woronora Notification Area
- Existing Underground Access Drive (Main Drift)
- 3a - Upland Swamp: Banksia Thicket
- 3b - Upland Swamp: Tea Tree Thicket
- 3c - Upland Swamp: Sedgeland-heath Complex
- 3d - Upland Swamp: Fringing Eucalypt Woodland

Source: Land and Property Information (2015); Department of Industry (2015); Bangalay Botanical Surveys (2008)

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Upland Swamp Vegetation Mapping by Bangalay Botanical Surveys (2008)

Figure 1

3 Revised Upland Swamp Mapping for Longwalls 301-303

Field inspections of upland swamp vegetation mapped by Bangalay Botanical Surveys (2008) within 600 m of Longwalls 301-303 secondary extraction were conducted by Eco Logical Australia (Eco Logical) in 2015. At each upland swamp mapped by Bangalay Botanical Surveys (2008), the extent of the mapped polygon was traversed to confirm the presence of upland swamp vegetation communities, confirm the boundaries and extent of these vegetation communities and identify the specific vegetation community present (i.e. Banksia Thicket, Tea Tree Thicket, Sedgeland-heath Complex or Fringing Eucalypt Woodland).

For each upland swamp, a description of the vegetation was recorded including the different strata present, the dominant species and an estimation of percent foliage cover for each stratum to assign vegetation communities described by NPWS (2003) and Bangalay Botanical Surveys (2008). Final delineation of vegetation community boundaries was undertaken by interpretation of recent aerial photographs. Patterns identified on aerial photographs were related to the field observations and used to delineate the boundaries of vegetation communities.

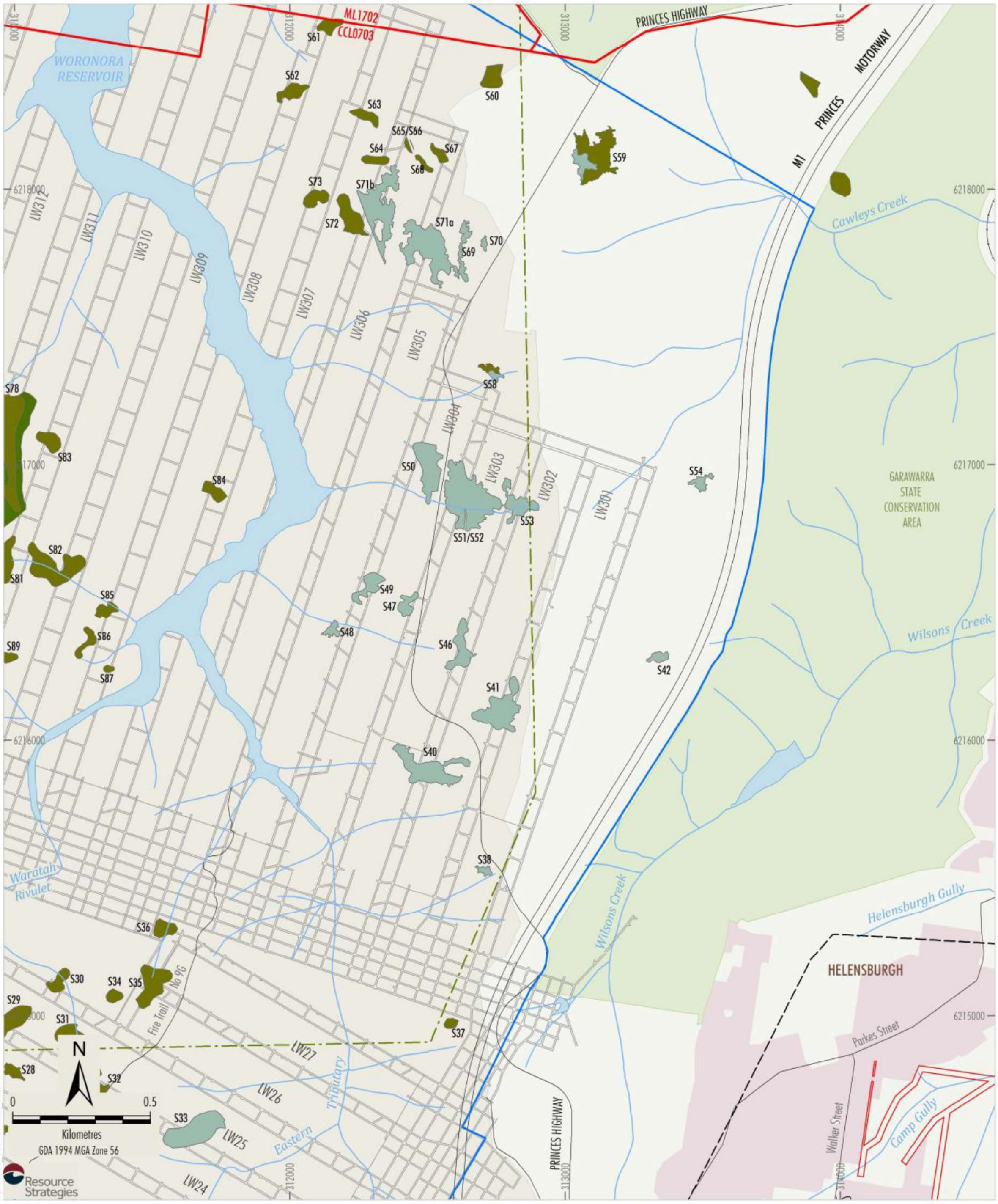
A total of 26 upland swamps were identified by Bangalay Botanical Surveys within 600 m of Longwalls 301-303 secondary extraction, namely, Swamps 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 69, 70 and 71 (Figure 1).

The field inspections by Eco Logical indicated that seven upland swamps identified by Bangalay Botanical Surveys (2008) (which was based on NPWS 2003 mapping) did not comprise upland swamp vegetation (i.e. they were identified as supporting non-swamp vegetation communities), namely, Swamps 39, 43/44/45, 55/56 and 57 (Figure 1) (Eco Logical 2016).

The boundaries of 19 upland swamps situated within 600 m of Longwalls 301-303 were revised as appropriate by Eco Logical, namely, Swamps 37, 38, 40, 41, 42, 46, 47, 48, 49, 50, 51, 52, 53, 54, 58, 69, 70 and 71 (Figure 1). The revised upland swamp and associated vegetation community mapping by Eco Logical (2016) of upland swamps within 600 m of Longwalls 301-303 is shown on Figure 2, and the revised vegetation community mapping for the Underground Mining Area and surrounds is shown on Figure 3.

All upland swamps within 600 m of Longwalls 301-303 secondary extraction were classified as Banksia Thicket, except for Swamps 58 and 59, which were mapped as a combination of Sedgeland-heath Complex and Banksia Thicket (Figure 2).

The Longwalls 301-303 revised upland swamp vegetation mapping is reported in Eco Logical (2016), included in Appendix 2 of the Longwalls 301-303 Biodiversity Management Plan.



LEGEND

- Mining Lease Boundary
- Woronora Special Area
- Railway
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Woronora Notification Area
- Existing Underground Access Drive (Main Drift)

Map Unit	Vegetation Community
3a	Upland Swamp: Banksia Thicket
3b	Upland Swamps: Tea Tree Thicket
3c	Upland Swamp: Sedgeland-heath Complex
3d	Upland Swamp: Fringing Eucalypt Woodland

Note: Swamps 37, 38, 40, 41, 42, 46, 47, 48, 49, 50, 51/52, 53, 54, 58, 69, 70, 71a and 71b were re-mapped by Eco Logical (2016)

Source: Land and Property Information (2015); Department of Industry (2015); after NPWS (2003), Bangalay Botanical Surveys (2008) and Eco Logical Australia (2015; 2016)

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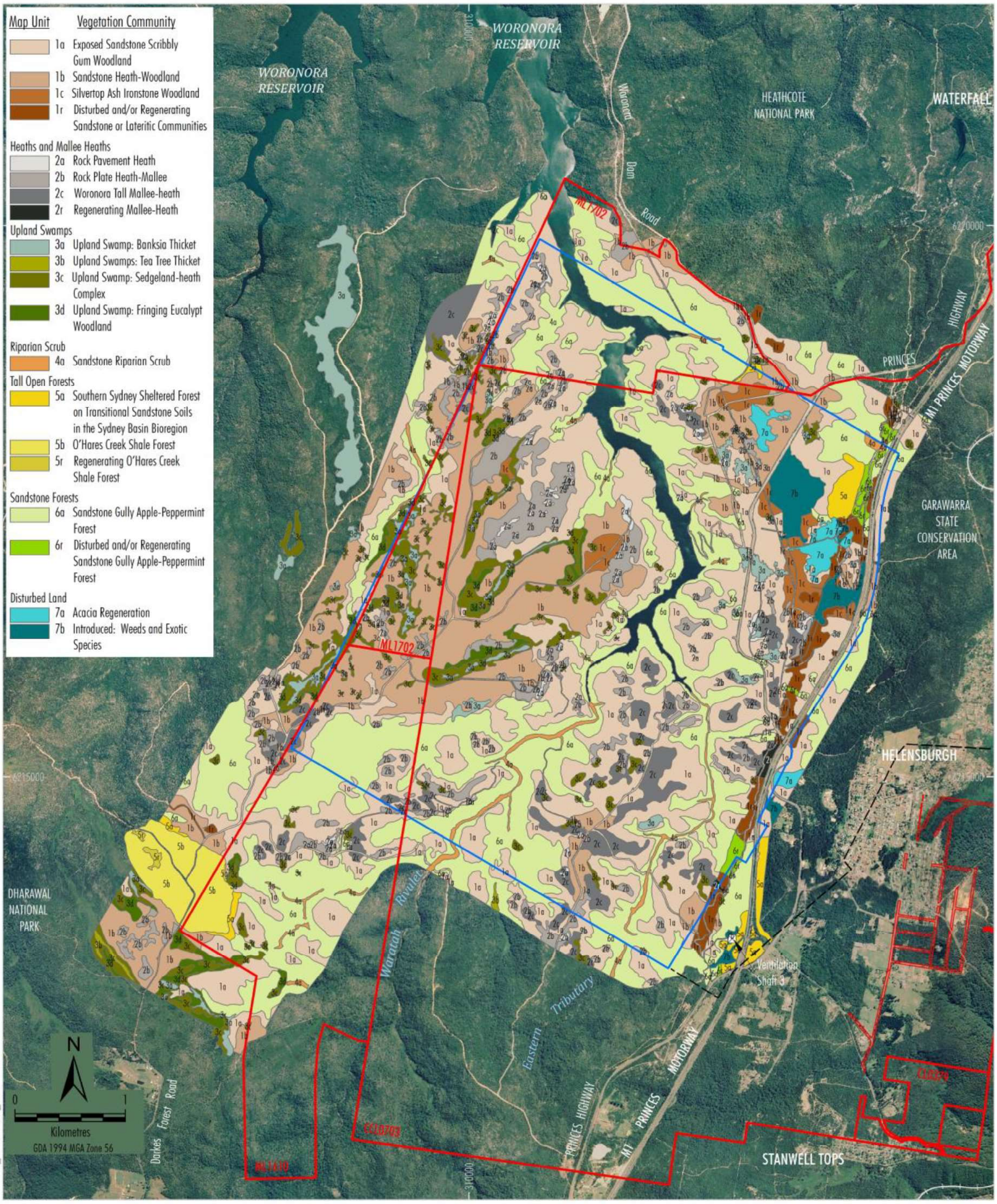
Upland Swamps over Longwalls 301 - 303 and Surrounds

Figure 2



LEGEND

- Mining Lease Boundary
- Railway
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Existing Underground Access Drive (Main Drift)

Source: Land and Property Information (2015); Date of Aerial Photography 1998; Department of Industry (2015); Metropolitan Coal (2016); after NPWS (2003), Bangalay Botanical Surveys (2008) and Eco Logical Australia (2015; 2016)

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Mapped Vegetation Communities Within the Project Underground Mining Area and Surrounds

Figure 3

4 Revised Upland Swamp Mapping for Longwalls 304-310

4.1 Background

A number of upland swamps were identified by Bangalay Botanical Surveys (2008) overlying or proximal to Longwalls 304-310. Excluding those upland swamps previously inspected and re-mapped by Eco Logical (2016) that are described in Section 3, these include Swamps 60, 61, 62, 63, 64, 65, 66, 67, 68, 72, 73, 81, 82, 83, 84, 85, 86, 87, 88, 89, 133 and 134 (Figure 1).

Of these, 21 swamps were identified by Bangalay Botanical Surveys (2008) as supporting Sedgeland-heath Complex, namely Swamps 60, 61, 62, 63, 64, 65, 66, 67, 68, 72, 73, 81, 82, 83, 84, 85, 86, 87, 88, 89 and 133 (Figure 1). Swamp 134 was identified by Bangalay Botanical Surveys (2008) as having a combination of Sedgeland-heath Complex and Banksia Thicket (Figure 1).

4.2 Methods

4.2.1 Revised Mapping Methodology

Field inspections of upland swamps overlying or proximal to Longwalls 304-310 to the east of the Woronora Reservoir (excluding those upland swamps previously inspected and re-mapped for Longwalls 301-303 described in Section 3) were undertaken by two ecologists, Elizabeth Norris and Brian Towle, on the 4th and 14th of July 2016 and the 19th of August 2016. Specifically, field surveys were conducted of Swamps 60, 61, 62, 63, 64, 65, 66, 67, 68, 72, 73, 133 and 134.

Field inspections of upland swamps overlying or proximal to Longwalls 304-310 to the west of the Woronora Reservoir were undertaken by two ecologists, Elizabeth Norris and Suzanne Eacott, on the 17th, 18th and 26th of July 2017. Specifically, field surveys were conducted of Swamps 81, 82, 83, 84, 85, 86, 87, 88 and 89.

At each upland swamp mapped by Bangalay Botanical Surveys (2008), the extent of the mapped polygon was traversed to confirm the presence of previously mapped vegetation communities, and to confirm the swamp vegetation community boundaries/extent.

The *NSW Native Vegetation Interim Type Standard* (Sivertsen 2009) requires patches of vegetation to be mapped if the dimensions of the representative polygon on a map sheet are 2 mm x 2 mm or greater (i.e. at a map scale of 1:25,000, patches of vegetation equal to or greater than 0.25 ha). Notwithstanding, the revised swamp vegetation mapping boundaries (including those swamps less than 0.25 ha in area) are shown on Figures 4 and 5 to document the changes to the previous Bangalay Botanical Surveys (2008) vegetation mapping. It is considered that these small areas comprising vegetation characteristic of the upland swamp vegetation communities doubtfully represent an ‘upland swamp’.

For each area confirmed as comprising upland swamp vegetation, a description of the vegetation was recorded, including the different stratum present, the dominant species and an estimation of percent foliage cover for each stratum. These descriptions formed the basis for assigning vegetation communities described by NPWS (2003) and Bangalay Botanical Surveys (2008). Final delineation of vegetation community boundaries was undertaken by interpretation of aerial photographs. Patterns identified on aerial photographs were considered with the field observations to finalise vegetation community boundaries.

4.2.2 Presence of Indicator Species

The presence of indicator species that are monitored as part of the current Longwalls 20-22, 23-27 and 301-303 vegetation monitoring programs was noted within each swamp overlying or proximal to Longwalls 304-310, and a rapid assessment of the number of individuals of each indicator species was made.

5 Results

5.1 Swamp Geomorphology

Three swamp types have been identified as occurring over the Metropolitan Coal Project underground mining area, as follows (Metropolitan Coal 2018):

- Headwater swamps: These are the largest swamp type. They occupy broad, shallow, trough-shaped valleys, usually on first order watercourses at the head of valleys on broad plateaux. They sit on a relatively impermeable, low gradient sandstone base with dispersed seepage flows that encourage the growth of hygrophilic vegetation that in turn traps sediment, thereby increasing the water holding capacity. These swamps usually terminate at points where the watercourse suddenly steepens or drops away at a ‘terminal step’. Terminal steps often occur at constrictions in the landscape where two ridges converge, causing a narrowing of the swamp and a concentration of water flows into a central channel.
- In-valley swamps: In-valley swamps are uncommon and occur on relatively flat sections of more deeply incised second and third order watercourses. Some are thought to develop behind obstructions in the watercourse, such as fallen rocks or log jams that result in a slowing of the water flow and deposition of sediments. Flat Rock Swamp is considered to represent a ‘classic’ in-valley swamp. Because of their relatively large catchment areas these swamps tend to be wetter than many headwater and valley side swamps.
- Valley side swamps: Valley side swamps occur on steeper terrain than headwater swamps and are sustained by small horizontal aquifers that seep from the sandstone strata and flow over unbroken outcropping rock masses. These ‘swamps’ have shallow soils because the gradient usually limits sediment accumulation. They tend to terminate either on a horizontal step in the bedrock, or where broken rock, scree or deeper soil occurs at the base of the outcropping rock.

All of the swamps overlying or proximal to Longwalls 304-310 were identified as ‘valley side swamps’. The highly dissected landscape with narrow ridges does not contain broad plateaux capable of supporting the larger ‘headwater swamps’. All of the swamps identified during the field inspections are located on the mid to upper portions of the slope and do not occur in association with an incised second or third order watercourse compared to in-valley swamps.

5.2 Upland Swamp Vegetation Communities

The field inspections of mapped upland swamps overlying or proximal to Longwalls 304-310 confirmed the presence of vegetation characteristic of upland swamps at the majority of upland swamps mapped by Bangalay Botanical Surveys (2008). However, the boundaries identified by Bangalay Botanical Surveys (2008) did not accurately reflect the boundaries of each upland swamp observed in the field and from current aerial photography (NearMap 2017). The revised swamp boundaries are shown on Figure 4, Figure 5 and in Attachment A.

Table 1 details the revised upland swamp vegetation revised by Eco Logical. Of the 22 swamps mapped by Bangalay Botanical Surveys, Eco Logical mapped:

- 15 swamps (Swamps 61, 62, 63, 64, 65/66, 67, 68a, 68b, 72, 81, 82, 83, 88, and 89) as Banksia Thicket.
- One swamp (Swamp 60) as Sedgeland-heath Complex.
- One swamp (Swamp 73) as a combination of Banksia Thicket and Tea Tree Thicket.
- Two swamps (Swamps 84 and 86) as a combination of Banksia Thicket and Sandstone Gully Apple-Peppermint Forest.
- One swamp (Swamp 134) as a combination of Sedgeland-heath Complex and Banksia Thicket.
- Two swamps (Swamps 85 and 87) as non-swamp vegetation.

Swamps 65 and 66 were identified as being a single swamp which has been dissected by a fire trail, and are herein referred to as a single swamp (Swamp 65/66) (Figure 4).

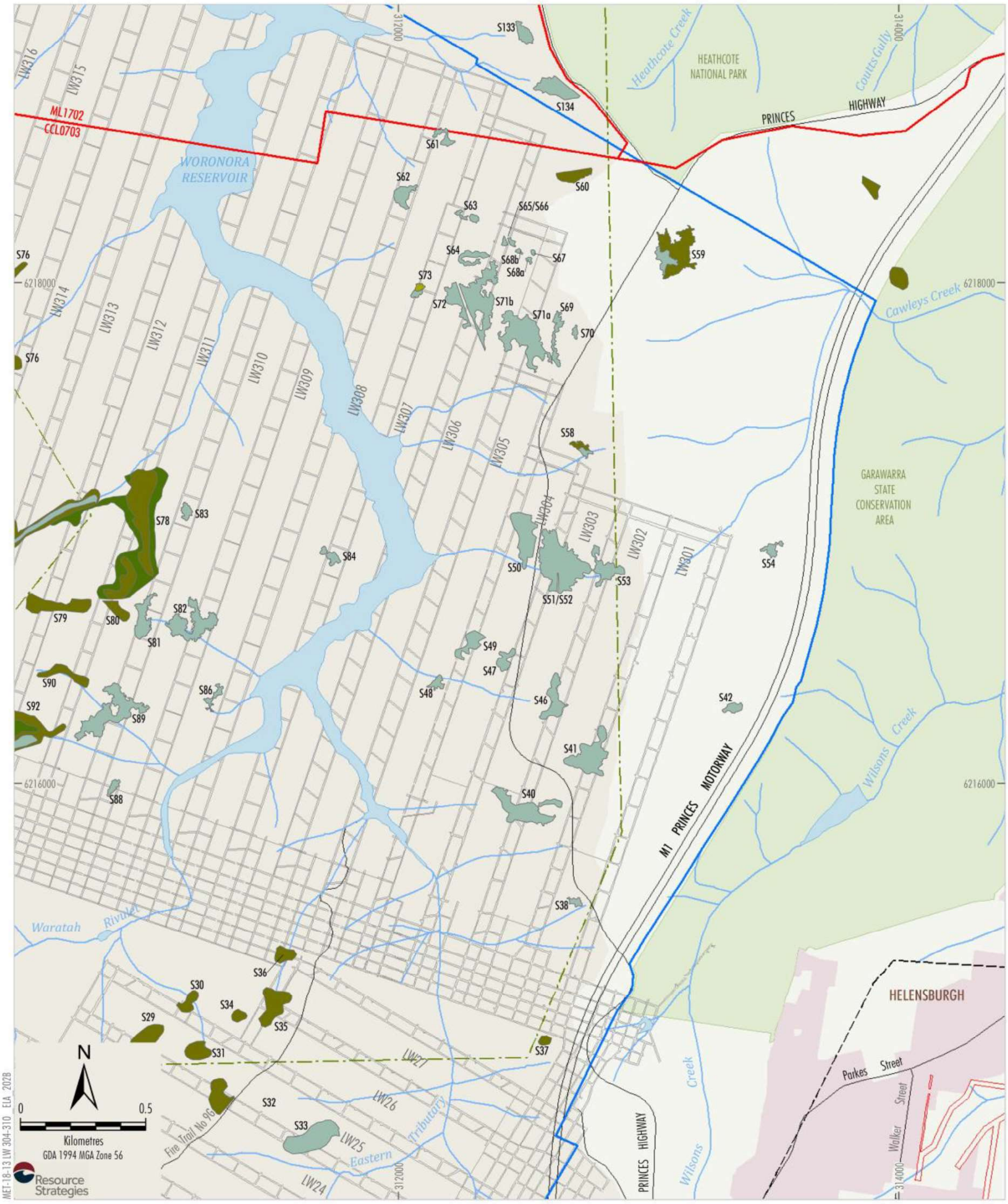
Swamp 68, as mapped by Bangalay Botanical Surveys (2008) (Figure 1), was found to include two small discrete areas comprising vegetation characteristics of the Banksia Thicket vegetation community, separated by an area of Sandstone Heath-Woodland (vegetation community 1b, Figure 5), re-mapped as Swamps 68a and 68b (Figure 4). Small-scale illustrations of the revised swamp vegetation boundaries are shown in Attachment A. As described above, it is considered that these small areas comprising vegetation characteristic of the upland swamp vegetation communities doubtfully represent an 'upland swamp'.

Swamps 84 and 86 are considered to be marginal upland swamps in that they contain non-swamp vegetation more consistent with sandstone woodland. Swamps 84 and 86 are located on steeper east to south-east facing slopes to the west of the Woronora Reservoir where the vegetation observed is a combination of swamp vegetation and Sandstone Gully Apple-Peppermint Forest (vegetation community 6a, Figure 5), containing a dense mid-layer of *Banksia ericifolia* subsp. *ericifolia*, and with patches of more open canopy present. Numerous sandstone ledges commonly occur on these steeper slopes, enhancing more dense understorey growth through maintaining higher soil moisture. Terminal rocky steps are not present. It is noted that Swamp 84 is marginally greater than 0.25 ha (0.256 ha), while Swamp 86 is less than 0.25 ha (0.209 ha).

Table 1: Upland Swamp Vegetation Communities Mapped by Bangalay Botanical Surveys and Revised by Eco Logical Australia

Swamp	Vegetation Community (Bangalay Botanical Surveys 2008)	Swamp	Vegetation Community (Eco Logical)
60	Sedgeland-heath Complex	60	Sedgeland-heath Complex
61	Sedgeland-heath Complex	61	Banksia Thicket
62	Sedgeland-heath Complex	62	Banksia Thicket
63	Sedgeland-heath Complex	63	Banksia Thicket
64	Sedgeland-heath Complex	64	Banksia Thicket
65	Sedgeland-heath Complex	65/66	Banksia Thicket
66	Sedgeland-heath Complex		
67	Sedgeland-heath Complex	67	Banksia Thicket
68	Sedgeland-heath Complex	68a	Banksia Thicket
		68b	Banksia Thicket
72	Sedgeland-heath Complex	72	Banksia Thicket
73	Sedgeland-heath Complex	73	Banksia Thicket/Tea Tree Thicket
81	Sedgeland-heath Complex	81	Banksia Thicket
82	Sedgeland-heath Complex	82	Banksia Thicket
83	Sedgeland-heath Complex	83	Banksia Thicket
84	Sedgeland-heath Complex	84	Banksia Thicket/Sandstone Gully Apple-Peppermint Forest*
85	Sedgeland-heath Complex	85	Sandstone Gully Apple-Peppermint Forest
86	Sedgeland-heath Complex	86	Banksia Thicket/Sandstone Gully Apple-Peppermint Forest*
87	Sedgeland-heath Complex	87	Sandstone Gully Apple-Peppermint Forest
88	Sedgeland-heath Complex	88	Banksia Thicket
89	Sedgeland-heath Complex	89	Banksia Thicket
133	Sedgeland-heath Complex	133	Banksia Thicket
134	Sedgeland-heath Complex/Banksia Thicket	134	Sedgeland-heath Complex/Banksia Thicket

* Swamps 84 and 86 are considered to be marginal upland swamps in that they contain non-swamp vegetation more consistent with sandstone woodland.



LEGEND

- Mining Lease Boundary
- Woronora Special Area
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Woronora Notification Area
- Existing Underground Access Drive (Main Drift)
- 3a - Upland Swamp: Banksia Thicket
- 3b - Upland Swamp: Tea Tree Thicket
- 3c - Upland Swamp: Sedgeland-heath Complex
- 3d - Upland Swamp: Fringing Eucalypt Woodland

Note: 1. Swamps 37, 38, 40, 41, 42, 46, 47, 48, 49, 50, 51/52, 53, 54, 58, 69, 70, 71a and 71b were re-mapped by Eco Logical (2016).

2. The NSW Native Vegetation Interim Type Standard 2009 requires patches of vegetation to be mapped if the dimensions of the representative polygon on a map sheet are 2 mm x 2 mm or greater (i.e. 0.25 hectares or greater at a scale of 1:25,000). Eco Logical Australia conducted field inspections of upland swamp vegetation previously mapped by Bangalay Botanical Surveys (2008) overlying or proximal to Longwalls 301-310 to confirm the upland swamp vegetation communities present and to confirm or update the swamp vegetation boundaries.
It is noted that the revised boundaries of a number of upland swamps (Swamps 37, 38, 42, 48, 54, 58, 61, 63, 65/66, 67, 68a, 68b, 70, 73, 83, 86 and 88) are less than 0.25 hectares in area and consistent with NSW vegetation mapping guidelines are not required to be mapped. Notwithstanding, the revised swamp vegetation mapping boundaries (including those swamps less than 0.25 hectares in area) are shown on this figure to document the changes to previous vegetation mapping.

Source: Land and Property Information (2015); Department of Industry (2015); Metropolitan Coal (2018); after NPWS (2003), Bangalay Botanical Surveys (2008), Eco Logical Australia (2015; 2016; 2018)

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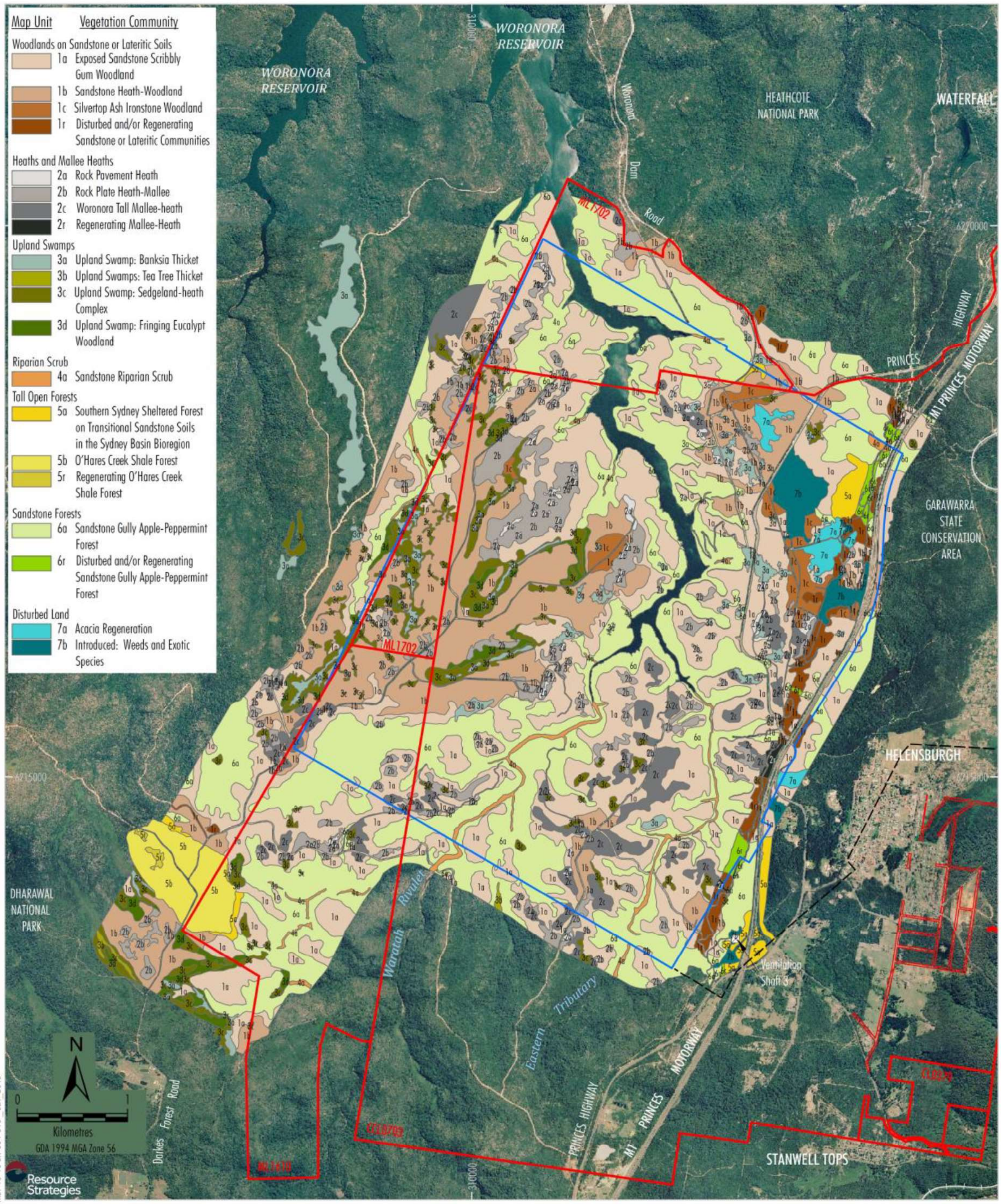
Upland Swamps over Longwalls 304-310 and Surrounds

Figure 4



LEGEND

- Mining Lease Boundary
- Railway
- Project Underground Mining Area Longwalls 20-27 and 301-317
- Existing Underground Access Drive (Main Drift)

The NSW Native Vegetation Interim Type Standard 2009 requires patches of vegetation to be mapped if the dimensions of the representative polygon on a map sheet are 2 mm x 2 mm or greater (i.e. 0.25 hectares or greater at a scale of 1:25,000). Eco Logical Australia conducted field inspections of upland swamp vegetation previously mapped by Bangalay Botanical Surveys (2008) overlying or proximal to Longwalls 301-310 to confirm the upland swamp vegetation communities present and to confirm or update the swamp vegetation boundaries.

It is noted that the revised boundaries of a number of upland swamps (Swamps 37, 38, 42, 48, 54, 58, 61, 63, 65/66, 67, 68a, 68b, 70, 73, 83, 86 and 88) are less than 0.25 hectares in area and consistent with NSW vegetation mapping guidelines are not required to be mapped. Notwithstanding, the revised swamp vegetation mapping boundaries (including those swamps less than 0.25 hectares in area) are shown on this figure to document the changes to previous vegetation mapping.

Source: Land and Property Information (2015); Date of Aerial Photography 1998; Department of Industry (2015); Metropolitan Coal (2018); after NPWS (2003), Bangalay Botanical Surveys (2008) and Eco Logical Australia (2015; 2016; 2018)

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Mapped Vegetation Communities Within the Project Underground Mining Area and Surrounds

Figure 5

Swamps 85 and 87 included in the Bangalay Botanical Surveys (2008) mapping (Figure 1) were comprised of non-swamp vegetation (i.e. they did not comprise vegetation characteristic of the upland swamp vegetation communities). Swamp 85 occurs on a steep east to south-east facing slope to the west of the Woronora Reservoir where the vegetation observed was Sandstone Gully Apple-Peppermint Forest (vegetation community 6a, Figure 5). Similar to Swamps 84 and 86, numerous sandstone ledges commonly occur on these steeper slopes, enhancing more dense understorey growth through maintaining higher soil moisture. Swamp 87 is located along a drainage line and also comprises Sandstone Gully Apple-Peppermint Forest (Figure 5).

The area of each upland swamp overlying or proximal to Longwalls 304-310 inspected by Eco logical is provided in Table 2. Of these swamps, ten upland swamps have an area of 0.25 ha or greater, and ten upland swamps have an area of less than 0.25 ha.

Table 2: Area of each re-mapped Upland Swamp Overlying or Proximal to Longwalls 304-310

Swamp	Area (ha)
S60	0.520
S61	0.237
S62	0.463
S63	0.170
S64	0.363
S65/66	0.112
S67	0.030
S68a	0.043
S68b	0.034
S72	0.606
S73	0.182
S81	0.728
S82	1.437
S83	0.202
S84	0.256
S86	0.209
S88	0.164
S89	1.982
S133	0.362
S134	0.891

Note: Highlighted swamps are less than 0.25 ha in area.

The *NSW Native Vegetation Interim Type Standard* (Sivertsen 2009) requires patches of vegetation to be mapped if the dimensions of the representative polygon on a map sheet are 2 mm x 2 mm or greater (i.e. at a map scale of 1:25,000, patches of vegetation equal to or greater than 0.25 ha). It is noted that the revised boundaries of a number of the upland swamps (Swamps 61, 63, 65/66, 67, 68a, 68b, 73, 83, 86 and 88) are less than 0.25 ha in area and consistent with NSW vegetation mapping guidelines are not required to be mapped. Notwithstanding, the revised swamp vegetation mapping boundaries (including those swamps less than 0.25 ha in area) are shown on Figures 4 and 5 to document the changes to the previous Bangalay Botanical Surveys (2008) vegetation mapping. It is considered that these small areas comprising vegetation characteristic of the upland swamp vegetation communities doubtfully represent an 'upland swamp'.

5.3 Fire History of Upland Swamps Overlying or Proximal to Longwalls 304-310

The field surveys conducted by Bangalay Botanical Surveys (2008) for upland swamps overlying or proximal to Longwalls 304-310 were undertaken between late 2006 and early 2008, five to six years post the fire of December 2001 and January 2002 respectively, and approximately 12-20 years post the fires in 1986-1987 and 1993-1994, all which extensively burnt the catchments of Woronora, O'Hares, Nepean and Avon.

The field surveys conducted by Eco Logical for upland swamps overlying or proximal to Longwalls 304-310 were undertaken in July/August 2016 for swamps to the east of the Woronora Reservoir, and in July 2017 for swamps to the west of the Woronora Reservoir. The inspections to the east and west of the Woronora Reservoir were conducted approximately 14-15 years post the fire of December 2001 and January 2002 respectively. The field surveys undertaken for this report were also undertaken at least 22 years after the fires in 1986-1987 and 1993-1994 described above.

Much of the upland swamp vegetation mapped as Banksia Thicket in this report likely had more affinity to the Sedgeland-heath Complex vegetation community in the years immediately following the fires in 2001/2002, as mapped by Bangalay Botanical Surveys in 2008. For example, Keith & Myerscough (1993) observed that the boundaries delineating Banksia Thicket may shift after fire, and speculated that fires influence the relative occurrence of upland swamp communities that occur in drier habitats, including Banksia Thicket, Restioid Heath & Sedgeland.

Profiles for each of the upland swamps overlying or proximal to Longwalls 304-310, including the vegetation 'communities' present, their updated boundaries, photos and key characteristics are provided in Attachment A. The revised vegetation community mapping (as a result of the revised boundaries and vegetation community classifications for upland swamps overlying or proximal to Longwalls 304-310) by Eco Logical is shown on Figure 5.

In October 2016 (and subsequent to the field inspections described in this report), Swamps 64, 65/66, 67, 68a and 68b, were subject to WaterNSW hazard reduction burns[1]. As a result, the swamps which comprised 'Banksia Thicket' may now represent 'Sedgeland-heath Complex' vegetation.

[1] It is noted that Swamps 69, 70, 71a and 71b that were previously re-mapped (Eco Logical, 2016) were also subject to the WaterNSW hazard reduction burns.

5.4 Presence of Indicator Species

Counts of *Epacris obtusifolia*, *Pultenaea aristata* and *Sprengelia incarnata* were conducted within each upland swamp. Within upland swamps overlying or proximal to Longwalls 304-310 to the east of the Woronora Reservoir (Swamps 60, 61, 62, 63, 64, 65/66, 67, 68a, 68b, 72, 73, 133 and 134) *Epacris obtusifolia* was widespread and common, while *Pultenaea aristata* and *Sprengelia incarnata* were comparatively infrequent (Table 3).

Within upland swamps overlying or proximal to Longwalls 304-310 to the west of the Woronora Reservoir (Swamps 81, 82, 83, 84, 86, 88 and 89), *Epacris obtusifolia* and *Pultenaea aristata* were widespread, however the individual numbers were low in many instances, whilst *Sprengelia incarnata* was comparatively infrequent (Table 3).

Pultenaea aristata was located in nine upland swamps overlying or proximal to Longwalls 304-310 (namely, Swamps 62, 64, 72, 81, 82, 84, 86, 88 and 89), however was only present in sufficient numbers for potential future monitoring in Swamps 81, 82 and 86 (Table 3).

Sprengelia incarnata, which typically occupies wetter areas with deeper soils within the Banksia Thicket vegetation community was observed within 12 upland swamps overlying or proximal to Longwalls 304-310 (Swamps 60, 62, 64, 65/66, 70, 72, 81, 82, 83, 89, 133 and 134), but was only present in sufficient numbers to allow for monitoring at three of these swamps (Swamps 60, 62 and 134) (Table 3).

Epacris obtusifolia was recorded in 13 upland swamps overlying or proximal to Longwalls 304-310 (Swamps 61, 62, 63, 64, 65/66, 72, 81, 82, 83, 88, 89, 133 and 134) and was present in sufficient numbers for potential future monitoring in all of these swamps, with the exception of Swamps 88 and 89. *Epacris obtusifolia* was also recorded in the marginal upland swamp, Swamp 86, but few were recorded (Table 3).

Ten individuals of *Banksia robur* (a Tea Tree Thicket vegetation community indicator species) were recorded in Swamp 73.

The results of the indicator species field inspections are provided in Table 3.

Table 3: Summary of Indicator Species Field Inspection Results

Swamp	Area (ha)	Number of Individuals Recorded		
		Pultenaea aristata	*Sprengelia incarnata*	*Epacris obtusifolia*
S60	0.520	NR	>20	NR
S61	0.237	NR	NR	>20
S62	0.463	~6	>20	>20
S63	0.170	NR	NR	>20
S64	0.363	15	4	>20
S65/66	0.112	NR	15	>20
S67	0.030	NR	NR	NR
S68a	0.043	NR	NR	NR
S68b	0.034	NR	NR	NR
S72	0.606	8	3	>20
S73	0.182	NR	NR	NR
S81	0.728	>20	11	>20
S82	1.437	>20	4	>20
S83	0.202	NR	15	>20
S84[#]	0.256	<20	NR	NR
S86[#]	0.209	>20	NR	3
S88	0.164	6	NR	11
S89	1.982	18	8	14
S133	0.362	NR	~10	>20
S134	0.891	NR	>20	>20

NR Not recorded.

[#] Swamps 84 and 86, which were mapped as Sedgeland-heath Complex by Bangalay Botanical Surveys (2008), are marginal swamps, comprised of a combination of Banksia Thicket and Sandstone Gully Apple-Peppermint Forest vegetation communities.

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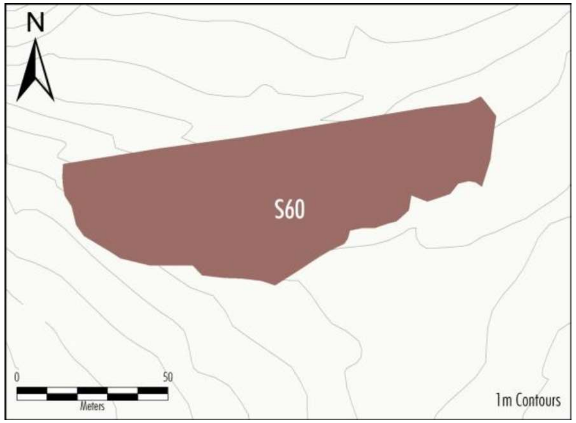
Attachment A - Upland Swamp Vegetation Mapping

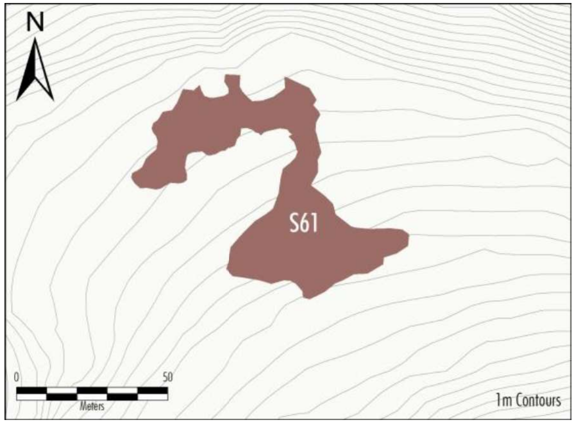
Swamp 60

- Swamp 60 is a valley side swamp.
- Swamp 60 was previously mapped as Sedgeland-heath Complex by Bangalay Botanical Surveys (2008) and field inspections confirmed the presence of this community across the entire revised extent of this swamp.
- Evidence of recent fire disturbance was observed at the time of inspection (July 2016), following hazard reductions burns undertaken in this area during the last three years.
- This swamp is approximately 0.520 ha in area.
- This swamp is generally characterised as having a variable, low and open canopy (*Eucalyptus haemastoma, Corymbia gummifera* and *Leptospermum trinervium*) with a moderately dense, low shrub layer (*Banksia oblongifolia* and *Lambertia formosa*) and dense understorey dominated by sedges (*Leptocarpus tenax, Cyathochaeta diandra, Schoenus brevifolius* and *Schoenus paludosus* with *Patersonia sericea* and *Xanthorrhoea resinosa* also common).
- No terminal step or seepage was observed within this swamp, although soils were saturated at the time of inspection.

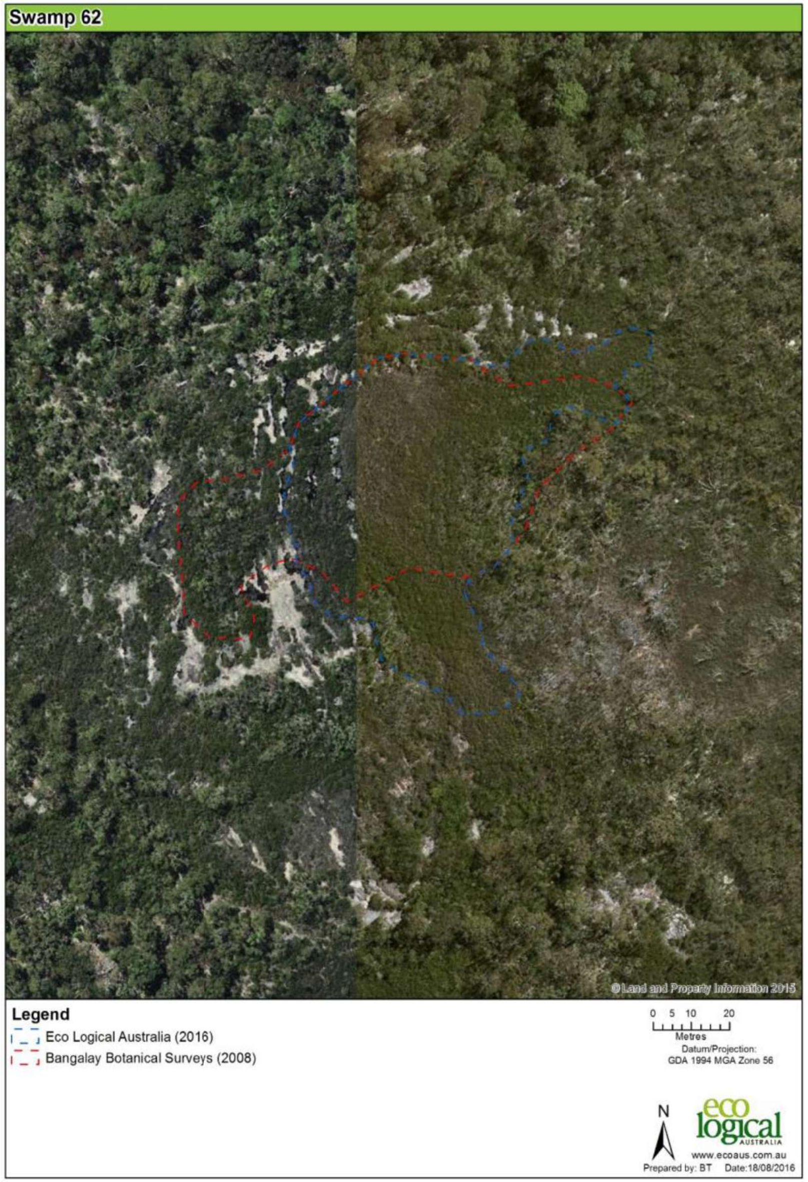


Swamp 61

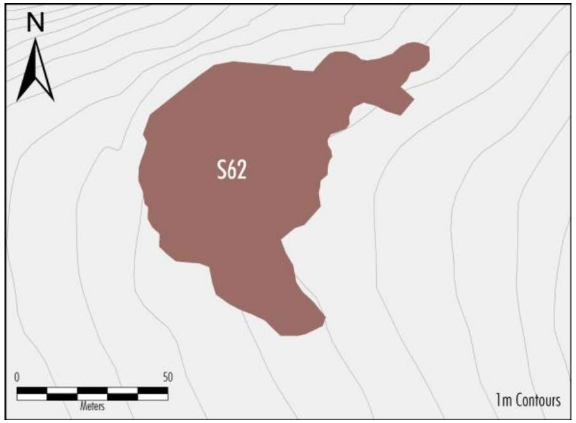
- Swamp 61 is a valley side swamp.
- Swamp 61 was previously mapped as Sedgeland-heath Complex by Bangalay Botanical Surveys (2008) though field inspections confirmed the presence of Banksia Thicket vegetation community across the entire revised extent of this swamp.
- This swamp is approximately 0.237 ha in area.
- This swamp is characterised as having a tall dense shrub layer (*Banksia ericifolia* subsp. *ericifolia* and *Leptospermum squarrosum* up to 4 m in height) over a comparatively sparse understorey dominated by sedges (*Lepidosperma neesii, Leptocarpus tenax, Empodisma minus* and *Schoenus brevifolius*).
- A very small area of outcropping sandstone is present at the lower end of this swamp, although this did not represent a 'terminal step' as Banksia Thicket Vegetation continued downslope of this outcrop.
- No seepage was observed across the small area of outcropping sandstone at the time of inspection (July 2016).



Swamp 62

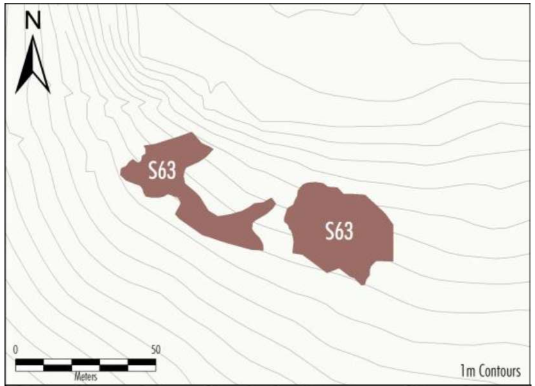


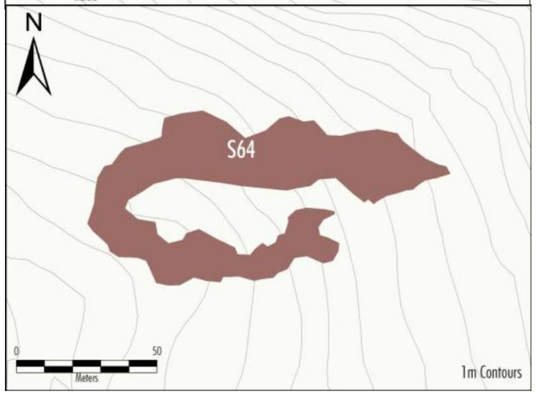
- Swamp 62 is a valley side swamp approximately 0.463 ha in area.
- Swamp 62 was previously mapped as Sedgeland-heath Complex by Bangalay Botanical Surveys (2008) though field inspections confirmed the presence of Banksia Thicket vegetation community across the entire revised extent of this swamp.
- This swamp is characterised as having a dense shrub layer (*Banksia ericifolia subsp. ericifolia, Leptospermum squarrosum* and *Epacris microphylla* up to 2 m in height) over a comparatively sparse understorey dominated by sedges (*Leptocarpus tenax, Chordifex fastigiatus, Lepidosperma filiforme and Schoenus brevifolius*).
- A terminal step of outcropping sandstone was present across the lower end of this swamp, and seepage and standing water was observed across this terminal step.



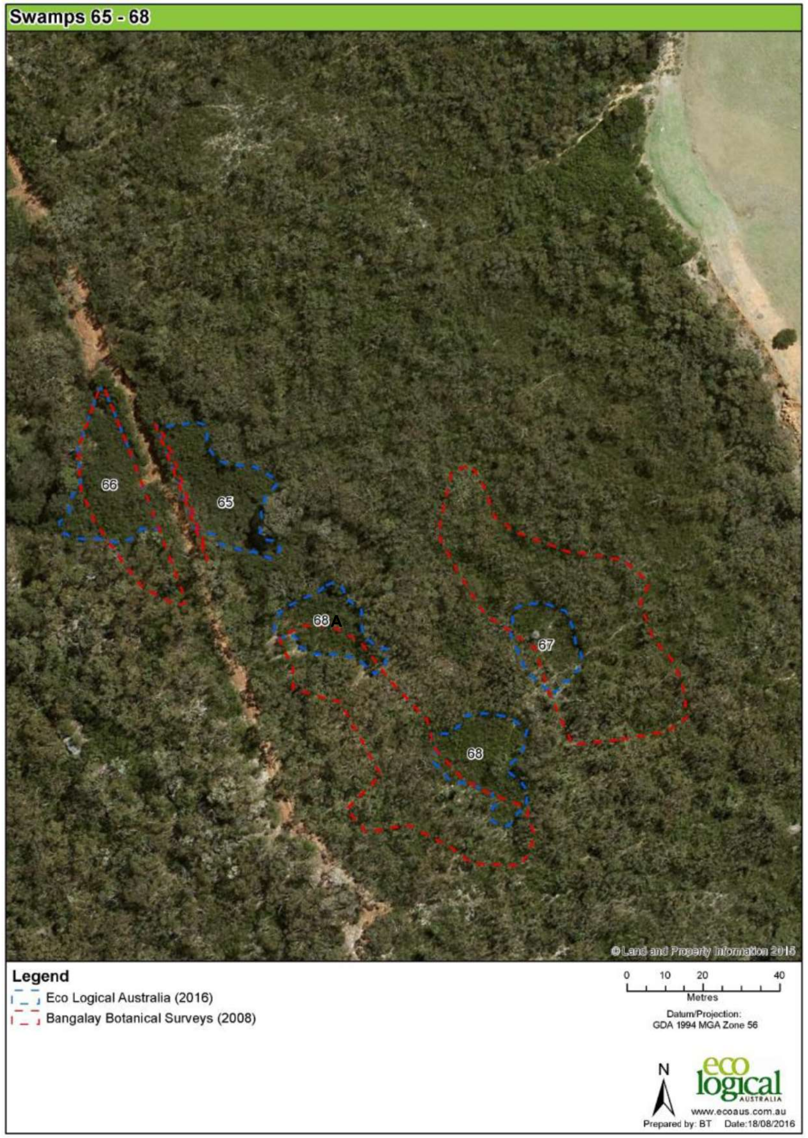
Swamps 63 and 64

- Swamps 63 and 64 are valley side swamps, approximately 0.17 ha and 0.363 ha in area, respectively.
- These swamps were both previously mapped as Sedgeland-heath Complex by Bangalay Botanical Surveys (2008) though field inspections confirmed the presence of Banksia Thicket vegetation community across the entire revised extents of these swamps.
- These swamps are all characterised as supporting tall dense shrub layers dominated by *Banksia ericifolia* subsp. *ericifolia, Leptospermum squarrosum* and *Hakea teretifolia* over a sedge dominated ground layers (*Lepidosperma neesii, Empodisma minus, Lepyrodia scariosa, Cyathochaeta diandra* and *Ptilothrix deusta*).
- No terminal step was observed for either of these two swamps and no seepage was recorded at the time of inspections (July 2016).
- A large trench is present adjacent to Fire Trail 9I which is located to the west of Swamp 64. There appears to have been some alteration to the local hydrology of Swamp 64 caused by this deep trench intercepting water flows.

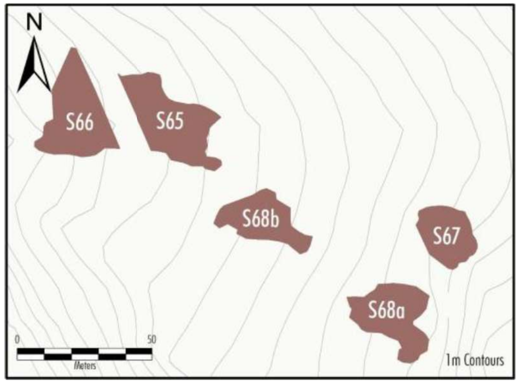




Swamps 65 - 68

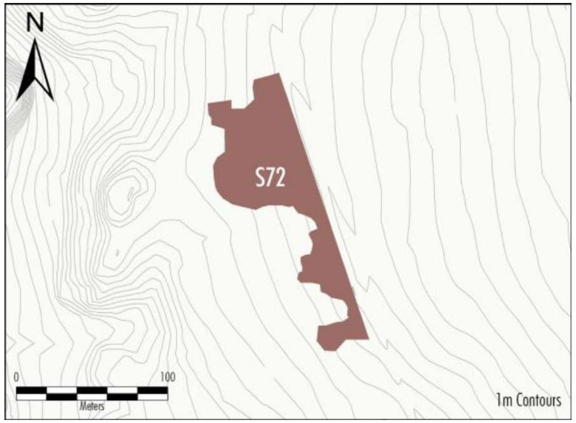


- Swamps 65 to 68 are all valley side swamps, approximately 0.055 ha, 0.057 ha, 0.030 ha and 0.077 ha in area, respectively.
- These swamps were all previously mapped as Sedgeland-heath Complex by Bangalay Botanical Surveys (2008) although field inspections confirmed the presence of Banksia Thicket vegetation community across the entire revised extents of these swamps.
- These swamps are all characterised as supporting tall dense shrub layers dominated by *Banksia ericifolia* subsp. *ericifolia, Leptospermum squarrosum* and *Hakea teretifolia* over a sedge dominated ground layer.
- These swamps form a mosaic with adjacent woodland and heath vegetation types. No terminal steps were observed for any of Swamps 65 to 68.
- Field inspections revised the boundaries of all of these swamps including a much-increased extent of Swamp 65 which was identified as being part of a single swamp with Swamp 66, separated by a cleared track. Additionally, the extents of Swamps 67 and 68 were much reduced with Swamp 68 being identified as two discrete areas of Banksia Thicket vegetation (68a and 68b).



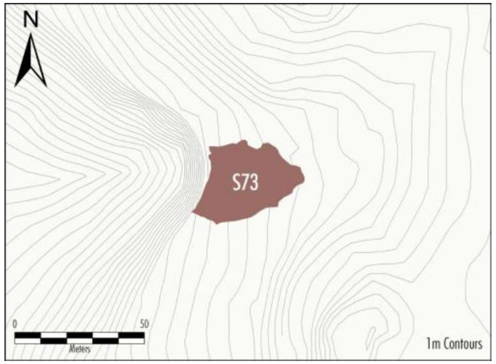
Swamp 72

- Swamp 72 is a valley side swamp approximately 0.606 ha in area.
- This swamp was previously mapped as Sedgeland-heath Complex by Bangalay Botanical Surveys (2008) though field inspections confirmed the presence of Banksia Thicket vegetation community across the entire revised extent of this swamp.
- This swamp is characterised as having a dense shrub layer (*Banksia ericifolia subsp. ericifolia* and *Hakea teretifolia* generally up to 2 m in height) over an understorey dominated by sedges (*Chordifex fastigiatus* and *Lepyrodia scariosa*).
- Extensive areas of sandstone outcropping are present at the downslope limit of this swamp forming a terminal step, with seepage from the swamp observed across this area. The extensive sandstone outcropping supported the 'Rock Pavement Heath' vegetation community.
- Impacted by track creation and water infrastructure along roadside.

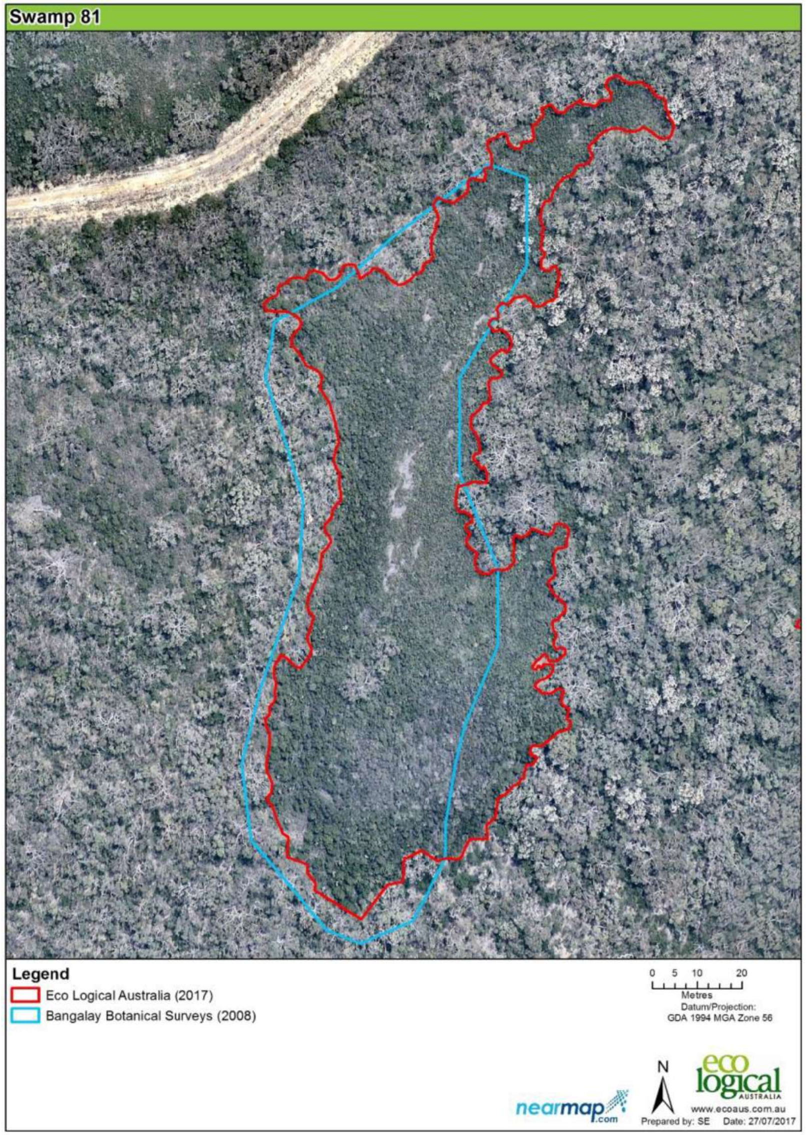


Swamp 73

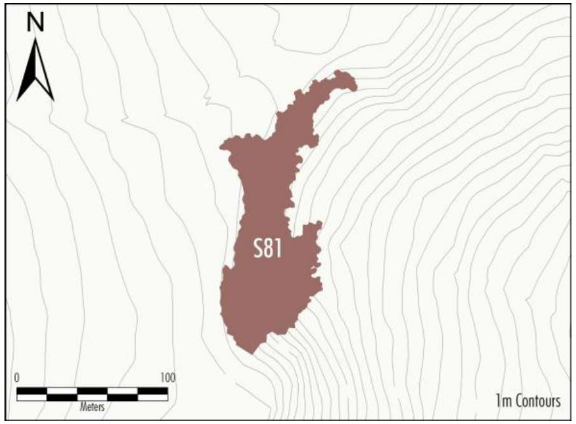
- Swamp 73 is a valley side swamp approximately 0.182 ha in area.
- This swamp was previously mapped as Sedgeland-heath Complex by Bangalay Botanical Surveys (2008) though field inspections confirmed the presence of Banksia Thicket and Tea Tree Thicket vegetation communities within the revised extent of this swamp.
- The northern portion of this swamp occurs in association with a poorly defined drainage line and supports Tea Tree Thicket vegetation with a moderately dense shrub layer (*Banksia robur, Persoonia pinifolia* and *Hakea teretifolia*) over an understorey dominated by the fern *Gleichenia microphylla*. The southern portion of this swamp is located away from the drainage line and supports Banksia Thicket vegetation with a tall dense shrub layer (*Banksia ericifolia* subsp. *ericifolia*, *Leptospermum squarrosum* and *Hakea teretifolia*) over and understorey dominated by sedges.
- A small to moderate cliff line forms the terminal step of this swamp. Abundant seepage was present at the time of inspection, creating a waterfall over the terminal step.



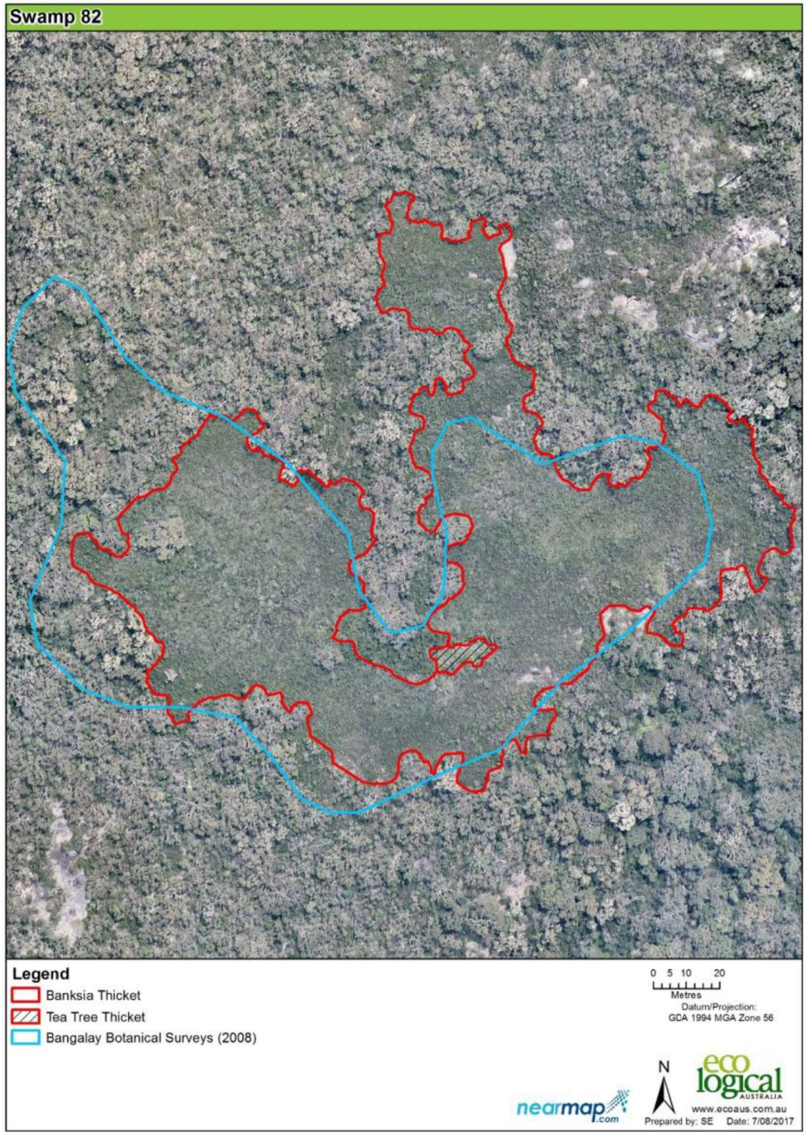
Swamp 81



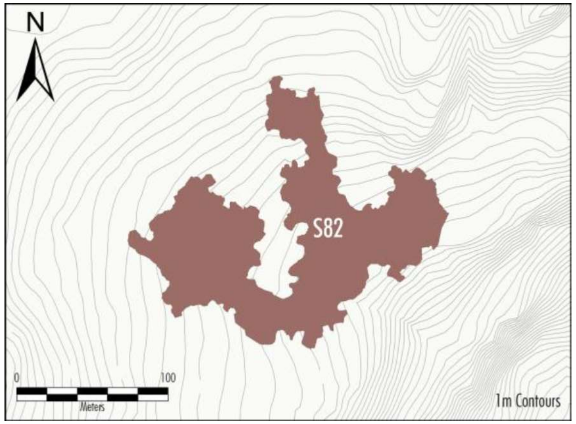
- Swamp 81 is a valley side swamp approximately 0.728 ha in area.
- This swamp was previously mapped as Sedgeland-heath Complex by Bangalay Botanical Surveys (2008) though field inspections confirmed the presence of Banksia Thicket vegetation community across the entire revised extent of this swamp.
- Fire history: burnt 1986-1987 and 1993-1994.
- This swamp is characterised as having a tall dense shrub layer (*Banksia ericifolia* subsp. *ericifolia* and *Leptospermum squarrosum* 2-3 m in height) over an understorey dominated by sedges (*Chordifex fastigiatus, Lepidosperma filiforme* and *L. neesii*).
- No terminal step was observed but an extensive mid-swamp step is present, with abundant seepage present.



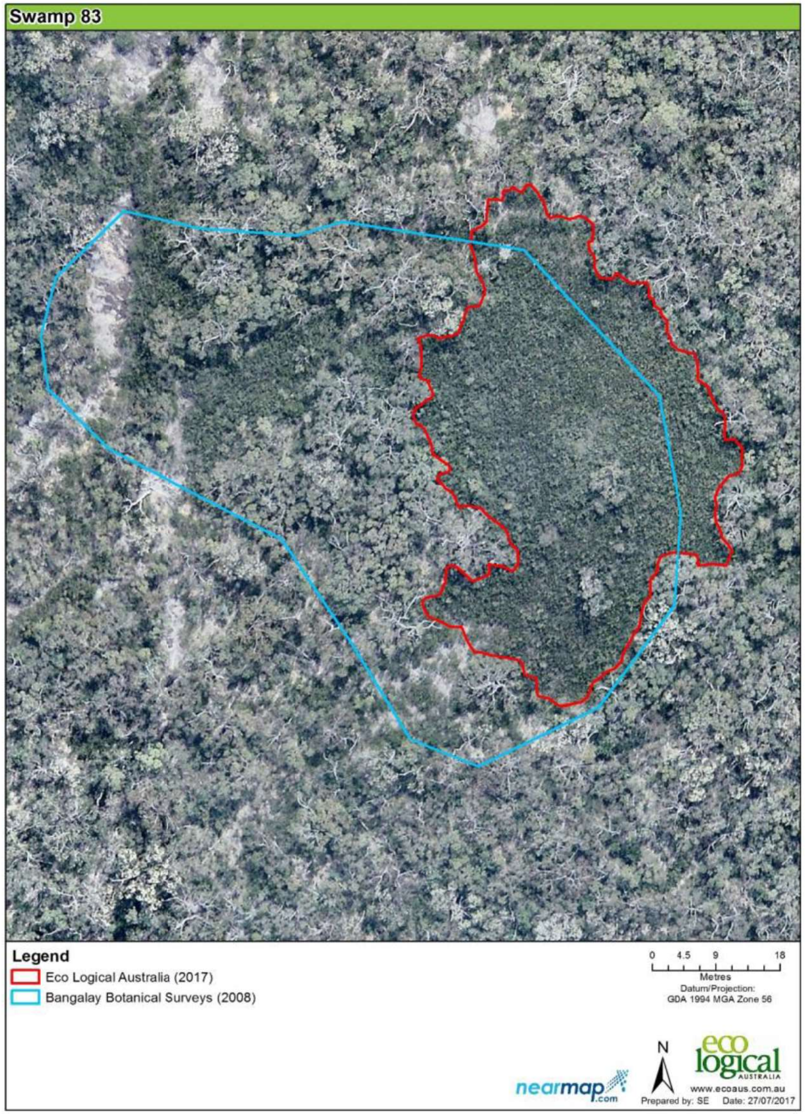
Swamp 82



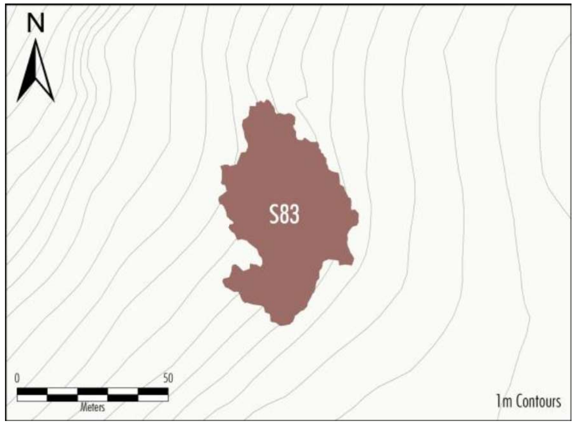
- Swamp 82 is a valley side swamp approximately 1.437 ha in area.
- This swamp was previously mapped as Sedgeland-heath Complex by Bangalay Botanical Surveys (2008) though field inspections confirmed the presence of Banksia Thicket vegetation community across the entire revised extent of this swamp.
- Some vegetation characteristic of Tea Tree Thicket was found embedded within a very small area of this swamp, overlying the drainage line upslope of the terminal step.
- Fire history: burnt 1986-1987 and 1993-1994.
- This swamp is characterised as having a tall dense shrub layer (*Banksia ericifolia* subsp. *ericifolia, Hakea teretifolia* and *Leptospermum squarrosum* up to 5 m in height) over a comparatively sparse understorey dominated by sedges (*Chordifex fastigiatus, Lepidosperma neesii, L filiforme, Empodisma minus* and *Schoenus brevifolius*).
- An intermittent area of outcropping sandstone/terminal step is present at the lower end of this swamp, below which a woodland community was present.
- A drainage line is present within the swamp, which flows out across part of the terminal step.



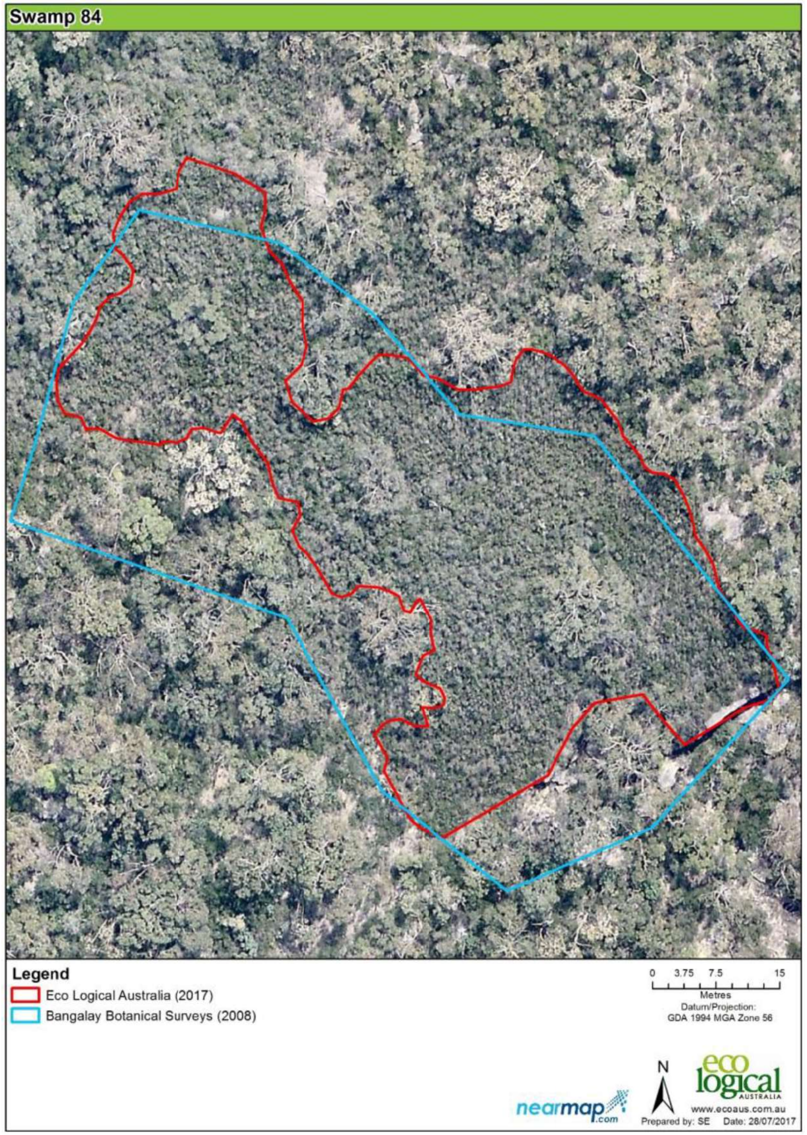
Swamp 83



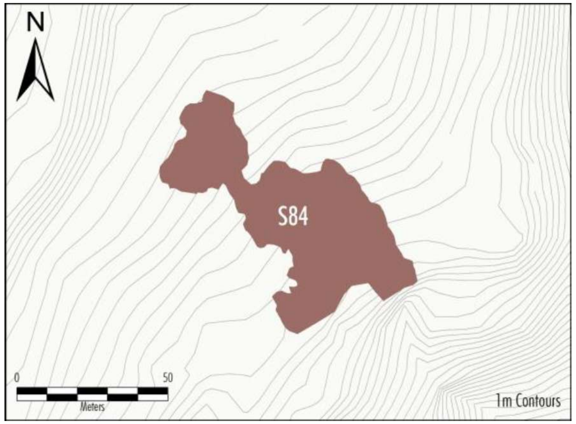
- Swamp 83 is a valley side swamp 0.202 ha in area.
- This swamp was previously mapped as Sedgeland-heath Complex by Bangalay Botanical Surveys (2008) though field inspections confirmed the presence of Banksia Thicket vegetation community across the entire revised extent of this swamp.
- Fire history: burnt 1986-1987.
- This swamp is characterised as having a dense shrub layer (Banksia ericifolia subsp. ericifolia*, Leptospermum squarrosum, Baeckea imbricata* and scattered *Hakea teretifolia* up to 2.5 m in height) over a sparse understorey dominated by sedges (*Chordifex fastigiatus, Lepidosperma neesii and Schoenus brevifolius*). *Bauera microphylla* is also common. Some woodland species are present including *Eucalyptus* sp., *Leptospermum trinervium* and *Allocasuarina distyla*
- No terminal step of outcropping sandstone was observed, however outcropping sandstone was present within the swamp.



Swamp 84



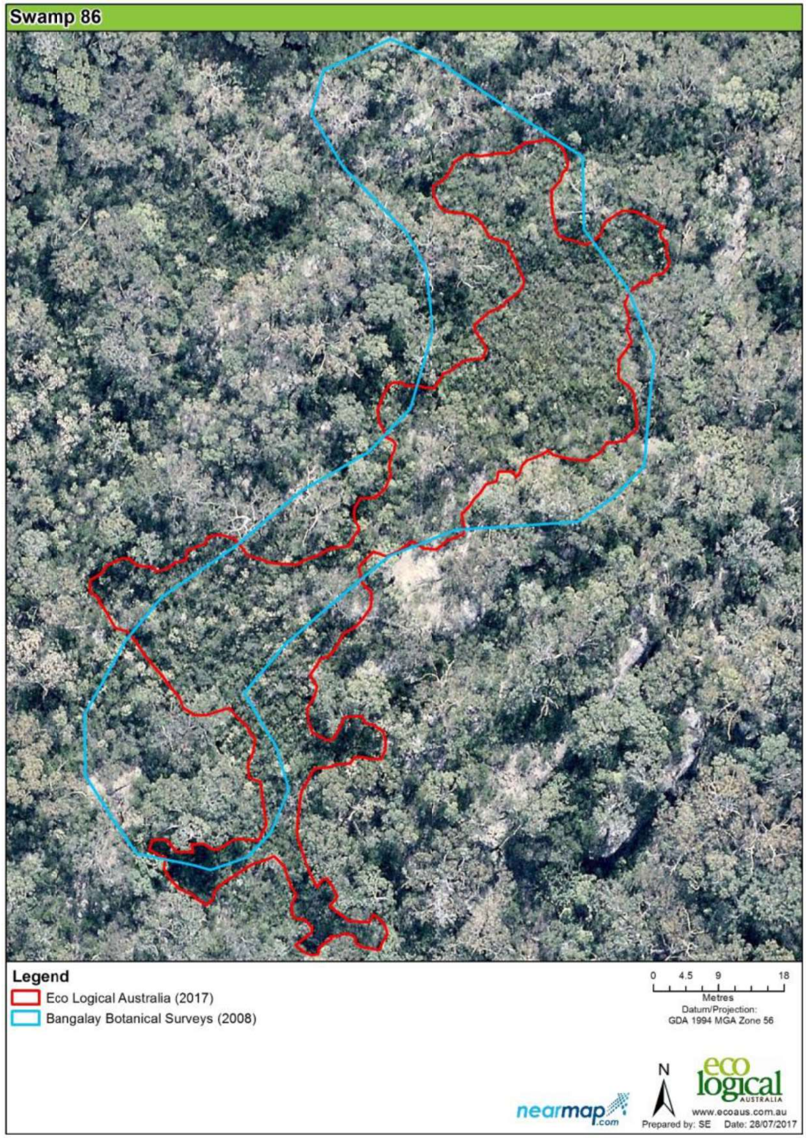
- Swamp 84 is a valley side swamp 0.256 ha in area.
- This swamp was previously mapped as Sedgeland-heath Complex by Bangalay Botanical Surveys (2008); though field inspections confirmed the presence of Banksia Thicket vegetation community across the entire revised extent of this swamp. The boundaries of this swamp are not well defined and woodland species are interspersed within this community.
- Fire history: unknown, greater than 30 years.
- This swamp is characterised by canopy species of *Angophora costata*, *Eucalyptus piperita*, *Corymbia gummifera* and *E. luehmanniana*, and shrub species including *Allocasuarina distyla*, *Persoonia pinifolia*, *Isopogon anethifolius*, *Grevillea diffusa*, *G. sphacelata* and *Boronia ledifolia*.
- Sandstone outcrops are present and a drainage line is located downslope of this area.



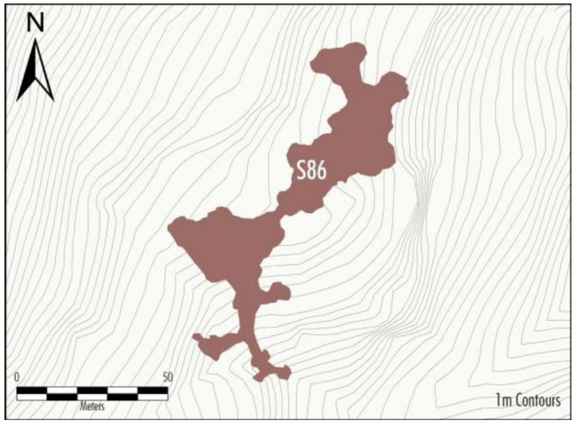
Swamp 85

- Swamp 85 mapped by Bangalay Botanical Surveys (2008) is located on a steep south-east facing slope.
- This swamp was previously mapped as Sedgeland-heath Complex by Bangalay Botanical Surveys (2008) however from aerial photography and field inspection it is considered that this area is more akin to Sandstone Gully Apple-Peppermint Forest as described by Bangalay Botanical Surveys (2008).
- Fire history: unknown, greater than 30 years.
- Area: not mapped.
- The vegetation is characterised by a canopy dominated by Angophora costata, with an understorey comprising the shrubs *Banksia ericifolia* subsp. *ericifolia*, *B. marginata*, *B. serrata*, *Woollsia pungens*, *Grevillea diffusa* and *Persoonia pinifolia*, and a ground layer of sedges and grasses including *Lepyrodia scariosa* and *Entolasia stricta*.
- Swamp boundaries have not been mapped in this instance as it is not a swamp. Rather, the vegetation is comprised of Sandstone Gully Apple-Peppermint Forest.

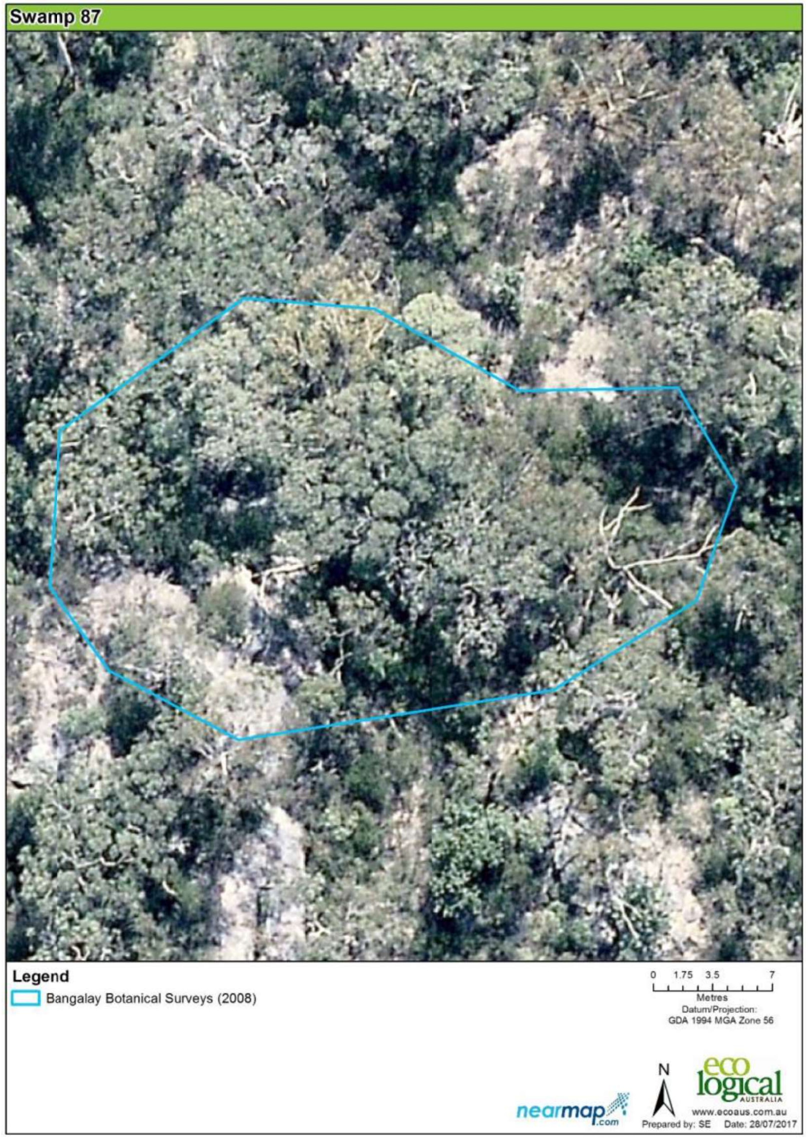
Swamp 86



- Swamp 86 is a valley side swamp 0.209 ha in area.
- This swamp was previously mapped as Sedgeland-heath Complex by Bangalay Botanical Surveys (2008) though field inspections confirmed the presence of Banksia Thicket vegetation community across the entire revised extent of this swamp. The boundaries of this swamp are not well defined and woodland species of the Apple-Peppermint Gully Forest are interspersed within this community.
- Fire history: unknown, greater than 30 years.
- This swamp is characterised by the presence of scattered canopy trees of *Angophora costata* and *Eucalyptus piperita* over a dense shrub layer of *Banksia ericifolia* subsp. *ericifolia*, *Leptospermum squarrosum* and *Hakea teretifolia* up to 5 m in height. Other shrub species include *Banksia serrata, Logania albiflora, Hakea dactyloides* and *Leptospermum trinervium.* The understorey is dominated by smaller shrubs and sedges (*Hibbertia riparia* and *Lepyrodia scariosa, Lepidosperma filiforme* and *L. neesii*).
- No terminal step was observed.

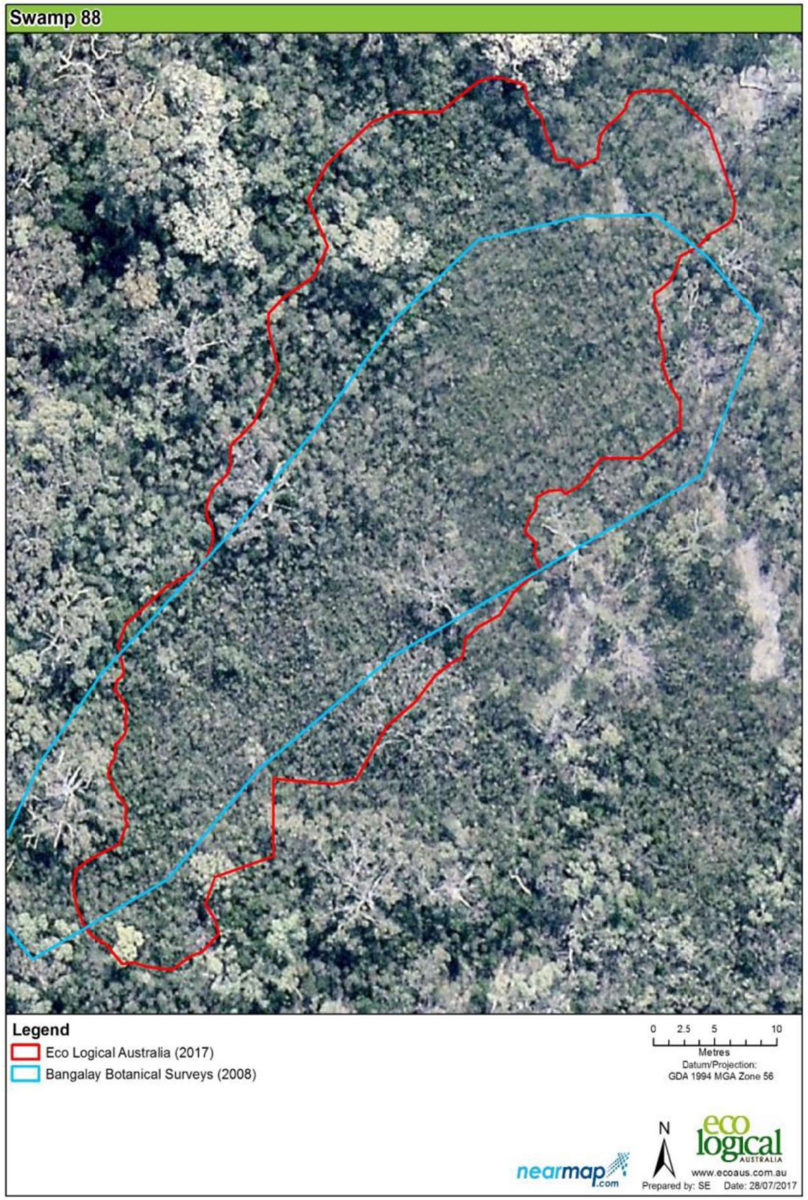


Swamp 87

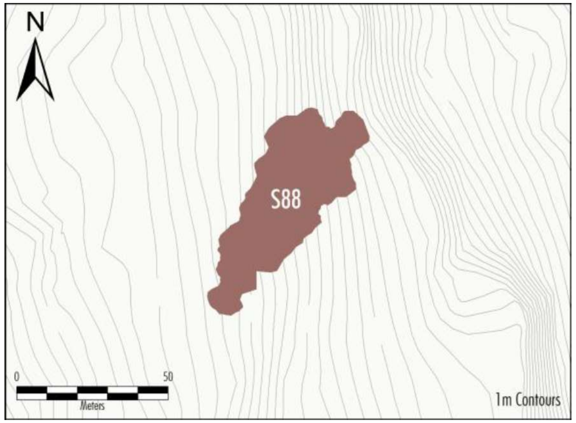


- This swamp was previously mapped as Sedgeland-heath Complex by Bangalay Botanical Surveys (2008) though aerial photography and field inspections confirmed that this swamp is a good example of the Sandstone Gully Apple-Peppermint Forest located in a valley containing a drainage line.
- Fire history: unknown, greater than 30 years.
- Area: not mapped
- The vegetation is characterised by a canopy dominated by *Angophora costata* and *Eucalyptus piperita* over a shrub layer dominated by *Banksia ericifolia* subsp. *ericifolia, Doryanthes excelsa, Ceratopetalum gummiferum* and *Banksia serrata.*
- A terminal step was not observed.
- Swamp boundaries have not been mapped in this instance as it is not a swamp. Rather, the vegetation is comprised of Sandstone Gully Apple-Peppermint Forest.

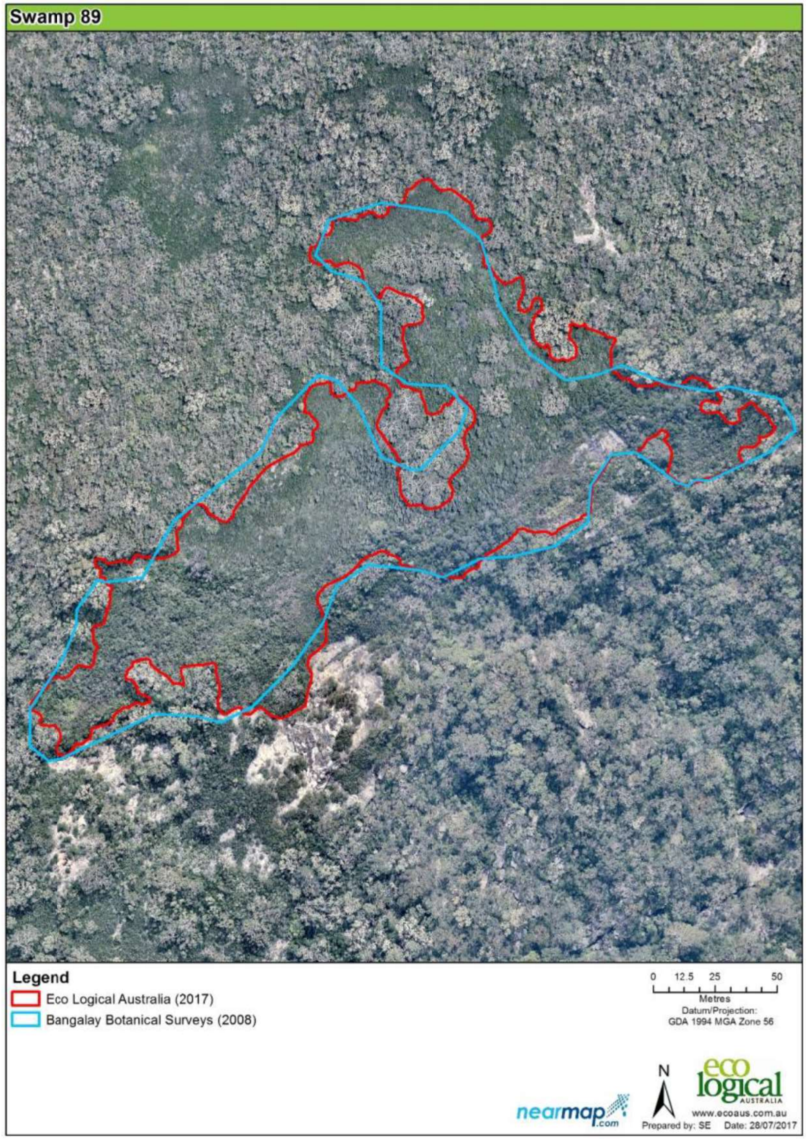
Swamp 88



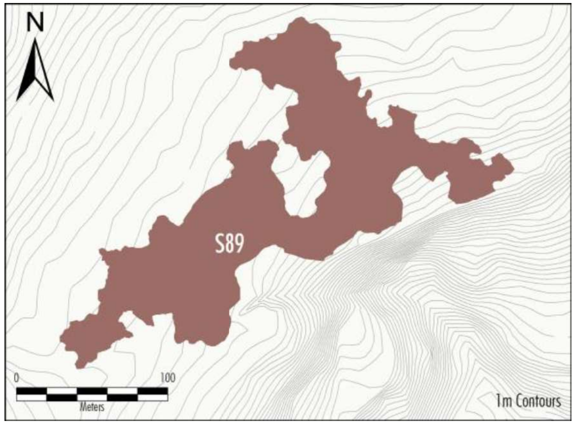
- Swamp 88 is a valley side swamp 0.164 ha in area.
- This swamp was previously mapped as Sedgeland-heath Complex by Bangalay Botanical Surveys (2008) though field inspections confirmed the presence of Banksia Thicket vegetation community across the entire revised extent of this swamp.
- Fire history: burnt 1993-1994.
- This swamp is characterised as having a tall dense shrub layer of *Banksia ericifolia* subsp. *ericifolia, Leptospermum squarrosum* and scattered *Hakea teretifolia* up to 4.5 m in height over a comparatively dense understorey dominated by sedges (*Empodisma minus, Chordifex dimorphus* and *Leptocarpus tenax*).
- A low sandstone step is present midway through the swamp.



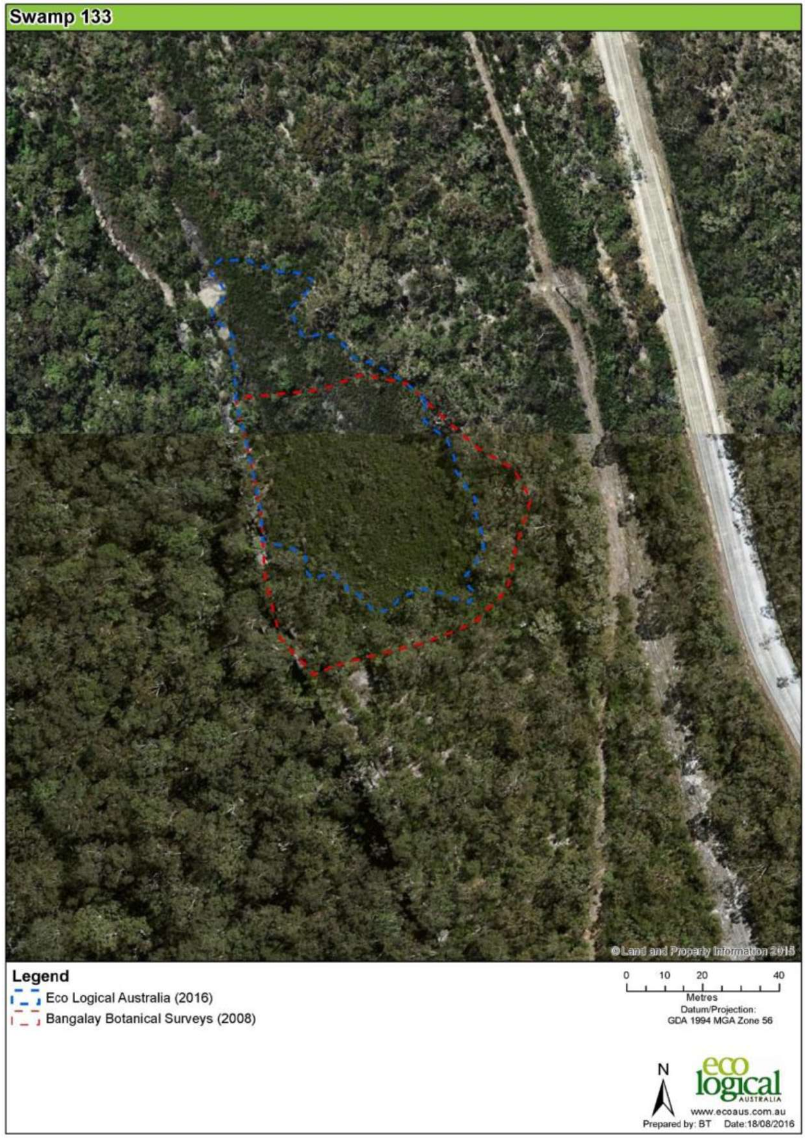
Swamp 89



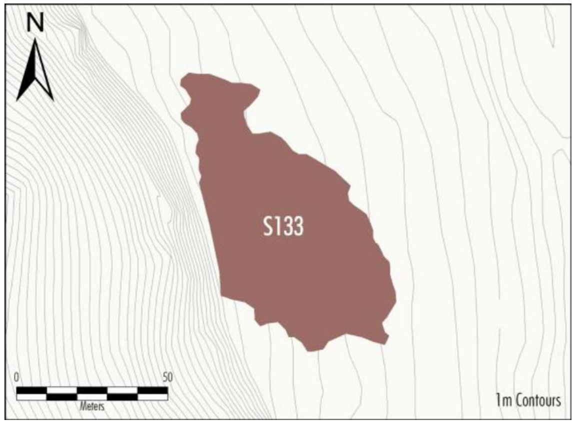
- Swamp 89 is a valley side swamp 1.983 ha in area.
- This swamp was previously mapped as Sedgeland-heath Complex by Bangalay Botanical Surveys (2008) though field inspections confirmed the presence of Banksia Thicket vegetation community across the entire revised extent of this swamp.
- Fire history: burnt 1993-1994.
- This swamp is characterised as having a tall dense shrub layer (*Banksia ericifolia* subsp. *ericifolia, Leptospermum squarrosum* and *Hakea teretifolia* up to 5 m in height) over an understorey dominated by sedges (*Lepidosperma neesii, Empodisma minus* and *Cyathochaeta diandra*). *Bauera microphylla* is also common. Emergent trees are present in low densities and include *Eucalyptus racemosa* and *Corymbia gummifera.*
- An extensive area of sandstone outcropping is present along the south-eastern edge of this swamp where seepage and water flow exiting from the swamp was observed.



Swamp 133

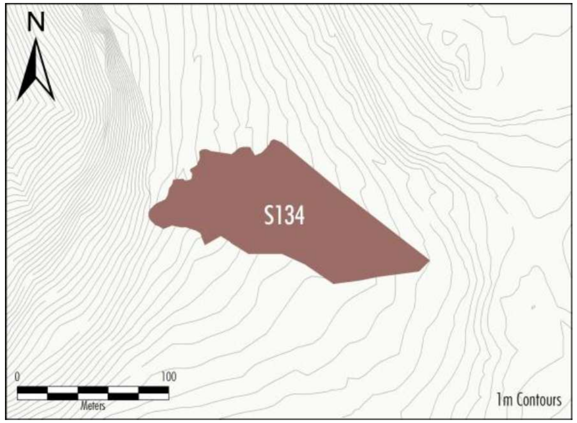


- Swamp 133 is a valley side swamp 0.362 ha in area.
- This swamp was previously mapped as Sedgeland-heath Complex by Bangalay Botanical Surveys (2008) though field inspections confirmed the presence of Banksia Thicket vegetation community across the entire revised extent of this swamp.
- This swamp is characterised as having a tall dense shrub layer (*Banksia ericifolia* subsp. *ericifolia, Hakea teretifolia* and *Leptospermum squarrosum* up to 4 m in height) over a comparatively sparse understorey dominated by sedges (*Lepyrodia scariosa* and *Leptocarpus tenax*). Emergent trees are present in low densities across this swamp including *Eucalyptus racemosa* with *Angophora costata* and *Eucalyptus piperita* occurring on the downslope margin of the swamp.
- A low sandstone cliff line represents the terminal step of this swamp, with seepage commonly observed across the terminal step.



Swamp 134

- Swamp 134 is a valley side 0.891 ha in area.
- This swamp was previously mapped as a combination of Sedgeland-heath Complex and Banksia Thicket by Bangalay Botanical Surveys (2008) though field inspections identified that Banksia Thicket vegetation occurred across the entire revised extent of this swamp.
- This swamp is characterised as having a tall dense shrub layer (*Banksia ericifolia subsp. ericifolia, Hakea teretifolia* and *Leptospermum juniperinum* up to 5 m in height) over an understorey dominated by sedges (*Empodisma minus*, *Lepyrodia scariosa* and *Leptocarpus tenax*). Emergent trees are present in low densities across the swamp including *Eucalyptus racemosa, Angophora costata* and *Eucalyptus piperita*.
- A terminal step comprising a small area of sandstone outcropping is present within this swamp, and seepage was not observed over the step at the time of inspection. The remains of an old vehicular track (which extends across the western edge of this swamp) and an associated table drain are present appearing to have diverted surface flows away from the terminal step.



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APPENDIX 3

VISUAL INSPECTION AND PHOTOGRAPHIC SURVEY OF STREAMS IN THE VICINITY OF LONGWALLS 304-310

Available in Electronic Version

HYDRO ENGINEERING
& CONSULTING PTY LTD

3 July 2024

Visual Inspection and Photographic Survey of Streams in the Vicinity of Longwalls 304 to 310

1.0 INTRODUCTION

A visual inspection and photographic survey of streams in the vicinity of Longwalls 304-310 was conducted by Hydro Engineering and Consulting Pty Ltd (HEC) in April 2018 to characterise and document the baseline conditions and prominent features in surface water streams overlying or in the vicinity of Longwalls 304-310 and, on the basis of the field inspections, consider surface water flow, pool water level or surface water quality monitoring.

HEC undertook a similar inspection and photographic survey of streams in the 301 to 303 area in July 2015 during preparation of the Longwalls 301-303 Water Management Plan. This exercise for Longwalls 304-310 expands on the previous HEC (2016)[1] stream survey.

2.0 DESKTOP REVIEW

An east-west divide runs approximately north to south to the east of the Longwalls 304-310 study area, dividing drainages which flow into the Eastern Tributary and the Woronora Reservoir (on the western side) from areas which flow into Wilsons Creek and Cawleys Creek (on the eastern side) (Figure 1).

One metre contours were used to refine the mapping available from the Department of Lands in the vicinity of Longwalls 304-310. The one metre contour mapping generated by Geo-Spectrum (Australia) Pty Ltd[2] was the most detailed mapping available and provided greater accuracy in terms of stream location, alignment and stream network for the field survey. Sixteen streams overlying or in close proximity to Longwalls 304-310 were identified using the one metre contours, as shown on Figure 1 (streams A, B, C, D, E, F, H, I, J, K, L, P, Q, R, S-East and T).

[1] Hydro Engineering & Consulting (2016). *Visual Inspection and Photographic Survey of Streams in the Vicinity of Longwalls 301 to 303*.

[2] Geo-Spectrum (Australia) Pty Limited (2007). *Orthophotomap (1:7,500) of Helensburgh Coal Metropolitan Colliery*. October 2007 from 1:20,000 Scale. Aerial photography from 27 August 2007. Ground survey by Monaghan Surveyors Pty Ltd.

The locations of stream lines shown in this report (Figure 1) have been adjusted from the locations shown in HEC (2016) so as to be more closely aligned to the valley floor and to reflect the actual stream bed alignment as observed during the reconnaissance surveys. The differences reflect the limitations of mapping produced from aerial photography of densely forested canopy and the difficulties of identifying the location of small first order streams in the underlying complex sandstone morphology.

The main streams that were inspected are shown as solid blue lines in Figure 1. Where tributaries to the streams have been observed, their alignments have been interpreted based on the 1 metre contours and are shown as dashed blue lines on Figure 1.

Streams A, B, C, H, I, J, K and L were considered and inspected as part of HEC's 2015 survey (Table 1).

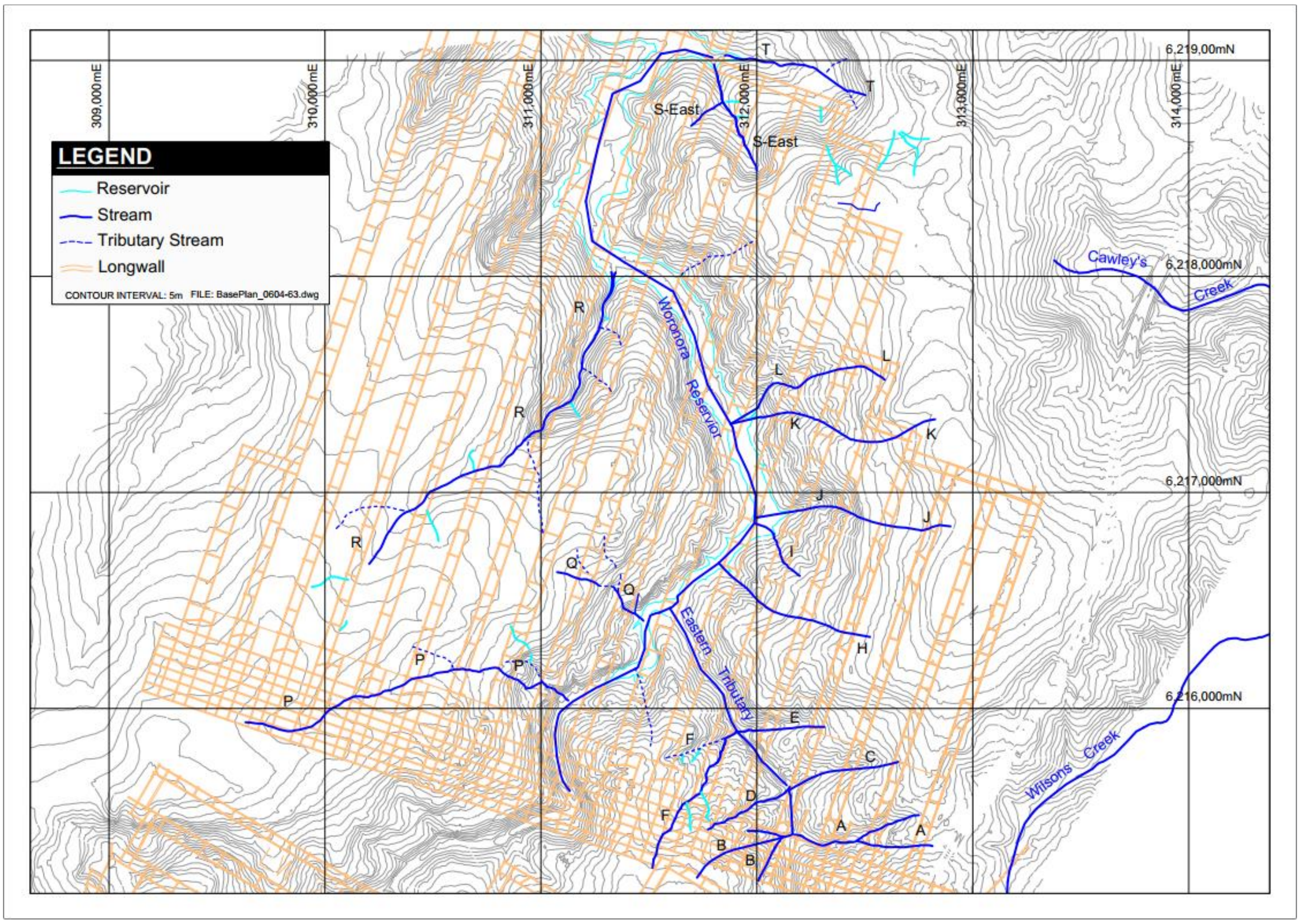


Figure 1 Streams Overlying or Near to Proposed Longwalls 304 to 310[3]

3 Streams J and L shown in Figure 1 were referred to as Streams I and K, respectively, in an earlier draft of the Longwalls 301-303 reconnaissance report. Streamflow monitoring stations have been installed on these streams as a component of the Woronora Reservoir Impact Strategy.

Details of the streams overlying or near to Longwalls 304-310 are summarised in Table 1 below.

Table 1 Stream Reconnaissance Summary

Stream Label	Stream Order*	Comments
A	2	Previously inspected (HEC, 2016)
B	2	Previously inspected (HEC, 2016)
C	1	Previously inspected (HEC, 2016)
D	1	Inspected April 2018
E	1	Previously inspected (HEC, 2016)
F	2	Inspected April 2018
H	1	Previously inspected (HEC, 2016)
I	1	Previously inspected (HEC, 2016)
J	1	Previously inspected (HEC, 2016)
K	1	Previously inspected (HEC, 2016)
L	1	Previously inspected (HEC, 2016)
P	2	Inspected April 2018
Q	2	Inspected April 2018
R	2	Inspected April 2018
S-East	2	Inspected April 2018
T	2	Inspected April 2018

2.0 FIELD CONDITIONS

The stream reconnaissance was conducted between the 9th and 13th of April 2018. The weather was fine during the course of the reconnaissance. The period leading up to the reconnaissance had relatively low rainfall (refer Figure 2). January and early February experienced unusually low rainfall with only minor falls being recorded through to late February. Two moderate rainfall events on the 20th and 26th of February (44 and 47.5 mm respectively) were recorded at Metropolitan Coal's pluviometer PV7. Following these events there was no significant rainfall recorded until the 21st of March when a total of 96.5 mm was recorded between the 21st and 23rd of March. There was no significant rainfall recorded between the 23rd of March and the reconnaissance survey – indicated by the red lines on Figure 2. Flow in the surface catchments would therefore have been in recession from the 21st to the 23rd March rainfall event.

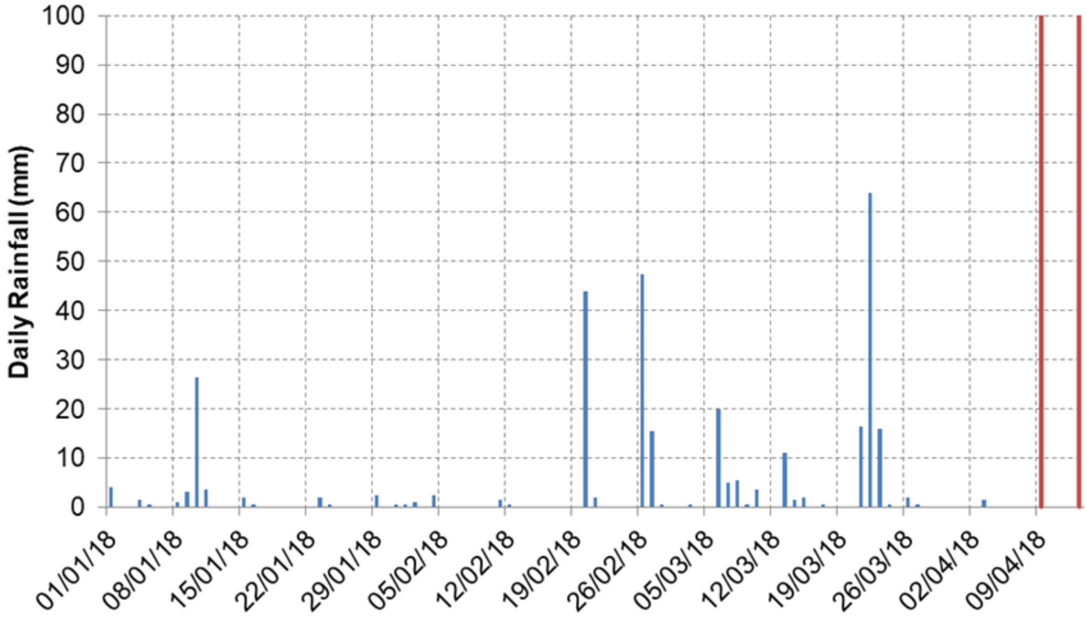


Figure 2 Rainfall Recorded at PV7 January to April 2018

Groundwater-fed baseflow in streams responds to dominant wetting (aquifer recharging) and drying (aquifer discharging) cycles. These cycles are typically evident in rainfall residual plots which can be correlated to periods when aquifers are predominantly recharging when groundwater levels are rising; and periods when aquifers are discharging and groundwater levels are declining. Figure 3 shows the rainfall residual for the period 1st January 2000 to 31st April 2018 derived from the rainfall record from the Bureau of Meteorology rain gauge at Darkes Forest – Station 68024. Periods where the residual rainfall curve is trending upward correspond to above average rainfall. Periods where the residual rainfall line decreases (slopes downward) reflect below average rainfall. The reconnaissance, shown by the vertical red line, was conducted during a pronounced drying period. The steep downward trend in the rainfall from mid-2017 indicates drying catchment conditions with declining groundwater outflows to streams (compared to the average) in the lead-up to the survey. The rainfall residual over this period is sloping unusually steeply downward for a prolonged period indicating likely low groundwater outflows to streams from groundwater sources.

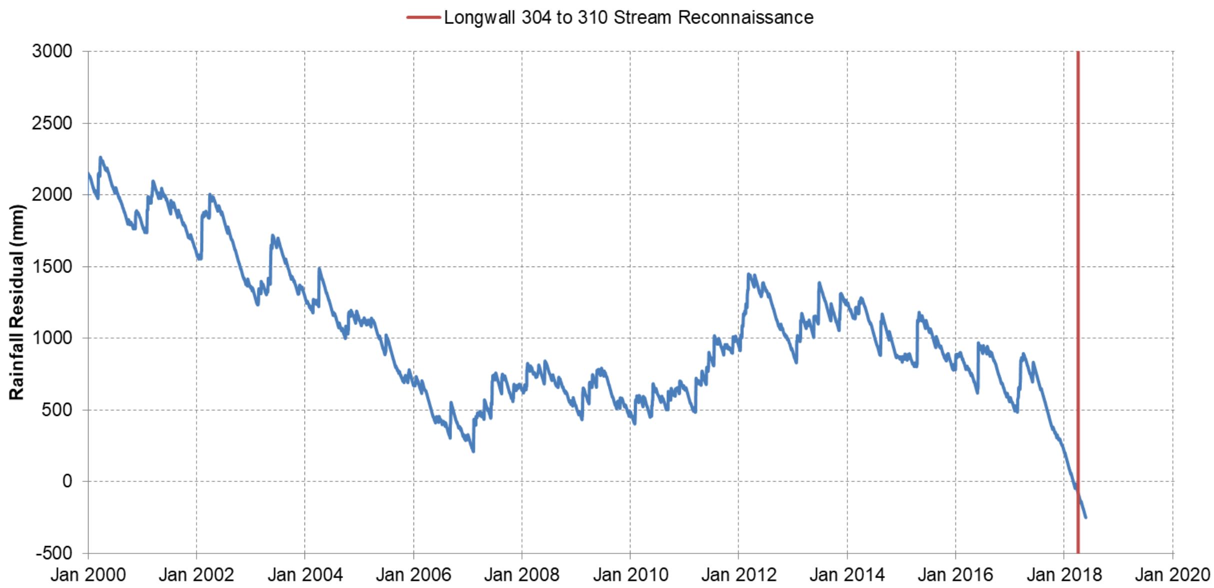


Figure 3 Darkes Forest Rainfall Residual Plot, January 2000 to May 2018

The water level in the Woronora Reservoir was about 5.4 m below the full supply level during the survey.

3.0 METHODOLOGY

Reconnaissance of the streams involved walking along the accessible length of the streams, mapping the geomorphic characteristics and features of the streams and compiling a photographic record. The observed features and mapping of each stream are shown and described in Section 4 and photographs of the features are provided in Attachment A.

Stream features have been mapped using the following alphabetic symbols:

(US) Upland swamp

(WF) Waterfall of at least 2 m near vertical drop.

(BC) Boulder cascade comprising a steep chute of boulders. Water would be highly aerated by rapid flow over and through spaces between the boulders.

(BF) Boulder field comprising an extended section of boulders with low flows passing through the interstices between the boulders and which acts to control upstream water level

(RS) Rock shelf comprising a hard and relatively smooth rock outcrop often containing shallow depression(s).

(RC) Rock cascade a steep chute of predominately cobbles and gravel sized bed sediment.

(P_s) Small pool between 1 m and 3 m long and less than 0.3 m deep. These features would likely be transient but persist for some time following cessation of flow.

(P_m) Medium sized pool larger than a small pool and typically 3 m to 5 m long and around 0.5 m deep. The largest pool observed was estimated to be less than 5 m long and less than 1 m deep at its deepest. These pools would be expected to retain ponded water under most climatic conditions.

(P_l) Large pool longer than 5 m and greater than 0.5m deep.

4.0 RESULTS OF STREAM RECONNAISSANCE

4.1 Stream D

Stream D comprised a small first order stream which drained into Eastern Tributary (Figure 4) adjacent to the flow monitoring flume at Pool ETAU.

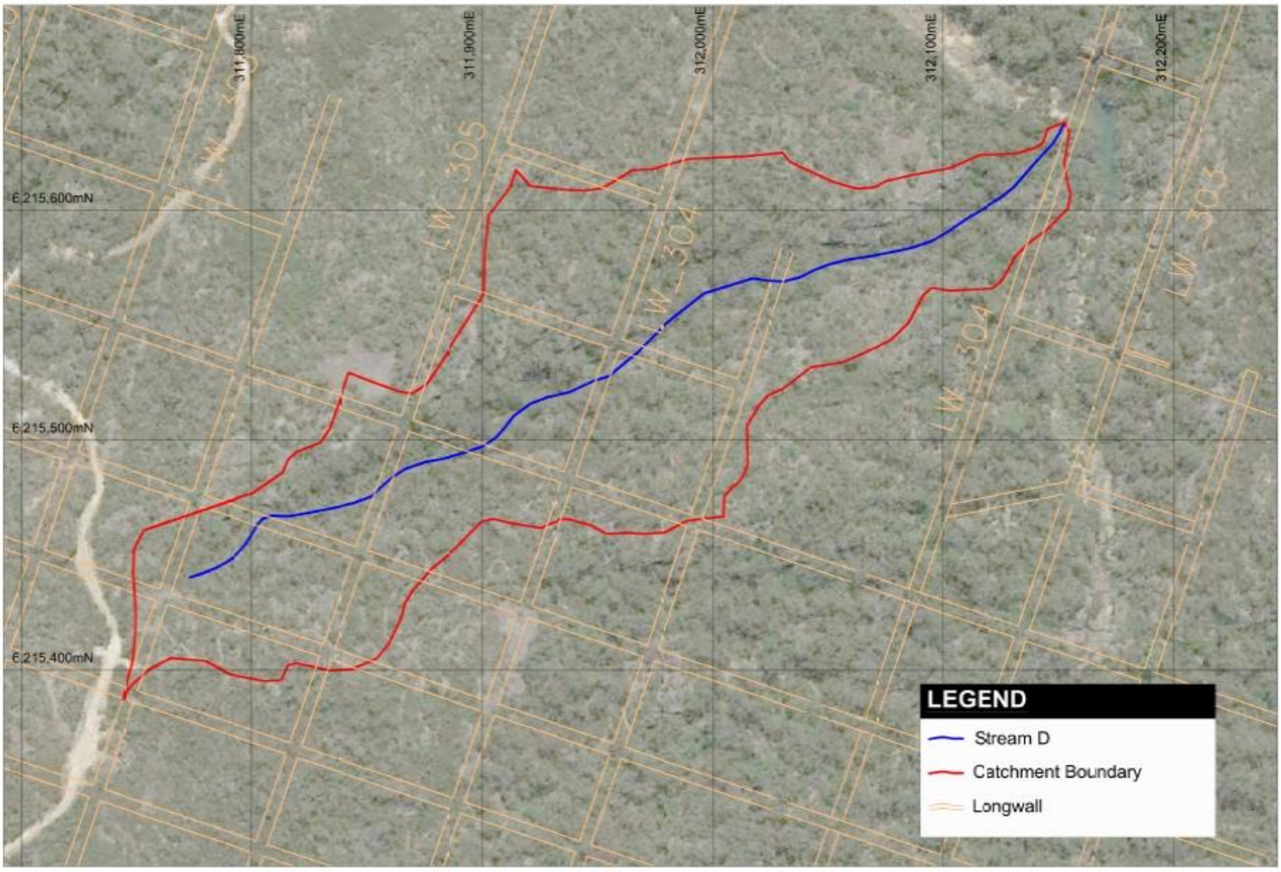


Figure 4 Stream D Catchment

There was no flow or significant water observed within the stream at the time of the reconnaissance. The upper sections comprised small localized and discontinuous drainage lines and depressions. The middle and lower sections of the stream comprised a steep incised channel with boulder cascades interspaced with rock shelves and shallow depressions – refer Figure 5. A summary of the catchment characteristics is provided in Table 2 below.

Table 2 Catchment Characteristics Stream D

Feature	Value
Stream order	1st
Catchment area (km^2)	0.04
Stream length (km)	0.45
Average gradient (%)	13.5

The observed features in Stream D are shown on Figure 5.

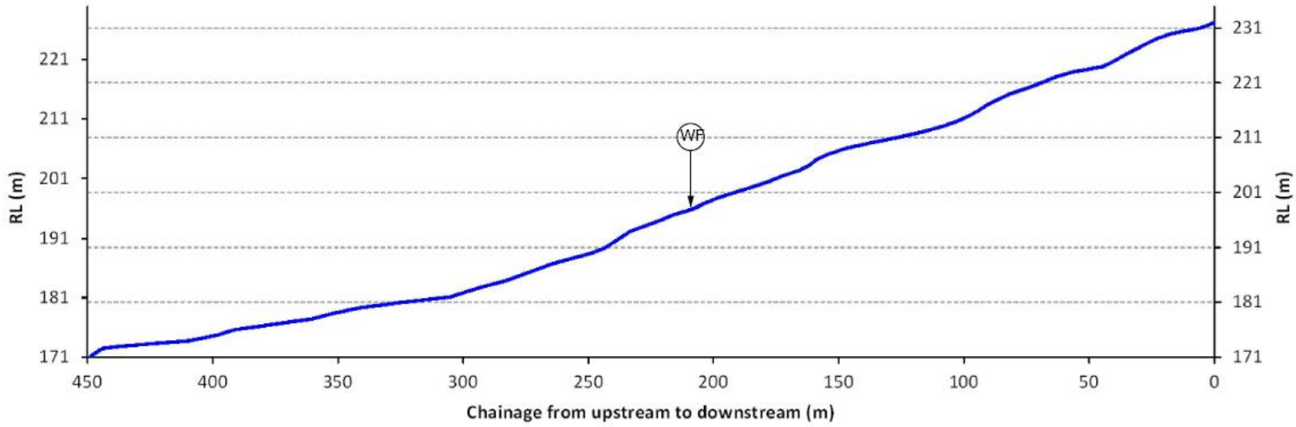


Figure 5 Features in Stream D

4.2 Stream F

Stream F is a longer stream which is joined by a one shorter stream near the inflow to the reservoir. The upper sections on the longer stream comprised a densely vegetated upland swamp – refer Figure 6 and 7. The only surface drainage features observed with in the swamp comprised discontinuous depressions in the topographic "low" points of the swamp. The swamp terminated at an extensive rock bar. There was a trickle of water overflow on one section of the rock bar. Moss and stain markings on the rock bar however suggested that larger overflows would have occurred frequently in the past.

The reach downstream of the swamp comprised a series of rock cascades, small waterfalls, instream pools, rock shelves and sections of straight incised channel. Small semi-continuous flow was observed along the downstream reach. The instream pools became larger and more dominant in the lower sections of the stream.

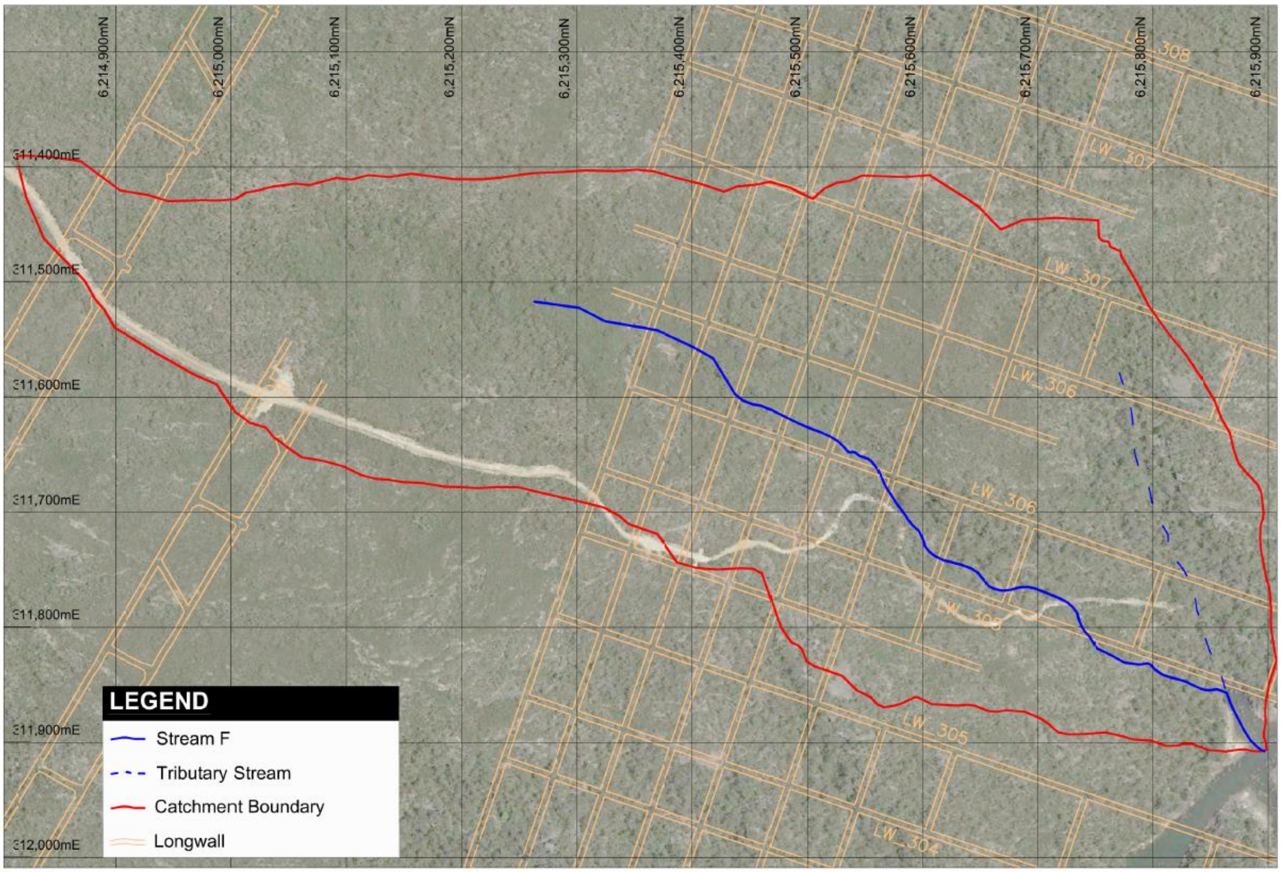


Figure 6 Stream F Catchment

The observed features in Stream F are shown in Figure 7.

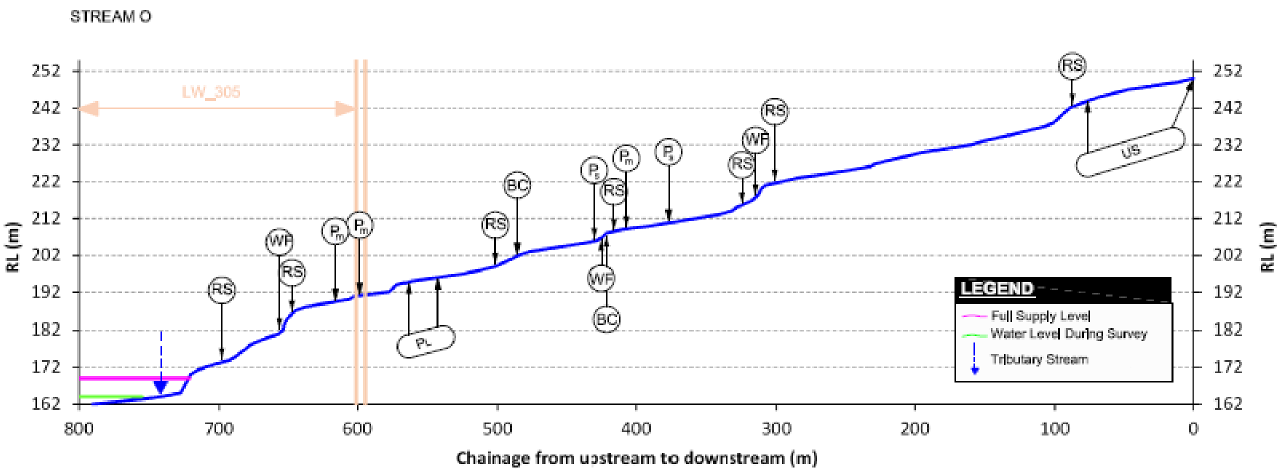


Figure 7 Features in Stream F

A summary of the catchment characteristics is provided in Table 3 below.

Table 3 Catchment Characteristics Stream F

Feature	Value
Stream order	2^{nd}
Catchment area (km²)	0.324
Stream length (km)	0.80
Average gradient of upland swamp (%)	8.2
Average gradient downstream of swamp (%)	7.6

4.3 Stream P

Stream P comprised a long stream with shorter tributary streams which flowed into the stream near the reservoir – refer Figure 8. The upper sections of the main (longer) arm comprised a densely vegetated upland swamp. The only surface drainage features observed with in the swamp comprised discontinuous depressions in the topographic "low" points of the swamp. The swamp terminated at an extensive rock bar. There was no overflow evident on the rock bar. Desiccated moss and staining markings on the rock bar suggested that overflows would have occurred frequently in the past and that the swamp would contribute flow to downstream reaches.

The reach on the main arm downstream of the swamp comprised a series of rock and boulder cascades, small waterfalls, instream pools, rock shelves and sections of straight incised channel. Small semi-continuous flow[4] was observed along the downstream reach. The instream pools became larger and more dominant in the lower sections of the stream. The lower reach of shorter arm was also inspected. It comprised a series of dry boulder cascades and rock chutes – refer Figure 9.

[4] Flow disappeared from view in the boulder cascades where it flowed along the base of the loose boulder field. Flow also disappeared from view in the sandy delta which had formed where the stream flowed into the reservoir.

Figure 8 Stream P Catchment

The observed features in Stream P are shown in Figure 9.

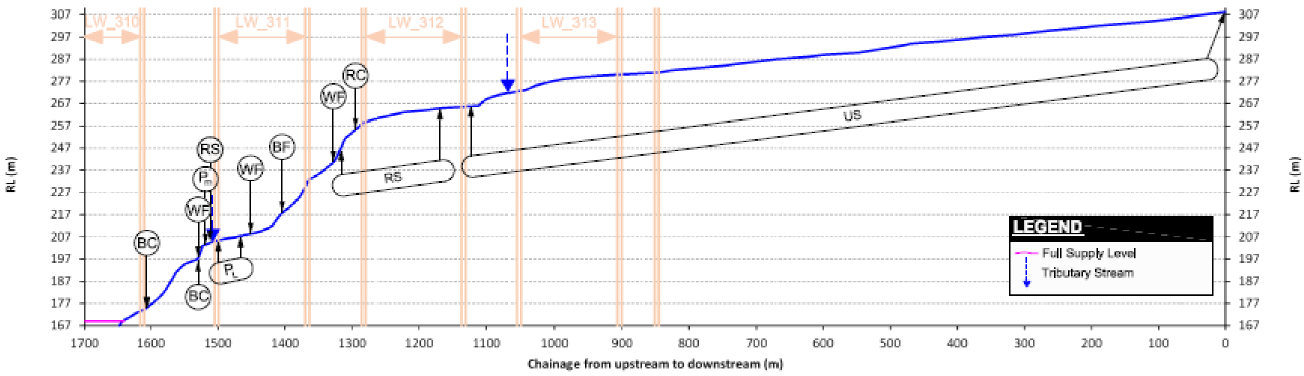


Figure 9 Features in Stream P

A summary of the catchment characteristics is provided in Table 4 below.

Table 4 Catchment Characteristics Stream P

Feature	Value
Stream order	2nd
Catchment area (km²)	0.864
Stream length main arm (km)	1.65
Stream length shorter arm (km)	1.62
Average gradient of upland swamp (%)	3.7
Average gradient downstream of swamp (%)	8.8

4.4 Stream Q

Stream Q comprised a small semi-continuous stream with small tributaries joining in three locations – refer Figure 10. The upper reaches comprised an ill-defined drainage path in a moderately steep gully. There was no water observed upstream of a significant waterfall which was partially obscured by dense vegetation. Access to the lower reaches of the stream was deemed too dangerous and completion of the planned reconnaissance of the lower sections of the creek was abandoned due to safety concern with very dense vegetation potentially obscuring steep drops.

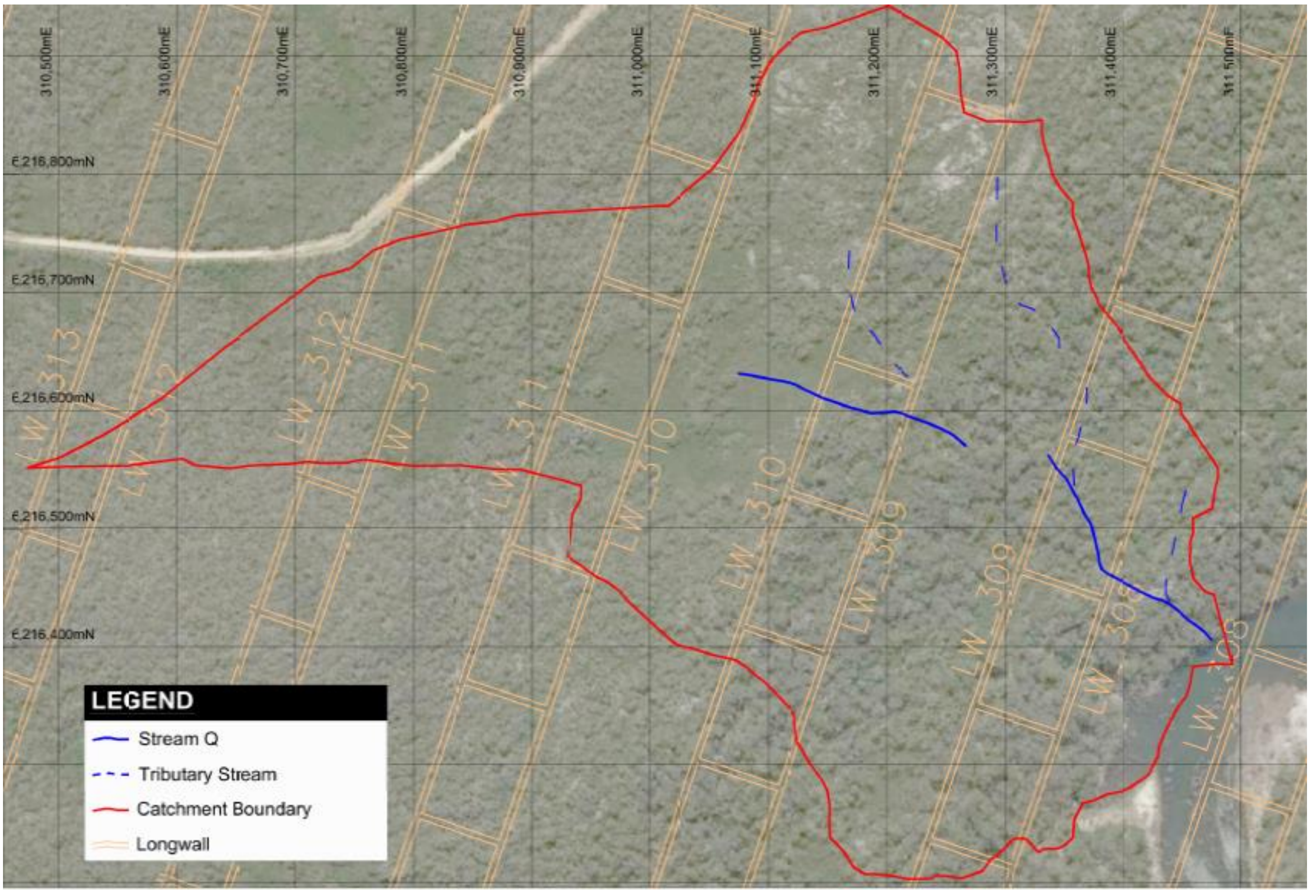


Figure 10 Stream Q Catchment

The observed features in Stream Q are shown in Figure 11.

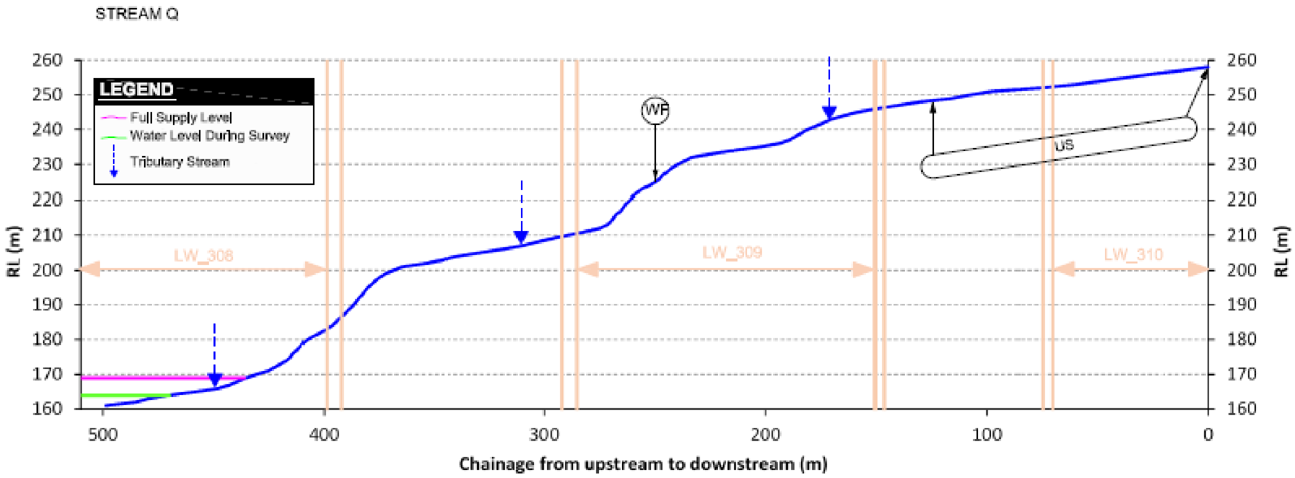


Figure 11 Stream Q Features

A summary of the catchment characteristics is provided in Table 5 below.

Table 5 Catchment Characteristics Stream Q

Feature	Value
Stream order	2nd
Catchment area (km²)	0.329
Stream length (km)	0.50
Average gradient (%)	19.1

4.5 Stream R

Stream R originates in an upland swamp and becomes a second order stream following inflow of a smaller stream line some 300m upstream of its outlet into the Woronora Reservoir – refer Figures 12 and 13.

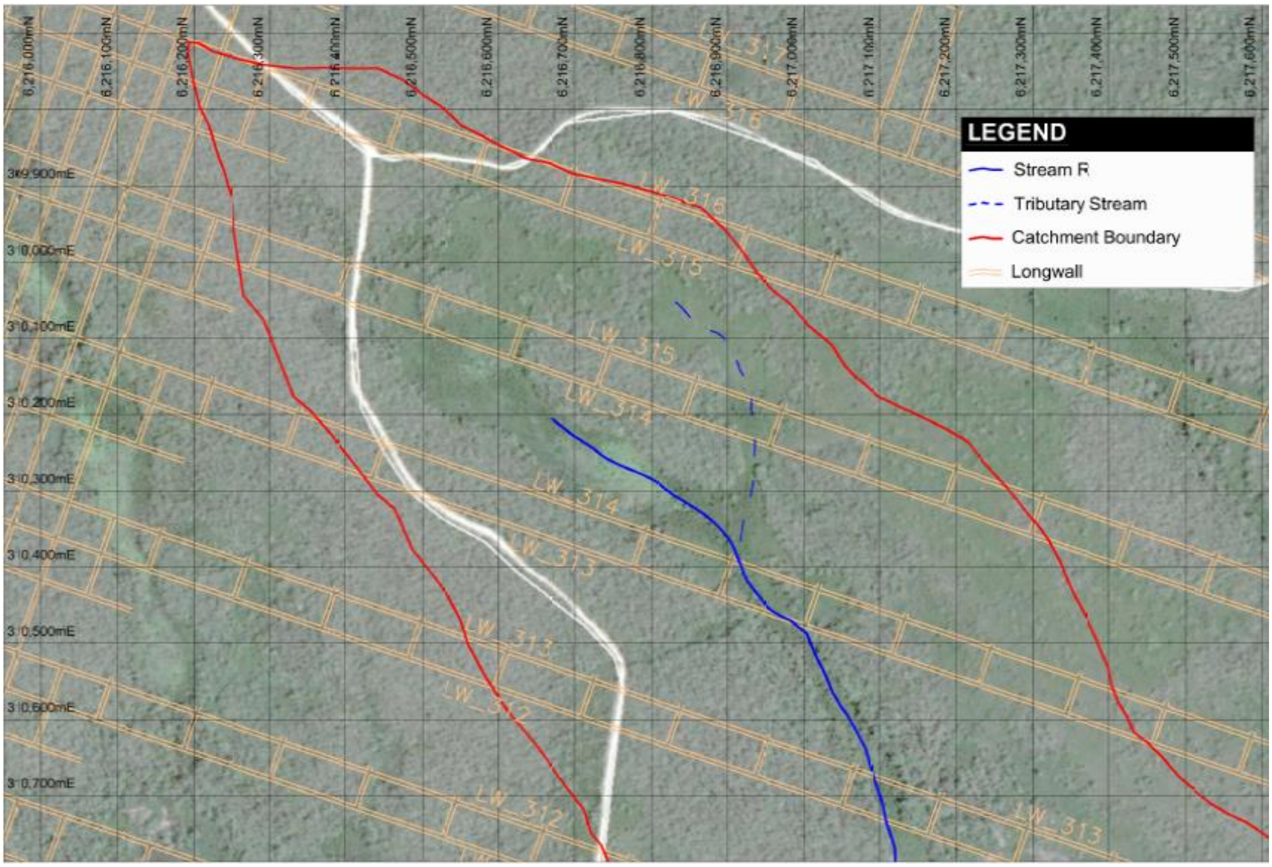


Figure 12 Stream R Upper Catchment

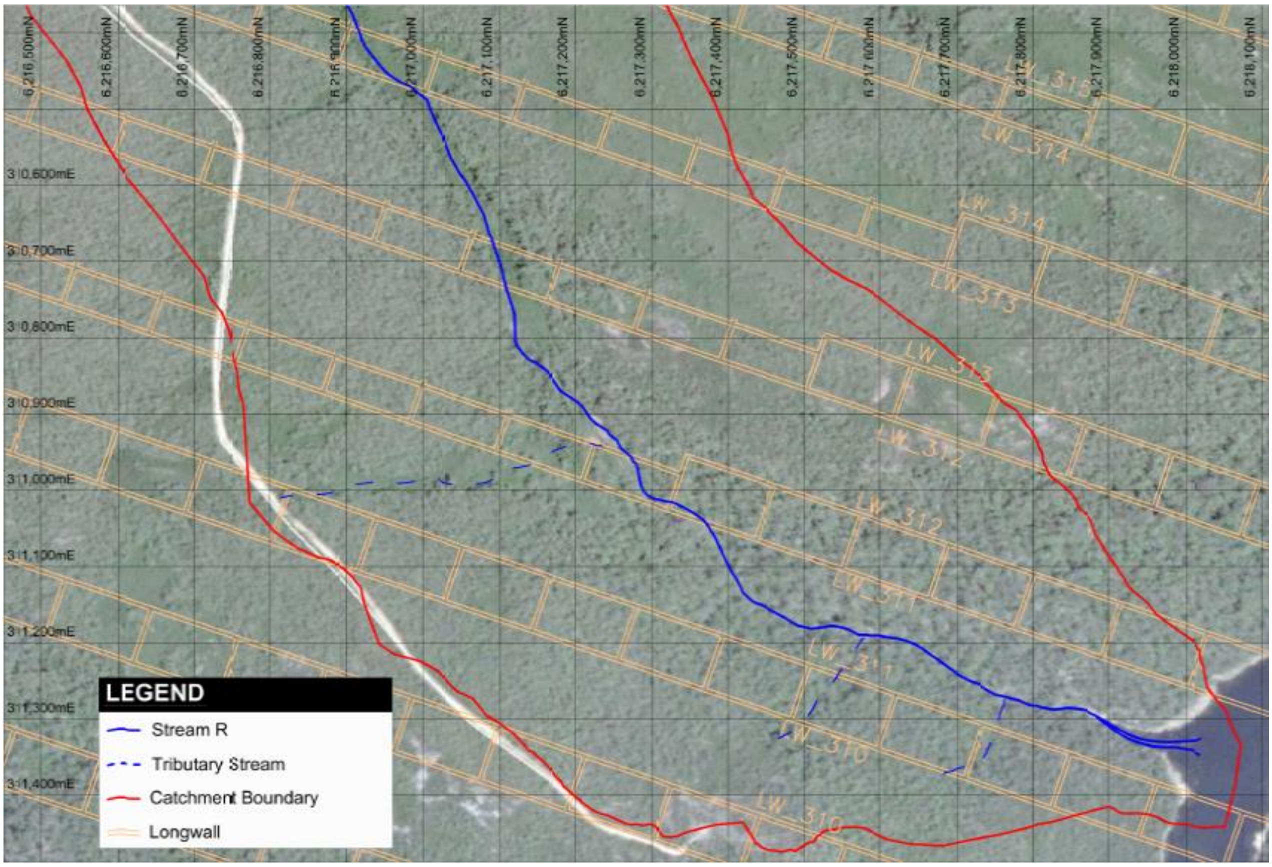


Figure 13 Stream R Lower Catchment

The upper reach comprised a large upland swamp. Swamp vegetation was very dense and inhibited access. The sections of the swamp accessed during the survey indicate it was similar to the swamps in the upstream reaches of Streams O and P with an ill-defined and discontinuous flow path. The swamp terminated at a large rock bar. There was no discernible flow over the rock bar however as with the other swamps it was apparent that there would be surface water flowing out of the swamp during wet periods. Downstream of the swamp the stream gradient changed with the stream morphology becoming more incised and comprising a series of rock and boulder cascades and waterfalls interspersed by pools and rock shelves. A continuous flow was observed in the lower reaches where relatively closely spaced pools become the dominant feature.

The tributary stream which flowed into the main arm some 250 m upstream of the outfall into Woronora Reservoir was dry. The largest pools downstream of this confluence were up to 25 m long which formed in depressions between low rock bars. The observed features in Stream R are shown in Figure 14.

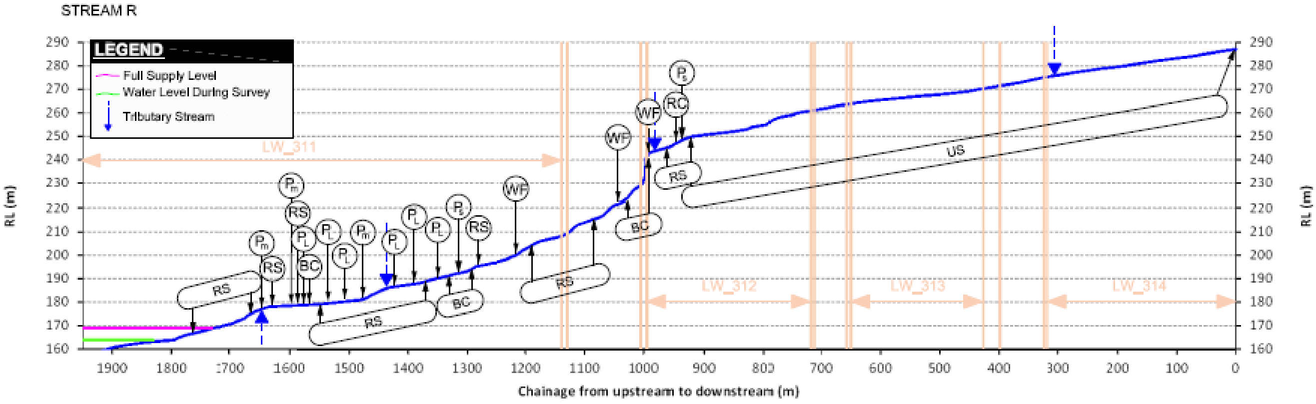


Figure 14 Stream R Features

A summary of the catchment characteristics is provided in Table 6 below.

Table 6 Catchment Characteristics Stream R

Feature	Value
Stream order	2nd
Catchment area (km²)	1.401
Stream length (km)	1.90
Average gradient (%)	6.7

4.6 Stream S-East

Stream S-East is joined by a small stream which flowed through a confined valley – refer Figure 15. The upper sections comprised a steep, gully form with ill-defined drainage channels and boulder cascades. Several pools were observed in the lower reaches with two medium pools near the confluence of the two arms of the stream. There was no significant flow observed and no visible flow at either the stream confluence or at the outflow to the Woronora Reservoir.

Figure 15 Stream S-East Catchment

The observed features in Stream S-East are shown in Figure 16.

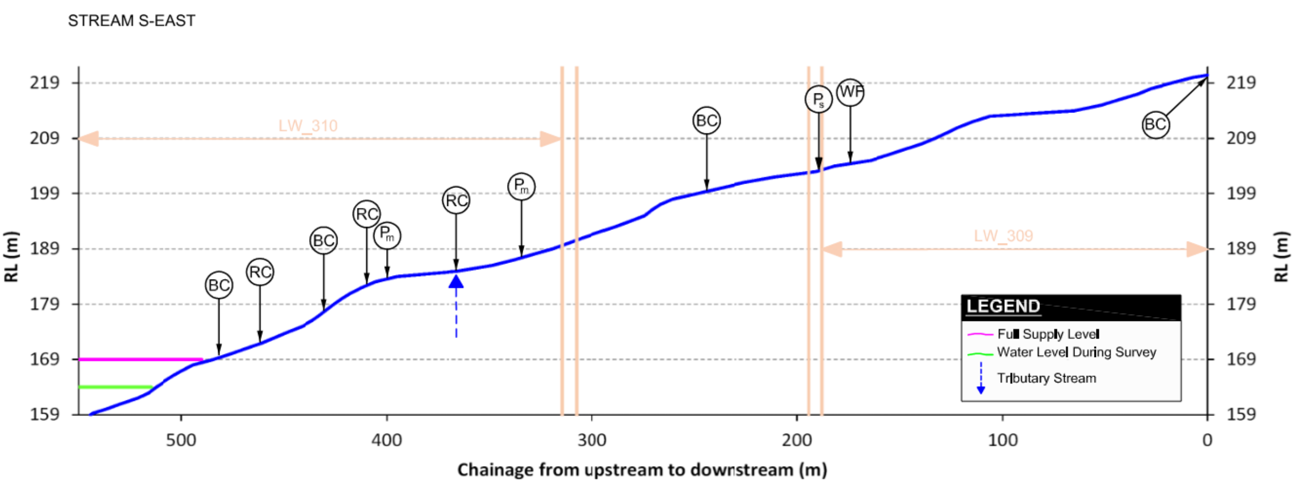


Figure 16 Stream S-East Features

A summary of the catchment characteristics is provided in Table 7 below.

Table 7 Catchment Characteristics Stream S-East

Feature	Value
Stream order	2nd
Catchment area (km²)	0.224
Stream length (km)	0.55
Average gradient (%)	11.3

4.7 Stream T

Stream T is a small second order stream – refer Figure 17. The stream morphology is similar to Stream S-East. There was a small continuous flow in the lower reaches of the stream which carried through to the Woronora Reservoir. The medium and larger pools mapped were larger than those observed in Stream S-East.

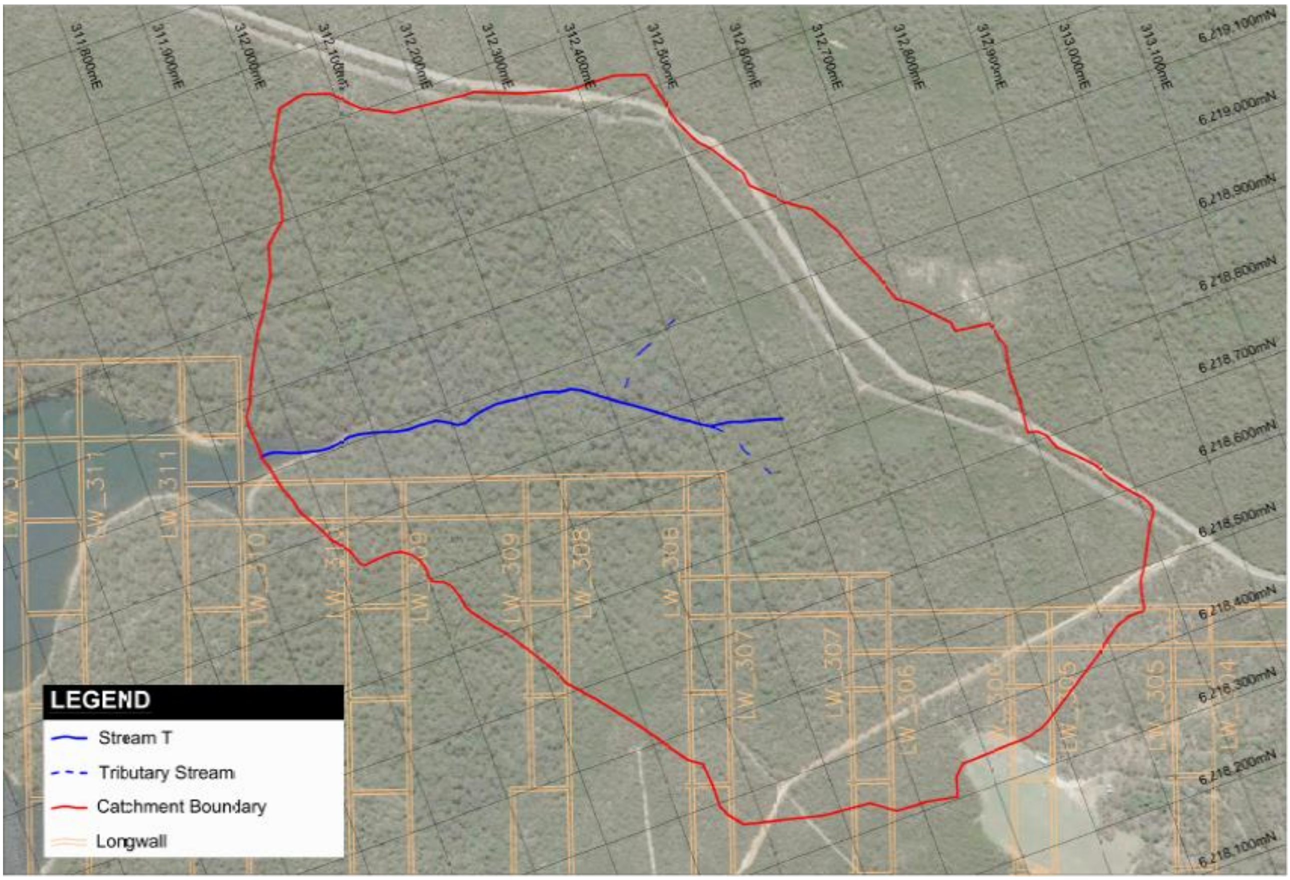


Figure 17 Stream T Catchment

The observed features in Stream T are shown in Figure 18.

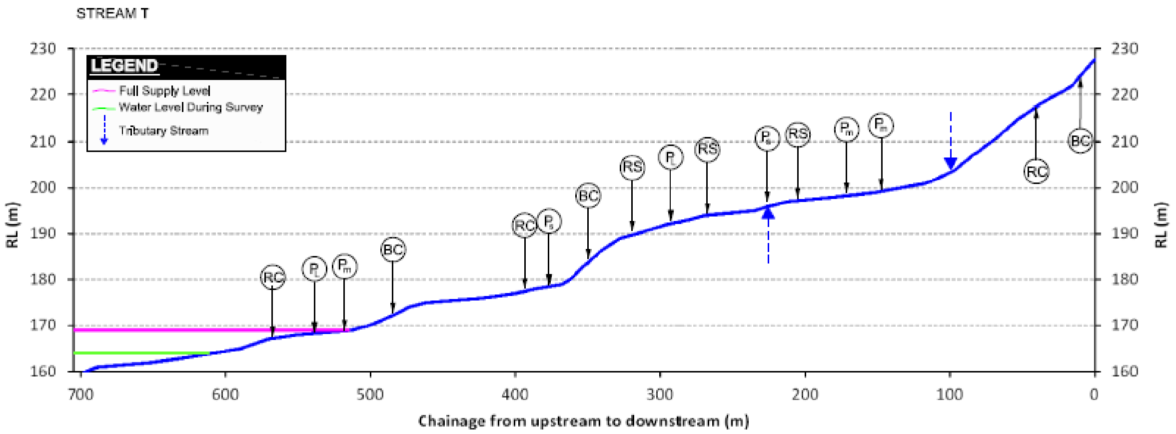


Figure 18   Stream T Features

A summary of the catchment characteristics is provided in Table 8 below.

Table 8   Catchment Characteristics Stream T

Feature	Value
Stream order	2nd
Catchment area (km²)	0.716
Stream length (km)	0.71
Average gradient (%)	9.8

5.0 RECOMMENDATIONS FOR MONITORING

The inspected streams are all small 1st and 2nd order streams. Based on observation of the effects of subsidence and non-conventional subsidence impacts on similar streams, including Forest Gully and Tributary B and D, it is expected that longwall mining will result in fracturing of bed rock and underflow and loss of function of some of what are currently a mixture of both intermittent and permanent pools.

It is recommended that, subject to access constraints, Metropolitan Coal investigate the potential to install:

- a pool water level meter in the large pool mapped on Stream P (Figure 9);
- a pool water level meter in two large pools in the lower reaches of Stream R (Figure 14);
- a small flow measuring flume immediately downstream of the upland swamp associated with Streams P (Figure 9) (no pool has been mapped at this location, however there may be potential to direct flow from the upland swamp toward a flume); and
- a small flow measuring flume in the vicinity of the first small pool mapped on Stream R to provide data on outflows from the swamp in the headwaters of this catchment (Figure 14).

Yours sincerely

Lindsay Gilbert
Principal Water Resources Engineer

ATTACHMENT A

Stream Reconnaissance Photographs

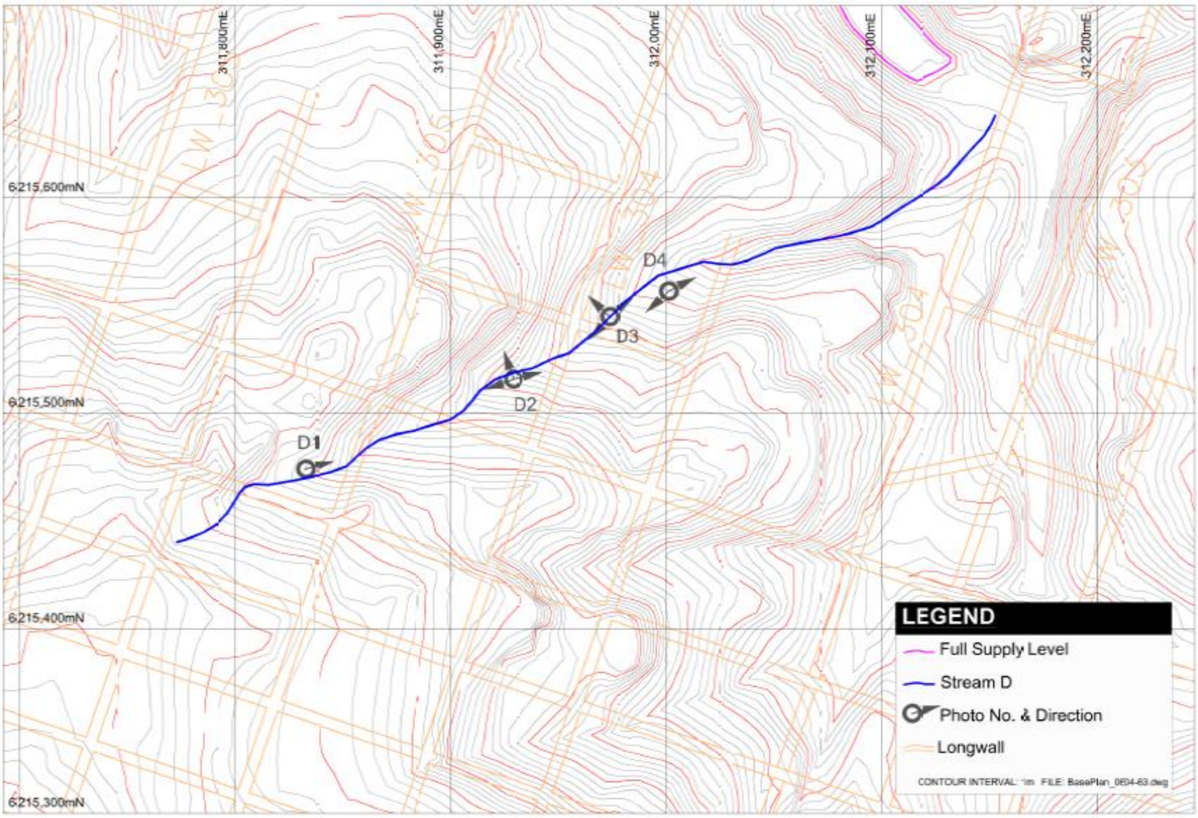


Photo D1 (Downstream)

Photo D2 (Downstream)

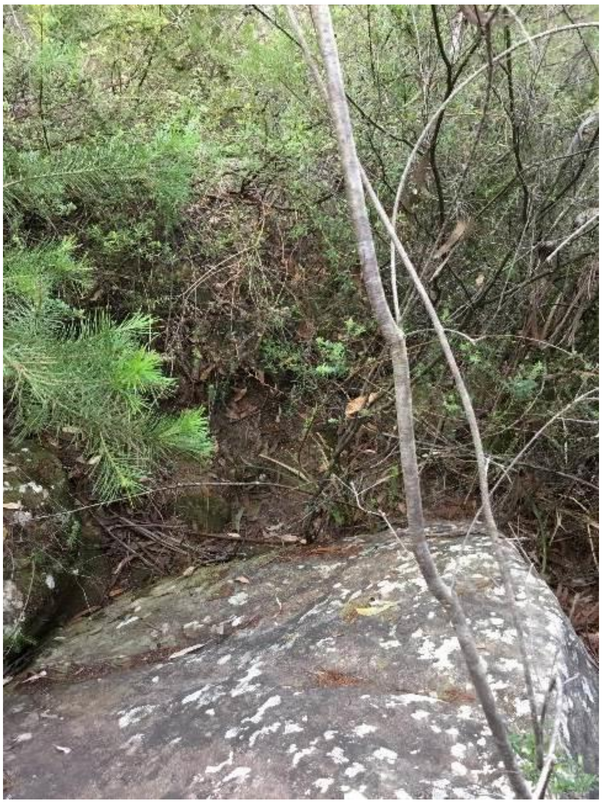


Photo D2 (Left Bank)

Photo D2 (Upstream)

Photo D3 (Downstream)

Photo D3 (Left Bank)

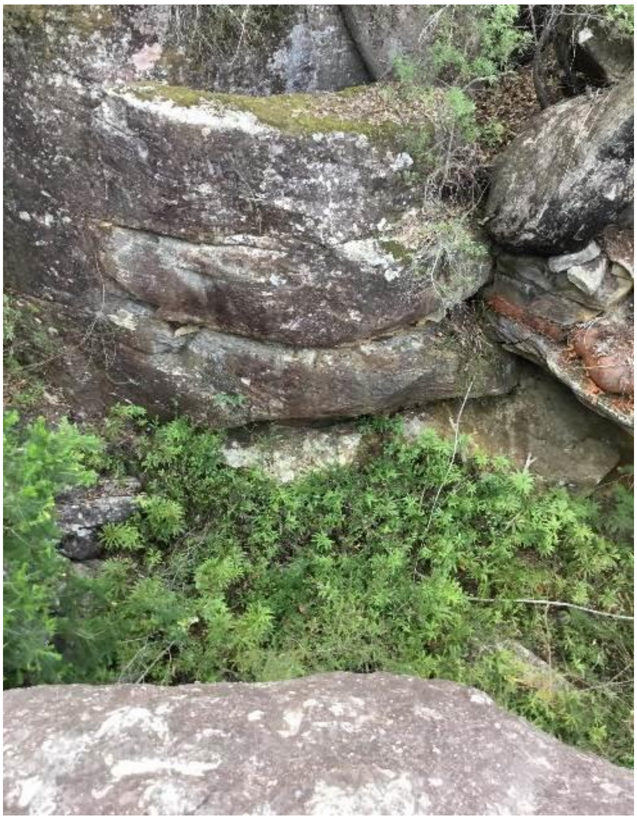


Photo D3 (Upstream)

Photo D4 (Downstream)

Photo D4 (Upstream)

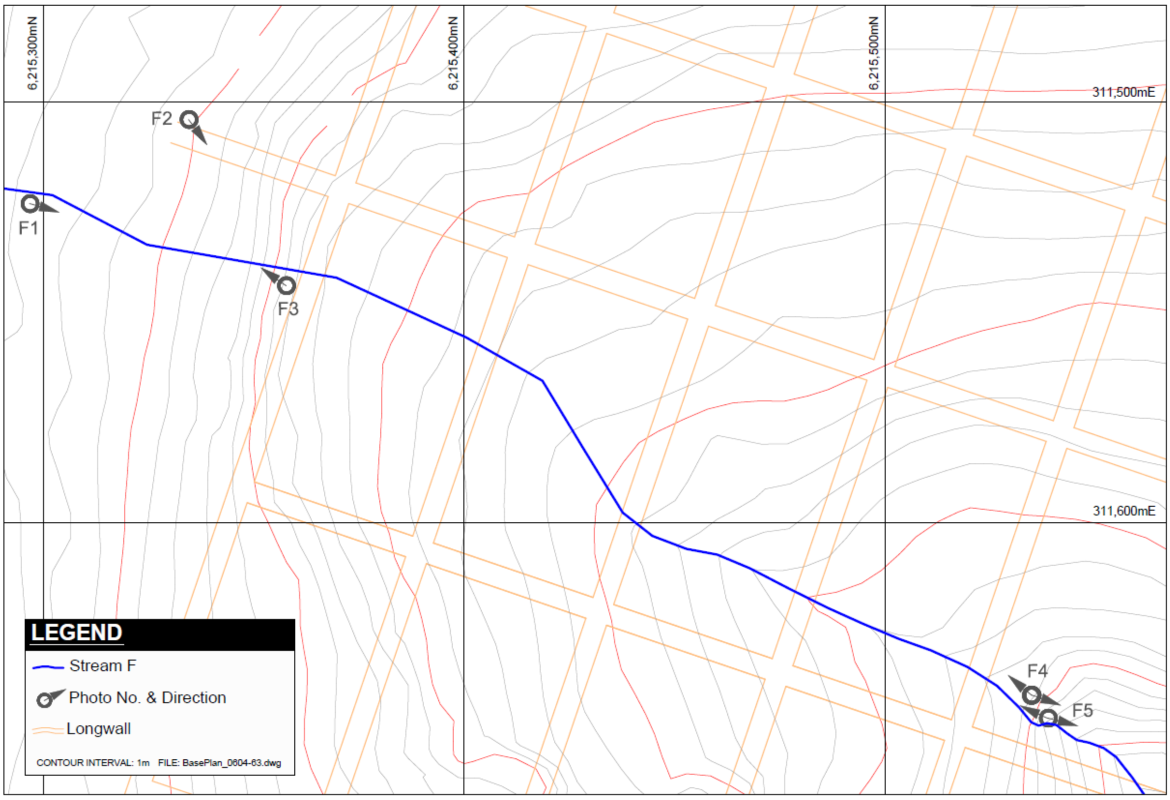


Photo F1 (Downstream)

Photo F2 (Downstream)

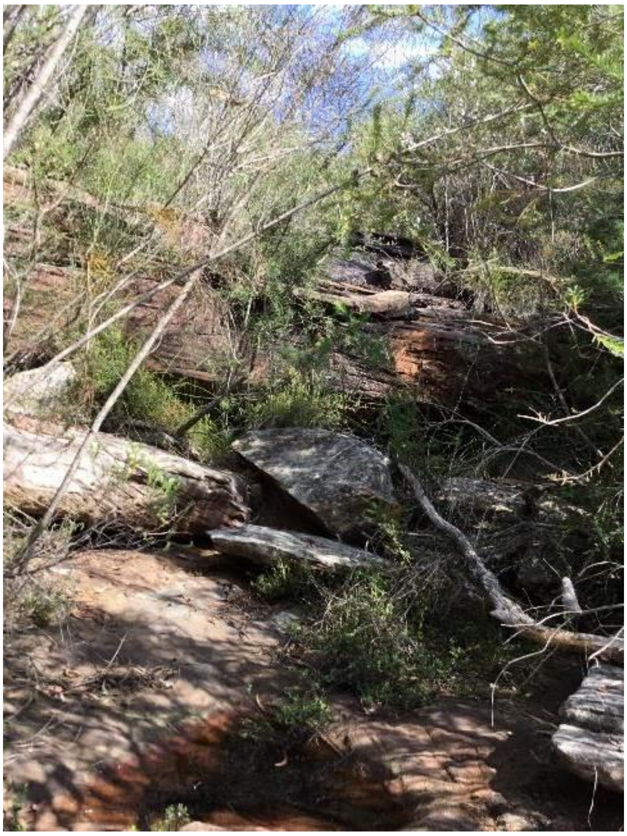
Photo F3 (Upstream)

Photo F4 (Downstream)

Photo F4 (Upstream)

Photo F5 (Downstream)

Photo F5 (Upstream)



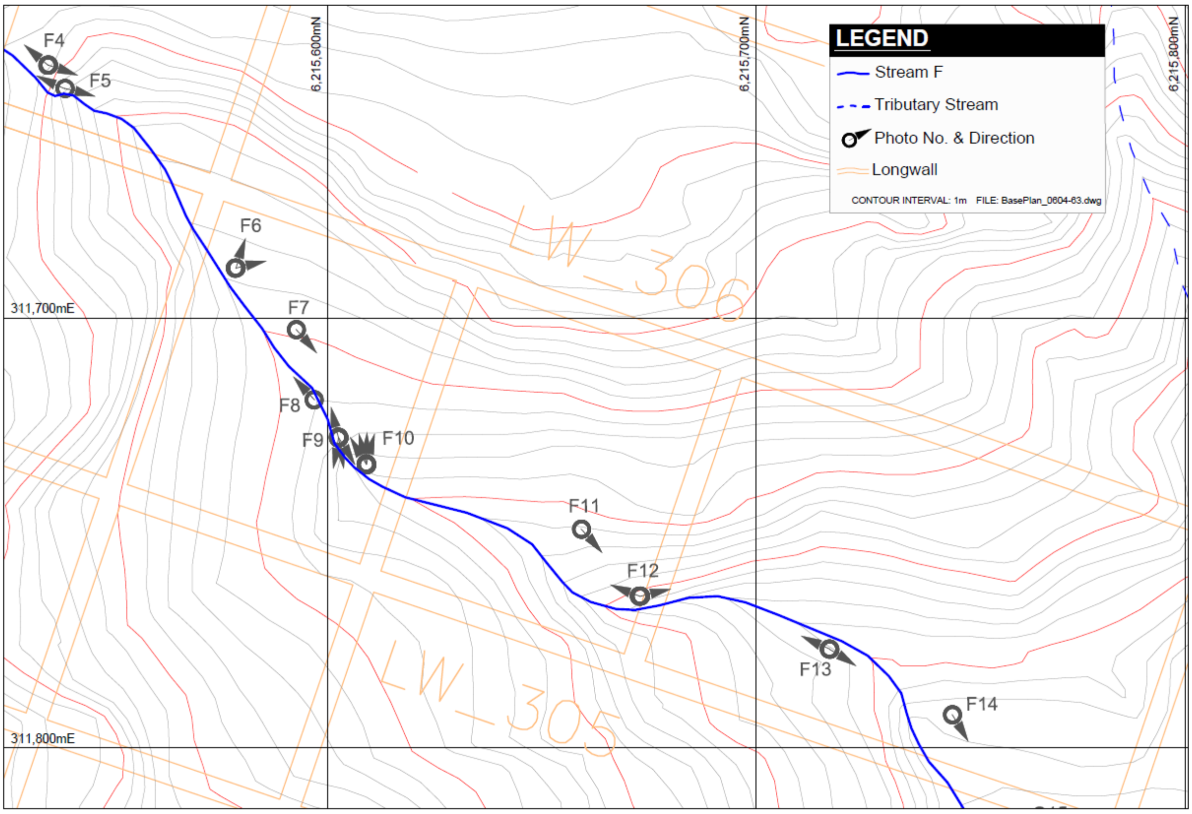


Photo F6 (Left Bank 1)

Photo F6 (Left Bank 2)

Photo F7 (Downstream)

Photo F8 (Upstream)

Photo F8 (Downstream 1)

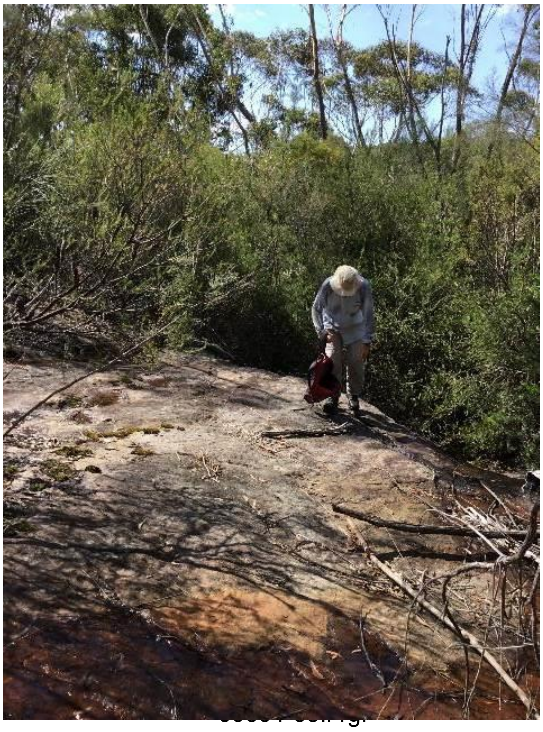


Photo F8 (Downstream 2)

Photo F8 (Downstream 3)

Photo F9 (Upstream 1)

Photo F9 (Upstream 2)

Photo F10 (Upstream 1)

Photo F10 (Upstream 2)

Photo F10 (Upstream 3)

Photo F10 (Upstream 4)

Photo F11 (Downstream)

Photo F12 (Downstream)

Photo F12 (Upstream)

Photo F13 (Downstream)

Photo F13 (Upstream)

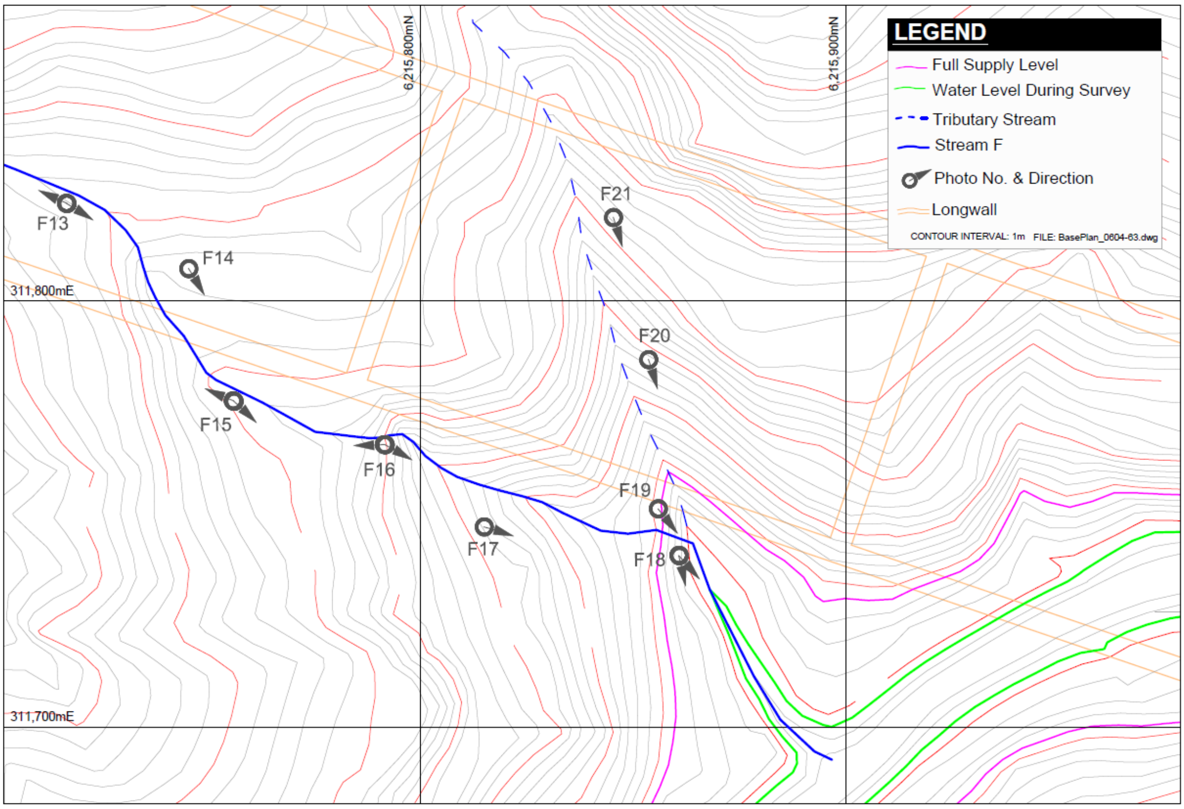


Photo F14 (Downstream)

Photo F15 (Downstream)

Photo F15 (Upstream)

Photo F16 (Downstream)

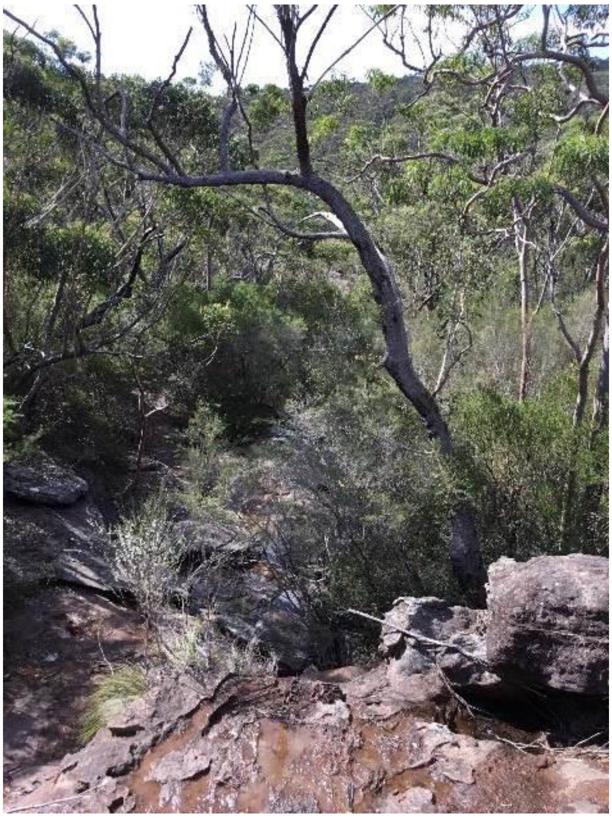


Photo F16 (Upstream)

Photo F17 (Downstream)

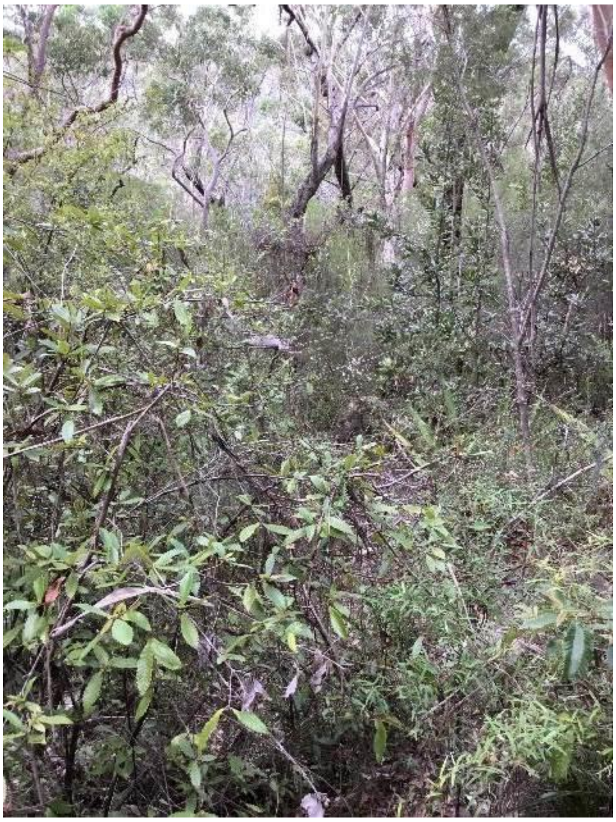
Photo F18 (Downstream 1)

Photo F18 (Downstream 2)

Photo F19 (Downstream)

Photo F20 (Downstream)

Photo F21 (Downstream)



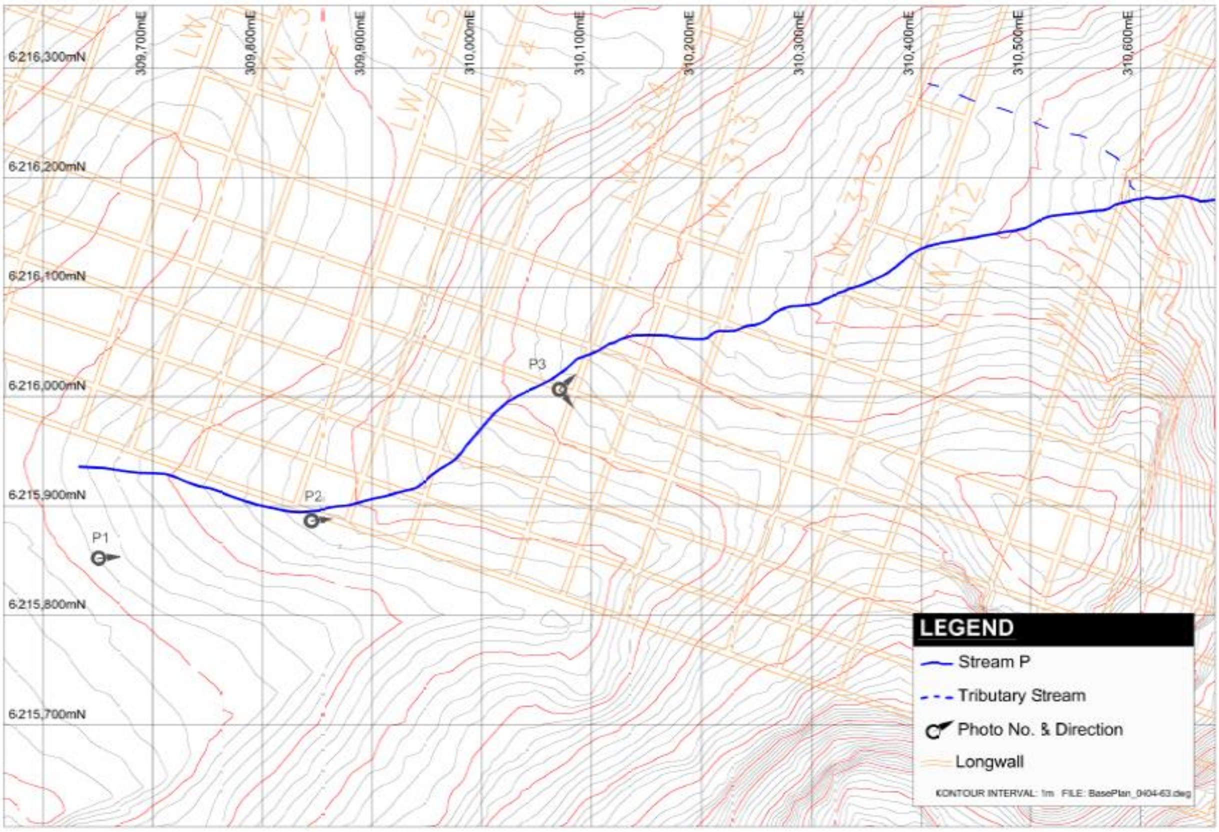


Photo P1 (Downstream)

Photo P2 (Downstream)

Photo P3 (Right Bank Bore)

Photo P3 (Downstream)

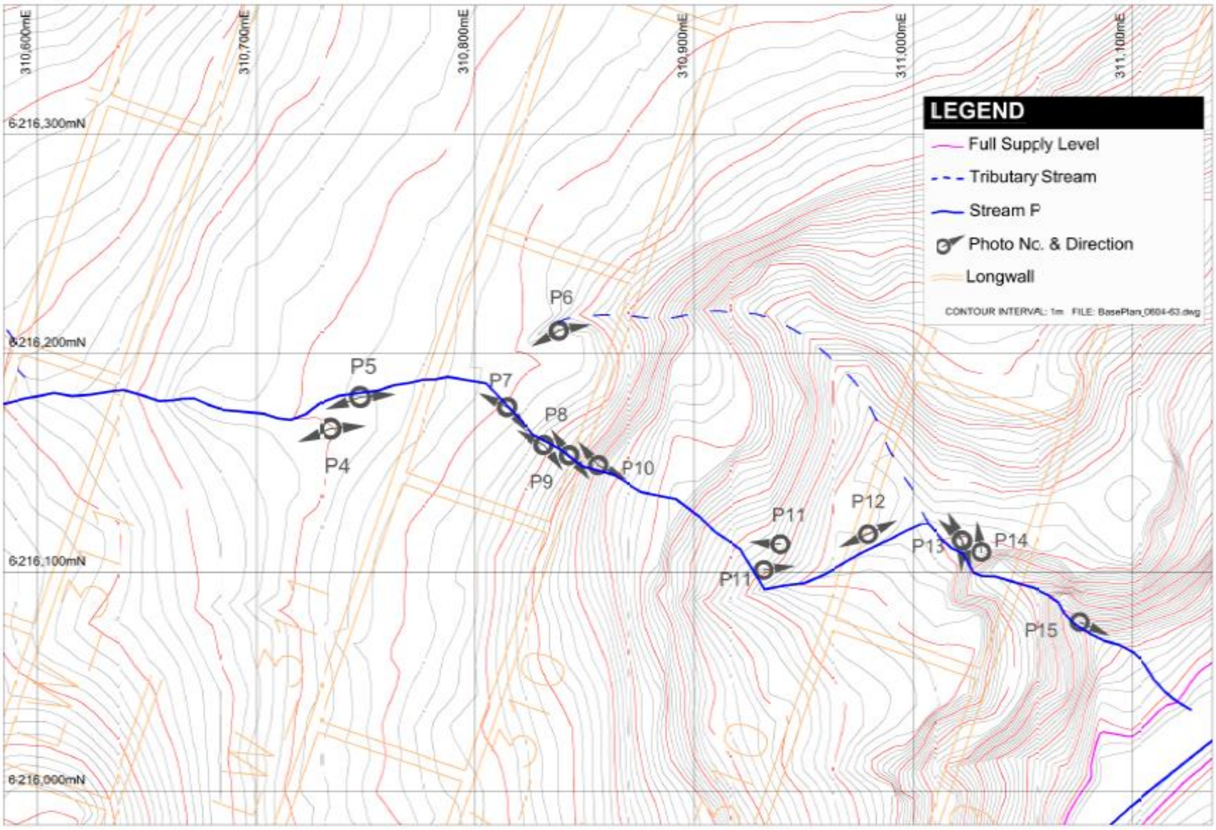


Photo P4 (Downstream)

Photo P4 (Upstream)

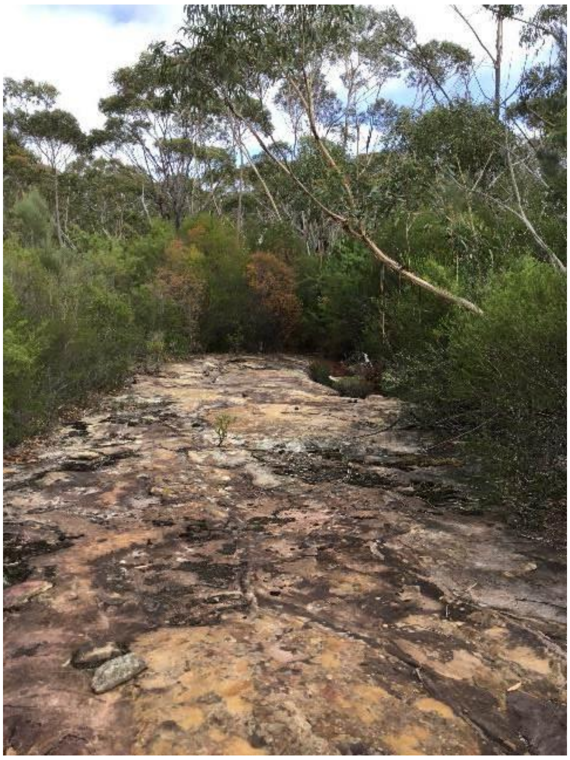


Photo P5 (Downstream)

Photo P5 (Upstream)

Photo P6 (Downstream)

Photo P6 (Upstream)

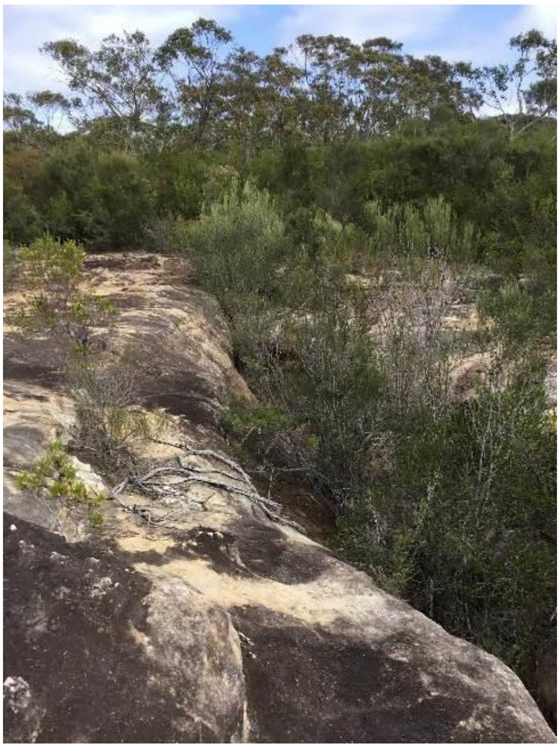


Photo P7 (Downstream)

Photo P7 (Upstream)

Photo P8 (Downstream)

Photo P8 (Upstream)

Photo P9 (Downstream)

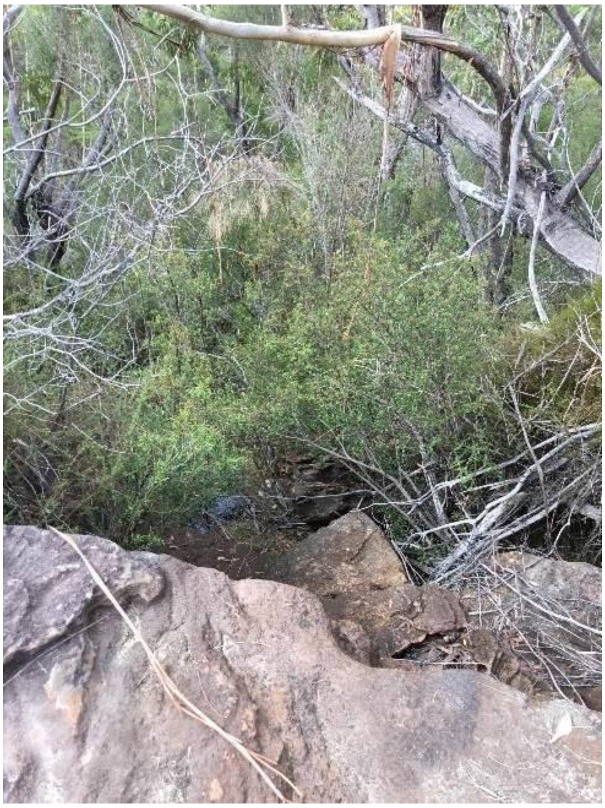


Photo P9 (Upstream)

Photo P10 (Downstream)

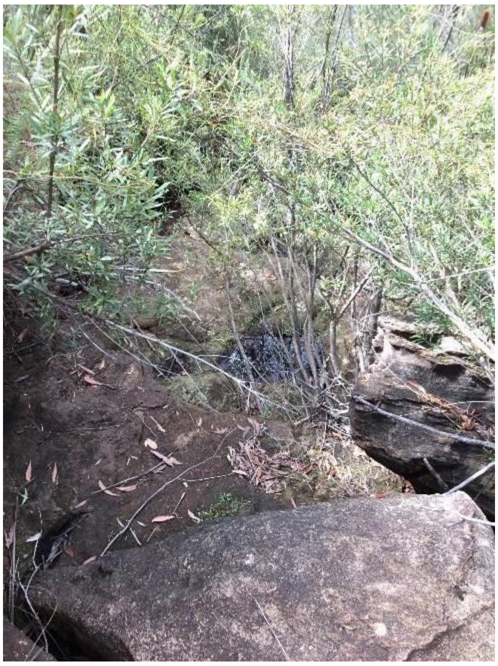


Photo P10 (Upstream)

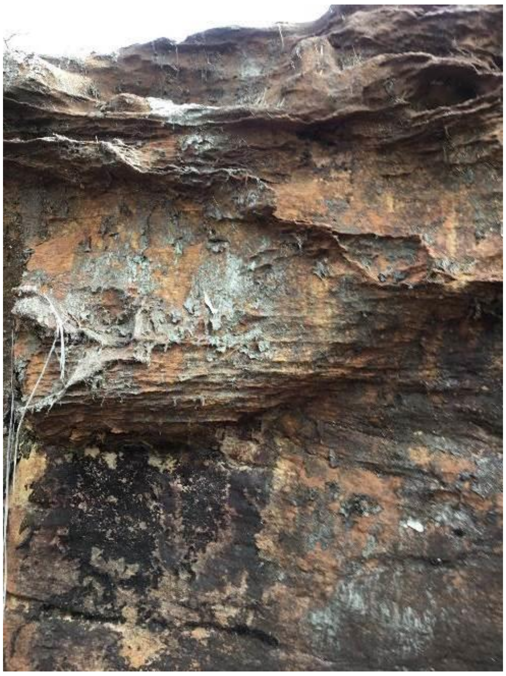


Photo P11 (Downstream)

Photo P11 (Upstream)

Photo P12 (Downstream)

Photo P12 (Upstream)

Photo P13 (Downstream 1)

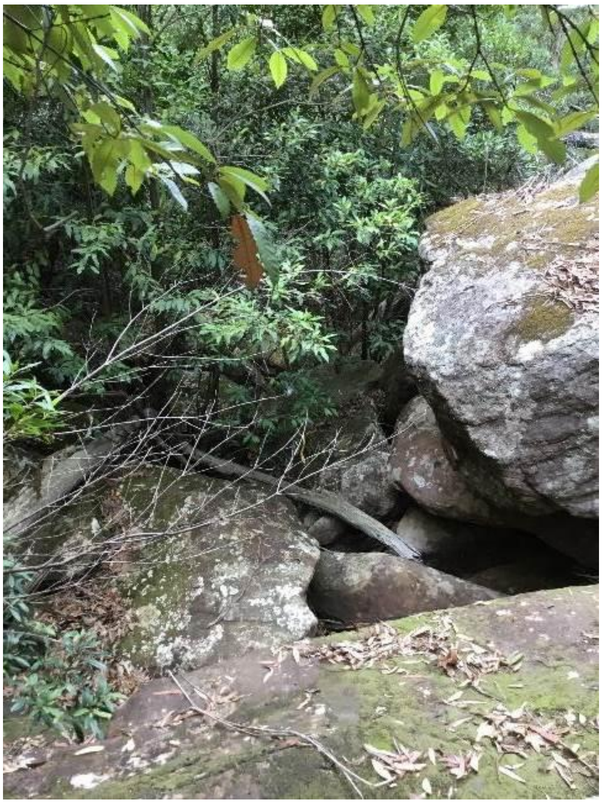
Photo P13 (Downstream 2)

Photo P13 (Upstream 1)

Photo P13 (Upstream 2)

Photo P14 (Upstream)

Photo P15 (Downstream)



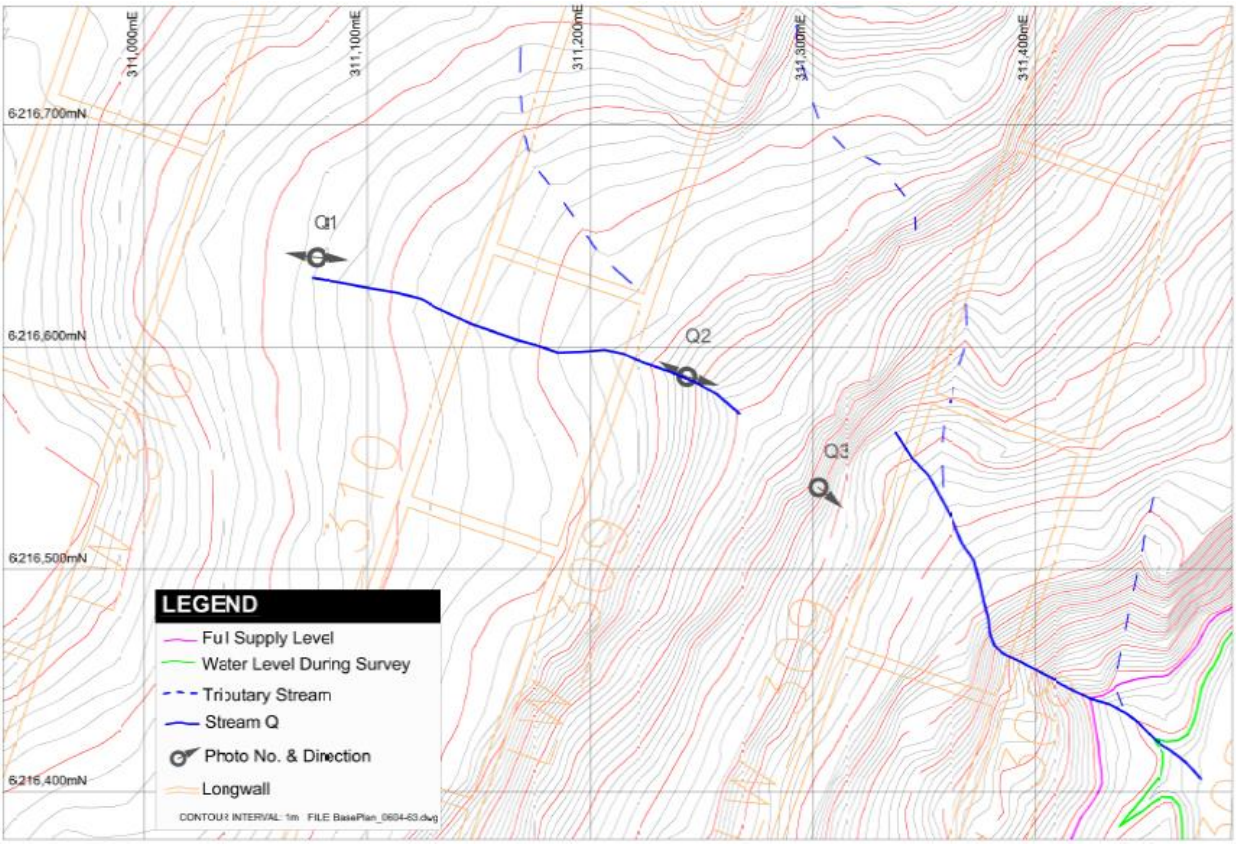


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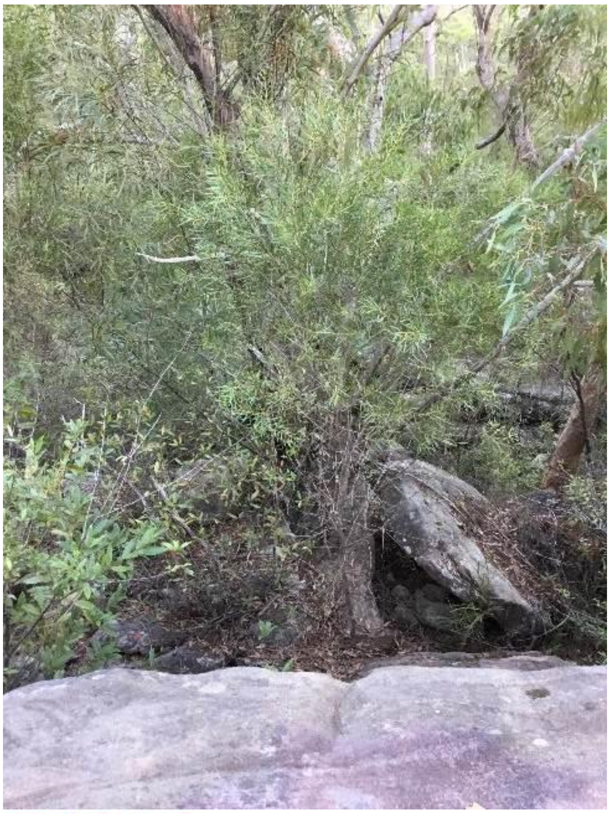
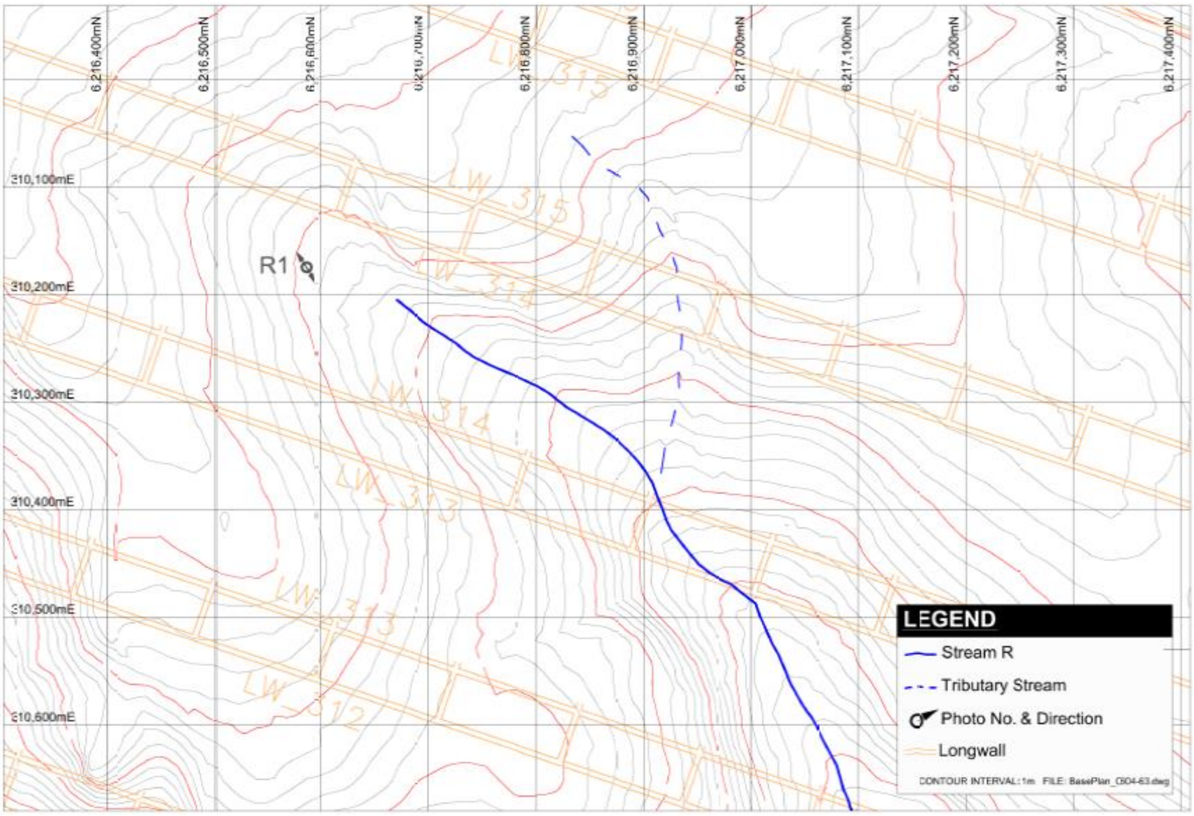
Photo Q3 (Downstream)





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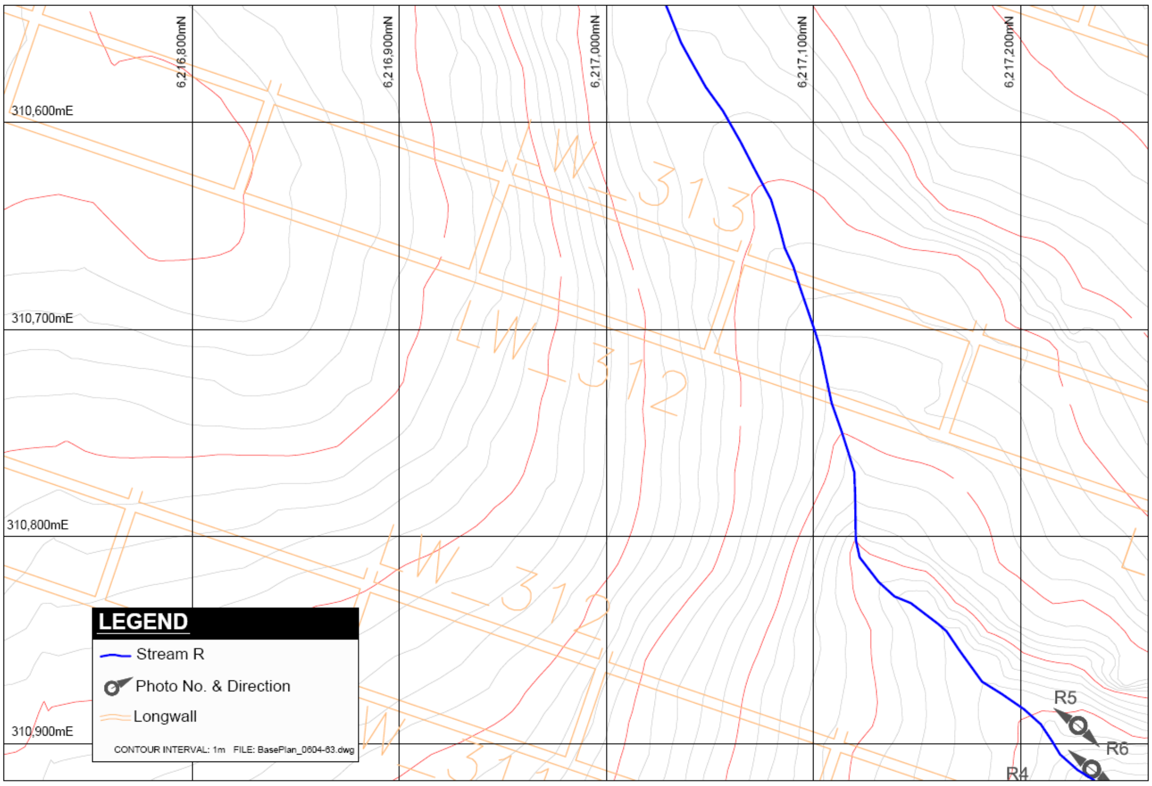

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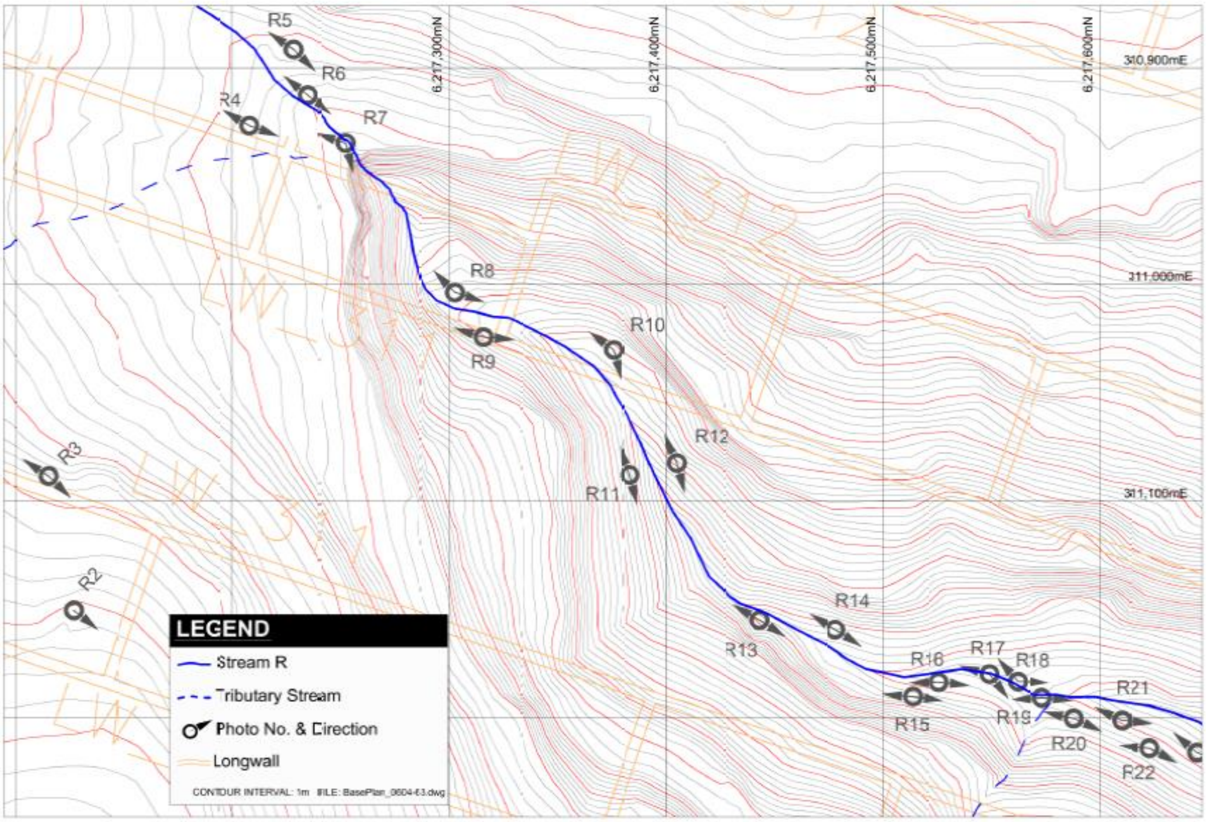

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Photo R6 (Downstream)

Photo R6 (Upstream)

Photo R7 (Downstream)

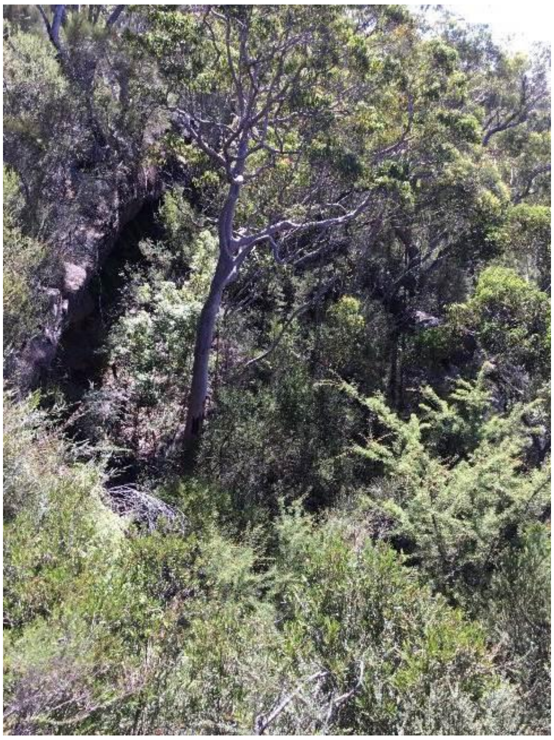

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Photo R11 (Upstream)

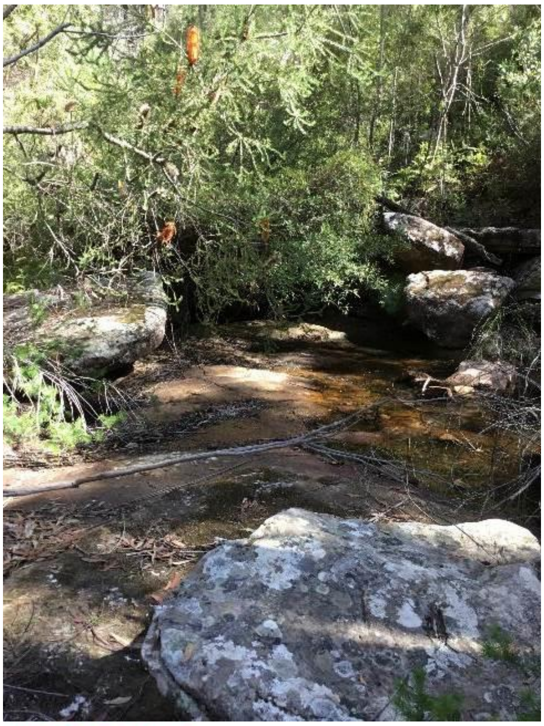

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Photo R16 (Downstream)

Photo R16 (Upstream)

Photo R17 (Downstream)

Photo R17 (Upstream)

Photo R18 (Downstream)

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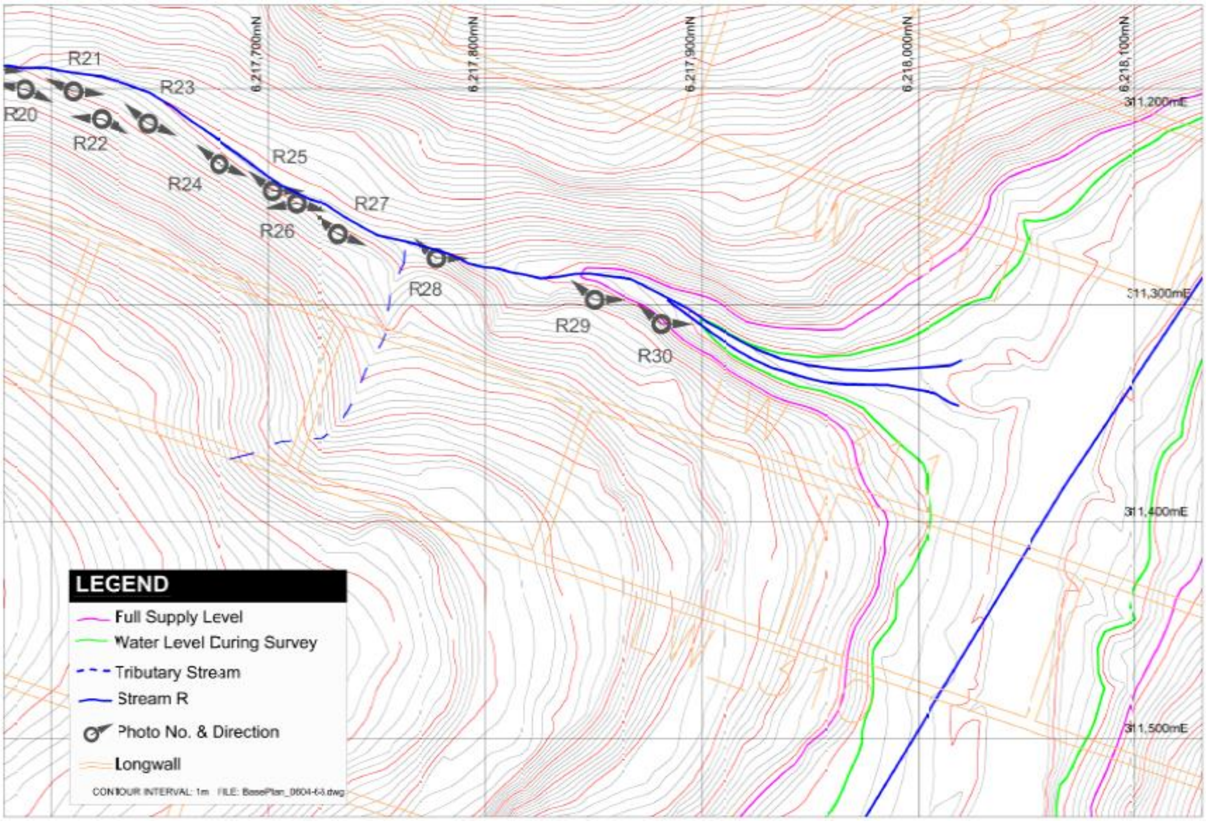

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Photo R24 (Downstream)

Photo R24 (Upstream)

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Photo R27 (Downstream)

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Photo R28 (Downstream)

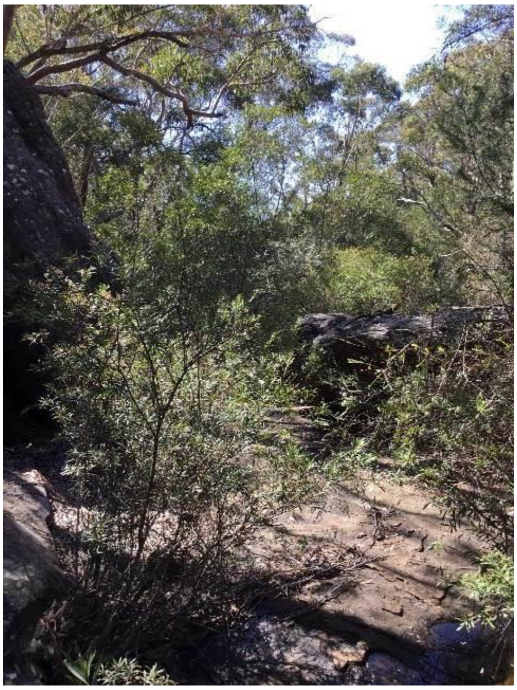

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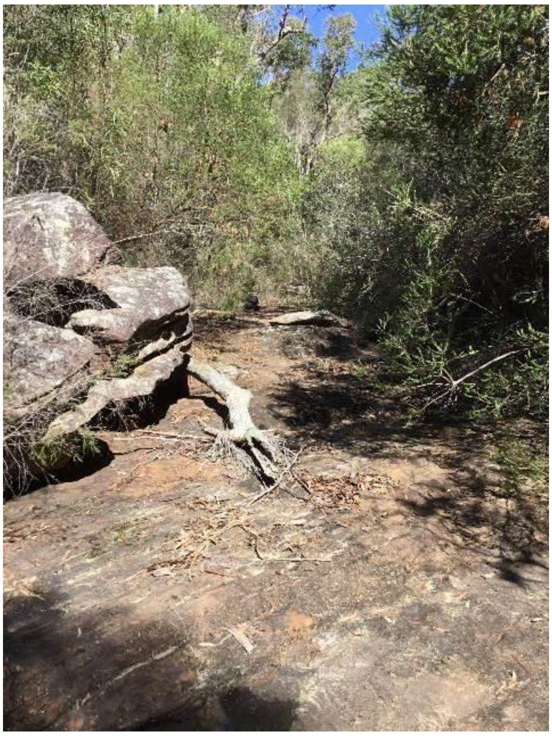
Photo R29 (Upstream)



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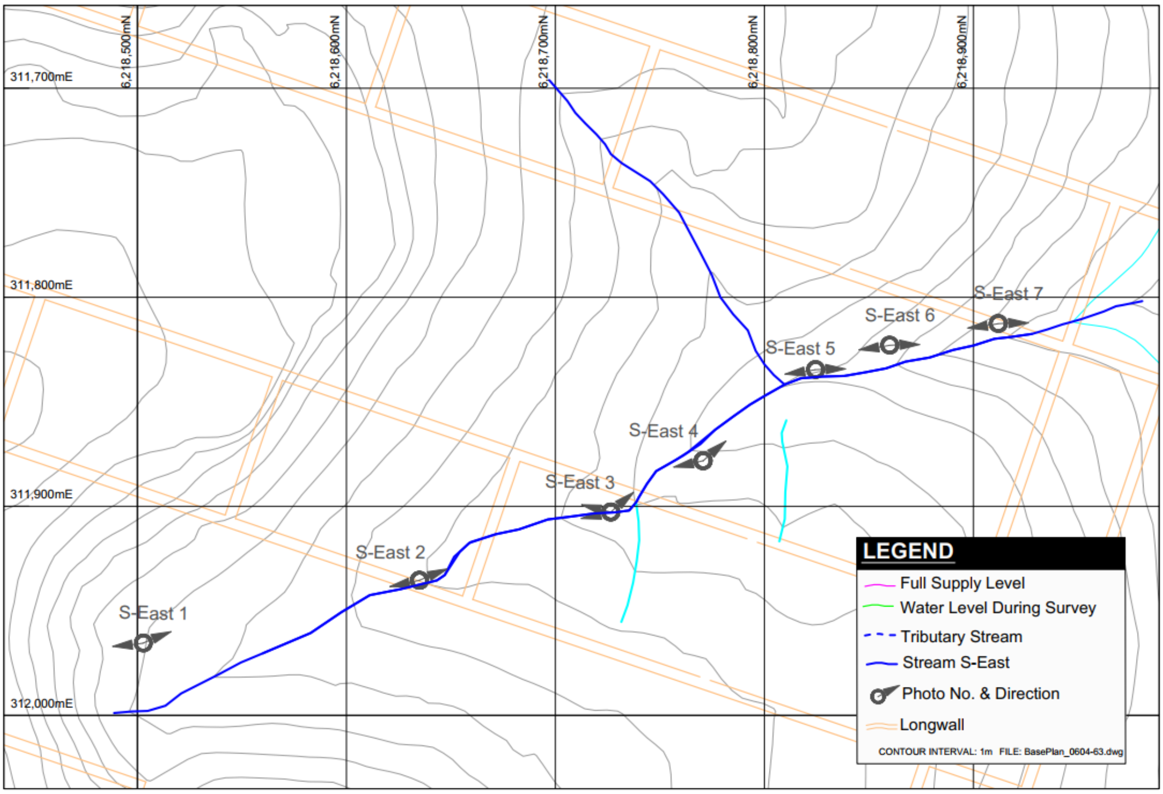

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Photo S-East 2 (Downstream)

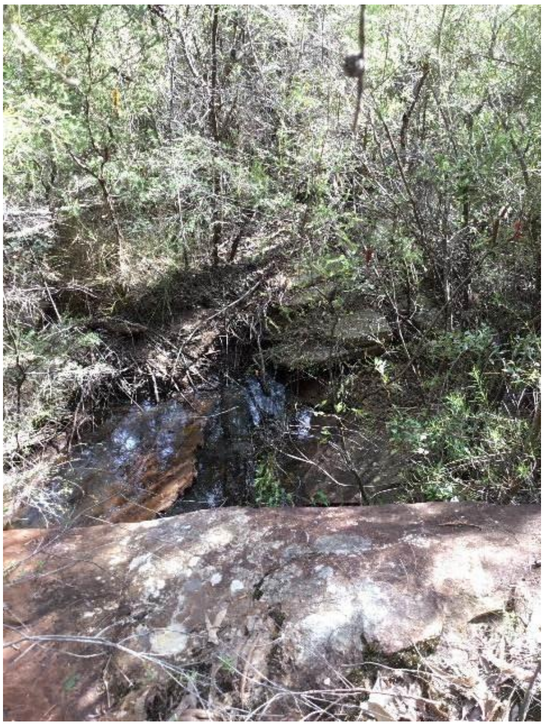

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Photo S-East 3 (Upstream 1)

Photo S-East 3 (Upstream 2)

Photo S-East 4 (Downstream)

Photo S-East 4 (Upstream)

Photo S-East 5 (Downstream)

Photo S-East 5 (Upstream)

Photo S-East 6 (Downstream)

Photo S-East 6 (Upstream)

Photo S-East 7 (Downstream)

Photo S-East 7 (Upstream)

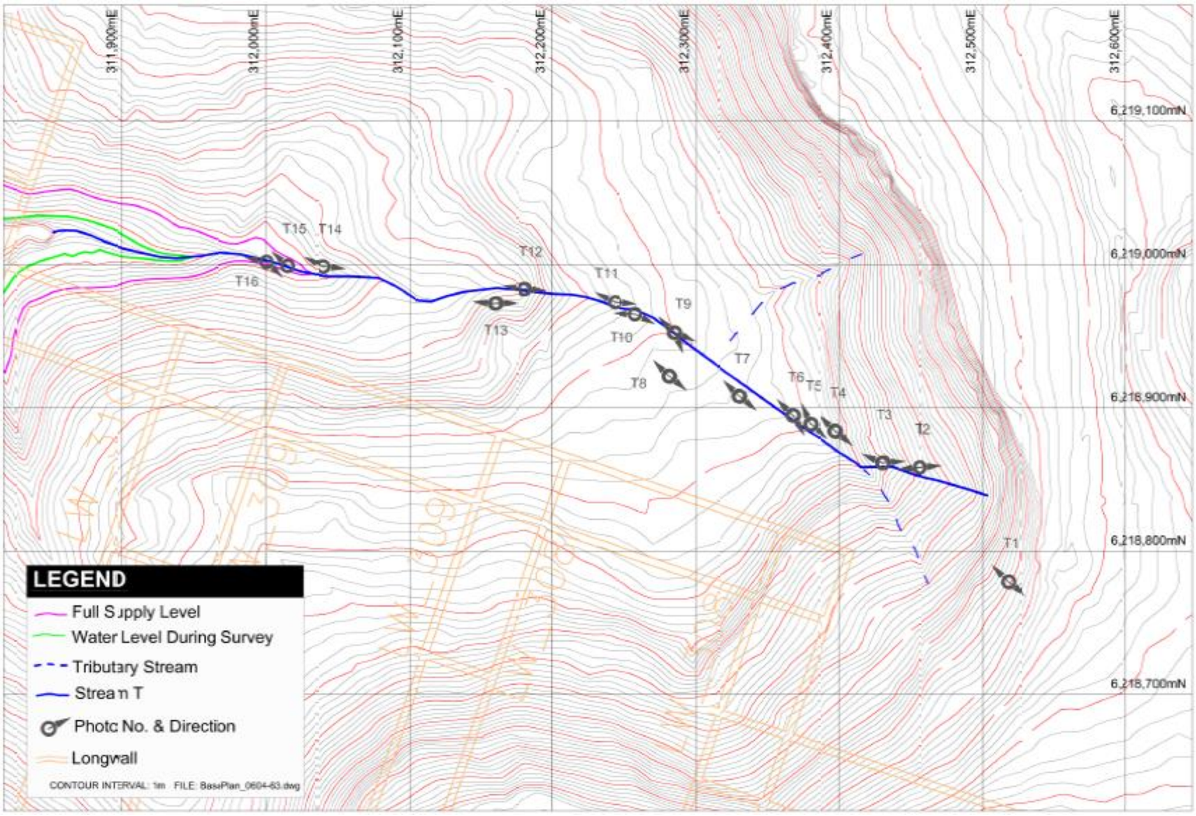

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Photo T2 (Upstream)

Photo T3 (Downstream)

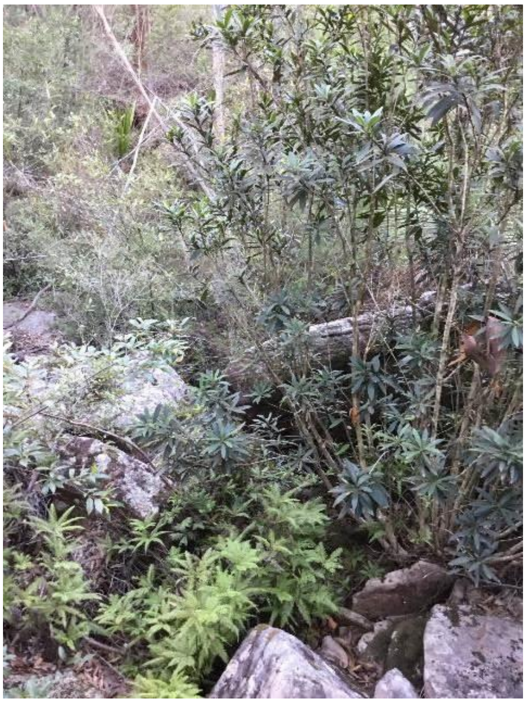

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Photo T5 (Downstream)

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Photo T6 (Downstream)

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Photo T7 (Downstream)

Photo T7 (Upstream)

Photo T8 (Downstream)

Photo T8 (Upstream)

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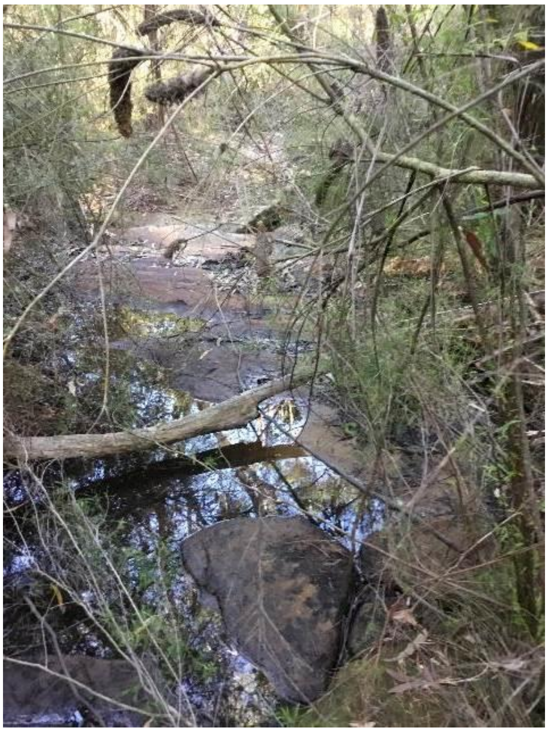
Photo T9 (Upstream 1)

Photo T9 (Upstream 2)

Photo T10 (Downstream)

Photo T10 (Upstream)

Photo T11 (Downstream)



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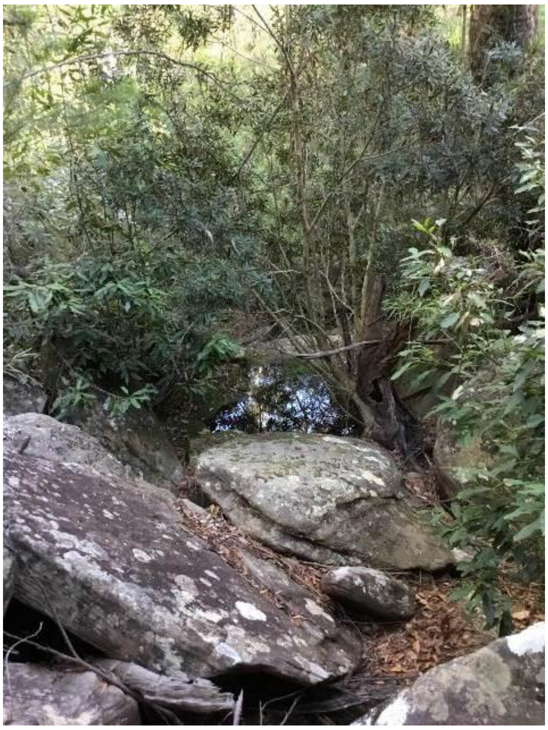

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Photo T13 (Downstream)

Photo T13 (Upstream)

Photo T14 (Downstream)

Photo T14 (Upstream)

Photo T15 (Downstream)

Photo T16 (Downstream)

Photo T16 (Upstream)

APPENDIX 4

LONGWALLS 311-317 UPLAND SWAMPS VEGETATION MAPPING AND CHARACTERISATION

Available in Electronic Version

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Ecoplanning 2019 - Longwalls 311-317 Upland Swamp Vegetation Mapping and Characterisation

Upland Swamp Vegetation Mapping and Characterisation

Prepared for: Metropolitan Coal

19 November 2021 Version: 1.0 – Final

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<tr><td>AUTHOR/S</td><td colspan="4">Elizabeth Norris, Brian Towle</td></tr>
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This report should be cited as: ‘Ecoplanning (2019). Ecoplanning 2019 - Longwalls 311-317 Upland Swamp Vegetation Mapping and Characterisation– Upland Swamp Vegetation Mapping and Characterisation. Prepared for Metropolitan Coal.’

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1 Introduction

Metropolitan Coal was granted approval (08_0149) for the Metropolitan Coal Project in accordance with Section 75J of the *Environmental Planning and Assessment Act, 1979* on 22 June 2009. In accordance with Project Approval Condition 6, Schedule 3, an Extraction Plan must be prepared for all second workings which must include a Biodiversity Management Plan (BMP) to manage the potential environmental consequences of the Extraction Plan on aquatic and terrestrial flora and fauna, with a specific focus on swamps. The term 'swamps' in this report is used to refer to all vegetation communities identified as forming the Upland Swamps Complex, as described by NSW National Parks and Wildlife Services (NPWS 2003).

This report has been prepared to validate and update previous vegetation mapping of five upland swamps and adjoining vegetation, to characterise these swamps, to identify and map adjoining vegetation of four large headwater swamps, and to inform relevant Biodiversity Management Plans. Specifically, the aims of this report are to:

- Validate existing mapping of upland Swamps 78, 79, 80, 90 and 91 overlying Longwalls 311-315, and where appropriate update vegetation mapping including adjoining vegetation communities.
- Validate and update existing mapping of adjoining vegetation communities of headwater Swamps 76, 77, 92 and 106 overlying Longwalls 312-317 following revised swamp vegetation mapping undertaken by FloraSearch (2016).
- Document any revisions to the existing vegetation mapping.
- Document the characteristics of each swamp.
- Conduct searches for indicator species within Swamps 78, 79, 80, 90 and 91 to inform the vegetation monitoring program design for Longwalls.

1.1 Bangalay Botanical Surveys (2008) vegetation mapping

A baseline flora survey of the Metropolitan Coal longwall mining area was undertaken by Bangalay Botanical Surveys (BBS 2008) for the Metropolitan Coal Project Environmental Assessment (Helensburgh Coal Pty Ltd, 2008). This baseline flora survey identified and mapped vegetation communities for a large area of the Metropolitan Coal lease boundary including the area overlying Longwalls 304-306 and surrounds. The identification of vegetation communities in the baseline flora survey (BBS 2008) largely followed the vegetation mapping of the Woronora, O'Hares and Metropolitan Catchments by NSW National Parks and Wildlife Services (NPWS 2003).

A number of distinct vegetation communities have been identified as comprising the Upland Swamps Complex within the Woronora, O'Hares and Metropolitan Catchments (NPWS 2003), with four distinct upland swamp vegetation communities identified by BBS (2008) namely:

- Tea Tree Thicket;
- Banksia Thicket;
- Sedgeland–heath Complex (an amalgamation of the Sedgeland, Restioid Heath and Cyperoid Heath vegetation associations identified by Keith & Myerscough [1993] consistent with NPWS [2003]); and

- Fringing Eucalypt Woodland.

The vegetation mapping of upland swamps is shown on **Figure 1.1**. Five upland swamps, identified by BBS (2008) as overlying of Longwalls 311-315 and associated chain pillars (Swamps 78, 79, 80, 90 and 91) were mapped as containing Sedgeland Heath communities (BBS 2008). Revised vegetation mapping for the large headwater swamps overlying Longwalls 312-317 and associated chain pillars (Swamps 76, 77, 92 and 106) is shown in **Figure 1.2** (FloraSearch 2016). Swamp vegetation mapping and characterisation of swamps overlying Longwall 310 and adjacent to Longwall 311 has been previously reported (Eco Logical Australia 2017). A number of other upland swamps identified by BBS (2008) occur west of Longwall 315 but are not the subject of this report (**Figure 1.1**).

A summary of the vegetation mapping and location relative to Longwalls 311-317 for each of these swamps is provided in **Table 1**.

Table 1.1: Upland swamp communities overlying Longwalls 311-317 (Bangalay Botanical Surveys 2008)

Swamp Number	Over Longwalls 311-315 or Pillars	Vegetation community (Bangalay Botanical Surveys 2008)
78	Yes	Sedgeland Heath
79	Yes	Sedgeland Heath
80	Yes	Sedgeland Heath
90	Yes	Sedgeland Heath
91	Yes	Sedgeland Heath
Swamp Number	**Over Longwalls 312-317 or Pillars**	**Vegetation community (Bangalay Botanical Surveys 2008)**
76	Yes	Banksia Thicket and Sedgeland Heath
77	Yes	Banksia Thicket and Sedgeland Heath
92	Yes	Banksia Thicket and Sedgeland Heath
106	Yes	Banksia Thicket and Sedgeland Heath

Figure 1.1: Upland swamp vegetation mapping over Longwalls 311-315 (Bangalay Botanical Surveys 2008)

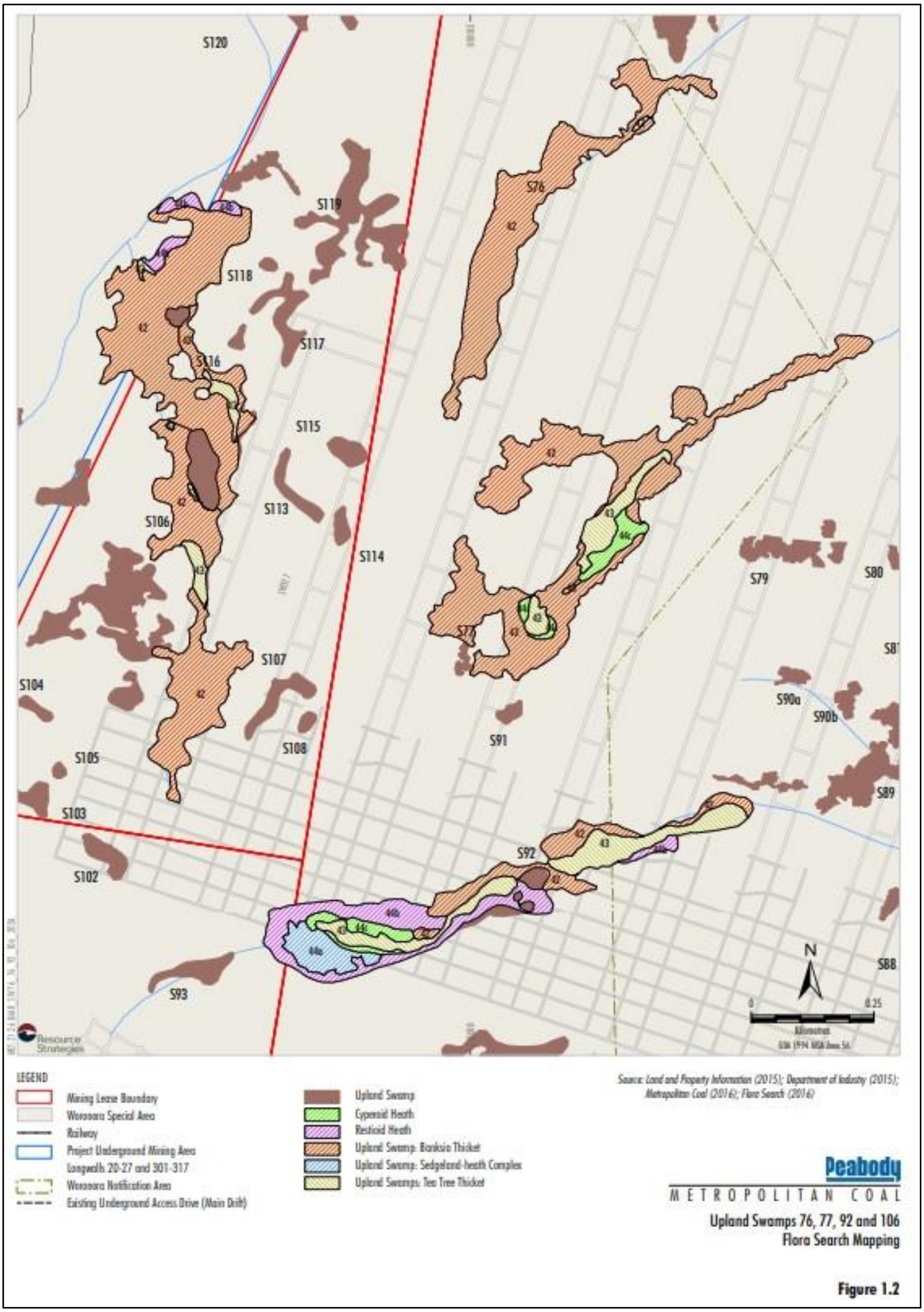

Figure 1.2: Revised upland swamp vegetation mapping – Swamps 76, 77, 92 and 106 (FloraSearch 2016)

2 Methods

2.1 Swamps 78, 79, 80, 90 and 91

Field inspections of areas mapped as upland swamp vegetation were undertaken by Brian Towle and Elizabeth Norris on the June 19 and 20, 2019. At each upland swamp mapped by BBS (2008), the extent of the mapped polygon was traversed where possible to confirm the presence of the mapped vegetation communities and to confirm the boundaries and extent of these vegetation communities.

For each area confirmed as an upland swamp a description of the vegetation was recorded including the different stratum present, the dominant species and an estimation of percent foliage cover for each stratum. These descriptions formed the basis for assigning vegetation communities described by NPWS (2003) and BBS (2008). Final delineation of vegetation community boundaries was undertaken by interpretation of aerial photography (SixMaps 2019 and NearMap 2019). Patterns identified on aerial photographs were related to the field observations and used to delineate the boundaries of vegetation communities.

2.1.1 Indicator species

For Swamps 78, 80, 81, 90 and 91 the presence of indicator species for each vegetation type (as identified and monitored within the vegetation communities as part of the Longwalls 20-22, Longwalls 23-27, Longwalls 301-303 and Longwall 304 vegetation monitoring programs) was noted, including a rapid assessment of the number of individuals for each indicator species. The indicator species targeted by the field survey and inspections were *Epacris obtusifolia, Sprengelia incarnata* and *Pultenaea aristata* for Banksia Thicket and Sedgeland-Heath Complex vegetation communities, and *Banksia robur, Callistemon citrinus* and *Leptospermum juniperinum* for the Tea Tree Thicket vegetation community in the event that this latter community may be identified during the survey.

2.2 Swamps 76, 77, 92 and 106

Swamps 76, 77, 92 and 106 are large headwater swamps containing complex patterns of vegetation. Revisions of upland swamp vegetation mapping within these swamps was undertaken by Flora Search (2016), for the purposes of refining swamp vegetation mapping including the swamp boundaries. With the revision and updating of the swamp boundaries, gaps in the vegetation mapping arose where changes to swamp boundaries did not overlap. Validation of the vegetation within these gap areas was required to complete the revised mapping. This updated mapping focused on identifying the vegetation communities present within 'gaps' between vegetation mapping of Flora Search (2016) and BBS (2008) but did not involve validating mapped vegetation extending away from identified gaps. Specifically, the vegetation immediately adjacent to each gap was inspected and most appropriate vegetation community across the gap was determined with reference to vegetation communities mapped immediately adjacent.

Field inspections of areas of adjoining vegetation was undertaken by Brian Towle and Elizabeth Norris on the June 20 and July 1 and 3, 2019.

3 Results

3.1 Swamp geomorphology

Three swamp types have been identified as occurring over the Metropolitan Coal Project underground mining area, as follows (Metropolitan Coal 2019):

- Headwater swamps: These are the largest swamp type. They occupy broad, shallow, trough-shaped valleys, usually on first order watercourses at the head of valleys on broad plateaux. They sit on a relatively impermeable, low gradient sandstone base with dispersed seepage flows that encourage the growth of hygrophilic vegetation that in turn traps sediment, thereby increasing the water holding capacity. These swamps usually terminate at points where the watercourse suddenly steepens or drops away at a 'terminal step'. Terminal steps often occur at constrictions in the landscape where two ridges converge, causing a narrowing of the swamp and a concentration of water flows into a central channel.

- In-valley swamps: In-valley swamps are uncommon and occur on relatively flat sections of more deeply incised second and third order watercourses. Some are thought to develop behind obstructions in the watercourse, such as fallen rocks or log jams that result in a slowing of the water flow and deposition of sediments. Flat Rock Swamp is considered to represent a 'classic' in-valley swamp. Because of their relatively large catchment areas these swamps tend to be wetter than many headwater and valley side swamps.

- Valley side swamps: Valley side swamps occur on steeper terrain than headwater swamps and are sustained by small horizontal aquifers that seep from the sandstone strata and flow over unbroken outcropping rock masses. These 'swamps' have shallow soils because the gradient usually limits sediment accumulation. They tend to terminate either on a horizontal step in the bedrock, or where broken rock, scree or deeper soil occurs at the base of the outcropping rock.

Swamps 79, 80, 90 and 91 were identified as 'valley side swamps' and tended to be located on the mid to upper portions of the slope. They did not occur in association with an incised second or third order watercourse and have comparatively small catchment areas compared to in-valley swamps. Swamp 91 contained a small drainage channel. Swamp 78 was identified as a north-south aligned small headwater swamp containing a first order drainage line flowing north and over a terminal step/small cliff. At the time of survey, this drainage line was dry.

Swamps 76, 77, 92 and 106 are all large headwater swamps occupying broad sandstone plateau areas, typically more common west of the Woronora Reservoir.

3.2 Upland Swamp vegetation communities

3.2.1 Swamps 78, 79, 80, 90 and 91

The field inspections confirmed the presence of upland swamp communities at Swamps 78, 79, 80, 90 and 91 mapped by BBS (2008) although the boundaries identified by BBS (2008) did not accurately reflect the boundaries of each upland swamp observed in the field and from current aerial photography (NearMap 2019 and SixMaps 2019).

The revised swamp boundaries are shown on **Figure 3.1** and details are provided in **Table 3.1**

Table 3.1: Revised upland swamps overlying Longwalls 311-315 (Ecoplanning 2019)

Swamp Number	Over Longwalls 311-315 or Pillars	Revised Vegetation Community (Ecoplanning 2019)
78	Yes	Banksia Thicket
79	Yes	Banksia Thicket
80	Yes	Banksia Thicket
90	Yes	Banksia Thicket
91	Yes	Banksia Thicket

The upland swamps overlying Longwalls 311-315 were all identified and mapped as the Sedgeland Heath (BBS 2008). Current field inspections confirmed the presence of Banksia Thicket at Swamps 78, 79, 80, 90 and 91. Following field inspections, two of the smaller upland swamps were found to contain areas of well-defined Sandstone Heath Woodland (Swamps 79 and 90), and one upland swamp (Swamp 80) was found to be more extensive and divided by Fire Trail 9E. In these instances, revising the extent of swamp mapping included splitting the swamps into discrete areas (**Appendix A**).

The mapping of BBS (2008) was based upon field surveys undertaken between late 2006 and early 2008, approximately 12-20 years post the fires in 1986-1987 and 1993-1994 which extensively burnt the catchments of Woronora, O'Hares, Nepean and Avon. The field surveys undertaken for this report were undertaken some 25 years post fire for all swamps.

Much of the upland swamp vegetation mapped as Banksia Thicket in this report is likely to have had more affinity to the Sedgeland-heath Complex in the years immediately following these fires (1986-1987 and 1993-1994). Keith & Myerscough (1993) observed that the boundaries delineating Banksia Thicket may shift after fire and speculated that fires influence the relative occurrence of upland swamp communities that occur in drier habitats, including Banksia Thicket, Restioid Heath & Sedgeland.

Profiles for each of the swamps including the specific vegetation community confirmed as occurring, updated boundaries, photos and key characteristics of each swamp are also provided in **Appendix A**. The revised vegetation community mapping (as a result of the revised upland swamp boundaries and vegetation community classification within 600 m of Longwalls 311-315 secondary extraction) by Ecoplanning (2019) is shown on **Figure 3.1** and **Figure 3.2**.

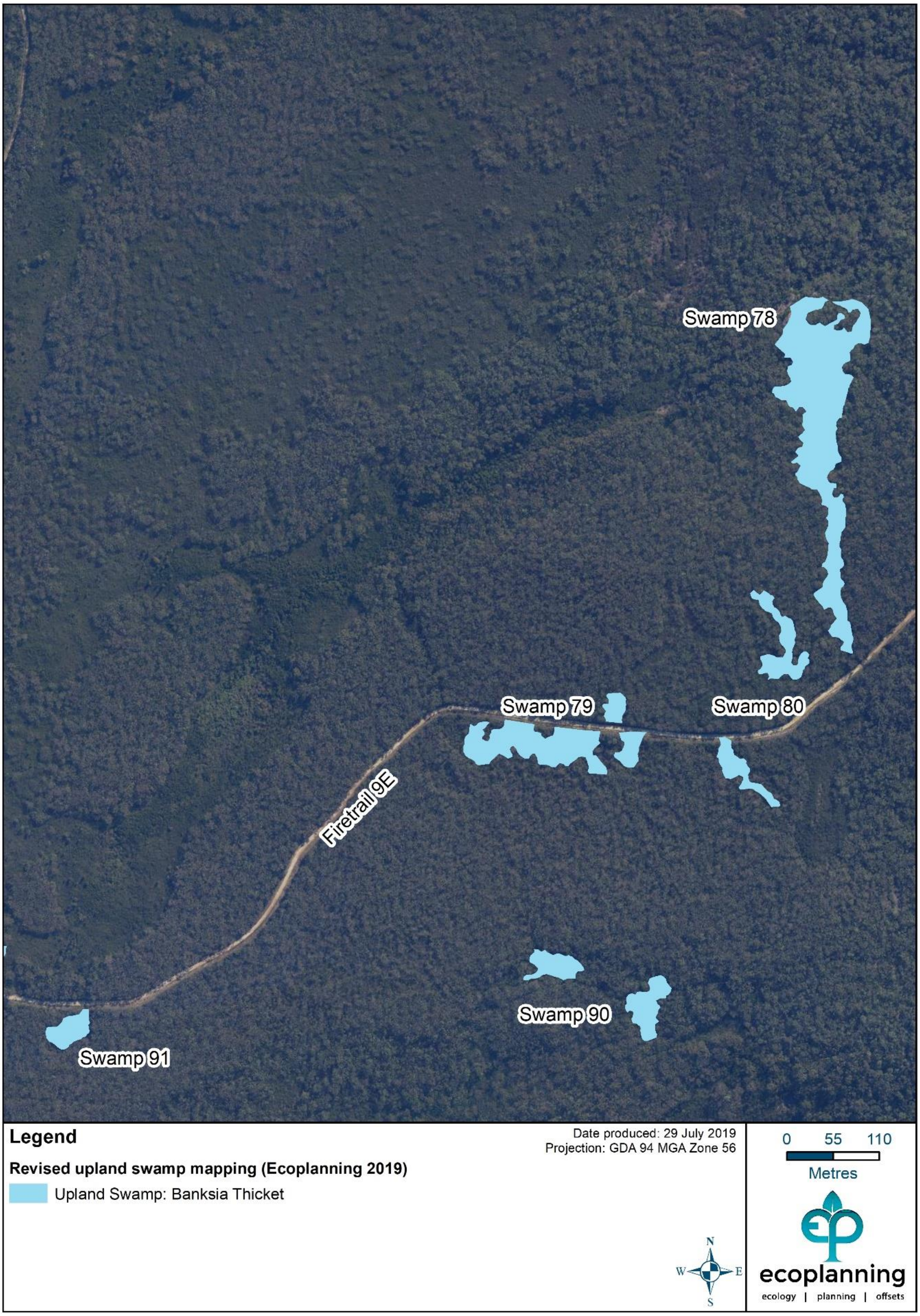

Figure 3.1: Revised upland swamp vegetation mapping extent (Ecoplanning 2019)

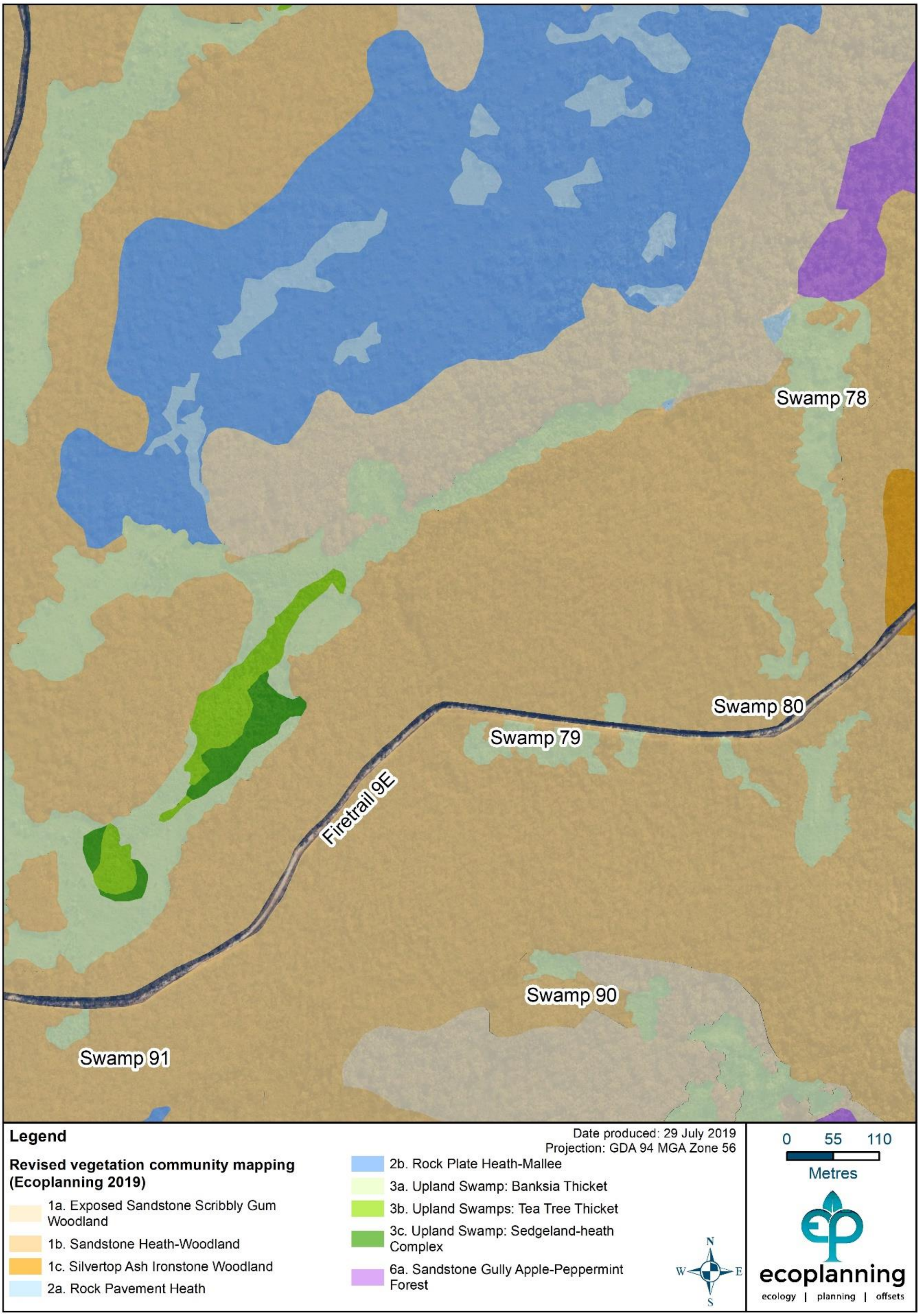

Figure 3.2: Revised upland swamp vegetation mapping, after BBS (2008)

3.2.2 Indicator species

Counts of Banksia Thicket indicator species, monitored as part of the LW301-303 BMP (Metropolitan Coal 2016) and to be monitored as part of the recently approved Longwall 304 BMP (July 2019) within upland swamps overlying Longwalls 311-315 identified that all three indicator species were not widespread across all five swamps. Sufficient numbers of *Pultenaea aristata* were recorded in Swamps 79 and 90. Sufficient numbers of *Sprengelia incarnata* were found in Swamp 79, and sufficient numbers of *Epacris obtusifolia* were found in Swamp 90.

Longwalls 311-315 are located at the northern limit of the distribution of *Pultenaea aristata.* This species was located in two of the upland swamps overlying Longwalls 311-315 (Swamps 79 and 90), and in sufficient numbers for potential future monitoring within these two swamps.

Sprengelia incarnata, which typically occupies the wetter areas with deeper soils within Banksia Thicket vegetation community, was observed within two upland swamps overlying Longwalls 311-315 (Swamps 79 and 90) but was only present in sufficient numbers for potential future monitoring in Swamp 79.

Epacris obtusifolia was recorded within three of the upland swamps overlying Longwalls 311-315 (Swamps 79, 80 and 90) but was only present in sufficient numbers for potential future monitoring in Swamps 90.

Details of indicator species in those swamps identified as upland swamps during the current survey are as follows:

- In Swamp 78, no indicator species were observed.
- In Swamp 79, swamp indicator species were present including *Pultenaea aristata* (>20 individuals) and *Sprengelia incarnata* (>20 individuals). *Epacris obtusifolia* was present but few in number (11 individuals observed).
- In Swamp 80, swamp indicator species were limited to *Epacris obtusifolia* (14 individuals). Additional individuals may be found following further detailed searches. *Pultenaea aristata* and *Sprengelia incarnata* were not recorded.
- In Swamp 90, indicator species were present including *Pultenaea aristata* (>20 individuals) and *Epacris obtusifolia* (>20 individuals). *Sprengelia incarnata* was also recorded (<20 individuals) although more individuals may be found following further detailed searches. A number of the *Pultenaea aristata* individuals were observed growing at the interface between the swamp vegetation and Sandstone Heath Woodland. *Pultenaea aristata* is found within communities ranging from dry sclerophyll woodland to heath and swamp heath on sandstone (Benson & McDougall 1996, PlantNet 2019) and hence not confined to upland swamps alone.
- In Swamp 91, no indicator species were observed.

3.3 Swamps 76, 77, 92 and 106 – revised adjoining vegetation community mapping

Swamps 76, 77, 92 and 106 overlying Longwalls 312-317 are all headwater swamps occurring on the broad plateaux characteristic of the Woronora Catchment areas west of the Woronora Reservoir. Vegetation within the large swamps and the surrounding vegetation has been previously mapped (BBS 2008), with some of these large swamps having several different vegetation communities adjoining them. These include Fringing Eucalypt Woodland, Sandstone Heath Woodland, Exposed Sandstone Scribbly Gum Woodland, Silvertop Ash Ironstone Woodland, Sandstone Gully Apple Peppermint Forest and Rock Plate Heath.

3.3.1 Fringing Eucalypt Woodland

Fringing Eucalypt Woodland is described by NPWS (2003) as occurring at the ecotone between upland swamp communities and adjacent sandstone woodland communities and consists of widely spaced eucalypts marking the transition between sandstone woodland and treeless heath and sedgelands. This community is described as a very open woodland with a canopy cover less than ten percent comprising widely spaced *Eucalyptus racemosa*, *E. oblonga* or *E. sieberi*. Within the areas investigated as part of this report an ecotonal community between upland swamp and adjacent woodland vegetation was identified however, this ecotonal community had a woodland structure with a canopy cover similar to adjacent woodland areas, although the understorey supported more hydrophilic sedge and fern species including *Lepyrodia scariosa* and *Gleichenia dicarpa*. The ecotonal community observed during field inspection are not considered part of the upland swamp complex (unlike the Fringing Eucalypt Woodland of NPWS [2003]) but rather is considered to represent a more mesic ecotonal example of sandstone woodland and heath communities.

Small areas within Swamps 93 and 106 were identified as forming part of the Fringing Eucalypt Woodland ecological community as described by NPWS (2003) and BBS (2008). These areas were generally isolated areas surrounded by other swamp types and included a sparse canopy of Eucalyptus species over characteristic swamp understorey species.

3.3.2 Swamps 76, 77, 92 and 106

Swamps 76, 77, 92 and 106 are large headwater swamps and support a mosaic of different swamp communities. Revised mapping of these swamps has been undertaken by FloraSearch (2016) (**Figure 1.2** and **Section 1.1**), providing more detailed mapping and characterisation of the swamp vegetation within these swamps.

As described in **Section 1.1**, following the revision of the mapping within these large swamps, a number of 'gap' areas were created where mapping boundaries between the swamp communities and surrounding vegetation did not overlap. These areas were targeted during the field inspections to identify the vegetation occurring within these gap areas and to subsequently update the vegetation mapping.

Following field inspections of these large swamps, the following summary is provided:

- Swamp 76 – for the most part, gap areas conform to the surrounding mapped communities of Sandstone Heath Woodland and Rock Plate Heath-Mallee.

Following field inspection, it was identified that the area of Banksia Thicket at the northern end of this upland swamp mapped by FloraSearch (2016) continues north, occurring within a narrow strip and bounded by Rock Plate Heath-Mallee (**Figure 3.3**). Other surrounding vegetation includes Rock Plate Heath-Mallee, Sandstone Heath Woodland and Exposed Sandstone Scribbly Gum woodland (**Figure 3.3**).

- Swamp 77 – Parts of Swamp 77 are bounded by or have inclusions of Fringing Eucalypt Woodland – a community identified and mapped by BBS (2008) (**Figure 1.1**). Other adjoining vegetation communities include Exposed Sandstone Scribbly Gum Woodland and Sandstone Heath Woodland.

  Following field inspection of gap areas, adjoining vegetation communities were identified as Sandstone Heath Woodland and Exposed Sandstone Scribbly Gum Woodland (**Figure 3.3**).

- Swamp 92 – Areas on the northern side of Swamp 92 are mapped as Fringing Eucalypt Woodland, whilst to the east and south, Exposed Sandstone Scribbly Gum Woodland and Sandstone Heath Woodland are mapped respectively (BBS 2008) (**Figure 1.1**).

  Following field inspection of gap areas, adjoining vegetation communities were identified as conforming to Sandstone Heath Woodland and Exposed Sandstone Scribbly Gum Woodland. Areas mapped as Fringing Eucalypt Woodland along the northern boundary were identified in the field as conforming to the ecotone of Sandstone Heath Woodland as described in **Section 3.3.1** (**Figure 3.3**).

- Swamp 106 – This upland swamp is mostly surrounded by Sandstone Heath Woodland, with Sandstone Gully Apple Peppermint Forest and Fringing Eucalypt Woodland mapped along the western edge (BBS 2008) (**Figure 1.1**).

  Following field inspection of gap areas, the vegetation communities were identified as conforming to Sandstone Heath Woodland as previously mapped. Areas of Fringing Eucalypt Woodland previously mapped along the western edge of Swamp 106 (BBS 2008) (**Figure 1.1**) were identified as Sandstone Heath Woodland (**Figure 3.3**).

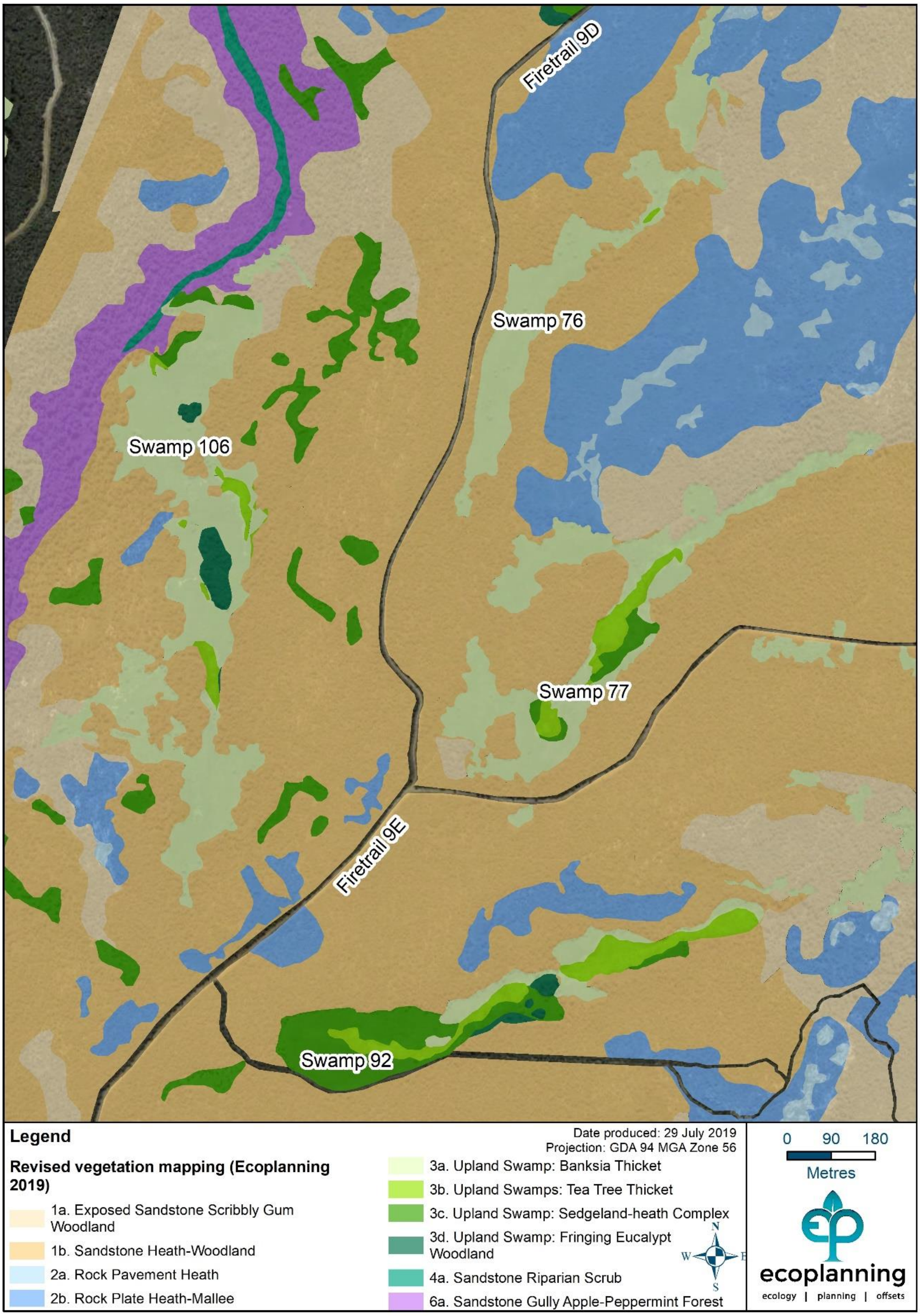

Figure 3.3: Revised vegetation mapping of adjoining communities surrounding Swamps 76, 77, 92 and 106

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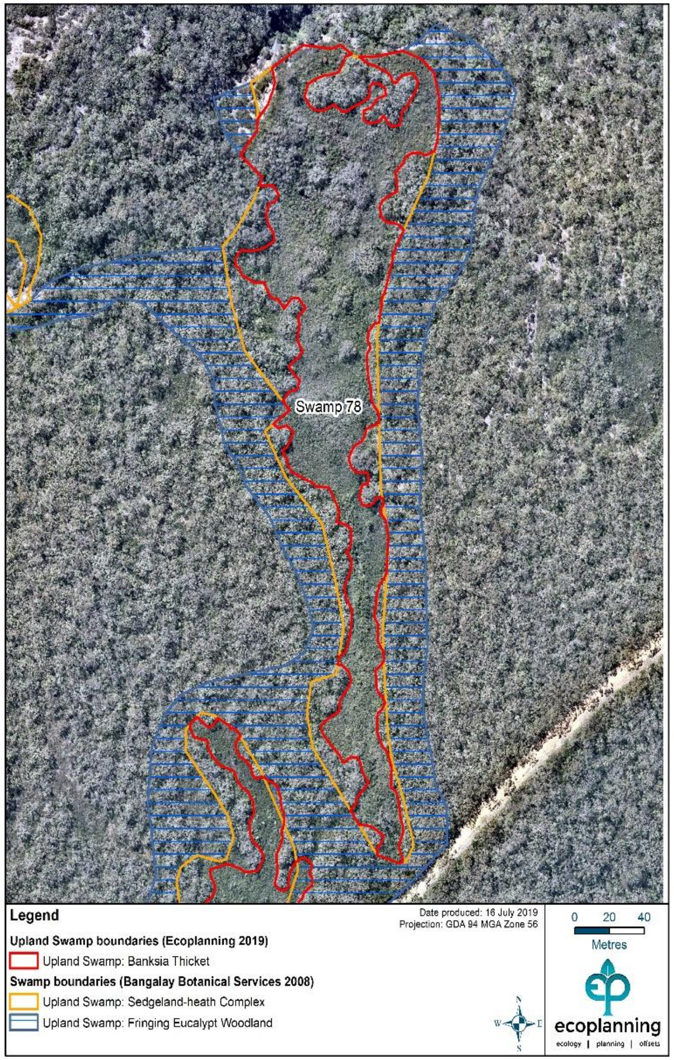
Appendix A Upland Swamp vegetation mapping and swamp profiles: Swamps 78, 79, 80, 90 and 91

Swamp 78



- Swamp 78 is a small headwater swamp located over Longwall 311 and in part over the adjacent Longwall chain pillars 310-311 and Longwall chain pillars 311-312.

- This swamp was previously mapped as Sedgeland-heath Complex (BBS 2008). Field inspections identified that the vegetation conforms to Banksia Thicket across the majority of the swamp but does contain some small woodland patches. Fringing Eucalypt Woodland was also mapped adjoining this swamp (BBS 2008), however, field survey identified Sandstone Heath Woodland to be a more appropriate community given the density of canopy species which included *Eucalyptus racemosa, E. sieberi and Corymbia gummifera*. The understorey was also dominated by species characteristic of Sandstone Heath Woodland.

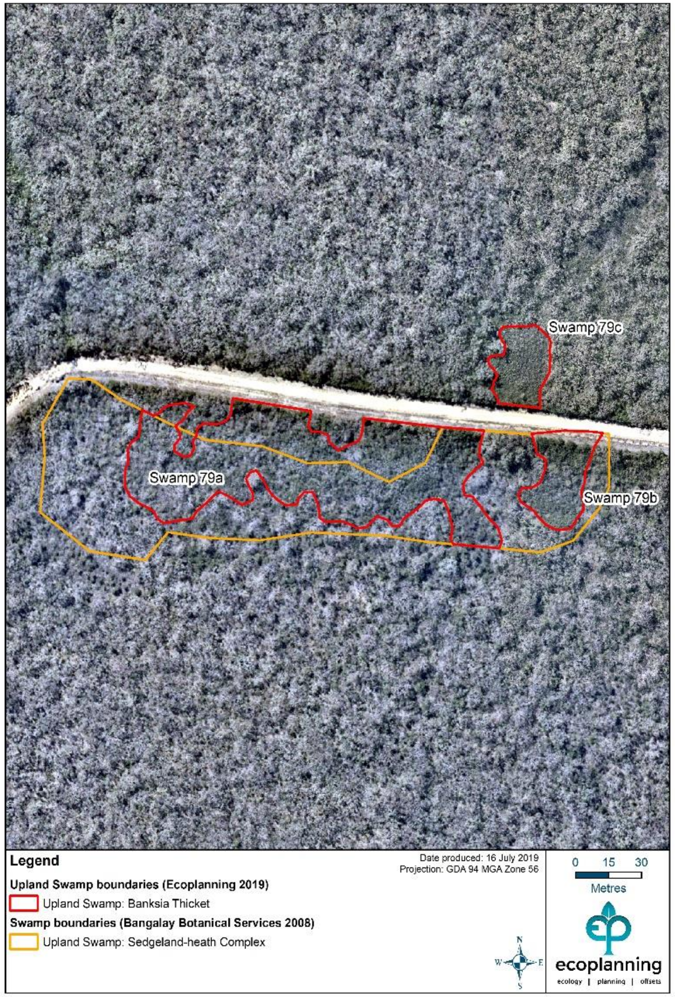
- Fire history: burnt 1986-1987.

- This swamp is approximately 1.79 ha in area.

- This swamp is generally characterised as having a tall dense shrub layer dominated by *Banksia ericifolia* subsp. *ericifolia* and *Leptospermum squarrosum* 1.5 m – 2.5 m in height over smaller shrubs and ground layer species including *Baeckea imbricata, Schoenus brevifolius* and *Lepyrodia scariosa.*

- A terminal step is present at the northern end represented by a small cliff below which is a first order drainage line that flows north east into the Woronora Reservoir.

Swamp 79



- Swamp 79 is a small linear swamp located over Longwall 312, Longwall 312-313 chain pillar and in part over Longwall 313.

- This swamp was previously mapped as Sedgeland-heath Complex (BBS 2008). Field inspections identified that the vegetation conforms to Banksia Thicket across the swamp and the adjoining vegetation is Sandstone Heath Woodland. Field survey also identified that Swamp 79 can be subdivided into three smaller swamps, herein referred to as Swamps 79a and 79b located south of Fire Trail 9E and 79c located north of Fire Trail 9E. Swamp 79a is the largest of the three with areas of Sandstone Heath Woodland dividing Swamp 79a and Swamp 79b.

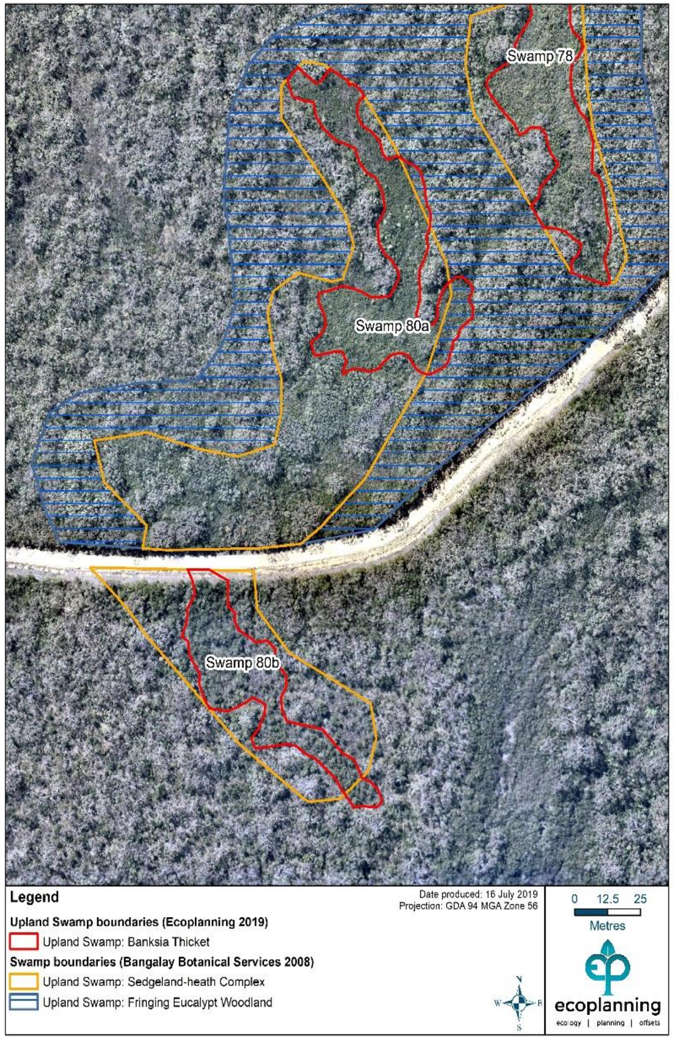
- Fire history: Swamps 79a and 79b burnt 1986-1987 and 1993-1994. Swamp 79c burnt 1986-1987.

- Swamps 79a, 79b and 79c form a combined area of 0.8 ha (S79a – 0.63 ha, S79b – 0.1 ha, S79c – 0.08 ha).

- This swamp is generally characterised as having a tall dense shrub layer dominated by *Banksia ericifolia* subsp. *ericifolia* and *Hakea teretifolia* 2 m – 3 m in height over smaller shrubs of *Petrophile pulchella, Melaleuca thymifolia* and *Baeckea imbricata* and ground layer species including *Cyathochaeta diandra, Schoenus brevifolius, Leptocarpus tenax* and *Empodisma minus.*

- Swamps 79a, 79b and 79c lack a terminal step.

Swamp 80



- Swamp 80 is a curved swamp located over Longwall 311 and over the Longwall 311-312 chain pillar in part.

- This swamp was previously mapped as Sedgeland-heath Complex (BBS 2008). Field inspections identified that the vegetation conforms to Banksia Thicket across the swamp with the adjoining vegetation identified as Sandstone Heath Woodland. Field survey also identified that Swamp 80 can be subdivided into two smaller swamps, herein referred to as Swamp 80a, the largest, and Swamp 80b located north and south of Fire Trail 9E respectively. Similar to Swamp 78, Fringing Eucalypt Woodland was also mapped adjoining this swamp (BBS 2008), however, field survey identified Sandstone Heath Woodland to be a more appropriate community given the density of canopy species including *Eucalyptus racemosa, E. sieberi and Corymbia gummifera*.

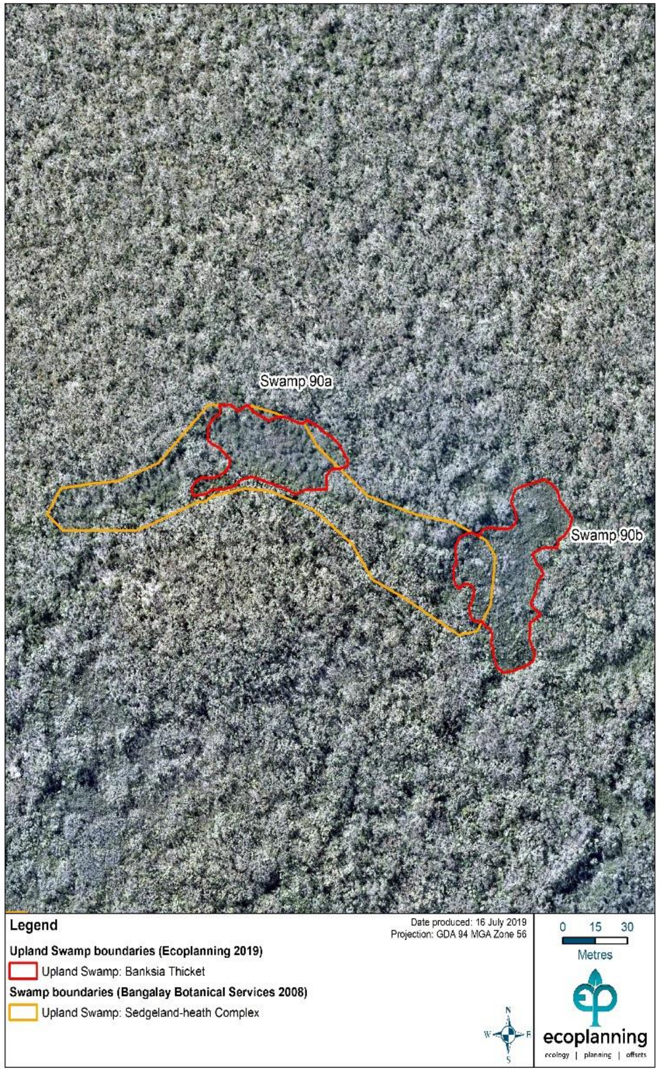
- Fire history: Swamp 80a burnt 1986-1987 and Swamp 80b burnt 1986-1987 and 1993-1994.

- Swamps 80a and 80b form a combined area of 0.42 ha (S80a – 0.26 ha, S80b – 0.17 ha).

- This swamp is generally characterised as having a tall dense shrub layer dominated by *Banksia ericifolia* subsp. *ericifolia* and *Hakea teretifolia* 2 m – 3.5 m in height over smaller shrubs of *Petrophile pulchella, Banksia oblongifolia, Epacris microphylla, Leptospermum squarrosum* and *Baeckea imbricata* and ground layer species including *Guringalia dimorpha, Chordifex fastigiatus, Leptocarpus tenax* and *Bauera microphylla*.

- Both Swamps 80a and 80b lack a terminal step.

Swamp 90



- Swamp 90 is a small east-west curved swamp located in part over Longwalls 311 and 312 and over the Longwall 311-312 chain pillar.

- This swamp was previously mapped as Sedgeland-heath Complex (BBS 2008). Field inspections identified that the extent of swamp vegetation is much reduced and located in two separate areas herein referred to as Swamp 90a and Swamp 90b located to the east of Swamp 90a. The vegetation across Swamp 90a and 90b conforms to Banksia Thicket with the adjoining vegetation identified as Sandstone Heath Woodland. Both areas are located south of Fire Trail 9E.

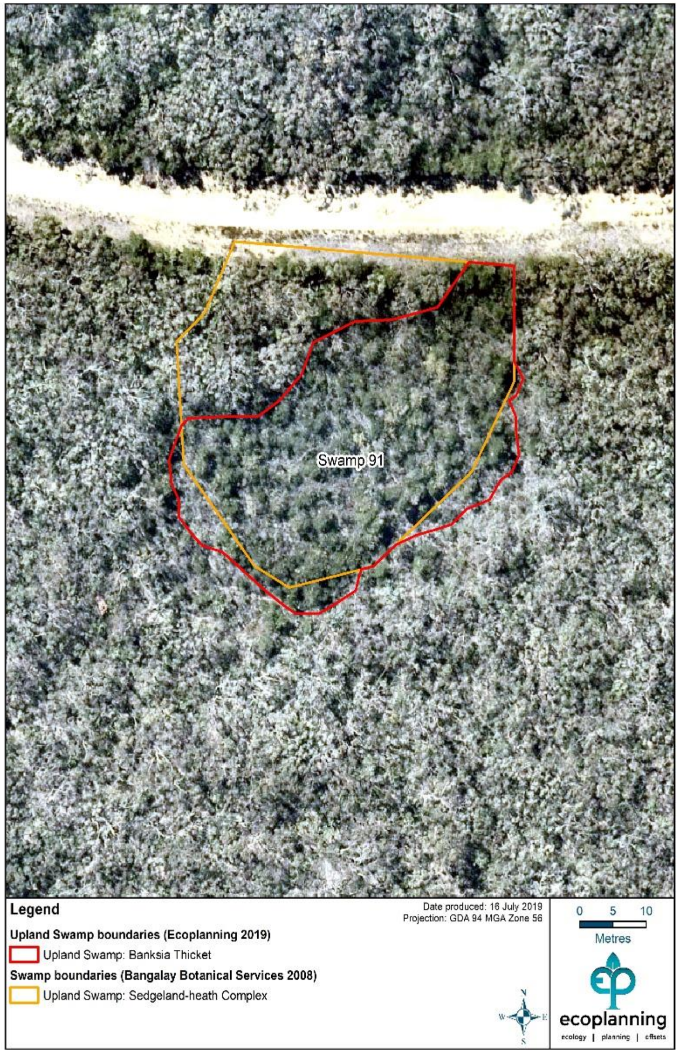
- Fire history: Swamp 90a and 90b burnt 1986-1987 and 1993-1994.

- Swamps 90a and 90b form a combined area of 0.38 ha (S90a – 0.16 ha, S90b – 0.22 ha).

- The vegetation of Swamp 90a is generally characterised as having a tall dense shrub layer dominated by Banksia ericifolia subsp. ericifolia, Hakea teretifolia and Petrophile pulchella 2 m – 4 m in height over smaller shrubs of *Baeckea imbricata* and ground layer species including *Chordifex fastigiatus*, *Lepyrodia scariosa* and *Schoenus brevifolius*. Swamp 90b is also characterised as having a tall dense shrub layer dominated by *Banksia ericifolia subsp. ericifolia*, *Hakea teretifolia* 1.5 m – 2.5 m in height over similar understorey species. A drainage line is present within S90b where *Banksia robur*, *Lepidosperma limicola* and *Gleichenia microphylla* occur in more wetter areas.

- Both Swamps 90a and 90b lack a terminal step.

Swamp 91



- Swamp 91 is a small oval-shaped swamp located over Longwall 315.

- This swamp was previously mapped as Sedgeland-heath Complex (BBS 2008). Field inspections identified that the extent of swamp vegetation is reduced in area and conforms to Banksia Thicket with the adjoining vegetation identified as Sandstone Heath Woodland. Swamp 91 is located south of Fire Road 9E

- Fire history: Swamp 91 burnt 1986-1987 and 1993-1994.

- Swamps 91 is 0.15 ha in area.

- The vegetation of Swamp 91 is generally characterised as having a tall dense shrub layer dominated by *Banksia ericifolia subsp. ericifolia, Hakea teretifolia* and *Leptospermum squarrosum* 2.5 m – 3.5 m in height over smaller shrubs of *Baeckea imbricata, Petrophile sessilis*, *Banksia oblongifolia* and *Epacris microphylla* and ground layer species including *Leptocarpus tenax, Schoenus brevifolius, Cyathochaeta diandra* and *Ptilothrix deusta*.

- Swamp 91 lacks a terminal step.

APPENDIX 4
UPLAND SWAMP SEMI-QUALITATIVE ANALYSIS METHODOLOGY

Available in Electronic Version

B.1 Summary of Methodology

The methodology was described in a letter (HydroSimulations, 2018) in detail. This section gives a summary of how the Recession/Recovery semi-quantitative methodology works and how it is interpreted.

Initially, a pre-processing step is performed on all data. Firstly, short-term fluctuations in the data, “noise”, are suppressed by finding the seven-day average water level from the range of daily data. This allows for changes and trends in the data to become clearer.

These seven-day average water levels are used to calculate a normalised weekly average of water level above the base of the piezometer (water level minimum), in turn providing an indication of the relative saturated thickness. Normalised values are calculated to be within a range of 0 and 1. The equation used to normalise the data is as follows:

$$n = \frac{\mathrm{WL} - \mathrm{WL}_{\mathrm{min}}}{\mathrm{WL}_{\mathrm{max}} - \mathrm{WL}_{\mathrm{min}}}$$

where: n is the normalised output (dimensionless), WL is any seven-day average water level from the data (m), and WL_{min} and WL_{max} are the minimum and maximum water levels for the specified data range (m), respectively. Normalising the data in this way allows data from different swamps to be meaningfully comparable while also accounting for occasional changes in piezometer elevation.

The recession-recovery method compares the change in gradient of rising and receding swamp water levels over time. It is plotted as a cumulative frequency distribution to highlight the gradient trends for a given period. Gradients of water level change are calculated using the normalised water levels, as calculated above. This involves finding the difference between normalised water levels (n_a and n_b) over a time period as per the equation:

$$Gradient = \frac{n_b - n_a}{\Delta t}$$

The time period (t) is usually seven days, if the data set is complete. For data gaps, the time period would be adjusted accordingly. The unit of the gradient is 1/day (note: this is a correction from HydroSimulations, 2018).

From these gradients, recession events are isolated by separating all those values less than zero. The method also provides information on rates of recovery during wet periods, using only positive gradient values. Both gradients of recovery and gradients of recession are then plotted on a cumulative frequency distribution (CFD) plot.

There are several ways the CFD plot can be interpreted, as it is dependent on the change relative to the control swamp and baseline period. It is assumed that both the control swamp and monitored swamp would have experienced the same regional climate and therefore would show similar trends in response to increased or decreased water levels as a result of changes in precipitation. There are three scenarios:

1. If the CFD curves for both baseline and post-baseline periods at the control and monitored swamps are similar, it can be assumed that changes in gradient are predominantly a result of climatic changes.
2. Post-baseline conditions that reflect more intense changes in water level: Compared to the gradient distributions in the baseline, the post-baseline is characterised by steeper rises and falls of water level with decreased stability as evidenced by the reduction in gradients around or at zero. Such a regime may be attributed to increased connectivity beneath the swamp substrate which has allowed enhanced drainage following a precipitation event.

3. The post-baseline gradient distribution has changed from one with high rates of water level fluctuation to one where relatively little change is occurring. A higher proportion of gradients at or near zero characterises the distribution of gradients in the post-baseline. In this case, the swamp substrate is less responsive to drying or wetting events post-baseline.

B.2 Results

<table>
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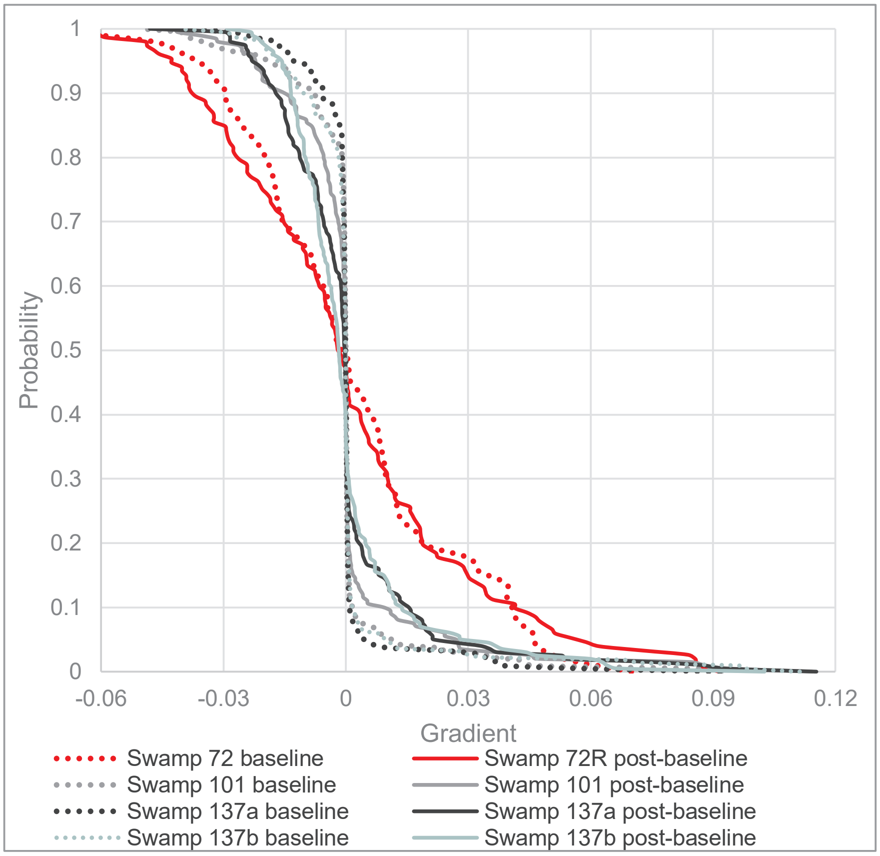
<tr><td>
</td><td>Note that the baseline was established using Swamp 72, and the post-baseline with Swamp 72R
Swamp 72 and 72R show a similar behaviour during and post-baseline.

Swamp 72 not impacted.</td></tr>
</table>